INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS INC. (IEEE)

Proceedings of the

1st International Conference

IEEE NIGERCON 2010

First published in Nigeria in 2010 by
IEEE Nigeria Section

Vol. 1 No. 1

Designed &Printed by
SKILLMARK MEDIA LTD.
18 Kagha Street, Owerri. Imo State, Nigeria.
Tel: 083231511, 08036690084, 08051090040

PREFACE

The papers in this Proceeding are from the first IEEE Conference in Nigeria, NIGERCON 2010, held at the Rockview Hotel Abuja, 17 th- 19 th June 2010. More than forty papers were received from the Industry and Academia **.** The theme of the conference was **Emerging and Sustainable Technologies for Power and ICT in a Developing Economy** The primary objective of the Conference was to provide a forum for discussion of new ideas, best practices, research & development results, etc, to stimulate growth and advance the state of knowledge and practice of Electrical Engineering and Information & Communication Technology in a developing society.

In line with IEEE core purpose of fostering technological innovation and promoting members careers, IEEE Nigeria Section subsidized the conference fee in order to provide opportunities for students and young engineers to attend and meet their experienced peers for better networking and productivity. In addition, a special provision was made for ***Challenge sessions*** for papers from universities, where guidance and steer was given for research towards Nigeria's most area of need for achieving the Vision 2020.

On behalf of the Conference Planning Committee, I wish to express our sincere gratitude to all our sponsors: the managements of Power Holding Company of Nigeria, Warri Refining & Petrochemical Co. Ltd., Federal University of Technology Owerri, Federal Polytechnic Nekede, Nigerian National Petroleum Corporation, Nigerian Communications Commission, Nigerian Television Authority, Digital Bridge Institute, Nigerian Electricity Regulatory Commission, DANEL EC Fze, and many others too numerous to mention. I thank all who submitted and presented papers. Finally, I thank in a special way, all members of my Committee who volunteered their time to make the conference successful.

Engr Dr Gloria Chukwudebe,SMIEE, FNSE.
Vice-Chair Nigeria Section & Chair, Conf. Planning Committee.

TABLE OF CONTENTS

THE ROLE OF IEEE STANDARDS IN WORLD ADVANCEMENT

Isaac Adekanye, SMIEEE, +Gloria Chukwudebe, SMIEEE and +Christian Mbaocha, MIEEE
Agip Energy and Natural Resources Ltd, Port Harcourt.
+Federal University of Technology Owerri.

ABSTRACT
To attain IEEE vision of advancing global prosperity by fostering technological innovation and excellence, the IEEE-Standards Association, over the years has unleashed numerous standards to drive the functionality, capabilities and interoperability of a wide range of products and services. The all-pervasive IEEE 802.X standards suite has radically transformed the way people live, work and do business. In this paper, the significance of standardization, the role of IEEE and its scope of activities are described. The IEEE-Standards Association (SA) process framework and how individuals and corporations can participate are explained. The various subscription and access options to the over 1,300 portfolio of IEEE standards, drafts and archived standards inclusive, are listed. The IEEE 802 committee successes since its 30years inception, the 802 standards on Local Area Network, Personal Area Network and Metropolitan Area Network for wired and wireless technologies are outlined. In view of the crucial role of standards education, inclusion in undergraduate curriculum is recommended. To facilitate diffusion and compliance, standards education training is also recommended for practitioners in the industry.

Keywords: Standards, standardization, globalization and IEEE standards.

I. Introduction

Institute of Electrical/Electronic Engineers Inc. (IEEE) advances global prosperity by fostering technological innovation through organising conferences all over the world, development of technical standards and publication of journals, newsletters, magazines and proceedings. By harvesting from its more than 375,000 members in 160 countries, IEEE has become a leading authority on a wide variety of areas ranging from aerospace systems, computers and telecommunications to biomedical engineering, electric power and consumer electronics. Hence, in order to promote and advance these fields of endeavour, setting standards has become a natural routine for IEEE Inc.

Everybody has benefited from the IEEE 802.X suite of standards for Local Area Network/Metropolitan Area Network (LAN/MAN) applications. Actually, in the practice of engineering and technology, the development of **technical** and **business standards** to meet design, manufacturing and market requirements, is fundamental to the delivery of products and services.

All products and services available in the market place are manufactured or supplied based on documented designs and/or processes. This is the only way that suppliers and their customers can be sure that each unit will be a replica of the prototype and other units sold or to be sold. This means that all products and services are created according to one or more standards. Therefore, *any agreement on how something is done, made, or used can be considered a standard*.

For instance, whenever one makes a local, long distance, or international telephone call, many standards are exercised to accomplish the desired connection. The dialling tones and the ring back signals are all realized in compliance with existing standards.

Many countries of the world have organisations charged with the responsibility of developing and accrediting standards that cover many familiar products ranging from safety glasses and shoes to how cellular telephones interconnect with wireless base stations and hence to other telephones. In the USA, American National Standards Institute (ANSI) is the standard accreditation body, while h

ETSI does for the European Union (EU) etc. The other standards organisations with global scope include: International Standard Organisation (ISO), the International Electrotechnology Commission (IEC) and the International Telecommunications Union (ITU), a special agency of the United Nations.

All over the world, standards development is carried out under an accredited process. The IEEE, a non-profit organisation is accredited by ANSI for standards development. ANSI carries out audit of Standards Development Organisations every 5 yrs for quality assurance of the process.

The structure of the paper is as follows: the significance and advantages of standardization are discussed in Section 2. A general overview of IEEE standards scope, standardization process framework and on-line resources are described in Section 3. The all-pervasive IEEE 802 standards are briefly presented in Section 4. The importance of standards education and available IEEE resources are highlighted in Section 5. The paper is summarised in Section 6 and recommendations are given in Section 7.

II. Significance of Standards and Standardization

Technical standards are formal documents that establish uniform engineering or technical criteria, methods, processes and practices developed through an accredited consensus process. For more than fifty years, standardization has progressed to a stage whereby, *standards* are developed based on guiding principles of openness, balance, consensus and due process in order to meet technical, safety, regulatory, societal and market needs.

In simplest cases, standards are codified by an individual supplier. In more complicated cases, the standard may be a formal agreement among all direct and materially affected interests who have come together in an organised fashion or forum to reach a consensus on the specifications that must be met for the product or service to be offered to the marketplace.

These *agreements/standards* are driven by the need for *inter-operation* of units sold into the market by two or more suppliers. In case of only one supplier, the standard is *proprietary* hence there is no need for an agreement outside of the supplier's own process. Proprietary standards are developed behind corporate closed doors. Proprietary standards that dominate in the market place is known as ***de facto*** standards [1].

The disadvantage of a *proprietary* standard is that, that organization may need to make all the products and interfaces for a limited market scope. On the other hand, *Consensus standards* are developed under the over-sight of non-profit organizations for the public good. Consensus standards have several advantages, one of which is that, new suppliers can enter the market once they can meet all applicable requirements. Consensus standards with many suppliers result in increased competition, reduced prices and improved quality.

Some standards are *Mandatory* because they are driven by social issues or environmental requirements. Standards whether mandatory or otherwise exist at all government levels, international, regional and national. Suppliers and manufacturers prefer international standards because of wider scope of the market.

Presently, standards influence everything we do, standards control markets, hence, standards and standardization systems will continue to play an increasingly important role in the world. Besides the effort of a global organisation such as IEEE, many countries and continents have evolved standardization programmes [2]. A survey in [3] revealed that standardization programmes offer one of the best means of evaluating current technology, driving innovation and forecasting where future technology innovations may occur.

Advantages Of Standards

Standards for business processes, products and services have become imperative because of the numerous benefits of standardization. Standards play a key role in defining relationship between product and service design features i.e. human interfaces, content and how they work. Standards facilitate mass production and multi-national participation.

When a new technology emerges from R & D, a standard development process acts as a catalyst to bring manufacturers, service providers and

users, to determine how, when and where this technology will fit so as to get the best value.

Generally, the creation of standards, establishes a healthy competition amongst manufacturers and suppliers, e.g telephone and connections, Internet Service provision, laptops, flash drives, etc. The resulting competition gives rise to increased sales, lower costs, numerous functions and higher quality.

Another benefit of standards is in consumer protection, for instance, when a new add-on or advance in an existing product is developed, standardization provides the forum and process for backward compatibility to accommodate existing consumers. Other benefits of standards include: creation of new and expand existing markets and boosting of consumer confidence, etc.

III. IEEE Standards

IEEE is a leading developer of industry standards in a broad range of technologies, as at the time of writing this paper, it has an active portfolio of nearly 1, 300 standards and projects under development. The IEEE Standards Associat ion (IEEE-SA) is in charge of development of standards. For over a century, the cornerstone of the IEEE - Standards Association, is its established standards development programme framework. The programme framework offers balance, openness, due process, and consensus.

Each year, the IEEE-SA conducts over 200 standards ballots, a process by which proposed standards are voted upon for technical reliability and soundness. With collaborative thought leaders in more than 160 countries, IEEE-SA promotes innovation, enables the creation and expansion of international markets, and helps protect health and public safety.

IEEE standards set specifications and best practices based on current scientific and technological knowledge. All of the policies, procedures and information that you may need while a member of the IEEE-SA Board of Governors are available on line [4].

Each IEEE standard follows a set path from concept to completion, which adheres to the principles of due process, openness anc consensus. These principles allow for equity and fair play so no one interest category dominates the process, and any organization or person with a desire to participate in a proposed standard can do so.

Membership Of IEEE-Standards Association

Individuals, including IEEE members of any grade, IEEE Society affiliates, or non-IEEE members are eligible for IEEE-SA membership. The many ways to get involved are, you can:

- Submit project request to start a new standard.
- Join working groups to develop sta ndards.
- Join invitation pools to express your interest in voting or balloting on standards.
- Become a member of a balloting group to vote on the technical integrity of the standard.
- Become a member of the Standards Board or Board of Governors.

Corporate Membership is designed for corporations, government agencies, trade associations, user groups, universities and other standards developing organizations that want to actively participate in standards development. In addition to many other benefits, C orporate Members can ballot on an unlimited number of corporate projects.

Getting involved in IEEE standards provides one with the opportunity to network with industry peers and broaden one's understanding of the industry and technology, as well as gain familiarity with the content of relevant standards. This facilitates compliance and ability to anticipate market requirements.

IEEE-SA has an Industry Connections programme to help like-minded organizations come together more quickly and cost-effec tively in the early stages of collaborative technical work. Through Industry Connections, groups can efficiently & economically build industry understanding and consensus in new technical areas, develop roadmaps, decide whether there is a need for standardization, and in what form it will take; then concentrate on their core purpose and move on projects rapidly.

The scope of IEEE SA activity includes:

- Local and Metropolitan Area Networks.

- Intelligent highway systems and vehicular technology.
- Distributed generation and renewable energy.
- Voting Equipment Electronic Data Interchange.
- Rechargeable Batteries for PCs.
- Motor Vehicle Event Data Recorder.
- Public Key Infrastructure Certificate Issuing and Management.
- Components Architecture for Encrypted Shared Media.
- Organic Field Effect Technology.

The IEEE standards are now available on-line, courtesy of the IEEE *Xplore*® digital library. ***Corporations, universities and government agencies*** can subscribe to the standards on-line. The All-Inclusive Sub scription provides access to the growing collection of over 1,300 IEEE standards, including drafts and archived standards. There are various options according to disciplines. The list is as follows:

- IEEE All-Inclusive Standards Subscription.
- IEEE All Information Technology Standards Subscription.
- IEEE All Telecommunications Standards Subscription.
- IEEE All Power and Energy Standards Subscription.
- IEEE Color Books Power Pack.
- IEEE LAN/MAN 802® Standards Subscription.
- IEEE Nuclear Engineering Standards.
- IEEE Software Engineering Standards Subscription.
- IEEE Power Transmission and Distribution Standards Subscription.
- IEEE Power Switchgear Standards Subscription.
- IEEE Power Protective Relaying Standards Subscription.
- IEEE Power Distribution and Regulating Transformers Standards
- IEEE Electromagnetic Compatibility Standards Subscription.

As at the time of writing, some companies are sponsoring free download of the following standards by any interested person: IEEE 802, IEEE/ANSI N42, IEEE 1666 and IEE E 2600.

IV. IEEE 802 Standards

Many things we fundamentally rely on such as the e-mail, for example, would not be as broadly available or as dependable without IEEE 802 local area networking standards. It is estimated that more than 98 percent of all Internet traffic crosses one or more IEEE 802 networks during its transmission [5]. Our computer, smart phone and may be your car tracker are just a few of the things containing interfaces compliant with the suite of network interoperability standards developed by the IEEE 802 LAN/MAN Standards Committee (LMSC).

The IEEE 802 LMSC was created in March of 1980 to bring together forward thinking technology leaders to develop interoperable network standards for computers and office equipment. The IEEE 802 committee began with the novel idea of creating a standard for local communications among devices manufactured by multiple vendors. The committee used ideas from the *High Level Data Link Control (HDLC)* protocols and *Xerox's Ethernet product*.

Originally, Ethernet was invented by Robert M. Metcalfe in 1973. His Ethernet was based on the idea of computers communicating over a shared coaxial cable as a broadcast transmission medium. For this work, IEEE recognized Robert M. Metcalfe in 1988 with the Alexander Graham Bell Award and in 1996 with its highest award, the IEEE Medal of Honor.

As the IEEE 802 Committee celebrates its 30 year history, this year, there is a portfolio of more than 100 standards for PAN, LAN and MAN. The 802 Committee operates by having an individual Working Group focus and produce a standard for a selected area, for example, Ethernet CSMA/CD (IEEE 802.3), Token bus (IEEE 802.5), Wireless LAN -Wi-Fi (IEEE 802.11), Bluetooth (IEEEE 802.15), Wimax (IEEE 802.16), etc.

The IEEE Local and Metropolitan Area Networks (LAN/MAN) Subscription contains the growing collection of IEEE 802® standards, including in-demand draft standards under development and archived standards. These standards form the foundation for nearly all data communication systems and help ensure that packets are delivered reliably from a source to a destination. The IEEE 802 standards apply to coaxial, copper and fiber optic cables, as well as to air interfaces

for radio frequency transmission in personal area networks (PANs) having scales of 10 m, local area networks (LANs) having scales of 100 m, and municipal area networks (MANs) having scales of 1,000 m.

The vibrant leadership of IEEE 802 committee is continuing to push the boundaries of innovation, the high quality and broad applications of 802 standards is a testament to the committee members' dedication, creativity, and vision. Anybody may attend an IEEE 802 meeting. For Plenary sessions, there is a required fee. Information on hotel location and pre-registration form is contained in the Plenary/Interim Session Information. The tutorial information for the plenary meetings and Meeting Agendas, Minutes and Reports are all available online [6].

V. IEEE Standards Education

Survey results in [2] revealed that, on-the-job training programmes used to address and resolve standardization issues will no longer suffice, in view of the growing complexity of globalization and the critical role of standards in technological advancement. In addition, it was found that for some nations, at least 50% of experienced standardization practitioners will retire in the near future. Hence, there is an urgent need for a strategy for training more young people who will replace the current generation of standardization practitioners. Consequently, IEEE has proffered a possible solution - *integrating standards into Science & Engineering education curricula.*

In response to the above need, IEEE SA has established a Standards Education Web site to acquaint students with the subject and to help engineers make good use of existing standards [3]. The Standards Education Web site provides educators and students with materials and resources for incorporating standards in undergraduate science and engineering technology programmes. The site contains free online tutorials and case studies introducing the history of standards, basic terminology, applications, standards' impact on product, processes, and service designs.

It is hoped that the knowledge of standards can help facilitate the transition fro m classroom to professional practice. The development of this web site is on going as IEEE has called for experts in various technical areas to create tutorials and case studies for demonstrating the application of standards.

Standards Education In Industry

Standards are playing an increasingly important role in the high-tech and electronics industries. Companies are including standards in their strategic plans, recognizing that standards can be leveraged into a competitive advantage. There are countless examples of how business climates have been changed as a direct result of using standards to establish “winners” and “losers” in the marketplace.

However, creating standards is a complex and often thorny undertaking. Employees ignorant of standards-setting may think it is a purely technical task. Whereas, there are several additional and crucial aspects, some of which include: legal processes, governmental, organizational, political, business, and even personal relationships. If a person isn't aware of all of these aspects, he or she can make mistakes in standards development tha t can have serious consequences, both for their company and for their own reputation. Hence it is important that industry and relevant government agency workers, marketing and sales persons have well structured formal training on standards to clearly appreciate the impact of standards on product delivery, performance interface quality, customer expectations, health & safety and compliance requirements. This is in addition to knowing where to find relevant standards, how to get standards changed or updated and how standards apply to technologies covered by patents and copyrights.

VI. Conclusion

Standardization of processes and products has become crucial for world's advancement. For more than a century, the IEEE has remained a leading developer of international standards that support many of today's products and services, particularly in telecommunications, information technology and power generation/distribution. IEEE- SA in charge of standards development, has been delivering highly valued standards since its inception, resulting in an active portfolio of nearly 1,300 standards with many projects currently under development. Individual scientists, engineers and corporations are free to be ds

members of SA and participate in standardization process. The IEEE standards Association has developed numerous for standards education to ensure diffusion of standards and sustainability.

IEEE-SA framework work is unique because of the diversity of the thousands of participants and the fact that some of the members can contribute from any where in the world. This year, 2010, IEEE 802 committee is celebrating its 30years anniversary and the all pervasive portfolio of several standards on LAN, MAN and PAN applications that have changed the way the world do business.

VII. Recommendations

Developing nations of Africa need to give priority and focus to meeting up with global standards in all relevant business processes. For any developing nation to be ranked amongst the top 20 in the whole world, she needs to train resources to understand standards, develop standards, manufacture products according to standards and regulate standards. Thus, inclusion of standards education in the science and technology undergraduate curricula is hereby recommended.

In view of the fact that it can take many years of "on-the-job training" for a professional who is unfamiliar with standards to become fully proficient, standards education and training is also recommended for Service providers, engineers, technologists and technicians.
IEEE offers many opportunities for individuals to be members of its Standards Association, this will boost the knowledge pool in standards.

All service providers, regulator-corporate organizations for power and ICT, government agencies in Science and Tech, Research and Develop in IEEE related fields will benefit from being corporate members of IEEE-SA.

REFERENCES

1. IEEE Tutorial on Standards Education, http://www.ieee.org/education_careers/education/standards/tutorials.html , accessed May 20, 2010.
2. ANSI Portal for Standards Awareness, http://standardslearn.org/
3. Donald E. Purcell, editor, The Strategic Value of Standards Education, A Global Survey conducted by The Center for Global Standards Analysis, August 2008.
4. Policy and Procedures, http://standards.ieee.org/prod-serv/index.html .
5. Kathy Kowalenko, IEEE 802 Committee Celebrates 30th Anniversary, http://www.theinstitute.ieee.org/portal/site/tionline/menuitem.be4d708ccca114d8fb22 accessed May 13, 2010.
6. IEEE 820 Committee Web page, http://grouper.ieee.org/groups/802/index.shtml

COMBATING INFORMATION SECURITY CHALLENGES IN ORGANIZATIONS

Adeolu Okanlawon
Shell Petroleum Development Company of Nigeria, Port Harcourt
adeolu.okanlawon@shell.com

ABSTRACT
The Internet is arguably the most important innovation of modern age. In less than twenty years of its commercial existence, the Internet has revolutionarised the way we live, work, do business and play. It has touched every facet of our lives so much that it has found its way into the most conservative of places religion! Imagine the evolution of real-time cross-border/atlantic collaboration, the possibility of initiating a business deal from one remote village in Africa and sealing same on the NYSE in split seconds. Imagine medical doctors in Europe, Asia and America collaborating on a medical procedure being carried out by their colleagues in a remote village in Russia. Imagine modern military weapons being deployed from a NATO base in Alaska to a battlefront in the Gulf by the simple act of pushing a mouse button by a General holidaying in Hawaii. The string of imagination is uncheckable as the Internet adds offspring into its lineage by the hour. Imagine that we now have cloud computing: a concept that has taken the world by surprise. As the growth and relevance of the Internet increases, so does its unthinkable or undesirable uses. Imagine all of the activities or transactions that can be carried out via the Internet (be they simple business transactions, medical procedure or high tech weapon deployment) can be hijacked, radicalised (by maliciously changing its content, intent or destination) to wreck havoc. Imagine the emergence of and sophistication of cybercrime, netwar or cyber warfare. Imagine the existence of a huge, yet invisible, market that trades/distribute criminal procedures, tools and loot. Imagine the limitless possibilities of misuse or abuse of the potentials of the Internet and welcome to the realm of Internet Security. Welcome to Information Security. In this paper, we will look at the many odds that businesses are faced with, the right response to fighting the battle and some best practice recommendations.

Keywords: Information Security, Countermeasure, Information Risk and Internet Risk

I. Introduction

We now live in a world interconnected by 'wires' that constantly bear information about us, as individuals, organizations or nations. We live in a world that no longer sleeps, a world where everything happens in an unending 24-7 cycle.

Our world has become a federation with organisations and people mere inhabitants. Regardless of where we 'live', we are exposed to issues of and from other lands. We are all faced by the same challenges: demand from investors, regulators or the scheming of hackers .

[1]. The position of Lugent Nori is a truism: everyone is at risk of Cyber Crime. The internet, so much a part of daily life is neither safe nor secure.

Investment in Information Security has therefore gone beyond consideration or debate. For organisations, you do it you pay, you don't, you pay heavily!
Lugent Nori also noted in the “Dark Side of the Internet”, that the close of 2009 and beginning of 2010 has been an exciting and disquieting time. The news has been saturated with reports of data breaches and cyber war scenarios. In addition to news accounts, on a personal level most people are aware of, and may have even personally experienced, cyber crime. More and more computer systems are vulnerable to attack by cyber thieves.

Years ago, most attacks were annoying, but were more like pranks than serious crime. For example, an intruder flashes a message across the screen, and then the computer under attack fades to a blue screen. But from 2001's Code Red worm onward, malicious computer attacks have increased in frequency and severity. So the landscape has changed.

According to Bill Cullifer in [2] “Beware of the Botnet: Attack hits corporations and agencies”, The Dutch police found a 1.5 million node botnet and the Norwegian ISP Telenor disbanded a

10,000-node botnet. Large coordinated international efforts to shut down botnets have also been initiated. It has been estimated that up to one quarter of all personal computers connected to the internet may be part of a botnet. Botnets are networks of poisoned PCs that are remotely controlled by hackers and behave like their criminal robots. Yet, this is just one of the many possible techniques of hackers!

The odd side is that when these things happen, victims don't appear to have been specifica lly targeted, neither are they usually aware.

A recent Federal Bureau of Investigation reports that the total dollar loss from all cases referred to its Internet Crime Complaint center (reported cases only) was $559.7 million in 2009. More than double the previous year: $264.6 million. Cybercrime has been recognized as a nightmare worse than the illegal drug trade. Figure 1 shows the entire gamut of Information Security risks that organizations are exposed to.

Figure 1: Threat to Information Assets

I. Definitions

According to British Standards [3], In formation is an asset that, like other important business assets, is essential to an organization's business and consequently needs to be suitably protected. This is especially important in the increasingly interconnected business environment. As a result of this increasing inter-connectivity, information is now exposed to a growing number and a wider variety of threats and vulnerabilities. Information can exist in many forms. It can be printed or written on paper, stored electronically, transmi tted by post or by using electronic means, shown on films, or spoken in conversation. Whatever form the information takes, or means by which it is shared or stored, it should always be appropriately protected.

Information security is the protection of information from a wide range of threats in order to ensure business continuity, minimize business risk, and maximize return on investments and business opportunities. Information security is achieved by implementing a suitable set of controls, including policie s, processes, procedures, organizational structures and software and hardware functions. These controls need to be established, implemented, monitored, reviewed and improved, where necessary, to ensure that the specific security and business objectives of the organization are met.

Information Security therefore means protecting information and information systems from unauthorized access, use, disclosure, disruption, modification or destruction. Information Security is that aspect of security tha t is concerned with the protection of confidentiality, integrity and availability of information and information systems (known as the CIA triad).

A. Confidentiality

Confidentiality is the term used to prevent the disclosure of information to unauthorized individuals or systems. Breaches of confidentiality take many forms. Permitting someone to look over your shoulder at your computer screen while you have confidential data displayed on it could be a breach of confidentiality. If a laptop computer containing sensitive information about a company's employees is stolen or sold, it could result in a breach of confidentiality. Giving out confidential information over the telephone is a breach of confidentiality if the caller is not authorized to have the information.

B. Integrity

In information security, integrity means the quality of ensuring that data cannot be modified or destroyed without authorization.

There are many ways in which integrity could be violated without malicious intent. In the simplest case, a user on a system could mis-type someone's address. On a larger scale, if an automated process is not written and tested

correctly, bulk updates to a database could alter data in an incorrect way, leaving the integrity of the data compromised. Information security professionals are tasked with finding ways to implement controls that prevent errors of integrity.

C. Availability

For any information system to serve its purpose, the information must be available when it is needed. This means that the computing systems used to store and process the information, the security controls used to protect it, and the communication channels used to access it must be functioning correctly.

D. Other Definitions

Vulnerability is a weakness that could be used to endanger or cause harm to an informational asset. The typical information system comes bundled with a lot of them while more and more are discovered daily.

Threat is any act, event or circumstance with a potential to adversely impact organizational operations. Also the potential for a threat-source to successfully exploit a particular information systems vulnerability.

Risk is the likelihood that something bad will happen that causes harm to an information asset (or the loss of the asset). It is also described as the product of the potential impact of a threat and the likelihood of that threat occurring.

Botnet is a jargon term for a collection of software agents, or robots, that run autonomously and automatically. The term is most commonly associated with malicious software, but it can also refer to a network of computers using distributed computing software. Botnets are often associated with computers that have been hijacked and radicalized.

III. The Need for and Growth of Information Security

The need for security has always been with humanity, so also is the need for securing Information. Information in human head is by far easier to protect, followed by documented facts. Crossing the border to process, store and transmit information with computing infrastructure heightens the security need. It is therefore right to say that information security need is promoted and heightened by the introduction of people, computing, networking and Internet, perhaps in that order.

According to British Standards [3], Information and supporting processes, systems, and networks are important business assets. Defining, achieving, maintaining, and improving information security may be essential to maintain competitive edge, cash flow, profitability, legal compliance, and commercial image.

Organizations and their information systems and networks are faced with security threats from a wide range of sources, including computer-assisted fraud, espionage, sabotage, vandalism, fire or flood. Causes of damage such as malicious code, computer hacking and denial of service attacks have become more common, more ambitious, and increasingly sophisticated.

[4]. Since the McAfee “2010 Threat Prediction Report” was released in December 2009 , which foresees an increase in threats related to social networking sites, banking security, and botnets, as well as attacks targeting users, businesses, and applications, a number of proof-of-concepts have been released that confirms the possibility of hacking or perpetuating a hack through some rather uncommon avenues as predicted by McAfee. This is the level of sophistication that we are talking about.

Information security is important to both public and private sector businesses, and to protect critical infrastructures. In both sectors, information security will function as an enabler, e.g. to achieve e-government or e-business, and to avoid or reduce relevant risks. Unfortunately, many information systems have not been designed to be secure. The security that can be achieved through technical means is limited, and must be supported by appropriate management and procedures. Identifying which controls should be in place requires careful planning and attention to detail. Information security management requires, as a minimum, participation by all employees in the organization. It may also require participation from shareholders, suppliers, third parties, customers

or other external parties. Specialist advice from outside organizations may also be needed.

Figure 2 shows the clear case for action on Information Security. While the threat of hacking has taken an increasingly dangerous dimension, organizations rely more and more on the use of Computers. In the past, these interconnected computers were isolated with such techniques as firewalling that prevented access from external sources and therefore limits organisational exposure. Increasingly, such techniques are becoming weak in the face of modern attacks. Furthermore, organizations are realizing the need to collaborate electronically across their networks thus necessitating the need to collapse such infrastructure that alienated them from the rest of the world. We have also seen disgruntled employees that perpetuate insider attacks, ambitious executives that wittingly overstate company fortunes and systems support personnel that inadvertently open a back-door to the hacker. All of these have contributed to the demand by regulators and investors for organizational information and information assets to be managed with a measure of assurance: assurance of compliance with strict regulatory codes or compliance with standards to indicate that due diligence is being observed in managing information and information assets.

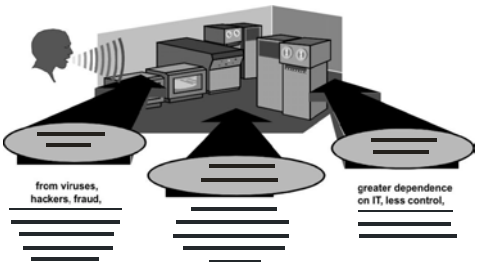


Figure 2: Growing Cause for Information Security

worry about the first two attacks while government agencies, regulators and nations will have to contend with all three. It is this response need that gave rise to legislation and regulatory requirements that demand organization & agents of government to appropriately protect their information assets.

Also, investors want renewed confidence in the wake of several crash and revelations of recent times. They want to be assured their investment dollar is protected, productive and rightly reported. It is such demands that gave rise to SOX404, BASEL II and such other regulatory demands.

Typical response model of organizations is to bar whatever is vulnerable: Intrusion - put firewall; Break-in - deploy armed guard; application risk - stop using the apps; new demand for compliance - define new process and make the people do it (who cares if they are overloaded!)

Responses built around this model have proved futile, expensive and burdensome leading oftentimes to colossal failures.

Smart response will demand that you aggregate IT response to regulatory requirements and information risk (by getting Audit, Legal and IT teams to work together in defining responses and); it will call for a tweaking of existing processes and infrastructure to accommodate new requirements as much as possible; it will teach you to sweat existing assets before adding more or new (knowing too well that each new creation or acquisition will come with its own demand).

With smart response, you will fortify network perimeter with intrusion prevention, harden hardware and protect end-point, guide what gets connected to your network, protect applications and test protection, and make you watch out for 'unwanted' user behavior.

You will need an orchestra for all these - a man in the middle that must stitch all your compliance/ Information Security response together (preferably accountable to the CEO). He defines policies, articulates IT response, monitor compliance and will be answerable to auditors. He will be supported in every function of the organisation that is required to contribute to your

security management.

The dimension of your organization (whether you successfully run business from one isolated office at the corner of an obscure street or trade internationally with collaborators across the world or with your offices replicated across the globe) will determine the size of your response.

One thing that is sure, however, is that no matter how much you try, the degree of success from applying the same level of protection to all your information & information assets will be something between zero or at best a quarter. That will amount to a huge wastage of investment dollars. In so much as we cannot have the Brigade of Guards watch over every citizen, you also will not be able to deploy same level of security on all your computing or information assets.

Again, considering the size and dimension of the heinous crime against people, organizations and nations, it will be inappropriate to jump into the battle and start fighting. No matter the level of your provocation or susce ptibility (even if you have been hit severally) you must measure your steps and punches into the game. As an organization, you must carefully understand the size of the pie for you, evaluate what your organization is vulnerable to, determine the impact of each vulnerability and start the fight from where it matters most. You will benefit from a comprehensive Information Security Risk Assessment to get the response game right.

Organisations will also need to understand that the response must be balanced to be effective. At the heart of the game of insecurity is the data that must be stolen and traded and the robots that will be used. It therefore means that the object that must be protected the most is the data followed by the device that hosts them. This is one place most organizations miss it.

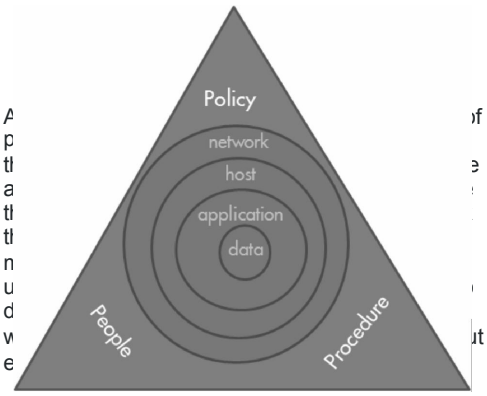


Figure 3: Defense-in-Depth

In putting all of these together, 4 things are clearly required:

A. Invest, Evaluate and Innovate

Organisations must invest in technology, tools, processes and people (both in hiring and consultation). Organisations must invest in innovative products and be innovative. In investing, you also invest in relationships with IT Security Companies (via outsourcing agreement for vulnerability alerts and remediation).

B. Educate, Motivate & Re-Educate

Educate and re-educate people, motivate and celebrate excellence and be firm with edu cation without exception.

C. Measure, Remediate & Sanction

Measure derived value from compliance readiness investment and be ready to shift if reviews dictate so. Organisations must also be humble enough to declare outcome to stakeholders before, establish gaps before they are forced to look and deal with people and issues that stand in the way.

D. Leadership

The ride is only smooth when there is visible executive support. Information Security is a journey with an expectation but without a destination and only the business visioner has the wherewithal to motivate all your players. Let the man that is answerable to investors or regulators lead the effort. Leadership is key.

VI. Security In The Cloud

With the onslaught of Internet-borne threats facing businesses today, it doesn't matter whether you're running a multinational corporation or a small family business. You have to protect your information assets or you could be in big trouble.

The problem for most businesses is that they rarely have enough full-time IT staff to effectively manage all the security measures necessary to fully protect their computers and data. In addition, given the rapid change in the internet crime climate, investm ent in countermeasures can be huge and repeated. Small businessestypically with 100 or fewer employeesoften don't have a dedicated IT person at all and the means to keep up with the trend. Even in larger businesses, IT people wear multiple hats, which means that critical security tasks get done only at the expense of other equally important business computing needs.

Fortunately, a new class of security solutions is emerging to address this dilemma: security delivered as a managed service (a variant of Cloud Computing).

The concept behind security as a service is simple. Rather than acquiring your own security software tools and the technical expertise to administer them internally, you contract with security vendors to have a turnkey service of virus defense, firewall management and e-mail filtering. Outsourcing cyber-security eliminates all the labor and infrastructure, while still giving you the state of the art in anti-virus, firewall and spam-fighting technologies. This approach also relieves IT staffers from having to become security experts as well.

Whether your organisation buys the service or implement security controls and infrastructure in-house, asking the right questions will help you find the best partner. Such consideration will include: Product Architecture, Security, Scalability/Ease of Use, Accuracy /Performance, Discovery/Mapping, Scanning, Reporting, Remediation, Policy Compliance, Management, Cost and Solution Vendor.

VII. Conclusions and Recommendation

Whereas regulations are widely unavailable in Nigeria and shareholder demands are less stifling, we are not immuned to the Global threat of Information Security.

Even if legislation and shareholder demand calls for no action, what about the possible odd that your data can become an object of trade in the criminal world or an element of your IT infrastructure hijacked, radicalized and enlisted in an army of botnet? If the laws and regulations are not here, what about the danger of reputational da mage to your partners or parent companies abroad?

The best time to prepare for Information Security hit is now when failure can be tolerated. It is better to fail now fast, but ensure you fail forward: Design, implement, test adequacy, remediate and roll out. Failure at this time will be innovative as long as you don't throw away the lesson. Fail fast before legislation starts frowning at your organisation.

Bruce Sheiner in “The Speed of Security” [5] says that traditional computer security has be en static: install a firewall, configure a public key infrastructure, add access control measures, and you're done. That might have been enough 10 years ago, when attacks traveled slowly and attack tools were primitive. On today's Internet, security is a moving target, so it must be dynamic.

Your Information Security response must be graduated and increased with the measure of importance of the information or asset to be protected.

There is no jumping in the way of the train. Your response to Info rmation Security threat or regulatory requirements must be calculated, carefully planned, painstakingly implemented and measured. Be prepared to also change the rule of the engagement mid-way into implementation and remember to watch out for signs that may indicate that your strategy isn't working.

Your defense strategy must also be in-depth and appropriately directed. Every dollar you spend must be treated like the bullet of a soldier besieged by enemy forces.

Finally, you must prepare for dooms day because your best defense strategy of today may become

obsolete before midnight. You must therefore put measures in place to enable speedy response to Information Security incidents and a mechanism to learn from those incidents. Information Security need not be a pain.

REFERENCES

1. Nugent Lori. "Dark side of the Internet", Internet: http://www.allbusiness.com/technology/software-services-applications-online/14343587-1.html, April 1, 2010 [April, 16 2020]

2. Bill Cullifer. "Beware of the Botnet: Attack hits corporations and agencies", Internet: http://webprofessio nals.org/blog/category/cyber-crime/, February 19, 2010 [April 16, 2010]

3. The British Standard. "BS ISO/IEC 27002:2005"

4. McAfee Labs. "2010 Threat Prediction", Internet: http://www.mcafee.com/us/local_content/white_papers/7985rpt_labs_threat_predict_1209_v2.pdf, December 2009, [Ap 20, 2010]

5. Bruce Schneier (August 2003). "The Speed of Security" IEEE Security & Privacy [On-line] Vol 1 No 4. Available: http://www.schneier.com/essay-013.html [May 3, 2010].

EMERGING TECHNOLOGIES FOR COMBATING SECURITY CHALLENGES IN ORGANISATIONS

Engr. Esther Gavou Gonda
Police Commission, Abuja, Nigeria

ABSTRACT
The Criminal justice system is entering a new era transformed by advances in science and technology. The society is experiencing new changes due to the latest strides in the fields of science and technology. Criminals too are using technology to accomplish their unjust demands. The time has come when we have to use technology in the crime prevention. There is an urgent need to evolve new methods to fight against different types of crime like theft, robbery, terrorism or any organized crime.

Keywords: Radio Frequency Identification (RFID); Global Positioning System (GPS); Close Circuit Television (CCTV) and Biometrics.

1 Introduction

Security is an all encompassing word. It implies a state of confidence, certainty, safety, stability, protectedness and sureness.

In the context of this paper, the aspect of safety and protectedness are more relevant. Provision of security involves measures taken to ensure that a person or item is protected from attacks or any malicious or harmful act. When security is guaranteed, then an individual is more able to perform other activities of life with confidence.

One of the greatest challenges co nfronting the country and the world in general is in the aspect of providing security. The increase of malicious acts or crime is very high. The variety or types of criminal acts are also on the increase. Crimes such as assassination, kidnapping, acid baths, terror attacks, 419 and other cybercrimes are now the rage. Preventing such crimes is now a very serious business. Criminal attacks come from individuals, groups and organization.

Detection and elimination of such crimes now requires very complex methods and systems. Essentially in crime control, what is need is the ability to:

(a) Detect an intruder, assailant or the presence of any malicious or menacing or generally unwanted item. There are many of such detectors.

(b) Generate a signal that raises an alarm or is sent to a monitor. An elaborate system that could also trap the intruder or neutralize the threat, may also be added.

(c) Record the event if necessary.

There are sensors that can detect movement, sound, light changes, heat, magnetic field changes, electric field changes, radioactivity and any others changes in material properties. These sensors, coupled with improved communications gadgets and alarms are improving efficiency of crime detection and combating same. Technology thus is a vital tool in combating security challenges.

In Nigeria, there is a great problem which is basically the fact that the criminals are in a better form to use technology for criminal activities than the security agencies. Many are not aware of simple devices or systems that could improve their security.

II Technologies in use for Combating Crime

The emergence of technologies had made the combat of crime easier and most effective. A few of the most common surveillance systems are here discussed:

A Closed Circuit Television (CCTV)

Closed-circuit television (CCTV) is the use of video cameras to transmit a signal to a specific place, on a limited set of monitors. CCTV is often used for surveillance in areas that may need monitoring such as banks, casinos, airports, military installations, and convenience stores.

In industrial plants, CCTV equipment may be used to observe parts of a process from a central control room; when, for example, the environment is not suitable for humans. CCTV systems may operate continuously or only as required to monitor a particular event [1].

CCTV systems are installed in a number of environments and have had positive feedback from the managers and owners that the systems have enabled them to reduce their security risk by minimizing theft, poor productivity, vandalism and the time spent seeking to reduce general criminal and nuisance behavior or identifying those responsible for it.

B. Global Positioning System (GPS)

The Global Positioning System (GPS) is a space-based global navigation satellite system that provides reliable location and time information in all weather and at all times and anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites. It is maintained by the United States government and is freely accessible by anyone with a GPS receiver.

The GPS technology is used in tracking stolen items or locating. It is simply to attach the GPS device to the item such as car. It location on the global can then be determined.

C. Radio Frequency Identification (RFID)

This is the use of an object (typically referred to as an RFID tag) applied to or incorporated into a product, animal, or person for the purpose of identification and tracking using radio waves. Some tags can be read from several meters away and beyond the line of sight of the reader.

Radio-frequency identification comprises interrogators (also known as readers), and tags (also known as labels).

The RFID also enables communications human human, human things, things to things. This would therefore enable the easy location of items and cause such items or even destroy or trap the miscreants or threat. The possibilities are endless. With the RFID and ubiquitous communications, there is no hiding place.

III. Biometric Measures to Combat Security Threats

Access control is a security measure that is being developed to contain access threats. Biometrics comprises methods for uniquely recognizing humans based upon one or more intrinsic physical or behavioral traits such as finger prints, face, DNA, hand, palm and voice etc. In computer science, in particular, biometrics is used as a form of identity access management and access control. It is also used to identify individuals in groups that are under surveillance.

A. Forensics

These involve the use of scientifi c tests, particularly in laboratories, to gather more information about the nature of the crime and the criminals. Tests are carried out on the materials recovered from crime sites.

B. Scanners

With the coming of terrorism, entrance into certain areas such as banks, airports, or even places of worship is becoming increasing tedious. Scanners are now available which can detect even materials that have been swallowed or hidden in any part of the body.

C. Magnetic Recognition System

A number of devices/systems using these exist. Most common are those using cards to grant access or deny such to restricted places. These are quite simple. They are used in hotels, offices, banks etc.

IV. Cyber Crimes

These are growing trends in Nigeria today. They have expanded the frontier of 419ners. The decision of former President Olusegun Obasanjo to setup a working group, the Nigeria Cyber Crime Working Group (NCWG) was an indication that cybercrime, especially Internet 419 was a source of concern and embarrassment. The Internet creates unlimited opportunities for commercial, social and educational activities. But as we can see with cybercrime the net introduces its own peculiar risks.

Cyber crime uses the unique features of the Net sending of e-mail in seconds, speedy publication/ dissemination of information through the web to in

anyone on the planet. Computer attacks can be generated by criminals from anywhere in the world, and executed in other areas, irrespective of geographic location. And often these criminal activities can be faster, easier and more damaging with the use of the Internet.

Since the loss suffered by consumers and investors creates serous credibility and image problems, many countries develop strategies for preventing, detecting and containing the threats associated with cybercrime.

How strong are the security agencies in the fundamentals of IT? You cannot fight today's crime with yesterday's technology. It will always be a losing battle if security professionals are way behind the cyber criminals in terms of tech knowledge. It's not just about computing skills, but IT Security expertise. Fighting cybercrime requires a holistic approach, not just addressing the cyber cafés alone. What is the culture towards cybercrime? All stakeholders should be involved. Security agencies should liaise with industry stakeholders. There is a need to create a security-aware culture involving the public, the ISPs, cybercafes, government, security agencies and Internet users.

To fight cybercrime, surveillance software needs to be developed. EFCC is said to have developed a software EAGLE CLAW to help catch fraudsters. This is encouraging. Obviously more complex technology needs to be developed to fight such crimes.

If technology is to be used to fight crime. It is necessary that the environment has to be created for innovation. A great draw back in Nigeria is power. There would be no point putting a complex system in place if there is no power for it to work. Stand alone systems using batteries can help especially with solar panels to change such. However, this may make the system conspicuous.

V. Conclusion

Criminals have developed intricate ways of committing crimes. The thief-catcher must be steps ahead of the thief. It is necessary for us in Nigeria to embrace new ways of fighting crimes. The Police are ages behind in the race. This is not to say that the Police is incapable of changing. They have no surveillance systems. Even the basic communication equipment are inadequate. They have no forensic laboratories. The country must commit to equipping the Police and other security agencies so that criminals are easily detected and their activities minimized. Technology is the key in this 21 ℃entury.

EMERGING BROADBAND TECHNOLOGIES FOR IMPROVED COMMUNICATION AND INTERNET ACCESS

Joseph Kyosu
Bureau of Public Enterprises, Abuja
joekyosu@yahoo.com

ABSTRACT

Many countries in Sub-Saharan Africa see ICT as a foundation of long-term economic development. The region has been very successful in increasing access to basic voice communications but there has been no comparable improvement in broadband connectivity. The broadband access gap between Sub-Saharan Africa and the rest of the world is getting wider, just as the gap in basic voice communications is getting smaller. Increasing access to broadband connectivity is therefore emerging as a high priority for policymakers across the continent. This report focuses on one important part of the challenge the lack of high-capacity backbone networks. It addresses three specific questions: What role do backbone networks play in the provision of broadband services, what is the current state of backbone network development in Sub-Saharan Africa (and why) and, what can be done to promote the development of backbone networks and thereby stimulate the take-up of broadband services? This paper takes a synoptic look at the emerging broadband technologies and the impact they will have on communications and internet access for a developing country like Nigeria. These technologies include: Wi-Fi, WiMax, 3G, 4G, Optic Fiber and Satellite Communications. In line with vision 2020, a Framework for a comprehensive National Broadband Strategy is proposed at the end.

Six Keywords: Broadband, Communications, Technologies, Wireless, Internet, Data

I. Introduction to Broadband Internet Access

Broadband Internet access, often shortened to just **broadband**, is a high data rate Internet accesstypically contrasted with dial-up access using a 56k modem.

Dial-up modems are limited to a bitrate of less than 56 kbit/s (kilobits per second) and require the full use of a telephone linewhereas broadband technologies supply more than double this rate and generally without disrupting telephone use.

Although various minimum bandwidths have been used in definitions of broadband, ranging up from 64 kbit/s up to 2.0 Mbit/s, the 2006 OECD report is typical by defining broadband as having download data transfer rates equal to or faster than 256 kbit/s, while the United States (US) Federal Communications Commission (FCC) as of 2009, defines "Basic Broadband" as data transmission speeds exceeding 768 kilobits per second (Kbps), or 768,000 bits per second, in at least one direction: downstream (from the Internet to the user's computer) or upstream (from the user's computer to the Internet). The trend is to raise the threshold of the broadband definition as the marketplace rolls out faster services.

Data rates are defined in terms of *maximum download* because several common consumer broadband technologies such as ADSL are "asymmetric"supporting much slower maximum upload data rate than download.

"Broadband penetration" is now treated as a key economic indicator.

Table 1: Data Transmission rates for Broadband Connection

Connection	DS-1 (Tx-1)	E-1	DS-3 (Tx-3)	OC-3	OC-12	OC-48	OC-192	OC-768
Transmission data rate	1.544 Mbit/s	2.048 Mbit/s	44.736 Mbit/s	155.520 Mbit/s	622.080 Mbit/s	2.488 Gbit/s	9.953 Gbit/s	39.813 Gbit/s

Broadband is often called "**high-speed**" access to the Internet, because it usually has a high rate of data transmission. In general, any connection to the customer of 256 kbit/s (0.256 Mbit/s) or greater is more concisely considered **broadband Internet access**. The International Telecommunication Union Standardization Sector (ITU-T) recommendation I.113 has defined broadband as a transmission capacity that is faster than primary

rate ISDN, at 1.5 to 2 Mbit/s. The FCC definition of broadband is 768 kbit/s (0.8 Mbit/s).

In practice, the advertised bandwidth is not always reliably available to the customer; ISPs often allow a greater number of subscribers than their backbone connection or neighborhood access network can handle, under the assumption that most users will not be using their full connection capacity very frequently. This aggregation strategy works more often than not, so users can typically burst to their full bandwidth most of the time; however, peer-to-peer (P2P) file sharing systems, often requiring extended durations of high bandwidth usage, stress these assumptions, and can cause major problems for ISPs who have excessively overbooked their capacity. For more on this topic, see traffic shaping. As takeup for these introductory products increases, telcos are starting to offer higher bit rate services. For existing connections, this most of the time simply involves reconfiguring the existing equip ment at each end of the connection.

As the bandwidth delivered to end users increases, the market expects that video on demand services streamed over the Internet will become more popular, though at the present time such services generally require specialized networks. The data rates on most broadband services still do not suffice to provide good quality video, as MPEG-2 video requires about 6 Mbit/s for good results. Adequate video for some purposes becomes possible at lower data rates, with rates of 768 kbit/s and 384 kbit/s used for some video conferencing applications, and rates as low as 100 kbit/s used for videophones using H.264/MPEG-4AVC. The MPEG-4 format delivers high-quality video at 2 Mbit/s, at the low end of cable modem andADSL performance.

II. Satellite Internet

Satellites in geostationary orbits are able to relay broadband data from the satellite company to each customer. Satellite Internet is usually among the most expensive ways of gaining broadband Internet access, but in rural areas it ma y be the only choice other than cellular broadband. However, costs have been coming down in recent years to the point that it is becoming more competitive with other broadband options.

Broadband satellite Internet also has a high latency problem due to the signal having to travel to an altitude of 35,786 km (22,236 miles) above sea level (from the equator) out into space to a satellite in geostationary orbit and back to Earth again. The signal delay can be as much as 500 milliseconds to 900 milliseconds, which makes this service unsuitable for applications requiring real-time user input such as certain multi-player Internet games and first-person shooters played over the connection. Despite this, it is still possible for many games to be played, but the scope is limited to real-time strategy or turn-based games. The functionality of live interactive access to a distant computer can also be subject to the problems caused by high latency. These problems are more than tolerable for just basic email access and web browsing and in most cases are barely noticeable.

For geostationary satellites there is no way to eliminate this problem. The delay is primarily due to the great distances travelled which, even at the speed of light (about 300,000 km/second or 186,000 miles per second), can be significant. Even if all other signalling delays could be eliminated it still takes electromagnetic radio waves about 500 milliseconds, or half a second, to travel from ground level to the satellite and back to the ground, a total of over 71,400 km (44,366 mi) to travel from the source to the destination, and over 143,000 km (88,856 mi) for a round trip (user to ISP, and then back to userwith zero network delays). Factoring in other normal delays from network sources gives a typical one-way connection latency of 500700 ms from the user to the ISP, or about 1,0001,400 milliseconds latency for the total Round Trip Time (RTT) back to the user. This is far worse than most dial-up modem users' experience, at typically only 150200 ms total latency.

A. Advantages

1. True global broadband Internet access availability
2. Mobile connection to the Internet (with some providers)

B. Disadvantages

1. High latency compar ed to other broadband services, especially 2-way satellite service
2. Unreliable: drop-outs are common during travel, inclement weather, and during sunspot activity

3. The narrow-beam highly directional antenna must be accurately pointed to the satellite orbiting overhead
4. The Fair Access Policy limits heavy usage, if applied by the service provider
5. VPN use is discouraged, problematic, and/or restricted with satellite broadband, although available at a price
6. One-way satellite service requires the use of a modem or other data uplink connection
7. Satellite dishes are very large. Although most of them employ plastic to reduce weight, they are typically between 80 and 120 cm (30 to 48 inches) in diameter.

III. Cellular Broadband

Cellular phone towers are very widespread, and as cellular networks move to third generation (3G) networks they can support fast data; using technologies such as EVDO, HSDPA and UMTS. These can give broadband access to the Internet, with a cell phone, with Cardbus, ExpressCard, or USB cellular modems, or with cellular broadband routers, which allow more than one computer to be connected to the Internet using one cellular connection.

IV. Power-line Internet

This is a new service still in its infancy that may eventually permit broadband Internet data to travel down standard high-voltage power lines. However, the system has a number of complex issues, the primary one being that power lines are inherently a very noisy environment. Every time a device turns on or off, it introduces a pop or click into the line. Energy-saving devices often introduce noisy harmonics into the line. The system must be designed to deal with these natural signaling disruptions and work around them.

Broadband over power lines (BPL), also known as Power line communication, has developed faster in Europe than in the US due to a historical difference in power system design philosophies. Nearly all large power grids transmit power at high voltages in order to reduce transmission losses, then near the customer use step-down transformers to reduce the voltage. Since BPL signals cannot readily pass through transformers, repeaters must be attached to the transformers. In the US, it is common fo r a small transformer hung from a utility pole to service a single house. In Europe, it is more common for a somewhat larger transformer to service 10 or 100 houses. For delivering power to customers, this difference in design makes little difference, but it means delivering BPL over the power grid of a typical US city will require an order of magnitude more repeaters than would be required in a comparable European city.

The second major issue is signal strength and operating frequency. The system is expected to use frequencies in the 10 to 30 MHz range, which has been used for decades by licensed amateur radio operators, as well as international shortwave broadcasters and a variety of communications systems (military, aeronautical, etc.). Power lines are unshielded and will act as transmitters for the signals they carry, and have the potential to completely wipe out the usefulness of the 10 to 30 MHz range for shortwave communications purposes, as well as compromising the security of its users.

V. Optical fiber

An **optical fiber** is a glass or plastic fiber that carries light along its length. **Fiber optics** is the overlap of applied science and engineering concerned with the design and application of optical fibers. Optical fibers are widely used in fiber-optic communications, which permits transmission over longer distances and at higher bandwidths (data rates) than other forms of communications. Fibers are used instead of metal wires because signals travel along them with less loss, and they are also immune to electromagnetic interference. Fibers are also used for illumination, and are wrapped in bundles so they can be used to carry images, thus allowing viewing in tight spaces. Specially designed fibers are used for a variety of other applications, including sensors and fiber lasers.

Light is kept in the core of the optical fiber by total internal reflection. This causes the fiber to act as a waveguide. Fibers which support many propagation paths or transverse modes are called multi-mode fibers (MMF), while those which can only support a single mode are called single-mode fibers (SMF). Multi-mode fibers generally have a larger core diameter, and are used for short-distance communication links and for applications where high power must be transmitted. Single-mode fibers are used for most communication links

longer than 550 meters (1,800 ft).

For short distance applications, such as creating a network within an office building, fiber-optic cabling can be used to save space in cable ducts. This is because a single fiber can often carry much more data than many electrical cables, such as 4 pair Cat-5 Ethernet cabling. Fiber is also immune to electrical interference; there is no cross-talk between signals in different cables and no pickup of environme ntal noise. Non-armored fiber cables do not conduct e lectricity, which makes fiber a good solution for protecting communications equipment located in high voltage environments such as power generation facilities, or metal communication structures prone to lightning strikes. They can also be used in environments where explosive fumes are present, without danger of ignition. Wiretapping is more dif ficult compared to electrical connections, and there are concentric dual core fibers that are said to be t ap-proof.

VI. Wi-Fi

Wireless Fidelity (**Wi-Fi**) allows communications directly from one computer to another without the involvement of an access point. This is called the *ad-hoc* mode of Wi-Fi transmission. This wireless ad-hoc

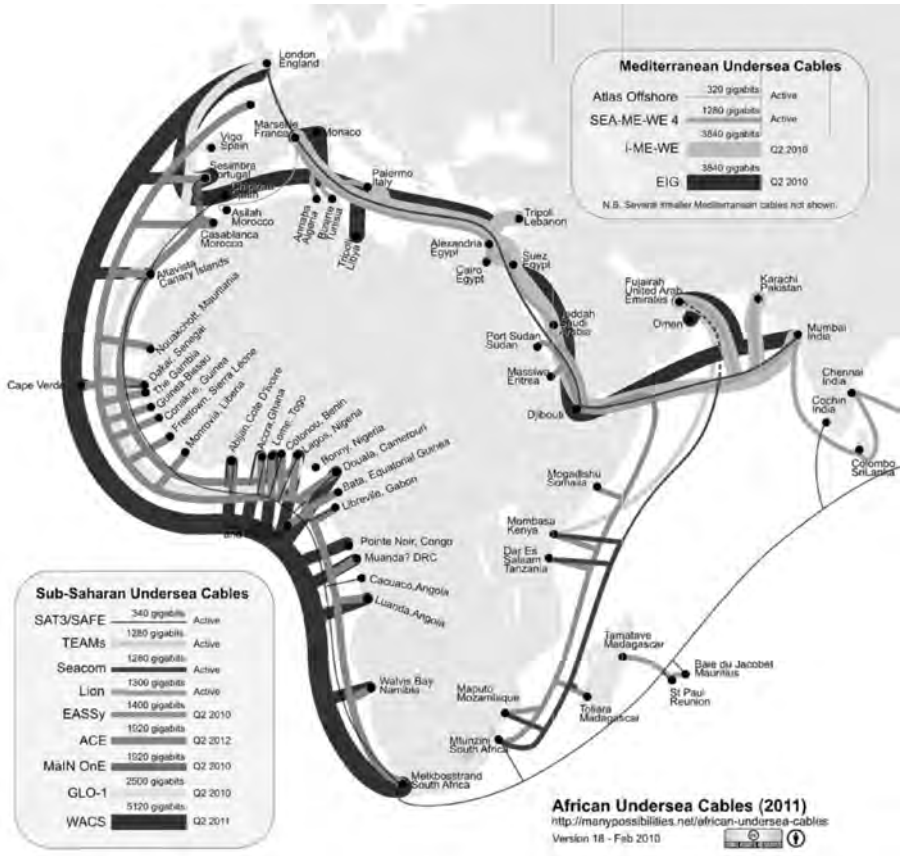


Fig. 1: Africa's Undersea Cables(Courtesy: http://manypossibilities.net)

network mode has proven popular with multiplayer handheld game consoles, such as the Nintendo DS, digital cameras, and other consumer electronics devices.

Fig. 2. A typical consumer-grade Wi-Fi access point (Courtesy: Wikipedia)

roaming and increased overall network capacity by using more channels or by defining smaller cells. Wi-Fi enables wireless voice-applications (VoWLAN or WVOIP). Over the years, Wi-Fi implementations have moved toward "th in" access-points, with more of the network intelligence housed in a centralized network appliance, relegating individual access-points to the role of mere "dumb" radios. Outdoor applications may utilize true meshtopologies. As of 2007 Wi-Fi installations can provide a secure computer networking gateway, firewall, DHCP server, intrusion detection system, and other functions.

A. Operational Advantages

Wi-Fi allows the deployment of local area networks (LANs) without wires for client devices, typically reducing the costs of network deployment and expansion. Spaces where cables cannot be run, such as outdoor ar eas and historical buildings, can host wireless LANs.

As of 2010 manufacturers build wireless network adapters into most laptops. The price of chipsets for Wi-Fi continues to drop, making it an economical networking option included in even more devices. Wi-Fi has become widespread in corporate infrastructures.

Different competitive brands of access points and client network-interfaces can inter-operate at a basic level of service. Products designated as "Wi-Fi Certified" by the Wi-Fi Alliance are backwards compatible. "Wi-Fi" designates a globally operative set of standards: unlike mobile phones, any standard Wi-Fi device will work anywhere in the world.

B. Reach

Wi-Fi networks have limited rang e. A typical wireless router using 802.11b or 802.11g with a stock antenna might have a range of 32 m (120 ft) indoors and 95 m (300 ft) outdoors. The new IEEE 802.11n however, can exceed that range by more than two times. Range also varies with frequency band. Wi-Fi in the 2.4 GHz frequency block has slightly better range than Wi-Fi in the 5 GHz frequency block. Outdoor ranges - through use of directional antennas - can be improved with antennas located several kilometres or more from their base. In general, the maximum amount of power that a Wi-Fi device can transmit is limited by local regulations, such as FCC Part 15 in USA.

C. Data Security Risks

The most common wireless encryption-standard, Wired Equivalent Privacy or WEP, has been shown to be easily breakable even when correctly configured. Wi-Fi Protected Access (WPA and WPA2) encryption, which became available in devices in 2003, aimed to solve this problem. Wi-Fi access points typically default to an encryption-free (*open*) mode. Novice users benefit from a zero-configuration device that works out-of-the-box, but this default does not enable any wireless security, providing open wireless access to a LAN. To turn security on requires the user to configure the device, usually via a software graphical user interface (GUI). On unencrypted Wi-Fi networks connecting devices can monitored and record data (including personal information), but such networks may use other means of protection, such as a virtual private network or secure Hypertext Transfer Protocol (HTTPS) and Transport Layer Security.

VII. High-Speed Downlink Packet Access

High-Speed Downlink Packet Access (HSDPA) is

an enhanced 3G (third generation) mobile telephony communications protocol in the High-Speed Packet Access (HSPA) family, also coined 3.5G, 3G+ or turbo 3G, which allows networks based on Universal Mobile Telecommunications System (UMTS) to have higher data transfer speeds and capacity. Current HSDPA deployments support down-link speeds of 1.8, 3.6, 7.2 and 14.0 Mbit/s. Further speed increases are available with HSPA+, which provides speeds of up to 42 Mbit/s downlink and 84 Mbit/s with Release 9 of the 3GPP standards.

Evolution-Data Optimized or **Evolution-Data only**, abbreviated as **EV-DO** or **EVDO** and often **EV**, is a telecommunications standard for the wireless transmission of data through radio signals, typically for broadband Internet access. It uses multiplexing techniques including code division multiple access (CDMA) as well as time division multiple access (TDMA) to maximize both individual user's throughput and the overall system throughput. It is standardized by 3rd Generation Partnership Project 2 (3GPP2) as part of the CDMA2000 family of standards and has been adopted by many mobile phone service providers around the world particularly those previously employing CDMA networks. It is also used on the Globalstar satellite phone network.

EV-DO was designed as an evolution of the CDMA2000 (IS-2000) standard that would support high data rates and could be deployed alongside a wireless carrier's voice services. An EV-DO channel has a bandwidth of 1.25 MHz, the same bandwidth size that IS-95A (IS-95) and IS-2000 (1xRTT) use. The channel structure, on the other hand, is very different. Additionally, the back-end network is entirely packet-based, and thus is not constrained by the restrictions typically present on a circuit switched network.

The EV-DO feature of CDMA2000 networks provides access to mobile devices with forward link air interface speeds of up to 2.4 Mbit/s with Rev. 0 and up to 3.1 Mbit/s with Rev. A. The reverse link rate for Rev. 0 can operate up to 153 kbit/s, while Rev. A can operate at up to 1.8 Mbit/ s. It was designed to be operated end-to-end as an IP based network, and so it can support any application which can operate on such a network and bit rate constraints.

Fig 3. Huawei CDMA2000 EVDO USB wireless modem (Courtesy: Wikipedia)

so on. Recently with the development of Pico nets and Bluetooth technology data sharing has become a child's play.

Earlier with the infra red feature you can share data within a line of sight that means the two devices has to be aligned properly to transfer data, but in case of blue tooth you can transfer data even when you have the cell phone in your pocket up to a range of 50 meters.
The creation and entry of 5G technology into the mobile marketplace will launch a new revolution in the way international cellular plans are offered. The global mobile phone is upon the cell phone market. With the emergence of cell phones which are similar to a PDA you can now have your whole office within the phone.

VIII. WiMAX

WiMAX, meaning ***Worldwide Interoperability for Microwave Access***, is a telecommunications technology that provides wireless transmissionof data using a variety of transmission modes, from point-to-multipoint links to portable and fully mobile internet access. The technology provides up to 20

Mbps in real world end-user throughput without the need for cables. The technology is based on the IEEE 802.16 standard (also called Broadband Wireless Access). The bandwidth and range of WiMAX make it suitable for the following potential applications:

? Connecting Wi-Fi hotspots to the Internet.

? Providing a wireless alternative to cable and DSL for "last mile " broadband access.

? Providing data, telecommunications and IPTV services (triple play).

? Providing a source of Internet connectivity as part of a business continuity plan. That is, if a business has both a fixed and a wireless Internet connection, especially from unrelated providers, it is less likely to be affected by the same service outage.

? Providing portable connectivity.

IX. Recommendations and Conclusion

The Internet is a global public space that must be open, affordable and accessible to all. As more and more people gain access to this space, many remain excluded. Like the process of globalisation with which it has been closely intertwined, the spread of internet access takes place with uneven results and often exacerbates social and economic inequalities. However, the internet and other information and communication technologies (ICTs) can be a powerful tool for social mobilisation and develop ment, resistance to injustices and expression of difference and creativity. With a population of 150 million people Nigeria's internet penetration is less than 8% compared with the USA which has an internet penetration of 60%. The cost of broadband internet is expected to crash by July 2010 when Globacom's Glo 1 cable arrives.

Access to broadband Communications

i. Broadband should be recognised as an essential facility in line with other basic infrastructure such as water, sewerage and electricity. Essential access (or the most ba sic level of access) should be conceptualized as a right.

ii. Incentives should be created for building more fibre and wireless broadband infrastructure. The needs of education, health, government services and job creation - e.g. access for small and medium enterprises (SMEs) - should be prioritized in the short-to-medium term.

iii. Incentives should be established for the construction of broadband networks to under-serviced areas.

iv. Clear, enforceable regulatory frameworks should be prioritised to ensure fair access to infrastructure and infrastructure sharing towards maximizing the network effect of having as many people online as possible.

v. A strategy to roll out broadband networks to smaller municipalities should be implemented so that equitable access to broadband in areas outside major centres is ensured. This could be done as part of a public works initiative to create jobs, stimulate private investment, and deliver public services.

vi. Local governments should be mandated to support the roll-out of municipal broadband networks, including enabling other stakeholders, such as the private sector, to build these networks.

vii. Additional spectrum for the deployment of wireless broadband access should be made available time ly, equitably and affordably to maximize the rapid deployment of infrastructure across the whole country.

viii. Coordination mechanisms should be established to ensure an integrated approach to fibre optic cable deployments in co-operation with other infrastructure build-outs, particularly with regard to power lines and roads and in new spatial developments. The potential of regulating this co-operative framework should be explored.

ix. All government departments should develop broadband strategies related to their mission delivery.

A. Availability in the Rural Areas of Nigeria

Broadband service is always slowest to reach less populated areas, due to economies of scale. The growth and reach of the GSM services will drive demand for technologies that serve these areas, such as satellite and most likely WiMax in the future.

B. A Framework for a Comprehensive National

Broadband Strategy in Nigeria
Goal: All Nigerians should have affordable broadband access to the Internet.

Objectives
? Maximize fibre and wireless broadband infrastructure in urban and rural areas in an equitable and environmentally responsible manner
? Stimulate the creation of digital broadband content by content providers and citizens
? Enhance e-governance and e-citizenship in a broadband environment.
? Accelerate the adoption and use of advanced broadband connections so that the potential of information and communications technologies (ICTs) for learning and teaching can be fully realized.

By 2020, Nigeria will:
? have broadband access in every town and village;
? have the cheapest broadband access on the continent; and,
? be number one in terms of broadband penetration on the continent.

Appendix A

Broadband implementations and standards
? Digital Subscriber Line (DSL), digital data transmission over the wires used in the local loop of a telephone network
? Local Multipoint Distribution Service, broadband wireless access technology that uses microwave signals operating between the 26 GHz and 29 GHz bands
? WiMAX, a standards-ba sed wireless technology that provides high-throughput broadband connections over long distances
? Other wireless technologies, including IEEE standards (802.11b, 802.11g, and 802.11a) and many proprietary wireless protocols. In 2008, with WiMAX still at the top of the learning curve in terms of price, these technologies dominate the market for fixed wireless broadband.
? Power line communication, wireline technology using the current electricity networks
? Satellite Internet access
? Cable modem, designed to modulate a data signal over cable television infrastructure
? Fiber to the premises, based on fiber-optic cables and associated optical electronics
? High-Speed Packet Access (HSPA), a new mobile telephony protocol, sometimes referred to as a 3.5G (or "3½G") technology
? Evolution-Data Optimized (EVDO), is a wireless radio broadband data standard adopted by many CDMA mobile phone service providers
? 802.20 MBWA (Mobile Broadband Wireless Access)

Appendix B
Africa's Underwater Cables Investors

	Seacom	EASSy	TEAMs	WACS	MainOne	GLO1	ACE
Cost (millions of USD)	650	265	130	600	240	150	???
Length (km)	13,700	10,000	4,500	14,000	7,000	9,500	14,000
Capacity	1.28 Tb/s	1.4 Tb/s	120 Gb/s – 1.28 Tb/s	3.84 Tb/s	1.92 Tb/s	2.5 Tb/s?	1.92 Tb/s
Completion	July 2009	June 2010	Sept 2009	Q2 2011	Q2 2010	Q2 2010	Q2 2012
Ownership	USA 25% SA 50% Kenya 25%	African Telecom Operators 90%	TEAMs (Kenya) 85% Etisalaat (UAE) 15%	Telkom Vodacom MTN Tata (Neotel) Infraco et al	US Nigeria, AFDB		France Telecom

Investor detail:

Seacom (http://www.seacom.mu)
Industrial Promotion Services (25%), an arm of the Aga Khan Fund for Economic Development (USD 75 million) (Kenya founded by Prince Karim Aga Khan IV of Pakistan)
VenFin Limited(25%) USD 75 million)
Herakles Telecom LLC (backed by Blackstone) (25%), New York-based lead company, no website (USD 75 million)
Convergence Partners(12,5%) USD 37.5 million
Shanduka Group(12.5%) USD 37.5 million
EASSY (http://www.eassy.org/)

EASSY is 90% African owned although that ownership is underwritten by a substantial investment by Development Financial Institutions (DFIs) including World Bank/IFC, EIB, AfDB, AFD, and DfW. Total DFI investment is apparently $70.7 million, with $18.2 million coming from IFC, 14.5 million from AfDB. This is a smaller amount than the originally advertised $120 million investment from DFIs.

South African investors in EASSY include Telkom South Africa ($18.9 million) , Neotel, and MTN. There are 26 telco operators in total invested in EASSY.

An SPV created to facilitate. open access will be the biggest shareholder, with 46%. In Jan 2008, VSNL announced an investment in EASSY

TEAMs
85 per cent of the cable is owned by TEAMs (Kenya) Ltd and the rest by Etisalaat of the United Arab Emirates (UAE). The TEAMS (Kenya) Ltd holding breaks down as follows:

? 20% Government of Kenya (through Min. of Finance)
? 20% Safaricom Ltd
? 20% Telkom Kenya Ltd
? 10% Kenya Data Networks Ltd
? 10% Econet/EssarTelecom Ltd
? 5% Wananchi Group
? 3.75% Jamii Telecom Ltd
? 1.25% Broadband Access/AccessKenya Ltd
? 1.25% Africa Fibrenet (Uganda) Ltd
? 1.25% InHand Ltd
? 1.25% iQuip Ltd
? 1.25% Flashcom Ltd

WestAfrican Cable System (WACS)
? Telkom
? Vodacom
? MTN
? Tata Communications (Neotel)
? Infraco
? Cable & Wireless
? PortugalTelecoms
? Telecom Namibia
? Togo Telecom
? Angola Telecom
? Sotelco (U.S.)

References

1. http://www.apc.org/en/node/5677/
2. http://www.infodev.org/en/Project.41.html
3. http://www.broadband4africa.org.za/
4. http://manypossibilities.net/what-im-working-on/open-spectrum/
5. http://ezinearticles.com/?5G-Cellular-Technology-is-Here&id=2522816

ELECTRONIC VOTING SYSTEM APPLICATION IN CORPORATE ORGANIZATIONS

Uche Amechi and Shell Cooperative Society
Shell Petroleum Development Company, Port Harcourt.
Email: *uche.amechi@shell.com*

ABSTRACT
The use of intranet in Corporate Organization today has been on the increase with all sort of application finding their way to the intranet/internet. This paper present one of the good uses of the intranet in a corporate organization. In this case electoral process which is a common issue in corporate organization where unionism, club house, corporative society exist and the officers who must run this association must need be elected by some electoral process. Study shows that Electoral process in this big organization where time is directly equated to money, production and performance has never been a simple task to conduct. More over some organisation are sparsely located which creates more reason for difficulties in exercising members voting right. The old tradition of paper form and ballot box therefore is becoming inadequate for this sector of the society. With this in mind, An Electronic Voting System (EVS) using available technology at the disposal of any corporate Organization is discussed. It is a simple tool to understand and easy to follow - by Just Clicking and following the instruction thereafter. It offers highest security and authenticity based on the already developed internet application and this is what is required in any voting system while offering widest electorates and almost instant computation of result.

Keyword: Intranet, Internet, Electronic voting system.

I. Introduction:

The Electronic Voting System (EVS) is the use of the intranet/internet web pages in big and corporate organisation in carrying out the process of electing officers into electoral positions of authorised associations and bodies within the organisation. This utilises the existing technology in the organisation.

It is a well known fact that all big Corporate Organisation now have their own private internetworking system where they share information, send electronic mails, and today share public info rmation via the web pages which is termed intranet. More over where there is no intranet the use of the internet is been deployed.

This EVS is simply employing the existing networking, mail services and web intranet of this organisation to create secure, simple and easy to use voting system that incorporate highest security and authenticity that is required in any voting system while offering widest electorates.

A. Tools:

? The web server of the corporate organisation, in this case and IIS (internet informat ion Service) web server, a product of Microsoft Company.

? Database of the Corporate Organisation, where correct record of the members or staff are store, from here, the members of the association are filter with the correct record. One good reason for the use of the database is that, the record stored there has been valid as the company uses this data for the payment of the staff salary, which is agreeable, the reason for staff stay in the company. This database is used to match the database of the association in question and a filter of the required record is obtained.

? Local Email services of the corporate organisation, many organisations today have email for its staff, which is used for communications between the personnel of the organisation. And sometimes for authorisation, evidence and empowerment. Example in SPDC email approval evidence is required for entering the company provided Flight services.

? Voting Points PC: Because the system utilises web, its therefore not completely necessary to own your personal computer before you can use the system, one can actually make use of the system from any PC connected to the intranet, the electoral committee could as well provide what is termed voting out lets for their members.

II. How It Works

A compilation of the member's data is placed in the

HOW IT WORKS (GRAPHICAL)

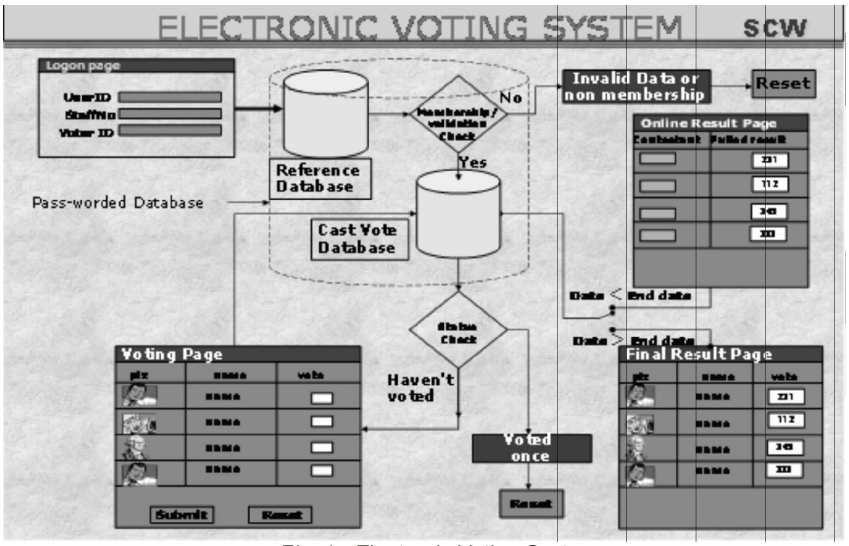


Fig. 1: Electronic Voting System

reference database which contain among other records, the three needed data information; user ID, s taff number and unique voter ID an eight character system generated code of combination of Alphanumeric Characters that are tested for uniqueness.

Table 1: Format for member data compulation

S/No	surname	Call name	userid	OFFICE TEL NO	Email address	univoid
7784245	MICHE	FREY	ZHGCH4	24303	Frey.n.miche@stan.com	HSU3P2T7
5678906	HILDA	FAITH	DAKJA0	54524	Faith.hilda@stan.com	LT64Y3J5

These vital data is sent to the member's mail system to his personal inbox or a unique assigned inbox in a situation the member do not have a personal address box. The necessary information on how to use the data is also added in the mail se nt and a URL to the web site.

A. To Vote

On accessing the web site and clicking on ready to vote, you are redirected to the logon page where you enter the appropriate data to the field display with the data supplied to you via email. This thre e data are submitted to web the server database end via the encrypted secure link.

On reception of these three data, a logical AND is performed on this data to match it with the refe rence data base, if there is no match the server returns and invalid data error and yo u are granted to re-enter the data again.

A lost or forgotten credential may retrieved by a click the **"send my voting detail"** and it opens with a form requesting for your staff number, which it matches with the references that base either send the de tails to your email box or inform you that you are not in the members list.

If the three data are correct and properly enter another matching is performed to check whither you have cast your vote before that time, if true, a page displays date and time you exercise your rig ht and the

system return you to the home page, otherwise you are launch to the voting page proper, where you are warned not to leave unattended and to ensure you do not make any mistake, because at this point any mistake made and submitted will not be redeemable.

All the candidate pictures will be presented to you with a check button adjacent to them, you check the candidate you wish to vote and submit the form.

After the submission of the form you are presented with a confirmation page and email is sent to your inbox telling you when you voted and the persons you voted.

B. Online Result:

The online result page displays the current result of the election. Immediately after casting your vote, you may wish to check the online result page which shows the status of the votes cast so far in a distribution according to vote cast for each candidate, in some cases the pictures of the candidates may not be display to avoid "band the wagon effect" where by members vote for the perceived most popular person there by undermining the aim of the secret ballot process.

C. Final Result

Furthermore the end date of voting is tested against the current time and date of the server hosting the EVS; once the end date and time is attained the system will automatically lock and would not allow submission of any further vote. Rather the Final Result is prepared and release by the system after about 2- 5 minutes.

III. Security Issues

To ensure that integrity and security is maintained at the back end or the server end of the system, the database is protected by encrypte d password, which has admin privilege and could be access by a SSL link which every vote cast ride upon.

More over the server OS security is also deployed in this case the NTFS server was used which have folder to file level security.

To further improve on the security, the administrative password to this folders and files are not held by one person rather portions of the password are entered by the electoral committee who could be up to 5 persons.

Physical security was assured by making sure that the system is in very secure location as other critical servers of the organisation.

Requirement

- Voting Credential
- Access to intranet web site.

Process

- Compile List of membership
- Send Voting Credential via email address
- Validation of Credential
- Checking for previous cast
- Casting of Vote
- Sending confirmation mail to voter
- Reporting of Result
- Checking of voting period
- Release of Final Result

Business Benefit

- Wide Electorates.
- Instant Result.
- Eliminate Human Error.
- Security using Encryption.
- Reduce Man-hour Waste During Voting Period

Wide Electorate is achiev e because of the use of the web at the convince of the member who may be living at dispersed location apart, in the case in study, the staff members to the corporative society span from Lagos to Warri to Port Harcourt and even some remote location where link have been provided. Prior to the introduction of this system the percentage voting population was rapidly declining. But with the EVS this has been reverse.

Instant Resultthis was achieved by simply polling the data stored in the voted database every 60 seconds and refreshed for the view to see the increase in the vote.

There are other analysis displayed on the result page such as then total vote of the day, how the votes were cast etc.

Elimination of human errorbecause they system checks the validity of your credential before you cast your vote there are no invalid submissions hence no disqualificati ons of vote cast. Also the counting is automatically counted by the system, which removes the error of sorting and counting.

Security Using Data Encryptionthe password is

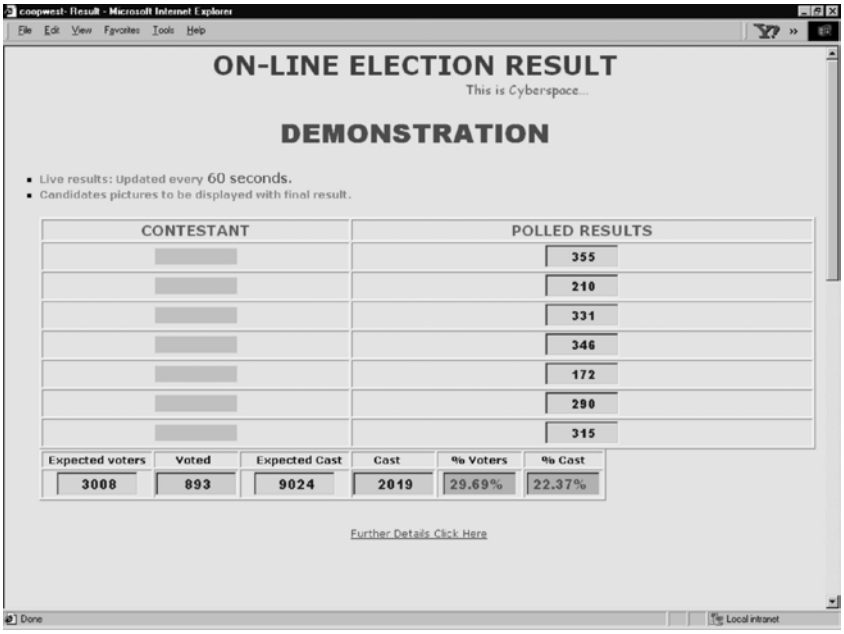


Fig. 2: Online Result without the Candidates Pix

encrypted before it is transferred via the networking equipment to the server end. Also the web server utilises the Server folder/file security which is further enhanced by the use of part password logon and denial of any body from accessing the folder and file locally including the administrator, by this means integrity and security Is built into the system.

Reduction of man-hour waste during voting period: In the past, staff of corporate organisation have to leave there office to go to a destined location before they can cast their vote, this time wasted is eliminated by the use of the EVS, also some may have to travel from their offshore location to the main office to cast their vote, this is also eliminated by the use of the EVS.

SimpleApplication

? Corporate Organization Union Election
? Club House Executive Election
? Corporative Societies of big Organisation

AdvanceApplication

? Governance Election (Using more secure system and some identification system like biometric system.)
? Party Preliminary election
? Party Primary Election
? etc.

Presently

? For 8 years running, all the staff Cooperative Society of Shell Petroleum Development Company has used this system for its annual elections.

Some view of the system

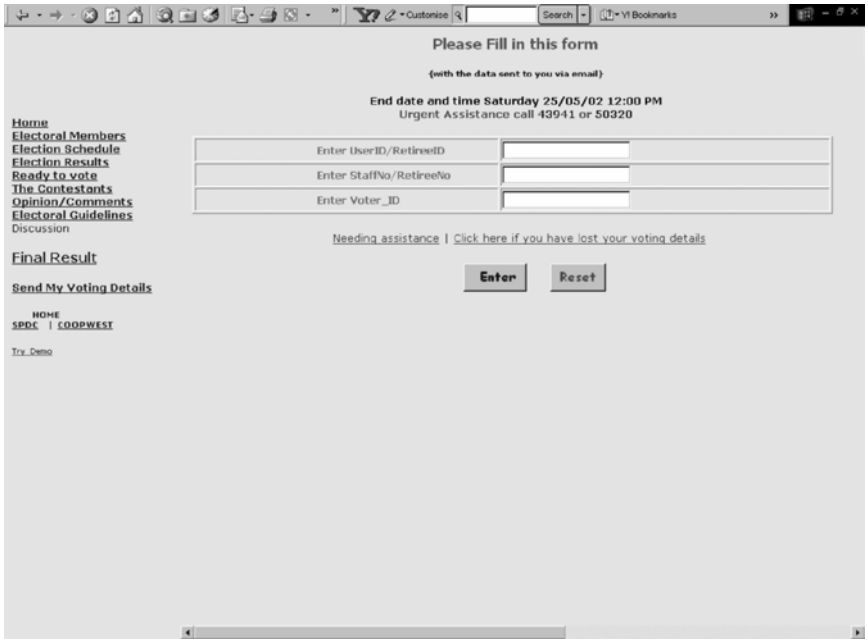


Fig. 3: Logon Screen

IV. Conclusion and Recommendation

That intranet can be used to provide a credible electoral process have been proven by the system above. This could easily be adopted for larger audience, and the use of other security system would be employed. Some comments by users are listed in Appendix A.

Going further, with the penetration of the mobile communication system in the developing world, it implies that the use of Mobile system could very well be used for voting in the near future.

Appendix A

Comment from Some Users

"*I must confess that this system is superb, especially in the area of instant result reporting in relation with the scrambled pictures. This fantastic presentation should stay Please keep it up!*"

"*It is worth lending my voice to the many others that have commended the brilliant efforts of the electoral committee. Even if an instantaneous transport of this system to the political elections in our country is not presently feasible, I would suggest that at least ways of informing the public and creating societal awareness of the possibilities exhibited here be found and done (and sent to INEC and other relevant groups). Once congrats for a job very well done.*"

"*While joining other members in appreciating the good work you are doing to make this election free and fair. I think it is high time we sell this good initiative to Nigeria government to save our nascent democracy. KEEP UP THE GOOD W O R K*"

"*The progress of this election points to the robust and transparent process adopted. The successes recorded in the past 3 years of using the e-voting shows is a proof that it can be modified to suit the Nigerian. I know this had been shown to INEC in the past, I believe you should not relent in contacting them. May be there is a single good man in INEC who will listen. Cap is off My Head for you guys.*"

"*I join others to commend this brilliant effort by the electoral committee. Both the process and the method used are highly commendable. I however wish to request that subsequent contests include a face-to-face interactive session (akin to the "Presidential TV Debate") between/among contestants and the voters. This will no doubt help voters in deciding who gets the votes.*"

"Please get national observers to witnness what is going on here. The IT designer and electoral board have worked so hard, congratulations. Next time show us their faces while the during the voting-the advantage is more than the disadvantage."

"Please we should not let this excellent voting system go unnoticed. The Nigerian press should be invited, to witness and capture the exercise in our Media. Greetings to the organisers and the system programmer(s) Cheers Frank"

"I am very proud to be part of this transparent system. Please keep up the good work .GOD BLESS YOU "

"Fellow co-operators, this brilliant and innovative ideas of electoral process should be sold to INEC in order to better Nigerian political process, devoid of rigging and litigation. Shalom."

"Wonderful system you have. Real-time election result is great."
"Your efforts are commendable. I respect this system."

STRATEGIES FOR IMPROVING SOFTWARE DEVELOPMENT AND ACQUISITION PRACTICES IN DEVELOPING COUNTRIES

Simeon Ozuomba, MIEEE and +Gloria A. Chukwudebe, SMIEEE
simeonoz@yahoo.com, gloria_chukwudebe@ieee.org
Dept of Electrical/Electronic & Computer Engineering, University of Uyo, Nigeria.
+Dept of Electrical/Electronic Engineering, Federal University of Technology Owerri, Nigeria

ABSTRACT
Use of software has become imperative for increasing productivity in all organizations. Software development and acquisition processes in developing countries are still facing challenges. Improvement in software development practices has been pursued through several Software Process Improvement (SPI) initiatives such as the software 'best practices' process models which include among others the Capability Maturity Model Integration (CMMI), the Software Process Improvement and Capability dEtermination (SPICE) and the ISO 9000 norms. However, successful implementation of such standard SPI methodologies in small and medium enterprises (SME) has been a challenge because of lack of adequate resources and the excessive cost of the SPI programmes. In this paper, the various factors that influence Software improvement such as process maturity models, software quality, market pressures are discussed. Some European and other countries SPI initiatives and the challenges with existing standard SPI methodologies are reviewed. The state of the software practices in developing countries, the issues and challenges are analyzed. A scaled down Software Process Development and Acquisition framework derived from the international best practices model is recommended for SMEs in developing countries. To quickly improve the market position of the SMEs in the developing countries, in the face of rapid evolution and competition in the software market, an action research by all relevant stakeholders to standardize software practices and develop enabling tools is recommended.

Keywords - Software Acquisition, Software Development Practices And Software Process Improvement,

I. Introduction

Presently, software constitutes a key component in almost all information industries' products, whether it is explicit software systems or software embedded in electronic products or systems [1]. Experts have observed that in the near future, the ability of organizations and their products, systems, and services to compete, adapt, and survive, will depend increasingly on software. As is being seen in current products (automobiles, aircraft, radios) and services (financial, communications, defens e), software provides both competitive differentiation and rapid adaptability to competitive change. It facilitates rapid tailoring of products and services to different market sectors [2].

Given the increasing relevance of software and the low capital entry requirements, the worldwide software market is growing at unprecedented rates. Many nations are reaping bountiful economic benefits and are struggling to be dominant in the emerging software market. This is being achieved through deliberate policies and actions, and through the setting up of committees to develop strategies and guidelines for players in the industry.

Evidently, software constitutes an important industry for developing countries too. Although, SMEs generally concentrate on niche markets, however, given the teeming population of software SMEs in the developing countries, the long-tail effect will prevail if the SMEs are enabled to improve on their software development capacity. However, in most of these countries, the SMEs that account for the majority of software development organizations face serious problems, when they start to grow. In many cases, the absence of a visible software development process creates chaos for the entire organization, including its products [3][4].

How are big software enterprises making it? One

reason is use of software process improvement (SPI) methodologies. SPI involves all activities performed to develop and maintain a software product. It is about introducing changes to the software development process with the purpose of meeting a set of criteria, which promotes performance within quality, cost, and schedule targets. SPI has been recognized as an effective way for companies to improve the quality of their software products and the productivity with which they work.

One attempt to facilitate SPI in software quality has been the development of international 'best practices' models such as the Capability Maturity Model Integration (CMMI) developed by the Software Engineering Institute (SEI), the Software Process Improvement and Capability dEtermination (SPICE) and the ISO 9000 norms from the International Standardization Organization. These models provide quality patterns that a company should implement to improve its software development process [5][6]. Unfortunately, successful implementation of such models is generally not possible within the context of small and medium-sized software organizations because they are not capable of bearing the cost of implementing these SPI programmes as they often operate on limited resources and with strict time constraints [6][7].

While Europe and some other developed countries have utilized CMMI to develop new assessment methods tailored to the context of small and medium size software companies, there is no evidence of suc h tailor-made process and process assessment reference models for the SMEs in developing countries. Moreover, the adoption of models defined for other countries without suitable adaptation is usually ineffective [3]. Indeed, SPI advocate, Sami Zahran observed that an organization will reject a process if it does not match its culture, just as the human body will reject a mismatched transplanted organ [8]. Software-engineering researcher Tore Dyba, noted that cultural differences play a role in t he success of software process improvement [9]. In addition, SEI emphasizes that it is expensive and difficult to implement CMMI and the Standard CMMI Appraisal Method for Process Improvement (SCAMPI) in the US [10][11]. Applying these models would be even more expensive and difficult for SMEs in the developing countries, which must make copyright and certification payments to the US.

Furthermore, in recent times, attention has shifted from mere 'pursuit of quality' to responsiveness to the dynamism in the software market. The current thinking is that process maturity is necessary but not sufficient for true improvement, as the real prize is increased competitiveness not a better maturity assessment score. In this paper, we highlighted the strategies for improving s oftware development practices in developing countries in the face of pressures due to rapid changes in the software market. Our focus is on strategies that will support the much needed responsiveness to the market demands without sacrificing software quality.

So far, it seems that the problems of the software industries in the developing countries can be effectively addressed when appropriate SPI methodologies are implemented by the software developers. However, because of the intimate interaction between software buyers (acquisition organizations) and suppliers (software developers) and the perceived immaturity of acquisition organizations in the developing countries, the acquirers of software-intensive systems will continue to be a large part of the software development problem. In view of this, today's software intensive products and business practices require companies to approach software purchases with a well informed and strategic method. Beside, studies have shown that software acquisition organizations that have a strong, consistent evolutionary environment and practices for setting product requirements, maintaining a disciplined development process and using metrics to oversee development progress achieve favorable cost, schedule and quality outcomes. In essence, while software developers are required to improve on their software development practices, it is also expedient that organizations improve on software acquisition practices. Consequently, in this paper, the proposed strategies require that the software “best practices' model should be extended to address the improvements in both software development and acquisition practices.

The rest of the paper is arranged as follows; in Section II, the strategic analysis of software development and acquisition practices in

developing countries is reviewed. Existing software process improvement methodologies and their shortcomings are presented in Section III. In Section IV, software acquisition, the challenges and process improvement are examined. The strategies for improving software development and acquisition practices in developing countries are proffered in Section V.

II. Strategic Analysis of Software Development Practices In Developing Countries

A. Effect of Poor Software Development Practices in Developing Countries

Soriyan and Heeks did a detailed study of the software development practices in Nigeria, their findings rightly captured the current trend in th e local software industry and market in the developing countries [12]. Based on the number of staff, companies were classified as follows; micro-enterprises (1-10 staff), small enterprises (11-50 staff), medium enterprises (51-250 staff), large enterprises (251-5,000 staff), very large ses (enterprises (above 5,000 staff) [12]. The software companies in the country were mostly small in size: a typical software company has 11-50 staff. Very few of the companies had more than 250 employees: such companies had more than one branch and were often involved in business activities other than software development [12]. In essence, the software products from such companies experience a vicious circle (Figure 1); a situation that results from lack of sufficient quality software processes an d methods. Without that quality, customers turn off, and go for foreign products.

However, if that quality can be built, then locally-produced software will be more effective than imports in meeting customers' requirements. In that case, a virtuous circle can be created in which local software enjoys a growing market and feedback loops of learning and improvement that can take it from strength to strength.

B. Strategic Positions Occupied by Software Firms in Developing Countries

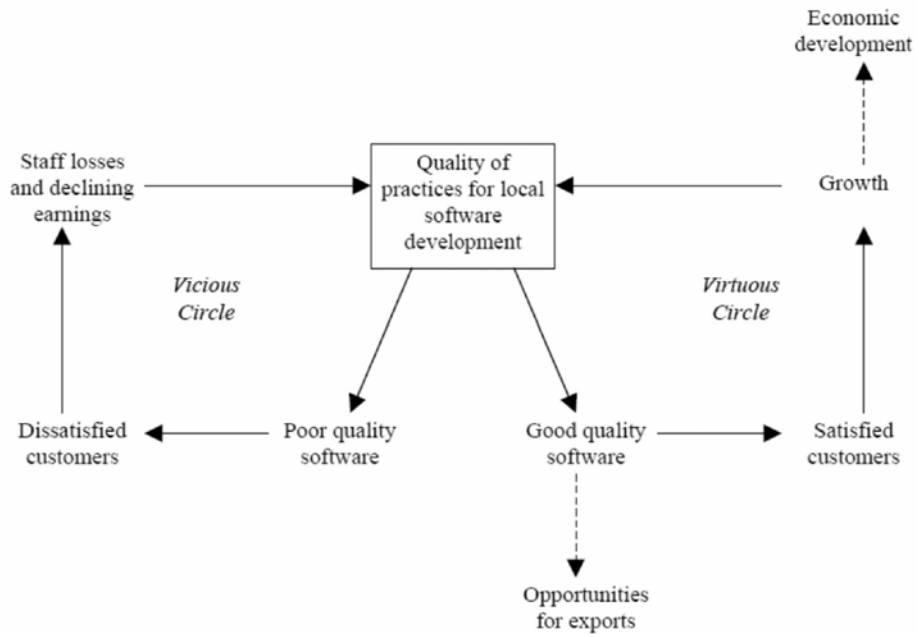


Figure 1. Vicious and Virtuous Circles for Development of Local Software in Nigeria

Heeks presented five strategic positions that may be occupied by software firms and sectors in developing countries, as summarised in Figure 2. India, for example much discussed as a developing country "giant" in software terms has achieved much of its success through a focus on quadrant A. Strategic analysis of the Nigerian software industry according to Heeks' quadrant model (Figure 2) showed that:

? there is no significant evidence of exports (thus, quadrant A,B and E are not applicable to th e country). (There was a significant concentration on the domestic market: three-quarters of customers were Nigerian firms based in Nigeria while the majority of the one-quarter of customers identified as "foreign" were actually representatives or joint ventures of multinationals also based in Nigeria [12 &13]. Software exports were therefore not significant).

? local software firms provide series of value-added services to imported packages, such services lie in quadrant D or on the C/D borders.

? in some cases, some firms may be involved in custom-building of software applications from scratch, and others creating what can be called a "semi-package" or "configurable package": something originally written for one customer that is then sold-on as a core of code with particular functionalities that can be configured for other customers. Such activities lie firmly in quadrant C.

Consequently, the local software industries in such developing country under study can be located in quadrant C and D. This indicates that export of software product and services is in jeopardy. The conclusion in [12] was that firms must strengthen their software development practices, something that will be partly dependent on improvements in the provision of software education by local universities [12].

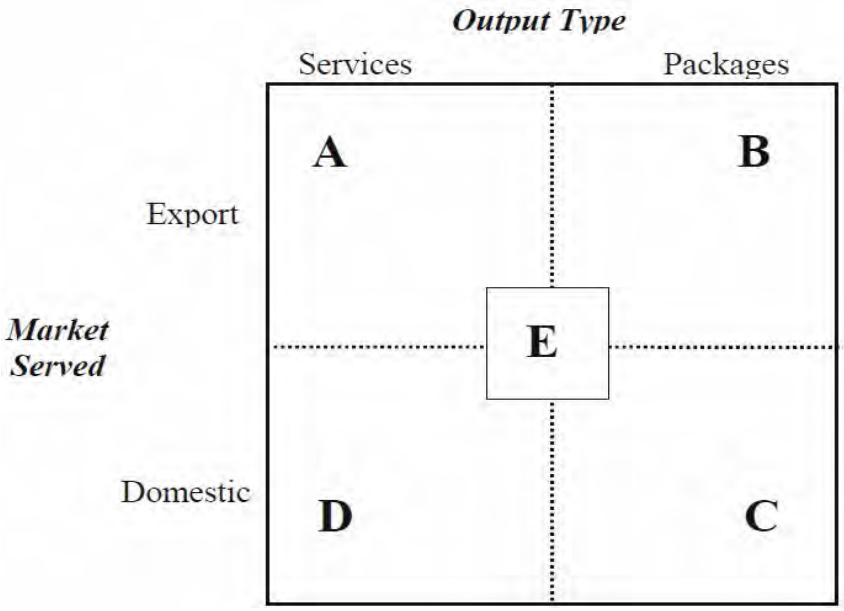


Figure 2. Strategic Positioning for Developing Country Software Firms/Sectors

III. Software Process Improvement Initiatives in Developed Countries

Software Process Improvement (SPI) facilitates the identification and application of changes to the development and management activities in order to improve the product. To support SPI programmes, the software engineering community has developed a set of normative maturity models for organisations to follow and enable the assessment of current capability. Within such norm-based models, improvement in the software process is considered to result in the maturing of the activities undertaken by a software development group. Evidence shows that benefits can be achieved as a result of this adoption. Consequently, the majority of the works to date on (SPI) have focused on software process assessment and "best practice" models such as the Capability Maturity Model Integration (CMMI) developed by SEI, the Software Process Improvement and Capability dEtermination (SPICE) and the ISO 9000 norms from the International Standardization Organization. These models provide quality patterns that a company should implement to improve its software development process [5][6]. Unfortunately, it has been observed that the successful implementation of such models is generally not possible within the context of small and medium-sized software organizations because they are not capable of bearing the cost of implementing these SPI programs as they often operate on limited resources and with strict time constraints [6].

In various countries, researchers have adapted the models for process assessmentand improvement to the special characteristics of small organizations in other to save time and cost. Some SMEs run the scaled-down class B or C assessment instead of class A, the SCAMPI (Standard CMMI Appraisal Method for Process Improvement) [7]. Some regional and national initiatives in this regard include :

a) Regional Initiative

? The SPI in Regions of Europe (SPIRE) programme is a European Systems and Software Initiative project financially supported by the European Commission. The Centre for Software Engineering in Dublin undertook the project in Ireland and coordinated activities with partners in Austria, Italy, and Sweden [1].

b) National Initiatives

? In Brazil, the Associação para promoção de Exçelência do Software Brasileiro (Assoc. for Promoting Brazilian Software Excellence) developed the MPS.BR model (Melhoria de Processo de Software Brasileiro, or Brazilian Process Improvement Model) based on the ISO/IEC 15504 standard and aligned it to the CMMI framework focusing on small and medium-sized software organizations [14] & [15]

? The Norwegian SPI program called SPIQ (Software Process Improvement for better Quality). The objective of SPIQ is to i ncrease the competitiveness and profitability of Norwegian IT-industry through a systematic and continuous approach to process improvement [33].

? The Mexican Ministry of the Economy developed a standards based on ISO/IEC 12207, including practices from ISO 9000:2000, CMMI, PMBOK, SWEBOK, and ISO/IEC 15504 [3][15].

Initiatives such as these demonstrate, among other things, the requirements of improved software practices in small and medium software organizations. In the case of Mexico for instance, such initiative called Competisoft projectwas used to provide the Latin American software industry with a reference framework for improvement and certification of its software processes [3]. There are after, MoProSoft offered a new process structure, some new process-documentation elements, a more precise process relationship, and an explicit SPI mechanism. MoProSoft was complemented by the EvalProSoft process-assessment method , based on the recommendations of ISO/IEC 15504 [3]. In August 2005, Mexico approved MoProSoft and EvalProSoft as national standard NMX-059-NYCE-2005. Together, they were intended to provide Mexico's software industry with an easy-to-understand model based on best international practices that would help organizations standardize their practices [3].

IV. Problems of the Existing Software Process Improvement Methodologies

Some SPI programmes have failed for several reasons, Garvin suggests, that one challenge is the need for “continuous improvement activities that require a commitment to learning” [16]. Learning in this context include the individuals capacity to acquire, transfer and interpret knowledge and utilise that learning in a work-based environment

[17]. Another challenge is that, without understanding the technological and social aspects of software, one cannot significantly improve the processes [18]. Consequently, the existing normative models are criticized for the rigidity of the predefined actions and their underlying deterministic assumptions about implementation [18].

Again, some enterprises feel the existing SPI methodologies emphasize on technology and a lot of documentations rather than people and that they are not flexible enough, such enterprises rather trust improvisations and experiences of their developers. Consequently, such commercial software producers do not, therefore, follow software process improvement according to the maturity models or quality standards [19]. The survey revealed that generally, SMEs focus on practice rather than formal process, as such, they lack 'process culture'. Hence, they are often averse to formal process improvement programs. However, research findings have shown that large successful software organizations emphasize exploitation of their "best practices" through formal procedures, process models, guidelines, rules, check-lists etc. in order to manage and improve their software processes.

Although, the aim of the process oriented paradigm is a stable and reliable software process, as a result of software process improvement based on rigorous project management and process control. The idea of a stable, repeatable software process contrasts with the competitive environment and sometimes time critical, of commercial software product development. In the SPICE (ISO 15504) SPI trials approximately 60 percent did not observe a major impact on the organization [19]. The concern is that the process has become more important than the quality of the product or any resultant business benefit. This internal focus on process is an untenable position for commercial software producers, where reacting to the market is seen as more important than following a prescribed process [18]. According to Allison [18] , customer based perspective is a better judgment for a commercial software organization; if the level of complaints rise, or the market share reduces then the company's product quality is insufficient for its purpose. In this case, the real prize is increased competitiveness not a better process maturity assessment score, as such process maturity is necessary but not sufficient for true improvement [19]. To support this more situated, market oriented perspective, there is a need to develop an agile approach to SPI so that the process improvement reflects the needs of the given context [19]. An agile approach to SPI would be responsive and flexible to local needs, encourage innovation in the process, build SPI projects around those who are motivated, encourage self-organising competent teams, and promote sustainable development of the processes.

IV Software Acquisition Challenges And Acquisition Process Improvement

A. Software Acquisition

Developing software applications take time and it requires expert programmers. In the past, big enterprises employed staff to write software applications. Today the easiest option may be to buy Commercial off the shelf applications, if one can find a package that meets one's business requirements. However, because it is not always easy to find, companies now acquire software by outsourcing (i.e the development of software system by one or more external providers).

Outsourcing the development of software does not relieve the acquirer of responsibility for the outcome. In fact, the activities, products, and behaviors of the acquirer have a significant influence on the success or failure of outsourcing activities [20][21]. The acquirer will bear most of the responsibility for the results from the planning, contracting, and follow-up on phases of the acquisition, while the developer is most accountable for the results coming out of the implementation and acceptance phases of the acquisition [22].

Depending on business requirements, Software acquisition involves several steps: *conceptualization, initiation, design, development, test, contracting, production, deployment, Logistics Support (LS), modification, and disposal of software systems, supplies or services* [23][24].

Several things can go wrong with any of these steps that can cause the project to fail. For instance, in developing countries, many Chief Executives have acquired software without proper

planning, user community acceptance, proper assessment of vendor support capability, etc.

Having a defined software acquisition and supplier management process helps insure that important steps in the acquisition process are not forgotten. Defined software acquisition also facilitates the propagation of lessons learned from one acquisition project to the next so we can repeat our successes and stop repeating actions that lead to problems.

B. The Challenges of Software Acquisition

As software becomes an integral part of our businesses and our lives, we can no longer afford not to learn from past mistakes. Consequently, before the task of purchasing commercially available software, contracting a supplier to create custom software package, or developing a "homegrown" software application can commence, adequate planning must take place [25]. Numerous software acquisition projects have failed for several reasons ranging from poor planning, inadequate requirements capture, inadequate testing of product before acceptance, no planned after project support, etc.

Additional challenge for Managers, is the need to understand topics as diverse as risk identification and mitigation, selection and integration of commercial off-the-shelf (COTS) components, process capability, business continuity, disaster recovery, survivability, interoperability, contract monitoring, etc. Thus, the challenges of acquiring software-intensive systems will continue to grow along with the increasingly critical role software plays in supporting commercial and government enterprise, business, and mission needs [26] [27]. These increasing challenges make the need for well informed and strategic approach to software acquisition and supplier management practices essential to the success of organizations acquiring software-intensive systems. According to Theresa and Linda [25], an acquisition project has a greater chance of a successful outcome if the acquirer:

- Properly plans the acquisition
- Gives appropriate attention to defining the software products business needs
- Decides on an acquisition approach only after consideration of each viable option
- Explores available sources to identify and evaluate potential suppliers
- Ensures that the software requirements are defined and fully understood
- Works to secure a capable supplier
- Formalizes the acquisition agreement in an appropriate contract vehicle

C. Software Acquisition Process Improvement

Some big enterprises have established frameworks for acquisition of applications. Many organizations in developing countries are afraid to computerize due to failure stories and fear of the unknown. The Software Engineering Institute has established the Software Acquisition Process Improvement (SAPI) [28]. SAPI has described the acquirer's or the buyer's role in software-intensive system acquisition and also given client or acquisition organizations guidance on how to improve their own capabilities for participating in outsourcing or acquirer-supplier agreements.

Existing best practice models for software acquisition are built on commonly accepted standards that either represent software acquisition as a standalone process or integrate the acquisition process into software process model suite that addresses both software development and acquisition practices. Three commonly used software process standards are the Capability Maturity Model for Software Acquisition (CMMI-ACQ), the Software Acquisition Capability Maturity Model (SA-CMM), and the ISO/IEEE 12207 software lifecycle standard (which integrates software acquisition into the lifecycle model as compared to the other two models, which describe it separately) [29][30]. CMMI-ACQ and SA-CMM are developed by the Carnegie Mellon University Software Eng ineering Institute (SEI) to provide a framework to benchmark and improve an organization's software acquisition process.

V Recommendations

A. Outline of the Strategies for Improving Software Development and Acquisition in Developing Countries

Software process improvement and re-engineering has gained considerable interest as a methodology for organizational change and for creating more mature software engineering practices. In this section, we recommend responsive SPI strategies for improving software development practices in developing countries.

Our proposal is informed by the contemporary views of software development practices which asserts that rather than maintaining the existing software process philosophy of stable and reliable software process, there is need to adjust the process to suit the local software (product) development needs. The aim of such thinking is to produce a successful product rather than following a pre-defined methodology at all costs. It is therefore necessary that the process improvement activity should be contextually responsive rather than externally pre-determined. In that case, responsiveness to the market demands is paramount, and that requires process innovation at organizational level. In fact, as stated earlier, the process maturity is necessary, however, it is not sufficient for the contemporary views of software development practices.

An increasingly popular way of starting a software process improvement program is to do an assessment in order to examine the existing processes being used b y an organization to determine whether they are effective in achieving their goals. In view of the the difficulties and cost of the internatational CMMI, the development of a scaled down version is proposed. The SPI methodology proposed will include among others:

a) Establishment of a tailor-made Software Process Development and Acquisition Suite as national standard in the developing countries.
b) Use of action research methodology to develop the human capacity required to support process evolutio n at organizational level.
c) Promotion of the Software Process Development and Acquisition Suite through Democratization of Tools of Production , Seminars , Case Studies etc.

B. Establishment of a tailor-made Software Process Development and Acquisition Suite as national standard in the developing countries.

The suite will include:

? a tailor-made Software Process Model (SPM) and Software Process Assessment (SPA) framework for the SMEs engaged in software development and
? a Software Acquisition Framework (SAF) to benchmark and improve software acquisition process .

The use of such *Software Process Development and Acquisition Suite* can help identify the capabilities of the SMEs to deliver software products and services on time and to the required level of quality and so becomes an important consideration during the contract tender and award stages. As the organizations grow in process capabilities and maturity, they may wish to implement the International Standards 'best practices' process models and process assessme nt framework.

C. Use Action Research Methodology to Develop the Human Capacity Required to Support Process Evolution and Commitment to Organizational Learning

Obviously, formulating, planning and implementing a national tailor-made 'best practices' process model and process framework for the assessment cannot be handled by the software firms alone as they are mainly SMEs with limited resources and expertise. The solution requires a bailout approach, an approach that involves all the stakeholders in the software industry; the government, the software enterprises, the customers (including other enterprises, systems integrators and consultants advising acquirers that may engage in software acquisition or outsourcing to software enterprises), the universities and research institutes. The bailout strategy should be in a form of an action research and collaboration initiative that will formulate, plan, develop enabling tools and facilitate the implementation of such process-oriented solution for SMEs. The benefit of this nationwide action research initiative will be development of in-house competence required for the formulation, planning, development of enabling tools, implementation, evaluations and adaptation of process-oriented solutions.

D. Promotion of the SPI Suite Framework through Democratization of Tools of Production , Case Studies, Seminars, etc.

Like every other improvement methodologies, the strategies proposed in this section need to be promoted, sustained and enhanced for it to continue to remain relevant in the fast c hanging software industry. First, there is need to develop the tools and templates that will facilitate the

implementation. For instance, rather than the existing automated modeling tools, an interactive modeling tool can be developed to facilitate process evolution at organizational level.

Furthermore, there is need to 'democratize the tools of production'. The relevant tools and resources essential for the effective implementation of the proposed strategies need to be readily available and at little or no cost to the SMEs. Finally, workshops, seminars etc should be conducted regularly to share ideas and update the SMEs and acquirers of case study results. Other stakeholders should also be informed of the developments in the local software industry. In all, the proposed strategy will only deliver the expected benefits of improvement in market share of the SMEs if the stakeholders are committed to the development, implementation and promotion of responsive SPI methodology and the software acquisition framework.

V. Conclusion

Process improvement and re-engineering has gained considerable interest as a metho dology for organizational change and for creating more mature software engineering practices. In this paper we have examined the effects of poor software development practices in the developing countries and the limitations of the widely used software process improvement (SPI) methodologies. We also discussed the contemporary view of software development practice which requires more flexible and responsive SPI methodology. Furthermore, we examined the challenges associated with software acquisiton. We then presented strategies for improving software development and acquisition practices in developing countries. To the software developing enterprises, the aim of the strategies is to support software quality along with responsiveness to the dynamisms in the market demands. At the same time, the software acquisition framework proposed in the strategies is meant to provide a framework to benchmark and improve software acquisition process.

Given the limited resources and lack of expertise in the SMEs that constitute the local software industries in the developing countries, the strategies are to be formulated and implemented in the SMEs through action research initiative that will be sponsored by the government and/or any well meaning organization. The key contribution of this paper is in identifying the need for alternative assessment method that can be used in a collaborative manner to assess organizations based on their organization-wide 'best practices' process model. Also, we provided a framework on how such organization-wide models can be harvested from process-in-use as well as from the national or global 'best practice' process models. Besides, such models can also be tailored and improved to achieve high capability and maturity level without following the specific practices of the existing 'best practice' models. The strategy requires process evolution at the organization level and that requires commitment to learning from practice.

Finally, the paper also contributed in the area of software acquisition. Specifically, we identified the need to address the problems of software development and acquisition in one software process suite. In this wise, the acquirers are provided with a Software Acqu isition Framework (SAF) to improve in their acquisition process where such framework follows the same architecture, design, and language of the Software Process Model (SPM) and Software Process Assessment (SPA) framework used by the developers. Such compatibility in the development and acquisition process facilitates better co-operation of the software developers with the acquirers.

REFERENCES

[1] J, Alastair , "Can Australia Improve Its Software Processes?", CrossTaalk ,The Jurnal of Defense Software Engineering, Aug 2001 Issue http://www.stsc.hill.af.mil/Crosstalk/2001/08/james.html

[2] B. Boehm, "Some future trends and implications for systems and software engineering processes", Systems Engineering archive , John Wiley and Sons Ltd. Chichester, UK Volume 9 , Issue 1, Pages: 1 - 19, January 2006.

[3] H. Oktaba, F. García, M. Piattini, F. Ruiz, F. Pino, C. Alquicira, Software Process Improvement: The Competisoft Project. Computer, IEEE Computer Society, October 2007, pp.21-28

[4] J. Batista and A. Dias de Figueiredo, "SPI in a Very Small Team: A Case with CMM," Software Process: Improvement and Practice, vol. 5, no. 4, 2000, pp. 243-250.

[5] E.M. Herrera, R.A. Trejo Ramirez, " A Methodology for self-diagnosis for software quality assurance in small and medium-sized industries in Latin America", The Electronic

Journal on Information Systems in Developing Countries, 15, 4, 1-13, 2003
[6] Deepti Mishra & Alok Mishra (2009) "Software Process Improvement in SMEs: A Comparative View", *Computer Science and Information Systems*, Vol. 6, No. 1, 111-140. http://www.comsis.org/ComSIS/Vol6No1/RegularPapers/pdf/9.pdf
[7] W. Hayes et al., "Handbook for Conducting Standard CMMI Appraisal Method for Process Improvement (SCAMPI) B and C Appraisals", (Version 1.1), tech. report CMU/SEI 2005-HB-005, Software Eng. Inst., 2005.
[8] S. Zahran, Software Process Improvement: Practical Guidelines for Business Success, Addison-Wesley, 1998.
[9] T. Dyba, "An Empirical Investigation of the Key Factors for Success in Software Process Improvement," IEEE Trans. Software Eng., vol. 31, no. 5, 2005, pp. 410-424.
[10] Mayer & Bunge Informática, Panorama de la Industria del Software en Latinoamérica, 2004, p. 97.
[11] M.B. Chrissis et al., CMMI Interpretive Guidance Project: What We Learned, special report CMU/SEI-2004-SR-008, Software Eng. Institute, 2004; www.sei.cmu.edu/pub/documents/04.reports/pdf/04sr008.pdf.
[12] R.Heeks, H. Soriyan. , "A Profile of Nigeria's Software Industry, IDPM Development Informatics", Working Paper 2004. http://www.sed.manchester.ac.uk/idpm/research/publications/wp/di/in dex.htm. Manchester.
[13] R.B. Heeks, "Software strategies in developing countries", *Communications of the ACM*, 42(6), 15-20, 1999
[14] MPS.BRMelhoria de Processo de Software Brasileiro [Brazilian Process Improvement Model], SOFTEX, 2006; www.softex.br/mpsbr.
[15] I. Richardson, Christiane Gresse von Wangenheim, "Guest Editors' Introduction: Why are Small Software Organizations Different?" IEEE Software, vol. 24, no. 1, pp. 18-22, Jan./Feb. 2007, doi:10.1109/MS.2007.12
[16] D. Garvin., Building a Learning Organisation, Harvard Business Review, July-August 1993. Pp 78-91.
[17] P, Halloran, "Organizational Learning from the Perspective of a Software Process Assessment & Improvement Program", Proceedings of the Thirty-Second Annual Hawaii International Conference on System Sciences-Volume 3, p.3059, January 05-08, 1999.
[18] I. Allisona, Y. Meralib, "Software process improvement as emergent change: A structurational analysis ", Information and Software Technology, Volume 49, Issue 6, June 2007, Pages 668-681.
[19] I. Allison, Towards an agile approach to Software Process Improvement: addressing the changing needs of software products, Communications of the IIMA, 5 (2005)(1), 67-76.
[20] H.F Hofmann, Y. K. Deborah, J. W. Mishler, and K., Susan." *CMMI(R) for Outsourcing: Guidelines for Software, Systems, and IT Acquisition"*. Boston, MA: Addison-Wesley, 2007.
[21] W.E. Hefley, and E.A. Loesche,, *"The eSCM-CL v1.1: Model Overview* and *The eSourcing Capability Model for Client Organizations (eSCM-CL) v1.1*", Information Technology Services Qualification Center, Carnegie Mellon University, 2006.
[22] B. Ellison, R. Creel, "Acquisition Overview: The Challenges "SIE Carnegie Mellon University 2007-06-04 , Https://buildsecurityin.us-cert.gov/bsi/articles/best-practices/acquisition/893-BSI.html
[23] A. K. Peter, J. Ferguson, "The Software Acquisition Capability Maturity ModelSM", http://www.stsc.hill.af.mil/crosstalk/1997/03/acq_cmm.asp.
[24] "ACQUISITION PROCESS IMPROVEMENT" http://www.goldpractices.com/practices/api/.
[25] T. Hunt, L. Westfall, "Software Acquisition & Supplier Management: Part 1 Product Definition & Supplier Selection" , http://www.westfallteam.com/Papers/Software_Acquisition_1.pdf
[26] "Acquisition Support", http://www.sei.cmu.edu/acquisition
[27] "Acquisition Overview: The Challenges", https://buildsecurityin.us-cert.gov/bsi/articles/best-practices/acquisition/893-BSI.html "
[28] S. Eslinger, , "Software Acquisition and Software Engineering Best Practices", SMC-TR-99-27, Aerospace Corp. TR-2000(8550)-1, 15 November 1999. Http://www.org/publications/papers/pdfs/TR-2000(8550)-1.pdf
[29] R.G, Turner, " Implementation of Best Practice in US Department of Defense Software-IntensiveSystem Acquisitions", Doctoral Dissertation, George Washington University , January 2002 http://www.goldpractices.com/survey/turner/turner_dissertation.pdf
[30] H. Alfaraj, S. Qin,, "Deriving software acquisition process from maturity models--an experience report", Journal of Software Engineering and Applications (JSEA) , March 1, 2010 . Http://www.thefreelibrary.com/Journal+of+Software+Engineering+and+Applications+(JSEA)/2010/March/1-p51542

EMERGING BROADBAND TECHNOLOGIES FOR IMPROVED COMMUNICATION AND INTERNET ACCESS

Oladipo Gani Omobolaji, MIEEE
Nigerian National Petroleum Corporation, Abuja
omobolaji_oladipo@yahoo.com

ABSTRACT
The quest by the developing countries to integrate with the global village through data and telecommunication is growing. This leads to the advancement of large data transfer technologies that is Inet and efficient. In this paper broadband communication technology is discussed. The paper highlights the applications of broadband communication to relevant sectors in the society.

Keywords: Broadband, data, high speed transmission.

I. Introduction

One of the major advantages of Broadband Communications is the ability to transfer large amount of data at high speed across two networks. It is generally used in Internet delivery and measured in terms of volume of bandwidth available for transmission. In order to achieve communication through the internet and have access to resources in the cyber space, computers are required to be connected together across offices, towns, nations and continents. For higher speed of data transmission and execu tion of demanding applications, bigger bandwidths are very essential and will be required.

In the late eighties when Computer communications across offices and Internet access just began gaining ground in Nigeria, we had few companies offering dial-up access to their premises and providing interconnection to either the Internet or adjourning offices through their sites. Because this type of connection has limited capacity to carry data (between 0-56Kbps), it is referred to as narrow band connection and is achieved using analogue modems.

Over the years, we have seen several developments in the advancement of data communications; from analogue modems to ADSL, to radio (VHF, UHF & Microwave) to VSAT and then fiber connections. Different technologies have evolved, some of which will be looked at in details in this paper. However, Fiber Optics Technology has been accepted as the best medium of transmission for broadband delivery for improving business interactions.

When development in communication technology is juxtaposed with other spheres of world development, it will be seen that provision of higher bandwidth to carry data across networks is amorphous and on the increase due to the following factors:

- Business /commercial demands
- Environmental demands
- Political demands
- Availability of funds
- Consumer Intents
- Government policies
- TechnologicalAdvancement

In Africa, the political wi ll to exchange data freely among collaborating nations have been very poor. Each country has always handled its communications demands internally. The northern countries in Africa have ridden on their proximity to Europe and Middle East to develop their infrastructure especially in the area of VSAT communications. But West African nations are yet to truly experience inter-national connections between African countries as we have in other continents.

Fig. 1: Shows the world Statistics of Undersea Fiber Cable as at 2007. This figure represents the inter-continent fiber distribution. As it can be seen, Africa has a long way to go but has a big advantage for growth because the market is still very green.

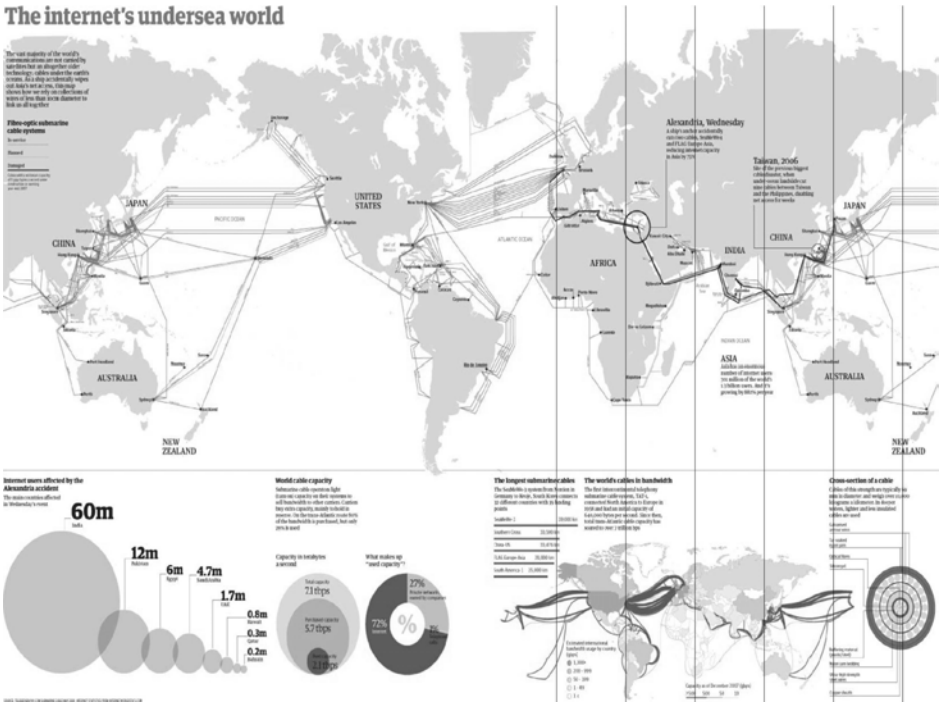


Fig. 1. World Statistics 2007: Undersea Fiber Cable
Taken from: http://image.guardian.co.uk/sys-images/Technology/Pix/pictures/2008/02/01/SeaCableHi.jpg

In her paper in 2005, Lishan pointed out that Domestic broadband penetration in Africa is very limited and demand is on the high side; this has been proved right by the enormous changes we have seen in broadband in the last four years. Though the study gave details of fiber in northern and southern Africa, showing that these areas have substantial broadband link as at that time but that West Africa still had a long way to go (Lishan 2005).

In Nigeria, since the licensing of GSM operators and the upgrade to unified licensing, our broadband picture has changed. Most of the companies have laid cable through the length and breadth of the nation. Their major focus was to ensure that voice communications is available nationwide. As bigger fiber network is established, there is need to increase customer demand, this can be achieved either by lowering prices or creating value added services that will improve penetration.

This paper is looking at the emerging technologies in the broadband industry with a view to suggesting ways by which communications can be improved in Nigeria and in Africa at large.

A. The Several Faces of Broadband

Broadband technology can be achieved in several ways, these are:

Copper cable

For several years, all we had were copper cables used for the telephone networks. When data

communications started, this network that has gained much ground and had already spread to all locations requiring data was majorly used. The analogue modem was used to carry data at a speed of as much as 56Kbps. Then the Digital transmission was developed and carried both data and voice; the sustaining standard has been ISDN. This standard came as Basic Rate Interface (BRI) at 144Kbps and Primary Rate Interface (PRI) 2048Kbps on E1. The copper connection is limited in the maximum distance betwe en active devices. To improve on this, the ADSL technology was developed. "ADSL (Asymmetric Digital Subscriber Line) is an Internet access technology that makes use of the existing telephone network to provide broadband Internet service to homes and businesses. Presently, ADSL is the most popular high-speed Internet access technology for homes and businesses in many parts of the world" (Altaviser, n.d). ADSL is always on, and does not disturb the analogue phone line on which it is carried. This implies that it can be used on existing lines. With ADSL, data at the rate of 640Kbps/9Mbps Up/Down can be achieved and decreases with distance.

Radio Systems

Radio started with High Frequency (HF) technology which has farther reach but limited capacity. Over the years, there have been several developments in HF Radios but they remained unpopular because of limited speed and their being prone to atmospheric noise. The UHF radios performed better but found more use in audio and video broadcasting and transmissi on than data. Only a few radios for UHF transmission exist today. Before their perceived extinction, there were UHF radios used to carry data at 2048Kbps. Provisions such as multichannel, auto scanning and frequency hopping technologies for PTT communications was predominant at this frequency band. Popular for broadband technology is the microwave radio. This radio frequency band has become prevalent in broadband transmission; they are used for several purposes such as back haul, last mile, back -up and multi client connections. You could also hear terms such as Wireless Fidelity (Wi-Fi) and Worldwide Interoperability for Microwave Access (WiMax) in the application of Microwave radios. Radio usage is mostly in areas where using fiber will be uneconomical in achieving the data rate required (this is controversial in today's demand rate). The advent of GSM has again impacted on broadband not only by the demand to satisfy more voice customers than was possible with land lines, but also by what recent developments in 3G and 4G has enabled on mobile phones.

Very Small Aperture Terminal (VSAT)

The VSAT also works on the microwave principle but the extent of reach between two terminals is extended with the help of the "mirror in the sky" which is the satellite. It can be used to provide Internet and essential data to places where the use of copper/ fiber or microwave is either not economical or cannot be estab lished. Bandwidth of up to 10Mbps is reasonably achieved in remote stations but it can also be as low as 64Kbps.

Fiber Optic Cable

This major breakthrough in data transmission has changed the face of broadband widely. With the current advancement in technology, fiber can carry data at between 10 to 40Gbps on each optical channel, and more channels are being introduced or multiplexed together on each fiber. This is typical of Dense Wave Division Multiplexing (DWDM) fiber optics systems.

"Although 'all-optical' tech nologies are replacing most transmission lines, the nodes of the networks, such as switching and cross-connect nodes, still depend on relatively slow electronic technologies. This poses a problem because nodes in the networks will limit the throughput due to the limitations of the electronic circuitry. The only solution to this problem is to make the nodes all-optical as well. Migration from electronic and/or electro-optic nodes to all-optical nodes requires multiplexing, de-multiplexing and cro ss-connection via optical technologies" (Rahman, nd). In order to fully utilize the potential of fiber delivery, advanced countries are now adopting different terms in the implementation of their fiber technology, these are:

- FTTN - Fiber-to-the-node - fiber is terminated in a street cabinet up to several kilometers away from the customer premises, with the final connection being copper.
- FTTC - Fiber-to-the-cabinet or fiber-to-the-curb - this is very similar to FTTN, but the street cabinet is clo ser to the user's premises; typically within 300m.
- FTTB - Fiber-to-the-building or Fiber-to-the-basement - fiber reaches the boundary of the building, such as the basement in a multi-

dwelling unit, with the final connection to the individual living space being made via alternative means.

? FTTH - Fiber-to-the-home - fiber reaches the boundary of the living space, such as a box on the outside wall of a home.

? FTTP - Fiber-to-the premises - this term is used in several contexts: as a blanket term for both FTTH and FTTB, or where the fiber network includes both homes and small businesses. (Wikipedia 2010). These terms help in identifying the level of fiber implementation in networks.

II. Identifying Where Broadband is Impacting

Could you imagine constructing a ten-lane highway which only three vehicles ply per week? Enormous waste you will call it, but in the case of broadband there is enough demand for all the advancement and broader highway created because there are demands in the areas stated below.

E-Commerce

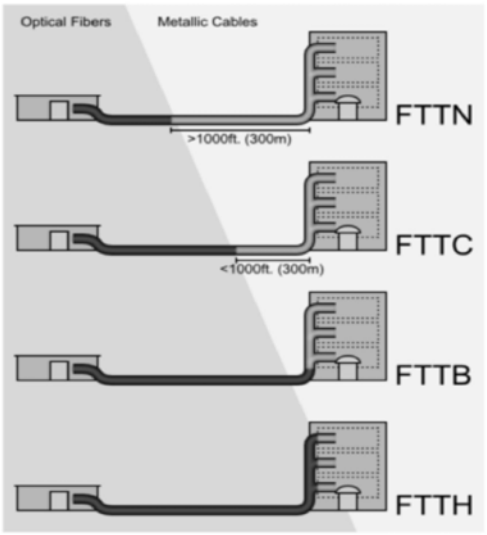
Each technological development is rated according to the economic value and its capacity to make profit. The greatest profit making impact of broadband is its support for e-commerce and e-business. Business owners sudden ly realize that they could perform business faster and more effectively by using the Internet. Broadband is the best form of connection for online banking, Automatic Teller Machines (ATM), online shopping and payments, marketing, trading and showcasing online, etc. This could be an avenue for marketing made in Nigeria products both nationally and internationally.

E-Government

This is a development where all Government transactions and other administrative functions are carried out electronically. For example, obtaining an international passport was a rigor until we started the e-passport system. Most of the processes are now undertaken online. Other areas affected are the taxation system and application system for most government services.

E-Health

There are lots of e-health initiatives going on around the world to ensure fast online access to health information that can be used to save lives. Also medical support can be given during a live operation by making the process available to experts across the wor ld to advice and direct the operation.



IP-Telephony

This is a major breakthrough in telephony which ensures that up to eight conversations can be taken in the same bandwidth that was hitherto used for only one conversation. Service providers use this to save cost most especially on international calls. Also once a subscriber pays for a broadband connection to the home, he could have as many IP telephony connections as he desires using a software like SKYPE or a MAGIC JACK to friends and family who use the same software free of charge.

E-Services

This is a registered service that will allow users to have access to a suite of web based products to enhance their business. This could include email marketing (technology solution for email distribution and deliverability), web development (including database hosting and management), tax & related consultancy, Advertising, Mobile Marketing Services, Statistical information, Surveys and so on.

Internet TV (IPTV)

Broadcasting of TV signals across and within nations have always been a challenge. Satellite television has been the major saving grace until the advent of IPTV. Now there are developments in IPTV that allows clients/subscribers all over the

world to watch their favorite stations at a very low cost. This can only be made possible if you have broadband connection. On the spot news materials are now delivered directly from mobile phones, thanks to broadband.

Mobile TV
Take your TV in your pocket. That is what mobile TV is telling its users. This is not micro television embedded inside a mobile phone to receive local signals, but TV delivered to the mobile phone through IP. Special channels are made available in this subscription.

E-Strategies
No man is an isl and, or the only repository of knowledge. e-Strategies allow the pooling of knowledge and assistance from experts all over the world. Broadband can be used for marketing and broadcasting indigenous ideas, inventions, and discoveries.

E-Environment
Our environment is changing and there is need to track changes all over the world and compare data in order to improve the habitat. Gone are the days when weather changes come unnoticed. You can follow the weather now at the comfort of your house. There is need for information exchange among administrators, environmental agencies, the populace, scientists and businesses.

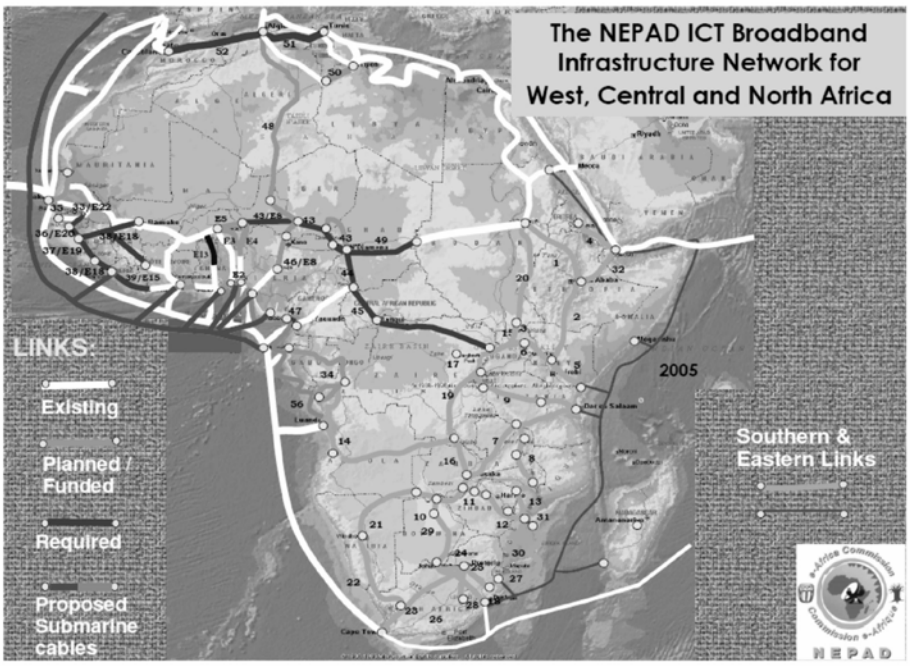
Fiber-To-Home
From all the above, we can see that there is increasing demand for broadband in our houses and offices. This is why some developed countries started the fiber to the home drive. This implies that broadband is gone right to the house at the blazing speed of fiber.

III. Nigeria's response to Broadband
In Nigeria we have not been proactive in the area of broadband readiness. We have always allowed one thing to lead to another. In the last seven years we have had a boom in our voice communication which has ridden on a zero broadband facility. Though the operators started from scratch to install their own networks, but we still have problem of broadband network availability. The operators must be commended for their efforts, but from a broad point of view, the numerous provisions have followed after the trend of high economic return areas. If you look at the fiber network of all the operators, they are all similar, passing through the same road, towns, cities and points of presence. This has confined growth since they are all building repetitions instead of expanding.

What sectors can take advantage of broadband?Health
- Commerce
- Banking
- Governance
- Security
- Election
- Media
- Social
- Education
- Transportation
- Recreation and holidays
  - Radio
  - Mobile
  - VSAT

What is the way forward?
We need to have a broadband policy in order to have a sustained electronic world in future. All the emerging technologies and areas that can be affected cannot enjoy the advantage unless we start collaborating to ensure spread redundancy and sustenance.

There are efforts all over Africa to develop broadband infrastructure, in the fore front is The New Partnership for Africa's Development (NEPAD) ICT Broadband Infrastructure Network initiative. This initiative has in mind two projects namely Umojanaet and Uhurunet. These projects are to close the submarine optical fibre loop around Africa; and establish a continent-wide basic broadband optical fiber network that links countries to their neighbors as well as to a submarine cable in two different directions. The top priority of NEPAD it to ensure that all African countries will be connected to a broadband fiber optic cable network that is in turn connected to the rest of the world. (NEPAD 2010).
On the home front, NCC must be commended for its effort at getting more people on the Internet. In a recent presentation, the NCC chairman explained three initiatives factored to encourage the growth of broadband infrastructure to facilitate economic growth and development. These initiatives are:
- The Wire Nigeria Initiative (WIN)



? The State accelerated Broadband Initiative
? The Community Communication Center Program of the USPF.

The operators also must be commended for their investment initiatives, and their quest to be self sufficient. However they must know that there is higher power in unity.

IV. Is There Hope For ICT/Broadband In Africa /Nigeria?

The awareness is there already that ICT broadband infrastructure is needed in Africa /Nigeria in order for the continent to catch up with the world economy. The cry of the Millennium Development Goals (MDG) operators for ICT to develop and support their operation is an indication of this need. Other points to consider are:

? Man power Nigeria is blessed with graduates in all fields of Engineering useful in ICT development. Therefore man power is not our challenge. The cost of man power is also not a challenge because we are generally a low income earning nation. We should however encourage our universities to enhance their syllabus and curriculum to include professional training that will allow graduates to fit quickly into the industry or even start their own businesses.

? Technology Even if we are not manufacturing, we have the capacity to buy good quality infrastructure that will stand the test of time and can be maintained in Nigeria. We shou ld encourage operators to ensure that they have well equipped workshops to repair their equipment even unto component level. We need technological transfer and this is where we can start from.

? Market In the year 1998 when our telephone penetration was low, it was assumed that mobile business may not be profitable in

Nigeria, but time has proved critics wrong. We have the population, the money and the will; so this market is very ripe for broadband growth. This is like the case of two shoes sales men who went to survey a city where no one wears shoes. While one saw the market as dead and could not support shoe business, the other saw it as a great opportunity to sell almost any kind of shoe. There is a lot to sell at every level of ICT infrastructure.

? Enabling Environment In this area, NCC and the legislator s have a lot to do, it is not enough to allow everybody to play freely until the market grows, we will end up playing into the hands of capitalists who are not interested in sustainable growth but to quickly recoup investment and milk the cow until it dies. For example, establishment of fiber network should be a joint contribution by all the operators to build the Nigerian Network Design of NCC and not for all of them to replicate networks while refusing to provide broadband in areas they see as being of low economic value.

V. What Role Can The Different Sectors Play?

? Government: We would want to see the Government putting more into the ICT sector of the economy instead of allowing capitalists to drive the sector. We need enabling policies that will force operators to be quoted on the stock exchange in order to allow Nigerians to participate in and benefit from the sector. All these companies are quoted in the stock exchange of their headquarter countries. More efforts should be put in place to assure electricity supply as ICT cannot survive where operators also have to generate their own electricity. Our Universities need to modify their curriculum for their graduate to fit in to the emerging national ICT landscape.

? Engineers We as Engineers need to believe in ourselves and study to make ourselves ready to support the initiatives without requiring external support. That is the only way that any ICT development can be sustained.

? The people We need to build the confidence of the people in the use of electronic transactions. We need to involve insurance companies to ensure that any loss is compensated.

VI. What Role Can Ieee Play?

? Nigeria Section Public enlightenment, University programs and short courses, young entrepreneurs coaching and mentoring, offer free unbiased advice to Government and NCC.

? Region 8 Support the different programs of the Nigeria section with manpower and substance. Play supervisory ro le.

? Globally Encouragement and supervision of programs.

VII. Conclusion

We have been able to show that there are emerging technologies in the use of the Internet that will enable broadband networks to recover any investments made in Nigeria. Ours is a starving market that will swallow any capacity of network provided. In order to properly support the MDGs, we need to have a network map that covers the whole of the nation and work things out with operators to ensure fiber is connected to every village, town and c ity in Nigeria.
Above all, we need to assist the people in developing interests in electronic transactions and support businesses to go e-business. Customer oriented initiatives should be given more priority to encourage development.

REFERENCES:

1. **ALTAVISER, N.D**: ADSL Broadband Guide for Consumers Altaviser Communications Limited, Canada. Available online at: http://adsl-broadband.net/dsl/introduction.html [Last Accessed 20th April 2010].

2. **Ernest C. A. Ndukwe, 2007** Promoting Internet-based Businesses in Nigeria NCC Available online at: http://www.ncc.gov.ng/speeches_presentations/EVC's%20Presentation/EVC%20presentation%20-%20NIG%20July%202007.pdf [Accessed 24 thApril 2010].

3. **eServices, 2010** Permission Email Services Overview. Available online at: http://www.eservices.com.au/email/services.asp [Accessed 28th April 2010]

4. **Lishan Adam, 2005** Broadband Infrastructure in Africa: Fiber Technology Association of African Universities. Available online at: http://www.aau.org/renu/ws/afren08/docs/broadband_africa.pdf [Last Accessed 27th April 2010]

5. **NEPAD 2010** The NEPAD ICT Broadband Infrastructure Network - Available online at: http://www.eafricacommission.org/projects/126/nepad-ict-broadband-infrastructure-network [Last accessed 28th April 2010]

6. **Rahman Anis, N.D**. A review of DWDM: The heart of Optical Networks. Available online at: http://www.arphotonics.net/DWDM_Review.pdf [Accessed: 24th March 2010]

7. **Wikipedia 2010**- Fiber to the X Available online at: http://en.wikipedia.org/wiki/Ftth [Last accessed 28 thApril 2010]

TELE-ICU: AN APPROACH TO INTENSIVE CARE UNIT TELEMEDINCE IN RURAL SUB-SAHARAN AFRICA

Apkar Salatian, Lawrence Oborkhale
School of Information Technology and Communications
American University of Nigeria, Yola, Nigeria
Email: {apkar.salatian, lawrence.oborkale}@aun.edu.ng

ABSTRACT
Intensive care unit (ICU) Telemedicine involves medical staff located at a remote location providing care to patients in multiple, scattered intensive care units using computer and telecommunication technology. ICU Telemedicine is most beneficial for populations living in isolated communities and remote regions such as rural sub-saharan Africa where there is shortage of trained critical care physicians and nurses to manage highly complex patients safely and efficiently. In this paper we propose a low-cost ICU Telemedicine system to allow data from the monitors of a rural ICU to be transmitted and received by another location anywhere in the world where an expert can provide advice remotely. Our system is based on the Model-View-Controller design pattern and uses the internet as the form of communication.

Key Words - Telemedicine, Intensive Care Unit, MVC

I. Introduction

Patients are admitted to the Intensive Care Unit (ICU) for the management of a wide variety of severe illnesses. These patients are connected to monitors to display and evaluate their vital signs in real-time. Our particular area of interest is the cardiovascular and respiratory data produced by the monitors,

The ICU monitors generate large volumes of noisy continuously sampled data. The frequency of the data can be as high as one value every second and require highly trained medical staff to in terpret them. In rural sub-saharan Africa there is shortage of trained critical care physicians and nurses to manage the highly complex patients safely and efficiently.

We therefore believe that medical staff in rural ICUs in sub-saharan Africa could benefit from remote assistance in the interpretation of ICU monitor data to decide which interventions are appropriate, particularly if such a decision has to be made in the absence of more senior staff. Indeed it has been proven that technology-enabled remote care can be used to provide continuous ICU patient management and to achieve improved clinical and economic outcomes when on-site intensivist coverage was not available [B.A Rosenfeld et al, 2000].

To assist in the delivery and quality of critical care we propose a low-cost telemedicine system called TELE-ICU for transmitting and receiving data from the monitors of a rural ICU in sub-saharan Africa for purposes of remote assistance. Telemedicine is considered to be medical services delivered over distance using communication technologies. ICU Telemedicine expands the geographic range of ICU staff and also allows a single specialist to simultaneously monitor multiple patients on a continuous basis [K. Nikus et al, 2009]. The goal of TELE-ICU is to duplicate on an internet browser the data that is being presented in real-time on the rural monitors and to provide additional services to specialists such as summarising, say, data from the last 24 hours to allow patient state assessments to be made.

The structure of this paper is as follows. Section 2 discusses the architecture of TELE-ICU system which is our approach to ICU Telemedicine for sub-saharan Africa. Section 3 discusses the results we have obtained so far. Section 4 discusses related work. Section 5 gives a discussion of our approach and future work. Final conclusions are given in section 6.

II. The TELE-ICU System

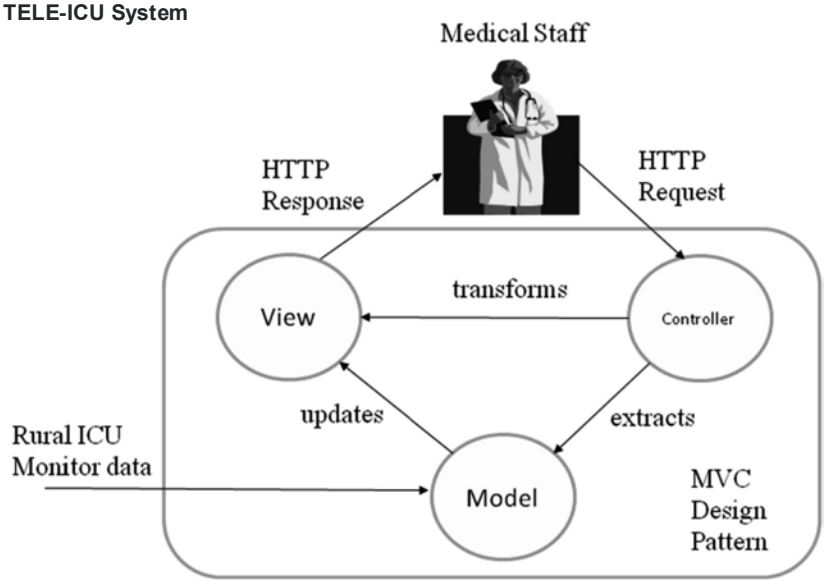


Figure 1: Processes for TELE-ICU

Figure 1 depicts the general architecture of the TELE-ICU system for receiving and transmitting rural real-time ICU monitor data in sub-saharan Africa for the purposes of remote assistance. TELE-ICU is based on the Model-View-Controller (MVC) Design Pattern. Design Patterns are a mechanism for expressing object-oriented design experience. They identify, name and abstract common themes in object-oriented design and capture the intent behind a design by identifying objects, their collaborations, a nd the distribution of responsibilities. They constitute a base of experience for building reusable software

We will describe each of the processes of the MVC design pattern and describe how they have been adapted for receiving and transmitting real-time rural ICU data.

The *Model* is the domain-specific representation of the information on which the application operates it is effectively the database. The Model manages the behaviour and data of the application domain. It receives data in real-time from the rural ICU monitors and stores it in a database for 2 purposes to be facilitated using the internet: to display the data in real-time to medical staff around the world and to provide summaries of past data. The data returned by the model is display-neutral, meaning that the model applies no formatting - this way, a single model can provide data for any number of display interfaces. This reduces code duplication, because model code is only written once and is then reused by all of the views.

The *View* renders the model into a form suitable for interaction, typically a user interface element in our case it is the internet browser. The View is the visualisation of the data (model). There is no real processing happening in the view. - it serves only as a way to output data and allow the user to act on that data. In TELE-ICU the View will output the remote ICU data in real-time to mimic the rural ICU monitor and will also display graphs of past data for patient state assessments.

The *Controller* interprets requests (mouse and keyboard inputs) f rom the user and calls portions of the model and view as necessary to fulfil the

request. It takes the request and determines which model components to invoke and which formatting to apply to the resulting data. In TELE-ICU, the Controller extracts the data obtained in real-time from the Model and transfers the data to the View process for it to display the data in real-time. The Controller will also receive requests from medical staff for summaries and will, in turn, query the Model to obtain the relevant data.

In summary, in TELE-ICU the model process receives real-time dat a from the monitors of a rural ICU. The Controller extracts this data and transforms it so it can be presented by the View process onto an internet browser to be viewed by medical staff anywhere in the world. Medical Staff can also make requests to the Controller e.g to get data summaries of, say, the last 24 hours for patient state assessments. Our system can, therefore, provide synchronous and asynchronous communication.

III. Results

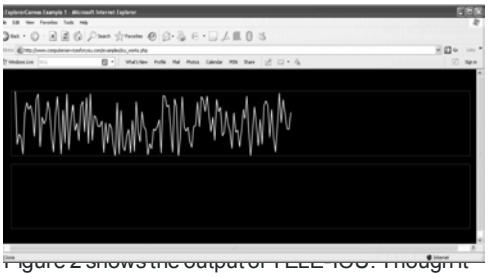


Figure 2 shows the output of TELE-ICU. Though it is a prototype and a simulation it demonstrates that data collected from the monitors of a rural ICU can be stored and then transmitted onto a browser for specialists around the world to view and analyse. The data is displayed as it arrives and, therefore, reproduces what is generated by the rural ICU monitor. The stored data allows past data to be viewed for patient state assessments.

IV. Related Work

A common architecture for telemedicine monitoring is the 3-tier architecture.
[S. Daðtaþ et al, 2008] propose a framework where vital sig nals are collected and processed using a 3-tier architecture. Likewise, PPMIM [Jea and Srivastava, 2006] use a remote medical monitoring 3-tier architecture with a GSM/GPRS peer-to-peer channel.

The 3-tier architecture is similar to TELE-ICU's MVC - however, topologically they are different. A general rule in 3-tier architectures is the client tier never communicates directly with the data tier - all communication must pass through the middleware tier. Conceptually the 3-tier architecture is linear whereas the MVC architecture is triangular; the View sends updates to the Controller, the Controller updates the Model, and the View gets updated directly from the Model. Moreover, the 3-tier architecture is a system architecture pattern, while MVC is an application architecture pattern.

In a 3-tiered system, it is expected to have different hardware for each tier whereas with MVC everything will most likely be on one system therefore, with MVC we save costs. There are a number of technologies used in telemedicine projects.

AMON [U. Aniliker et al, 2004] uses GSM/UMTS. GSM (Global System for Mobile communication) i s a wireless technology that is capable of voice and data transmission. GSM is not suitable for our application because it has limited bandwidth and is infrastructure location dependent. UMTS (Universal Mobile Telecommunications System) is third-generation (3G) broadband, packet based transmission of data. UMTS is based on the GSM standard and also has limited bandwidth and is infrastructure dependent.

PPMIM [Jea and Srivastava, 2006] uses a GSM/GPRS peer-to-peer channel for telecommunication. G PRS (General Packet Radio Service) is a packet oriented mobile data service available to users of the 2G cellular communication system associated with GSM. Like with GSM, GPRS is not suitable for our application because it has limited bandwidth, and is infrastructure location dependent.

As well as using GPRS, MobiCare [R. Chakravorty, 2006] employs Bluetooth as a means of transmitting data. Bluetooth is a wireless technology that uses low power and short range radio frequencies to communicate bet ween two or more devices. This technology is not suitable for our application because of its limited distance

coverage and inadequate security of our transmitted data.

[E. Kyriacou et al, 2001] data interchange is done using the TCP/IP network protocol, which allows operations over several communication means including POTS. POTS (Plain Old Telephone Service) is a voice-grade service associated with PSTN (Public Service Telephone Network). This telephone service remains the basic form of telephone service connection in most parts of the world. POTS is restricted to low bandwidth and has no mobile capabilities. It is, therefore, not suitable for our application.

[S. Daðtaþ et al, 2008] propose a framework for a wireless health monitoring system using a WPAN (Wireless Personal Area Networking) technology called ZigBee. ZigBee is a standard wireless communication technology that is an open global standard to address the unique needs of low-cost, low-power, wireless sensor networks. Although ZigBee has short-range connectivity, it can be set up as a *mesh network* in which communications can be passed on between remote nodes; therefore there is no limit to the number of devices in a network or the distance it can cover in multiple hops if there are enough devices within range of each other. However this technology is not suitable for our application because of the limitation in range of transmission. Moreover, the number of mesh networks that may be required for our system would make the cost of ZigBee prohibitive. Other technologies include WIMAX and WiFi. WIMAX (Worldwide Interoperability for Microwave Access) is a wireless communication technology that provides transmission of data using different transmission modes such as IEEE 803.11a, IEEE 803.11b. WIMAX uses point to point or point-to-multipoint links for portable and fully mobile internet access. This technology is not suitable for remote application of distance more than 50kilometres.

WiFi (Wireless Fidelity) is a wireless communication technology that allows devices such as PC, laptop, mobile phones to link and access internet through a router. Wi-Fi networks are very limited in range. This technology is not suitable for our application because of limited distance coverage and inadequate security of our transmitted data.

For our system we need to use VSAT. VSAT (Very Small Aperture Terminal) is a two-way satellite system with a little dish antenna. The VSAT system is based on the TCP/IP network protocol with a very broad spectrum of applications. VSATs access satellites in orbit to relay data to various remote stations around the world. VSAT technology is used for two-way satellite internet provisions this allows medical staff around the world to transmit back information to rural medical staff. Apart from the terminal, no other infrastructure is required therefore it is very useful in remote area data transmission since remote sites distance will not hamper data transmission.

In developed countries, the ability to bypass existing infrastructures with a private network has achieved cost savings. In remote regions such as rural sub-saharan Africa, the possibility of establishing a distance-insensitive, modest cost network, using a satellite transponder with VSATs and a hub station, enables many cost-effective applications. The broad generality of VSAT uses and applications makes VSAT cost effective.

V. Discussion And Future Work

Telemedicine is an engineering and financial challenge because of costs associated with hardware, software, networking, administration and human expertise. Telemedicine would be cost effective if existing telecommunications infrastructures are capable of providing, at the least, the minimum required bandwidth for a system to operate. However, more often than not, remote locations lack good telecommunication infrastructure.

For our proposed system we only need a modem and antenna for our architecture to be operational this will make our system a cost-effective application.

Since we are not transmitting large data sets such as images, we do not need a bandwidth-on-demand network. However, for our application we need support of isochronous traffic that is time bound and time dependent. Our data must be transferred within a specific time frame and have a low tolerance for delay and loss. This can be achieved using VSAT.

TELE-ICU at the moment is a prototype and uses historical data for testing purposes. However, our architecture has great potential which forms the basis for future work.

The MVC design pattern is very flexible. It has the ability to have multiple views that rely upon a single model. Since the model returns data without applying any formatting, the same components can be used and called for use with any interface. With MVC, it does not matter if the user wants a Flash interface or a WAP one; the same model can handle either. Code duplication is limited because you've separated the data and business logic from the display. If carefully developed, the MVC will allow changes in one or more of the processes to be made with little or no impact to the rest of the system.

VI. Conclusions

We agree with [Groves, et al, 2008] when they say that numerous challenges remain before remote ICU systems become more broadly accepted and applied. These include cost of implementation of the system, resistance to the system by ICU physicians and nurses, and integration of data systems and clinical information into a remote electronic ICU model.

TELE-ICU is a low-cost system which has potential and its results (though limited) are encouraging. Although not fully developed, we believe it to be a step forward in the development of systems for transmission and receiving rural ICU monitor data for the purposes of remote assistance.

REFERENCES

[U. Aniliker et al, 2004] U. Anliker, J.A. Ward, P. Lukowicz, G. Tröster, F. Dolveck, M. Baer, F. Keita, E. Schenker, F. Catarsi, L. Coluccini, A. Belardinelli, D. Shklarski, M. Alon, E. Hirt, R. Schmid, and M. Vuskovic, AMON: a wearable multiparameter medica l monitoring and alert system," IEEE Transactions on Information Technology in Biomedicine, vol. 8, no. 4, pp. 415427, 2004.

[R. Chakravorty, 2006] R. Chakravorty, "A programmable service architecture for mobile medical care," in Proceedings of the 4th Annual IEEE International Conference on Pervasive Computing and Communications Workshops (PerCom '06), pp. 532536, Pisa, Italy, March 2006.

[S. Daðtaþ et al, 2008] S. Daðtaþ, G. Pekhteryev, Z. Þahinoðlu, H. Çam and N. Challa, Real-Time and Secure Wireless Health Monitoring, International Journal of Telemedicine and Applications, Volume 2008, Article ID 135808, doi:10.1155/2008/ 135808, 2008.

[Groves, et al, 2008] Groves RH Jr, Holcomb BW Jr, Smith ML, Intensive care telemedicine: evaluating a model for proactive remote monitoring and intervention in the critical care setting, Stud Health Technol Inform. 2008;131-46, 2008.

[Jea and Sriva stava, 2006] D. Jea and M. B. Srivastava, A remote medical monitoring and interaction system, in Proceedings of the 4th International Conference on Mobile Systems, Applications, and Services (MobiSys '06), Uppsala, Sweden, June 2006.

[E. Kyriacou et al, 2001] E. Kyriacou, S. Pavlopoulos, D. Koutsouris, A. S. Andreou, C. Pattichis, C. Schizas, Multipurpose health care telemedicine system, Proceedings of the 23rd Annual International Conference of the IEEE, Engineering in Medicine and Biology Society, Volume: 4, On page(s): 3544- 3547 vol.4 ISSN: 1094-687X , ISBN: 0-7803-7211-5, 2001.

[K. Nikus et al, 2009] K. Nikus, J. Lähteenmäki, P. Lehto, M. Eskola, The role of continuous monitoring in a 24/7 telecardiology consultation servicea feasibility study Journal of Electrocardiology, Volume 42, Issue 6, Pages 473-480,2009.

[B.A Rosenfeld, et al , 2000] B.A Rosenfeld, T. Dorman, M.J Breslow, P. Pronovost, M. Jenckes, N. Zhang, G Anderson, H Rubin, Intensive care unit telemedicine: alternate paradigm for providing continuous intensivist care, Crit Care Med. 2000 Dec;28(12):3925-31, 2000.

ANALYTICAL STUDY OF DEVELOPMENT PLANNING AND MANAGEMENT APPROACH IN DIFFERENT COUNTRIES

Muhammad Salim Javed, Dr. Ahmed Kamil Bin Mahmood, Dr. Suziah B. Sulaiman
Computer and Information Sciences Department
Universiti Teknologi PETRONAS
Bandar Seri Iskandar, 31750 Tronoh, Perak, Malaysia
msjgandapur@yahoo.com, kamilmh@petronas.com.my, suziah@petronas.com.my

ABSTRACT
For most of the 3rd world countries, the development projects have been a list of their good intentions. Throughout the history of their independence, management of development projects remains on top priority. Therefore, development planning is being practiced to achieve the economic growth and development at national level. In this paper, we have discussed different approaches to development planning in detail. We have also discussed the issue regarding management paradigm in Pakistan, South Asia and the West which shows that the project in Pakistan is formulated through Central Planning System while the incrementalist Planning System is followed in the West. The main objective of this paper is to draw the difference in the approaches, their subsequent effects and reasons for adopting such a paradigm. We have also highlighted the issues regarding implementation and monitoring of the planning for the development projects. The Research Paper will also analytically examine issues relating to the Incrementalist Planning System as an option for Pakistan and their impact on the Performance of Development Projects.

Keywords- Central Planning System, Incrementalist Planning System, South Asia, Pakistan, the West

I. Introduction

For most of the 3rd world countries, development projects have been a list of their good intentions. Throughout the history of Pakistan independence, management of development projects remains on top priority. Therefore development planning is being practiced to achieve the economic growth and development at national level. In the following paper, different approaches to development planning are highlighted and a comparison between the management paradigm in the Pakistan, South Asia and the West h as been made. The main aim of this paper is also to draw the differences in the approaches, their subsequent effects and reason for adopting the paradigms. We also consider here that the meaning of planning development projects is not only the management of projects but it also encompasses its implementation and monitoring.

The paper is divided into four sections. First we will put forward a brief introduction. Next we will discuss development planning and their major dimensions. In the third se ction we look for detailed discussion of development planning approaches and their practices in different countries. In the final section implementation of Incrementalist Planning System as an option in south Asia particularly in Pakistan are outlined.

II. Development Planning

The term development planning and national planning are used interchangeably. To distinguish these forms of planning, the element of "social change" as an objective of the planning process is added to the main objective, to the "economic growth". For example, in all industrial advanced countries, the basic g oal of economic planning is to increase demand to fully utilize resources. This goal is achieved within the prevailing economic as well as social framework of these countries [Lindblom & woodhouse, 1993]. However, in developing countries, to accelerate the economic growth, the development planning system was introduced [Bhende, 1984; Hyden 1993]. While economic planning in the developed countries is carried out mainly by the private sector, central governments in most developing countries including Pakistan play a major role in the national development and development planning [Hyden,

1993]. Like most developing countries, in the 1950s and 1960s, Pakistan pursued a development strategy aimed at promoting industrialization through import substitution policies and planning, with the state playing the leading role. However, unlike many other countries public enterprises in the manufacturing sector in Pakistan were set up to pave the way to the private sector and many were subsequently sold to private entrepreneurs. [Hamid & Naved, 2008]

A. The Main Dimensions of Development Planning:

The multi-dimensionality of the developm ent planning is explained by the Sagasti [1988] as follows:

1. Development planning is an effort to promote or co-ordinate through central planning institution and the activities of :
   a. Intermediate bodies, such as national government, business federations and large nationwide enterprises.
   b. Operating units such as enterprises, associations, local governments, agencies, communities, families and individuals.

2. National economic planning consists of the coordinated efforts by central institutions to develop some combinations of :
   a. Aggregate planning for general levels of output and income, employment, price levels, consumption, investment and balance of payments etc.
   b. Cross sectoral planning for supply or distribution of income and of such resources as manpower, goods, credit or information.
   c. Sectoral or sub-sectoral planning for such area of activity as agriculture, health, education, mining, road construction, railways, electric power and other specific sectors.
   d. Enterprise planning by or for the geographical distribution of activity.
   e. Spatial planning for the geographical distribution of activities.

3. Many of the conscious objectives and unintended consequences, as well as many of the means required for goal formulation implementation and elevation are usually political, cultural, social or biophysical rather than merely economic.

4. National planning is economic planning to the extent that it deals with decision on the allocation of scarce resources and the production and distribution of goods and services.

The most relevant area of this research, among the above stated planning area is (2-b) which is the sectoral planning area. It is this form of planning to which the term “Project planning” is related. Sectoral planning is practiced in Pakistan in order to evaluate all sectors constituting the economy to determine the merits of each sector for further development. In this case, there is planning for crop husbandry, irrigation, health, education, energy development, transportation etc. More desirable development levels are achieved by implementing projects in all those sectors. Also assessing the impact of implementing a specific projects in one of the sectors on the rest of economy is an important function of sectoral planning [Sagasti, 1988; Van Dusseldorp, 1990] .

III. Approaches for Development Planning:

Here we have discussed approaches to the development planning, a brief comparison between the management paradigm in Pakistan, South Asia and the West. We will also draw the difference in the approaches and their subsequent effects and reason for adoption of the paradigms. It also highlighted that planning of development projects not only means the management of projects but it includes implementation and monitoring.

A. Central Planning Approach:

The concept of central planning was originated from the spatial planning discipline [Banfield 1959; Altshuler 1965]. Central planning coincides with alternative terms such as “Structured Planning”, Technique Planning” and “Comprehensive Planning”. It is, therefore, fairly loosely defined here and concerns a process of public development which is built on the premise that government assumes main responsibility for the economy and welfare of the people and development of the country.

The approach has been adopted due to absence of professionals, society and high prevalence of the illiteracy, due to which no other institution except government can lead the policies and pursue the development through the central planning. Faludi's [1974] Reader on Planning Theory provides a good starting point for a summary of essentials:

1. Central planning follows a means to an end scheme, list all the opportunities for action, identify all consequences from each of the possible action and sel ect the action which would be followed by the preferred set of consequences
2. An objective comes ideally speaking from the politicians- choice of means constitutes the task of planners.
3. It assumes that it is possible to weigh objectives meaningfully.
4. It presupposes knowledge of the society and their interests.

B. Planning Paradigm in Pakistan :

Central Planning system in Pakistan is practiced in the following ways.

? Central & Provincial planning agencies have been established with the supervisory and coordinating roles assigned t o them.
? Prospective plans, Five Years Plans and Annual Plans are prepared reflecting variety of projects to be executed and the objective to be achieved through these projects.
? Preparation of development projects in different sectors with the aim to achieve development goals in respective sectors that help together to achieve economic growth and development as a whole.
? Establishment of monitoring and evaluation system for the supervision of line agencies and departments for central control.

For implementation and execution of these projects, institutional arrangements have been made available by the government. All such projects are conducted by the government agencies. The role of the private sector and other non-government organizations to take part in the process of development is largely ignored [Hussein, 1991].

C. Planning Paradigm in South Asia:

A review of experience with government planning and management approaches in South Asia has been conducted by Viqar Ahmed & Michael Bamberger for Economic Development Institute (EDI) of the World Bank in the late 1980s [Ahmed & Bamberger, 1989]. Their study also illustrates that in all South Asian countries (such as India, Pakistan, Bangladesh, Sri Lanka & Maldives etc.) a hierarchical and interlocking system of central planning and management is operative. The system is usually controlled by a central agency, responsible for formulating the Five Years Plans and Annual Plans, who hold central control of development process, for implementation and monitoring of the projects. Apart from central planning agencies focusing on national and foreign aid projects, there are sub-systems at the state or provincial levels under the control of planning and development departments. These systems also serve internal purpose in many departments. Many projects frequently have their own monitoring unit s and systems. The function of planning and implementation system is largely the same that is to plan, operate and maintain the development projects to achieve economic growth. The system usually comprises standardized monthly or quarterly reporting covering all the development projects. The main source for completing the standard reports is implementation of the projects. At the level of national planning agency, the information is occasionally complemented by site visit reports, inspections or evaluation. At the level of the state or province, such counter-checking is usually not present or it is rudimentary. [ibid., 16]

D. Planning and Management System in the West:

In Western Europe and United States, a different approach of planning and management is employed. This is called Incrementalist Planning. In this approach, planning is carried out step by step processes of successive limited comparison of alternatives rather than through lying down momentous plans and policies as practiced in the developing countries. The step-wise p lanning decisions are dispersed at various places, levels, times and by many different decision makers.[Lindblom & Woodhouse, 1993].

Hynes[1984, p.6-7] gives a summary of the

Incrementalist Planning as follows:

? Eschews the comprehensive planning in favor of strategy which differs marginally from existing strategy.
? The model is incremental or tending towards small changes and remedial in that decisions are made to move away from ills rather than towards goals.
? Serial in approaches, in that problems are not solved in one stroke but are successively attacked.
? Exploratory in nature, in that goals are continually being redefined or newly discovered.
? Fragmented, in that problems are tackled by considering a limited number of alternatives.
? Disjointed, in that there are many dispersed decision points.
? Rather than adjusting means to goals, ends are chosen that are appropriate to available means and progress is achieved through a marginal process of adjustment.

In the Incrementalist Planning process, a broad range of stakeholders or participants are involved in a decentralized manner. These autonomous participants (business community, bureaucracy, politicians, labor unions etc.) mutually influence the policies by adjusting the interests of each other. The planning and budgeting models are then used as strategic choice [Friend & Hickling, 1978]. The Incrementalist planning model works systematically with subjectivity, uncertainty and selectivity [ibid. p.21]. It also leads to the monitoring system of public services by the private sector.[Mawhood 1997, p.135] .It is worth to mention here that contract management, contracting out and decentralization of tasks to local authorities are the parts of the Incrementalist model [Frissen, 1989]. However, a criticism of this approach has been that if policies are to be decided through a process of mutual adjustment of all actors in a society, this would, under capitalist and mixed economics, lead to a predominance of decisions in favor of those who can wield financial powers i.e. big firms and corporations and large government institutions. But still government plays a significant role to minimize such risks.

IV. Incrementalist Planning as an Option for Pakistan:

The question arises that can the Instrumentalist planning model be more appropriate for Pakistan? Some of the development analysts such as Sagasti[1989], Esman[1991], Putman[1992] and Rondinelli[1993] have some recognition to this question.

Sagasti proposes that:

o Short- , medium-, and long- term planning should be abandoned in favour of an approach which focuses on clusters of issues and problems.
o The Old style, comprehensive development planning system would have to be replaced by much a more loosely organized structure on the basis of participation of a wide variety of institutional acto rs. (both government and non-government organizations) and allow planners to respond more quickly to a changing environment.
o Each of these actors should pursue his own goals rationally, but can also be expected to pursue them strategically.

Gradually more members of the think- tanks on development are favoring the abandonment of the comprehensive planning approach and the change to a more consultative approach [Cernea 1985; agarwala 1993; Wolfensohn 1999, p. 7-8; Maxwell & Conway 2000]

However there are certain reasons due to which the Western model of Incrementalist planning can not be adopted, these are summed up as:

? The social centre-field or the private sector needs to be sufficiently articulated, competitive and professionalized to take over the control of essential public needs, which are largely scarce in Pakistan.
? The approach is also vulnerable to new dangers of corruption [Turner & Humle 1997, pp.234-235]
? At any rate, the new project management techniques have not spread very fast within public sector so far.
? Due to the absence of an organized civil society 9 a pre-condition for the model0 and weak regulatory and monitoring frameworks, the potential benefits of a more disjointed Incrementalist approach to public sector management have not yet been understood.

Therefore, a central planning approach in tan.

combination with hierarchical system and decision making has been established and followed in Pakistan.

V. Summary & Conclusion

This research paper has analytically examined the planning and management approaches that are followed in Pakistan and the West. It also shows a brief comparison among these countries. The project in Pakistan is formulated through central planning system wherein policies, strategies, economic goals, planning and budgeting decisions for all the sectors are made at the national level. These are t hen reflected through Five Year Plans and Annual Financial Plans. The development projects are used as an instrument for development which enables to combine the human and material resources in coherent way to cause a determined amount of economic and social development. The desirable development levels are pursued through implementation of projects in all those sectors.

On other hand, the Incrementalist planning approach is followed in the West where planning is carried out step by step process with dispersed places, time and level of decision making and bring the development step by step. It also involves a broad range of stakeholders in decentralized manner.

The Incrementalist Planning is not deemed fit for Pakistan due to lack of organized civil society, non-existence of competitive and professional private sector and nonadoption of project management techniques. Therefore the central and national planning system is pursued. However this system is functioning, whatever institutions, mechanism and strategies are adopted.

REFERENCES

Bhende, V.P. 19984. Development Planning in Under-developed Countries. Management Sciences, Vol. 10(4):796.

Hyden, G. 1993. No Shortcuts to Progress: African Development Management in Perspective University of California Press, Barkley, USA.

Lindblom, C.E., and E.J. woodhouse. 1993. The Policy Making Process. Third Edition, Printec Hall, Englewood Cliffs, New Jersey.

Sagasti, F.R. 1988. National development planning in Turbulent times: New Approaches and criteria for Institutional Design, World Development, vol. 31 |(4): 431-58.

Van Dusseldorp, D. 1990. Planned Development via Projects; its necessity, limitation and possible improvements. Sociologia Ruralis, Vol. XXX (3-4): 336-352.

Banfield , E.1959. Ends and Means in Planning. Pergamon Press, Oxford, pp. 139-149.

Altshuler, A. 1965. The goals of competitive planning Urban and Regional Planning series, vol. 5, pp. 193-209.

Faludi's , A 1974. Readers in Planning Theory, Urban & Regional Planning series, Vol. 5, Oxford.

Hussein, C.M. 1991. Projects Appraisal, Monitoring and Evaluation Processes with special reference to Pakistan. Second Edition, Royal Book Company, Karachi, Pakistan.

Friend, J., & Hickling. 1978. Planning under Pressure: the Strategic Choice Approach, Pergamon Press, Oxford.

Frissen, P. 1989. The Cultural impact of informatization in public administration. International Review od Administrative Services, Vol. 55, pp. 569-586.

Esman, M. 1991. Local Organization , Intermediate in Rural development. Kumarian Press, west Hartford, Connecticut.

Putman, R.D. 1992. Democracy , Development, and the Civic Society: Evidence from an Italian Experiment. Proceedings of Environmentally Sustainable Development, The World Bank, Washington. Serial No. 1, pp. 33-73.

Rondinelli, D.A. 1993. Development Projects as Policy Instruments. An Adaptive Approach to Development Administration. Second Edit ion, Rutledge, London.

Cernea, M. 1985. Putting People First:

Sociological Variable in Rural Development, Oxford University Press London.

Agarwala, R. 1993. Planning in Developing Countries: Lessons of Experience, Staff Working P|aper No. 576, World Bank, Washington D.C

Wolfensohn, J.D. 1999. A Proposal for a Comprehensive Development Framework, Memo to the Board, Management and Staff of the World Bank Group. Washington World Bank.

Maxwell S., and Conway, T. 2000. New approaches to Planning: Lessons from Experience. Vol. No. 14. Washington: The World Bank.

Hamid, Naved, 2007, "A Development Strategy for the Information Age. Asian Development Bank," Report on the South Asia Department Economists' Annual Conference, pages 7-16.

Planning Commission, 2008, Annual Plan 2007-08, Government of Pakistan, Islamabad, Pakistan.

Reardon, Thomas, and Julio A. Berdegue, 2006, "The Retail-led Transformation of Agrifood Systems and its Implications for Development Polices." Rimisp-Latin American Center for Rural Development. Http://www.rimisp.org/getdoc. php?docid=6432.

Rodrik, Dani, 2006, "Goodbye Washington Concensus, Hello Washington Confusion?" Journal of Economic Literature: 44 (2006): 973-87.

Hamid, Naved (2008): *Rethinking Pakistan's Development Strategy.* Published in: The Lahore Journal of Economics (2008): pp. 47-62.

DATA MINING: A PRACTICAL TECHNIQUE FOR INCIDENT PREDICTION IN OIL AND GAS INDUSTRIES

Nnebedum, V. I and Chukwudebe G.A
Department of Electrical and Electronics Engineering
Federal University of Technology Owerri
vincent.nnebedum@shell.com.

ABSTRACT
In view of the importance of safety in many oil and gas industries, incident reports are collected on daily bases. The volume of incident data is always very high and interpretation, often purposes a challenge. With the ability of decision tree induction, this paper practically demonstrates how data miming technique could be used not only for the analyses but to predict incident scenarios that have the highest likelihood of occurrence at a particular location of the industry. The result of this work is important because it will let the decision maker predict which of the location is greatly to be affected if certain incidents are recorded and in turn guide them on how to deploy incident control measures.

Keywords: Data mining, Decision Tree Algorithm, Entropy, Information gain and Incident Prediction.

I. Introduction

Data mining is a process of efficiently extracting previously unknown interesting knowledge from large databases. It's a powerful technology with great potential to help users focus on the most important information stored in data warehouses.

Data mining uncovers patterns in data using *predictive* techniques. The patterns play a critical role in decision making because they reveal areas for performance improvement in industries and businesses [1]. It is a new discipline lying at the interface of statistics, data base technology, pattern recognition, and machine learning, and concerned with secondary analysis of large databases in order to find previously unsuspected relationships [2].

Decision tree induction is one of the most popular data mining and machine learning tool. It uses the tree structure as a logical model whereby at every node, a binary or two-way split, represents how the value of a dependent (target) variable can be predicted by using the values of a set of independent (predictor) variables.

The attractiveness of decision trees is that it can be easily converted to a set of classification rules. The Rules can be expressed so that human beings can understand them or even directly use them in a database access language like SQL [3].

Examples of decision tree algorithms are ID3, C4.5 and CART [4].

The objective of this paper is to practically demonstrates how data miming technique, could be used to predict incident scenarios that have the highest likelihood of occurrence at a particular location of an industry. With the result, the decision maker can predict which of the locations is to be greatly impacted if certain incidences are recorded, thus he can deploy appropriate incident control measures.

In Section 2 of this paper, using ID3 algorithm on a sample incident data set, the method of decision tree construction is described. The tree was transformed to rules, which eventually translated into a data-mining model. In Section 3, the model was tested for accuracy and eventually used for making useful predictions. The conclusion and recommendations for further studies are presented in Section 4.

II. Methodology

The method adopted in the research typically involves building of a decision tree model using information theory functions. The technique used is precisely ID3 algorithm, which has proved successful in many predictive decisions. In this research, a sample input dataset is used and the built model is tested for predictive accuracy on another (unknown) incident dataset.

A. Application Of Decision Tree Induction For Incident Prediction

The task is to use the **ID3 strategy** to predict incident occurrence at certain locations of an industry. The incident dataset has predictive attributes: *incident ID, incident type, cause of the incident, incident impact, incident severity* and the target (or class) attribute *location*.

The dataset Information.

The dataset has 27 records with categorical attributes only. There are no missing values in the 27 records used in the experiment and is split into *training* set (20 records) and *testing* set (7 records). The attributes of the dataset are as defined as in Table 1.

Table1: The Incident dataset attributes.

Name	Class	Type	Categories
ID	Predictor	Categorical	27
Type	Predictor	Categorical	2
Cause	Predictor	Categorical	3
Impact	Predictor	Categorical	4
Severity	Predictor	Categorical	3
Location	Target	Categorical	2

The attribute values are represented with codes 0, 1, 2 etc. The codes are used to make tree representations simpler as no order or weight is attached to the values. Table 2 shows the meaning of the codes assigned to the attribute value as used in the experiment.

Table 2: The Attribute Values And Codes

Type:	Cause:	Impact:
0 - Potential/Near miss	0 – Human error/negligence	0 – People
1 - With Consequence	1 – Equipment Failure	1 – Asset
	2 – Sabotage/Theft	2 – Environment
		3 – Reputation

Severity:	Location:
0 – None	0 – East (Positive)
1 – Slight/Minor/ Moderate	1 – West (Negative)
2 – Major/Massive	

The Dataset: Separated Into Training And Test Dataset.

The incident dataset is divided in two (Tables 3 and 4), at a proportion of 70:30 or 2/3:1/3. This ratio has been tested and proven to have produced the best classification result [5].

The training set is used for building the classifier (i.e. the decision tree). The classifier is then used to predict the classification for the instances in the test set.

B. Building the Decision Tree.

The algorithm used in this paper for the construction of the decision trees induction is called **ID3 Algorithm**(Iterative Dichotomiser 3rd) .

Table 3: The Training Dataset With Attributes Coded

	Attributes					Class
Rec	ID	Type	Cause	Impact	Severity	Location
D1	151904	0	0	3	0	1
D2	152202	0	0	0	0	0
D3	149784	0	1	0	0	0
D4	149826	1	0	1	1	0
D5	150261	1	2	2	1	1
D6	149909	1	2	2	2	1
D7	149916	1	1	2	1	1
D8	150283	0	0	1	1	1
D9	149830	0	2	1	1	0
D10	150827	0	0	1	1	0
D11	150360	1	1	2	2	0
D12	150750	1	0	1	1	1
D13	149900	1	0	0	1	0
D14	150172	1	2	0	2	1
D15	162734	1	0	0	1	0
D16	157732	1	1	1	1	0
D17	149917	1	0	0	0	0
D18	149964	1	0	0	1	0
D19	153944	0	2	0	0	1
D20	150014	0	2	1	0	1

Table 4: The Test Dataset With Attributes Coded

	Attributes					Class
Rec	ID	Type	Cause	Impact	Severity	Location
D21	150202	1	2	1	1	1
D22	149971	0	0	1	0	0
D23	150106	1	0	0	1	0
D24	150013	1	1	1	1	0
D25	149993	1	0	0	1	0
D26	152487	1	0	1	1	1
D27	150152	1	2	1	1	1

It was introduced by **J. Ross Quinlan** for inducing decision trees for data modeling [5]. It constructs decision tree in a ***top-down recursive divide-and-conquer*** manner [6]. ID3 adopts a simplified strategy as follows:

1. Starts the tree as a single node representing the training samples.
2. If the samples are all of the same class, then the node becomes a leaf and is labelled with that class.
3. Otherwise, the algorithm uses an *entropy* based measure known as *information gain* as

a heuristic for selecting the attribute that will best separate the samples into individual classes.

4. The algorithm uses the same process recursively to form a tree for the samples at each partition. Once an attribute has occurred at a node, it need not be considered in any of the node's descendants [7].
5. The recursive partitioning stops only when any one of the following conditions is true:
   - ? All samples for a given node belong to the same class
   - ? There are no remaining attributes on which the samples may be further partitioned. In this case, majority voting is employed. This this case, majority voting is employed. This involves converting the given node into a leaf and labelling it with the class in majority among samples.
   - ? There are no samples for the branch test-attribute. In this case, a leaf is created with majority class in samples.

The algorithm in Figure 1 summarizes the basics of **Id3.**

There are 2^m possible ways of assigning the attributes and 2^{2m} possible decision trees that can be constructed. The intuition is to select the best among the possible trees. Shallower trees are better; they are the ones in which classification is

Using ID3 Decision Tree Learning Algorithm

Input *– The training samples (Examples) represented by discrete-valued attributes, the Class Attribute, the set of candidate attributes (Attributes).*
Output *– A Decision Tree*
Method:
ID3 (Examples, Class, Attributes)
Create a root node
If all Examples have the same Class value, give the root this label
Else if Attributes is empty label the root according to the most common value
Else begin
Calculate the ***entropy*** *and* ***information gain*** *for each attribute*
Select the attribute, A, with the lowest entropy (highest information gain) and make this the attribute tested at the root
For each possible value, v, of this attribute
Add a new branch below the root, corresponding to A = v
Let Examples(v) be those examples with A = v
Examples(v) is empty, make the new branch a leaf node labelled with the most common value among Examples
Else let the new branch be the tree created by ID3(Examples(v), class, Attributes - {A})
end

Figure 1: ID3 Decision Tree Algorithm

reached in fewer levels [5].

C. Splitting the Decision Tree.

The first step in building a decision tree is to select the attribute to split on. The best attribute to split on depends on the degree of impurity of the child nodes. The task therefore is to select the attribute that minimizes the value of *entropy*, and maximizes the *information gain*[8].

This task is recursive: - repeatedly splitting the training dataset into smaller sets until entropy of each subset is zero or the following stopping conditions are met.

? All samples for a given node belong to the same class

? There are no remaining attributes on which the samples may be further partitioned.
? There are no samples for the branch test-attribute.

Calculating The Entropy For The Training Dataset.

The method used is to calculate the entropy and information gain for all the attributes, and then select the one with the lowest entropy (and the highest information gain).
From the training dataset:

? Number of instances for the class *(Location = 0)* is 11,
? Number of instances for class *(Location = 1)* is 9 and
? Total number of instances N in the training dataset is 20

Since the entropy formula i s Then the Entropy for the training dataset is:
Entropy (**E**) = $-11/20*\log_2(11/20)$ $9/20*\log_2(9/20)$ **= 0.9928**
The splitting is done on levels e.g. levels 1, 2, 3, etc as follows:

Level 1 Splitting.

Level 1 splitting produces the *root node*.Root node is the node at the top of a decision tree and the process of selecting it is to first calculate the best suited attribute from the all the attributes. The steps are as follows:

(a) Calculating Entropy and Gain for *Type*.

The training dataset is sort according to *Type* and split it into subsets *Type* = 0 and *Type* = 1 (Tables 5a and b):

Table 5a: Subset for *Type* =0

Rec	Type	Class
D1	0	1
D2	0	0
D3	0	0
D8	0	1
D9	0	0
D10	0	0
D19	0	1
D20	0	1

Table 5b: Subset for *Type* =1

Rec	Type	Class
D4	1	0
D5	1	1
D6	1	1
D7	1	1
D11	1	0
D12	1	1
D13	1	0
D14	1	1
D15	1	0
D16	1	0
D17	1	0
D18	1	0

The Entropy for the subsets are:
$E_0 = -4/8*\log_2(4/8)$ $4/8*\log_2(4/8)$ = 1.0000 and

$E_1 = -7/12*\log_2(7/12)$ $5/12*\log_2(5/12)$ = 0.9799

Therefore, The Entropy for *Type* is:
E_{type} = 8/20* 1.0000 + 12/20* 0.9799 = **0.9879**

and the Information gain is:
$Gain_{type}$ = 0.9928 - 0.9879 = **0.0049**

The result of the calculation is arranged in this tabular format in Table 5c:

Table 5c: *Result of Entropy and Gain Calculation for Type*

Type	N	East	West	E	n/Σn*E
0	8	4	4	1.0000	0.4000
1	12	7	5	0.9799	0.5879
	20	**13**	**7**		**0.9879**

E_{type} = sum of **n/∑n*E** column = 0.4000 + 0.5879 = 0.9879, and
$Gain_{type}$ = **E -** E_{type} = 0.9928 - 0.9879 = 0.0049

The tree diagram for *Type* is thus shown in figure 2.

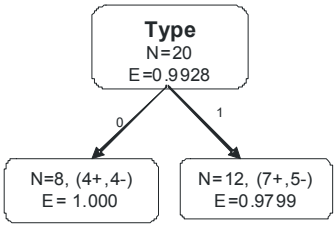


Figure 2: The tree diagram for attribute *Type*.

(+) is used to represent East and (-) to represent West in the tree diagrams.

(B) Calculating Entropy and Gain for *Cause*.
Following same steps as in (a) above, the following tables are generated showing subsets of training dataset for *Cause*.

Table 6a: Subset for *Cause* =0

Rec	Cause	Class
D1	0	1
D2	0	0
D4	0	0
D8	0	1
D10	0	0
D12	0	1
D13	0	0
D15	0	0
D17	0	0
D18	0	0

Table 6b: Subset for *Cause*=1

Rec	Cause	Class
D3	1	0
D7	1	1
D11	1	0
D16	1	0

Table 6c: Subset for *Cause* =2

Rec	Cause	Class
D5	2	1
D6	2	1
D9	2	0
D14	2	1
D19	2	1
D20	2	1

Table 6d: Result of Entropy and Gain Calculation for *Cause*.

Cause :	N	East	West	E	n/Σn*E
0	10	7	3	0.8813	0.4406
1	4	3	1	0 8113	0.1622
2	6	1	5	0.6500	0.1950
	20	**11**	**9**		**0.7979**

E_{cause} = 0.7979, $Gain_{cause}$ = 0.9928 - 0.7979 = 0.1949 and the tree diagram is shown in Figure 3.

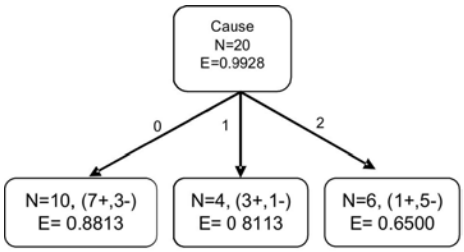


Figure 3: The tree diagram for attribute *cause*.

(c) Calculating Entropy and Gain for *Impact*.

Table 7a: Subset for *Impact* =

Rec	Impact	Class
D2	0	0
D3	0	0
D13	0	0
D14	0	1
D15	0	0
D17	0	0
D18	0	0
D19	0	1

Table 7b: Subset for *Impact* = 1

Rec	Impact	Class
D4	1	0
D8	1	1
D9	1	0
D10	1	0
D12	1	1
D16	1	0
D20	1	1

Table 7c: Subset for *Impact* = 2

Rec	Impact	Class
D5	2	1
D6	2	1
D7	2	1
D11	2	0

Table 7d: Subset for *Impact* = 3

Rec	Impact	Class
D1	3	1

Table 7e: Result of Entropy and Gain Calculation for *Impact*

Impact:	N	East	West	E	n/Σn*E
0	8	6	2	0.8113	0.3245
1	7	4	3	0 .9852	0.3448
2	4	1	3	0 .8113	0.1623
3	1	0	1	0	0
	20	**11**	**9**		**0.8316**

E_{impact} = 0.8316, $Gain_{impact}$ = 0.9928 - 0.8316 = 0.1612

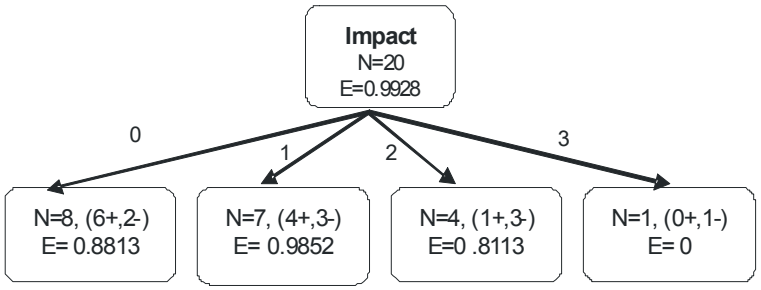


Figure 4: The tree diagram for attribute *Impact*.

(d). Calculating Entropy and Gain for *Severity*.

Table 8a: Subset for *Severity = 0*

Rec.	Severity	Class
D1	0	1
D2	0	0
D3	0	0
D17	0	0
D19	0	1
D20	0	1

Table 8b: Subset for *Severity = 1*

Rec	Severity	Class
D4	1	0
D5	1	1
D7	1	1
D8	1	1
D9	1	0
D10	1	0
D12	1	1
D13	1	0
D15	1	0
D16	1	0
D18	1	0

Table 8c: Subset for *Severity = 2*

Rec	Severity	Class
D6	2	1
D11	2	0
D14	2	1

Table 8d: Result of Entropy and Gain Calculation for *Severity*

Severity	N	East	West	E	n/Σn*E
0	6	3	3	1.0000	0.3000
1	11	7	4	0.9457	0.5201
2	3	1	2	0.9183	0.1377
	20	**11**	**9**		**0.9578**

$E_{severity}$ = 0.9578, $Gain_{severity}$ = 0.9928 - 0.9578 = 0.0350

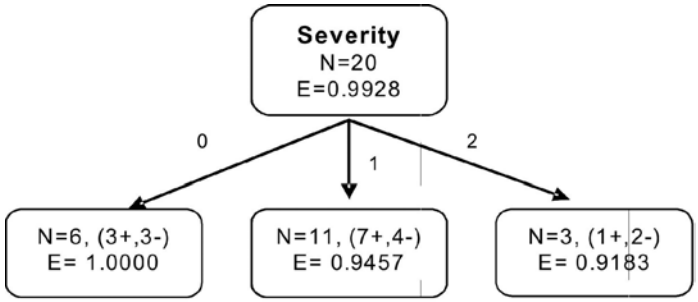


Figure 5: The tree diagram for attribute *Severity*.

After getting the *entropy* and *gain* for all the attributes, the *best attribute* is then the attribute that leads to the split of maximal reduction of impurity i.e. lowest Entropy and highest Gain.
Looking the calculated values:

Type: E = 0.9879, Gain = 0.0049
Cause: E = 0.7979, Gain = 0.1949
Impact: E = 0.8316, Gain = 0.1612
Severity: E = 0.9578, Gain = 0.0350

The lowest ***Entropy*** **and highest** ***Gain*** **is** ***Cause***. Therefore, the root node is *Cause*

Level 2 Splitting.
The first task here is to determine positions of the remaining attributes (***Type***, ***Impact*** and ***Severity***) i.e. which one comes first and which one follows, within the level 2 node arrangement. The steps also involve recursion- finding the minimal entropy (maximal information gain).

From the dataset generated in level 1 operation:
Cause = 0, N = 10 (7+, 3-), therefore E= 0.8813
Cause = 1, N = 4 (3+, 1-), therefore E = 0.8113
Cause = 2, N = 6 (1+, 5-), therefore E = 0.6500

Calculating the Entropy and Gain for Cause = 0, Cause =1 and Cause = 2
Following same steps as in level 1 above, the result of the class sorting (for determining the number of the class values) and the entropy of each class value were calculated and stated in Tables 9a to 9h. *Entropy* alone is used to determine the best attribute. *Gain* is dropped since it is inverse proportion.

Table 9a: Entropy Calculation for *Type* on *Cause* =0

Type	N	East	West	E
0	4	2	2	1.0000
1	6	5	1	0.6500
	10	**7**	**3**	

E = 0.7900

Table 9b: Entropy Calculation for *Impact* on *Cause* =0

Impact	N	East	West	E
0	5	5	0	0
1	4	2	2	1.0000
2	0	0	0	0
3	1	0	1	0
	10	**7**	**3**	

E = 0.4000

Table 9c: Entropy Calculation for *Severity* on *Cause* =0

Severity	N	East	West	E
0	3	2	1	0.9183
1	7	5	2	0.8631
2	0	0	0	0
	10	**7**	**3**	

E = 0. 8797

Table 9e: Entropy Calculation for *Severity* on *Cause* =1

Severity	N	East	West	E
0	1	1	0	0
1	2	1	1	1.0000
2	1	1	0	0
	4	3	1	

E = 0.5000

Table 9f: Entropy Calculation for *Type* on *Cause* =2

Type	N	East	West	E
0	3	1	2	0.9183
1	3	0	3	0
	6	**1**	**5**	
Type	N	East	West	E

E = 0.4591

Table 9g: Entropy Calculation for *Impact* on *Cause* =2

Impact	N	East	West	E
0	2	0	2	0
1	2	1	1	1.0000
2	2	0	2	0
3	0	0	0	0

E = 0.3333

Table 9d: Entropy Calculation for *Type* on *Cause* =1 .

Type	N	East	West	E
0	1	1	0	0
1	3	2	1	0.9183
	4	**3**	**1**	

E = 0.6887

Table 9h: Entropy Calculation for *Severity* on *Cause* =2 .

Severity	N	East	West	E
0	2	0	2	0
1	2	1	1	1.0000
2	2	0	2	0
	6	**1**	**5**	

E = 0.3333

Table 10: Summary for Entropy Calculation for *Cause* attributes.

Test Attribute	Entropy Values		
Cause	**Type**	**Impact**	**Severity**
0	0.7900	**0.4000**	0.8797
1	0.6887	0.5000	**0.5000**

Table 10 is the summary of results for the three runs (cause = 0,1,2). Note that once an attribute is selected in a run, it is not considered for selection in the next run. Bold typed figures (lowest entropy value, if not selected in the previous run) shows attributes selected.

The Tree diagram

The tree diagram so far i.e. for Cause = 0 (*Impact*), for Cause = 1 (*Severity*) and Cause = 2 (*Type*) is shown in Figure 6.

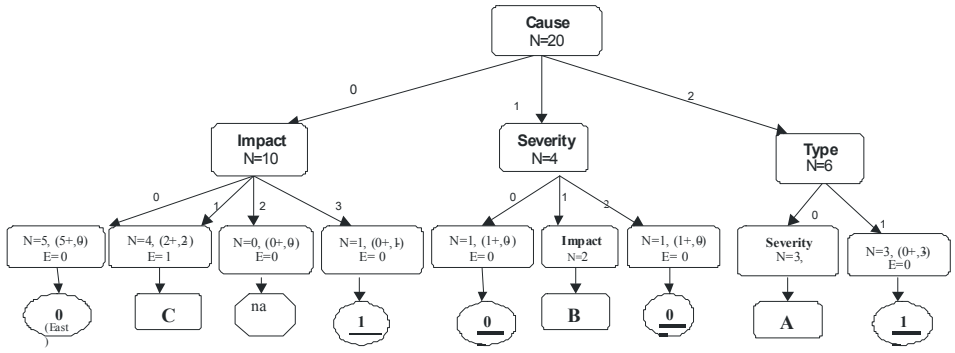


Figure 6: The tree diagram after level 2 splitting.

From the tree Figure 6, the nodes **A, B** and **C** are yet to get to the terminal (leaf) nodes because:

- the attribute's entropy is yet to be zero
- the samples in each node does not belong to the same class
- there are more attributes on which the samples may be further partitioned.

Therefore they are to be subjected to further (level 3) splitting or forcefully terminated (i.e. pruned).

Level 3 splitting
Dealing with Pruning and Overfitting

Trees that are too long are susceptible to *overfitting*. Causes of overfitting are mainly due to presence of noise or due to lack of representative samples [9]. Pruning helps to trim down the branches of the tree in a way that improves the

generalization capability of the decision tree. The subset that is *inconsistent* is said to have *clashed*

In decision tree, there are many ways of dealing with inconsistency or clashes, but the two principal ones are:

1. The "delete branch strategy" where the branch with the clash is completely discarded and thus removing the instances from the training set.
2. The "majority voting strategy" where the node with the more instances is taken, discarding the one with much less instances.

Again a tree that contains smaller number of nodes will always have a high training error rate, and a lower test error rate, when compared to the more complex tree. Realistically, overfitting or underfitting to greater or lesser extent is inevitable in classification modeling. One way out is to ensure that the classification accuracy is not significantly high [ALSABTI 1998].

Splitting node A (i.e. *cause* =2, *Type* =0)
From Table 3, the records that match node **A** are D9, D19 and D20. Arranged as in Table 11a, the best attribute is Severity.

Table 11a: The attribute of records D9, D19 and D20 .

	Type	Cause	Impact	Severity	Class
D9	0	2	1	1	0
D19	0	2	0	0	1
D20	0	2	1	0	1

Table 11b: Entropy Calculation for severity on *Type* = 0 and *Cause* = 2 .

Severity	N	East	West	E

Splitting node B (i.e. *cause* =1, *Severity* =1)
From Table 3 again, the records that match node **B** are D7 and D16, and the next attribute (from Table 12a) is ***Impact***.

Table 12a: The attribute of the records D7 and D16 .

	Type	Cause	Impact	Severity	Class
D7	1	1	2	1	1
D16	1	1	1	1	0

Table 12b: Entropy Cal culation for *Impact* on Type = 1 and Cause = 1 .

Impact	N	East	West	E
0	0	0	0	0
1	1	1	0	0
2	1	0	1	0
3	0	0	0	0
	2	**1**	**1**	

Splitting node C (i.e. *Cause* =0, *Impact* =1)
From Table 3, the records that match node **C** are D4, D8, D10 and D12 and the last and only attribute is ***Type.***

Table 13a: The attribute of records D4,D8,D10 and D12.

	Type	Cause	Impact	Severity	Class
D4	1	0	1	1	0
D8	0	0	1	1	1
D10	0	0	1	1	0
D12	1	0	1	1	1

Table 13b: Entropy Calculation for *Type* on Cause = 0 and Impact = 1 .

Type:	N	East	West	E
0	2	1	1	1
1	2	1	1	1
	4	**2**	**2**	

Node C is pruned off because the subsets of attribute ***type*** are *inconsistent* and is said to have *clashed*

The Overall Tree Diagram

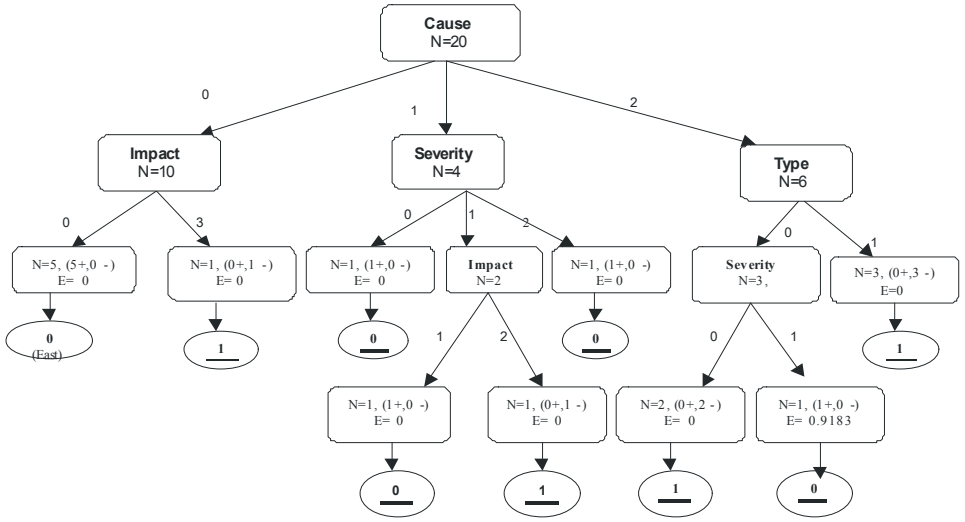


Figure 7: The final tree diagram at level 3.

III. Analysis and Discussion

A. Extracting Rules from the Tree

Once the construction of a decision tree is completed - as in Figure 7, the next step is to convert it into an equivalent set of rules. This rule is called the ***model*** or ***classifier***.

To generate rules, each path is traced in the decision tree, from root node to leaf node, recording the test outcomes as *antecedents* and the leaf-node classification as the *consequent*

i.e IF *antecedent(s)* **THEN** *consequent*

The rules derived from the tree are:

R1: IF *Cause = 0* **AND** *Impact = 0* **THEN** *Location = 0*
R2: IF *Cause =0* **AND** *Impact =3* **THEN** *Location = 1*
R3: IF *Cause = 1* **AND** *Severity = 0* **THEN** *Location = 0*
R4: IF *Cause = 1* **AND** *Severity = 1* **AND** *Impact = 1* **THEN** *Location = 0*
R5: IF *Cause = 1* **AND** *Severity = 1* **AND** *Impact = 2* **THEN** *Location = 1*
R6: IF *Cause = 1* **AND** *Severity = 2* **THEN** *Location = 0*
R7: IF *Cause = 2* **AND** *Type = 0* **AND** *severity = 0* **THEN** *Location = 1*
R8: IF *Cause = 2* **AND** *Type = 0* **AND** *severity = 1* **THEN** *Location = 0*
R9: IF *Cause = 2* **AND** *Type = 1* **THEN** *Location = 1*

B. Evaluating the Accuracy of the Model

Many techniques are used to measure the performance of a model (classifier). Some require considerable amount of computation than others. Some require substantial more training instances to give reliable results. As a matter of fact, there is no method that satisfies all constraints [5]. The methods used in this paper for evaluating the accuracy of the classifier are, re-*substitution and holdout* methods.

Re-substitution method uses same training dataset (used in deriving the rule) in determining the accuracy. It indicates only how good (or bad) our results (rules) are on the training data. The accuracy here is called *Rules Accuracy*. Re-substitution error/rate is always very low, and not an excellent way of determining the accuracy of a rule. To critically analyze the result of this experiment, both methods are explored.

Evaluating the Model accuracy using re-substitution method

Using the Training dataset in Table 4: The accuracy of the 9 rules on the 20 training data are tested and the results are as shown in Table 14.

Table 14: Test result of the rules on the training data set.

Rules	Record(s) that fit(s)	Test Result
R1: IF *Cause = 0* **AND** *Impact = 0* **THEN** *Location = 0*	D2, D13, D15, D17, D18	Correct
R2: IF *Cause =0* **AND** *Impact =3* **THEN** *Location = 1*	D1	Correct
R3: IF *Cause = 1* **AND** *Severity = 0* **THEN** *Location = 0*	D3	Correct
R4: IF *Cause = 1* **AND** *Severity = 1* **AND** *Impact= 1* **THEN** *Location = 0*	D16	Correct
R5: IF *Cause = 1* **AND** *Severity = 1* **AND** *Impact= 2* **THEN** *Location = 1*	D7	Correct
R6: IF *Cause = 1* **AND** *Severity = 2* **THEN** *Location = 0*	D11	Correct
R7: IF *Cause = 2* **AND** *Type = 0* **AND** *severity = 0* **THEN** *Location = 1*	D19	Correct
R8: IF *Cause = 2* **AND** *Type = 0* **AND** *severity = 1* **THEN** *Location = 0*	D9	Correct
R9: IF *Cause = 2* **AND** *Type = 1* **THEN** *Location = 1*	D5, D6 D14	Correct

Hence, we have the entire 9 rules test correctly on the 20 records, then

- **Error = 0**
- **Error rate = 0**
- **Accuracy = 100%**

This therefore demonstrates that using *training dataset* to estimate the accuracy of the learned model could be misleading and over-optimistic. The error rate is very low (0% in this case). A more realistic estimate is to use *test dataset* (Holdout method).

Evaluating the Predictive Accuracy of the Model using the holdout method

With holdout method, a separate sample (the *test dataset)* is used to get an unbiased estimate. Predictive Accuracy is calculated based on the test data (Table 4) with 7 records.

The accuracy of the 9 rules is teste d on the 7 test records and the results are:

Record **D21** is correctly classified by R9
Record **D22** is misclassified
Record **D23** is misclassified
Record **D24** is correctly classified by R4
Record **D25** is correctly classified by R1
Record **D26** is misclassified
Record **D27** is correctly classified by R9

Thus 4 records out of 7 records are correctly classified.

Using the formula:

- **Predictive Accuracy = 4/7 = 57.14%**
- **Error Rate = 3/7 = 42.86%**

C. Testing the Model with any other dataset from an Industrial safety record.

The model constructed is like a *black box* that automatically assigns a class label when presented with attribute set of unknown records [10]. To confirm that the designed model works, is to test it with and unknown (but similar) records.

A scenario:

Faced with a scenario with the following record attribute set (Table 15a), what is value of the class (location)?

Table 15a: A "black box" (attributes) with unknown location

Type	Cause	Impact	Severity	Location
1	1	1	1	?

The Model application:
Using the designed model, the rule that fits the attribute set is **R4**, which is **(IF** *Cause = 1* **AND** *Severity = 1* **AND** *Impact = 1* **THEN** *Location = 0)*
This attribute set fits record D29 (one of the records in the database), which has the following at tribute set:

Table 15b: A "box" (attributes) with predicted location .

	ID	Type	Cause	Impact	Severity	Location
D29	150013	1	1	1	1	0

Then the prediction for the class is therefore 0 (i.e. East)

Predictive Interpretation:
The prediction for the scenario therefore is that:
If the incident that occurs in a company is of the **type** with *great consequence*, and the **cause** is *equipment failure*, and with **impact** is mainly on *asset/property* of the company, and with *slight/minor/moderate* **severity,** then the incident is likely to occur in the **eastern location** of the company.

IV. Conclusion and Recommendations

Data mining attempts to identify valid, potentially useful, and understandable patterns from huge volume of data to aid decision-making and this was practically and manually demonstrated in the paper. Even though, the predictive accuracy of the design model was not too high, yet it was able to make reasonable and understandable prediction.

Further work on this research work is the automation process. This is the process of converting the rule model into software programs. This will enable further scrutiny of the model because it will further run through more datasets and bigger volume of the database
This paper has proffered solution to the real life industrial challenges of predicting safety conditions and also delivered a good research effort on the study of the greedy approach of decision tree induction.

REFERENCES

[1]. SPSS - Business Solutions & Technologies Data mining Improves Decision Making" http://www.spss.com/data_mining/, 2007.

[2]. D. Hand, H. Mannila, P. Smyth, *Principles of Data Mining*. MIT Press, Cambridge, MA. ISBN 0-262-08290-X, 2001.

[3]. H. Hamilton. E. Gurak, L. Findlater W. Olive "Overview of Decision Trees", http://www.cs.uregina.ca/~dbd/cs831/notes/ml/dtrees/4_dtrees1.html.

[4]. Breiman, L. Friedman, J.H., Olshen, R.A., Stone, C.J. Classification and Regression Trees. Chapman & Hall, New York, 1984.

[5]. T. Mitchell, "Decision Tree Learning", in T. Mitchell, *Machine Learning* The McGraw-Hill Companies, Inc., 1997, pp. 52-78.

[6]. Ian H. Witten and Eibe Frank, Data Mining: Practical Machine Learning Tools and Technique.Elsvier Inc. Morgan Kaufmann Publisher, 2006.

[7]. Clark, P., Niblett, T. The CN2 Induction Algorithm. Machine Learning, 3(4), 1989, pp.261-283.

[8]. Max Bramer, Principle of data mining, Pub: Springer Verlag London, ISSN 1863-7310, 2007.

[9]. Edelstein, Herbert A. *Introduction to Data Mining and Knowledge Discovery,* Third Editon. Potomac, MD: Two Crows Corporation, 1999.

[10]. Peter Cabena, Pablo Had jinain, etal (1998); Discovering Data Mining From Concept to Implementation Prentice Hall PTR, 1998.

DESIGN AND IMPLEMENTATION OF A WEB-BASED LOCAL AREA NETWORK (LAN) MONITORING SYSTEM WITH SMS NOTIFICATIONS

Oluwaranti, A. I., and Talabi, Y.O.
Department of Computer Science and Engineering
Obafemi Awolowo University, Ile Ife, Nigeria.
Email: aranti@oauife.edu.ng

ABSTRACT
*The paper presents the design and implementation of a web-based LAN monitoring system. The objectives of this work include the detection of the reachability of network hosts, the provision of a web application interface for easy monitoring and an alert mechanism to signal network failures. A model network comprising a proxy server, a monitoring server, a 3-host representation for Ethernet subnets and a mobile phone interfaced via a SMS server with the monitoring server forms the design architecture. The means of detection of network host employed generates minimal network traffic relative to the use of **ping** tool. A polling application on the proxy server provides the monitoring server with the list of machines connected to the Internet through gateway proxy. The troubleshooting detects which network hosts are **up** or **down**, while the web application provides a graphic interface for viewing dynamic network information on all host machines on the network A message stream containing the location of critical network disconnection is sent through SMS to a network administrator when such occurs.*

I. Introduction

This research work is focused on making network monitoring activities easier through the use of a web interface, thereby improving an aspect of network management namely, fault management.

The monitoring system was designed after a study of the network topology of the campus wide network on which it may be put to use: the Obafemi Awolowo University Campus Network (OAUNet). The Obafemi Awolowo University campus is located at Ile-Ife, Nigeria. The distributed client server network architecture comprises several Ethernet local area networks (or subnets). Access to the Internet is possible through proxy servers that assign IP addresses through dynamic host configuration protocol (DHCP) [1]. This network access property of the Ethernet network was found useful in the means of acquisition of reachability information for host machines on the network. The network connection status is first determined from the proxy server, thereby reducing the ping and ping - reply packets generation to the barest minimum.

II. Objectives of the research

This paper aims at developing an easy- to-manage, cost-effective independent system for monitoring a Local Area Network (LAN). The objectives of the LAN monitoring system are stated as follows:

a. Detect and distinguish between hosts that are down due to power failure and hosts that are unreachable as a result of network connection.

b. Develop a web-based application with color-coded display feature for viewing network status, notification and problem history.

c. Create SMS notifications to specific contacts when such network problems occur and specify the location of affected host.

III. Methodology.

Data for the work (e.g. host's properties, host' s unique media access control (MAC) identification, IP address and the subnet structure) were sourced by physical observation of the machines running on selected subnets of the campus network. A random sampling of the computers on each subnet indicated that most of the machines function as hosts. These hosts are interconnected through a central network device (i.e. a switch) in a star-star network topology. The implementation involves the development of:

1. a network monitoring application for det ecting connection status of network machines.
2. a monitoring software in form of a web

application, which is compatible with the LINUX operating system. This web interface shall display information regarding the status of network hosts using color coded display.

3. a SMS gateway application which interfaces a mobile phone with the monitoring system to generate short messages when critical network disconnection problem occur. The program notifies of the occurrence and location of unavailability.

IV. Literature Review.

The network management model as designed by the International Standard Organization (ISO) consists of five functional areas, which are: **F**ault management, **P**erformance management, **A**ccounting management, **C**onfiguration management, and **S**ecurity management, popularly known as **FPACS**[2].

A common network management protocol is the **Simple Network Management Protocol** (SNMP). SNMP is an internet protocol designed to facilitate the management of information between network devices. It allows for remote and local management of items on the network including servers, workstations, routers, switches and other managed devices. SNMP is part of a larger architecture called the Internet *Network Management Framework* (NMF), which is defined in Internet documents called *requests for comments* (RFCs 1065, 1066, and 1067). SNMP is a standardized lightweight protocol that is universally supported, and allows distributed management access [3].

SNMP uses User Datagram Protocol (UDP) as the transport mechanism for SNMP messages. By using SNMP- transported data (such as packets per second and network error rates), network administrators can more easily manage network performance, find and solve network problems, and plan for network growth.

A. Existing tools

Numerous application software (open source and commercial) have been developed to focus on one or more elements from the ISO Network Management Reference Model. They include amongst others, the Multi-Router Traffic Grapher (MRTG): a common tool for bandwidth monitoring on networks - an aspect of performance management [4] ; Network Management Information System (NMIS) that employ tools such as round robin database, Perl, SNMP Session, Apache, and Net-SNMP to implement performance, security, configuration and fault management and Network Top (NTOP): a network performance manager as well as a protocol analyzer which displays a list of hosts that are currently using the network through a web browser and reports information concerning the (IP and non-IP) traffic generated and received by each host [5].

B. Related works on campus network

A study of related works was carried out in order to understand what has been done in the area of open-source, campus-wide network management. The study of Obafemi Awolowo University Campus network (OAUNet) shows that the existing network management software in use is the Multi-Router Traffic Grapher (MRTG), which is applied in the area of performance management to monitor the bandwidth utilization of the network. This assists the network administrator to determine what part of the network is mostly used, and when. With the MTRG in place, graphical reports can be generated periodically in order to know which part of the network is always busy, and at what time of the day. As at the time when this research was carried out on OAUNet, there was no existing system in use for monitoring the availability and location of LAN hosts.

IV. Design Architecture

The design architecture pres ented as figure 1 is a test network set up to model the network topology of the OAUNet taken as case study. It comprises a proxy server, a monitoring server and a representation for each subnet using three machines connected through a switch.

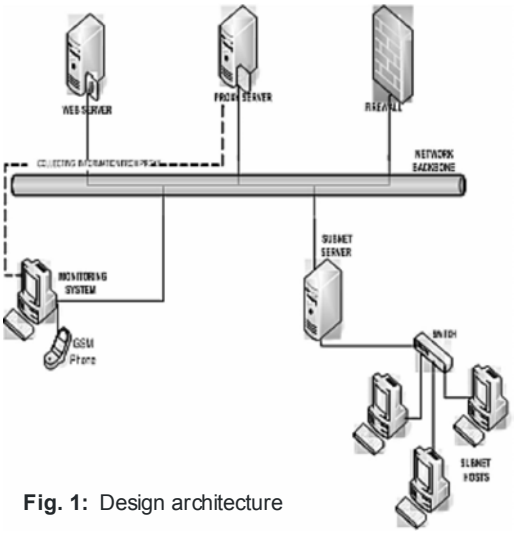


Fig. 1: Design architecture

Attached to the network backbone is the monitoring system, such that it is on the same Ethernet network as the network servers. Acting as a monitoring server, it communicates with the proxy server which functions as the gateway to the Internet for all network hosts through its external network interface. From the proxy server, the connection status for each host machine is obtained. Connected to the monitoring system, via a data cable, is a GSM phone which is used to send SMS notification alerts to the network administrator.

The proxy server is the secondary source of network information for the monitoring server. Normally, in order for all the computers in a company to have Internet access they would all have to be assigned routable (or public) IP addresses that could pass through the Internet. For a conservative use of the Internet address space however, all the host computers on a local area network are assigned private or unique addresses and they all share a single "public" address to access resources on the Internet. This sharing is accomplished by configuring the privately-addressed hosts to use a special server, referred to as a **proxy server** to access the Internet. A proxy server has two Network Interface Cards (NIC) because it is connected to two different networks. One NIC is connected to the Internet and is assigned a single public IP address (This NIC is referred to as the **external interface**). The other NIC is connected to the internal local area network. It is assigned a private IP address so that it can communicate with all of the other privately-addressed computers in the company (This NIC is referred to as the **internal interface**). The proxy server acts as a **gateway** onto the Internet and also acts as a **firewall** that protects the internal network.

However, in addition to acting as a gateway, it acts as an **address translator**. When a computer on the internal network with a private address wants to request information from a Web site, it actually sends the request to the internal interface of the proxy server. The proxy server, with its public routable address on the external NIC, is the one that actually sends the request to the Internet Web server. The Web server sends the response back to the proxy server's external NIC, and the proxy server then forwards the response on to the computer on the internal network that made the initial request. The proxy server keeps track of which internal computers make which requests.

Design Model

The implementation comprises a set of applications running at the back-end, (i.e., modules which run silently at the background) and a web application user interface at the front-end to capture the essence of the monitoring system. Figure 2 represents the design model, comprising the various aspects of the system and the flow pattern.

The first back-end application is a polling agent that provides current connection information of host machines on the network. It is used to detect the sockets opened on the proxy server for the purpose of Internet communications. The socket information include the local and remote IP addresses as well as the local and remote port numbers used by the network connection, the connection status and the associated process identification. The information collected by the polling agent is stored in a MySQL database as input data to be processed by the next back-end application, the troubleshooting engine. The function of this module is to identify the network hosts that are not reachable by cross-checking the list of hosts connected to the internet against a table of recognized network hosts also in the same

database, and then determining whether such hosts are reachable on the local network. In the event of critical disconnection problem, such as the disconnection of a backbone switch leading to the unavailability of network service for an entire subnet, control is transferred to a SMS server that controls the generation of SMS alert to the network administrator via a GSM phone. The network administrator's contact is specified and a specific message stream indicating the physical location affected is sent.

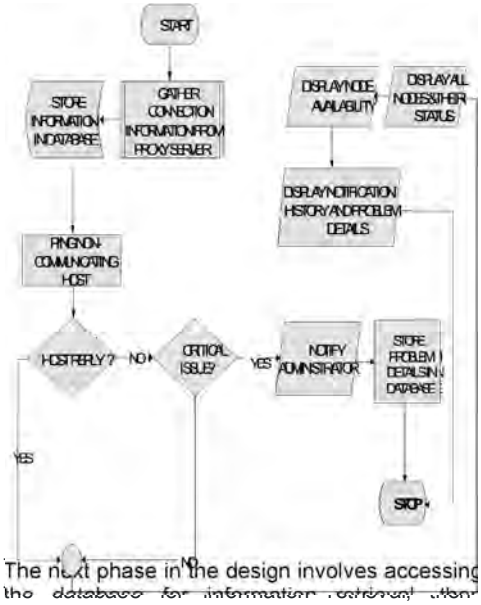


Figure 2. Design model

The next phase in the design involves accessing the database for information retrieval, then generating a color coded graphic display of host availability.

V. Implementation And Expected Results

The implementation of the design model groups the monitoring application into four separate projects which are integrated to give a complete solution. These include: a polling agent, a troubleshooting application, a web application server and a SMS gateway server.

A. The Polling Engine

The test at this phase provides a feedback of the application's abilit y to filter relevant monitoring information, which includes the IP addresses of the hosts that are currently using the Internet services. This application uses the **netstat** command with optional attributes to gather opened sockets from the virtual **proc** file system which gives access to the kernel (i.e. the core of the operating system) status information on Linux operating system via the network files. The information on open sockets include connection status, process identification and process name of the program that has the socket opene d, the IP address and port number of both the remote and local ends of the socket and the type of protocol used by the socket. Table 1 shows a sample result obtained by running the program statement:

Netstat -a -A inet -n p

Table 1. Sample test result for polling engine

Proto	Local Address	Foreign Address	State	PID / Program Name
TCP	10.105.21.121 :32829	66.249.85.1 04:80	SYNSNT	220/mozil 0la
UDP	10.105.21.121 :32829	10.105.40.2 53:53	ESTAB	624/kdein 8it
UDP	10.105.21.121 :138	0.0.0.0:0	CLOSE	200/nmb 3d
TCP	192.168.0.2:3 2816	192.168.0.1 :139	LISTEN	211/nautil 0us

The **Proto** column specifies whether the connection uses a transmission control protocol (TCP), a user datagram protocol (UDP) or a Raw Ethernet Communication (RAW). Also included in the result are the destination and source IP addresses and port combinations (se parated by a colon) used for the connection. The **PID / Program Name** column describes the application that is being used for communication, for example, the Mozilla Web Browser indicated in column 8 of the first row of the table. The program is identified by a numeric program identity (PID) 2200. The **state** of the connection refers to the status of the opened socket. This could take any one of these values:

- **??,** which implies that the state is unknown
- **ESTAB**, which indicates that the socket has an established connection

- **SYNSNT,** which implies that the socket is actively attempting to establish a connection
- **SYNRCV**, which denotes request for connection has been received
- **CLOSE** state, which indicates that the connection socket is not in use
- **LISTEN**, which implies that the connection is established and there is information exchange between both local and remote sockets
- **FIN_WAIT1, FIN_WAIT2**, which describe the shutting down of the connection

The polling agent then retrieves distinct host IP addresses in the **LISTEN** state from the **netstat** result column and stores in an array variable. The selected result is passed on by means of server-client socket communication from the proxy server to the monitoring system and the **HostStatus** field of the reference table in the MySQL database (running on the monitoring system) is automatically updated.

B. The Troubleshooting Application

The database server keeps the record of machines to be monitored in a database table **H_REF**. The table fields include **IP address, MAC Identifier, Hostname, Machine Type, SubnetID and HostStatus**. While all other fields have almost static values, the values in the **HostStatus** field changes with a change in the status of a monitored host. A periodic update of this field is performed by the monitoring system on receiving the information from the proxy server.

The **HostStatus** field is scanned for hosts that are in the OFFLINE (0) state. The IP addresses of the hosts are again collected in an array, and then the list is passed on to the troubleshooting application. Such hosts are sent ping packets to confirm unavailability. Any host that does not reply the ping is considered unavailable. However, the **ping** is not adequate where a large number of host machines may be affected in a subnet. With a large a number of IP addresses for each subnet, its becomes more and more time consuming to check which of the IP addresses are actively in use are reachable using a ping command. A modification to the ping is used for achieving the desired purpose. This modification (known as **fping**) entails the use of the Internet Control Message Protocol (ICMP) echo request to determine if a host is up. A list of hosts to ping is specified, and instead of trying one host until it timeouts or replies, the program sends out a ping packet and moves on to the next host in the list. If a host replies, it is noted and removed from the list of hosts to check. If a host does not respond within a certain time limit and/or retry limit it is considered unreachable.

In situations whereby the number of confirmed unreachable hosts exceeds a specified maximum for a subnet, the time of day in which this occurs is considered and if it is during a period when there should be network activity, a critical network failure is assumed. Table 2 shows the test results for the database table H_REF. A value '1' represents an ONLINE status; while a zero (0) value indicates the machine is OFFLINE.

C. Testing the web application server

Information given on the web page includes links to hosts on each subnet, as shown in figure 3. The map of the campus network is the major feature on this ***home*** page. It shows at a glance the subnets monitored.

Table 2. Example inputs for database table H_REF

HostIP	HostMAC	HostName	Type	Subnet ID	Location	Host Status
10.105.31.26	00-14-85-04-3A-C6	Aadewuyi	Desktop	1	Rm 223 Demography	1
10.105.31.158	00-08-0D-02-FB-18	Aakinlo	Laptop	1	Rm 116 Economics	1
10.105.31.165	00-30-4F-2B-6C-A3	Oribosep	Desktop	1	Rm 127 Administration	0
10.105.31.246	00-11-5B-6D-B4-2D	Polomoh	Desktop	1	Rm 120 Economics	1
10.105.1.240	00-E0-B8-A7-71-3B	Tripleo	Laptop	2	Rm 005 Computer	0
10.105.47.246	00-20-ED-5C-A7-17	Ajayi	Desktop	3	Rm 227 Paediatrics	0
10.105.50.12	00-34-7A-54-23-12	Topjee	Desktop	4	Rm 12 Hum. Block 1	0
10.105.30.110	00-30-4F-2B-6C-A3	Jegede	Laptop	5	Rm 002 Dentistry	1

Figure 3: Links to hosts monitored per subnet

Figure 4 is an instance of the status of all machines on a selected subnet the Computer Building subnet. A color-coded view of the host status is given alongside the host identification, i.e. the host IP address and the hostname. The status indicator shows GREEN for an online host and RED for any host in the offline state. The network address portion of the IP address is identical for all machines on the same local network, e.g. '10.105.1' for the computer subnet.

Figure 4: Color coded display of host status

The machines are distinguished by the last octet of their IP address. All other hosts on the campus network are also grouped according to their subnets on this dynamic page known as the ***hosts*** page. Each host's IP identity serves as link to the ***details*** page shown as figure 5. The web page displays the physical location (building and room) of the machine, the machine type (desktop or laptop), the machine status, connection speed, and its MAC address. The ***details*** page summarizes all information stored in the H_REF table about each host.

Availability statistics is a measure of the network usage by each host on a monthly basis. The content of the HISTORY database table is accessed through the ***Notification History*** web page shown in figure 6. The page displays the alerts generated when critical problems occur and the present status of the problem, whether resolved or otherwise.

The date of occurrence and the exact time of fault log are also displayed. The network administrator is given the option of deciding the order of information presentation. Ordering by the **problem status** helps to distinguish between resolved and unresolved network issues.

A view of notification history ordered by the **date of occurrence** determines how many issues are detected per day. The **alert message** order option specifies how many times a particular subnet has experienced critical fault over a period of time. The number of notifications received by distinct administrators can be inferred when the information is ordered by the **network administrator**.

Fig. 5: Detailed information on host machine

Figure 6: History of notification alerts

D. SMS Notification Short Message Service (SMS) alert is generated by running codes that triggers a SMS server application. The trigger is raised on specific need of notifying a critical network disconnection affecting an entire subnet. The mechanism notifies the administrator in a few minutes after the occurrence.

The implementation uses a Nokia 3310 phone model connected via a serial cable port to the computer's serial port (identified as */dev/ttyS1* on Linux OS). A SMS gateway server (GAMMU) is installed on the Linux platfor m of the monitoring system. It is then configured to make connection with mysql database, while the tables required are exported onto the database. Using PHP script, message is sent from the phone to the recipient when the specified condition is met.

A database table HISTORY is at the same time updated with the message specific to the problem location, the message recipient, the date and time of occurrence and problem status (the default value for the status is unresolved, i.e. 0).

V. Conclusion

The web-based monitoring system was designed for use on a campus wide network is able to determine whether a host machine is up or down. However, capabilities for detecting the power state of a machine are yet to be included. The implementation requires the development of agents that may reside on host machines and alert the monitoring system when the host is about to be turned off. This is an area which still requires much development. Instead, emphasis was laid on detecting network hosts without generating considerable network traffic, and providing a web interface that would eliminate the need for tasking configurations before a monitoring tool can be utilized.

The problem reports generated will find useful application in making decisions related to the regular causes of network failure in different subnets. The notification alert through SMS reduces the time to detect and correct localized network problem and reduce frequent visits to the subnets.

The monitoring system is recommended for campus network monitoring based on the relatively cheap cost of implementation and deployment, and scalability. Additional functionality that may be added to the monitoring system includes the monitoring of network services such as HTTP service, DHCP service, etc.

REFERENCES

[1] O.O. Abiona, C.E. Omine, A. I. Oluwaranti, L.O. Kehinde, S. M. Radicella (2006). Development of a non-intrusive network traffic monitoring and analysis system. *African Journal of Science and Technology, vol. 7, No. 2, December 2006, pp. 54-69.*

[2] www.cisco.com. Internet document; accessed o n 25/01/06<http://www.cisco.com/univercd/cc/td/~doc/nmbasics.html>

[3] Ballew, S. (1997). *Managing IP Networks with CiscoRouters*. O'Reilly and Associates, Carlifornia. pp 183-209.

[4] MRTG. Internet Document; accessed on 16/01/2006.<http://p eople.ee.ethz.ch/~oetiker/webtools/doc/mrtg.en.html>

[5] Lopez, R. (2000). 'Monitoring your network with Linux'.Internet document; accessed on 25/01/06. Http://www.ntop.org/ntop-man.html

AESS A TECHNOLOGY FOR COMBATING SECURITY CHALLENGES IN TERTIARY INSTITUTIONS IN NIGERIA

CHUKWUEMEKA, ETUS
Department of Electrical and Electronic Engineering,
Federal University of Technology (F.U.T.O),
Owerri, Nigeria. Etuscw@yahoo.com

FELIX KELECHI OPARA, MIEE
Department of Electrical and Electronic Engineering,
Federal University of Technology (F.U.T.O),
Owerri, Nigeria. Kefelop@yahoo.com

ABSTRACT
Automatic Examination Screening System (AESS) is a computer based database management information system designed and implemented for tertiary institutions in Nigeria to assist lecturers and security personnel in the prompt detection of the presence of unqualified students and impersonators in the examination halls. The AESS system is an automatic software based system having two major parts: the hardware and the software, respectively. The hardware includes the PC and two biometric devices - the fingerprint scanner and the web camera (webcam). The biometric devices serve as data capture and input devices to the PC, which is a fast multimedia data processing computer. Again, structured programming method of software design and development was adopted for AESS implementation. The software implemented includes; the visual basic script input and output program, and then the Microsoft access database. The AESS system designed and implemented is a veritable, flexible, reliable and effective registration, screening and information management solution for the combat of examination malpractices on campus in a more organized and coordinated manner.

Keywords - Automatic Examination Screening System, Management Information System, biometric devices, softwarebased system, stand-alone system, distributed wireless system.

1. Introduction

Since September 11, 2001 tragic event in the United States of America, there has been a great deal of interest, world over, in using biometrics for identity verification [US GAO release, 2002], particularly acute in the areas of visa and immigration documentation and government-issued identification card programs [STGISC release, 2001]. Soon after the attack, Larry Ellison, head of California-based software company Oracle Corporation, advocated the deployment of mandatory national ID cards with fingerprint information to be matched against a national database of digital fingerprints to confirm the identity of the ID card carriers [Bowman, 2000]. Also, there has been a recent discussion between the United States and the European Union concerning the creation of biometric passports, of which the outcome is expected to be interesting.
Back in Nigeria, conducting examinations in the country universities has become a very stressful process due to the fact that the number of students in the institutions exceeds the staff available to manage them. The lecturers barely know the number of students in their classes let alone their names. This has led to conducting examinations being bedeviled by such malpractice as impersonation and their likes. It is hard for one to effectively identify by sight students (identical twins, triplets and their likes), who come to take examinations since they are too many. Again, students are in the habit of avoiding school and departmental fees payments. These debts run into huge amounts which would have been used for administrative and infrastructural bills. Most times, it may be difficult to, at a glance, identify those that have completed all their necessary payments and those that have not.

Known methods of authentication like the use of

identification (ID) cards have failed since the identification cards can be faked. Other systems like punched cards, codes and voice sensors, operated with limited securities, capabilities and efficiencies. Furthermore, with the advent of Integrated Circuit (IC) technology and various levels of integrations, especially the Very Large Scale Integration (VLSI), automatic microprocessor-based screening systems were designed and implemented [Paul, Alane, and Ari, 2004]. These have tremendous screeni ng and control capabilities due to their high reliability and flexibility at the design and implementation stages, but without database. Therefore, it is now pertinent to put in place an automated database system which would effectively manage the students' information, authenticate and identify them before they enter the examination halls. And since the students' information includes their payment status, it is ensured that not only genuine students, but also students who are up-to-date in thei r payments, take examinations. These gave rise to AESS system.

II. AESS Predecessor Systems

Prior to the advent of computerized access control system, authorized personnel in establishments and high security facilities presented identity cards to security personnel at the entrance to these establishments or facilities before they were granted access into the establishment, restricted area or facility. Its major pitfall is the issue of identity theft [Hornby, 2000]; due to faking of ID cards. Alternatively, systems involved ent ering a combination of numbers and characters known as Personnel Identification Number (PIN) known to the authorized personnel on a computerized interface, which has password guessing as its short coming. Generally, the methods of granting access to a restricted area can be classified into three(3) namely [Fingerprint Basics, 2009]: (a) What you have where tokens are used such as identity card with a magnetic strip, passport or access card, typical of the first systems mentioned above. (b) What you know where one is required to enter a password, as seen in the second system described above. (c) Who you are where physical (biometric) attributes such as fingerprints, retina patterns, voice identification, are used to grant access to users. Of all these three, the biometric systems offer a more reliable system with less susceptibility to intrusion by unwanted persons. Biometrics is so closely bound to a person, more reliable and not easily forgotten, lost, stolen, falsified, or guessed. Hence, biometric systems is been introduced to forestall the discrepancies inherent in the previous systems. This is because biometric identifiers rely on unique biological information about a person, for example, a 3-D image of the individual's hand, a scan of the person's iris, a fingerprint, a voice print or a facial image, used to recognize individuals by the sound of their voice, color of their eyes, shape of their faces, and so on. Devices using biometric identifiers attempt to automate this process by comparing the information scanned in real time against an “authentic” sample stored digitally in a database. The technology had several teething problems, but now appears poised to become common features in the technological landscape.

III. AESS Technology Considerations And Applications

AESS majorly implements biometric technology. Biometric is defined as the “measure of an individual's unique physical or behavioral characteristics to recognize or authenticate identity” [Halstead and Bornby, 2001]. Biometric technologies are therefore defined as “automated methods of identifying or authenticating a living person based on his physiological or behavioral characteristics” [Fingerprint Basics, 2009]. It is necessary to “automate” because without it, variety of very common but significantly less reliable identification such as inked fingerprint on an ID card (badge) would also become desirable [Fingerprint Basics, 2009]. In biometric access control, automation implies that three major components are present: (a) Mechanism to scan and capture a digital or analog of a living personal characteristics; (b) Compression, processing and comparison of the image; and (c) Interface with the application systems. These pieces can be configured in a variety of ways for different situations.

Again, the most important aspect of biometric technology is the identification and authentication aspect. In the effort to clarify the difference between identification and authentication, Dr George Tomko (a leading Canad ian researcher in the field of biometric phonics), describes identification as “a process of matching physiological or behavioral characteristics of a person to an established preconfirmed record” [Halstead and Bornby, 2001]. He further describes it as a “oneto-many” (or “1:N”) search process. The question answered by the machine is “Do I know

you?" The search algorithm searches a database and returns a likely list of candidates that has been previously entered in the system. On the other hand, the submitted identification characteristics are used to authenticate the individual by matching them with those existing in the database. This he called a "onetoone" (1:1) search process, where the question answered by the machine is "Are you who you claim to be?"

Considering the term "living person", the question being answered is "what if the intruder uses a latex finger, digital audio tape, prosthetic eye, etc?" Many, but not all systems include methods of determining whether the characteristics presented are alive, thus separating the field of biometrics from the forensic identification field; though basic principles transcend both fields. A final point about the definition is the examination of physiological and behavioral characteristics. A physiological characteristic is a relatively stable physical characteristic, such as fing erprint, iris pattern, and blood vessel patterns on the retina. This type of measurement is basically unchanging and unalterable without significant duress. A behavioral characteristic is more like a reflection of an individual's physiological makeup majorly influenced by physical traits such as sex and size, which includes signature, keystroke patterns (how one types on a keyboard) and voice. Because of the variability over time of references (database) each time they are used, generally, behav ioral biometrics work best with regular use.

The differences between physiological and behavioral characteristics and methods are important for several reasons. Apart from injury, the fingerprint of an individual is the same day in and day out. The voice however, is influenced both by controllable actions and psychological factors. Developers of behavior based systems, therefore, have a tougher job adjusting for intrapersonal variations. For instance, it is easier to build a machine where you pl ace your hand every time for identification than it is to build algorithms that take emotional states and little variations into consideration. Also, physiological systems tend to be larger, more expensive and may be threatening to user. Because of these differences, no biometric technology can serve all security needs. Given the accuracy of current technology, a number of scientists have pointed out that biometric systems based solely on a single biometric system may not always meet performance requirements" [Fingerprint Basics, 2009]. The easiest solution to this is the use of multi-biometrics from which "data from multiple and independent biometric identifiers are fused; reinforcing the identity of a subject." [Halstead and Bornby, 2001].

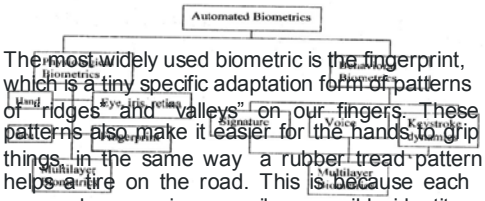


Figure 1: Biometric technologies

The most widely used biometric is the fingerprint, which is a tiny specific adaptation form of patterns of ridges and valleys" on our fingers. These patterns also make it easier for the hands to grip things, in the same way a rubber tread pattern helps a tire on the road. This is because each person has a unique, easily accessible identity design, which represents him/her alone on his/her finger tips. The genetic code in DNA gives general orders on the way skin should form in a developing fetus, but the specific way it forms is a result of random events. The exact position of the fetus in the womb at a particular moment and the exact composition and density of the surrounding amniotic fluid decides how every indiv idual's ridge and valley would form [STGISC release, 2001]. So, in addition to the countless things that go into deciding our genetic make-up in the first place, there are innumerable genetic and environmental factors influencing the formation of the fingers. Just like the weather conditions that form clouds in the coastline of a beach, the entire development process is so chaotic that, in the entire course of human history, there is virtually no chance of the same exact pattern forming twice. C onsequently, fingerprints are a unique marker for any person.

A typical fingerprint ridges are the dark areas of the fingerprint while the valleys are the white areas that

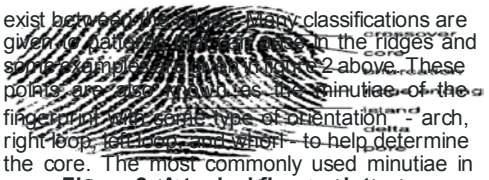


Figure 2: A typical fingerprint

exist between individuals. Many classifications are given to patterns found in the ridges and some examples are shown in figure 2 above. These points are also known as the minutiae of the fingerprint with some type of orientation - arch, right loop, left loop, and whorl - to help determine the core. The most commonly used minutiae in current fingerprint recognition technologies are ridge endings and bifurcations because they can be easily detected by only looking at points that surround them. Extensive research has been done on fingerprints in humans. Two of the fundamentally important conclusions that have risen from the research are that fingerprints of individuals are unique, and also that a person's fingerprint will not naturally change structure after about one year of birth. In practice two humans with the same fingerprint have never been found - even the fingerprints in twins are not the same. However, while two fingerprints may look basically the same at a glance, a trained investigator (fingerprint reader / scanner) or an advanced piece of software can pick out clear, defined differences [Jain et al, 2004], and use them to identify the person by comparing them to other samples on record. These are the basic ideas of fingerprint analysis, for both crime investigation and security, as in AESS.

IV. AESS System Design and Analysis

AESS component sub-systems, parameter definitions and specifications, algorithms and flowcharts (in line with structured programming design principles and standard symbolic representations of step-by-step events in top-down design method), control programs, input processing programs, output processing programs, and user interface forms as designed with their functional analysis are hereby investigated. The block diagram of the complete system design is presented in the figure below, as consisting of five major blocks: the fingerprint scanner and web camera connected to the computer through the Universal Serial Bus (USB) port all make up the hardware components, while the Visual Basic Application and Microsoft Access Database blocks make up the software components.

A AESS Hardware Analysis

The fingerprint scanner hardware component used

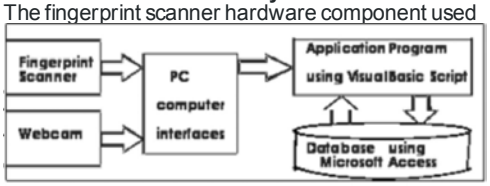


Figure 3: Block diagram of AESS complete system

extracted features with a template or stored features in the computer. Here is a typical capacitance finger print scanner device as used in the design.

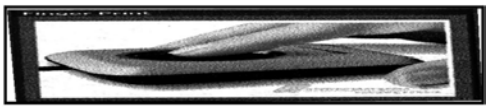


Fig. 4(a): Capacitance fingerprint scanner

Fingerprint enrollment and scanning (image

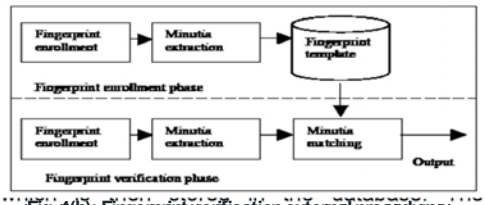


Fig. 4(b): Fingerprint verification external procedures

Figure 4: Fingerprint scanner device and procedures

extraction) success is first served by: (i) taking several images of the same fingerprint to cover various aspects of the image, which includes Position, dryness, humidity, dust, brightness, darkness, etc.; and (ii) setting a threshold for the acceptance or rejection of a specific fingerprint for recognition, verification and matching. Most modern fingerprint matching technologies use minutiae matching [Karu and Jain, 1996; Senior,

2001; Jain and Hong, 1997; Jain et al, 2000; Mehtre and Murthy, 1986; Daugman, 1985]. Minutiae are usually matched together by their distance relative to other minutiae around it such that if multiple points in one image have similar distances between them and multiple points in another image then the points are said to match up and are most likely from the same fingerprint. It is the idea of this paper to add that the minutiae algorithm is fast and also that the region constraints between minut iae edges should be approximately the same as well. Figure 5 gives the fingerprint scanner enrollment flowchart and extraction interface.

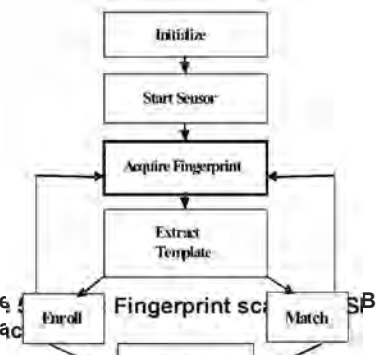
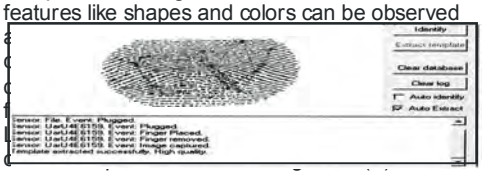


Figure 5: Fingerprint scanner USB port interface

The webcam picture also follows the flowchart above but with the interface in figure 6(a) for picture storage in the database. Further features like shapes and colors can be observed



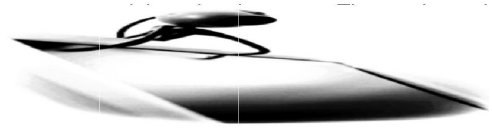
(b) Fingerprint acquisition window

for hands-free computer

accessibility, provide higher degree of freedom (DOF) and ensure interactivity.

(a) AESS Picture capture window

show how controls work together in regular relations to achieve the design phase of AESS



(b) Webcam device mounted on PC

designed were source-coded (source codes and algorithms not included here for space) and compiled to run the application in every computer that meets its minimum requirements. The design is to achieve the goals and objectives of this work and thereby overcoming the shortcomings and limitations of the existing manual system.

To ensure that AESS system is developed with proper and necessary control functions, within budget, on schedule and to a good quality expectation, a number of checkpoints were employed for qu ick reviews, and timely decisions in organized basis. AESS data processing is done by the input and output programs under the supervision of the control program. The types of control considered in the design of AESS include: (i) Input / access Control (ii) Data entry control (iii) Processing control (iv) Output control (v) Data

Organization and file storage controls.

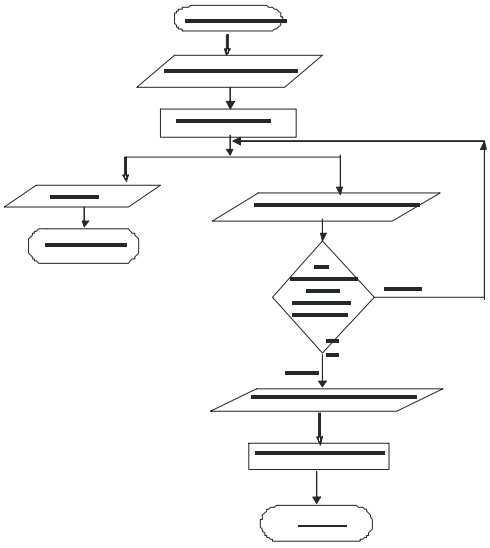


Figure 8: AESS Log on/off account module flowchart

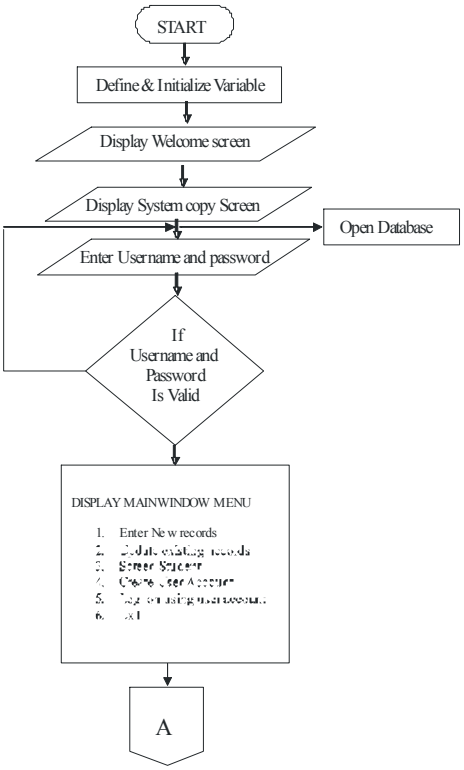
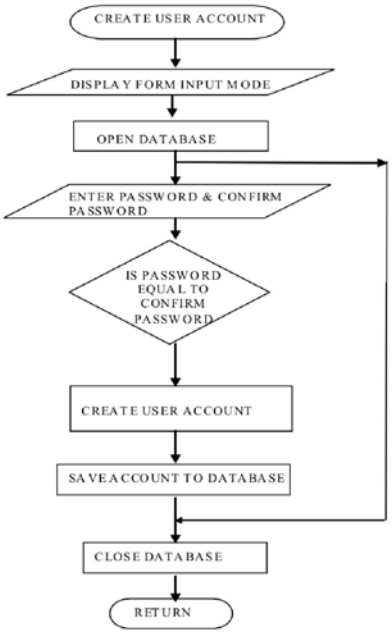


Figure 7: AESS Main program module flowchart

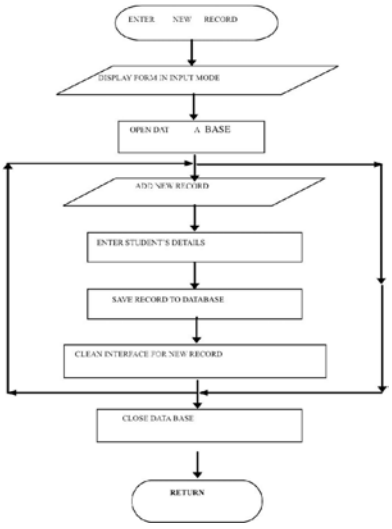
(a) The splash screen form

(b) The Welcome/Administration form

Fig. 9a and b: AESS Control form



(a) Create user account module



(b) Enter new record module

Fig. 10(a) and (b): AESS input module flowcharts

(a) The sign-up form

(b) The registration form

Figure 11(a) and (b): AESS Input forms

C. AESS Output Design

For an effective design of this system output the following evaluation for a number of trade-offs were involved. These criteria include: (i) Use (ii) Volume (iii) Quality and (iv) Cost. Work begins by establishing data content, for design of out document of display obtained by building a list of data elements included in each of the sub-system.

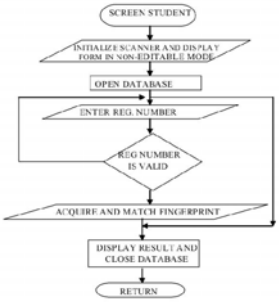
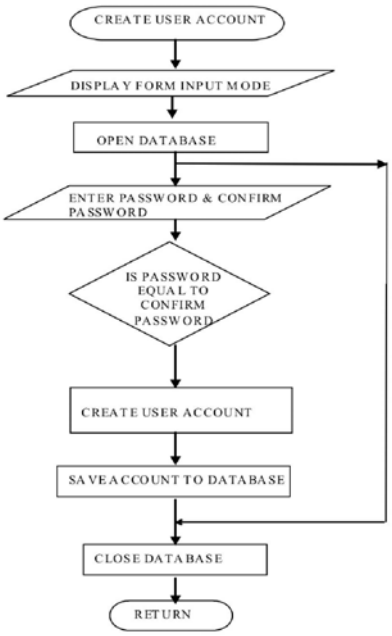
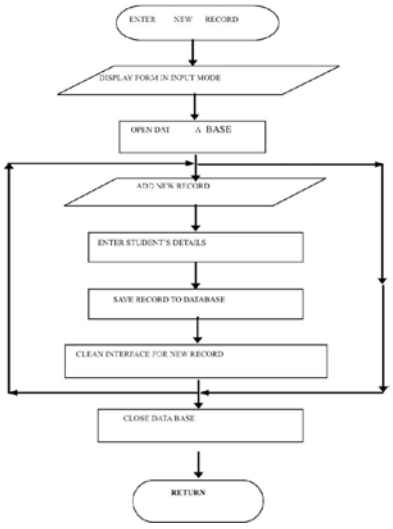


Figure 12: Student screening module flowchart



(a) Create user account module



(b) Enter new record module

Fig. 10(a) and (b): AESS input module flowcharts

(a) The sign-up form

(b) The registration form

Figure 11(a) and (b): AESS Input forms

C. AESS Output Design

For an effective design of this system output the following evaluation for a number of trade-offs were involved. These criteria include: (i) Use (ii) Volume (iii) Quality and (iv) Cost. Work begins by establishing data content, for design of out document of display obtained by building a list of data elements included in each of the sub-system.

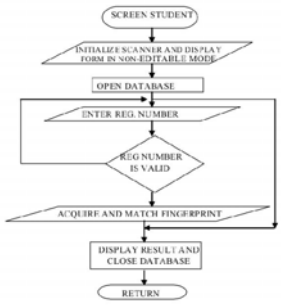
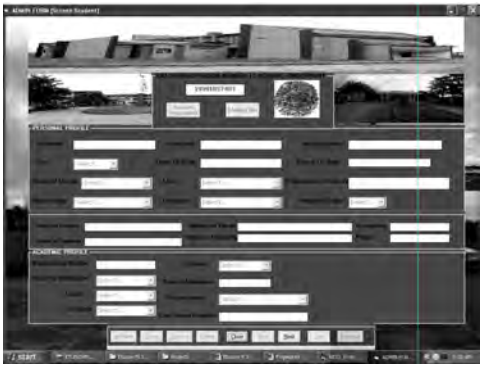


Figure 12: Student screening module flowchart

(a) Screen form (student Identified)



(B) Screen form (student unidentified)

Figure 13(a) and (b): AESS Output forms

V. AESS Testing and Implementation

AESS software may be packaged for deployment using the Microsoft Visual Studio 6.0 Package and Deployment wizard, which enables one to add crucial files needed for the proper running of the software, including the database, into a distributable package and sent to a distribution environment such as a server. It also contains Object Linking and Embedding (OLE) - a technology that allows a programmer of windows-based applications to create an application that can display data from different applica tions and also allows the user to edit the data from within the application in which it was created.

There are minimum system requirements for all software, and this software is no different. For adequate deployment and running of AESS software for optimum performance, the following requirements must be met: (a) CPU: Intel Pentium 1 compatible systems and above (b) RAM: at least 32MB (c) Operating system: Windows 95/98/NT/2000/XP/Vista (d) USB ports.

When the software runs, the splash screen form appears first and then the homepage form. On entering "admin" or "ADMIN" as the username and password, the "enter new records" and "update existing records" labels becomes highlighted. On clicking any of the two labels, the new records form or records update form, as appropriate appears and initializes the fingerprint scanner and webcam interfaces ready for data capture. After entering the necessary information, uploading and saving the information, each student new record registration or record update is confirmed and stored in the database. The "screen student" label becomes highlighted on entering "screen" or "SCREEN" as the username and password, and clicking on the label, the screeni ng form appears and the fingerprint scanner interface and form are initialized and loaded respectively. On placing the index finger on the fingerprint reader, the scanner program automatically starts running. The fingerprint finally obtained is compared with the ones in the database. If a match is found, the student's information, photograph and an appropriate confirmatory (identity and fees payment status) messages are displayed and verified. The confirmatory message displayed may read "IDENTIFIED BUT FEES NOT PAID-UP!" or "IDENTIFIED AND FEES PAID-UP!" depending on whether the student has paid-up the school and/or departmental fees or not. But if no match is found, then no student information is displayed but only a message which reads "NOT IDENTIFIED AND PAYMENTS UNVERIFIABLE!" is displayed.

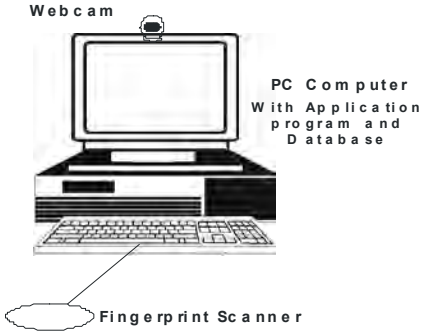
VI. AESS Deployment

AESS as designed can be quickly deployed as a stand-alone system (see figure 14a), with about two hundred and eighty thousand naira (N280,000) cost requirement. The database software is stored, accessed and managed together with the application software in the same computer, where each student's information in the database is accessed and displayed by fingerprint matching on the stand-alone system. Also, AESS is ultimately designed to operate in a client-server environment wirelessly linked (see figure 14b),

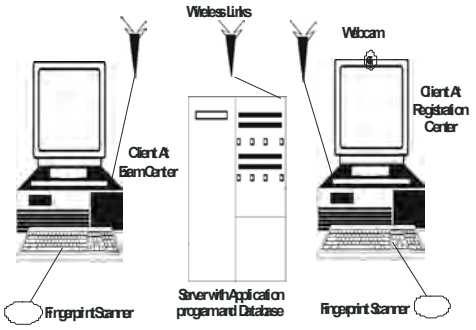
and may cost a minimum of about two million five hundred thousand naira (N2,500,000.00) to fully implement it. The database software is accessed, managed and stored in the server using application software installed in both server and client systems from where the database is accessed and studen t's information matched, displayed and updated.

Figure 14(a) and (b): AESS System deployment Models

VII. Conclusion



(a) Stand-alone AESS Model



(b) Distributed Client-server AESS system Model

The AESS system, fully implemented as a stand alone, was successfully tested and results ascertained. Also, its implementation design strategy as a client-server based (distributed) system over wireless LAN network was equally attempted to ensure that the system is deployed to cover all examination halls on campus, using central dynamic database. As a 21st century system, AESS can be expanded and extended to enhance its administration, compatibility, robustness, security, and reliability.

REFERENCES

Bowman, E. (January, 2000); "*Everything You Need to Know About Biometrics,"* Second Edition. Identix Corporation.

Daugman, J. (1985); "Uncertainty relation for resolution in space, spatial frequency, and orientation optimized by two-dimensional visual cortical filters, J. Opt. Soc. Am. 2 11601169. *Fingerprint Basics,* http://www.wikipedia.com/fingerprint [Accessed May 22, 2009].

Halstead, B. D. and Bornby, S. U. (2001); "Biometric Authentication and Identification Systems for Border Controls: A look at U.S. and Canadian Programs," New York, Hilltop Publishers.

Hornby, A. S. (2000); "Oxford Advanced Learners' Dictionary of current English", Sixth Edition, London, Oxford University Press.

Jain, A.K., Prabhakar, S., and Hong, L., Pankanti, S. (2000); "Filter bank based fingerprint matching," IEEE Trans. Image Process, 9 (5) 846859.

Jain, A.K., Prabhakar, S., Hong, L., and Pankanti, S., (August 2004); "*Biometrics: A Grand Challenge,"* Proceedings of International Conference on Pattern Recognition, Cambridge, U.K., pp.2-6.

K. Karu, and A.K. Jain, (1996); Fingerprint classification, Pattern Recognition 29 (3) 389404.

Mehtre, B., and Murthy, M. (1986); "A minutiae-based fingerprint identification system," in: Proceedings of the Second International Conference on Advances in Pattern Recognition and Digital Techniques, Calcutta, India.

Paul, Rosenzweig, Alane, Kochems, and Ari Schwartz (June 21, 2004); "Biometric Technologies: Security, Legal, and Policy Implications", Published by heritage foundation.

Senior, A. (2001); "A combination fingerprint classifier," IEEE Trans. Pattern Anal. Mach. Intell. 23 (10) 11651174.

STGISC release, (Nov. 14, 2001); "Biometric Identifiers and the Modern Face of Terror: New Technologies in the Global War on Terrorism," Hearing before the Subcommittee on Technology, Terrorism and Government Information of the Senate Committee on the Judiciary, 107 tCong. 1st Session.

U.S. GAO release, (Nov. 14, 2002); "Technology Assessment: Using Biometrics for Border Security", U.S. General Accounting Office (GAO), (GAO-03-174).

MICRO-CONTROLLER-BASED SOLAR TRACKING SYSTEM: A MEANS TO SUSTAINABLE SOLAR POWER GENERATION AND UTILIZATION IN DEVELOPING COUNTRIES

Joshua Abolarinwa (MNSE, MIEEE)
abolarinwajoshua@yahoo.co.uk
Department of Electrical and Computer Engineering,
Federal University of Technology, Minna, Nigeria

ABSTRACT

In this paper, we examine how the energy from the sun as a source of renewable energy can be effectively tracked and utilised for the purpose of alternative source of power supply and other domestic applications. A tracking system was designed and developed using a programmable microcontroller as the main system unit, together with other elements. By tracking the sun, the angle of incidence of the sun on the solar panels will be maximized, and the power output from the panels will be near maximum all day. With the incorporation of automatic reset and start mechanism in the tracker, maximum energy was collected as the sun rotate from east to west.

I. Introduction

The sun is an ever present source of power (energy) of all life on earth. We are living at a time when there is greater energy problem facing the world than at any period in history. Going solar, we could be leading the way towards a cleaner world where all our energy demands are tapped from the infinitely free source (the sun) without harming the environment through reducing carbon emission and global warming.

The energy collected by systems that make use of the sun as their source (such as a solar panels) always dependent in part on the angle of incidence of the sun upon the collector (i.e. panel). Traditionally, most of the collectors are mounted on a fixed position, which leaves them in a sub-optimal orientation for most of the day. The various movements of the earth make the solar radiation pattern to vary with time of the day and year. As a result, it becomes impossible to collect maximum radiation during the day with fixed collectors. It then become pertinent that consistent ali gnment of the collectors must be ensured in order to always obtain maximum radiation from the sun [1].

The sun tracker is an automated system that actually follows the sun for increase power. The tracking was accomplished using microcontroller driven device. The need to reduce system complexity and other shortcomings of analogue electronic system led to the introduction of the microcontroller.

II. Historical Background of Solar Tracking Technology

The earliest known record of the direct conversion of solar radiation into mechanical power belongs to Auguste Mouchout, a mathematics instructor at the Lyce de Tours [1]. Mouchout began his solar work in 1860 after expressing grave concerns about his country's dependence on coal. By the following year he was granted the first patent for a motor running on solar power and continued to improve his design until about 1880. During this period, the inventor laid foundation for our modern understanding of converting solar radiation into mechanical steam power.

Mouchout initial experiment involved a glass-enclosed iron cauldron. Incoming solar radiation pass through the glass cover, and the trapped ray transmits heat to the water. In late 1865, he succeeded in using his apparatus to operate a small, conventional steam engine. By the following summer, he enlarged his invention's capacity, refined the reflector, redesigning it as a truncated cone, like a dish with slanted side s, to more accurately focus the sun's rays on the boiler. Mouchout also constructed a tracking mechanism that enables the entire machine to follow the sun's altitude and azimuth, providing uninterrupted solar reception.

William Adams, the deputy register for the English Crown in Bombay, India built a large rack of many

small mirrors and adjusted each one to reflect sunlight in a specific direction [2]. To track the sun's movement, the entire rack could be rolled around a semicircular track, projecting the concentrated radiation onto a stationary boiler. The rack could be attended by a laborer and had to be moved only three or four times during the day, or more frequently to improve performance. Adam's legacy of producing a powerful and versatile way to harness and convert solar heat survives. Engineers today k now this design as the *Power Tower Concept,* which is one of the best configurations for large scale centralized plants [1].

As the years wore on, newer methods were designed for collecting power as well as tracking the sun. These included; Engineer Charles Tellier's method of collection without reflection. By 1889 Tellier had increased the efficiency of the collectors by enclosing the top without glass and insulating the bottom. Around 1870, U.S engineer john Ericsson invented a novel method for collecting solar ray s known as parabolic trough. A parabolic trough is more akin to an oil drum cut in half lengthwise that focuses solar rays in a line across the open side of the reflector. This type of reflector offered many advantages over its circular counterparts: it was comparatively simple, less expensive to construct, and unlike a circular reflector, it only track the sun in a single direction thus eliminating the need for complex tracking machinery. The downside was that the device's generated energy and efficiencies were not as high as with a dish- shaped reflector. The first commercial Venture was by Aubrey Eneas who began his solar motor experimentation in 1892, and formed the first solar power company (The solar Motor Co.) in 1900. Though the machine did not become a fixture as Eneas had hoped, the inventor contributed a great deal of scientific and technical data about solar heat conversion and initiated more than his share of public exposure. [2]

III. Previous works on Tracking

Over the years, much developmental work has been carried out in the solar energy domain and the scope of research conducted during the intervening two to three decades is quite diverse and fruitful result being approximating a process of explosion since the first fuel crisis in the earth 1870s and solar research programme began to grow and multiply on many fronts.

The solar energy experts at Denver based Conergy Americas and officials at California's South San Joaquin Irrigation District (SSJID) have installed what is believed to be the world's first single axis solar tracking system featuring thin film cells. The sun tracker is an automated solar panel that actually follows the sun for increased power. The system is capable of rotating over a 180^{0} east to west. The sun tracker will increase the power output of photovoltaic arrays by over 200% by keeping the face of the panels parallel to the sun throughout the day. [3]

Frank Shuman among solar energy pioneers declared more than 80 years ago, the sun is the most rational source of power. Shuman developed a sun tracker which tracks movement of the sun across the sky. The mirrors would turn to keep the rays focused on the tower, where oil was heated to 300 degrees Celsius. The heat from the oil was used to generate steam which then drove a generator capable of providing 10kW of electrical power. That is a fair amount of power . Power generated by harnessing the energy from the sun. Solar one was very expensive to build, but as fossil fuels run out and become more expensive, solar power station may become a better option. [4]

In the 1950s, the Philips research laboratory in Eindhoven, Holland, conducted a successful large scale research programme concerned with the fabrication of solar illumination solar tracker, his research achieved an efficiency equal to that of contemporary internal combustion engine. Two Indian scientists, Cihai and Khanna, constructed a sun tracking system in New Delhi using solar position data would look up or calculate the sun's path for a given day, and would follow that path. Such system allow for very good tracking accuracy. However, this approach is also the most complex, and for a system as small as this, such control is not necessary. They used the heat from a parabolic collection surface to develop 1/6 hp hot air engine operating at 100 120^{0} F. [5]

The past 25 years have witnessed the emergence of various methods of solar energy collection as a result of the improvement in technology witnessed within this period. Some of our brightest engineers have even produced some exemplary designs

during the period.

A shadow method for automatic tracking, which is an automatic method that uses 'back- to- back' semi-cylinders to mask solar irradiation was described and presented for publication at the Solar World Congress 1987 in Hamburg by Sode Shinni Nmadu Rumala. [6]

A time-based solar tracking system was also designed based on single axis tracking, on the equatorial tracking axis to track the sun from east to west daily during sun hour periods in October 2006, by Jabir Garba. An open loop control mode was adopted using logic control circuit and suitable interface for the stepper motor and other circuitry. [7]

In April 2008, Audi Ibrahim realized Microprocessor-based solar tracker. The system which is time based is to be controlled by the INTEL8085 Microprocessor and it peripheral devices. [8]

So many projects which have been realized are designed to be of the discrete electronic devices which offer numerous shortcomings like low speed of response, low accuracy and power consumption. In this project, most of these lapses have been done away with.

In this project, modification and improvement was done. Design and implementation of a microcontroller-based sun tracker is realized, offering advantages of high accuracy (very minimal error). The basic innovation in this project is the automatic SET and RESET of the sun tracker, which allows the system to come ON during the day (from 6AM to 6PM) and go OFF during the night (6AM to 6 PM) to ensure power conservation. Also, the ability of the system to adjust to the time set by the user, thus mak ing it user friendly. A microcontroller was incorporated into the system to reduce the use of discrete components, as result making the system design less complex, straight forward and cheap in terms of cost. Finally the overall system is smaller in size compared to earlier designs.

IV. Design Description and Analysis of the Tracking System

Figure 1 shows the overview of the solar tracking system. Each block represents a module and all the modules are linked together to make the entire system unit.

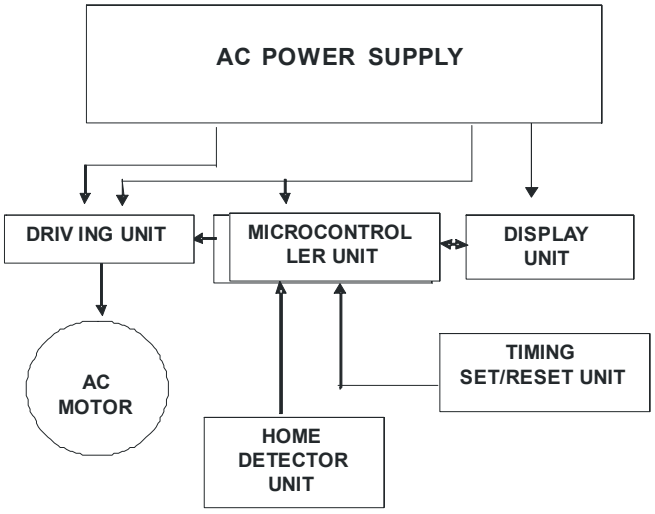


Fig. 1 Overview of the Solar Tracking System

A. Design Elements and Requirements

The sun tracker system was built around the under listed subsystems.

1. System power supply
2. 8 Bit 89C51 System Controller
3. AC Motor Driver
4. 4 Digit 7 - Segment Display
5. Tracker's Mechanical Assembly

The system was designed to meet the following requirements.

- To provide an automated tracking of the sun in its east to west trajectory across the sky.
- To provide an automatic positioning of the collector plate as a function of the time set by the user.
- To provide a 24 hour digital clock correspondi ng with the movement of the sun.

B. System Controlling Unit

For intelligence and flexibility, software driven approach was implemented. This implementation necessarily required the incorporation of a programmable device. An 8- bit microcontroller was used. The AT89C51 has the following characteristics: It s a low power, high performance 40-pin DIP, 8 bit microcontroller with 4 kilobytes of in-system reprogrammable flash memory, 128 bytes of SRAM and 32 programmable I/O lines. The device was run- off a 12MHz clock source. Since microcontroller characteristic frequency was internally divided down by 12, the effective system operating frequency is 1MHz yielding an instruction execution time of 1 microsecond (1 μs).

The system controller was programmed to execute the following functions:-

1. Provide a real time clock operation to serve as reference for every motor control operation.
2. Provide automatic collector plate adjustment on an hourly basis.

   The controller execute the system control software that was modularized to enable easy updateability and separation of functions. The software was divided into major blocks that implemented the following:-

- System initialization
- Keypad scanning
- Computation of the step count needed to position the collector plate
- Detection of maximum west oriented excursion and return to the left (east oriented) positioning.
- Maintenance of system time.

The control signal generated by the microcontroller was decided by the logical output of the different routines making up the control software.

C. Motor Driving Mechanism

A geared down AC motor was used to provide precision positioning of the collector. The motor was power switched by a BT139 power triac gated ON/OFF by an MOC3023 opto triac as shown in figure 2.

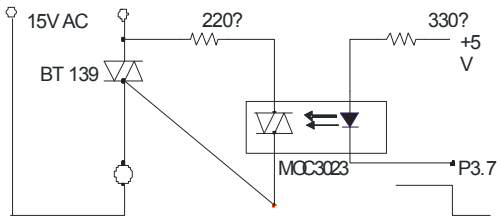


Fig. 2 Triac Ac Motor Driver

A power triac provided the motor current control functionality. Motor turn ON was via an MOC3023 optocoupler activated by P3.7 of the system controller. P3.7 was directly controlled by software.

The motor used had a 2.5r.p.m, which corresponds to 15 per sec. Thus, to move the motor through, say, 60, the motor must run for 4s and turned off. Tests carried out on the system confirmed that the software control routine worked well.

V. Solar Energy Radiation Geometry

Availability of solar energy is accompanied with so many erratic characteristics and unpredictabilities which are caused by the motion of our planet, including the earth's revolution around the sun, the earth's daily rotation about its own axis, and tilt of that axis with respect to the plant of the earth's orbit. The distinct motions predictably yield characteristic effects. In fact, the mean distance between the earth and the sun is **1.4 x 109 meters** and due to eccentricity of the earth's orbit, this distance varies by **± 1.7%.** An interesting fact regarding this is that the earth is farthest from the

sun during the summer months in the northern hemisphere and closest during the winter season. This variation in earth's orbit causes little variance in the amount of radiation to which it is exposed.

The extreme annual changes in the earth's radius of elliptical orbit only amount to some 2%, thus allowing the consideration of the orbit as circular without introducing various errors. Observing the sun's motion from position on the earth's surface for sufficiently regular patterns of daily movement across the sky of course, the patterns do vary gradually throughout the years. The position of the sun at any chosen instant can be defined fully in figure 3 using two angles that measured from a fixed location, one of these angles is called the solar altitude and the other is the azimuth and both depend upon time of the year, time of the day and latitude of the point of reference. [12]

Solar Positioning

One should not become overly concerned about the "haphazard" factors involved in solar availability. Superimposed on the unpredictability's, there are stron g cyclic behaviors

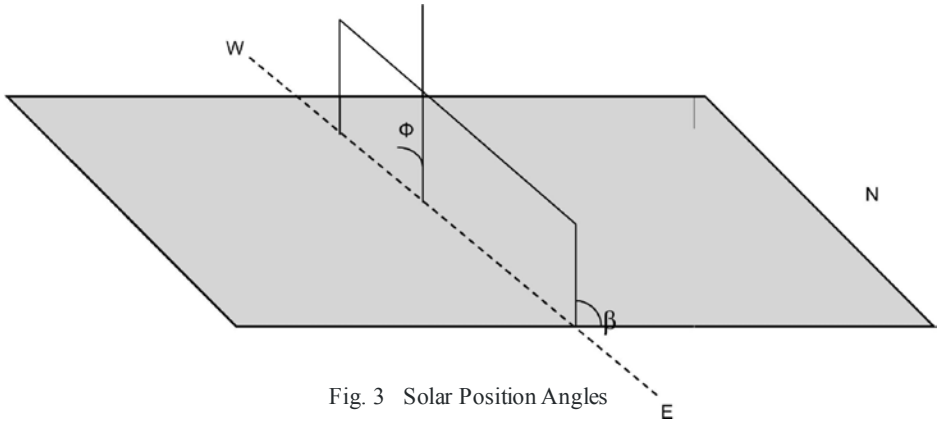


Fig. 3 Solar Position Angles

that provide the observer with a foundation of precise regularity. These behaviors are caused by the motions of our planet, including the earth's annual revolution around the sun, the earth's daily rotation about its axis, and tilt of that axis with respect to the planet of the earth's orbit. These distinct motions predictably yield characteristic effect.

In and of itself, the yearly orbit of the earth cause little variance in the amount of solar radiation to which it is exposed. The extreme annu al changes in the earth's radius of elliptical orbit only amount to some 2% allowing us to think of the orbitas circular without serious error. An interesting fact regarding this is that the earth is farthest from the sun during the summer months in the northern hemisphere (95.90 million miles) and closest during the winter season (89.83 million miles). A schematic diagram of this is shown in fig. Earth's changing season are not caused by our orbit alone, but rather by that orbit in conjunction with another feature of the earth, its "tilt".

The equator of the earth is tilted some 23 .27' with respect to an imaginary, but precise, planet in space the "ecliptic". This plane is defined by earth's orbit, and in turn defines the sun equator. As we circle the sun, a slight variation occurred daily "the angle between the earth sun *line (on the ecliptic), and the equatorial plane (of earth). This angle called the solar* declination ä (delta), varies continuously". The variation of delta causes the earth to present a slight different face to the sun each day, and it is the motion responsible for those seasonal changes in the weather available each year. It also causes the mysterious annual lengthening and shortening of the intervals between sunrise and sunset, in spite of the earth's very regular daily rotation above its own axis. [12]

Definition of Angles of Solar radiation

- Zenith Angle (θ): Is the angle subtended by a vertical line to the zenith (that is point directly overhead) and the line of sight to the sun.
- Latitude (ô): Is the angular position north or south of the equator.
- Declination (d): Is the angular position of the sun at solar noon with respect to the plane of the equator.
- Tilt Angle (β): Is the angle between the surface in question and the horizontal ($0^{0} < â < 180^{0}$)
- Hour Angle (w): Is the angular displacement of the sun east or west of the local meridian due to radiation of the earth on its axis at 15^{0} per hour.
- Angle of incidence (?): Is the angle between the beam radiation on a surface and normal to the surface.
- Solar azimuth angle (Ts): Is the angular displacement from South of projection of the beam radiation on the horizontal plane.

Optimum Orientation of a Flat Collector

For the sake of obtaining maximum radiation at solar noon for a given day, the flat collector should be set in such a way that the angle of incidence is zero: That is, the beam radiation from the sun should be orthogonal to the collecting surface as shown in figure 3.

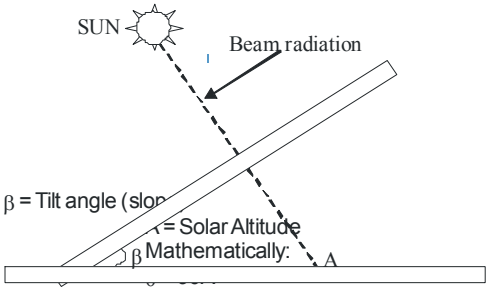


Fig.3.0 Flat collector

δ.....1

Where

L = local latitude δ= declination

The declination is given by:

$$\delta = 23.44 \sin\left(360 \times \frac{284 + N}{360}\right) \quad \text{.....2}$$

N = the day of the year.

A generally acceptable orientation for flat collectors is that, the collectors should always point towards the direction of the solar beam (that is θ = 0). The optimum direction of a fixed flat collector is perhaps not obvious, however a suitable collector orientation for most purposes is facing the equator (e.g. due south in the northern hemisphere) with a slope (tilt angle) equal to the local latitude. [12]

VI. Solar Tracking

Since the various movements of the earth make radiation pattern to vary with the time of the day, year (seasonal) and so on, it become impossible collect maximum radiation during the day with fixed collectors. Therefore, it becomes obvious that consistent alignment of the collectors must be ensured to always obtain maximum illumination from the sun. In some applications, most especially for concentrators, tracking become expedient to obtain maximum energy conversion. In the application of photovoltaic cells, solar tracking enhances concentrators' efficiency. Automation of the solar collector could be obtained where the unit can operate without the need of human intervention. Such system can track the sun so that the collector receives maximum radiation at all time.

Single and Dual Axis Tracking

In most application that requires tracking, one axis tracking (East to West) is utilized and this becomes justifiable when cost is considered. However, for higher concentrations and high precisior applicatio ns, two orthogonal tracking may be required. The rotation of the earth about its axis is the most noticeable in solar radiation collectors, while the impact of other movements has very gradual effects which are mostly neglected in many applications without introducing much error. This makes single axis tracking more acceptable, as it represents a relatively high investment, and it still finds application in special areas like research work and high precision tracking applications [13].

VII. Performance Evaluation

At system power ON, the software automatically position the collector plate facing the east, at the

system default time of 6AM. Every one hour the motor runs for 1s to step it through 15. If the syst em time is not adjusted, the collector's orientation is hence adjusted every 1 hour to align it with the sun's angle of inclination. If the system time is however adjusted, to prevent accumulation of mechanical errors, the collector initially returns to the home position, the software then computes the degree of rotation by

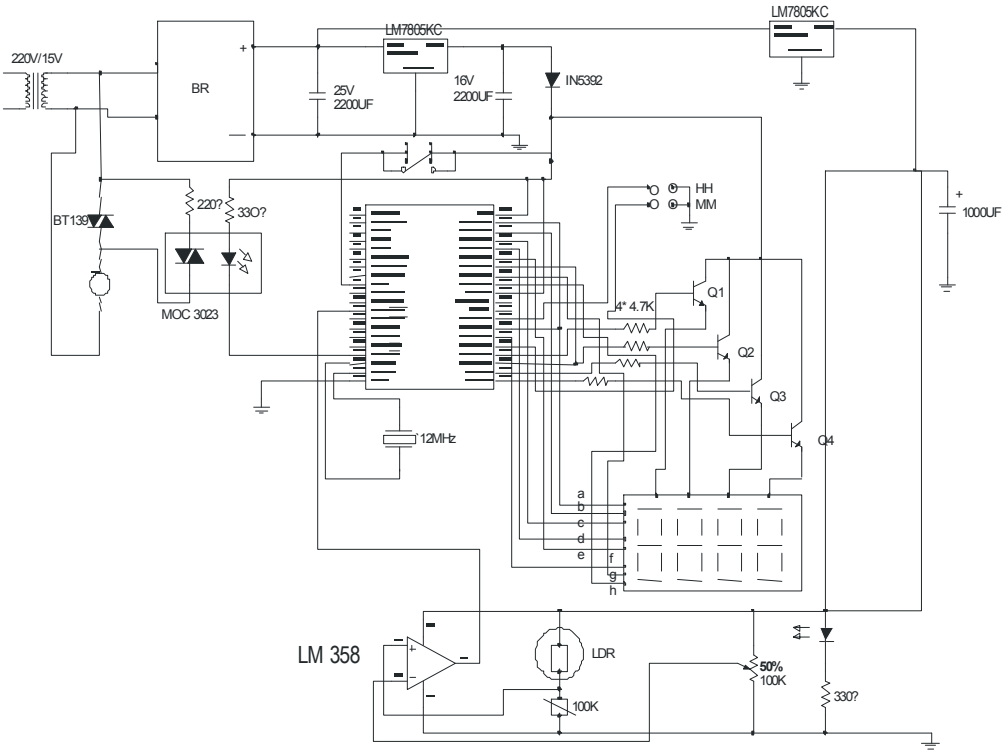


Fig. 5 Complete System Circuit Diagram

subtracting 6 from the set time. The collector is hence positioned correspondingly. At 6PM, the software automatically returns the collector to the home position until 6AM, 12 hour later, when tracking commences again. Generally, the programmed values were found to conform to experimented values with a very precise real time clocking system.

Table 1: Experimental result

Time of the Day	Collector Orientation (°)	Duration of Current Pulse sent to Motor (s)
6AM	Vertically facing the east - ward direction.	0
7AM	15	1
8AM	30	2
12 Noon	90	6
3PM	135 East and 45West.	9
5PM	165 East and 75West.	11
6PM	Back to the home position and tracking stops until 6am	12

VIII. Conclusion

The system was developed and tested to conform to the design specifications indicating a successful implementation. From the test and results obtained, it can be seen that the tracker satisfactorily tracks the sun during the preset periods, resets after, hibernates during the night time and resumes at a preset period in the day time.

In the design and construction of a microcontroller based solar tracker, the system satisfactorily tracked the sun. However due to seasonal changes, the system could be expanded to accommodate both elevation and lateral tracking.

The system could also be modified to source its own power directly from the sun or from the one generated by the solar panel that could be mounted on top of the collector. Then it would be completely self - driven.

REFERENCES

R. Carlson, D. Felnhofer, P. Roneau, "Design and Construction of a Maximum Power Tracking System for a Solar Panel", Final Year Project, Faculty of Engineering of the University of Manitoba.

C. Smith, "Revising Solar Power's Past", Retrieved March 5, 2009 from *http://www.solarenergy.com/infor-history.html.*

Http://scientificsonline.com/product.asp?, Retrieved May 16, 2009.

Http://www.redrockenergy.com/sun tracking system, Retrieved September 22, 2009.

[N. Kasa, T. Fida, and G. Majmdar, 2002, "Robust Control for Maximum Power Point Tracking in Photovoltaic Power System", Proceedings of the Power Conversion Conference, Osaka - Japan 2002, Vol. 2, pp. 827-832.

S. N. Rumala, "Solar Tracking by the Use of Back to Back Semi Cylindrical Shades", Solar Energy Journal, Vol. 37 No. 3, 1986, pp. 245-247.

J. Garba, "Time Based (Constant Velocity) Solar Tracker Using Stepper Motor", Final Year Project, Department of Electrical Engineering, School of Enginee ring, A.T.B.U Bauchi, 2006.

A. Ibrahim, "INTEL 8085 Microprocessor Based Solar Tracker and its Peripheral Devices", Final Year Project, Department of Electrical Engineering, School of Engineering, A.T.B.U Bauchi, 2008.

M. Durham, PhD, PE: System Design and the 8051, ISBN: 0-9719324-6-8.

L. Boylestad and L. Nashelsky, Electronic Device and Circuit Theory, *Pearson Educational* Ltd., inc. ISBN 81-7808-590-9.

B.L Theraja and A.K Theraja, A Text Book of Electrical Technology, S. CHAND & COMPANY LTD, RAM NAGAR, NEW DELHI-110 055.

Piao, Z.G Park, J.H Cho, G.b Baek, H.L. Kim, " A study on the Tracking Photovoltaic System by Program Type", Electrical Machines and Systems. 2005. ICEM 2005.

[13] Photovoltaic Specialist Conference, 1990, Conference Record of the 21st IEEE.

ANALYTICAL DETERMINATION OF ELECTROMAGNETIC RADIATION (EMR) DISTRIBUTION AROUND GSM BASE STATIONS IN NIGERIA

Olatunbosun, A. and Ahmed, A.A.
Dept of Electrical and Electronic Engineering, University of Ibadan, Nigeria
aolatunbosun@yahoo.com

ABSTRACT

Introduction of mobile telephony and subsequent liberalization of the telecommunications market in Nigeria have brought about a proliferation of new radio antenna sites. The country's high population density has necessitated locating practically all types of antenna stations within densely built and highly populated environments. Lack of public information and rapidity of deployment of these sites contributed to the concern among the conscious public that the perceived increase in exposure to RF electromagnetic fields could be harmful to human health.

This paper is a discourse on our preliminary investigation on determining the RF field intensities emanating from local GSM base stations in Nigeria, using those within the main campus of the University of Ibadan as a case study.

Our initial results somehow give credence to this concern and required wide spread investigations. The methodology used for the survey, which includes a hybrid of calculation techniques and field measurements are presented. Some preliminary results are discussed and comparisons made between measurements and calculations are presented. Based on the survey of University of Ibadan as a case study, a set of criteria and some simple calculations are proposed as a practical scheme to select potentially problematic sites for detailed and on-site measurement campaigns in the future.

I. Introduction

For many, the word radiation conjures up frightening images, such as Hiroshima, and deadly cancers infections. In reality, radiation surrounds us and most forms do not cause us harm. It has the potential to destroy lives but it is also used to save lives (L. Griffeth 2000). Radiation is simply the transmission of energy in the form of light or radiant heat from a body as it undergoes internal changes. Radiation comes in many forms that fall into two categories, ionizing radiation and non-ionizing radiation.

A. Types of Radiation

Ionizing Radiation is a particle or wave high enough in energy to eject a charged particle from an atom, in a process called ionization. There are many forms of ionizing radiation with varying levels of energy and penetration potential (Fig.1). The most common are alpha particles, beta particles, gamma rays, and x-rays.

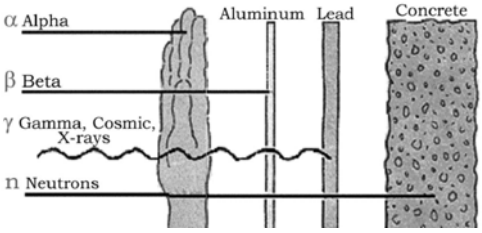


Figure 1. A visual comparison of the penetration potentials of different forms of ionizing radiation. Source: http://www.uic.com.au/

Non-Ionizing Radiation includes forms of radiation such as ultraviolet light, visible light, infrared, microwaves, and radio waves.

The focus of the study was on non-ionizing radiation, particularly those from GSM base

stations.

B. Electromagnetic Field (EMF) and Spectrum

RF is any electromagnetic (EM) wave with a frequency between 1MHz and 300GHz. Common industry definitions have RF ranging from 1MHz to about 1GHz, while the range from 1 GHz to about 30GHz is called microwaves and 30 300 GHz is the millimeter-wave (MMW) region. RF waves are non- ionizing type of radiation. The GSM uses the 900MHz and 1800/1900MHz frequency bands for signal transmission and reception.

RF (Wireless) communications systems have recently become more ubiquitous. Mobile cellu lar networks make extensive use RF waves - a slice of the electromagnetic spectrum for its access, and transport networks. Some attendant undesirables are, degradation of aesthetics of the environment and health problem concerns, that could be associated with non-ionizing EM radiation.

C. Justification To The Study

Few subjects in electrical engineering evoke as much controversy as the debate over safe levels of exposure to electromagnetic energy. Any system that is designed to radiate RF energy should be analyzed and/or test ed to verify that the RF exposure of the user and the public is within safe limits. This is due to higher power densities (electromagnetic field intensities) sometimes involved and the potential for public exposure.

The density of BTS towers per square Km has gone from 8 to 9 in the metro cities resulting in a very heavy density of Electromagnetic Field, thus, resulting in RF radiation pollution. In the last decade growing scientific evidence has shown that our homes and workspaces can be more seriously polluted than urban outdoor areas. This pollution presents a serious health challenge. A distinct need is therefore felt that the non ionizing electromagnetic radiations be considered as a potent polluting agent and, therefore, be dealt with by the government agencies (like the NCC).

Seeing the adverse biological effects of this pollution, the world organizations like ICNIRP had taken up formulation of these guidelines according to our knowledge.

II. The University of Ibadan Campus as Case Study

University of Ibadan and vicinity with land area of about 130 Square kilometers was chosen for this study. The campus has enough BTSs (a total of 7 GSM 900/ DCS 1800 BTSs within the study area). The campus is highly populated with students and staff who live around these BTSs and are regular mobile phone users. Therefore the sample study area is believed to be a fair representation of typical BTSs clusters in any urban area in the country.

III. Biological Effects of RF Exposure

RF radiation is non-ionizing radiation. This is due to the fact that the photonic energy at radio frequencies is insufficient to cause ionization (Cleveland et al., 1999). For non-ionizing radiation, tissue heating (thermal effect) is the only verified mechanism for tissue damage. However, possible a-thermal biological effects of non-ionizing radiation have been postulated. In recent times, scientific evidence on the deleterious biological effect of low-level RF radiations is being published.

It is important to appreciate the distinction between a biological effect and a biological hazard. A small amount of localized tissue heating is a measurable effect, but may not be a hazard (Tanwar, 2008). The frequency of the electromagnetic wave and the part of the body exposed are important considerations. The two areas of the body that are most vulnerable to damage from tissue heating are the eyes and the testes as they lack adequate means (blood flow) to rapidly dissipate heat. So while tissue heating is an effect, above a certain level it can become a hazard. Since tissue heating is the focus, in addition to the electromagnetic field intensity, the duty cycle of the electromagnetic emissions is incorporated into the exposure calculations.

Absorption of RF energy is frequency-dependent based on resonance. The (adult) human body absorbs the maximum amount of RF energy at 35MHz if grounded and 70 MHz if insulated. Parts of the body may resonate at different frequencies and have different sensitivities. Maximum whole-body absorption occurs when the long axis of the body is parallel to the E field and is 4/10 of a wavelength (Hare 1998) (2/10 if grounded since body then acts as a monopole). The frequency of maximum absorption then depends upon the size of the individual, position (arms raised up,

squatting down, etc.), and whether or not the individual is grounded. The maximum permissible exposure (MPE) is defined based on average power level. Thus the signal power (peak envelope power, PEP), transmit duty factor (for push-to-talk or PTT systems), and exposure duration must all be factored into a computation of exposure. The averaging time is 6 minutes for controlled exposure and 30 minutes for uncontrolled exposure. If the exposure time cannot be controlled, continuous exposure must be assumed. There is also a requirement that the peak power exposure be limited so that an arbitrarily short pulse is not allowed to become arbitrarily powerful. This is addressed by reducing the MPE average over any 100 ms by a factor of five for pulses shorter than 100 ms (IEEE Std C95.1a-1999).

The fields of interest from a safety standpoint will occur in the vicinity of the transmitting antenna. The purpose of the safety analysis is to determine the region where the RF field strength is low enough that the MPE limits are not exceeded.

A. Antenna Considerations

Any system that is designed to radiate RF energy should be analyzed and/or tested to verify that the RF exposure to the user and the public is within the stipulated safe limits. Unsafe levels could be reached due to high transmission power, high antenna gain, close proximity to the transmitting antenna, or any combination thereof.

Due to the geometric spreading of electromagnetic waves as they radiate from a source, the strongest fields and highest exposure levels occur in close proximity to the transmitting antenna. When highly directional antennas are used, the safe distance will be a function of the angular location relative to the beam direction, with the side-lobes and back-lobes requiring less distance.

In most cases the reactive near-field region is generally taken to be withi n one-half wavelength of the antenna surface. Accurate measurement of the fields in this region is difficult due to coupling between the probe and the antenna. The near-field region is

$$\frac{\lambda}{2} < d < \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where d is the distance from the centre of radiation of the antenna, D is the largest linear dimension of the antenna; λ is the wavelength. The transition region is defined as:

$$D^2 < d < \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$
$$4\lambda$$

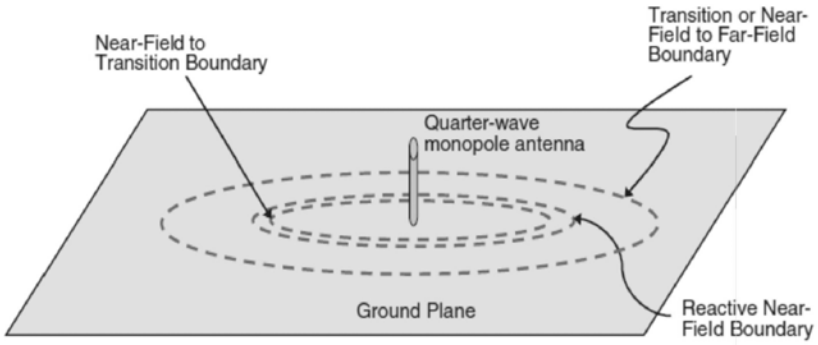


Figure 2 Omni directional antenna field boundaries for RF safety analysis.

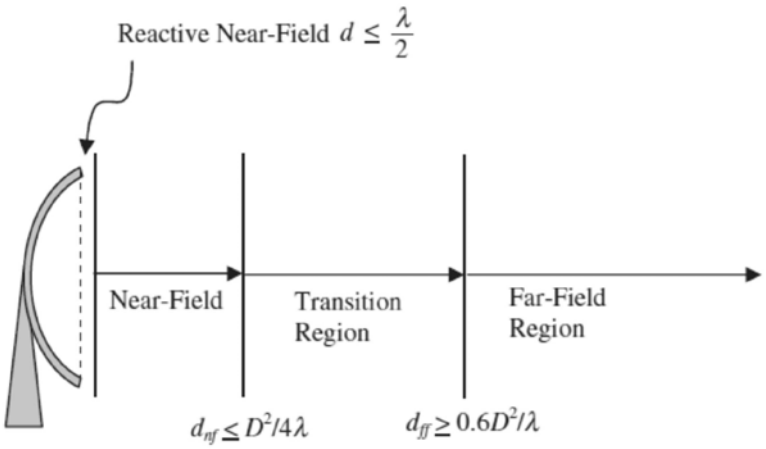


Figure 3: Directional antenna field boundaries for RF safety analysis.

The far-field region is defined as:

$$d > 0.6D^2/\lambda \quad \ldots\ldots (3)$$

D is the largest linear dimension of the antenna. In the far-field, E, H and Z are all mutually orthogonal and the free space loss equation applies. Figure 2 is a conceptual diagram of how the radiation region would appear around a quarter-wave vertical antenna. Figure 3 shows the boundaries for a directional (aperture) antenna and includes the boundary definitions. For antennas with dimensions on the order of a wavelength (such as a monopole) the reactive near-field boundary may fall outside of the transition region, in which case the transition region is not used.

B. Main Beam and Omni-directional Antenna Analysis

The estimated power density in the far-field as a function of the distance is given by

$$S = \frac{PG}{4\pi d^2} \text{ mW/ cm}^2 \quad \ldots\ldots (4)$$

W is the transmit power (mW)

G is the antenna gain; d is the distance from the centre of radiation of the antenna (cm). The product of the power and the antenna gain, PG, is the EIRP. The effective isotropic radiated power may be expressed relative to a dipole rather than an isotropic source. In this case it is called effective radiated power (ERP) and the value is adjusted by the gain of an ideal dipole in free space.

ERP = EIRP 1.64 (or, -2.3 dB)

If the radiator is over a reflective surface, the worst case is a doubling of the electric field intensity. This corresponds to a quadrupling of the power density

$$S = \frac{EIRP}{\pi d^2} \quad \ldots\ldots (5)$$

The developed models for ground level power (Cleveland et al., 1999), which suggest a factor of 1.6 rather than 2for the electric field multiplier over a reflective surface. Applying the EPA result produces a scale factor of 2.56 rather than 4.

$$S = \frac{2.56EIRP}{4\pi d^2} = \frac{0.64EIRP}{\pi d^2} \quad \ldots\ldots (6)$$

IV. Field Measurement and Analysis

A commercial radiation measuring device with trade name EMF rmfield meter was used for this investigation. This was complemented by the use of an Electrosmog ED15SA meter. This is a handheld

Electromagnetic power level and power density meter with a 2.4GHz band spectrum analyzer. Its range of frequency is between 100 kHz to 3 GHz, hence it cover the GSM frequency range available in the country. In addition, a Surveyor's measuring tape was used for ground distance measurements from the base of the BTS. A digital camera was used to track swift (per second) changes in Phone PD values during a telephone conversation.

A. Methods of Measurement

There is no established measurement techniques used for this kind of survey. The technique used for this measurement is such that multiple (3 to 5) readings were taken at every point of measurement and the average is recorded. This technique proved effective in eliminating errors due to fluctuations in power density values due to environmental conditions.

B. Measurement Results and Analysis

Once the survey was been completed and all measurements have been recorded, the measurements were analysed in order to assess compliance of the emissions from the site with the reference levels.

Base Transceiver Station (BTS) Power Density

a. BTS Power Density Variation with Distance

The result of measurements as per ground distance variation from each BTS is summarized in 3.1. BTS PD directly below (at the foot of) the antenna mast is close to the ambient PD but sharp rises in PD was observed between 5 to 20m from the base of the base station. Beyond this point the PD starts to drop as shown in the plots in figures 3.1*a* and *b*.

The probable cause of this may be due to an unproven relationship between telephone traffic on a BTS and the BTS PD. But an inference cannot be accurately drawn because all other BTS were not identified. Another possibility is that the PD could be related to the distance coverage (field of view) range for the BTS (whether it is a Macro-BTS for large cells or Micro-BTS for smaller cells.)

Table 1.0: PD at different Distances from each BTS

	BTS 1	BTS 2	BTS 3	BTS 4	
DISTANC E (m)	PD1(mW/m^2))	PD2 (mW/m^2)	PD3 (mW/m^2)	PD4 (mW/m^2)	**AVERAGE PD/ distance**
0	0.1264	0.1076	0.1667	0.1667	**0.1336**
5	0.1667	0.1153	1.3534	1.3534	**0.5451**
10	12.8345	0.47	2.1534	2.1534	**5.1526**
15	15.9565	1.3365	11.7344	11.7344	**9.6758**
20	16.1657	9.3675	11.734 3	10.03	**12.4225**
25	16.3986	11.5434	11.6743	9.68	**13.2054**
30	*16.4573*	13.8456	11.6434	9.6	**13.9821**
35	15.4298	13.6754	11.4343	9.51	**13.5132**
40	13.6445	13.4545	11.3243	9.2	**12.8078**
45	12.8546	13.6754	11.2643	9.16	**12.5981**
50	12.6546	13.0745	11.0843	9.04	**12.2 711**
55	13.2955	11.6754	11.0343	8.93	**12.0017**
60	12.0856	10.8455	11.1434	8.69	**11.3582**
65	11.2556	10.5354	10.9143	8.46	**10.9018**
70	11.0002	10.0557	10.8434	8.28	**10.6331**
Av. PD/BTS	**12.02174**	**8.918513**	**9.300167**	**7.732527**	**10.08014**

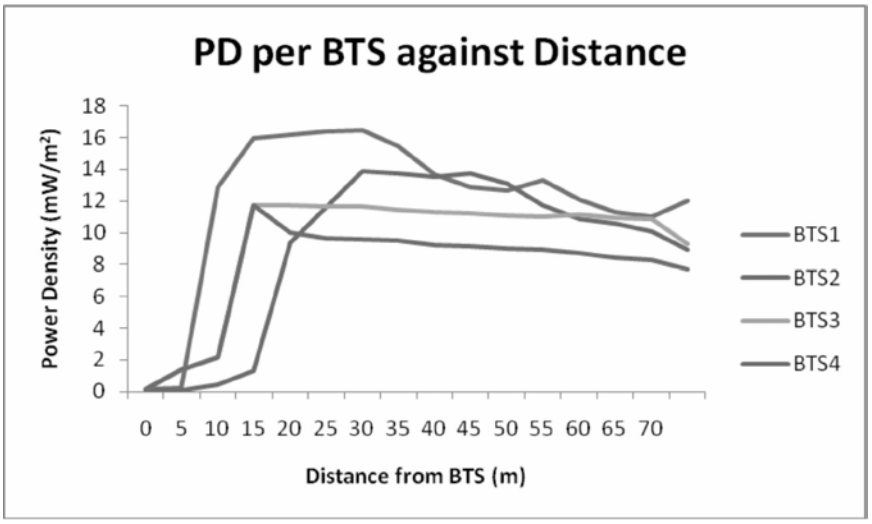


Figure 4a: Plot of PD at different Distances from BTS.

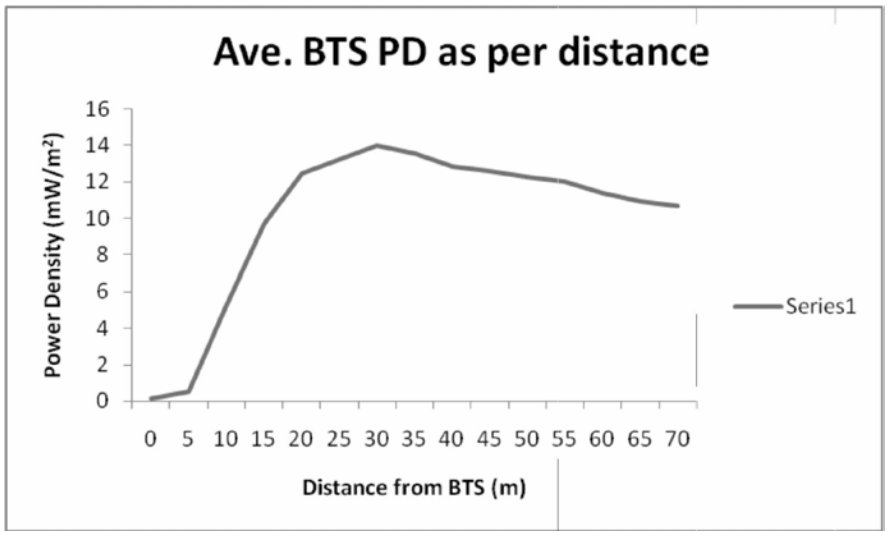


Figure 4b: Plot of Ave. PD of all BTSs at different Distances

b. BTS Power Density Variation with Time of the Day

Values of power density taken hourly at a ground distance of about 4m from each BTS are shown in Ta ble 3.2. Higher average PD (between 10 and 18mW/m^2) was noticed in the afternoon from 13.00 hours to 15.00 hours. This informs a suspicion of higher PD for heavy traffic (busier) hours. BTS 2 had the highest average daily PD at 6.150462 mW/m ^{2}followed by BTS 3 at 5.357572 mW/m $.^2$

Table 2.0: PD at diff times of the dayfor the diff. BTSs

	PD(m W/m^2)				
Time of the day	BTS1	BTS2	BTS3	BTS4	**Average**
8hrs	0.6789	0.1153	0.09354	0.3033	**0.29776**
9hrs	1.74	0.3033	0.1076	0.5871	**0.6845**
10hrs	2.051	0.9026	0.1568	0.835	**0.98635**
11hrs	9.08	1.027	0.205	2.831	**3.28575**
12hrs	10.51	1.153	6.79	5.52	**5.99325**
13hrs	13.55	7.793	13.55	6.12	**10.25325**
14hrs	17.05	21.077	20.04	11.17	**17.33425**
15hrs	2.051	17.05	10.51	9.74	**9.83775**
16hrs	1.418	3.1722	0.7265	0.3033	**1.405**
17hrs	0.5871	6.12	0.835	11.17	**4.678025**
18hrs	0.568	13.55	6.79	0.1076	**5.2539**
19hrs	0.6821	6.79	2.051	5.52	**3.760775**
20hrs	0.1153	0.9026	7.793	1.027	**2.459475**
Av. Value / BTS	**4.621646**	**6.150462**	**5.357572**	**4.248792**	**5.094618**

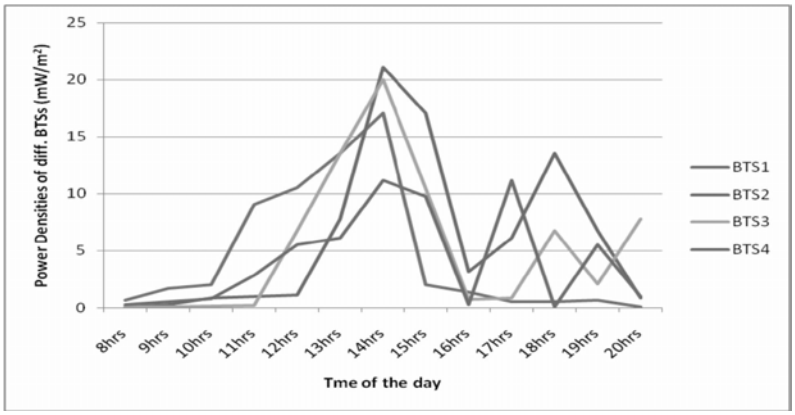


Figure 5a: Plot of PD for each BTS against diff. times of the day (superimposed).

The trend is easier to notice when we Plot Av. PD of all BTSs vs.time of a day in Fig 3.2b

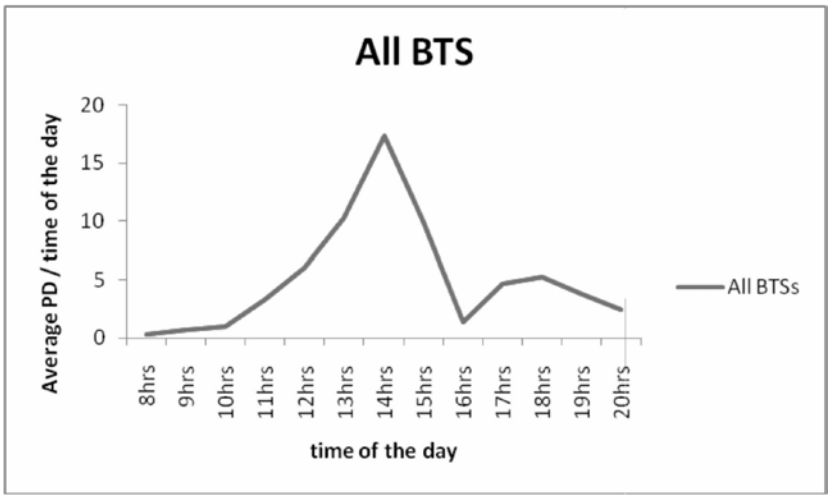


Figure 5b: Plot of Ave. PD of all BTSs vs. diff. times of the day

c. Phone Power Density

Table 3.3 shows Phone PD per second for a 56 seconds phone call using a Nokia5300 phone, about 60meters from BTS 2. Immediately after initiating the call the Phone PD rises to the peak P value after which it continues to oscillate as shown in Figure 3.3. Mobile Phone PD during call setup is much h igher than that of BTS. It fluctuates according to the intermittent speech and silence.

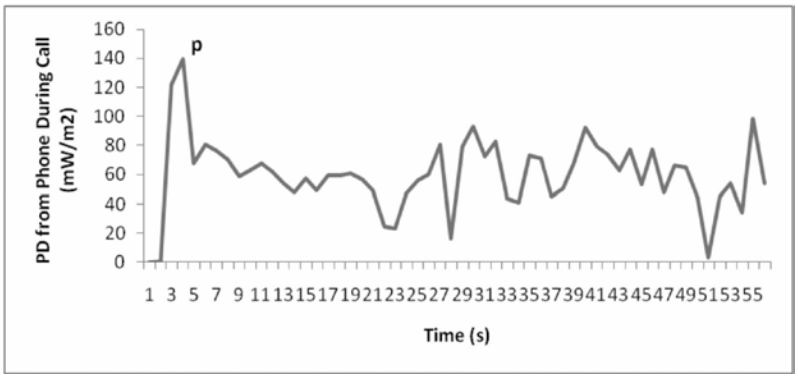


Figure 6: Plot of PD fluctuations during a Telephone Conversation

Table 3.3: Average Phone PD during a Telephone conversation

Time (s)	PD (mW/m^2)	Time (s)	PD (mW/m^2)
0	0.1567	28	79.3
1	0.763	29	93.2
2	122.1	30	72.4
3	139.7	31	82.7
4	68.0	32	43.8
5	80.7	33	41.0
6	76.7	34	*73.4*
7	70.7	35	71.0
8	59.1	36	45.5
9	63.3	37	50.9
10	68.0	38	67.9
11	62.5	39	92.7
12	54.2	40	79.7
13	48.0	41	73.7
14	57.3	42	63.3
15	49.3	43	77.3
16	60.0	44	53.3
17	59.5	45	77.3
18	61.3	46	48.3
19	56.6	47	66.6
20	49.6	48	65.2
21	24.7	49	44.3
22	23.3	50	3.9
23	47.3	51	45.6
24	56.4	52	54.0
25	60.2	53	34.7
26	81.2	54	98.5
27	16.3	55	54.2

V. Conclusion

The following conclusion arises from the results of this experiment: First; it is found that the measured values are in general consistent with their mathematically predicted ones. Second; at rare places, the measured values are found quite higher than calculated ones. Third; it is noticed that the measurements of radiation levels in our area of study due to mobile phone base stations as well as other RF broadcast sources are well below the reference levels established by the international health organizations, however, prudent avoidance of non-ionizing radiation is recommended.

It is to be noted that Mobile phones give much higher power density levels especially during call setup. Hence, for a start the public should be informed to keep mobile phones at reasonable distance from the body during call setup.

The result of this preliminary investigation shows that a more elaborate study and multidisciplinary survey is urgently required to either allay existing fears or lead to the development of needed national regulations, guidelines and exposure limits of RF radiations in urban areas. In the meantime, standard setting organizations and government agencies should continue to monitor the on-going experimental findings to confirm their validity and determine whether alterations in safety limits are needed in order to protect human health.

REFERENCES

C. Balanis, *Antenna Theory Analysis and Design*, Wiley, New York, 1997, pp. 3233.

Hare, *RF Exposure and You*, ARRL, Newington, CT, 1998, p. 3.2. - 4.7

ETSI TR 101 870 V1.1.1 (200111), *Fixed Radio Transmitter Site; Exposure to Nonionising Electromagnetic Fields; Guidelines for Working Conditions*, European Telecommunications Standards Institute.

Hubert, W.G. (2007) ; Non-ionizing radiation-specific biomarker research at the united states air force research laboratory, Life Science Systems and Applications Workshop, 2007. LISA 2007. IEEE/NIH Publication Date: 8-9 Nov. 2007, page(s): 221-224.

IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3kHz to 300GHz (Incorporates IEEE Std C95.1-1991 and IEEE Std C95.1a-1998), ANSI standard C95.1-1999, www.ansi.org

K. R. Foster, and J. E. Moulder, "Are Mobile Phones Safe?" *IEEE Spectrum*,

August 2000, pp. 2328.

M. Abdelati (2005) Journal of The Islamic University of Gaza (Natural Sciences Series) Vol.13, No.2, P129-146, 2005 available at http://www.iugaza.edu/ara/research/

Perez-Vega, C. Zamanillo, J.M. (2005); Measurements of non-ionizing radiation levels in an urban environment, The European Conference on Wireless Technology, 2005. Vol. 3-4 Oct. 2005, page(s): 205-208.

R. F. Cleveland, Jr., D. M. Sylvar, and J. L. Ulcek, *Questions and Answers about Biological Effects and Potential Hazards of Radio Frequency,* OET bulletin 56, 4th ed., FCC, August 1999, p. 5. http://www.fcc.gov/oet/info/documents/bulletins/#65

Tanwar V.S. (2008); Guidelines for control of Non-Ionized Radiation pollution, International Conference on Recent Advances in Microwave Theory and Applications, 2008. MICROWAVE 2008. Volume Issue 21-24 Nov. 2008 Page 557.

SCALABLE MULTIPLE DESCRIPTION CODING FOR 3D VIDEO OVER WIRELESS NETWORKS

Umar Abubakar
Department of Electronic & Computer Engineering
Brunel University, Kingston Lane
Uxbridge, UB8 3PH, London, UK
Umar.Abubakar.Sadiq@brunel.ac.uk

Abdul H. Sadka
Electronic & Computer Engineering
Brune University, Kingston Lane
Uxbridge, UB8 3PH, London, UK
Abdul.Sadka@brunel.ac.uk

ABSTRACT
In this paper, we propose an MDC schemes for stereoscopic 3D video transmission over LAN networks. In the literature, MDC has previously been applied in 2D video but not so much in 3D video. The proposed algorithm enhances the error resilience of the 3D video using the combination of even and odd frame based MDC while retaining good temporal prediction efficiency for video over error-prone networks. Improvements are made to the original even and odd frame MDC scheme by adding a controllable amount of side information to improve frame interpolation at the decoder. The side information is also sent according to the video sequence motion for further improvement. The performance of the proposed algorithms is evaluated in error free and error prone environments especially for wireless channels. Simulation results show improved performance using the proposed MDC at high error rates compared to the single description coding (SDC) and the original even and odd frame MDC.

I. Introduction

Immersive media will be the next potential candidate in multimedia communication applications. The technological advancement of stereoscopic video capture, compression and display technologies enables the scaling of existing video applications into stereoscopic applications. 3D video allows users to feel the presence of the persons they are communicating with or be truly immersed in the event they are watching. 3D video is mainly being used in entertainment applications such as in cinema. To be able to have 3D video on consumer devices, a lot of research has been carried out on 3D video, with the aim of simple provision of 3D contents to users and of exploring the potential for 3D video communication [1] [2]. Over the years, many manufacturers have developed 3D displays that offer auto-stereoscopic 3D displays, allowing multiple users to view 3D content at the same time without 3D glasses [3]. 3D mobile phones are also being built, such as in [4], allowing communication in 3D.

When 3D video is compressed and transmitted over error prone channels, error propagation due to packet loss leads to poor visual quality. Hence, error resilience techniques for 3D video are needed. MDC is an effective way to combat burst packet losses in wireless and Internet networks. MDC is a promising approach for video application where retransmission is unacceptable [5]. MDC divides a source into two or more correlated layers. This means that a high-quality reconstruction is available when the received layers are combined and decoded, while a lower, but still acceptable quality reconstruction is achievable if only one of the layers is received. Hence, with 3D video MDC, users can have a 3D visual communication system that is robust to packet losses.

Several MDC methods have been proposed in the literature. One of the most popular one is the multiple state video coding (MSVC) proposed in [6]. This method splits the input video into sequences of even and odd frames, each being coded as an independent description.

In this paper, the MSVC technique is used to produce the MDC for stereoscopic 3D video. Other MDC types are potentially more efficient, but MSVC is computationally simple, and standard compliant bit streams can be produced. It also introduces no mismatch when only one of the

descriptions is received because the decoder uses the same prediction signal as the encoder for each generated description.

The rest of this paper is organized as follows, proposed MDC for stereoscopic 3D video in Section II. The performance of the algorithms is investigated through extensive simulation in error free and error prone channels in Section III. The paper is finally concluded in Section IV.

II. Proposed Multiple Description 3d Video Coding

A. Even and odd MDC (MDC-EO)

The general block diagram for even and odd frame based MDC (MDC-EO) for 3D video is shown in Fig. 1. It is built upon the existing MPEG-4 video coding standard that has Multiple Auxiliary Component (MAC) tools to support depth information. There are texture part that includes luminance (Y) and chrominance (U and V) components, and also depth part (also called alpha plane) for each macro block in an even/odd video frame. The even and odd frames are predicted from previous even and odd frame respectively as in multi-sate encoder [6]. The even and odd frames are encoded into streams 1 and 2 respectively.

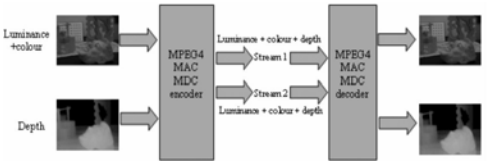


Fig. 1: The proposed MDC-EO encoder and decoder block diagram

The content of the two bit streams at the frame level for texture and depth information is shown in Fig. 2. Streams 1 and 2 contains even and odd frames respectively. The content of the two bit streams at the macro-block level for texture and depth information is shown in Fig. 3. The alpha information is actually the depth information.

If both even and odd streams are received, the decoder can reconstruct the coded sequence at full temporal resolution. If only one stream is received, the decoder can still decode the received stream at half the original temporal resolution. Since the even frames are predicted from previous even frames (independent from odd frames), there will be no mismatch if one of the streams are lost at the decoder.

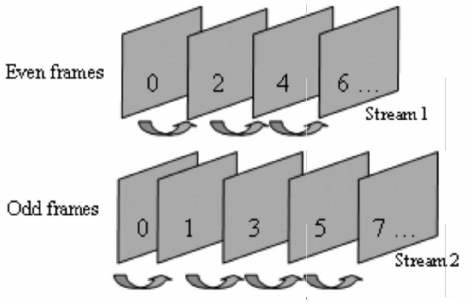


Fig. 2: Contents of stream 1 and 2 at frame level

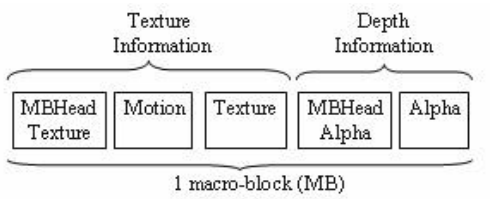


Fig. 3: Contents of stream 1 and 2 at macro-block level

the decoder can decode at full resolution by interpolating between the received frames as in [6]. Frame interpolation is performed using (1).

$$I_{ip}(i,j) = (I_{prev}(i,j) + I_{fut}(i,j))/2 \quad (1)$$

where $I_{ip}(i,j)$ is the frame to be interpolated at pixel location (i,j), $I_{prev}(i,j)$ is the previous frame and $I_{fut}(i,j)$ is the future frame. This average frame interpolation is used in the simulation when there are errors in a frame. Motion compensated frame interpolation can also be used to obtain impro ved performance as in [6] but at the expense of decoder complexity.

The even and odd MDC is developed on top of the MPEG-4-MAC codec. A frame buffer is used to store the previous $(n-2)$reconstructed frame, $F'(n-2)$. If the input is an even frame, then the coded residual, $Ecq(n)$ is appended into stream 1 and vice versa for the odd frame.

B. Even and odd MDC with side information (MDC-EOS)

MDC-EO in Section III-A performs better than SDC in a high error rate situation. If for example, one stream is corrupted, it can be replaced with the interpolated frames of the other stream provided

descriptions is received because the decoder uses the same prediction signal as the encoder for each generated description.

The rest of this paper is organized as follows, proposed MDC for stereoscopic 3D video in Section II. The performance of the algorithms is investigated through extensive simulation in error free and error prone channels in Section III. The paper is finally concluded in Section IV.

II. Proposed Multiple Description 3d Video Coding

A. Even and odd MDC (MDC-EO)

The general block diagram for even and odd frame based MDC (MDC-EO) for 3D video is shown in Fig. 1. It is built upon the existing MPEG-4 video coding standard that has Multiple Auxiliary Component (MAC) tools to support depth information. There are texture part that includes luminance (Y) and chrominance (U and V) components, and also depth part (also called alpha plane) for each macro block in an even/odd video frame. The even and odd frames are predicted from previous even and odd frame respectively as in multi-sate encoder [6]. The even and odd frames are encoded into streams 1 and 2 respectively.

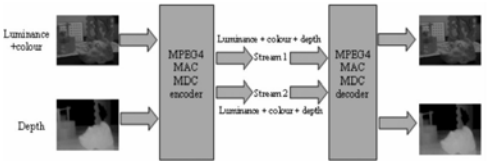


Fig. 1: The proposed MDC-EO encoder and decoder block diagram

The content of the two bit streams at the frame level for texture and depth information is shown in Fig. 2. Streams 1 and 2 contains even and odd frames respectively. The content of the two bit streams at the macro-block level for texture and depth information is shown in Fig. 3. The alpha information is actually the depth information.

If both even and odd streams are received, the decoder can reconstruct the coded sequence at full temporal resolution. If only one stream is received, the decoder can still decode the received stream at half the original temporal resolution. Since the even frames are predicted from previous even frames (independent from odd frames), there will be no mismatch if one of the streams are lost at the decoder.

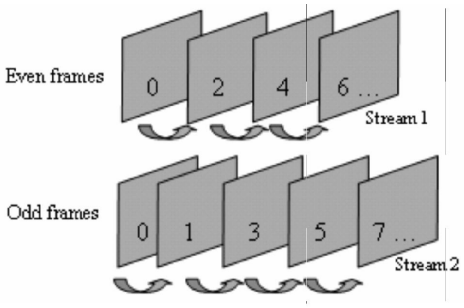


Fig. 2: Contents of stream 1 and 2 at frame level

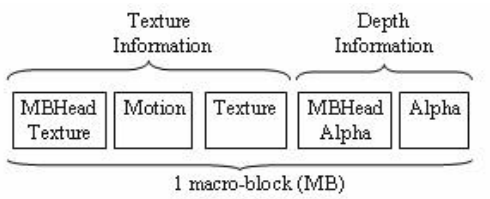


Fig. 3: Contents of stream 1 and 2 at macro-block level

the decoder can decode at full resolution by interpolating between the received frames as in [6]. Frame interpolation is performed using (1).

$$I_{ip}(i,j) = (I_{prev}(i,j) + I_{fut}(i,j))/2 \quad (1)$$

where $I_{ip}(i,j)$ is the frame to be interpolated at pixel location (i,j), $I_{prev}(i,j)$ is the previous frame and $I_{fut}(i,j)$ is the future frame. This average frame interpolation is used in the simulation when there are errors in a frame. Motion compensated frame interpolation can also be used to obtain impro ved performance as in [6] but at the expense of decoder complexity.

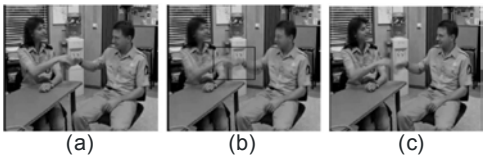
The even and odd MDC is developed on top of the MPEG-4-MAC codec. A frame buffer is used to store the previous $(n-2)$reconstructed frame, $F'(n-2)$. If the input is an even frame, then the coded residual, $Ecq(n)$ is appended into stream 1 and vice versa for the odd frame.

B. Even and odd MDC with side information (MDC-EOS)

MDC-EO in Section III-A performs better than SDC in a high error rate situation. If for example, one stream is corrupted, it can be replaced with the interpolated frames of the other stream provided

that the other stream is not in error. The interpolation produces a blurred image, especially if the difference between the frames used in the interpolation is large as shown in the example in Fig. 4. It also produces large PSNR variation between frames when errors occur. The frame PSNR is low for the interpolated frame and high for the uncorrupted frame in the other stream. The frame PSNR for the following frames predicted from the interpolated frame are also affected by the error.

To reduce the PSNR variation and the blurring effect, it is proposed to send controllable side information on top of the MDC-EO at the expense of reduced coding efficiency in error free environments.



(a) (b) (c)

Fig. 4: Frame Interpolation (a) previous frame (b) blurred interpolated frame (especially in the highlighted box) (c) next frame

The block diagram for our proposed MDC for 3D video (MDC-EOS) is shown in Fig. 5 (encoder) and Fig. 6 (decoder). The even and odd frames are encoded into streams 1 and 2 respectively. Each frame contains texture, motion and depth data. Side information for even and odd stream frames is also appended to their cor responding streams.

At the encoder, the central encoder is used to produce even or odd frames. The frame buffer is used to store the reconstructed frames, *F'(n-1)* and *F'(n-2)*. Even frames are predicted from previous reconstructed even frames and vice versa for odd frames.

Side encoder 1 and 2 are used to produce the side information for even and odd stream respectively. In side encoder 1, frame interpolation is performed between the current reconstructed even frame, *Fe'(n)* and the previous reconstructed even frame, *Fe'(n-2)*. Equation (1) is used to produce the interpolated frame. Only side encoder 1 is shown in Fig. 5, but side encoder 2 has similar structure.

The interpolated frame is subtracted from the previous reconstructed frame, *F'(n-1)* and the difference, *Ee(n)*, which is the side information, is coded using DCT and quantisation. Hence, the redundancy introduced can be controlled by varying the quantisation parameter (Q1) of the side information.

At the decoder in Fig. 6, the central decoder is used to decode the central information (even or odd frames). If for example only an even stream is received, side decoder 1 is invoked to recover the odd frame, *Fo'(n)*. The results of frame interpolation of the previous reconstructed even frame *Fc'(n-2)*, and previous reconstructed frame *Fc'(n)*, is added to the decoded side information, *Ee'(n)*, to get *Fo'(n)*.

In this way, if the quantisation parameter of the side information (Q1) is low, a high quality interpolated frame is produced at the decoder at the expense of higher redundancies. On the other hand, if Q1 is high, a reduced quality interpolated frame is produced but at lower redundancies. These features allow us to control the amount of redundancies needed for the MDC coder. These operations are extended to include the depth data. The content of the two bit streams at the macro block level for texture and depth information is

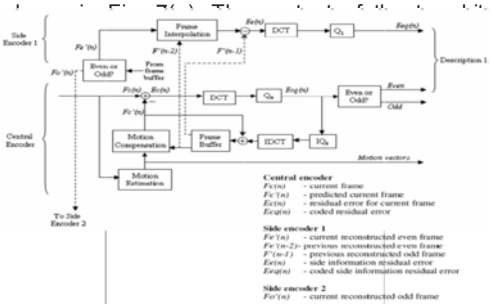


Fig. 5. Block diagram of the proposed MDC-EOS encoder

It is mentioned in [8] that one of the redundancies in a predictive multiple description video coder is any bit-rate used to describe side information in excess of that used by an SDC. For the MDC-EOS method, this extra signal is called *Ee(n)* (*Eon(n)* for odd frame), which is the difference between the

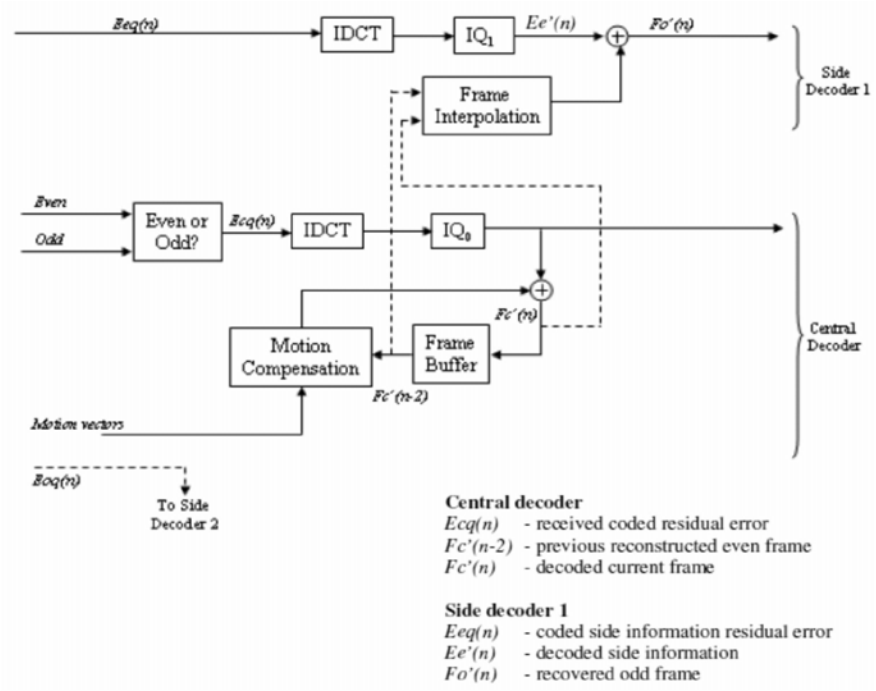


Fig. 6. Block diagram of the proposed MDC-EOS decoder

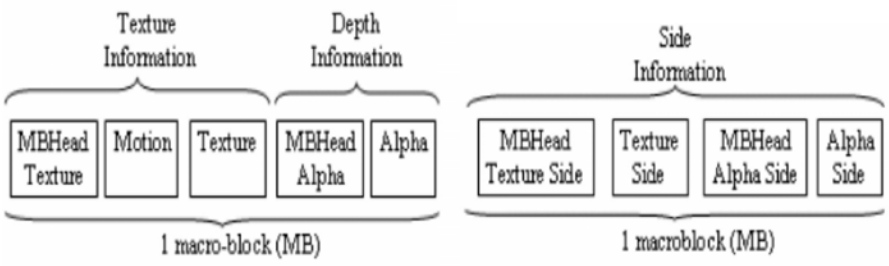


Fig. 7. Content of bit stream at macro-block level for (a) Central information and (b) Side information

In other words, this side information is ignored when both descriptions are received, similar to [7]. Hence, it is proposed in Section III-C to use *Ee(n)* in error free conditions.

C. Even and odd MDC with side information and prediction (MDC-EOSP)

In both MDC-EO and MDC-EOS method, frame *n* is predicted from frame *n-2*, causing a decrease in coding efficiency in the central prediction due the usage of predictor that is less efficient than the SDC predictor (in SDC, frame *n* is predicted from frame *n-1*). Hence we proposed to use the side information, *Ee(n)*, to improve the central prediction in error free conditions.

The detailed block diagram of MDC-EOSP is shown in Fig. 8. Compared to MDC-EOS, there is a new block called P in the central encoder. The decoded *Ee(n)* is added to the interpolated frame to obtain *Fip'* and is used for the prediction of frame *n*. Using the idea of multiple predictions as in [22], frame *n* is predicted from the superposition of *Fip'* and *F'(n-2)* frame.

For *n>=4*, *n* is predicted from P, which is defined in (2),

$$\mathbf{P} = a_1 F_{ip}' + a_2 F'(n-2) \quad (2)$$

Where a_1 and a_2 are the weighting factors for F_{ip}' and *F'(n-2)* respectively. F_{ip}' is the interpolation of frames *n-2* and frames *n-4* plus the difference of the interpolated frame and the reconstructed odd frame.

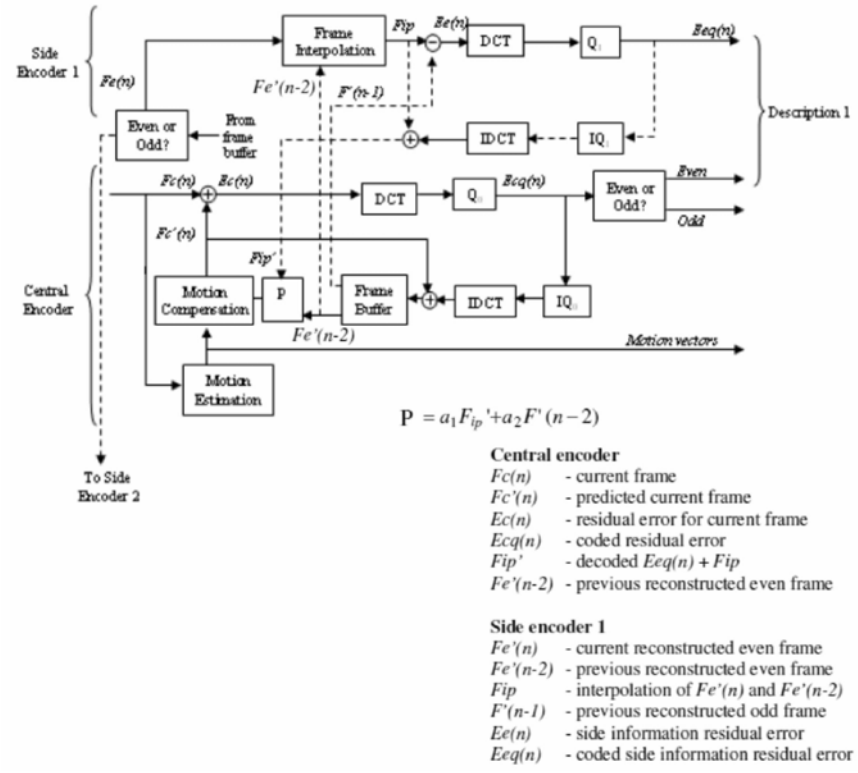


Fig. 8. Block diagram of the proposed MDC-EOSP encoder

In (2), $F'(n-2)$ is $Fe'(n-2)$ if the current frame is an even frame.
The sum of a_1 and a_2 must be equal to 1 following the approach of leaky predictor in [22]. Note that F_{ip}' is equal to the reconstructed $n-3$ frame if quantisation and inverse quantisation block are absent. Basically, for $n=4$, the prediction comes from a weighted sum of reconstructed frames $n-3$ and $n-2$. The prediction is applied to frame $n>=4$ because the interpolated frame of $n-3$ is available only from $n=4$. As an example, for $n=3$ frame, the interpolated frame is frame $n=0$, which is not available. a_1 and a_2 values can be adjusted to provide different weighted sums of prediction. It is found from experiments, that a_1 =0.1 and a_2 =0.9 gives the best result in terms of PSNR and total bit rate, which means more weight to frame $n-2$.

The side encoder section performs frame interpolation between the current even frame, $Fe(n)$, and the previous even frame, $Fe'(n-2)$ to produce Fip. The difference between the interpolated frame, Fip and the previous reconstructed frame (or the odd frame), $F'(n-1)$, is coded using DCT and Q1 (side information quantiser) to produce $Eeq(n)$. Decoded $Eeq(n)$ is added back to Fip to form Fip'. Ideally, $Ee(n)$ should be added back to Fip, but to avoid mismatch prediction at the decoder, decoded $Eeq(n)$ is used. In other words, $Ee(n)$ is not available at the decoder, but decoded $Eeq(n)$ is available to be added to Fip.

The difference between this method and [7] is block P which is located before the motion compensation process. Also with the proposed configuration, there is no motion vector sent as side information, and no mismatch signal needs to be coded as the even and odd frames are separately predicted.

Application of the proposed method to existing video coder will involve minimal addition of side encoder and decoder for the purpose of frame interpolation. The frame interpolation block only requires simple addition and division. The central encoder will require memory of previous $n-2$ frame which is made available by the current video coding standard such as H.264.

D. Even and odd MDC with adaptive side information

It was found that MDC-EOS and MDC-EOSP have reduced coding efficiency due to the large redundancies in the side information. Hence, it is proposed in this section to send the side information adaptively according to the motion in the sequence. If the motion is larger than a threshold, side information is appended to the bit stream. If the motion is smaller than the threshold, no side information is sent. This is because interpolation does not cause much degradation at low motion.

A method in [9] is used to estimate the amount of motion between frames. It exploits the data partitioning mode of MPEG-4 that placed the motion in first partition of the video packet. A value named 'A', which is the proportion of the video packet size occupied by the first partition, can be related to the amount of motion. 'A' can be expressed as:

$$A = \frac{Y_{MB}}{X_{MB} + Y_{MB}} \quad (3)$$

where Y_{MB} is the average number of bits per macro block in the first partition, and X_{MB} is the average number of bits per macro block in the second partition. Fig. 9 shows the variation in 'A' over the Interview sequence used in this paper for 300 frames. The period of high motion can be detected through the large values in 'A'. In the Interview sequence for example, this period is after about frame 70 when the two subjects shake their hand.

The side information for MDC-EOS and MDC-EOSP is then sent according to this 'A' value. The MDC-EOS and MDC-EOSP are now known as MDC-EOAS and MDC-EOASP respectively. If the value of 'A' is bigger than a pre-determined threshold, then the side information is sent. The threshold value is determined from Fig. 9. It was selected so that only minimum needed amount of side information is sent. For Orbi sequence the threshold value is set to 0.34 and for Interview threshold value is 0.15.

III. Simulation Results And Discussion

A. Error free environment

In order to evaluate the coding performance of the encoder in error free environments, we plotted a rate distortion curve for the Orbi sequence. The tests are carried out using CIF format (352x288).

The basic encoding parameters are: 300 frames, IPPP… sequence format (only the first frame is encoded as an I-frame and all others are encoded as P-frames), 30 frames/s original frame rate, variable length coding (VLC) and without error resilience. The quantisation parameter (QP) in the configura
range sho
distortion
measured
against th
streams a
central dis

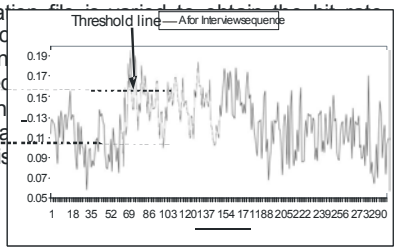


Fig. 9. Variation of A, the proportion of a packet occupied by the first partition, over the Interview sequence

Fig. 10 shows the rate-distortion curves for Orbi colour and depth sequences for SDC, MDC-EO, MDC-EOAS and MDC-EOASP. For MDC-EOAS and MDC-EOASP, the quantisation parameter for the side information is set to 20. The rate distortion curve is quite close to MDC-EO because most of the side information is not sent as it is below the threshold. Hence, more bits are available to send the central information using a lower quantisation parameter.

Fig. 11 and Fig. 12 show the improvement obtained by MDC-EOAS and MDC-EOASP respectively for the luminance only. Same improvement is obtained with the depth information. At the same bit rate, the MDC algorithms with adaptive side information are about 1 to 2 dB better than without the adaptive side information.

B. Same Bit Rate Experiment in Error Prone Environment

The compressed 3D video is transmitted over a simulated wireless LAN channel. The WLAN error patterns used in this paper are obtained from the simulated WLAN channel described in [32].

The system parameters for the WLAN IEEE802.11g are: 1) Carrier Modulation: OFDM, 2) FFT Size: 64, 3) Carrier Frequency: 2.4 GHz, 4) Sampling Rate: 20 MHz, 5) Channel Coding: Punctured Convolutional Coding. The combination of channel coding and modulation schemes produces several transmission modes with different data rate as up to 54 Mbit/s. Several channel models are adopted with different environments and delay spreads. Rayleigh fading mobile channel i s used and the environment characteristics include small office, medium office, large office and outdoor with or without LOS.

If an error occurs in a frame of one stream of the MDC-EOAS and MDC-EOASP algorithm, the frame is replaced by the interpolated frame from its

Table I. Quantisation parameter for Interview sequence and the corresponding error free PSNR

Encoder	Texture		Average PSNR	Depth		Average PSNR	QP Side
Frame	I	P		I	P		
SDC	12	7	35.30	13	8	38.21	N/A
MDC-EO	5	9	34.16	8	12	35.83	N/A
MDC-EOAS	3	10	33.99	6	15	34.98	15
MDC-EOASP	4	10	33.99	4	16	35.14	15

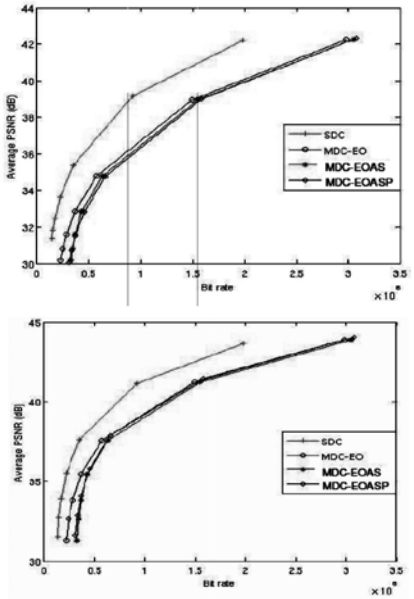


Fig. 10. Rate-Distortion curves for 'Orbi' sequence (a) Colour image sequence (b) Depth image sequence

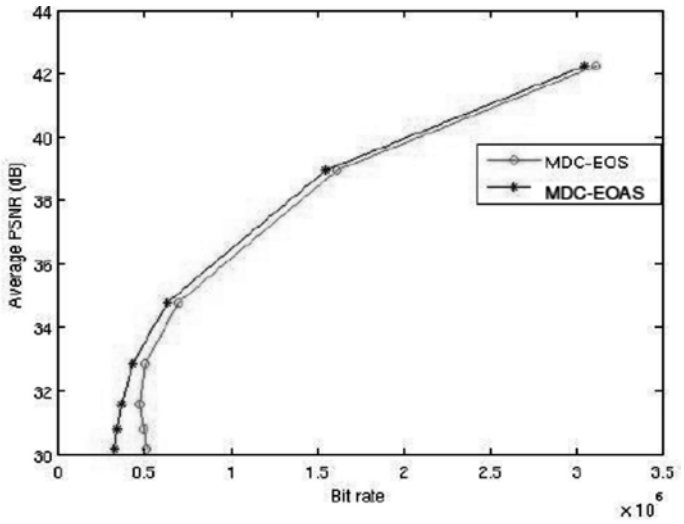


Fig.11. Rate-Distortion curves for MDC-EOS and MDC-EOAS for the luminance of 'Orbi' sequence

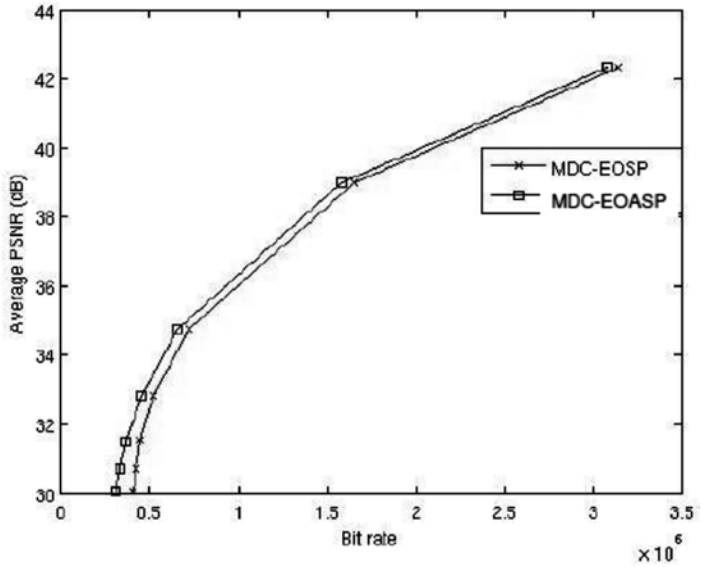


Fig.12. Rate-Distortion curves for MDC-EOSP and MDC-EOASP for the luminance of 'Orbi' sequence

the other stream plus the adaptively received side information. In this section the side information may be corrupted by the error. The QP used in the simulation for SDC, MDC-EO, MDC-EOAS and MDC-EOASP to achieve 512 kbit/s and its corresponding error free PSNR is shown in Table I for Interview sequence.

Fig. 13 shows the results for the experiments for the Interview sequence. From the mean PSNR results, it can be seen that for the Interview sequence, MDC-EOASP result is comparable to MDC-EOAS for luminance and slightly better for depth. MDC-EOAS and MDC-EOASP is also better than SDC and MDC-EO at packet loss above 10%. At 20% packet loss, MDC-EOASP mean PSNR is about 0.5 dB better than SDC for luminance and about 3 dB better than SDC for depth.

The small gain in luminance achieved by MDCs algorithms in error prone environment is probably due to the corruption of both MDC streams at the same time, which, violate MDC assumptions. Nevertheless, more gain is achieved in depth than luminance. Due to its content, the corrupted frame for depth data that is concealed or replaced using frame interpolation and the side information in MDC-EOASP is better than corrupted macro block in a frame of SDC that was replaced with the corresponding macro block in the previous frame. This factor makes the average PSNR of MDC-EOASP is largely better than SDC for depth information, but slightly better than SDC for luminance information in high error rates.

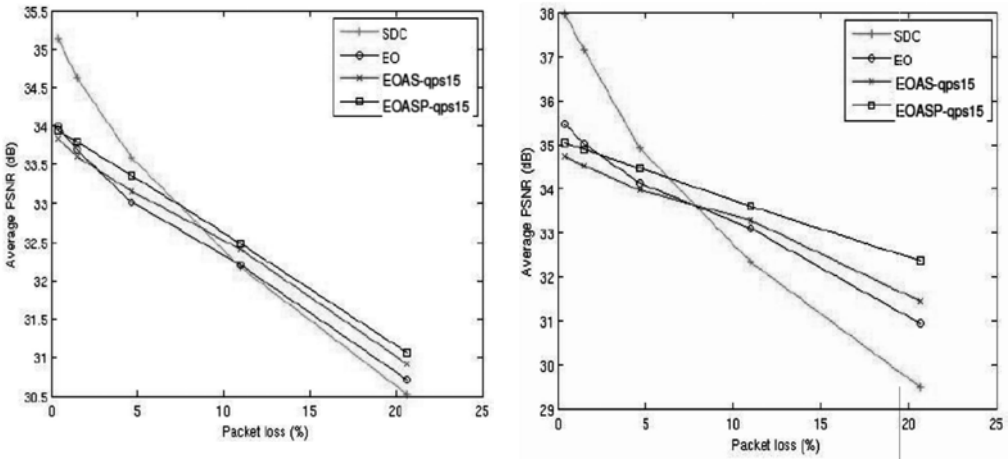
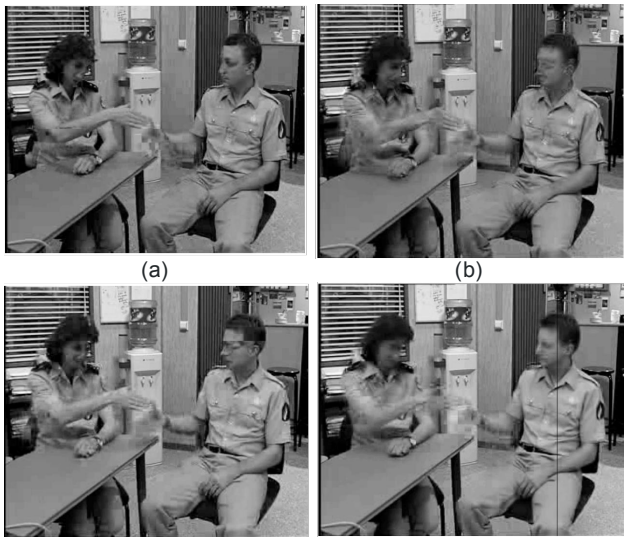


Fig. 13. Mean PSNR vs packet loss for Interview (a) luminance and (b) depth

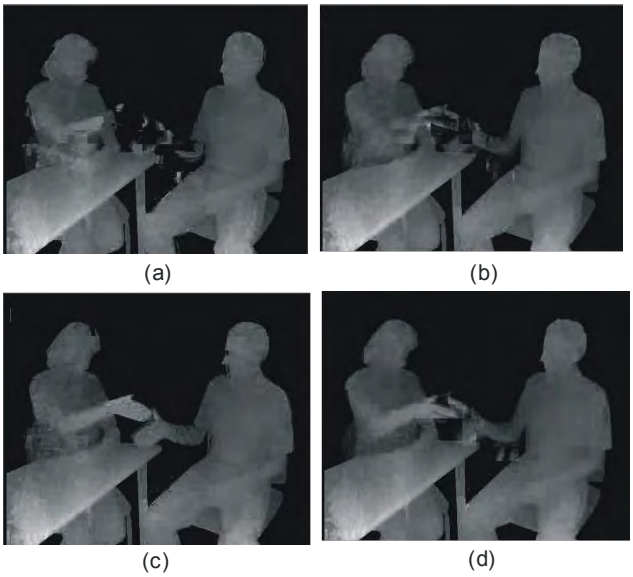
Error free performance of MDC-EOAS and MDC-EOASP are comparable to MDC-EO because their coding efficiency is quite close as the side information is adaptively sent to the decoder. A similar pattern of results can be observed in the Orbi sequence. The luminance subjective quality of frame 78 for the Interview sequence when subjected to 20% packet loss is shown in Fig. 14. The luminance PSNR for that frame is 26.79 dB, 28.54 dB, 31.17 dB and 31.33 dB for SDC, MDC-EO, MDC-EOAS and MDC-EOASP respectively. The depth frame PSNR for Fig. 15 is 24.24 dB, 27.47 dB, 32.18 dB and 32.10 dB for SDC, MDC-EO, MDC-EOAS and MDC-EOASP respectively. The 3D stereoscopic video quality can be obtained from the combination of the luminance, colour and



(a) (b)

(c) (d)

Fig. 14. Subjective quality Interview - at 20% packet loss of luminance for (a) SDC and (b) MDC-EO (c) MDC-EOAS and (d) MDC-EOASP



(a) (b)

(c) (d)

Fig. 15. Subjective quality Interview - at 20% packet loss of depth for (a) SDC and (b) MDC-EO (c) MDC-EOAS and (d) MDC-EOASP

IV. CONCLUSION

In this paper, we proposed MDC-EOS & MDC-EOSP. The side information in MDC-EOS and MDC-EOSP contributes to the high redundancy of these algorithms hence decrease in coding efficiency. We have proposed in this paper to send the side information adaptively according to the motion in the sequence. Large motion will make the algorithm sends the side information at low motion no side information is sent. We have also proposed a novel MDC-EOAS and MDC-EOASP to enhance error resilience by sending the adaptive side information.

The coding efficiency of these two algorithms is better than MDC-EOS and MDC-EOSP and very close to MDC-EO. The error prone performance of MDC-EOAS and MDC-EOASP is better than SDC and MDC-EO at high packet loss objectively and subjectively. The gain achieved by MDC-EOAS and MDC-EOASP for depth is larger than the gain achieved for luminance. As a conclusion, MDC with side information is promising approach to combat channel errors for stereoscopic 3D video transmission, but the side information should be carefully sent as it can cause huge redundancies. It can be sent adaptively according to motion, and network conditions.

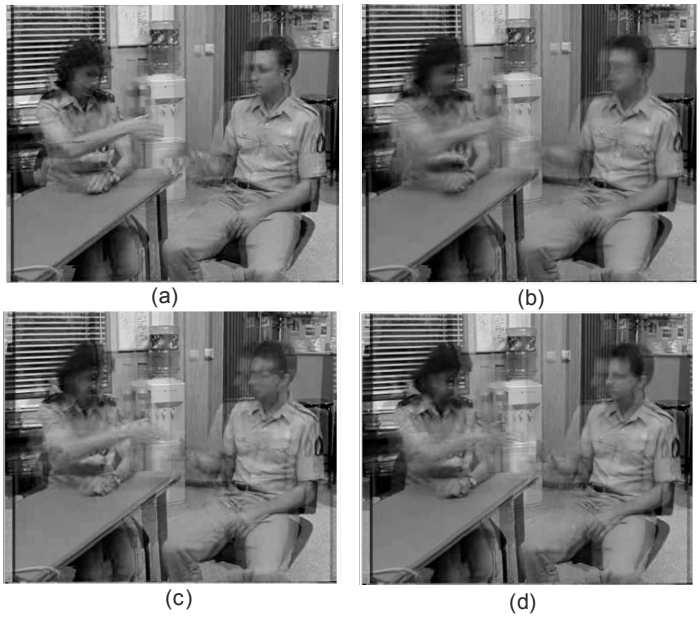


Fig. 16. Subjective quality Interview - at 20% packet loss of stereoscopic 3D video for (a) SDC (b) MDC-EO (c) MDC-EOAS (b) MDC-EOASP

ACKNOWLEDGMENT

The work presented was sponsored by Petroleum Technology Development Fund (PTDF) under the Overseas Scholarship Scheme (OSS). We thank the anonymous reviewers for their invaluable comments that will significantly help improve the quality of this paper.

REFERENCES

- A. Redert, M. O. d. Beeck, C. Fehn, W. Ijsselsteijn, M. Pollefeys, L. V. Gool, E. Ofek, I. Sexton and P. Surman, "ATTEST: Advanced three-dimensional television system technologies," *in proc. of the 1st Int. Symp. on 3D Data Processing and Transmission (3DPVT'02)*, Padova, Italy, June 2002.
- http://www.3dtv-research.org/, 3DTV NoE, Last visited: March 2009.
- A. Sullivan, "3-deep," *IEEE Spectrum* vol. 42, no. 4, pp. 22-27, April 2005.
- http://www.3dphone.org/, 3DPHONE-Project, Last visited: March 2009.
- Y. Wang, A. R. Reibman and S. Lin, "Multiple description coding for video communications," *IEEE Proc.*, vol. 93, no. 1, pp. 57-70, January 2005.
- J. G. Apostolopoulos, "Error-resilient video compression via multiple state streams," *in Proc. of Int. Workshop on Very Low Bit rate Video Coding, VLBV99*, Kyoto, Japan, October 1999.
- H.A. Karim, C. Hewage, S. Worrall, A. Kondoz, "Scalable multiple description video coding for stereoscopic 3D", *IEEE Trans. Consumer Electronics*, vol. 54, No. 2, pp. 745 752, May 2008.
- S. T. Worrall, A. H. Sadka, P. Sweeney and A. M. Kondoz, "Motion adaptive intra refresh for MPEG-4", *Electronics Letters*, Vol. 36, No. 23, pp. 1924-1925, November 2000.
- SUIT Project, http://suit.av.it.pt/index.htm, Last visited: June 2008.

WIDE AREA NETWORK EFFICIENCY THROUGH OPTIMIZATION OF KEY PERFORMANCE INDICES

John S.N.
Department of Electrical and Information Engineering,
Covenant University, Ota, Nigeria
johnsam8@hotmail.com
&
Akinade B.A. and Chukwu I.S.
Department of Electrical and Electronics Engineering,
University of Lagos, Akoka, Yaba, Lagos, Nigeria
bayonleakinade@yahoo.com, sunnymentus@yahoo.com

ABSTRACT
This paper discuss the implementation of an optimized remote network, using latency, bandwidth and packet drop rate as key performance indicator (KPI) to measure network performance and quality of service (QoS). We compared the network performance characteristics derived on the Wide Area Network (WAN) when using Fiber, VSAT and Point-to-Point VPN across the internet respectively as the network infrastructure. Network performance variables are measured across various links (VAST, Fiber and VPN across the internet) and the corresponding statistical data is analyzed and used as base-line for the optimization of a corporate network performance. The qualities of service offered on the network before and after optimization are analyzed and use to determine the level of improvement on the network performance achieved.

I. Introduction

Most network users often attribute the problem of slow network and poor quality of service to lack of sufficient bandwidth, which is not generally correct. Sometimes, poor network performance can be traced to network congestion, high packet drop rate, chatty protocols and high latency [1] among others. This paper uses the technique of network base lining to obtain the best combination of network metrics that can enhance the performance of network resources up to maximum data flow energy (MDFE) which allows maximum amount of data to be sent in the fastest amount of time using the optimum bandwidth capacity [2]. We assume that the Server and client processing time are minimal relative to the total time it takes to complete a transaction. Hence, it attributes the cause of service transaction delays to WAN delay. It try to find out the causes of poor quality of service across the WAN and makes recommendation or how to implement efficient remote network with better quality of service (QoS) [3]. In the methodology, three sets of parallel links (Fiber, VSAT and Point-to-Point VPN across the internet) of equal bandwidth are set up between two geographically separate locations. Files of different size were sent between the locations across each link respectively. The key performance indicators (latency, bandwidth and packet drop rate) [4, 5, 6] were recorded using standard monitoring tools to monitor each of the experiment performed.

Graphical analysis of the data obtain from the link performance were used as the bases for the conclusion made in this paper using latency, bandwidth and packet drop rate as key performance indicator for network performance.

II Network Performance Criteria

A network can be rated as performing when end-users are able to access applications and carry out given task without undue perceived delay, error or irritation. The primary measure of user perceived performances are availability and completion time. It is important to identify whether utilization factors, collision rate or bandwidth congestion are responsible for network problems [7]. In general, the performance of a computer network can be divided into three sections for easy analysis and trouble-shooting:

? The performance of the application,

? The performance of the servers,
? The performance of the Network infrastructures.

Based on end-user perception of the network, we can also view the network performance in terms of service oriented and efficiency oriented as shown in the Fig. 1.

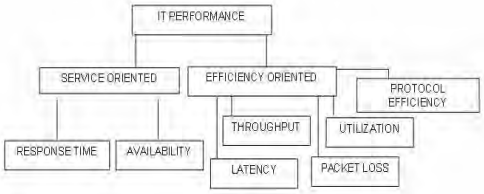


Fig:1. Block diagram of IT performance

It is noted that, service oriented performance measures how well an application provides service to the customer, whereas efficiency oriented performance measure how much of available channel resource are actually used to provide end-user request. This tend to measure how much of available channel resources are being wasted due to inefficiencies inherent in the communication channel.

III. Methodology

The performance of a wide area network can be verified by studying the effect of network contribution to transac tion time (NCTT) on the network [3].

In a high performance network, TCP packets are transferred across the WAN with minimal delay (low latency) within the optimum load limit. When the network becomes overloaded, congestion sets in and TCP packets are drop and consequently re-transmitted which adds to the total time required to complete a transaction in a busy network [8]. Network contribution to transaction time is the sum of the round-trip times necessary to complete a given transaction type, plus the time for recovery from any lost packets during the transaction [3]. The network contribution to transaction time can be calculated as:

$$NCTT = E * RTT + L * RTO$$

where, E number of round-trip exchange necessary to complete the transaction,
RTT round-trip time for packet transfer,
L number of round-trips exchanges that experience packet loss,
RTO retransmission time-out

The number of losses experienced in the course of a transaction depends on round-trip packet loss probability, *p*.

For a two-ways traffic path, loss probability is given by:

$$p = 1 - (1 - p_{network})(1 - p_{otherway})$$

If each round-trip exchange takes *A* attempt to complete successfully, and the client attempts to complete a transaction given as:

$$A = \sum_{i}^{E} A_i$$

, then

Expected value, *A* is given by:

$$\Pr ob(A_i = a) = p^{a-1}(1-p)$$

This converges as:

$$E\{A\} = E_x \sum_{a=1}^{\infty} axp^{a-1}(1-p) = \frac{E(1-p)}{p} \sum_{a=1}^{\infty} axp^{a}$$

A is equal to the constant *E* plus a random number of losses *L*, so $E\{A\} = \frac{E}{1-p}$ for $0 < p < 1$

, and the average

$$E\{A\} = E + E\{L\}$$

$$E\{L\} = \frac{E}{1-p} - E = E(\frac{p}{1-p})$$

Note that the probability distribution of NCTT is a set of discrete values: {(E x RTT), {(E x RTT) + (1 x RTO)}, {(E x RTT) + (2 x RTO)},

$$E\{NCTT\} = E * RTT + [E\{L\} * RTO]$$

The performance of the WAN and remote network can also be viewed in terms of its effective throughput. Throughput is the quality of error-free data that can be transmitted over a specified unit of time [9].

Also, , bps

$$Throughput = \frac{Bandwidth}{Maximum\ segment\ size}, bps$$

Where, MSS Maximum segment size (fixed for each internet path, typically 60 bytes)

RTT Round trip time (as measured by TCP)

$$Throughput = \frac{MSS}{RTT} \frac{1}{\sqrt{p}}$$

P Packet loss rate (%)

The efficiency of the WAN link can be calculated

from statistical data on the link utilization, where Utilization (U) [7] is the percentage of total channel capacity currently being consumed by aggregate traffic.

Also

$$Utilization = \frac{Traffic}{Channel\ capacity} * 100$$

Further more, in this research, three point-to-point WAN link were setup between two separate locations A and B using three different WAN technologies, namely:

$$Utilization = \frac{Traffic}{Link\ speed \times sample\ time} * 100$$

(i) 128/256Kbps leased fiber line
(ii) 128/256Kbps point-to-point VPN across the public internet.
(iii) 128/256Kbps VSAT link

The key performance indicators (KPI) metrics for the research were Latency, Bandwidth and Packet Drop Rate. The following approach methods were used to obtain the required performance characteristics of the various WAN technologies adopted:

(a) Files of various sizes were sent from Host A to Host B across the different WAN links.
(b) These KPI values were measured and recorded for different remote network infrastructure in use (Fiber, VSAT, Point-to-Point VPN across the internet with bandwidth of 128/256 kbps respectively)
(c) The performance statistic values obtained in both cases were plotted in graphical form and analyzed.
(d) Recommendation for error correction and performance improvement were made
(e) Conclusion was drawn based on the result obtained from the key performance indices.

The alternative WAN links between two remote locations shown in Fig. 1, were r outed to Host A and Host B using different connection links (Fiber, VSAT, P2P VPN) to measure the KPI of the network.

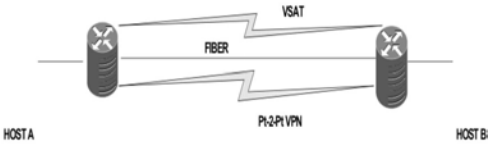


Fig. 1. Schematic diagram of alternative WAN links between two remote locations

The Table 1, shows the result of the throughput obtained from the remote link of the WAN with diffe rent Packet Drop Rate of the links.

Table 1. Throughput result of a network as affected by both the latency and the packet drop rate

LATENCY (ms)	THROUGHPUT						
	TP1(KBPS) 0.01% PDR	TP2(KBPS) 0.05% PDR	TP3(KBPS) 0.10% PDR	TP4(KBPS) 0.50% PDR	TP5(KBPS) 1.00% PDR	TP6(KBPS) 2.00% PDR	TP7(KBPS) 3.00% PDR
9	1822.22	814.95	576.29	257.70	182.22	128.85	105.20
30	546.67	244.48	172.89	77.31	54.67	38.66	31.56
60	273.33	122.24	86.44	38.66	27.33	19.33	15.78
90	182.22	81.50	57.63	25.77	18.22	12.86	10.52
120	136.67	61.12	43.22	19.33	13.67	9.66	7.87
150	109.33	48.90	34.58	15.46	10.93	7.73	6.32
300	54.67	24.45	17.29	7.73	5.47	3.87	3.16
500	32.80	14.70	10.37	4.64	3.28	2.32	1.90
800	20.50	9.17	6.48	2.90	2.05	1.45	1.18
1000	16.40	7.34	5.19	2.32	1.64	1.16	0.95

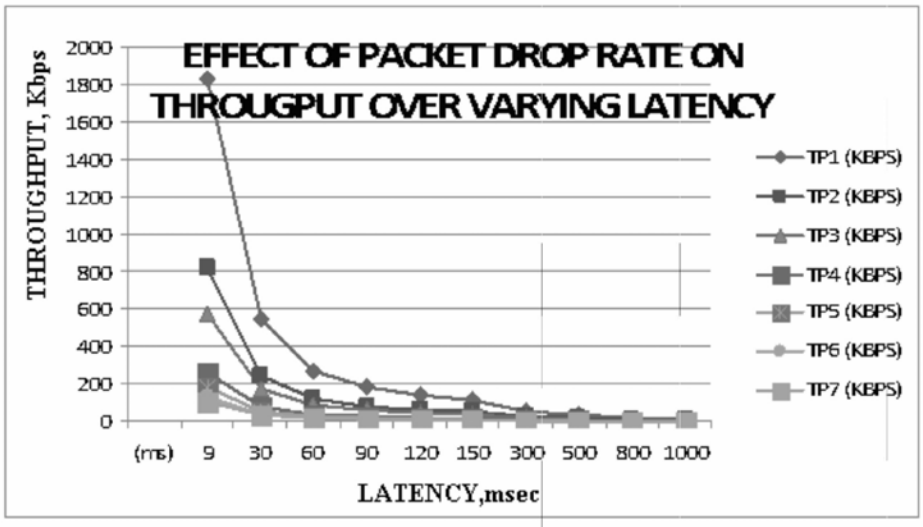


Fig. 3. Graph of throughput against latency for different packet drop rates

The Fig. 3, shows the effect of packet drop rate on the network throughput over different latency. The throughput of a network is affected by both the latency and the packet drop rate of the link where an increase in latency decreases the network throughput performance. Similarly, the throughput also decreases as the packet drop rate increases which might put the network quality of service to network degradation. Analysis of the achieved result indicates that, the best quality of service will be obtained by using a link whose latency is between 1 30 milliseconds and packet drop rate of 0.01% or less. Such latency can only be achieved using Fiber or radio link where packets are propagated at the speed of light with very low bit-error-rate.

The worst quality of service occurred when latency is between 800 1000 milliseconds and the packet drop rate stands at 3% or more.

The link latency of 800 milliseconds and above is usually associated, with VSAT link because of its technological limi tation caused by distance along the propagation path between two locations via the orbital satellite.
However, VSAT links could still be used for none delay-sensitive application if there are no packet loss. The situation becomes worse when increasing packet drop rate is associated with VSAT links. For a Point-to-Point virtual private network (VPN) across the public internet with average latency of 250 milliseconds, most real-time and data-based applications performance is considered favourable. However, Point-to-Point VPN is always associated with higher packet drop rate than VSAT or Fiber links because of the large number of hop and routing protocols across the part from source to destination. This is even worse when considering a two-way traffic situation usually experienced in real life scenario.

IV. Improvement In Quality Of Service

The improvement in quality of service (QoS) can be seen by comparing the network throughput of the Fiber, VPN, and VSAT link of a network. If we assume a minimal packet loss for all the three infrastructures: latency of 850ms for VSAT, Point-to-Point VPN across the internet at 260ms and Fiber link of 25ms.
Throughput for VSAT gives 0.6168M bps that of the VPN across the internet gives 2.016Mbps and the throughout for fiber gives 20.97 Mbps. By nt in QoS

replacing the VSAT infrastructure with Fiber Optic link, the following improvement in QoS would be achieved.

Hence the improvement in QoS gives

=> 3300%

Similarly, replacing the VPN with Fiber optic link would be achieved with an improvement in quality of service QoS as follows:

=> 530%

V. Conclusion

The Key Performance Indices of network services (packet drop rate, latency and throughput) affects the network performance as one the factors goes out of the optimized range value obtained in the research work.

Under perfect conditions (assuming minimal percent of packet loss), the use of WAN link with low latency, and use of optimized bandwidth would significantly enhance the quality of service (QoS) experienced by a remote network user over a WAN link.

REFERENCE

Bilal Haider, M. Zafrullah,M.K. Islam, "Radio frequency optimization & quality of service evaluation in operational GSM network," Proceedings of the world Congress on Engineering and Computer Science 2009, Page 1, Volume 1. WCECS, Oct 20-22, 2009, San Francisco USA.

Daniel Nassar, "Network Performace Baselinning," Publisher MTP, 201 West, 103rd Street, Indianapolis, IN46290 USA, 2002.

Network contribution to transaction time. ITU-T Recommendation G.1040 ITU-T Study Group 12 under the ITU-T Recommendation A.8 procedure (2005-2008).

"Effect of network latency on load sharing in distributed systems," Journal of parallel and distributed computing volume 66, issue 6 Inc Orlando, FL USA (June 2006).

Jorg Widmer, Catherine Boutremans, Jean-Yves Le Boudec: End-to end congestion control for TCP friendly flows with variables packet size. Publisher: ACM, 2004.

Gregory W. Cermak, "Multimedia Quality as a function of bandwidth, packet loss and latency," International Journal of Speech Technology. Publisher: Springer Netherlands Issue: Volume 8, Number 3, 2005.

Michael Lemm, "How to improve WAN application performance," 2007 http://ezinearticles.com.

Lai King Tee, "Packet error rate and Latency requirements for a mobile wireless access system in an IP network," Vehicular Technology Conference, Pages 249 -253, 2007.

J.Scott Haugdahl, "Network Analysis and Troubleshooting," Publisher: Addison Wesley, 2003.

FUZZY GAME APPROACH TO INVESTIGATE IMPACT OF POOR INFRASTRUCTURES ON BUSINESS PROFITABILITY IN DEVELOPING ECONOMIES

Festus Oluseyi Oderanti
Department of Computer Science
Heriot-Watt University, Edinburgh,
United Kingdom
foo8@hw.ac.uk

Philippe De Wilde
Head of School of Mathematical and Computer Sciences
Heriot-Watt University, Edinburgh,
United Kingdom
pdw@macs.hw.ac.uk

ABSTRACT
Attracting and sustaining investments from both local and foreign investors is one of the key strategies for consolidating good governance in an economy. Availability of adequate infrastructure is a key factor to attract investors. We therefore investigated impacts of low level of infrastructural development on economy of developing nations. Nigeria was chosen as a case study and we analysed effects of poor road networks on business profitability in the country. This further investigates part of many reasons developing nations are less attractive to investors. An automated fuzzy decision making system was designed to illustrate how entrepreneurs can effectively capture uncertainties that surround such business environments and make effective business decisions. We introduced learning to train and analyse how the fuzzy player adapts over time during the game and we finally offered useful recommendations to governments on how to attract local and their much dreamed foreign investors.

Index Terms fuzzy logic, membership functions, decision, network games, business games, game theory, zero sum.

I. INTRODUCTION

It is a common knowledge that leaders of developing nations, most especially in Africa, both past and present, have made frantic efforts to woo foreign investors into their countries. However, most of or all these attempts have resulted into exercises in futility [1]. According to Jacques Morisset in [1], when these countries did attract multinational companies, it was principally because of their (abundant) natural resources and the size of their domestic market and this was equally emphasized in [2]. Most of the few foreign investors that show interest in the countries are those interested in feasting and scooping the abundant natural resources of these nations.

In Nigeria, several leaders of governments, at federal and state levels have in the past embarked on numerous foreign trips with the objectives of attracting foreign investors. However, these have been with little or no results. Rather than attracting new businesses, the existing companies are systematically relocating from the country and an example of this was the famous Michelin Nigeria Limited [2] which cited high production cost and other factor as reasons for the closure of their production plants.

In this research work, while we acknowledge that there are several factors [3] contributing to unattractiveness of these developing nations to investors, we have looked with keen interest into poor transportation networks as one of these major factors. We have also introduced a model that illustrates how an entrepreneur can compete effectively, grasp and overcome the uncertainties that surround such business environments and make effective and efficient business decisions. We designed this model using concepts of fuzzy

logic and game theory.

We viewed competitions in industries as games on boards and a business board game model was designed to investigate how level of road networks affect business profitability. The uncertainties aspects of the business environment were captured using the concepts of fuzzy logic in making the business decisions. We refer to our model as fuzzy strategy decision making system on business board (FSDBB) games.

A decision maker is frequently confronted with fuzzy constraints, fuzzy u tility maximization, and fuzziness about the state of competitors [4]. Decision processes in firms have been modelled in different research papers [5; 6; 7; 8; 9]. Also, concepts of fuzzy logic have been applied in various decision processes [4; 5; 10; 11; 12; 13; 14] and in many types of games [5; 10; 12; 13]. Analysis of interaction and cooperation among people in a group has been performed in the prisoners' dilemma game [10; 15], snow drift game [16] and different types of board games have be en used to model people interactions. For the first time, we have combined the concepts of fuzzy logic and game theory to model interaction and decision making processes in businesses as games on boards. In this model, while a player knows information about himself, he has incomplete information about his opponents and these incomplete information are modeled using the concepts of fuzzy logic. We believe that actions or strategies of competitors and the way they are linked can affect profit of a business and we would like to design a framework to understand how the board connectivity, constraints or restrictions on the board and other network structures [17] affect payoffs of players. This work contributes to knowledge in the area of understanding uncertainties in business competitions as games played on boards to investigate how level of availability of vital infrastructures such as transportation networks affects the profitability (known in this paper as payoffs) of business enterpri ses. The board games are investigated as games with incomplete information and with different levels of connectivity.

A. Objectives

Our main objectives are to investigate:

- Competition among business organisations as games on boards and examine various board characteristics such as level of connectivity, number of nodes (players), patterns of board connections and moves and strength of individual player's strategy. We would investigate how these characteristics affect the payoff of players in the games.
- How level of availability of vital infrastructures such as transportation (also communication) in a geographical location can affect the profitability (known here as payoffs) of business enterprises.
- Why industries tend to concentrate in highly developed locations than less developed ones.
- Why developing nations are less attractive to industrialists when compared to the developed ones.
- How to advise the management of a business organization on how to formulate business strategic decision policies that will keep the business in a strategic advantage over its competitors in the market. How fuzzy reasoning or fuzzy inference system (FIS) can help to improve the performances of businesses in an environment that is clouded with uncertainties and adverse condition such as low level of infrastructural development.
- How performances of these business enterprises can be improved or enhanced through adaptation or learning (training of the fuzzy players) of the fuzzy inference system. We are providing trained and optimized fuzzy rules that simulate the relationship between demand (D), production cost (CP) as well as those marketing strategies that an entrepreneur can follow in forecasting the selling price (Esp) of a commodity and thereby, the profit or wealth to be generated or accumulated (Aw).

B. Assumptions

Gender and Economic terms: Throughout this paper, we shall be using he/his or him as appropriate to represent agents. Also, since this work represents a model of a real system, some of the economic terms and formulas used in this work such as demand (D), cost of production (Cp), membership functions, game modelling

equations, strategies [C;W;M] other variables as well as the fuzzy rule base may be modified by anybody adopting the model to suitably represent the situation in question. Our aim is to show that uncertainties in business environments can be suitably modelled or represented using fuzzy logic and game theory concepts.

II. Transportation

A. Importance of Transportation in a Nation's Economy

The importance of effective transportation infrastructure as one of the major backbones of nations' economic development cannot be overemphasized. In [18], it is stated that "better infrastructure will lead to lower transport costs or to a wider range of choice and more competition. Improved access to input material and to markets will cause firms in such region, ceteris paribus, to be more productive, more competitive and hence more successful than those in regions with inferior accessibility". In developing nations, such as Nigeria, poor road networks do not only pose as major problems to national economic development but also to human life. This is because the state of the available ones are poor and without adequate maintenance.

In this paper, we investigated impacts of these poor road infrastructures and offer valuable advice to entrepreneur on how to make effective and efficient business decisions despite these uncertain and adverse business environments.

III. GAME THEORY

A. Game Theory Framework

Game theory is the study of the ways in which strategic interactions among rational players produce outcomes with respect to the preference (or utilities) of those players, none of which might have been intended by any of them [19].

It is part of a large body of theories concerning decision making [9]. It deals with decision-making processes involving two or more parties, also known as players with partly or completely conflicting interest [13; 7] and it is one of the methodologies designed for application to the social sciences [8]. All situations in which at least one agent can only act to maximize his utility through anticipating (either consciously, or just implicitly in his behaviour) the respon ses to his actions by one or more other agents are called games and agents involved in games are referred to as players [20; 19; 4] and could represent people, military, firms, countries or other organisations [5; 21; 13].

B. Business Games

1) Why Business Games?: In business games, the firm identifies the moves that the rival could make in response to each of its strategies. The firm can then plan counter-strategies [22]. As Doug Ivester, Coca-Cola's president put it [23] "I look at the business like a chessboard. You always need to be seeing three, four, five moves ahead; otherwise, your first move can prove fatal". Game theory [4; 13; 19; 20; 5; 12; 24] helps explore the impact of calculations about future market advantages on a firm's current market strategies. In business games, the conflicting interest of a firm may be to minimize the cost function, maximize the market share, or maximize the profit [13]. In this game, profit maximization of the fuzzy player is to be achieved through learning by the fuzzy player, and minimization of the payoffs of the opponents.

2) Decision Making Processes in a Firm: For decisions to be adequately made in a firm, decision makers of the firm are assumed to have access to three different types of information; product-demand information, factor-supply information and production-technology information [20]. Under the assumptions of neoclassical marginal analysis, product-demand information usually takes one of two possible forms. Either the firm knows the prices of each of its products (and these prices are assumed to be constant) or it knows its total revenue function.

Laws of Demand and Supply: Demand and supply are two of the most important market information items to any firm and perhaps, the most fundamental concepts in Economics. The relationship between the two determines how resources are allocated [22; 25; 20]. Meanwhile, since there are many and well known works on microeconomics that address those economic terms briefly explained above, no further discussion will be given on them in this paper.

C. Fuzzy Logic and Fuzzy Decision Making System

Fuzzy logic is a problem solving technique that was introduced by Lotfi Zadeh in [26] to deal with vague or imprecise problems [4; 27; 11; 28; 24]. In general, a fuzzy decision making system (FDMS) uses a collection of fuzzy membership functions (Figure 4) and decision rules that are solicited from experts in the field to reason about data [11]. Typical components of a fuzzy decision making system are as shown in Figure 1. The components of an FDMS, as shown in the figure are: a fuzzification se ction, a fuzzy rule base, fuzzy decision logic and a defuzzification section.

1. Fuzzification section: This is the section where the process of making a crisp quantity fuzzy [29] is carried out. This is done by simply recognising that many of the quantities that we considered to be crisp and deterministic are actually not deterministic at all. They carry considerable uncertainty. If the form of uncertainty happens to arise because of imprecision, ambiguity, or vagueness, then the variable is probably fuzzy and can be re presented by a membership function.

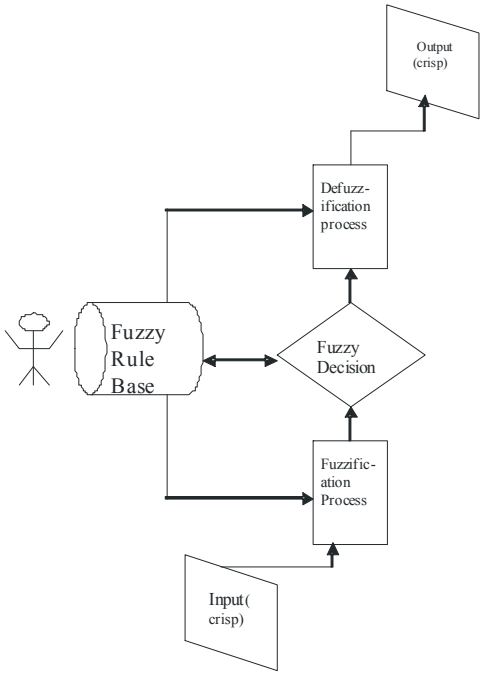


Figure 1. Fuzzy decision making system (FDMS)

2. Fuzzy rule base: These rules are expressed in conventional antecedent-consequent form. The collection of such rules constitutes the fuzzy logic knowledge base that is used for inference of the decision agent. In a fuzzy system, if the antecedent is true to some degree, then the consequent is also true to that same degree. For a small number of inputs, there exists a compact form of representing a fuzzy rule-based system which consists of a tabular format with different partitions representing different inputs.This compact graphical form is called fuzzy associative memory table, or FAM table as shown in Table I.

3. The decision making logic (DML): The decision making logic is analogous to classical logic for reasoning [29] and is similar to simulating human decision making in inferring fuzzy control actions based on the rules of inference in fuzzy logic [11].

4. Defuzzification process: This is the procedure that converts the fuzzy results into a crisp output. It converts a fuzzy control action (a fuzzy output) into a non-fuzzy control action (a crisp output) [11]. Defuzzification has the result of reducing a fuzzy set to a crisp single-valued input, or to a crisp set; of converting a fuzzy matrix to a crisp matrix; or making a fuzzy number a crisp number. Fuzziness helps to evaluate the rules, but the final output of a fuzzy system has to be a crisp number and the input for the defuzzification process is the aggregate output fuzzy set and the output is a single number [30]. Mathematically, the defuzzification of a fuzzy set is the process of 'rounding off' from its location in the unit hypercube to the nearest (in a geometric sense) vertex. If one thinks of a fuzzy set as a collection of membership values, or a vector of values on the unit interval, defuzzification reduces this vector to a single scalar quantity - presumably to the most typical (prototype) or representative value [29]. Several defuzzification methods have been discussed in the literatures such as [11; 30; 29]. In this paper, we are using centroid method and we shall give a brie f explanation of it. Centroid defu zification method: This meth od is also referred to as centre of area (COA) or centre of gravity (COG). It is the most commonly used [11], most p opular [30], most physically appealing [29] defuzz cation technique and it finds the point where a ertical line would

$$\mu_{\tilde{A}}(x^*) \quad (2)$$

slice the aggregate set into two equal masses. In theory, the centroid method of defuzzification is calculated over a continuum of points in the aggregate output membership function but in practice, a reasonable estimate can be obtained by calculating it over a sample of points. Mathematically, the centroid method can be expressed as:

Fuzzy inference techniques: In general, fuzzy decision making system can be implemented using any of the three common methods of deductive inference for fuzzy syste ms based on linguistic rules [29] listed as follows: Mamdani system, Sugeno systems and Tsukamoto models.

In this work, the design and implementation of this fuzzy decision making system was achieved with the aid of Matlab software. Matlab is a menu driven software that allows the implementation of fuzzy constructs like membership functions and a database of decision rules [11].

D. Board Games

The definition of a particular game is generally considered or otherwise transparent by listing the rules of the game. B oard games are games with a fixed set of rules that limit the number of pieces on a board, the number of positions for these pieces and the number of possible moves [31]. Board games have intrigued researchers in a number of sciences either as object of study or as models for developing analogies [31].

Board games have a universal appeal and there can be few people who have not at some time, been excited or stimulated by a board game [32]. There are different types of board games and in [32], they are grouped according to the following categories: Games of position, Mancala games, War games, Race games, Dice, Calculation and other games.

In this research work, we have formulated a board game named; fuzzy strategy decision making system on business board (FSDBB) games to simulate strategic competitions in business environments.

E. Fuzzy Strategy Decision Making System on Business Board (FSDBB) Games Models The general model for our proposed FSDBB is as

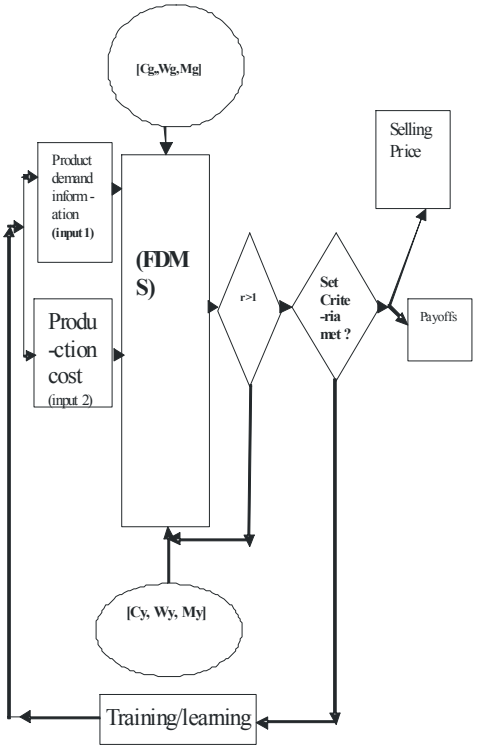


Figure 1. A model of FSDBB game showing inputs, processes and outputs.

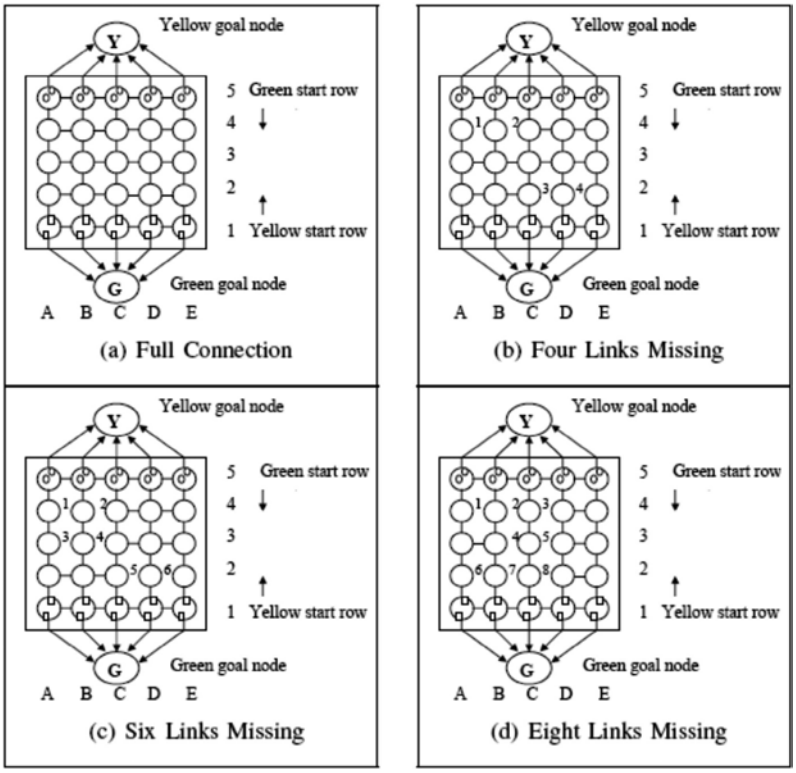


Figure 3 Different Board Connectivity figures: (a) shows a board with complete links/connectivity (i.e fully connected), (b)board with four missing links, (c)board with six missing links and (d) board with eight missing links. Our results show that the less the connectivity on the board, the less the payoffs of the players. That is, the payoff of fuzzy player in (a) is greater than his payoff in (b) which in turn is greater than that of (c) and finally, the payoffs in (d) turn to be the lowest.

Each of the two players has ten pieces which represent trucks which are loaded with firms' products. The trucks are positioned initially, as shown in Figure 3, at the start nodes which are at row 1 and row 5 for yellow and green players respectively. As shown in the figure, each node at the start row contains two pieces (trucks) each at the initial (start) stage of the game. These ten trucks own by each player contain products which are to be distributed at their respective goal nodes (destinations). The goal node for each player resides at the opponent's side of the board which necessitates for each player to travel across the board in order to take as many of his resources as possible to his destination (the goal node).

The board is used here to represent the road networks in a particular geographic location (such as between Lagos and Abuja in the Nigeria) and where each player represents companies (involve in logistics with trucks) at each of these mentioned locations.

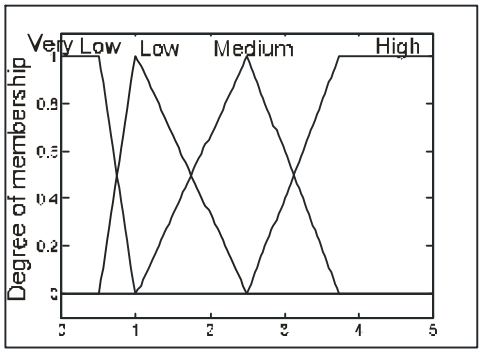
We varied level of connectivity (number of links) on the board by removing links arbitrarily and we investigated how these restrictions (missing links)

affect payoffs (profitability of businesses). This level of connectivity is used to investigate how level of availability of vital infrastructures such as transportation networks in a geographical location can affect the profitability of business enterprises.

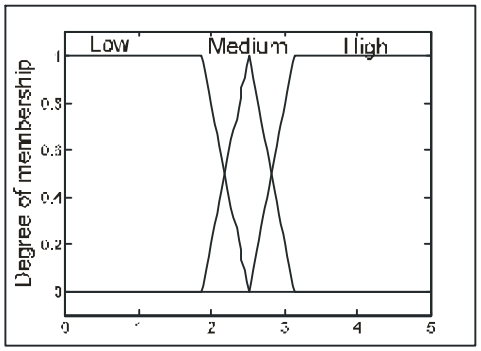
A. Board Variables

The following variables would be used in the simulation: n represents the number of players (n = 2), l' is the number of missing links on the board, d is the total number of nodes on the board, t is the total number of links in the fully connected n etwork, cost of production is represented as C_p, estimated demand of the product at destination node is represented as D. The payoff, P of a player y will be represented as P(y).

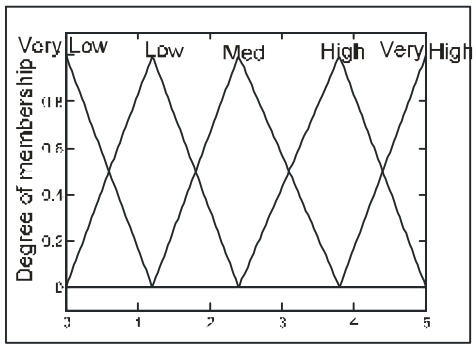
B. A Case Study of a Fuzzy Strategic Decision



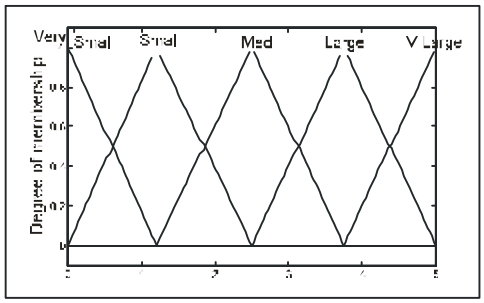
(a) Demand



(b) Production Cost



(c) Expected Market Consolidation



(d) Expected Wealth Created

Figure 4: Membership functions for fuzzy variables of FSDBB rule base- inputs: Demand (D) and Production cost (C_p) and outputs: Expected consolidation efforts (Ec) and Expected wealth (Ew).

Making System on Business Board (FSDBB) Games

We shall illustrate our fuzzy strategic decision making system on business board (FSDBB) games with different board connections in Figure 3. The model involves two players which represent firms that deal in logistics by road and are based at different geographical locations in a particular country or region. We shall represent the players as green (g) and yellow (y). Yellow represents the fuzzy player. Given the boards with different patterns of connections as shown in Figure 3, the game state is represented as vector [g;y;Aw;r]. Where g represents green player's amount of resources, y represents yellow player's amount of resources, Aw represents green's

accumulated wealth (profit) and r is the number of rounds the game is played. Green player strategy is denoted as [Cg;Wg;Mg] and yellow player strategy is denoted as [Cy;Wy;My] where:

3)

Because the $C+W+M=10$ total resources of each player at any point is ten. These resources are trucks of products to be taken to the players' respective goal nodes.

1) FSDBB Game Rules: From Figure 3, row1 is the yellow player start row while row5 is the green player start row. As shown on the diagram, the goal node of play er y is represented as Y while the goal node of player g is represented as G. Other rules are as follows:

- A node can only contain maximum of three trucks at a time.
- A node can only contain maximum of two trucks from same firm (player).
- A player that has two trucks in same node (other than the start node) would get his profit reduced to half because his goods are in excess for that particular location. This means the less the connectivity among the nodes, the more the need for branching of a truck into neighbours' paths and therefore the more the risk of that player having two trucks in same node and thereby reducing his profits.
- A player must follow legal moves through connected nodes and cannot jump nodes.
- At any particular location, a player seeks the shortest path to move to the next location.
- For game to exist, there must be a minimum valid connection on the board. A minimum valid connection is the connection such that there exists at least a single path for a player to take his resou rces (trucks) from the start node to reach the destination node.

2) Game procedures: Following the FSDBB general model in Figure 2 and with respect to board diagrams in Figure 3, the procedures necessary for designing the proposed automatic business decision system are as follows: The probability that there exist a connected link through which a truck will move from its start node to the destination node is denoted as p. Therefore, the probability that a piece will not arrive at the destination n ode due to lack of links between the nodes is given as 1- p.

On a fully connected board of twenty five nodes as shown in Figure 3a, the total connections the board would have if fully connected is 40; (t = 40). Since l' represents the number of missing links, therefore:

(4)

In this FSDBB game our fuzzy player is represented as yellow. Other procedures are as listed in the following steps:

1) List all uncertain (fuzzy) factors that will be considered in taking the business decision: the uncertain or fuzzy information (factors) we are taking into consideration are anticipated market demand information (D) and the production costs (CP).

2) Determining the strategy: We shall use the strategy vector [C,W,M] as our model strategy. This represents products being taken to the destination node to consolidate existing customers (Consolidation C), those that are not moved or reserved at the base as unused wealth (Wealth W) and those being taken to the goal nodes to market new customers (Marketing M). We have two players (firms) represented as green (g) whose strategy is represented as [Cg;Wg;Mg], and yellow (y) with strategy represented as [Cy;Wy;My].

3) Determine the input and output variables of FSDBB FIS: The inputs are market demand information (D), production costs (C_p) and the outputs are expected consolidation efforts (Ec), expected wealth (Ew) and expected aggressive marketing efforts (Em) where: Em = 10- (Ew +Ec) (Because the total (expected) resources of each player at any point is ten). These variables Ec, Ew and Em relate to the fuzzy player y, and we will not index them by y.

4) Develop fuzzy sets, subsets and membership functions for all the input and output variables: This can be accomplished by soliciting knowledge from the experts or searching through literature data. Our adopted fuzzy sets, subsets and membership functions are as shown in Figure 4.

5) Formulate decision rules for the rule base:

These also, ought to be solicited from experts. In this case study however, our adopted decision rules are as highlighted in Table I and few of the decision rules are as stated below:

a) If (Demand is High) and (Production Cost is Low) then (Expected Market Consolidation is Medium).
b) If (Demand is Very low) and (Production Cost is High) then (Expected Wealth Created is Very large).

TABLE 1: FAM TABLE FOR EXPECTED MARKET CONSOLIDATION (E_c) EFFORTS AS OUTPUT.

D/Cp	Low	Medium	High
Very Low	Very low	Very low	Very low
Low	Low	Low	Low
Medium	Medium	Medium	Low
High	Medium	High	Medium

6) Establish relationships between input values and their fuzzy-sets and applying the decision rules: Table I shows the FAM table for the rule base and the fuzzy rule base can be coded into Fuzzy Inference System using Matlab toolbox as shown in Figure 5.

7) Play the game: Procedures for playing the game are as follows: The game state is represented as vector S = [g; y;Aw; r]. Where g represents green player's amount of resources, y represents fuzzy player (yellow) amount of resources, Aw represents opponents' accumulated wealth (profit) and r is the number of rounds the game is played. Both the green and fuzzy player strategies are as stated in Step 2 above.

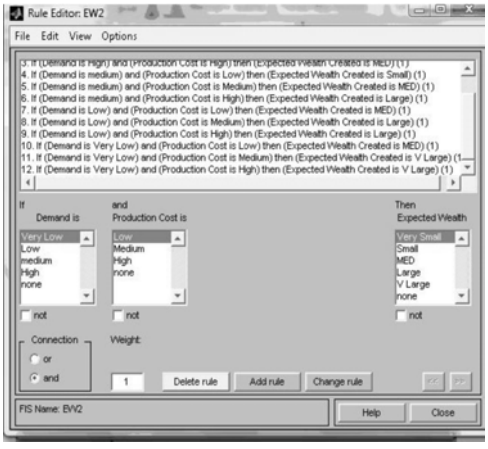


Figure 5 Rule base with Matlab rule editor for expected wealth (Ew) as output.

General rules of the game are as follows:

- Initial state of the game is [10; 10; 0; 10] (i.e according to vector [g; y; Aw; r]).
- At every state [g; y; Aw; r], green chooses his move by allocating to his strategies [Cg;Wg;Mg] where: Cg + Wg + Mg = g = 10 and yellow who is the fuzzy player chooses his strategy [Cy;Wy;My] where Cy +Wy +My = y = 10. From (3), these are constraints that must be met and as stated at the beginning of this section, because the total resources at any stage is ten.
- With respect to explanation on Section I-B, Equations 6- 13 depict the zero-sum nature of the game such that at any stage of the game, the player's current value of resources (such as g or y) is calculated by adding his new resources from the current state in the game to his previous value. We then subtract the competitors' resources from this value. Therefore from different board connections shown in Figure 3a-d, the game changes states according to the following model equations:

(5)

(6)

(7)

(Where d is the total number of rounds and p as in (4))

$$A_w = A_w + W_g - W_y \quad (8)$$

$$g = ((g + C_{g+} M_g r) - (y + C_y + M_y r)) * d * p \quad (9)$$

where temp represents game payoff. Then,

$$y = ((y + C_{y+} M_y r) - (g + C_g + M_g r)) * d * p \quad (10)$$

because the total resources of expected resources of each player at any point is ten. Now,

$$temp = A_w + g - y \quad (11)$$

$$E_m = 10 - (E_w + E_c) \quad (12)$$

Where represents other costs which are taken to be zero to avoid needless complication (i.e). We define E_w (expected profit/wealth) where:

$$C_p = (M_y + C_y + v) \,/\, (M_g + C_g + v) \quad (13)$$

and v represents the expected selling price of the product.

- The game ends when r = 0 and if temp is greater than zero (temp > 0), the green player wins, if less than zero (temp < 0), then the fuzzy player (yellow) wins else, the game is draw (i.e if temp=0). Also, the game can also end when one of the players has successfully taken all his resources to the goal node and in that case, such player wins.
- This 2-player game is a zero sum game and therefore, yellow loses whenever green wins and vice versa and since our aim is to develop an agent that would win as much as possible, maximize his payoff and minimize that of the opponents, Nash equilibrium [35; 36] is not considered in this context.

8) Evaluate the fuzzy inference system (FIS): Using Matlab fuzzy toolbox, all the fuzzy inputs are passed into the Mamdani type FIS.

9) Get the defuzzified output from the FIS: The crisp output for the FSDBB is computed using centre of gravity method (COG) and sampled results are as shown in Figure 6 using rule view from Matlab FIS editor.

10) Determine whether the conditions for the end of the game have been met: In this case study, the condition for the end of the game is when the number of rounds r reaches one counting down from five (i.e when $r = 1$).

11) Training and performance evaluation: Training and learning of the FSDBB decision agent was accomplished through the optimization of the fuzzy logic parameters while using the game payoff as the basis for t he performance measure after playing a series of the game as in [5]. This training or learning of the fuzzy player to optimize its performance was achieved through the use of the "fminsearch function" in Matlab having considered other optimization algorithms such as gradient descent [37] and genetic algorithm [38].

Fminsearch uses the Nelder-Mead Simplex Search Method [33; 34] for finding the local minimum x of an unconstrained multivariable function $f(x)$ using derivative-free method and starting at an initial estimate. This is generally referred to as unconstrained non-linear optimization. If n is the length of x, a simplex in n-dimensional space is characterized by the $n + 1$ distinct vectors that are its vertices. In two-space, a simplex is a triangle; in three-space, it is a pyramid. At each step of the search, a new point in or near the current simplex is generated. The function value at the new point is compared with the function's values at the vertices of the simplex and, usually , one of the vertices is replaced by the new point, giving a new simplex. This step is repeated until the diameter of the simplex is less than the specified tolerance (33). We maximized the fuzzy player's payoff based on the fuzzy membership functions (MFs) and therefore, algorithm stops when opponent's wealth is minimized. However, during the algorithm, the membership functions need to retain a valid shape as shown in Figure 7 in comparison with those in Figure 6.

Meanwhile, a better optimizati on result may be achieved through simulated annealing [39; 40] but this is outside the focus of this research work and may be considered as an avenue for further research. Furthermore, in this FSDBB game, we do not employ "maxmin" strategy but rather, we attempted to maximize the number of times that the fuzzy player wins and his payoff while at the same time minimize those of the opponents.

The results of training are shown in Figure 7. When compare to the output triangles of Figure 6, it can be observed that after training, the membership functions (triangles) of the fuzzy sets have shifted considerably towards left to minimize the opponent's payoff and thereby maximize the fuzzy player's payoff.

C. Results Discussion for Business Games on Boards

Based on the procedures highlighted in Section IV-B2 above and from board diagrams in Figure 3, We varied level of connectivity (number of links) on the boards by removing links arbitrarily and we investigated how these restrictions (missing links) affect payoffs (profitability of businesses). This level of connectivity was used to simulate (investigate) how level of availability of vital infrastructures such as transportation networks in

a geographical location can affect the profitability of business enterprises and to achieve other objectives stated in Section I-A. The results obtained as shown on Table II show that the higher the level of connectivity on the board, the higher the payoff of the players and vice-versa. This means that the less the availability of road networks in a geographical location, the less the prospects of businesses in such location. This therefore, shows why developing nations are less attractive to investors.
Also, yellow wins more often than green because he takes his decisions based on the output of fuzzy reasoning from the fuzzy inference system (FIS). This shows the extent to which fuzzy reasoning can prosper a business operating in an adverse business environment that is clouded with diverse uncertainties as in developing nations.

We also observed that the stronger the strategy, the higher the payoff. That is, agent that allocates more resources to marketing has stronger strategy and is more likely to have higher payoff.

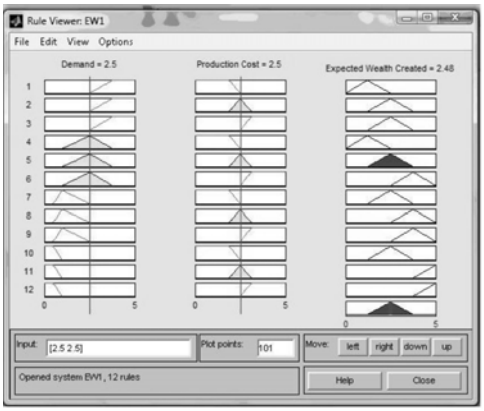


Figure 6. Defuzzified (crisp) values for expected wealth reserved Ew at inputs D = CP = 2:5.

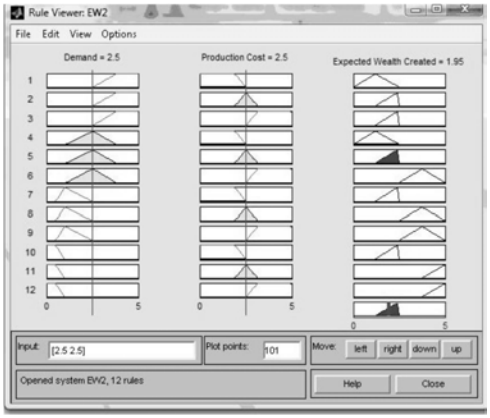


Figure 7. Output of the trained FSDBB fuzzy player: It can be seen that triangles of the membership functions have changed considerably and thereby minimized opponent's wealth accordingly.

Yellow, the fuzzy player begins to lose when the links on the board are extremely low. This shows the extent to which extremely poor road networks (and other infrastructures) can run a vibrant business down.

After training, the fuzzy player performs better with higher payoffs as shown on Table III. This shows that the learning is important as the fuzzy player is able to adapt with fuzzy reasoning over time as also shown in FIS interface in Figure 7.

V. Conclusion

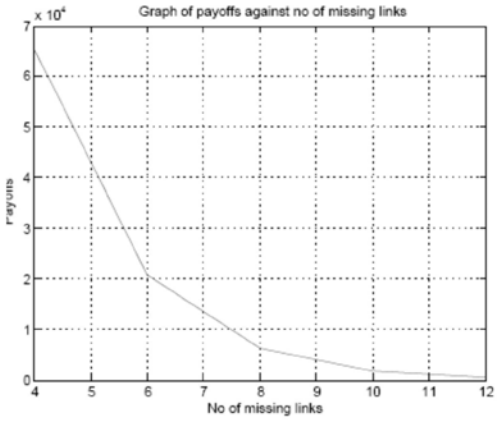


Figure 8. A graph showing how payoff of fuzzy player decreases as links on the board decerease.

We have modelled decision making processes under uncertainties on boards using concepts of fuzzy logic and game theory. Our general model was termed fuzzy strategy decision making system for business board (FSDBB) games. The model simulates how various board characteristics such as level of connectivity or restrictions on the board affect the payoffs of players on the boards. Also, we examined this model with examples. The system was designed and implemented using MATLAB software. Fuzzy rules were constructed in developing the FSDBB model using MATLAB toolbox and the implementation of this model heavily depends on expert knowledge and experience to facilitate the development of a reasonable fuzzy rule base for the determination of the if-then rules that represent the relationship between input and the output variables. Furthermore, we have applied a learning algorithm to the decision process which enables the decision agent to optimize his performance in the decision process as the gam e is played so as to meet the set criteria. To do the learning, Nelder-Mead simplex method for finding the minimum of an unconstrained multivariable function was used.

Our FSDBB model has practical uses in business contexts as they can serve as very useful decision tools in the hands of entrepreneurs trading in developing nations like Nigeria. The experiment shows that businesses are less profitable in situations where there are restrictions such as lack of availability of vital infrastructures or by other constraints which inhibit business productivity. This model can also be applied to some other infrastructures such as communication. Also, given the fuzzy demand and cost of production information, the estimated selling price (Esp) can be predicted according to Equation 13.

represents number of missing links on the board. It can be observed that as increases, the payoff of fuzzy player decreases. This means that the less the level of connectivity on the business board, the less the payoff of fuzzy player and vice-versa. This implies that the less the availability of road networks in a geographical location, the less the profitability of businesses in such location. The minus signs on payoffs merely show zero-sum. When it is minus, fuzzy player y wins but otherwise, green wins.

It can be observed that the trained agent is able to perform better after training as he wins more often than when he was not trained as compared to the

TABLE II: RESULTS OF SIMULATION OF THE FUZZY BUSINESS BOARD GAMES (FSDBB)

Player Moves			Payoff Vs Missing Links l^1 ("000)				
	Green	Yellow	$l^1 = 4$	$l^1 = 6$	$l^1 = 8$	$l^1 = 10$	$l^1 = 12$
1	0, 0, 10	10, 0, 0	-12954.00	-3954.10	-1117.00	-288.60	-67.20
2	10, 0, 0	0, 0, 10	-130410.00	-41844.00	-12541.00	-3480.30	-885.10
3	0, 10, 0	0, 0, 10	-131450.00	-42196.00	-12653.00	-3513.40	-894.10
4	0, 0,10	0, 10, 0	- 965.40	- 105.40	37.30	32.00	14.40
5	0, 0, 10	0, 0, 10	-120830.00	-38588.00	-11503.00	-3173.00	-801.30
6	0, 10, 0	0, 10, 0	-11570.00	-3708.80	-1110.50	-307.90	-78.20
7	10, 0, 0	10, 0, 0	-22520.00	-7205.30	-2152.60	-590.00	-150.80
8	8, 0, 2	0, 8, 2	-32590.00	-10402.00	-3099.10	-854.30	-215.60
9	5, 0, 5	3, 0, 7	-93253.00	-29824.00	-8905.30	-2461.10	-622.90
10	0, 5, 5	4, 5, 1	-23071.00	-7302.40	-2154.90	-587.50	-146.40
11	7, 0, 3	10, 0, 0	-19659.00	-6233.20	-1843.00	-503.63	-125.81

results obtained on Table II. Where he does not win (such as in iteration 4), opponent's payoff is minimized considerably and thereby maximized his own. The strongest opponent and weakest opponent (explained in Section IV-B2 Step 11) are shown in iterations 4 and 3 respectively. The minus sign on payoffs m erely shows zero-sum. When it is minus, fuzzy player y wins but otherwise, green wins.

TABLE II: RESULTS OF SIMULATION OF THE TRAINED FSDBB FUZZY PLAYER PAYOFFS

	Player Moves		Payoff after training ("000)				
	Green	Yellow	$I^1 = 4$	$I^1 = 6$	$I^1 = 8$	$I^1 = 10$	$I^1 = 12$
1	0, 0, 10	10, 0, 0	-12965.00	-3958.20	-1118.40	-289.00	-67.31
2	10, 0, 0	0, 0, 10	-130420.00	-41848.00	-12542.00	-3480.70	-885.23
3	0, 10, 0	0, 0, 10	-131460.00	-42201.00	-12654.00	-3513.90	-894.26
4	0, 0, 10	0, 10, 0	- 976.72	- 109.44	35.89	31.53	14.28
5	0, 0, 10	0, 0, 10	-120850.00	-38593.00	-11505.00	-3173.50	-801.48
6	0, 10, 0	0, 10, 0	-11583.00	-3713.60	-1112.10	-308.38	-78.37
7	10, 0, 0	10, 0, 0	-22531.00	-7209.40	-2154.00	-595.74	-150.92

A. Recommendation

While we recommend the scheme presented in this paper to entrepreneurs as an effective decision tool, we will also like to advise the government leaders at various levels that providing effective basic infrastructure is a key factor to attract local and foreign investors. When these infrastructures are in place, investors will be lobbying to come to the country but not the country lobbying investors. Apart from effective road networks, among other infrastructures that governments need to pay absolute attention to include power sector (electricity) which is the bedrock of economic development. As blood is important to human life, so is electricity to businesses. Also, other important area the government need to pay attention to is security. An entrepreneur is not only interested in his monetary profits but also on security of his life so that he can live to enjoy the profits. On this issue, we will like to recommend that rather than laundering huge money abroad to purchase bullet-proof cars for individuals [41] and bullet-proof bullion vans for banks [42], we should rather look for ways to provide effective and permanent solutions to insecurity in the country. We should adopt the policy of solving the problems rather than learning how to live by the problems. Purchasing bullet proof vehicles is like learning how to live by the problems. A permanent solution to insecurity may be to create more jobs for the unemployed and to consider installation of security devices including closed-circuit televisions (CCTV) at strategic places in the country such as state capitals and Federal Capital Territory. These are the backbones of effective security in developed nations such as United Kingdom. Law enforcement agencies should also be re-oriented.

B. Future Research

Future research will be developed along the following lines. We will apply this model in a wider range of micro and macroeconomic models that are targeted to specific industries and international trades among countries. More specifically, we will model the adverse effects of international sanctions (disconnections) on the economy of nations. We will do experiments to determine the actual duration and number of steps in the business games. We plan to apply the model to other different strategic games and to replace the adaptation of the membership functions by operations on type-2 fuzzy sets [43]. Also, the model can be applied for optimizing bidding in auctions and a variety of human resource allocation decisions.

REFERENCES

J. P. Morisset, "Foreign direct investment in Africa: Policies also matter," World Bank Policy Research Working Paper, no. 2481, 1999.

E. Anim, "Michelin's exit, what to do next," Energy News, no. 3, 2007.

C. R. Hulten, "Infrastructure capital and economic growth," National Bureau of Economic Research Working Paper, no. 5847, pp. 139, 1996.

P. De Wilde, "Fuzzy utility and equilibria," IEEE Transaction on Systems, Man, and Cybernetics-Part B: Cybernetics, vol. 34, no. 4, pp. 17741785, 2004.

S. Braathen and O. J. Sendstad, "A hybrid fuzzy logic/constraint satisfaction problem approach to automatic decision making in simulation game models," IEEE Transactions on Systems, Man, and Cybernetics-Part B: Cybernetics, vol. 34, no. 4, pp. 17861797, 2004.

G. M. Chapman and J. F. Martin, "Computerized business games in engineering education," Computers and Education, vol. 25, no. 1-2, pp. 6773, 1995.

M. Shubik, "The uses of game theory in management science," Management Science, vol. 2, no. 1, pp. 4051, 1955.

M. Shubik, "Game theory as an approach to the firm," American Economic Review, vol. 50, no. 2, pp. 556559, 1960.

M. Shubik, "On gaming and game theory," Management Science, vol. 18, no. 5, pp. 3753, 1972.

P. S. Borges, R. C. S. Pacheco, R. M. Barcia, and S. K. Khator, "A fuzzy approach to the prisoner's dilemma,"Biosystems, vol. 41, no. 2, pp. 127137, 1997.

F. T. Dweiri and M. M. Kablan, "Using fuzzy decision making for the evaluation of the project management internal efficiency," Decision Support Systems, vol. 42, no. 2, pp. 712726, 2006.

A. Kandel and Y.-Q. Zhang, "Fuzzy moves," Fuzzy Sets and Systems, vol. 99, no. 2, pp. 159177, 1998

K. W. Li, F. Karray, K. W. Hipel, and K. M., "Fuzzy approaches to the game of chicken," IEEE Transactions on Fuzzy Systems, vol. 9, no. 4, pp. 608623, 2001.

F. O. Oderanti and P. De Wilde, "Automated fuzzy decision making system with learning in business networks of varying connectivity," in Proceedings of UK Workshop on Computational Intell igence 2009 7th-9th September (UKCI), Nottingham, 2009, pp. 3136.

G. Abramson and M. Kuperman, "Social games in a social network," Physical Review E, vol. 63, no. 3, pp. 14, 2001.

W. X.Wang, J. Ren, G. Chen, and B. H.Wang, "Memory-based snowdrift game on networks," Physical Review E, vol. 74, no. 5, pp. 16, 2006.

D. Oluwade, "A model for constructing subgraphs of hypercubes," in IEEE AFRICON 2007. Windhoek: IEEE, 2007, pp. 17.

R. Vickerman, K. Spiekermann, and M. Wegener, "Accessibility and economic development in europe," Regional Studies, vol. 33, no. 1, pp. 115, 1999.

D. Ross, "Game theory," Stanford Encyclopedia of Philosophy, 2006.

T. H. Naylor and J. M. Vernon, MicroEconomics and Decision Models of the Firm. USA: Harcourt, Brace and World Inc, 1969.

J. Bracken and M. Shubik, "Worldwide nuclear coalition games: a valuation of strategic offensive and defensive forces," Operation Research, vol. 4, no. 3, pp. 655668, 1993.

A. Griffitts and S. Wall, Intermediate Microeconomics Theory and Applications. England: Pearson Education Limited, 2000.

S. Himmelweit, R. Simonetti, and A. Trigg, Neoclassical and Institutionalist perspectives on Economic Behaviour MicroEconomics. Italy: G. Canale and C, 2001.

Y. Zhang and A. Kandel, "An efficient hybrid directvague fuzzy moves system using fuzzy-rules-based precise rules," Expert Systems with Applications, vol. 13, no. 3, pp. 179189, 1997.

E. J. Working, "What do statistical demand curve show?" Quarterly Journal of Economics, vol. 41, no. 2, pp. 212 235, 1927.

L. A. Zadeh, "Fuzzy sets," Information and Control, vol. 8, no. 3, pp. 338353, 1965.

P. De Wilde, "Fuzzy constraints, choice, and utility," in IEEE International Conference on Systems, Man, and Cybernetics. Piscataway: IEEE, 2002, pp. 28.

A. O. Ajayi, G. A. Aderounmu, H. A. Soriyan, and A. David, "An adaptive fuzzy information retrieval model to improve response time perceived by e- commerce clients," Expert Systems with Applications, vol. 37, no. 1, pp. 8291, 2010.

T. J. Ross, Fuzzy Logic with Engineering Applications. England: John Wiley and Sons Limited, 2005.

M. Negnevitsky, Artificial Intelligent Systems. England: Pearson education, 2005.

F. Gobet, A. J. De Voogt, and J. Retschitzki, Moves in mind: the psychology of board games. East Sussex: Psychology Press., 2004.

R. Bell and C. M., Board Games Round the World.

Cambridge, UK: Cambridge University Press., 1998.

J. C. Lagarias, J. A. Reeds, M. H. Wright, and P. E. Wright, "Convergence properties of the nelder-mead simplex method in low dimensions," SIAM Journal of Optimization, vol. 9, no. 1, pp. 112147, 1998.

M. O. Donald and S. N. Lloyd, "The Nelder-Mead simplex procedure for function minimization," Technometrics, vol. 17, no. 1, pp. 4551, 1975.

D. Abreu and A. Rubinstein, "The structure of Nash equilibrium in repeated games with finite automata," Econometrica, vol. 56, no. 6, pp. 12591281, 1988.

C. Holt and A. E. Roth, "The Nash equilibrium: A perspective," PNAS, vol. 101, no. 12, pp. 39994002, 2004.

D. Simon, "Innovertia software," 2007, gradient descent optimization of fuzzy functions.

D. Simon, "Innovertia software," 2007, genetic optimization of fuzzy functions.

S. Kirkpatrick, C. D. Gelatt, and M. P. Vecchi, "Optimization by simulated annealing," Science, vol. 220, no. 4598, pp. 671680, 1983.

D. J. Ram, T. H. Sreennivas, and K. G. Subramaniam, "Parallel simulated annealing algorithms," Journal of parallel and distributed computing, vol. 37, no. 2, pp. 207212, 1996.

E. Onyewuchi, "2011 elections: Politicians in mad rush for bullet-proof cars," Punch on the Web of 24th April, 2010.

O. Adetayo, "Armed robbery: Bullet-proof bullion vans to the rescue," Punch on the Web of 26th March, 2010.

G. M. M´endez and M. A. Hernandez, "Hybrid learning for interval type-2 fuzzy logic systems based on orthogonal least-squares and back-propagation methods," Information Sciences, 2008.

CYBEROAM INTRUSION PREVENTION SYSTEM

Jonathan Francis
University of Uyo, F2jonat@hotmail.com

ABSTRACT
Attackers are increasingly turning to highly targeted external and internal attacks. Sometimes, these attacks are so highly focused that they target key individuals with access to enterprise resources. With many attacks being too big to be detected and corrected within the anti-virus and anti-malware radar, enterprises are turning to advanced IPS engines for zero-hour protection. Intrusion Prevention System (IPS) solution provides powerful protection by blocking intrusion attempts, protecting against malware, Trojans, DoS attacks, malicious code transmission, backdoor activity and blended threats when combined with Application Firewalls, Unified Threat Management, and other application filtering services. This paper considers how an enterprise can be protected against the many attacks that looms in the enterprise network and resources using IPS, with CYBEROAM's INTRUSION PREVENTION SYSTEM as a case study. The title of the paper is, 'INTRUSION PREVENTION SYSTEM Toward a Safer Enterprise Network'.

I. Introduction

Companies today are increasingly losing valuable resources, time and money to malicious attacks directed at them. These attacks oftentimes defy supposed protection offered like traditional antivirus (AV), anti-malware (AM), and anti-spyware (AS) Intrusion Detection Systems. This brings about a need for the system or network to not only detect when there is an attack but also correct this attack and protects the entire system from such attacks in the future time without external updates and permission. It is with this backdrop that security experts have come-up with the Intrusion Prevention System.

Why Use IPS?

Consider a typical attack that could affect an enterprise network:

Your network performance is unusually low, the system is so slow. You want to open or access a file or a website and it's taken a long while to open. Infact, a website you often access (say your company's website) suddenly becomes unavailable, or your company's email dramatically and suddenly becomes mail-filled with spam, what is otherwise known otherwise called EMAIL BOMB like the *love bugs* that affe cted the world many years ago. Then you are affected by an attack antivirus don't cure. It is known as *denial-of-service (DoS)* attack. This attack typically makes company resources unavailable to it intended users. Although the means to carry out, motives for, and targets of a DoS attack may vary, it generally consist of the efforts of a person or people t prevent an internet site or server from functioning efficiently or at all, temporarily or indefinitely. Perpetrators of DoS attacks typically target sites or services hosted in high-profile web server such as banks, credit card payment gateways, and even root name servers.

You don't need to let this happen to you, an IPS can protect you from things like this.

When an enterprise uses an IPS, it protects itself against these threats:

- UNDESIRED ACCESS wherein intruders gain access to such va luable assets as proprietary intellectual property or customer's identity/credit card information;
- MALICIOUS CONTENT including viruses, spyware, and other types of attack which can cause troubles that range from the mild annoyances to cost-prohibitive extended network downtime and loss of stored material; and
- RATE-BASED ATTACKS which intentionally overload computers or networks with garbage traffic for the purpose of preventing legitimate traffic from reaching its destination, resulting in lost revenue and brand damage for the attacked.

A three-dimensional approach which addresses all three of these complex hybrid attack techniques is critical to prevent losses due to complex hybrid attacks that use multiple techniques to quickly

spread malicious executables, techniques that can beat traditional security point measures. It is IPS.

What Is An IPS?
Like most term, it depends on whom you ask. But in this paper, it's defined as any device (hardware or software or both) that has the ability to detect attacks, both known and unknown attacks, and prevent that attack from being successful. It can further be said to be a network security device that *monitors* network and/or system activities for malicious or unwanted behavior and can *react* in **real-time**, to block or *prevent* those activities.

Intrusion Prevention, in itself is a preemptive approach to network security used to identify potential threats. The system that does this, IPS, monitors the network traffic and takes real-time action when an attack is detected.

Intrusion Prevention Systems evolved in the late 1990s to resolve ambiguities in passive network monitoring by placing detection systems in-line. Early IPS were IDS that were able to implement prevention commands to firewalls and access control changes to routers and other effects at different layers in the network.

Definition Of Terms
APPLICATION FIREWALLS: A form of firewall which controls I/P, O/P and/or access from, to, or by an application or service.

PORT 80: The primary passageway for web content to enter and exit the corporate network.

SECURE BGP TECHNOLOGY: a core internet routing infrastructure that uses PKI, Digital signatures, and IP Sec encryption to secure transmission.

DoS and DDoS: A denial-of-service (DoS) of distributed denial-of-service (DDoS) attack is an attack that makes a computer resource unavailable to its intended users.

SOURCE PATH ISOLATION ENGINE: A technology that provides the ability to identify the source of an individual IP Packet.
ENTERPRISE NETWORK SYSTEM: an array of system and/or network belonging to a corporate entity. Or a network built by an enterprise to .t.c) in interconnect the various company sites (production sites, head offices, remote offices, ships e.t.c) in order to share company's resources over the network.

IPS Types
In this paper, we shall consider the types of IPS based on the way they function. The protection IPS offers are either at the Network level or System level. These are typed as:

- Network based IPS
- System based IPS

Network Based Ips
A network based IPS (NIPS)is one where the IPS application/hardware and any actions taken to prevent an intrusion on a specific network host(s) is done from a host with another IP Address on the network.

NIPS are purpose-built hardware/software platforms that are designed to analyze, detect, and report on security related events. NIPS are designed to inspect traffic and based on their configuration or security policy, they can drop malicious traffic.

Apart from protecting unknown attacks, NIPS also inspects the content of network packets for unique sequences called signatures, to detect and hopefully prevent known types of attack such as worm infections and hacks. This is sometimes called Content based IPS (CIPS).

How It Works
The NIPS device (hardware) is placed in front of the server(s). They inspect specific traffic for malicious content defined by the policy that is configured. This hardware does not have an IP Address assigned to it, making it a 'stealth' interface. So no one can send packet to it or cause it to reply any. If after its inspection it finds a packet that contains a piece of information that trips a signature, the packet can be forwarded or dropped and either logged or unlogged. It can also take it a bit further by rewriting the offending packet(s) to something that won't work, a procedure known as *packet scrubbing,* so that the attacker ends up not knowing if the attack was successful or not.

To stop unknown attacks, the device watches all the network traffic and figures out what is 'good

traffic', and 'profiles' these. Then, when it sees attempts to connect services that does not exist or at least exist on that server, it sends back a response to the attacker. The response will be 'marked' with some bogus data so that when the attacker comes back and tries to exploit the server, the IPS will see the 'marked' data and stop all traffic coming from that attacker.

NIPS also use protocol analyzer like the other type of IPS. Protocol analyzers can natively decode application-layer network protocols like HTTP or FTP. Once the protocols are fully decoded, the IPS analysis engine can evaluate different parts of the

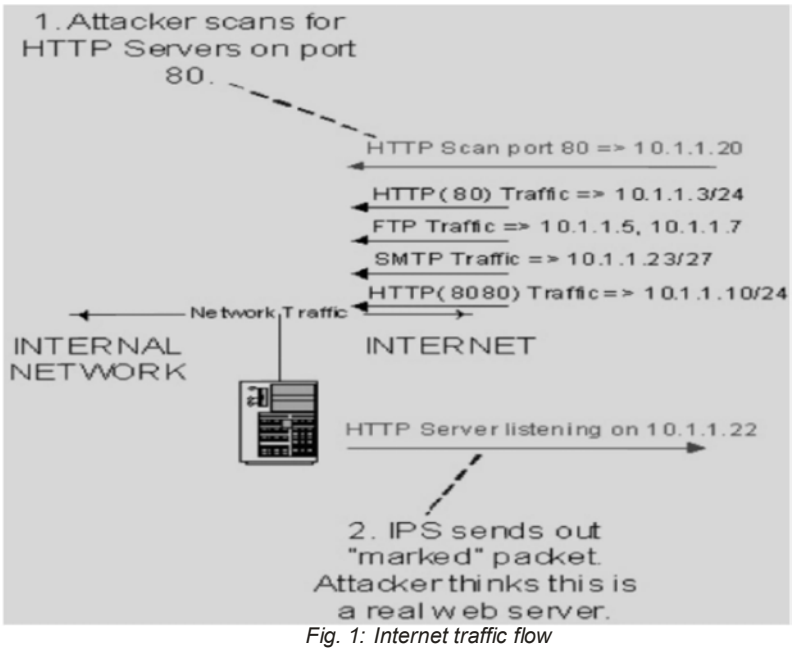


Fig. 1: Internet traffic flow

protocol for anomalous behavior or exploits. For example, the existence of large binary file in the user-agent field of an HTTP request would be very unusual and likely an intrusion. A protocol analyzer could detect this anomalous behavior and instruct the IPS engine to drop the offending packets.

System Based IPS

In system based IPS (SIPS), the intrusion prevention application is resident on a specific IP Address, usually on a single computer. This kind of IPS doesn't need continuous updates to stay ahead of new malware or attacks. Since an ill-intended code needs to modify the system or other software residing on the system to achieve it evil aims, a SIPS will notice some of the resulting changes and prevent the action by default or notify the user for permission.

How It Works

Since this type of IPS is loaded on the server that it is to protect they are customizable to each application that they are to protect. They don't look at packet level information unlike NIPS; rather, they look at API Calls, memory management (i.e. buffer overflow attempts) how the application interacts with the operating system, and how the user interacts with the application, thus, protecting the system against poor programming and

unknown attacks.Before protecting a system, SIPS first profiles the system. During the profiling phase, the IPS can watch the user's interaction with the application and the application's interaction with the operating system to determine what legitimate interaction looks like. After the IPS has created a profile, or policy of the application, it can be set to enforce it. These kinds of system are a 'fail close' kind of system, which means that if some action is attempted that is not predefined, then IPS will stop the action from taking place.

The Drawback

One drawback of this system is that when an application is profiled, the user needs to make sure that every aspect of the application is used so that the SIPS can see the interaction and write a rule for it. If thorough testing isn't carried out, then some parts of the application may not work properly.

Another drawback is that when the application is updated, it might have to be profiled again to ensure that the policy does not block legitimate use.

By profiling the application prior to enforcing the policy, you can get very granular with the policies that are made. This type of IPS offers the greatest amounts of protection for custom written application. Since SIPS is loaded on each physical server, you can customize each policy so that it can offer the greatest amount of protection. This IPS is the one that majorly considers how application interacts with the operating system and memory management on the server.

NIPS and SIPS The Variation

1. NIPS has the ability to detect attacks scattered over the network whichever system on the network is being attacked and react promptly to the attack, but SIPS only react in an event of attack on the system it sits on.
2. NIPS has dedicated processor and memory because it is a standalone device but SIPS shares processor and memory with the system that serves as host for it.

IPS Goes Wireless

Since IPS is meant to monitor and protect a network, what happens to a wireless network, a hotspot for example?

Wireless Intrusion Prevention System (Wips): This is a network device that monitors the radio spectrum for the presence of unauthorized access points, and can automatically take counter measures. In its own case, WIPS does the monitoring and protection of a RADIO SPECTRUM.

It primarily prevents unauthorized network access to local area networks, and enterprise information assets/resource via a wireless device.

Most organization with many employees is particularly vulnerable to security breaches caused by rogue access points. If an enterprise (trusted entity) in a location brings in an easily available wireless router, the entire network can be exposed to anyone within range of the signal and that could lead to intrusion into the enterprise network where untold damage could be inflicted. Hence the need for air-wave ranges protection.

How It Works

WIPS configurations consist of three components :

1. **SENSOR** these devices contain antennas and radios that scan the wireless spectrum for packets and are installed throughout areas to be protected.
2. **SERVER** the WIPS server centrally analyzes packet captured by sensors.
3. **CONSOLE** the Console provides the primary user interface into the system for administration and reporting.

The WIPS could be in any form from a single computer connected to a wireless signal processing device and antennas placed throughout the facility, to a Multi Network Controller with a Central Console of multiple WIPS servers, based on the manufacturers but its mode of operation is the same.

Users first define the operating wireless policies in the WIPS. The WIPS Sensors then analyze the traffic in the air and send this information to WIPS server. The Server in turn correlates the information, validates it against the defined policies and classifies if it is a threat. The administrator is then notified of the threat, or, if a policy has been set accordingly, the WIPS takes automatic protection measures. It can be configured either as:

- Network based WIPS or
- System based WIPS

In a network-based WIPS, Servers, Sensors and Console are all placed inside a private network using a private port to communicate and are not accessible from the internet. While, in a system-based WIPS, the Servers are installed inside a private network but the server is hosted in a secure data center and is accessible on the internet where users access the console.

CYBEROAM'S IPS It Scorecard

- Delivers application and network-layer protection with more than 3000* signatures which are automatically updated.
- Supports multiple protocols like HTTP, FTP, SMTO, POP3, IMAP, P2P and IM and automatically detects, blocks, or drops suspicious traffic.
- Ability for user to create policy, enabling enterprise to customize policies per user or group rather than create blanket policies. In the process, it eliminates false positive that occurs with blanket policies.
- The multi-policy support allows enterprises to define identity based policies that restrict access, or provide limited access to applications, including IM and P2P.
- Enterprises gain easy visibility into applications with user name, source, destination, period and extent of usage, enabling them to zero in on rogue users and system easily.
- Enterprises can create their own signatures to tackle attacks that are specifically directed at that enterprise and unique to it.
- It signature database also includes HTTP Proxy signatures that prevent masking of users surfing through an anonymous open proxy.
- The Centralized Security Enterprise can centrally create custom signatures for branch offices through the Cyberoam Central Console (CCC).
- Policies can be centrally pushed across distributed networks, enabling enterprise to enjoy zero-hour protection at branch offices against emerging network attacks despite the lack of technical resources at those locations.

Conclusion/Recommendation

It is possible that an enterprise owns an enviable corporate network and still goes home to sleep. IPS offers a reasonable and real alternative to traditional antivirus products. But more is needed in an enterprise network protection than putting an IPS solution on the network.

For maximum protection of the entire network from external intrusion, an IPS should be used. Though IPS varies in the level of protection offered, which is based on their manufacturers and company's policy configuration for it, as in the case of most technologies, there is no 'one size fit all' solution.

However, most security technologies succeed in managing the risk only partially. This is because, ***in addition to technologies, effective risk management also requires the right mix of people and processes.***

So I recommend that you do an honest recruiting. Get reasonable and responsible workforce. Humans that are security conscious (not rogues). Thank you for reading this far.

REFERENCES

Common Vulnerabilities and Exposure (CVE) http://www.cve.mitre.org/compatible/product.html

NIST SP 800-83, Guide to Malware Incident Prevention Handling http://csre.nist.gov/publications/nistpubs/index.html

Http://en.wikipedia.org/wiki/Intrusion_Prevention_System

ENHANCING THE NIGERIAN MANUFACTURING INDUSTRY WITH SYNERGY AMONG THE STAKEHOLDERS: THE EXPERIENCE OF A LOCAL TRANSFORMERS MANUFACTURING INDUSTRY

Giandomenico Massari, SMIEE
Danelec Ltd, Port Harcourt
gmassari@danelec-ltd.com

ABSTRACT
The bedrock of manufacturing, and in fact globalization of production and marketing is science and technology. Some industrialized countries that are poorly endowed with natural resources have become affluent societies through the execution of sound manufacturing productions developed through the application of science and technology. Despite the various National Development plans put in place in Nigeria to enhance industrialization, the country still remains a mono-resource (crude oil) based economy. The poor performance of the manufacturing sector has been attributed to a number of factors which include: High interest rates, Unpredictable government policies, Diversion of fund set out for manufacturing in the public sector by government, Nonimplementation of existing policies, Lack of effective regulatory agencies, Infrastructural inadequacies, Dumping of cheap products, Unfair tariff regime, Low patronage. This paper based on the experience of a local transformers manufacturing industry, proffers technological and economical solutions tackling the problems encountered so as to have high standard products with lower cost in the local and international market.

I. Introduction

Players in the Nigerian industrial and manufacturing sector can be classified into four groups, namely: multinational, national, regional and local. Apart from the multinational operators, most of the other players have disappeared in the last two decades, due to unpredictable government policies, lack of basic raw materials, most of which are imported.

Today, the Nigerian Industrial & Manufacturing sector accounts for less that 8% of Nigeria's GDP, with manufacturing capacity utilisation remaini ng below 35% for the most part of the last decade.

This paper tries to suggest a solution in making the Nigerian industry have a leading role, not only in the country but even in the whole continent.

II. History Of Manufacturing In Nigeria

The history of industrial development and manufacturing in Nigeria is a classic illustration of how a nation could neglect a vital sector through policy inconsistencies and distractions attributable to the discovery of oil. The near total neglect of agriculture has denied many manufacturers and industries their primary source of raw materials. The absence of locally sourced inputs has resulted in low industrialization.

While agriculture's relative share of GDP was falling, manufacturing's contributions rose from 4.4 percent in FY 1959 to 9.4 percent in 1970, before falling during the oil boom to 7.0 percent in 1973, increasing to 11.4 percent in 1981, and declining to 10.0 percent in 1988. On the following years, the trend continued to follow the decline reaching a present figure of 7.3 percent. Whereas manufacturing increased rapidly during the 1970s, tariff manipulations encouraged t he expansion of assembly activities dependent on imported inputs; these activities contributed little to indigenous value added or to employment, and reduced subsequent industrial growth. This trend is still present in today industries situation.

III. New Concept of Manufacturing - Non Autarky

For us to have a high standard in production, the individual industry must specialize in one product while forming a synergy with other ones that produce materials used as components for their final product. This can be applied in the Nigerian industry thereby creating an enabling environment where different specialized manufacturers work together.
Normally, there is a conception to establish an

industry having an autarky model. This means that the industry will manufacture all the necessary components that will be used to manufacture a final product. For example, the automobile industry will manufacture electrical, chemical and mechanical components necessary for the final product. Such type of industry will have a very high overhead cost and poor quality of the various components necessary for the final product. Starting from this point, a solution can be proffered in the decentralization of this production model and establishing various industries that specialize in specific components. This will imply a high skill for the human resourcing manpower to fabricate and to perfect the construction of the components in different sizes and shapes; and a more competitive price will be achieved on the final cost of the component. For instance, the autarky model involves purchasing of raw materials to manufacture the various components according to the figure of the final product while in the second model, due to the higher quantity requested by the various customers to manufacture the component, the raw material purchase will have a greater quantity that will lead to a lower price. It is obvious that in the market, the more quantity you acquire, the lower the price for the single unit of the measurement for the production material.

For instance, a transformer manufacturing industry, can cooperate with other stakeholders specializing in the various components, (e.g. steel manufacturing, bush manufacturing, coil manufacturing, wire manufacturing, cable manufacturing, etc.) work in synergy, we will have a new dimension in the environment of the industry in the country. Having a higher quality and a higher technology in one side, a cheaper and more competitive price in the other hand will lead to the advancement of the industries in the country. Such industry will have a prospect, not only in the domestic market but even in the international one.

IV. Local Content/Capacity Building For Engineering And Technology Transfer

Local Content: In this context, Local Content could be a product that will be mainly manufactured in Nigeria with the material, energy and man power coming for the majority from the country.

The need to develop and implement a local content policy within the Nigerian economy, especially in the engineering industry, can be traced to the growing need to build and develop local capacity in all the sectors of the economy with Nigerians taking active participation in the exploitation of the country's natural resources.

A. Capacity Building: Capacity building is defined as the 'process of developing and strengthening the skills, instincts, abilities, processes and resources that organizations and communities need to survive, adapt, and thrive in the fast-changing world. In my opinion, capacity planning is an activity that should be conducted in parallel with priority planning. The available capacity should match the workload; too little capacity decreases service levels and increases tied-up capital, whereas too much capacity is associated with unnecessary costs.

B. Technology Transfer and Personnel Training: Technology Transfer is the process of developing practical applications for the results of scientific research. It could also be defined as the process of sharing of skills, knowledge, technologies, methods of manufacturing, samples of manufacturing and facilities among governments and other institutions to ensure that scientific and technological developments are accessible to a wider range of users who can then further develop and exploit the technology into new products, processes, applications, materials or services. This will pave the way to develop a new national technology.

Although there is technology transfer, but there is also need for personnel training so as to e nhance that same technology, which increases the quality and reduces the cost of the final product.

Technology transfer and personnel training enable the Nigerian industry to have the technological expertise and the way to produce. These also enable the industry to source in Nigeria, for raw materials and the production of a product from the design to the final production. This process will create high standards, high specifications and lower costs, having as manpower, local competent workers doing the job.

V. APPP Program And Way Out

If I may suggest, the best formula to apply in order to manufacture a high standard and low cost

product is the **APPP system.** APPP is an acronym that stands for academia and public and private partnership. On this partnership, Academia will become the centre for technology research.

The industry, in interacting with the academia, will in terms of brain and equipment, enhance research and human capital. Hence the private sector, represented by the manufacturers, will not be involved in extraordinary costs and investments to establish within its structures research points that will lead to very poor impa cts and results compared to the money invested. The interaction will bring sustainability and good benefit to the industries. Academia offer financial benefits to the industry bringing about low investment, high standard in technology (developing the one that has been acquired) and high competitiveness in both domestic and international market. On the other side the Academia staff will receive financial and professional benefits. These motivations will translate in a very positive effect to the whole education sector carrying on a new technological dimension to the teaching strategies.

With the academia serving its purpose as centres for the development of technological knowledge, the final result will be acquiring of mostly theoretical and practical knowledge, self sustenance and human capital application by the personnel from these industries. In this process, will be experienced a transfer of knowledge from the academia to the industry and vice versa. The government is also not left out in the benefit derived from this kind of formula; there will be a high level of financial benefits.

The role of the Government will be to facilitate through policy and assistance, the incoming investors and the settlement of factories.

Finally, the Private Sector will be the one that will have the capital investments, technology and expertise that will be essential for the creation of the industry. The synergy among the stakeholders will create an enabling environment that springs the manufacturing at a higher level in a position to be competitive, not only in the domestic market but internationally.

VI. Industrialization for Economic Leap Frogging

Nigeria needs much more manufacturing than trading. It is very evident that in a well established country economy, the industries play a vital role in the growth and sustainability of the economy. Through the development of the country's manufacturing industry, you can achieve the development of the country's human resources, capacity building, technological development and economic growth. It's very vital to sustain and promote all the stakeholders in the manufacturing industries in order to promote the national growth.

Unfortunately, Nigeria has never followed this pathway and has sustained trading than manufacturing; leading the country to be a dumping ground for numerous sub-standard products.

We could note that neither technology advancement nor enhanced human resource capacity will be achieved in a country when the trading will have a leading role in the country's economy. Manufacturing industries will develop all the research that will produce a higher standard product with the consequent benefit for the citizen as individual and as a whole.

Manufacturing industries in Nigeria if encouraged and assisted will leap frog the country's economy. Nigeria needs much more manufacturing industries than trading in a ratio of 80:20. The preset ratio is the opposite figure.

VII. Experience With Transformers Manufacturing Industry

I like to mention a personal experience to establish in Nigeria a manufacturing industry for power transformer. In such industry, there is a practical application of local content enhancement, capacity buildin g and technology transfer. The industrial production transformers that meet regulatory strategy and customer requirement are based on standard processes that are open to regular improvement. That means that all the personnel (99 percent) are Nigerians when we have a very minimal percentage of expatriates (one percent).

The head of human resources has been intensively trained overseas and after such courses, there is extension of technical knowledge to the other personnel, establishing in-house

courses in Nigeria. There will be technology transfer utilizing the original engineering drawings that are necessary in the manufacturing of transformers. As much as possible, most of the components and materials are sourced in Nigeria to practically apply local content policy. We have established contact to work in synergy with some Nigerian Universities in the faculty of Engineering to develop and enhance the existing technology to a higher grade.

In the same vein, we are trying to establis h a relationship with the government at the federal and local level in order to achieve a sort of partnership for mutual benefit. The industry is even prone to receive a number of students from universities and polytechnics in order to give training and skill on the process to manufacture transformers.

This is a practical application of the model proffered before on APPP program. We are expected that this one will stimulate the interest of the various stakeholders and the full commitment of participation of all concerned.

VIII. Conclusions and Recommendations

The points analysed so far, are to proffer possible solutions to overtake the challenges that Nigerian industries will face in the domestic economy and in the international one.

The synergy among stakeholders should be put into practice for the promotion and transformation of the sector based on the points enlisted in the paper.

Finally, if these actions are to be implemented, I strongly believe that the development will be in a positive way, changing the present negati ve trend that the Nigerian industries are facing. Otherwise, if the Nigerian manufacturing industries will not take advantage of the suggested solutions following the consequent economical changes, they will be technologically marginalized and economically stagnant in the future than they are today.

REFERENCES

Bureau of Public Enterprises, Courtesy Embassy of Nigeria, Washington March 2002.

Library of Congress Country Studies: CIA World Factbook, June 1991 .

J.C. Ekeh et al, Department of Electrical and Information Engineering, Journal of Engineering and Applied Science, Medwell Journal, 2008.

CHALLENGES FACING POWER INFRASTRUCTURAL DEVELOPMENT IN AFRICA: NIGERIAN EXPERIENCE

Inugonum Thomas and Israel Esehoghene Abraham, MIEEE
Transmission Company of Nigeria, PHCN HQ, Abuja, Nigeria
elkarisnig@yahoo.com and inugonum2000@yahoo.com

ABSTRACT
Infrastructure determines the flexibility of a system to meet future requirements for the purposes of being efficient and productive which translates to job creation. It will be noted also that developing power infrastructure is the first step in a country's economic development. The power sector in Nigeria suffered so many years of neglect, however, with the coming in of the 4th republic, the democrats resolved to embark on reconstruction of the power infrastructures by constructing four (4) federal government power plants and additional seven (7) medium power plants in the Niger Delta Region. The development of these infrastructures will be made lighter if all tiers of government participate including the private sector, since the quantity and quality of infrastructures provided by a system determines its development and civilization. This paper examines the challenges facing infrastructural development in Nigeria and proffers solution.

I. Introduction

Infrastructure in its general terms can be defined as the basic facilities, services, and installations needed for the functioning of a community or society, such as transportation, communications system, water and power equipment, and public institutions including schools, hospitals, post offices and prisons.

In all the parastatals, the power sector has been the only sector that could not hide the inadequacies of the past administrations, this is because the development of the country's economy depends on the viability of the power sector, and it has a visible output that can be measured by the masses.

It will be true to mention also that lack of power infrastructural development has brought about the recession in the technology development and the unattractive investment climate in Nigeria, with only 40% of the population served with electricity from its 4954MW available capacity from the 7784MW old installed capacity.

This Paper reveals the importance of Power Infrastructural develop ment as a vital component toward achieving greater access to electricity by the masses in Nigeria. It shows the relationship between economic growth and infrastructural development as a key factor to access to electricity. Also the coordination of the developed infrastructure between Transmission and distribution shall be viewed with all seriousness since their output determines the access to electricity by the consumers.

Secondly, it outlines mitigation factors required towards achieving greater access to Power supply to the populace.

The paper also suggest other alternative inputs that will help sustain this access to electricity such as good governance, sector reform, international world best operational practices in the field, grid discipline, regulation and harmonization of standards.

II. Challenges Facing Power Infrastructure Development

The Challenges facing power infrastructure development includes the following:

1. Poor Project Planning
2. Poor Implementation
3. Funding.
4. Project Management
5. Environmental Problem

A. Poor Project Planning

In this part of the world, we are faced with the problem of materialism and wealth acquisition, this greed and insincerity creeps in when planning a project of enormous magnitude, we try to cut

corners in other to reap benefits, thereby failing to follow the right process of conducting feasibility studies on the proposed project which may reveal some technical difficulties that will be experienced in the process of executing the project thus requiring technical analysis for solution.

B. Poor Implementation

The process of implementation starts with the Front End Engineering Design (FEED), Advertisements, Tendering and Evaluation processes for the award of contract both for the Engineering Procurement and Const ruction (EPC) and Consultancy Services which sometimes end up in favour of the unqualified bidder who is a non professional, just because he has someone in authority that he is representing.

When this is done, because of the inexperience of the contractor or the consultant, they employ half baked or unqualified persons from outside or within who will not be able to interpret designs and so end up with wrong implementation of the project, this however increases the time frame for the completion of the project and require more money to be spent in realizing the project.

Another area that brings about the delay that leads to poor implementation is usually caused by too many bottlenecks associated with agencies that will give approval for the award of the contract all in the name of due process. The delay witnessed during the award is enough for the genuine contractors to loose their qualified staff that can't afford to be on standby.

C. Poor Funding

After the release of the initial contract sum known as the mobilization fees or the Advance Payment Guarantee (APG) to kick start the project, subsequent fund releases are delayed thereby affecting the opening of letters of credit that will be used for equipment procurement. Sometimes the delay stems from the bottleneck surrounding the process of receiving approval from the affected Ministry and that of finance. Presently, there are projects in the systems that are experiencing this problems.

D. Project Management

Lack of project management initiatives of both the EPC contractor and the consultant supervising the project translates to poor implementation of the project. This is as a result of using the wrong and inexperienced personnel for the job. Power projects require a competent project manager with at least 15- 25years experience, same with the project engineers and together they should know how to set their target and follow a drawn up time line to enable them achieve their milestones.

The use of inexperienced personnel becomes a set back on the project and affects the method of material procurement , this will not only elongate the completion time of the project but will make it look cumbersome and ambiguous.

E. Environmental Problems.

In developing nations; the feasibility studies will reveal steps to take with regards to compensating the communities where the proposed project will be located after a public enquiry had been set up to seek their views and their contributions. If negative, the government will look for alternative way of developing the infrastructure.

In Nigeria, it is the other way round, the project award must have been completed with the contractor paid his mobilization fees before the issue of compensation and the right of way for a power project will be tabled. This will delay the project physical implementation and completion because the community will not allow the contractor to start work at the site meanwhile the time to deliver the project is elapsing while the consultants and the contractors are targeting project extension translating to more money for them.

This is one of the major problems that discourage the independent power producers from completing their project timely because you see them paying a lot of compensation compared to the cost of the project.

III. Mitigation

1. Good Corporate governance as an important key to the acceleration of the Infrastructural development
2. International World best Practice
3. Diversification of Supply Sources
4. Harmonization of Standard and
5. Interconnection to other neighbouring super highways.

A. Good Governance structure

The inability to establish a good governance structure within the utility and the power sector in general brought about the set-back in the development of power infrastructures. The interference of the government in the utility has resulted to a negative impact mostly in the planning process and its implementation just because they want to benefit from power infrastructure projects. The utility management received numerous interferences from the government hence utility's management decision comes secondary during planning and implementation; however, a well governed system must have the following attributes:

1. It must be accountable
2. It must be transparent.
3. It should provide quality and efficient services to her customer.
4. It must have a set of objectives that will enable it achieve her objectives.

? Suggestion on the way forward is to introduce a political reform in the Government circle to avoid these interferences.

? **Share holders relationship:** This is a system where the shares given to the director Generals or Managing directors and other board directors are
Reviewed regularly to dissuade them from greed and to propagate the good governance in all the departments within the utility in order to ensure that the international best practices in the execution of their jobs are imbibed.

? The frame work of regulation must be explained by the Regulator as it relates to the power sector reforms on tariff issues to the customer.

B. International World best Operational Practices.

In the development of Power infrastructure, the utility must perform her opera tion within the ambits of the world best practices for both administrative and technical compatibility, our mode of operations should follow new innovation in terms of technology transfer and the proper way to carry out maintenance.

Usually before, the practice was the construction of single circuit lines which dominates the transmission lines for both 132kv and 330kV networks.
Nowadays along with the world international best practices in the power sector we design and construct a minimum of double circuit lines for security, redundancy and reliability of supply.

The continuous development of power infrastructure such as transmission grid and its component will grant us more access to quality electricity.

Finally a good business where the world best practice is in place should be able to absorb low cost of losses.

C. Grid development

The development of power infrastructure is the starting point of having access to electricity. Mostly the transmission lines in Nigeria have the subtransmission and transmission lines at their different voltage levels of 11/33kV, 132kV and 330kV lines respectively.

In most developed nations most of these transmission lines are sustained by well designed tower structure capable of carrying the 3 levels of voltage just to avoid the problem of right of way and compensation paid during environmental impact assessment.

It will be observed tha t in Nigeria the problem of right of way hinders timely completion of our power projects, the present NIPP, most of the lines are yet to commence just because of compensation problem.

Funding at the same time has not helped matters as the government delayed in releasing most of the fund for the procurement of the material and payment of compensation.

This delay in the development of this infrastructure has impeded the commencement of most IPPs that have gotten their generation license because ofthe fact that when they are ready on ground with their power plant ready to evacuate to the grid, you find out that the transmission substation where they intend to connect for purposes of evacuation is not ready.

Presently in Nigeria we have the Ikot Ekpene, Ugwuaji and Erukan 330kV substations, these are

hubs of switching station where many IPPs intend coming into the grid but up till now they are not ready

D. Grid discipline

This plays a vital part in the development of the grid, this deals with the operational ethics that rely on the grid code.

The operational staff must abide by the rules on generators merit order dispatch in order to match it with the demand. He therefore must follow the laid down rules, which requires a lot of discipline to follow in order to operate the grid.

Not adhering to these rules may le ad to overloading of the lines and or substation equipment thus resulting to the system being in the abnormal states. The world best practice stipulates that a good operating engineer must have a knowledge of the 5 operating states vis a vise (1) Normal - (2) Alert - (3) Emergency, (4) Extreme (5) Restoration.

The other aspect of grid discipline has to do with the consumers discipline, an awareness on the need to maximize energy used at our residential and commercial outlet is very important, the use of energy saving lamps and equipment is important.

E. Harmonization of standards.

In the development of power infrastructure, or grid facilities, harmonization of standards plays a vital role in realizing access to cheap electricity because, it will reduce the cost of material procurement which will lead to low cost of connection and translate to cheap tariff.

When the materials used are standardized as well as operational parameters, we experience security and reliability of supply since through the inter-connected grid, a country can supply power to her neighbors.

F. Data Management

The formation of a data bank is very important in knowing the utility asset and these data are the basis of carrying out load forecasting, power flows, short circuit and transient stability studies plus the compensation study.

Effective and efficient data management will ensure that the data bank is duly updated and thus give the right parameters of the system facilities.

Maintenance of the grid is another aspect that helps the grid development and it stem from equipment/asset auditing that also rely on data update

We should be able to predict the grid if we follow the planned, routine, and scheduled maintenance culture.

G. Diversification of Supply Source

This is a process of looking inwards on the energy resources that abound within the country. The availability of an energy master plan showing the gas pipelines, the transmission grid, the hydro terrain and other sources available will be another easy way of developing power infrastructure in order to strike a balance between supply and demand.

Sustainable renewable energy sources, such as wind farms, solar cells, voltaic cells and mini- hydro that can be connected off grid can be used to supply captive as well as suppressed loads.

The implementation of a National energy policy, this will assign a lager and appropriate role to the use of coal, lignite, solar, wind and other renewable energy sources in developing a long term supporting energy infrastructure for the country.

IV. Power Sector Reform

This is one of the problems of grid development, in Africa, a good number of utilities have keyed into the unbundling and for those that did it well got the benefit in both technical and administrative operation and cost.

The key priority is to allow NERC a greater autonomy to formulate, apply and enforce the basic rules governing the sector.

This autonomy to regulators will give the required confidence to private investor. It will be observed that sector reform in Africa is still very young and the staff of this regulatory agency should be given the required capacity development if the agency will thrive.

The burden of financing power infrastructure will continue as long as the power tariff is still low, lower than the cost of production of the power.
The private sector will not venture into the sector

unless the tariff is looked into by the government and allow the Regulator to price this power correctly.

It was noted in a survey by World Bank that private sector placed a high premium on adequate tariff levels and collection discipline and the investors are not likely to invest where these conditions do not exist.

In fact the introduction of the regulatory agency or the sector reform is to ensure that changes in the governing structure of the sector introduce a new institutional mechanism of ac countability and transparency.

State ownership of the power sector has given the politician a lot of leverage over managers of utilities allowing them to influence management decisions and actions. In the case of Nigeria with effect from July 1 st2008 the government agreed to subsidize the tariff for 3 years after increasing it using the Multi year tariff order method from N6/kwh to N11.5kwh the president endorsed the tariff increase on the 30th of April 2008 and it will take effect from the 1 stof Ju ly 2008. Energy should be paid for and not subsidized.

V. Conclusion

Development of the Power infrastructure will increase access to quality power/electricity; it will enhance the development of rural areas and increase technology development in Nigeria.

Development of power infrastructure will accelerate the economy of any country and redirect government attention to other parastatals such as Education, Health,Transport, etc.
We should note that the power utility of any country is the hub around which theeconomy of that country grows or revolves, therefore power infrastructural Development cannot be relegated.

Development of power infrastructure will increase and attract private investment that will translate to private capital involvement in the growing economy. Development of power infrastructure will increase the system reliability and security, it will also enhance effectiveness of the system, wealth creation andsustainability of the organization.

All these mentioned above will be achieved where there is Good Governance and international best practices in operation, also Bench marking as a means of improving utility performance, set out rules and criteria for handling results to be made to follow a standard due process in order to provide the customers with the right service delivery.

Most of these challenges has discouraged the unbundling of the vertically integrated power utility in Nigeria and even when the process was on-going a lot distraction were obse rved which left most of the successor companies not viable.

The sector reform process when adequately observed will fast track the power infrastructural development in Nigeria and remove most of the bottlenecks.

BEST PRACTICES IN POWER SECTOR REGULATION
A CASE STUDY OF NIGERIA PUBLIC POLICIES ON POWER GENERATION

E. N. C. Okafor, MIEEE and E. E. Ehighebolo
Electrical/Electronic Engineering Department,
Federal University Of Technology Owerri. Nigeria.

ABSTRACT
Availability of electricity remains a major factor in the location of industries and a strong instrument of social development. Access to electricity services is critical to achieving economic and social development targets in any developing country. The Federal Government of Nigeria has shown its commitment to reaching this development targets by creating policies to serve as blue prints towards achieving increased electric power generation and utilization in the country. These policies, if implemented will lead to great improvement in the total available electric power and could serve as a path way to improved power sector regulation for other developing countries.

Key Words: Public Policies, Energy, Electrical Power, renewable energy, strategies, electrification, electricity, renewable energy

I. Introduction

Energy has a major impact on every aspect of our socio-economic life, economically, socially, and even in political development of our nation. Inadequate supply of energy restricts socio-economic activities, limits economic growth and adversely affects the quality of life. Improvement in the standard of living are manifested in increased food production, increased industrial output, the provision of efficient transportation, adequate shelter, health care and other human services. These will r equire increased energy consumption. Thus, future energy requirements will continue to grow with increase in living standards, industrialization and a host of other socio-economic factors. It is pertinent to note that the impact of energy goes beyond national boundaries. Energy supply can be used as an instrument of foreign policy in the promotion of international cooperation and development.

Public policy on energy is a national policy made by government concerning some aspects of energy and electricity supply. The public policy on electric power supply sets out the Government's provision, policies and objectives for promoting energy delivering in the power sector.

This paper extracts the different policies on electricity generation sources, energy utilization, renewable electricity promotion and various electricity regulatory institutions in Nigeria.

II. Need For Public Policy On Energy

The level of energy utilization in an economy, coupled with the efficiency of conversion of energy resources to useful energy, is directly indicative of the level of development of the economy. In order to ensure optimal, adequate, reliable and secure supply of energy and its efficient utilization, it is essential to put in place a coordinated, coherent and comprehensive energy policy. The policy will serve as a blue print for sustainable developm ent, supply and utilization of electric energy within the economy and for the use of such resources in international trade and cooperation.

III. Objectives Of Public Policy On Electric Power

One of the cardinal objectives of public policy in electric power is implementation strategies which have been carefully defined with the fundamental guiding premises that energy is crucial to national development goals and that government has a prime role in meeting the energy challenges facing the nation. Furthermore, the dependence on oil can be reduced through the diversification of the nation's energy resources, aggressive research, development and demonstration, human resources development etc.

IV. Review Of Existing Policies

Several policy documents have provisions that are

relevant to the development of the Policy Guideline. These include the 1999 constitution of the Federal Republic, the National Economic Empowerment and Development Strategy 2004, the National Electric Power Policy 2001, Electric Power Sector Reform Act 2005, and the National Energy Policy 2003.

The 1999 Constitution of the Federal Republic of Nigeria places generation, transmission and distribution on the concurrent legislative list. This allows all tiers of government to be involved in most aspects of the electricity supply industry[1]1

A. National Economic Empowerment And Development Strategy

The National Economic Empowerment and Development Strategy proposes a set of targets to be met by the power sector before 2007, among which are:

? Increase generation capacity from 4,200MW to 10,000 MW (138% increase)
? Increase transmission capacity from 5,838MVA to 9,341 MVA (60% increase)
? Increase distribution capacity from 8,425 MVA to 15,165 MVA (80% increase)
? Reduce transmission and distribution losses from 45% to 15%. The NEEDS document also highligh ts the Federal Government's mandate to the former public utility NEPA now Power Holding Company Nigeria (PHCN), some of which are:
? Expeditiously implement the electric power sector reform program
? Generate 10,000 MW by 2007, from existing plants, new host generation, and reasonably priced independent power plants.
? Develop the capacity to transit and distribute the higher level of generation.
? Deregulate the power sector to allow increased private sector participation.

B. National Electric Power Policy (NEPP) And Electric Power Sector Reform Act (EPSR)

The National Electric Power Polic y (NEPP) of 2001 was the precursor to the Electric Power Sector Reform (EPSR Act of 2005). Indeed most of the significant provisions of NEPP are included in the EPSR.

The EPSR Act 2005, emphasises the role of renewable electricity in the overall energy mix, especially for expanding access to rural and remote areas. In Part IX under rural electrification Section 88 (9), stipulates that *information shall be presented to the President by the Minister of Power and Steel on, among others[9]:*

a. Expansion of the main grid
b. Development of isolated and mini grid systems and
c. Renewable energy power generation

The REA is mandated to provide the strategy and plan for expanding access to electricity including the use of renewable energy.

C. Policies On Energy Sources

There exist variety of energy sources in Nigeria that can be converted to electricity these include; coal, nuclear, hydro, solar, biomass, wind and hydrogen, some of which will be discussed. In other to maximize these energy resources into electrical energy have been put in pla ce by the National Energy Policy (NEP) of August 2003. The following are the relevant provisions of NEP for the development of the policy guidelines [7[8

Coal:
Policies:

i. The nation shall pursue vigorously a comprehensive programme of resuscitating of the coal industry.
ii. Extensive exploration activities to maintain a high level of coal reserves shall be carried out.
iii. Private sector as well as indigenous participation in the coal industry shall be actively promoted.
iv. The exploitation and utilization of th e coal reserves shall be done in an environmentally acceptable manner.

Objectives:

i. To promote production of coal for export.
ii. To promote effective utilization of coal for complementing the nation's energy needs and as industrial feedstock.
iii. To attract increased investment into the coal industry
iv. To utilize coal in meeting the critical national need for providing a viable alternative to

fuelwood in order to conserve our forest.

v. To minimize environmental pollution arising from the utilization of coal

Strategies

i. Intensifying the drive for coal exploration and production activities.

ii. Providing adequate incentives to indigenous and foreign entrepreneurs so as to attract investments in the coal exploration and production.

iii. Providing adequate incentives to indigenous and foreign entrepreneurs for establishment of coal-based industries.

iv. Organizing awareness programmes for the use of smoke less coal briquettes as an alternative to fuel wood

v. Encourage research and development in the processing and utilization of coal.

vi. Introducing clean coal technologies into coal utilization.

Nuclear:

Policies: The nation shall pursue the exploration of nuclear energy for peaceful purposes

Objectives:

i. To pursue the introduction of nuclear power into the generation of electricity in the long term.

ii. To apply nuclear science and technology in industry, agriculture, medicine and water resources management.

iii. To pursue the exploration of nuclear mineral resources in the country.

iv. To institute nuclear safety and environmental protection measures.

v. To promote the development of nuclear science and technology.

Strategies:

i. Intensifying manpower development in the utilization of nuclear energy for peaceful purposes.

ii. Providing adequate resources to the Nigerian Nuclear Regulatory Authority (NNRA) for the enforcement of nuclear laws and regulations.

iii. Intensifying research and development efforts in nuclear science and technology.

Hydropower:

Policies:

(i) The nation shall fully harness the hydropower potential available in the country for electricity generation.

(ii) The nation shall pay particular attention to the development of the min and micro hydropower schemes.

(iii) The exploitation of the hydropower resources shall be done in an environmentally sustainable manner.

(iv) Private sector and indigenous participation in hydropower development shall be actively promoted.

Objectives:

(i) To increase the percentage contribution o f hydroelectricity to the total energy generated.

(ii) To extend electricity to rural and remote areas, through the use of mini and micro hydropower schemes.

(iii) To conserve non-renewable resources used in the generation of electricity.

(iv) To diversify the energy resource base.

(v) To ensure minimum damage to the ecosystem arising from hydropower development.

(vi) To attract private sector investments into the hydropower sub-sector.

V. Energy Utilization

Electricity is a form of energy which enjoys considerable and diverse application because of its flexibility and ease of transmission and distribution. Commercial electricity is generated mainly from Hydro, steam plants and Gas turbines in Nigeria, and 98% of generating plants are owned by the Government.

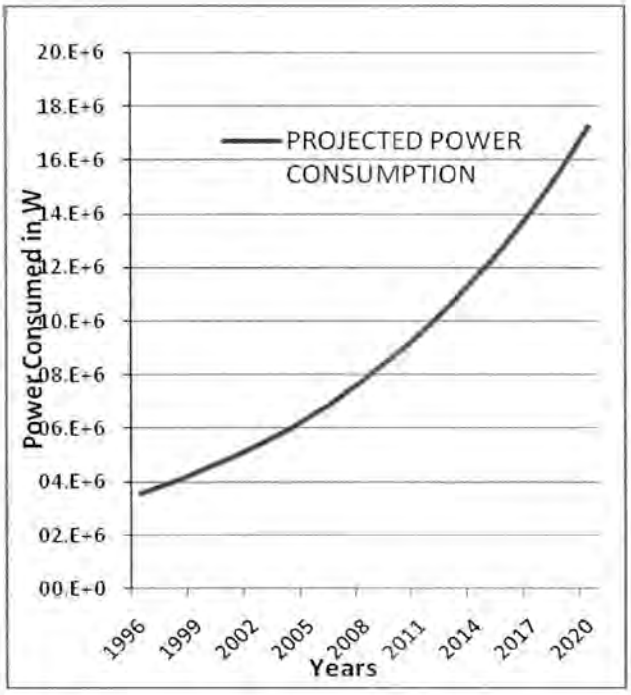


Fig 1: growth of power consumption from 1996 to 2001 and projected to 2020.

The above figure was drawn using the growth equation $y = ab^x$ where, y is the power consumed in Watts, a and b are growth constants, and x is time in years. The graph shows the rapid growth in demand for electricity, and predicts that by 2020 the demand would have increased to 20MW. The inability for generating stations to meet the demand for electricity has lead Government to set policies to meet with present and future electric demand [10].

A. Policies

1. The nation shall make steady and reliable electric power available at all times at economic rates, for economic, industrial and social activities of the country.
2. The nation shall continue to engage intensively in the development of Electric Power with a view to making reliable electricity available to 75% of the population by the year 2020
3. The nation shall promote private sector participation in the electricity sub-sector while ensuring broad based participation of Nigerians.

Objectives

i. To provide electricity to all state capitals, local government headquarters as well as other major towns by the year 2010.
ii. To stimulate industrialization in the rural areas in order to minimize rural urban migration.
iii. To provide reliable and stable power supply to consumers, especially to industries.
iv. To ensure the removal of bottlenecks militating against the utilization of the full capacity of the existing electric power plants.
v. To broaden the energy options for generating electricity.
vi. To attract adequate investment capital, both foreign and domestic, for the development of the electricity industry.
vii. To maximize access by Nigerians to the investment opportunities in the electricity industry.

Strategies

i. Rehabilitating existing power plants in order to derive optimum power from the installed capacity.
ii. Completing on-going projects designed to enable the National Electric Power Authority (NEPA) satisfy the national demand
iii. Reinforcing the transmission and distribution networks necessary to allow consumers to enjoy steady and reliable supply of electricity.
iv. Establishing basic engineering infrastructure for the local manufacture of electrical equipment, devices and materials.
v. Encouraging research and development in the generation, transmission and distribution of electricity.
vi. Reducing high import duties paid on generation, transmission and distribution materials.
vii. Setting up a National Electric Supply Training Institute and zonal training centres where the core of the middle level manpower and artisans, various cadres of professional technical officers, operators, linesmen and cable joiners are to be trained and groomed in the art of operation and maintenance of equipment for the generation, transmission and distribution of electricity.
viii. Ensuring the participation and involvement of indigenous engineers and applied research groups in the execution of on-going and future projects right from feasibility studies, with the objective of establishing local capacity in the long term.
ix. Developing and implementing a programme for the participation of the private sector in the various sectors of the electricity industry.

x. Developing other potential sites for hydropower, gas and coal-fired power plants for electricity generation.
xi. Intensifying the national effort in training, research and development with a view to generating electricity using nuclear, solar, wind and other renewable resources in order to conserve our fossil fuels.
xii. Taking effective measures to ensure the security of electrical installations.
xiii. Providing appropriate incentives to entrepreneurs to ensure adequate returns on investment.
xiv. Providing appropriate financing facilities to support indigenous investments in the electricity industry.
xv. Encouraging off-grid generation and supply of power in remote or isolated areas.
xvi. Establishing a Rural Electrification Fund to facilitate electrification in the rural areas.
xvii. Establishing a reduced tariff regime for low income and especially handicapped electricity consumers and a mechanism for funding the subsidy.

VI. Renewable Electricity Promotion And Regulatory Policies

In order to encourage investment in the renewable electricity production the following policies have been made:

POLICY1: The Federal Government of Nigeria shall expand the market for renewable electricity by

- Licensing and fees schedule
- Local manufacture and assembly
- Subsidies
- Technical standards and certification of personnel

POLICY 2: The Federal Government shall establish stable and long-term favourable pricing mechanisms and ensure unhindered access to the grid. Grid operators must guarantee the purchase and transmission of all available electricity from renewable electricity producers. While renewable electricity plant owners bear the cost of connection, grid operators must ensure the necessary system upgrade. All upgrade cost must be declared to ensure necessary transparency.

Policy 3 was created to provide Off-Grid connection of electricity to those outside the reach of the National Grid. Policy 4 was made to provide electricity for rural based businesses.

POLICY 3: The Federal Government supports the construction of independent grid to provide power service for local economic activities and sustainable living.

POLICY 4: The Federal Government will develop innovative, cost-effective and practical measures to accelerate access to electricity services in rural areas through renewable sources [6]. The Federal Government shall promote the role of the private sector in the delivery of rural electrification through renewable sources. This will be achieved through the support of entrepreneurship, training, marketing, feasibility studies, business planning, management, financing and connection to banks and relevant institutions. This approach includes integrating renewable electricity provision with other services, including water, telecommunication, fertilizers, pumps, generators, batteries, kerosene, LPG, electronics.

POLICY 5: There shall be a Renewable Electricity Trust Fund which shall be set up under the Rural Electrification Fund.[4]

Renewable Electricity Trust Fund

The purpose of the Renewable Electricity Trust Fund (RETF) shall be to promote, support and provide renewable electricity through private and public sector participation. The RETF seeks to provide support to the following:

- Construction of independent renewable electricity projects, especially in rural and remote areas;
- Establishment of domestic production of technologies for development and utilization of renewable electricity;
- Provision of resources for micro financing to stand-alone systems under 20KW capacity.
- Support to research and development and construction of pilot projects;
- Promote training and capacity building in renewable electricity technology and business development;
- Encourage public awareness initiatives; and
- Provision of surveys and assessments of renewable electricity resources and other relevant information.

Support from RETF shall be guided by the following principles:

- Support shall be temporary and targeted
- Support shall be spread out over time
- There shall be competition in the financial support system
- Support to projects shall be subject to continuous reviews and evaluations.

Source of Funds:

The Renewable Electricity Trust Fund is a proportion of the Rural Electrification fund which consists of the following capital assets [4]

- Monies appropriated by the National Assembly
- Revenue from surcharge on eligible consumer of electric power as may be determined by the NERC
- Donations, gifts and loans from all eligible local and international sources.

The sources of funds for the Renewable Electricity Trust Fund is a proportion of Rural Electrification Fund as may be determined by the Honorable Minister of Power and Steel. RETF shall be managed under the Rural Electrification Fund.

Electricity Regulatory Institutions and Policies

POLICY 6: The Federal Government is committed in the delivery of electricity to meet national development goals [10].

The Federal Executive Council

The Federal Executive Council will:

- Provide the overall direction for the development of the electricity industry in Nigeria
- Ensure the general consistency of electric power policy with all other national policies and specifically, with other aspects of energy policy;
- Facilitate the alignment of the policy and regulatory guideline on renewable electricity with Nigeria's international obligations, especially on climate change and
- Enact promptly the necessary laws, regulations and other measures required to support the policy guidelines.

Federal Ministry Of Power And Steel

The Federal Ministry of Power and Steel will have the overall responsibility for formulating electric power policy, including the policy on renewable electricity. Their specific functions include:

- Proposing policy options and recommendations to the Federal Government concerning legislation, policy and investment on renewable electricity.
- Monitoring and evaluation of implementation and performance of the policy within governmental agencies and in the electricity market.
- Establishing, monitoring and evaluating the performance of renewable electricity policy on increasing the access to electricity in rural areas;
- Facilitating the close coordination of renewable electricity activities among agencies of the Federal Government;
- Ensuring that Nigeria's electricity policy is consistent with national obligations in regional and international organizations; and liaising with the National Assembly on matters relating to renewable electricity production and use.

Nigerian Electricity Regulatory Commission

Established to carry out the following functions;

- Lower licensing charges for renewable electricity licensees
- Develop and maintain quality standards for renewable electricity equipment and installations;
- Lessen the regulatory compliance and reporting burden;
- Ensure that appropriate Environmental Impact Assessments are conducted prior to award of licenses; and
- Report specifically on the status of the renewable electricity industry in its quarterly report to the President and the National Assembly.

Rural Electrification Agency

Established by the EPSR Act 2005, its primary functions are:

- Extension of the main grid
- Development of isolated and min-grid systems and
- Renewable energy generation
- Serve as an implementation agency for Policy Guideline;
- Provide a coordinating point for renewable electricity activities among state and federal agencies; and
- Carry out such duties as may be assigned by the Honorable Minister.

Energy Commission Of Nigeria
Established by Act 62 of 1979 constitution and amended by Acts 32 of 1988 and 1989 is charged with conducting strategic planning and coordination of national policies in the field of energy in all its ramifications; Major objectives of the commission are:[7][8]

- Guarantee increased contribution of the energy sector to national income and economy
- Guarantee adequate, sustainable and optimal supply of energy at appropriate cost and in an environmentally responsible manner to the various sector of the economy by utilizing all viable energy resources.
- Promote an efficient consumption pattern of energy resources;
- Promote indigenous acquisition of energy technology and managerial expertise as well as indigenous participation in the energy sector industries; and
- Promote increased investment and the development of energy sector industries with private sector participation.
- Ensure that evolving policies conform and are harmonized with the overall thrust of the National Energy Policy;
- Ensure broad-based participation by key stakeholders in the energy sector; and
- Provide overall coordination of renewable electricity within the broader energy sector.

Other Agencies include State Rural Electrification Board, related State Ministries, Organized Private Sector, NGOs and CBOs.

VII. Conclusion

Public policy is an attempt by the government to address a public issue, to this end the Federal Government of Nigeria has established laws and regulations to help boost the electricity generated in the country. These policies are some of the practices that can be put in place to help improve the power sector of any developing country.

Public policies on encouraging private participation in the generation of power have been implemented by the creation of Independent Power Plants IPPs to help boost the generated power and achieve the 10,000 MW goal of 2010. Though these policies have been laid, and some successfully carried out, the policy on providing cheap and affordable electric energy (by regulating electricity bills) to nationals need to be enforced.

The Federal Government is yet to implement the renewable energy generation and active participation of this sector in contributing the national pool of electric energy. The government must not relent in its effort to provide sufficient generated electric power, in the sense that even after achieving the proposed 10MW, consumption of electricity as projected will keep increasing so there is a need to put in place measures to continuously boost the total electric power being generated until generation power plants have a total production capacity far greater than peak demand only then will the nation have actually achieved solving the electric power problem completely.

REFERENCES

1. Federal Executive Council, 'Policy Guidelines on Energy in Nigeria', the Presidency, (1984).
2. Ojo A. T. 'An Analytical Study of Energy Supply in Nigeria', Energy Policy, **12**, 24 pg 22. (1984).
3. Energy Commission of Nigeria (2002), National Energy Policy, Abuja. August.
4. Energy Commission of Nigeria (2005). Renewable Energy Master Plan, Abuja. November.
5. Ibitoye, F and Adenikinju A. (2007); 'Future Demand for Electricity in Nigeria', pg 492-504.
6. ECOWAS (2006) White Paper for Regional Policy Geared towards Increasing Access to Energy Services for Rural and Peri-urban Population in Order to Achieve the Millennium Development Goals.
7. Energy Commission of Nigeria (2003) National Energy Policy.
8. Energy Commission of Nigeria (1999), 1999 Constitution of the Federal Republic of Nigeria.
9. National Planning Commission (2004), National Economic Empowerment and Development Stategy (NEEDS)
10. Nigerian Electricity Regulatory Commission (2006), Licence and Operating Fees Regulation. NERC: Abuja.
11. Federal Government of Nigeria (1999) Constitution of the Federal Republic of Nigeria.
12. Wolf, Robert, "Definitions of Policy Analysis", 2010

ELIMINATION OF LOAD SHEDDING IN OUR NETWORK (PHCN NIGERIA): A CASE STUDY NIGERIA.

Thomas A. Inugonum and Isreal Abraham, MIEEE
Power Holding Company of Nigeria, Plc, Abuja.
elkarisnig@yahoo.com and inugonum2000@yahoo.com

ABSTRACT
Electricity transmission and distribution requires adequate load balancing for effective operation. Load shedding had been adopted as a solution method in cases of increase in demand strains on the power generating system. This paper describes new strategies that offer better alternative to load shedding. The paper uses Nigeria electricity network as a case study.

Keywords: Load balancing, load shedding, Electricity network, Power Transmission

I. INTRODUCTION

Load shedding is defined as the deliberate shot-down of electric power in a part or parts of a power transmission and distribution system to prevent the failure of the entire system when demand strains the generating capacity of a system [1].

This could be likened to a relief valve attached to pressure equipment of a boiler.

The purpose of load shedding in a system is to balance the load (customers demand) and the generation (plant capacity) in the event that there is no balance in load demand/sup ply and the system becomes overloaded i.e. the load becomes more than the generation thus impacting on the generator negatively by slowing it down [2].

The result leads to a drop in the system frequency which if allowed to deteriorate leads to system collapse. An automatic frequency load shedding program can also be achieved through an under - frequency relay scheme.

In planning, we employ different types of intervention methods as a way of obtaining solutions to load shedding.

These intervention me thods could be in the form of short, medium and long term planning of the system network for reliability and security.

In PHCN network we have these under frequency relay scheme at the 132 and 33kv network and at pre set frequencies below the nominal frequency of 50Hz.

Actually this is more of frequency control but sometimes deployed as a means of load shedding.

The benefits of this under-frequency relays installed in the network are many but most importantly [6]:

- It eliminates total system collapse.
- It assures frequency stability of the system
- It may guarantee voltage stability of the network.
- It protects most of our thermal generating units from severe damage due to load rejection.
- It helps the system to moni tor the frequency during the course of gradual restoration of shaded loads.

Finally, the speed of load shedding is paramount to the stability and reliability of the network thus suggesting ways to reduce or eliminate it totally.

II. Methods of Eliminating load shedding.

We shall consider the following ways/suggestion to reduce load shedding as it will be entirely difficult to eliminate it from a network where both the infrastructure and demand do not meet need with surplus or redundancy.

A. Quick intervention:

- The use of an automatic under frequency relay scheme is a fast way of securing the system network from collapsing as a result of

frequency excursion.

- The extension of the Supervisory Control And Data Acquisition system (SCADA) from our 132kv to 33kv distribution network to monitor the loads and the overloaded lines and it should be able to isolate overloaded lines when it exceed the thermal rating of these lines as well as the substations equipment.
- All control rooms in the network should be equipped with effective and efficient telecommunication gadgets for fast dissemination of instruction/information to fellow operators as well as other participants in the network. However, Optic fiber network shall be encouraged in a network like ours.
- Adequate training of both management, operational and maintenance staff will reduce to minimal the amount of load shedding experienced in our system. It is true that most times we avert a total collapse; there must be an experienced operation engineer who uses his skills properly in operating the network.
- The provision of the state of the art equipment for fast fault analysis to the maintenance staff also contributes to the fast response and quick restoration of faulty equipment into network.
- The introduction and maintenance of an auto re-closure relay in remote areas of our network will go a long way in reducing the time of feeder restoration in the case of a transient fault.

B. Medium Intervention

Network Islanding

In PHCN network we operate two islands, and for the efficient operation of a network we must have a slack bus which is capable of generating and absorbing the reactive power in the system, therefore it is suggested that the automatic frequency relays in this islands should be set at slightly different frequency values from the operating frequency of 50Hz and also there should be two slack busses for such network in percentage values so as to:

i. Guide against a severe fault that will lead to frequency excursion thereby cascading to total collapse
ii. Provide the required automatic separation of the islands during system disturbances by applying this scheme at a set frequency on Benini Omotoso -Ikeja West and Benin Osogbo 330 KV lines [3].
iii. Help the gradual restoration of the shaded loads in small blocks.
iv. Help in the control and rotation of set frequencies of the automatic under- frequency relays on blocks of load to shed in any future frequency excursion [2].

Spining Reserve

In large networks, like ours there is the need to ensure that there is a reasonable level of spinning reserve set by the transmission company (TCN) for each power plant participating in the network. This however depends on the capacity of the generating plant (3).

The need for this reserve is to act as a safety measure in the event of a severe fault on the network lines or substations equipment leading to frequency excursion, the system operator should be able to call up the reserve to help stabilize the system thus reducing the long time it will take to restore the system if it had degenerated to a system collapse.

Technical Equipment Auditing

Conducting technical equipment auditing is very useful because it will reveal the transmission /distribution equipment that needs upgrading like the circuit breakers, transformers and lines.
This auditing should be performed quarterly since development in the distribution is a continuous activity.

Compensation Equipment

This is a very important intervention method, mostly for distance load centers that has little or no generation like Maiduguri, Kano, Sokoto and Birini Kebbi in Nigeria. We observe low voltage profile in these areas of the network; therefore to reduce load shading we install some Capacitor Banks as a way of boosting the voltages and reduce the frequency of load shading.

III. Long Term Intervention

A. Adequate Generation

Provision of adequate generation is another measure that will reduce load shading in our network. This would have been treated under quick intervention but the cost of constructing a power plant is enormous.

Load shading is as a result of low voltage profile

observed in our network busses, and when electrical equipment is fed with a low voltage, the tendency is that:

- The equipment will malfunction
- Heating of the transmission and distribution lines will eventually lead to line snapping thus throwing off of the load resulting to the pulling out of synchronism of some generator units.
- It will eventually destroy the equipment.

Therefore, if we have an adequate generation, the voltage profile at the buses will improve to the acceptable voltage range of the u tility; this will reduce load shading as most of the shaded load is to improve the voltage profile of some distant areas from generation. In our net work, the voltage range is +5% and -15% for 330KV and + 10% and -15% for 132KV transmission and ±6% for distribution networks respectively (5).

B. Free Governor Operation

For effective operation of a network system, it is recommended that the governor of some of the generating units in a generating station be selected to operate in the free governor's mode.

The reason is for it to respond very fast to the changes in the network that may have resulted from switching, faults and general perturbation of the system.

The generator when set in this mode has the capability of regulating itself thereby restoring stability to the system. In the contrary if the governor is fixed the tendency is that the system will collapse.

C. Redundancy

Most of our transmission lines are usually single circuit however, in the event of the line being severed; the load will be thrown off thereby impacting neg atively on the generator units.

This transient instability can be checked if the lines were to be double circuit since the load on one line could be transferred to the other automatically provided that the thermal capacity of the conductor will withstand the load.

In the generation and transmission substation there are some critical transformers that should not be three phase in one, instead they should be three phases in three independent units plus a spare single phase unit that can be switched ON whenever one unit of the transformer fails.

The same with back up circuit breakers reserve bus bars as well as reserve battery banks for effective network operation with regards to elimination of load shading.

D. Distributed Generation

Development of off - grid distributed generation could be used to reduce and or eliminate load shading in our net work. It can also assist in capturing captive and suppressed loads in the rural areas since a lot of suppressed and captive load exist in our network.

E. Interconnection

Interconnection between neighboring countries is another way of reducing load shading in our network, if we consider a major fire outbreak in an utility with only one or two generating stations such as Benin republic or Togo, you find out that the result will be a total collapse of their network.

If there is an interconnection link they can easily restore supply after isolating the faulty plant in a very short time.

It equally help s to stabilize the system in the event of system disturbance.

Presently, we have interconnection/power highways amongst African countries e.g Nigeria and Niger Republic, Rep of Benin and Togo, with Ghana and Cote d" Ivoire and Burkina Fasso whilst there are on-going construction of Nigeria to (Sakate) Benin Republic(7).

F. **Siting Of The Generation Plant**

When a generation plant is sited in the right location, the result is that:

- It will boost the voltage profile of that area and reduce load shedding.
- Compensation will not be neces sary within a given radius of the plant location.
- Line losses due to long distances will disappear
- It will capture suppressed and captive loads in that area.

Therefore, proper sitting of generator plants

suggest that a good location, integration and evacuation studies must be carried out before a generator will be allowed to tie its capacity to the utility grid.

G. Load Forecasting

Adoption of good load forecasting methods to be implemented quarterly will help us study the system behavior, this method should be reviewed annually so as to be in line with the development and load growth of the entire system.

PHCN NETWORK

IV. Conclusion

It is quite clear that frequency excursion leads to system collapse, therefore, to forestall it or reduce the rate of load shading and collapse the above measures suggested should be employed in our networks.

REFERENCES:

Guam Power Authority (Website)

The Grid Code And Guidelines For The Nigeria Electricity Transmission System. December 2005.

Inugonum , Iyang And Ogwu "Investigation Of System Collapse".Dec 2004.

Operational Procedure For Electric System Operators In PHCN.

West Africa Regional Stability Study Vol 1 Master Plan By USAID & NEXANT 2004.

National Grid Operations (2005) Annual report.

GREEN VILLAGE ELECTRICITY PROJECT; A SUITABLE MODEL FOR RELIABLE RENEWABLE ENERGY DEPLOYMENT IN NIGERIA

Ifeanyi B. Orajaka
Department of Electrical/ Electronics Engineering,
Federal University of Technology, Owerri Imo State
Email: ifeanyi.b.orajaka@gmail.com

ABSTRACT
As a result of the pressing challenges in the Nigerian power sector and the looming effects of global climate change, the need arises for engineers to design and implement reliable renewable energy systems to mitigate the duo. This paper proffers the Green Village Electricity Project as a suitable model for providing off-grid solar electricity to remote settlements in Nigeria while dousing the effect of climate change on a

I. Introduction

The Nigerian state has over the years been experiencing epileptic power supply, transmission and distribution problems. The country has an installed capacity of 15,000MegaWatts of electricity drawn from such sources as hydro, coal, steam, and gas generation stations, but the amount of energy available for distribution as at end of January 2009 was a pauper 1600MegaWatts which cannot be compared with her large population of over 150million inhabitants. This means energy per capita of 10.67Watts a nd has been one of the major setbacks to her rapid socio-economic development.

Equally conventional power stations are obsolete with little or no maintenance operations resulting to poor performances and high carbon and green house gases emission in this era when the environment is threatened by serious environmental problems caused by the emission of these gases. Furthermore, the areas connected to the national grid lack constant supply of electricity not to talk of those living in remote regions of the country that has no hope of receiving electricity. Equally it would be economically impossible to connect these areas judging by their distances from the grid lines.

This paper discusses the various sources of generating electricity in Nigeria, highlighting the pros and cons of each. It equally compares the energy generation index of the Nigerian state with that of the developed countries of the world.

Consequently, the paper suggests the adoption of solar as a viable alternative/ supplement to conventional energy sources in the country. It discusses the analysis, pre-design, design, installation, maintenance, and troubleshooting methodologies of solar electricity systems for both domestic and industrial utilization. The paper also highlights possible causes of solar electricity malfunctions and ways to mitigate them.

Furthermore, the paper examines the economic implications of adopting solar electricity while pointing out the various economic and environmental advantages of its utilization both to the primary consumer and the entire human race.

Ultimately, the paper presents Green Village Electricity Project a brainchild of the IEEE Presidents' Change the World Students Competition which is intended to serve as a suitable Micro scaled model for reliable solar electricity deployment in Nigeria so as to jump-start economic sustainability.

II. Nigeria Power Sector In Review

Conventionally, electricity generation in Nigeria is drawn from such sources as coal, hydro, thermal and predominantly Oil& Gas. The organization responsible for electricity production and supply in Nigeria is the Power Holding Company of Nigeria (PHCN).

Nigeria has 15,000MW of installed capacity; however the country is only able to generate 1600

MW because most facilities are poorly maintained. The country has proven gas reserves and about 8000 MW of hydro development has been planned. The country has plans to increase access to electricity throughout the country to 85% by 2010. This implies the construction of 16 new power plants, approximately 15,000 KM of new transmission lines as well as distribution facilities.

The Nigerian power sector has high energy losses (30-35% from generation to billing), a low collection rate (75-80%) and a low access to electricity by the population (36%, energy per capita of 10.67watts). Presently, only about 10% of households and 40% of the country's total population have access to electricity. The Nigerian Energy Commission and the Solar Energy Society of Nigeria have been tasked with generating a solar-powered solution for the remote rural dwellers not served by the national power grid.

Nigeria has fourteen power stations consisting of:

Table 1. Power generating plants in Nigeria

Power Generating Plants in Nigeria			
S/No	***Description***	***No of Power Stations***	***Composition***
1.	FuelOil/ Coal Power Stations	7	Egbin Electric Power Business Unit, Afam Electric Power Business Unit, Delta Electric Power Business Unit, Shiroro Electric Power Business Unit, Jebba Hydro Power Station, Shiroro Hydro Power Business Unit, Kainji Hydro Power Station
2.	Gas Turbine Power Stations	3	Afam, Sapele and Delta Power Station
3.	Hydro Power Stations	3	Jebba, Kainji, Shiroro
4.	Thermal Power Stations	1	Egbin

Furthermore, comparing the Nigerian energy indices with that of other countries of the world gives rise to the following charts.

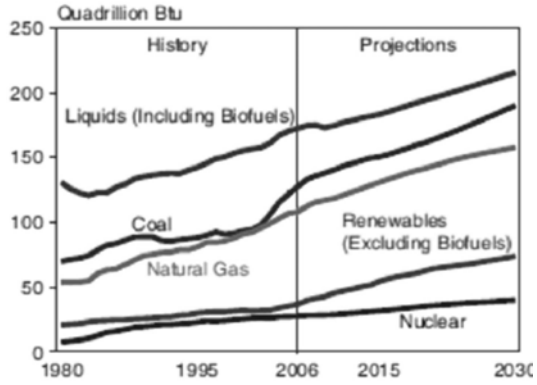


Fig 1. World energy generation projection

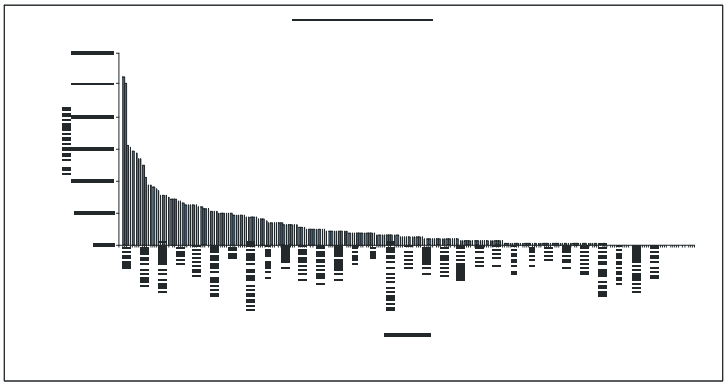


Fig 2. Energy Comsumption indices

A. Renewable Energy

By definition, renewable energy are those energy sources that are replenishing in nature, which do not contribute to further global warming and global climate change.

They are also those sources of energy and/or power that non-polluting in nature and are fundamentally environmental friendly.

The sources of renewable energy are:

1. Solar:
2. Wind
3. Geothermal
4. Oxygen/ Hydrogen
5. Timber
6. Fruits and Vegetables
7. Meat from Animals
8. Water

Of all these sources the most adopted form of global renewable energy are; wind, solar, biomass, water and geothermal.

B. Solar Electricity Case Study

Solar Electricity is the generation of electricity from the radiations of the sun through the use of photovoltaic cells.

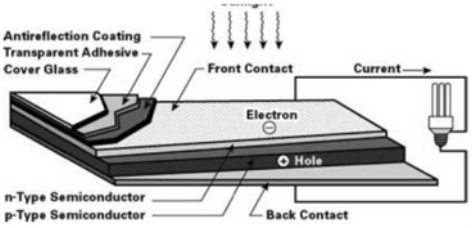


Fig. 3 A Photovoltaic cell

The generated power in DC form can be converted to AC through the use of inverters for a wide range of applications.

The basic components of solar electricity generation are:

a. Sun
b. Solar Cell Module
c. Charge Controller
d. Battery (Energy Storage)

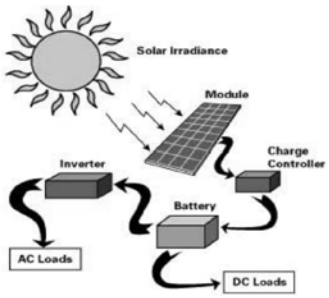


Fig 4. Solar electricity generation process

In recent times, solar electricity generation has found wide spread application in many developing and developed countries of the world. This is as a result of the relative availability of her primary element (sunlight), its environmental friendliness, zero pollution nature, low or no maintenance nature and the use of no traditional fuel.

In china for instance, solar electricity is the major supply source in the Tibet region and other remote villages where grid connecting is both practically and economically challenging.

Percentage of population with no electricity

The nation has a total of about 50MW of solar electricity supply from about 1000 installed PV arrays in various remote energies.

Equally, solar electricity has been proved to have diverse areas of application. This flexibility in utilization has enhanced the call for is utilization. Recent developments allow the integration of energy from various sources for both commercial and domestic utilization, this equally contribute to the flexibility of solar electricity.
However, solar electricity has the following down turns;

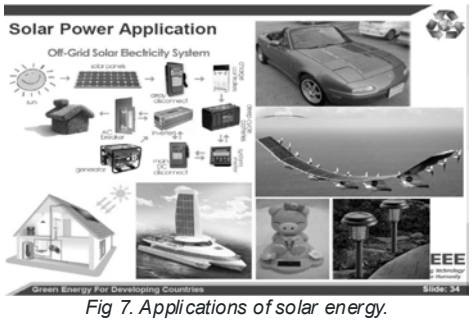


Fig 7. Applications of solar energy.

a. High installation cost
b. Needs large area for solar panels
c. Production is affected by weather conditions.

Nevertheless, the positive attributes of solar electricity greatly outweighs the above demerits.

C. Green Village Electricity Project

The Green Village Electricity Project (A.K.A. Project Spread the Light) is a student design project and was a competitor in the maiden IEEE Presidents' Change the World Students Project Competition. The project is designed to provide off-grid solar electricity (Lighting points, wall sockets to power small gadgets and streetlights) to about twenty houses in a remote settlement. The project emerged fourth (4th) out of about two hundred (200) competitors globally. The aim of the project is to canvass the concept of renewable energy in Nigeria while helping the country overcome her climate change challenges.

Equally, the project was developed to inspire youths in developing countries towards creativity and productivity.

Most importantly, the project was designed to serve as a model for reliable renewable energy deployment throughout Nigeria specifically in remote settlements where it will be most economically and technically effective to implement such micro systems.

The project was specifically designed to suite the Nigerian state which has high availability of sun-hours.

The project team is constituted of undergraduates from the department of Electrical/Electronics Department, Federal University of Technology, Owerri, Imo State.

The project will utilise student volunteers who will assist in the wiring of the individual houses, installation of the solar module and in the sensitization phase. PSL has an estimated

execution time of twelve (12) months after which the planned maintenance phase follows.

PSL will operate with six full and part time staff members. In addition, a Governing Body made up of community leaders and university staff will operate to provide overall sanctioning of the project implementation. Periodic evaluations will be conducted to assess the effectiveness of PSL based on its evaluation indices as stipulated in this proposal. Equally, the sustainability of the project is highlighted and discussed in a later section of the proposal.

III. Project Technical Details
The project design details are as represented below:

System Load Analysis

Hourly consumption per house
No of bulbs: 4 (13 watts each)
No of sockets: 2 (40 watts each)
Tolerance per house= 13 watts
Total utility per house= (4*13) + (40 *2) + 13= 145 watts

Hourly utility for power house
No of bulbs: 2 (13watts each)
No of Street Lights: 30 (15 watts each)
Tolerance: 24 watts.
Total utility= (2*13) + (30*15) + 24= 500watts.
No of houses:20

Total System Utility=(20*145)+500= 3.4KiloWatts.

System Design Parameters
Energy expected from solar panels= 2.5*Total Load= 2.5*3.4KW= 8.5KW/ Hr

Panel Ratings:
Power=210Watts
Voltage= 24 volts DC
No of solar panels= 8500/210 ˜ 40 Panels.

Charge Controller Rating: 80Amperes
(this is to withstand the high DC current at this terminal)

Inverter Rating:
Power: 5Kilowatts
Primary DC voltage input = 180 VDC
Output Voltage= 220Volts

NB: (this high input DC voltage is designed to drop the surging current at the charger and to ensure that a high fidelity output voltage is maintained irrespective of distribution losses and other parameters)

Battery Rating
Amp-Hr rating= 200AHR
Terminal voltage= 24 volts
Desired Bank array voltage= 192VDC

Bank Capacity Computation
No of batteries (N)= (L*T) / (V*AH*0.8)
Where:
L= system hourly load: 3.4KW.
T= No. of Hours of no sunlight (15hrs 17:00hrs 08:00hrs of next day).
V= battery voltage, 24volts.
AH= Battery Amp-Hr rating
0.8= system efficiency.

N= (3400*15)/ (24*200*0.8) ˜ 14 batteries.
N.B: To conform to desired battery output voltage, 2 additional batteries will be added resulting in a bank capacity of **16 batteries**.

Transmission/ Distribution:
Transmission & Distribution is a hybrid of Ring, Serial & Star topologies.
Ring: covers the settlement perimeter.
Serial: transmits to four clusters of five houses each.
Star: distributes to five houses within a cluster.

Cabling:
The 2.5mm cable will be used for the internal wiring of the individual houses and power house.

The 5mm TRS flex cable will be used for the overhead Star distribution cablings from the Low Voltage Distribution Board to the Individual houses.

The 6mm armoured cable will be used for the underground Serial transmission cablings from the ring circuit to a low voltage Distribution board.
The 30mm armoured cable will be used for the underground Ring cabling from the power source to two injection points in the ring to improve power integrity.

Isolators/ Breakers:
100Amp Circuit breaker= Mains between inverter and Distribution Board.

Two 100 Amps DC Isolators= between charge controller and inverter unit.

Two 100 Amps DC Isolators= between charge controller and battery bank.
Two 100 Amps DC Isolators= between PV array and the charge controller.

63 Amp Circuit Breaker= between house mains and House Distribution board.

Flow line fuses will be attached along the transmission and distribution line for proper isolation.

Panel Arrangement
The solar panels are designed to be arrayed 5 panels per stand, resulting in 8 stands for the total number of 40 panels in the system.

II. Project Time Line
The project is intended to be roll out as follows;
Month One
Advertising of Project staff positions
Meeting with university administrators
Finalizing location of power house
Selection/hiring of remaining Project staff members
Preparation for project operation

Month Two
Execution of phase 1 of the project
Evaluation of progress

Month Three
Execution of phase 2 of the project
Evaluation of project operation
Month Four
Execution and evaluation of phase 3 of the project
Preliminary advertising/publicity of project operations
Hosting community meetings
Recruitment/selection/training of student volunteers

Month Five Twelve
Execution of phase four of the project
Conducting of regular formative evaluation
Final summative evaluation at end of twelfth month

The execution of phases 3 & 4 of the project will continue after the end of the first year of project execution.
Currently, the project team is working with the IEEE Humanitarian Technology Network HTN towards its implementation. Through adequate publicity, the project team intends to advocate the benefits of widespread implementation of renewable energy solutions within the country and beyond.

Included in the project scope is a sensitization scheme to educate the benefiting comm unity(s) on basic electricity principles and optimal utilization of the system.

IV. Conclusion
It is no longer news that the Nigerian power sector needs to be repositioned so as to meet up with challenges in the global scene.

In this paper, the current situation of the Nigerian power sector was reviewed highlighting her generation and consumption capacity. Also, the various sources of renewable energy were discussed with predominant emphasis on solar electricity.

Most importantly, the paper presents design details for the deployment of micro scaled solar electricity to remote off-grid settlements in Nigeria.

REFERENCES
Soon Wan, “Green Energy For Developing Countries”, Dallas/ Forth-worth, Texas. April, 2005.

Green Village Electricity Project design document, www.energytoday.com

Müller, Reto (2007). "Band-approximated radiative heat transfer analysis of a solar chemical reactor for the thermal dissociation of zinc oxide". *Solar Energy*81 (10): 1285-1294. Doi:10.1016/j.solener.2006.12.006 .?

Pohlmann, B. (1993). "Photochemical Production of Fine Chemicals with Concentrated Sunlight". *Solar Energy*61 (3): 159-168. doi:10.1016/S0038-092X(97)00043-1 .?

Scheer, Hermann (2002). *The Solar Economy (Renewable Energy for a Sustainable Global Future)*. Earthscan Publications Ltd. ISBN 1844070751.

Schittich, Christian (2003). *Solar Architecture (Strategies Visions Concepts)*. Architektur-Dokumentation GmbH & Co. KG. ISBN 3764307471.

Smil, Vaclav (1991). *General Energetics: Energy in the Biosphere and Civilization, Wiley, 369, ISBN 0471629057.*

ALTERNATIVE ENERGY FOR SUSTAINABLE NATIONAL DEVELOPMENT: A CASE FOR NIGERIAN RURAL COMMUNITIES

Ogbuka, C. U.
Department of Electrical Engineering,
University of Nigeria, Nsukka
E-mail: ucogbuka@yahoo.com

Madueme T.C.
Department of Electrical Engineering,
University of Nigeria, Nsukka
E-mail: theoella3000@yahoo.co.uk

ABSTRACT
There is power supply limitation from the Nigeria National Grid which has adversely affected the economic and social development of the populace particularly in the rural areas. Nigerian's population is largely rural and to meet the Millennium Development Goals (MDG's), proactive measures have to be taken by the government and its relevant agencies to enhance the living standard of the rural dwellers considering their strategic role in the economy, particularly in the agricultural sector. Nigeria is endowed with abundant renewable energy resources, the significant ones being solar energy, biomass resources, wind energy and small hydropower potentials. These have, so far, been grossly underutilized. Some definite steps have, however, been taken by the Federal Government of Nigeria in the recent past notable among which is the launch of the Renewable Energy Master Plan (REMP) aimed at aggressively pursuing the utilization of her abundant renewable energy potentials. In this paper, a case is made for the adoption of alternative energy in the Nigeria energy mix. Strategies for improving and strengthening the existing national energy policy with strong emphasis on alternative energy for sustainable national development are advocated.

Keywords: Renewable Energy, Energy policy, Solar, Wind, Small Hydro, Biomass, Power Generation

I. Introduction

The energy sub-sector, especially petroleum, continues to maintain its prominence as the single most important source of government revenue and foreign exchange earner, contributing over 70% of Nigeria's federal revenue and an average of 25% to Nigeria's Gross Domestic Product (GDP) in the last five years, representing the highest contributor after crop production. The contribution of energy to GDP is expected to be higher when we take into account renewable energy utilization, which constitutes about 90% of the energy used by the rural population [1]. However, despite the fortunes of the oil sector, other sectors of the economy are declining. For example, consumption of electricity actually declined by 13.4% between 2002 and 2006 even though the overall or total electricity consumption showed a marginal increase of 1.8% from 5.63GWh in 2002 to 7.47GWh in 2006. Only about 40% of households in Nigeria are connected to the national grid. There is high-energy loss due to the physical deterioration of the transmission and distribution facilities, inadequate metering system and increase in the incidence of power theft through illegal connections. Other problems of the power sector includ e manpower constraints and inadequate support facilities, the high cost of electricity production, inadequate basic industries to service the power sector, poor billing systems, poor settlements of bills by consumers and low available capacity, about 40% out of the installed

capacity of about 6,000MW [2].
The situation in the rural areas of the country is that most end users depend on fuelwood. Fuelwood is used by over 60% of Nigerians living in the rural areas. Nigeria consumes over 50 million metric tonnes of fuel wood annually, a rate, which exceeds the replenishment rate through various afforestation programmes. Sourcing fuel wood for domestic and commercial uses is a major cause of desertification in the arid-zone states and erosion in the southern part of the country. The rate of deforestation is about 350,000 hectares per year, which is equivalent to 3.6% of the present area of forests and woodlands, whereas reforestation is only at about 10% of the deforestation rate[1].

The rural areas, which are generally inaccessible due to absence of good road networks, have little access to conventional energy such as electricity and petroleum products. Petroleum products such as kerosene and gasoline are purchased in the rural areas at prices 150% in excess of their official pump prices. The daily needs of the rural populace for heat energy are, therefore, met almost entirely from fuelwood.

Provision of reliable and cost-effective electricity sources in the rural communities of developing countries for the achievement of social and economic empowerment and poverty alleviation is imperative within the context of the global Millennium Development Goals (MDGs) [3]. With the ongoing restructuring of the power sector and the imminent privatization of the electricity industry it is obvious that for logistic and economic reasons especially under the privatized power sector, rural areas which are remote from the grid and/or have low consumption or low power purchase potential will not be attractive to private power investors. Such areas may remain unserved for the distant future.

II. Estimated Energy Potentials In Nigeria

Nigeria is endowed with abundant energy resources of oil, natural gas, coal, tar sands, hydro (large and small), biomass, solar and wind [4] as shown in Table 1.

For a scenario of 10% economic growth rate, for example, the corresponding projected electricity and commercial fuel demands for the Nation in th e short, medium and long terms and with 2005 as the base year, are as sown in Table 2 [4]
The logical solution to this very challenging energy

TABLE 1. Nigeria's Energy Resources

S/N	Resource Type		Natural Units	
1	Crude Oil		36.22 billion barrels	
2	Natural Gas		187 Trillion SCF	
3	Coal and lignite		2.175 billion tonnes	
4	Tar Sands		31 billion barrels of equivalent	
5	Hydropower large		11,250 MW	
6	Small Hydropower		3,500 MW	
7	Solar Radiation		3.5 - 7.0 kWh/m^2/day	
8	Wind		(2-4) m/s at 10mheight (main land)	
9	Biomass	Fuelwood	11 million hectares of forest and woodland	
		Animal waste	211 million assorted animals	Excess of 1.2m tonnes/day
		Energy Crops and Agric Residue	28.2 million hectares of Arable land (?30% of total land)	

TABLE 2. PROJECTED FINAL ENERGY DEMAND FOR 10% GROWTH RATE.

Year	Electricity (MW)	PMS (Millions litres/day)	DPK (Million litres/day)	AGO (Million litres/day
2005	5,746	6.9	5.9	6.4
2010	15,920	38.0	8.2	16.5
2015	30,210	61.4	11.5	26.7
2020	58,180	99.2	16.8	43.2
2025	107,220	159.9	25.4	69.8
2030	192,000	257.8	39.2	112.5

demand is increased penetration of renewable energy into the energy supply mix. There is the need for proactive action to develop alternative energy sources that will guarantee reliable supply over time and adequately serve the immediate energy needs of the teeming rural population in view of their role in agricultural sector.

III. A Review Of The Renewable Energy Alternatives In Nigeria

A review of the four most viable renewable energy alternatives in namely Small Hydro, Solar, Wind, and Biomass is undertaken below.

A. Small Hydro Schemes

Nigeria has many rivers widely scattere d across the nation, enhancing the potential for small hydro schemes across the country. Run-of-the-river and pump-storage schemes are the most appropriate schemes to implement. Small hydro schemes are environmentally friendly and renewable energy sources, thus making them cheaper and easier to operate, maintain and manage. The high transmission cost, the large amount of power lost during transmission and the incessant vandalization of power infrastructure rampant at present will reduce, hence cheaper power can be produced [5]. Small Hydro Potential (SHP) sites exist in virtually all parts of Nigeria. There are over 278 unexploited sites with total potentials of 734.3 MW. So far about eight (8) small hydropower stations with aggregate capacity of 37.0 MW has been installed in Nigeria by private company and the government as shown in Table 3. The map of Nigeria (figure 4 shows the Rivers and Hydrological Basins in the country [6].

TABLE 3:. EXISTING SMALL HYDRO SCHEMES IN NIGERIA

S/No	River	State	Installed Capacity (MW)
1	Bagel (I)	Plateau	1
	(II)		2
2	Kurra	Plateau	8
3	Lere (I)	Plateau	4
	(II)		4
4	Bakalori	Sokoto	3
5	Tiga	Kano	6
6	Oyan	Ogun	9

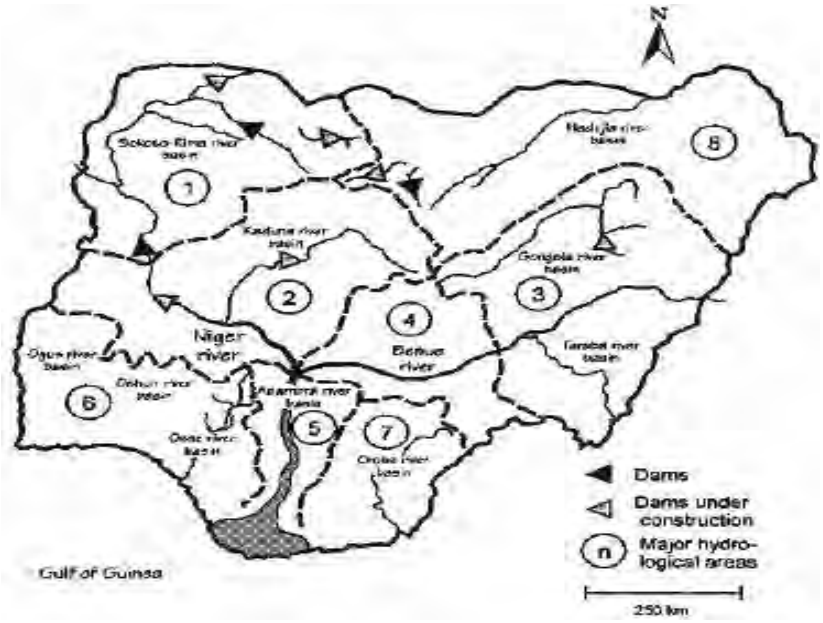


Figure 1. Map of Nigeria Showing Major Rivers and Hydrological Basins

TABLE 4. IDENTIFIED HYDRO POTENTIALS OF RIVER BASINS IN NIGERIA

ORGANIZATION	POTENTIAL S ITE	STATUS	CAPACITY
Upper BenueRiver Basins Development Authority	1.•Jada Dam 2.•Monkin Dam 3.•Kiri Dam 4.•WayaDam 5.•Dandinkowa Dam	Pre-feasibility level	5MW 500KW 1083KW 61.8KW 33KW
Owena Benin River Basin Development Authority	1.•River OWENA 2.•Ele River 3.•River Okhuanwan	Pre-feasibility level	1.3MW 1.29MW 600KW
Anambra-Imo River Development Authority	1.•River Igwu 2.•Imo River 3.•IvoRiver	Identified	7.55 KW
Chad Basin Development Authority	1.•Biusite 2.•JangaDoleDam site 3.•Majeekin Dam site	Identified	
Ogun-Osun River Basin Development Authority	1.•OyanRiver Dam 2.•IkereGorge Dam 3.•LekanAre Dam	Pre – feasibility level	9MW

A. Wind Energy

Wind is a natural phenomenon related to the movement of air masses caused primarily by the differential solar heating of the earth's surface. Seasonal variations in the energy received from the sun affects the strength and direction of the wind. Wind energy is available in Nigeria at an annual average speed of about 2.0 m/s at the coastal region and 4.0 m/s at the far northern region of the country. Assuming an air density of 1.1 kg/m3, wind energy intensity, perpendicular to the wind direction , ranges between 4.4 W/m^2 at the coastal areas and 35.2 W/m^2 at the far northern region [2].

The technologies for harnessing this energy have, over the years been tried in the northern parts of the country, mainly for water pumping from open wells in many secondary schools of Sokoto and Kano States as well as in Katsina, Bauchi and Plateau States. A 5 kW wind electricity conversion system for village electrification has been installed at Sayyan Gidan Gada, in Sokoto State. Other areas of potential application of wind energy conversion systems in Nigeria are in "green electricity" production for the rural community and for integration into the national grid system. It has been reported that an average annual wind speed of not less than 5 m/s at a height of 10m above ground level is the feasible speed for the exploitation of wind energy at today's cost.

The nation is found to sit in the midst of enormous potential for wind harvest for power generation. The far northern states, the mountaino us regions and different places of the central and south-eastern states have been identified as good areas for wind harvest together with the offshore areas spanning from Lagos through Ondo, Ogun, Cross-Rivers to Rivers states along the Atlantic Ocean in the south-south. Despite this great potential and huge prospect, the country is found to still suffer from serious energy crises due to her over dependence on hydropower which also is susceptible to seasonal variation in the amount of water levels at dams [7]. The frequent disruption of gas supply to the nation's thermal stations is also a major cause of irregular power supply.

B. Solar Energy

Solar energy is the most promising of the renewable energy sources in view of its apparent limitless potential. Nigeria lies within a high sunshine belt and thus has enormous solar energy potentials. The mean annual average of total solar radiation varies from about 3.5 kWhm2day-1 in the coastal latitudes to about 7 kWhm2day-1 along the semi arid areas in the far North. On the average, the country receives solar radiation at the level of about 19.8 MJm 2 day-1. Average sunshine hours are estimated at 6hrs per day. Solar radiation is fairly well distributed. The minimum average is about 3.55 kWhm2day-1 in Katsina in January and 3.4 kWhm2day-1 for Calabar in August and the maximum average is 8.0 kWhm2day-1 for Nguru in May. Although solar radiation intensity appears rather dilute when compared with the volumetric concentration of energy in fossil fuels, it has been confirmed that Nigeria receives 5.08 x 1012 kWh of energy per day from the sun and if solar energy appliances with just 5% efficiency are used to cover only 1% of the country's surface area then 2.54 x 106 MWh of electrical energy can be obtained from solar energ y. This amount of electrical energy is equivalent to 4.66 million barrels of oil per day [8].

Solar thermal applications, for which technologies are already developed in Nigeria, include: solar cooking, solar water heating for industries, hospitals and households, solar evaporative cooling, solar crop drying, solar incubators and solar chick brooding

C. Biomass

Organic non-fossil material of biological origin is called Biomass. The Biomass resources of Nigeria can be identified as wood, forage grasses and shrubs, animal waste and waste arising from agricultural, municipal and industrial activities, as well as aquatic biomass [9].

As an energy resource, biomass may be used as solid fuel, or converted via a variety of technologies to liquid or gaseous forms for the generation of electric power, heat or fuel for motive power. Biomass resources are considered renewable as they are naturally occurring and when properly managed, may be harvested without significant depletion. Biomass resources available in the country include: fuelwood, agricultural waste and crop residue, sawdust and wood shavings, animal dung/poultry droppings, industrial effluents/municipal solid waste. Over the period 1989-2000, fuelwood and charcoal constituted

between 32 and 40% of total primary energy consumption [10]. Recent studies show that national demand for traditional energy (mostly fuelwood and charcoal) is 39 million tonnes per annum (about 37.4% of the total energy demand and the highest single share of all the energy forms). It is projected to increase to 91 million tons by 2030 [11]. The deforestation rate is expected to similarly increase if no special programme is put in place to discourage the use of fuelwood, promote the use of its alternatives and replenish through deliberate afforestation.

The three-stone stove commonly used in rural households have efficiencies as low as 15%. Improved versions have been developed locally by the Energy Commission of Nigeria (ECN) through its energy research centers at the University of Nigeria, Nsukka and Usman Dan Fodio University in Sokoto. These stoves which could reduce fuelwood consumption for a particular process by 50 % are already being adopted. For instance the International Instit ute for Tropical Agriculture (IITA) cottage cassava industry at Moniya, Ibadan adopted these technologies. Indeed the improved wood-burning stoves are found in many local markets in the northwestern part of the country. Biogas digester technology has been domesticated and a number of pilot biogas plants have been built.

Considerable local capability exists for building both floating dome and fixed dome biodigesters using a variety of bioresources. Examples include a human waste biogas plant at the Zaria prison, cow dung based biogas plants at the Fodder farm of the National Animal Production Research Institute (NAPRI), Zaria and Mayflower Secondary School Ikenne, Ogun State; an 18m^3 capacity pig waste biogas plant at the piggery farm of the Ojokoro/Ifelodun Cooperative Agricultural Multipurpose Society in Lagos State. A number of indigenous outfits are producing economically viable systems for converting municipal waste to energy [2].

IV. Renewable Energy Master Plan (REMP)

The Renewable Energy Master Plan (REMP) articulates N igeria's vision and sets-out a road map for increasing the role of renewable energy in achieving sustainable development. The REMP is anchored on the mounting convergence of values, principles and targets as embedded in the National Economic Empowerment and Development Strategy, the Millennium Development Goals, the National Energy Policy and the National Policy on Integrated Rural Development. The Renewable Energy (RE) programmes are classified into: National Biomass Programme, National Solar Energy Programme, National Hydropower Programme, National Wind Energy Programme and based on an optimistic GDP growth rate scenario of 10% in line with the IAEA model. The Energy Commission of Nigeria predicts RE contributions in meeting the nation's energy needs as shown below tables 5 and 6 [4].

V. Strategies for improving the excisting national energy POLICY

The following strategies for the improvement and strengthening of the National energy Policy are presented

- Strengthening of the existing National Energy Policy and the Renewable Energy Master Plan through an Act of National Assembly for sustainability.
- Establishment of a Renewable Energy Fund to serve as instrument for the provision of financial incentives to suppliers and users of renewable energy.
- Sustenance of the deregulat ed energy sector policy by successive governments.
- Intensification of the promotional and advocacy activities by the Energy Commission of Nigeria and all stakeholders.
- Growing and encouraging public and private sector partnerships
- Intensification of research and development into renewable energy technology to further bring down costs.

Because of the high cost of the RE technologies, Nigeria surely need the technical assistance of pro-active nations and multinational agencies in achieving the followi ng:

- The widespread establishment of renewable energy data recording stations.
- Acquisition of small scale solar cells producing plant
- Acquisition of a manufacturing plant for components of the small hydro turbines.
- Acquisition of a manufacturing plant for components of wind turbine and generators.

Table 5. Projected RE Contribution in Meeting National Electricity Demand (MW)

S/N	RESOURCE	SHORT (2010)	MEDIUM (2015)	LONG (2030)
1	Hydro (large)	1930	5930	11,250
2	Hydro (small)	100	734	3,500
3	Solar PV	5	120	36,750
4	Solar Thermal	1	2	15,500
5	Biomass	1	100	1,300
6	Wind	1	20	50
	All Renewables	2,308	6,907	68,350
	All Energy Resources	15,000	30,000	192,000
	% of Renewables	13%	23%	36%

Table 6. Projected RE Contribution in Meeting National Non-electricity Energy Demand

Activity/Item	Timeline/Quantity		
	Short	*Medium*	*Long*
Total Thermal Energy Production (GWh)	193,709	202,128	248,809
Renewable Energy Share (%)	85	80	79
Other Non-Renewable Share (%)	15	20	21

VI. Conclusion

This paper has highlighted the expected role of renewable energy technologies in meeting the present and projected energy challenges of Nigeria. Also consideration has been given to the factors affecting developments in the renewable energy sector, and efforts made to ensure capacity building for renewable energy, stimulation of the private sector, developing the markets for renewable energy, obtaining the necessary finance for renewable energy projects and the assistance of multilateral institu tions in advancing renewable energy technologies in the country. For Nigeria to achieve her vision 20:2020 objective of being among the 20 most industrialized nations of the world by the year 2020, energy issues has to be taken very seriously by the government and other relevant stakeholders. The exploration of the renewable energy potentials of this country will go a long way in enhancing lives, particularly in the rural areas where agricultural activities are predominantly practised. This paper, therefore, calls on the government to translate its numerous policies on renewable energy into action to ensure the full realization of target objectives.

REFERENCES

Report of the Inter-Ministerial Committee on Combating Deforestation and Desertification, August 2000.

Sambo, A.S. ''Strategic Developments in Renewable Energy in Nigeria". International Association for Energy Economics. Pp.15-19. 2009.

Oparaku, O.U. "Solar-Pho tovoltaics in the Deregulated Electricity Industry of Developing Countries". Proceedings of the International

Conference on Renewable Energy for Developing Countries, 2006.

Sambo A.S., "Global Energy Crisis: The Need for Renewable Energy Programmes" Paper Presented at the International Seminar on Raw Materials Research, Development and Utilization (RMRDC TECHNO-EXPO '09). 2009.

Tunde, A.O., "Small Hydro Schemes - Taking Nigeria's Energy Generation to the Next Level".Power Engineering Society Inaugural Conference and Exposition in Africa. Pp.112-119. 2005.

Akanmu J., A. Y. Sangodoyin, V.O.S. Olunloyo, and E.M. Ezeh. "Small Hydropower Development: A Solution to Achieve Millennium Development Goals (MDGs)" NSE Technical Transaction Vol. 43 No.3 Pp 1-13. .2008 Ajayi O.O. "Assessment of Utilization of Wind Energy Resources in Nigeria", Energy Policy,Vol.37 No.2, Pp.750-753. 2009.

Sambo, A.S., "Renewable Energy for Rural Development: The Nigerian Perspective" ISESCO Science and Technology Vision. V o l. 1, Pp. 1 2 22. 2005

Rugbere, D .K . "The Use of Renewable Energy in Developing Countries", United Nations/Austria/European Space Agency Symposium On Space Application For Sustainable Development To Support The Plan Of Implementation Of The World Summit On Sustainable Development: "Space Tools For Monitoring Air Pollution And Energy Use For Sustainable Development." Graz, Austria. 2006.

The Presidency, "Report on the National Fuelwood Substitution Programme, 1992.

Energy Commission of Nigeria. "W orld Solar Programme, 1996 2005", Projects of the Government of Nigeria: Project Documents, ECN Abuja. 1998

ASSESSMENT OF ENERGY RESOURCE POTENTIALS FOR POWER GENERATION IN SOKOTO STATE

Faruk Yusuf Yabo,[+] Muhammed Bashir Mu'azu, and [+] Buba G. Bajoga
Federal Ministry of Power, Abuja
[+]Department of Electrical Engineering, A. B. U, Zaria, Nigeria
fyyabo@yahoo.com, muazumb1@yahoo.com

ABSTRACT
This paper assessed the energy resources potentials of Sokoto State towards providing vital information as to what type of power station can be established in the State. Power stations based on fossil fuels are not a good alternative in Sokoto due to the problems associated with fuel supply to the area, mainly non availability and long distance from sources of supply while using only 1% of the total land area of Sokoto State, up to 36,792MWh/year can be generated using photovoltaic modules. It was estimated that the area surrounding Badaga measument site can generate up to 20,000MWh/yr of wind power with a 10MW wind farm. The Goronyo dam can generate up to 3MW of electric power with a flow rate of 50m^3/s at a height of 7m without any adverse effect on the dam's primary purpose. Biomass based power plants can be established in Sokoto State to generate up to 3,565,706MWh of electric power per year.

I. Introduction

The decision to establish a power plant, which is the trend now due to the precarious power supply situation in the country, at a particular location depends on a number of factors ranging from the availability of energy resources or fuel supply in a particular area, the nature and size of electricity demand and supply, nearness to load centers and available power transmission infrastructure and Commercial and Regulatory [1].

In order for a power station to operate both effectively and efficiently, feasibility studies, energy and load demand forecasting using simple extrapolation techniques and fuel supply planning studies should be carried out prior to establishing the plant. The choice of type of power station and size of power station to build depends on the load variation over a period of time, which determines the steady component (base load); the varying component whose daily pattern depends on time of the day, weather, season or a popular festival etc. (intermediate load) and randomly varying component of relatively small amplitude (peak load) [1].

The process of assessing the potentials of establishing a power station in a particular area will involve assessing the energy resources availability (both renewable and non-renewable resources), transmission infrastructure and market (demand). These assessments will provide valuable and much needed information to enhance the proper evaluation of energy resources such as solar, wind, hydro and biomass power potentials and help management decision on optimal system expansion needed [2]. This paper will focus on assessing the energy resource potentials of Sokoto State as a case study.

Sokoto State has a land mass area of about 32,000sq.km [3] and is generally blessed with various renewable resources including small hydro potentials, solar energy, wind energy and biomass etc. However, the state is not a known producer of non-renewable energy resource like hydrocarbons (crude oil, natural gas, coal and lignite, tar sands etc). This is, however, not to say the resources are non-existent or cannot be sourced elsewhere for use in the State. But any plant that requires these types of fuels to run will have to rely on supply from other parts of the country with the associated high cost of transportation.

II. Statement of the Problem and Methodology

Irregular supply of electricity in Sokoto State has resulted in lack of economic growth and development in the State in recent times. The objective of the work is to assess the energy resource potentials of the State with a view to

establishing power stations in Sokoto State.

To determine the energy resources availability in Sokoto state, the results of studies previously carried out to ascertain the reserves of energy resources in the state were obtained and reviewed. Data was obtained for both renewable and non-renewable energy resources:

i) The data on renewable energy was collected from satellite observatories and then compared with ground sites measurement data [2][4]. Data on renewable energy resources was analyzed to determine the energy yields of various resources using various scientific and engineering theories and principle, employing relevant mathematical equations. The data on renewable energy resources was also compared with the data from other areas.
ii) The data on non-renewable energy resources was obtained from Government records to determine fossil fuel demand and supply to the state.

III. Energy Resource Data Analysis

Data on energy resources availability is vital in the processes leading to the establishment and sustainance of a p ower station in a particular area. Electric power is usually generated through the conversion of one form of energy to another; the material converted being the primary source of energy. There are many types of primary energy resources mainly classified in to two major groups: renewable and non-renewable energy sources.

Renewable energy utilization is relatively new when compared with the use of fossil fuel globally. The uncertainties associated with fossil fuel supply and their adverse effect o n the environment (global warming due to ozone layer depletion) has continued to drive the need for an alternative source of reliable energy resource. The natural choices to replace fossil fuels are renewable energy sources mainly because they are in abundance naturally and also because they are eviromentally friendly.

To obtain a reliable data for analysis, the four renewable energy resources (small hydropower, solar, biomass and wind) identified in Sokoto State were assessed by using results of studies carried out by reputable organizations. The screening criteria used to evaluate the resources potentials is based on determining the abundance and quality of the primary energy source in the state, transmission capacity, land and access road [2]

A. Assessment of Petroleum Products Potentials

Data on the capacity of petroleum products supply infrastructure in Nigeria and petroleum product average daily demand projections from 2005 to 2030 is presented in Fig. 1[5]. This shows a rising demand for petroluem products and declining supply.

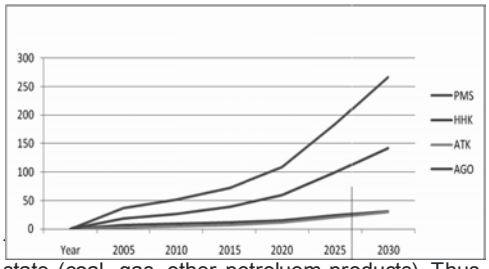


Fig. 1: Projected Demand for Petroluem Products in Nigeria Up to Year 2030

state (coal, gas, other petroluem products). Thus, all fossil fuels demands of Sokoto state have to be sourced from other parts of the country or through importation. At the moment the fuel depot nearest to the State capital is at Gusau (200km away) with no pipeline for products supply to Sokoto State. Also, the only means of transporting fuels to Sokoto State is by roads (no railway) and the roads are generally in a poor state, making products supply both expensive and risky.

Presently there are only four (4) refineries in the country with installed capacity of 445,000 barrels per day (bpd), while the projected demand for the nation petroluem product is estimated at 574,277 bpd in 2010 and will increase to 1,226,164 bpd by the year 2020 (at 10% growth rate) [5]. Also, currently no new refinery is under construction in the country. Based on the above fuel supply analysis, Sokoto State is considered not ideal for power generation using fossil fuel fired plant.

B. Assessment of Solar Radiation and Wind Resource Potentials

Solar radiation (insolation) data is par ticularly important because of its criticality to the estimates of solar field performance and physical sizing for

both technical and economic analysis. Since the comprehensive insolation data set known as Typical Meteorological Year (TMY) on Sokoto State is not available locally, solar isolation data on Sokoto State was collected from Surface Meteorology and Solar Energy (SSE) dataset Release 6.0 2008, which is a satellite based product from various Meteorological and Climatic research projects supported by NASA to provide reliable data on global meteorology including solar and wind energy resource distribu tion. [4]

Since the data from the satellite observations and modelling are not site specific, it is necessary to validate this data with some ground site measurements. To achieve this objective, data on solar radiation and temperature rise was collected from research work under taken at the Sokoto Solar Energy Research Center (SERC) jointly with the Japan International Cooperation Agency (JICA), while site data on wind potentials in Sokoto was collected from research works carried out by Lahmeyer International (Wind Energy Resource Mapping and Related Works Projects: 2003 - 2005) sponsored by the Federal Government of Nigeria.

The information is then used to compare with SSE 6.0 dataset [6][7][4]. Tables 1 and 2 show the solar insolation for Sokoto state from ground measurements carried out in 2006 by the masterplan study for utilization of solar energy in Nigeria under the sponsorship of Japanese International Cooperation Agency (JICA) [7]. The JICA study team had carried out measurements and collected data on solar energy in Sokoto State within a period of four (4) months, February to May 2006. The data was collect ed through conducting isolation measurements on some existing solar pilot projects executed by the Sokoto Solar Energy Research Centre (SERC) including PV unit, solar cookers (various types), solar dryers etc. which were used to measure tilt angle and solar irradiance, solar orbit, isolation, weather temperature etc. [8].

Table 1: Tilt Angle and Solar Radiation in and around Sokoto (Unit: W/m ^{2}) (**Source: JICA Report**)

Tilt Angle	**0°**	**10°**	**13°**	**15°**
5/06/2006		753.2	738.1	
6/06/2006			813.6	810.1
7/06/2006	780.5		726.2	

Table2: Movement of the Sun (**Source: JICA Report**)

	Latitude (°)	**Passing Date**	**Passing Date**	**Remarks**
Tropic of Cancer	N23	23/6		Towards the North
Sokoto	N13	23/5	18/8	Towards the North
Nsukka	N7	20/4	27/8	
Equator	0	23/3	23/9	Towards the South
Tropic of Capricorn	S23	23/12		Towards the South

The best tilt angle was found to be between 13°N to 15°N (facing south) [7]. Data from NASA was used to show the variabilty of solar insolation in Sokoto state throughout the year as in Figs. 2 and 3.

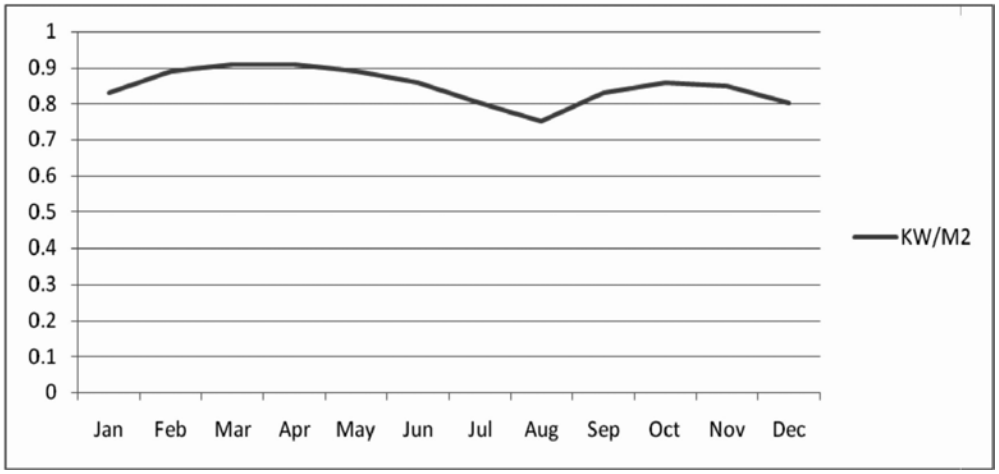


Fig. 2: Monthly Averaged Midday Insolation Incident on a Horizontal Surface (kW/m^2) for 22 years

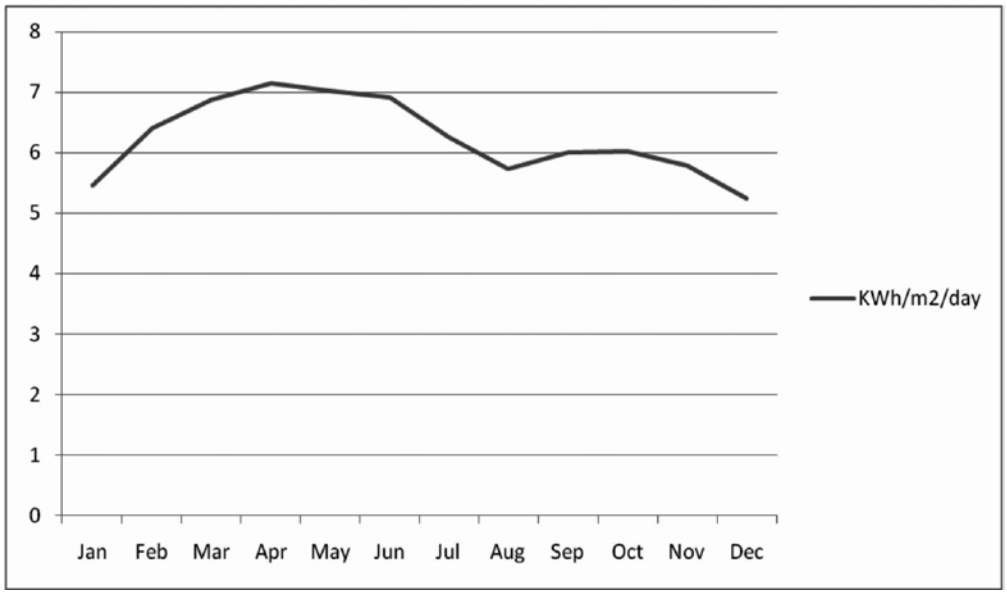
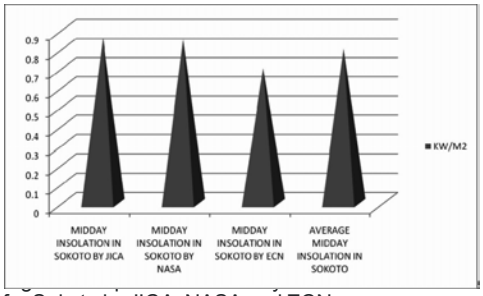


Fig. 3: Monthly Averaged Isolation Incident on a Horizontal Surface for 22 years (kWh/m^2/day)

The data from JICA study showing Average Insolation for Sokoto (at Usmanu Danfodio University Sokoto) during the months of January and May 2006 was used to compare with solar insolation data on Sokoto State sourced from NASA (SSEdatasets) [4]. The data obtained from JICA and NASA indicated that the midday insolation in Sokoto State during the months of January and May to be 830W/m ^{2} and 915W/m ^{2}. However, while JICA report suggested the tilt angle of between 13°N to 15°N, the data from NASA showed tilt angle of between 19.1°N to 20.7°N to be the optimum tilt angle for Sokoto area. Also, the data obtained from the two independent sources (JICA and NASA) and that estimated by Energy Commission of Nigeria for Nigeria (350 7000W/m^2) [9] have all indicated a good solar energy potential in the State capable of hosting a solar power plant [2].

The comparison of data on solar insolation of Sokoto state obtained from JICA, NASA and ECN was made in Fig. 4 and the average of the three values was computed and found to be approximately 0.8kW/m ^{2}.



for Sokoto by JICA, NASA and ECN

In order to further prove the technical feasibility of establishing a solar power plant in Sokoto state, the following analysis was carried out:

If the average solar radiation of Sokoto State is assumed to be: 0.7kW/m ^{2} instead of 0.8kW/m ^{2} and if 1% of the 32,000 sq.km total land mass of Sokoto State is dedicated for solar energy generation, The energy yield can be computed as follows:

Average Irradiance in Sokoto State = 700W/m ^{2} (0.7kW/m^2). Thus, taking 1 percent (1%) land mass of Sokoto State, that is 320sq.km (320,000sq.m)

Assuming five hours of insolation and solar to electricity conversion efficiency of 18% [10]:
(320,000 sq.m/2) × (700W/sq.m × 0.18) × 5hrs/day
= 100.8MWh/day

Therefore, annual energy yield will be:
100.8MWh/day × 365days/yr = 36,792MWh/yr

The above analysis shows that Sokoto has enough solar energy resource and land mass to support a solar energy power station, more so the state is among states in Nigeria with lowest rain fall. Thus most of the tim e, the sky is clear. In particular, solar power plant can be established at Kware town to supply Illela and other towns near the Nigeria's border with Niger Republic. The output power can then be fed in to the 33kV Kware feeder for distribution in the area as shown in Fig. 5.

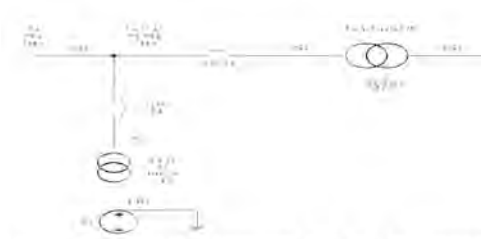


Fig. 5: Single Line Drawing for the Proposed 20.1MW Solar PV Power Plant at Kware Town

Table 3 show data of wind energy resource mapping for ten (10) sites in Nigeria including Sokoto collected from on ground measurement carried between May 2004 and May 2005 by Lahmeyer International, a leading German consultacy firm contracted by the Federal Government of Nigeria through the Federal Ministry of Science and Technology [6].

Table 3: Ranking of the Wind Speed at the various Measurement Stations

Site ID	Site Name	Measured Mean Wind Speed at 30m Height [m/s]
Sok01	Sokoto/Badaga	5.4
Jos01	Jos Airport/Kassa	5.2
Gem01	Gembu/Mambila Plateau	5.0
Pan01	South Part of Jos Plateau/ Pankshin Hotel	5.0
Kan01	Kano/Funtua	4.9
Mai01	Maiduguri/Mainok	4.7
Lag01	Lagos/Lekki Beach	4.7
Enu01	Enugu/Nineth Mile Corner	4.6
Gum01	Gumel/Garki	4.1
Ibi01	Ibi Metorological Station	3.6

The criteria used to determine the site with high wind energy potential was as follows:

i) Mean wind speed (m/s) at 10m, 30m and 40m
ii) Measured wind direction (0 360 degree)
iii) Wind speed distribution
iv) Weibull distribution based on 10 minute average of the wind speed

The data obtained from Badaga site in Sokoto State indicated that among the ten sites investigated in Nigeria, Sokoto State has the best wind energy potentials with an average wind speed of 5.39 m/s at 30m height with the wind direction predominantly towards the east direction. However, the data from NASA gave the average wind speed of Sokoto state as 3.15m/s, which is lower than the 5.39m/s from Lahmeyer. This difference is because the NASA data is based on extrapolations and not ground site measurements, while the Lahmeyer data is based on measurement carried out at site and therefore more reliable. The wind speed data from Badaga site is compared in Fig. 6 with data obtained by Lahmeyer from the other sites in Nigeria. Also the wind speed variability at Badaga site during the year is presented in Fig. 7.

An initial study by ECN has indicated that Sokoto State has one of the best wind potentials in Nigeria, with the total actual exploitable wind energy reserve at 10m height varying from 8MWh/yr in Yola to 51MWh/yr in the mountain areas of Jos, Plateau and as high as 97MWh/yr in Sokoto [11].

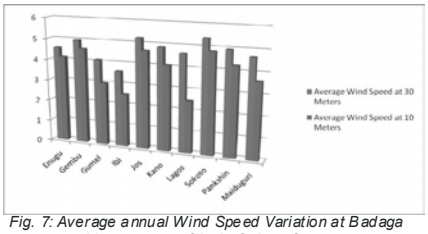


Fig. 7: Average annual Wind Speed Variation at Badaga Measurement Site in Sokoto State

From the position held by ECN and the wind speed measurements carried out by Lahmeyer, Sokoto State has a good average wind speed. With an average wind speed of 5.39m/s at 30m above ground level presented by the Lahmeyer report, Sokoto State can be considered as an average/moderate wind site capable of delivering electrical power output on annual basis of about 850kWh per sq.m of rotor surface area as confirmed by previous works. Another simple rule for estimating the annual energy yield of a wind turbine in an average/moderate wind site area like Sokoto is to assume the output power of about 2000 full load hours of turbine rated capacity per annum [4].

From the analysis above, it therefore follows that a 10MW wind farm if installed in Badaga wind si te will produce about 20,000MWh/yr, while the wind farm will require a land area of about 2000sq. km [2] The wind power plant can then be connected to the 33kV Yabo/Shagari feeder at Badaga village near Bodinga town to supply the area at 33kV voltage level, as shown in Fig. 8.

Fig. 8: Single Line Drawing Showing the Proposed 10MW Wind Farm at Badaga Site

C. Assessment of Small Hydro and Biomass Resources Potentials

Goronyo, Acida, Dinawa, Karkirko and Marnona are dams in Sokoto State with hydro-power capabilities according to the Nigeria Dams Register published by the Federal Ministry of Water Resources, Nigeria

From the data available Goronyo dam (Table 4) was identified as the most promising for hydro power generation. The selection was based on the dam's reservoir capacity and maximum head as recorded in the Nigeria Dams Register [12]

The gross reservior capacity of Goronyo dam is 942 × 106m^3 with maximum head of 20m. However, the dam is primarily designed to provide annual regulated flow of 425 × 106m^3 in order to double rice cultivation from 40,000 hectares to 80,000 hectares [13]

Table 4: Data on Goronyo Dam from Nigeria Dams Register

1	Name of Dam	Goronyo
2	Owner	(S.R.B.D.A)
3	Longitute	5° 50′E – 6°10′E
4	Latitude	13° 25′N – 13° 40′N
5	River	Rima
6	Nearest Town	Goronyo
7	Type of Dam	Earthfill+ Concrete
8	Purpose	IR,WS, FC, RC, WL, FI, HE
9	Construction by	Impresit Bakalori
10	Year of Completion	1983
11	CrestLength	5,285
	Crest Width (m)	8.5
12	Max. Height (m)	20
13	Volume of Fill (m^3)	4,500,000
14	Total Dam Vol. (m^3)	5,300,000
15	Catchment Area (km^2)	21,445
16	Reservoir Capacity (mcm)	942
17	Spillway Type	OGEE
18	Spilway Design Flood (m^3/s)	1,540
19	Power Units Installed (MW)	Nil
20	Max. Capacity of Power Units (MW)	
21	Instrumentation	

Olatunde [13] concluded that a head of between 7 8m with a flow rate of 50m^3/s will generate up to 3MW of electric power. From the data collected on Goronyo dam, the dam has an annual regulated flow rate of 425 × 106m^3 and this confirmed that the water will be enough all year round, both in the dry season and rainy seasons to generate 3.0MW of electricity. A Kaplan turbine of efficiency rating of 0.9 was adopted in the design of hydro power generation in Goronyo dam. This was because it is a reaction turbine useful for low head hydro projects. However, generating hydro power in excess of 3.0MW from Goronyo dam will affect the dam ability to provide water for irrigation which is the primary purose of the dam.
Thus,

P = 0.9x1000 x 9.81 x 50 x 7 = 3.09MW
The annual energy yield from Goronyo dam can be computed as follows:
E = working hours × P = 24 × 365 × 3.09 = 27,068 MWh/yr.

The power generated can be fed in to the 33kV Isa feeder at Goronyo town for supply to Goronyo and near by towns and villages at 33kV voltage level as shown in Fig. 9.

Fig. 9: Single Line Drawing Showing the Proposed 3MW Small Hydro Plant at Goronyo

Data on actual quantities of biomass resource available in Sokoto State is scanty. However, from available records, biomass materials in the State can be classified into two groups: Human/Animal waste and food crops residue. The human/animal waste consists of Municipal solid waste and livestock manure, while food crop residue consist mainly of - food crops residue extrapolated from the the ration of crops yield and residue [14]. This type of biomass can be found in many parts of the State, in quantities adequate to supply fuel to generate power in small and medium size power plant. The data on crop yield of Sokoto state for twelve years (1994/95 2005/06) was obtained from National Bureau of Statistics [15] population figures of Sokoto State for 2005 and livestock population figures were obtained from National Population Commission and a Sokoto State sponsored website (www.onlinenigeria.com) dedicated to provide information on Sokoto State respectively. [16][3]

According to the provisional figures of the 2006 National Population Census, Sokoto State has a population of 3,696 ,999 people [16]. The National Livestock Survey showed that Sokoto State has a livestock population of nearly 1.18 million cattle, nearly 2.90 million goats, 1.98 million sheep, 2.0 million chickens, 45,000 camels, 34,532 horses and 51,388 donkeys [3]. Data on the Agricultural commodity yield of Sokoto State obtained from National Bureau of Statistics was used to establish that between 1994 2006 the State had produced an average of 566,000; 105,000; 17,000; 12,000 and 130,000 tonnes of Agricultural wastes from Millet, G/Corn, Maize, Rice and Groundnuts respectively [17][1 4] and a total of 6,520,533 tonnes of Human/Animal waste was estimated to be available from the human and animal population in Sokoto State [3][14]

The information indicates a high potential for biomass resources in the State. Tables 5 and 6 present the estimated energy potentials based on biomass resources assessment. In Table 5 the total quantity of dry crop residue in the state was found to be 829.67 thousand tonnes, after taking into consideration the crop to residue ratio, and the percentage moisture content for each crop. Also, estimates of the total energy that can be produced per year from crops residue was computed using multiplying factors (mega joules (MJ) per Kilogram (Kg)) [14]. The total energy from crops residue in mega joules (MJ) was then converted into mega watt hour [42]. Thus, it was estimated that the electric power potential of the state from food crops residue is around 3,558,000MWh/yr.

In Table 6, the waste/manure yield of human and animal population in the Stat e was estimated using waste/manure yield factors (kg/head/day) [17]. The total waste/manure yield per year was then determined in kilogram (kg). To further determine the quantity of biogass in m ^{3}that can be extracted from one kilogram of each of the waste/manure a multiplying factor was obtained [17]. The factors were then used to compute the annual total biogass potentials of the state from human and animal waste/manure in m^3. The estimated annual quantity of biogass potentials of the state in m ^{3}was then used to determine the electric power generation potential of the state from human and animal waste/manure using an approximate calorific value of biogass of 6KWh/m ^{3}[17][42]. Thus, the total power potential in the State from biogass was found to be 7,706MWh/yr.

This analysis has indicated that large quantities of

biomass can be sourced in the state; therefore biomass based power plants can be established in Sokoto state to generate up to 3,565,706MWh of electric power per year from biomass resources available in the state. This can be achieved by establishing a biomass power plant with a number of generating units to be powered by both biogass and biomass pellets. The plant can have a cumulative capacity of 407MW to be established in Sokoto town and to be connected to the grid at 132kV voltage level for power transmission to other parts of the country as shown in Fig. 10.

Fig. 10: Single Line Drawing Showing the Proposed 400MW Biomass Power Plant at Arkilla Area, Sokoto.

IV. Conclusion

The research while assessing the potentials for energy resources in Sokoto state made the following conclusions:

Power stations based on fossil fuels are not a good alternative in Sokoto due to the problems associated with fuel supply to the area, mainly non availability and long distance from sources of supply. The present short fall in the supply of all types of petroluem products in the country and the

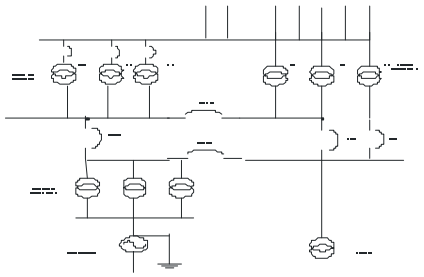
Table 5: Food Crop Residues (Thousands Metric Tones) in Sokoto State

Commodity	Production (Tonnes)	Residues	Crop to Residues Ratio	Moisture Content (%)	Residue (Dry Tonnes)	MJ/kg	MJ/Yr	MWh
Millet	495.21	straw	1.25	10.75	565.78	15	8.5x109	2,363,000
Ginea Corn	92.06	straw	1.25	10.75	105.18	15	1.6 x109	445,000
Maize	14.97	straw	1.25	10.75	17.10	15	0.3 x109	83'000
Rice	18.65	husk	0.75	12.54	11.65	17.5	0.2 x109	56,000
Cassava	9.01	husk	0.12	15	-	17.5	-	-
Groundnut	48.51	shell	2.78	10.1	129.96	17	2.2 x109	611,000
TOTAL					**829.67**			**3,558 ,000**

Table 6: Human/Animal Waste and Biogas Potential in Sokoto State

Human/Livestock type	Population in 2005	Manure Kg/head/day	Biogas Yield (m^3/kg)	Annual Biogas Production (m^3)	MWh
*Human	3,696,999	0.6	0.05	110,900	665
Cattle	1,180,000	10	0.04	472,000	2,832
Goat	2,900,000	2	0.05	290,000	1,740
Sheep	1,980,000	2	0.05	198,000	1,188
Donkey	51,388	6	0.04	12,320	74
Camel	45,000	7	0.04	12,600	76
Horse	35,532	6	0.04	8,520	51
Chicken	2,000,000	1.5	0.06	180,000	1,080
TOTAL				1,284,340	7,706

*domestic and industrial waste per head



projected exponential rise in demand for fossil fuels as forcasted by ECN is an indication of the problems that fossil fuel based power station will face.

With solar energy resource data from NASA, JICA and ECN and using only 1% of the total land area of Sokoto State, up to 36,792MWh/year can be generated using photovoltaic modules. It was also discovered that Sokoto State has the best wind energy resource in Nigeria and it is estimated that the area surrounding Badaga measument site can generate up to 20,000MWh/yr of wind power with a 10MW wind farm. Goronyo dam stands out as the most promising for small hydropower generation considering that the dam is in full operation for irrigation and water supply. The dam can generate up to 3MW of electric power with a flow rate of 50m^3/s at a height of 7m without any adverse effect on the dam's primary purpose. Biomass based power plants can be established in Sokoto State to generate up to 3,565,706MWh of electric power per year. This can be ach ieved by establishing biomass power plant with a number of generating units to be powered by both biogas and biomass pellets.

REFERENCES

M. R. Milligan and R. Artig (1999), Choosing Wind Power Plant Locations and Sizes Based on Electric Reliability measures using multiple-year wind speed measurements, Conference Paper, US Association for Energy Economics, Orlando, Florada www.doe.gov/bridge/home.html

R. Karsteadt (2005), Assessing the Potentials for Renewable Energy on National Forest System Lands, Technical Paper, United State Forest Service, Washington DC. www.osti.gov/bridge

OnlineNigeria (2010), Natural Resources Potentials for Development Sokoto State, Devace Nigeria Website, Devace Inc, USA, www.onlinigeria.com

National Aeronautics and Space Administration (NASA) - Surface Meteorology and Solar Energy (SSE) Data base, Release 6.0 (www.eosweb.larc.nasa.gov/PRODOCS/srb/table.html)

A. S. Sambo (2008), "Energy Demand Forcasting" unpublished.

Lahmeyer International (2005), Wind Energy Resources Mapping and Related Works Project Final Report submitted to Federal Ministry of Science & Technology/Federal Ministry of Power, Nigeria.

Japan International Cooperation Agency (JICA)(2007), the Master Plan Study for Utilization of Solar Energy in the Federal Republic of Nigeria, Final Report Vol. 5 Submitted to the Ministry of Power.

C. B. Christension (2001), "Effects of Tilt and Azimuth on Annual incident Solar Radiation for United State Location", Proceeding of Solar forum, Solar Energy Conference, Washington DC

Energy Commission of Nigeria (ECN) (2006), Renewable Energy Master Plan, Federal Government of Nigeria, Presidency.

Rajaramesh (2007), Photovolatiac Effiency, Global Energy Consulting Engineers, www.african energy.com

Energy Commission of Nigeria (ECN) (2005), Renewable Energy Master Plan, Executive summary, Federal Government of Nigeria, the Presidency

Federal Ministry of Water Resources (1995), Nigerian Dams Register

K. O. Olaore (2005), Design of a Small Hydro Electri Power Station: Case Study of Goronyo Dam, M. Sc. Thesis Department of Physics, Usmanu Danfodio University, Sokoto

A. Milbrandt (2009), Assessment of B iomass

Resources in Liberia, US Agency for International Development (USAID), www.nrel.gov ; www.osti.gov/bridge

National Bureau of Statistics (2006), Agric Filling Data Gap 1995 2006, Abuja, Nigeria, www.nigeriastat.gov.ng

National Population Commision (NPC)(2006), National Population Census Report.

T. J. Glover (2007), Pocket Reference, Avo Training Institute and Bookstores, Dallas TX, USA

CONCENTRATING SOLAR POWER
CLEAN ENERGY FOR THE ELECTRIC GRID

Diala .H. Uchenna and Ndinechi M.C.
Dept. of Electrical/ Electronic Eng.
Federal University of Technology,
Owerri, Imo State, Nigeria.
Dialauchenna@yahoo.com

ABSTRACT:
Electricity generation is faced with the problem of generating electricity friendly enough for the environment at a cheap cost and at the same time, supplies enough power to the ever demanding consumers. Concentrating Solar Power (CSP) is a system for generating environmental friendly electricity and yet sufficient enough to serve electricity users using energy from the sun at an affordable cost.

Keywords: Solar cells, trough systems, dish systems, central receiver, photovoltaic cells.

I. Introduction

Mirror, mirror on the wall, what's the greatest energy source of them all? The Sun! Enough energy from the sun falls on the earth everyday to power our homes and workplaces yet; we have only just begun to tap its potentials. There exit, solar-electric power generation using solar cells (Photovoltaic cells) which are quite expensive, to light homes and also power other electrical appliances but the deployment and application of Concentrating Solar Power (CSP), also referred to as concentrating so lar thermal power, represents a powerful, clean, endless, and reliable source of energy with the capacity to entirely satisfy the present and future electricity needs. Concentrating solar power plants produce no carbon IV oxide (CO_2), thus reducing carbon emissions from electricity generation by approximately 600 pounds per megawatt-hour (Bright-Source Energy, 2008) [1]. The evolution of CO_2 emissions regulations, the pressure of international fossil fuel prices, and the experience, knowledge, and technological readiness amassed during several decades of CSP research have launched the technology into a new era of commercial reality.

The United States and Spain have integrated CSP into their national electricity supply grids through large-scale commercial plants. Eight of the 13 biggest planned CSP projects in the world will be located in California and Arizona. The Sun Belt region of the United States, particularly the Southwest, is one of the largest areas in the world for CSP exploitation because of its abundant sunshine. The Southwest receives up to twice the sunlight as other regions in the country.

This abundance of solar energy makes concentrating solar power plants an attractive alternative to traditional power plants, which burn polluting fossil fuels such as oil and coal. Fossil fuels also must be continually purchased and refined to use. Unlike traditional power plants, concentrating solar power systems provide an environmentally benign source of energy, produce virtually no emissions, and consume no fuel other than sunlight. About the only impact concentrating solar power plants have on the environment is land use. Although the amount of land a concentrating solar power plant occupies is larger than that of a fossil fuel plant, both types of plants use about the same amount of land because fossil fuel plants use additional land for mining and ex ploration as well as road building to reach the mines.

Other benefits of concentrating solar power plants include low operating costs, and the ability to produce power during high-demand energy periods and to help increase our energy securityour country's independence from foreign oil imports. Because they store energy, they can operate in cloudy weather and after sunset. When combined with fossil fuels as a hybrid system, they

can operate around the clock regardless of weather. Concentrating solar power plants also create two and a half times as many skilled jobs as traditional plants [2].

II. Types of Systems

CSP, also called solar thermal power, uses mirrors to focus sunlight onto a heat transfer medium. The steam produced from the heat transfer medium powers a turbine or engine that generates electricity. Depending on the type, CSP plants can supply up to 100 megawatts (MW) with a potential to produce up to 300 MW, on par with other utility scale power plants. Effective CSP requires solar radiation of at least 5.5kWh/m2/day California averages 6.75-8.25 kWh/m2/day1 and functions best in arid, flat locations. The U.S. Southwest, Sahara Desert, and Australia have the highest potential capacity for CSP in the world. There are three main types of concentrating solar power systems: parabolic troughs, dish/engine systems, and central-receiver systems. These technologies can be used to generate electricity for a variety of applications, ranging from remote power systems as small as a few kilowatts (kW) up to grid-connected applications of 200-350 megawatts (MW) or more. A concentrating solar power system that produces 350 MW of electricity displaces the energy equivalent of 2.3 million barrels of oil [3].

A. Trough Systems

These solar collectors use mirrored parabolic troughs to focus the sun's energy to a fluid-carrying receiver tube located at the focal point of a parabolically curved trough reflector as shown in figure 1.

The energy from the sun sent to the tube heats oil flowing through the tube, and the heat energy is then used to generate electricity in a conventional steam generator. Many troughs placed in parallel rows are called a "collector field." The troughs in the field are all aligned along a north-south axis so they can track the sun from east to west during the day, ensuring that the sun is continuously focused on the receiver pipes. Individual trough systems currently can generate about 80 MW of electricity. Trough designs can incorporate thermal storagesetting aside the heat transfer fluid in its hot phaseallowing for electricity generation several hours into the evening. Currently, all parabolic trough plants are "hybrids," meaning they use fossil fuels to supplement the solar output during periods of low solar radiation. Typically, a natural gas-fired heat or a gas steam boiler/reheater is used. Troughs also can be integrated with existing coal-fired plants[4].

Figure 1. A 30MW parabolic trough plant.

B. Dish Systems

Dish systems use dish-shaped parabolic mirrors as reflectors to concentrate and focus the sun's rays onto a receiver, which is mounted above the dish at the dish center.

Figure 2: Picture of dish Stirling Eurodish.

composed primarily of a collector, a receiver, and an engine. It works by collecting and concentrating the sun's energy with a dish-shaped surface onto a receiver that absorbs the energy and transfers it to the engine. The engine then converts that energy to heat. The heat is then converted to mechanical power, in a manner similar to conventional

engines, by compressing the working fluid when it is cold, heating the compressed working fluid, and then expanding it through a turbine or with a piston to produce mechanical power. An electric generator or alternator converts the mechanical power into electrical power. Dish/engine systems use dual-axis collectors to track the sun. The ideal concentrator shape is parabolic, created either by a single reflective surface or multiple reflectors, or facets. Many options exist for receiver and engine type, including Stirling cycle, micro turbine, and concentrating photovoltaic modules. Each dish produces 5 to 50 kW of electricity and can be used independently or linked together to increase generating capacity. A 250-kW plant composed of ten 25-kW dish/engine systems requires less than an acre of land. Dish/engine systems are not commercially available yet, although ongoing demonstrations indicate good potential. Individual dish/engine systems currently can generate about 25 kW of electrici ty. More capacity is possible by connecting dishes together. These systems can be combined with natural gas, and the resulting hybrid provides continuous power generation [4].

C. Central Receiver Systems

Central receivers (or power towers) use thousands of individual sun-tracking mirrors called "heliostats" to reflect solar energy onto a receiver located on top of a tall tower. The receiver collects the sun's heat in a heat-transfer fluid (molten salt) that flows through the receiver. The salt's heat energy is then used to make steam to generate electricity in a conventional steam generator, located at the foot of the tower. The molten salt storage system retains heat efficiently, so it can be stored for hours or even days before being used to generate electricity [4]. Therefore, a central receiver system is composed of five main components: heliostats, receiver, heat transport and exchange, thermal storage, and controls. This is illustrated in Fig. 3

III. Night Time Generation

CSP generates power during daylight hours when demand for electricity is greatest. The heat transfer process ensures stable generation for 15-30 minutes, enough time to endure passing clouds, but during the night or extended cloud

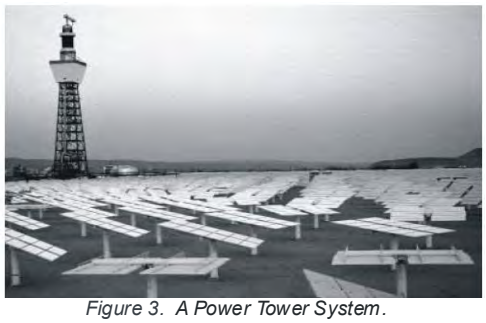


Figure 3. A Power Tower System.

cover, power generation requires one of two options: supplemental fuels or thermal storage.

The majority of CSP today is supplemented with natural gas so a plant can provide base-load power at all times. Like most CSP systems, many natural gas plants use steam engines to generate power, so the two systems can be hybridized easily. Alternatively, thermal storage technology can allow CSP plants to meet base-load demand without the use of backup fuels. CSP systems with storage can operate by sunlight alone for 70 percent of the year, as opposed to 15-30 percent without storage. One branch of the U.S. Department of Energy (DOE)'s Solar Energy Technologies Program is conducting research on advanced heat transfer fluids and storage techniques [5, 6].

IV. Water and Land Impacts

Because CSP functions best in sunny desert climates, water scarcity is often an issue. CSP plants with a steam engine require a cooling system to recirculate the water used. Wet cooling systems can use 758-957 gallons of water per MWh, a level com parable with coal plants. Dry cooling systems, such as the Heller system, use air instead of water and can reduce water usage up to 97 percent. However, they are more expensive and can reduce energy efficiency by 5 percent.

Land requirements vary from a single rooftop for Micro CSP to 500 acres for a power tower system. The largest nonhybrid CSP system, Nevada Solar One, is a 64 MW parabolic trough plant on 400 acres. The acreage needed to generate power from coal or hydroelectric dams is higher when the mining or reservoir sites are considered. In 2009,

the Department of the Interior designated 24 areas in six Western states totaling 670,000 acres of federal land as Solar Energy Study Areas, where environmental impact statements and solar resource surveys will be conducted by a new task force in the Bureau of Land Management. This advance work will accelerate the permitting process for future projects [4, 6].

V. CSP COST

The economics of a CSP installation is strongly dependent upon its size. The size is defined in terms of the power output, but it is als o directly related to land area. Nowadays, the minimum size of power plants is 1MWe for parabolic dish installations, 10MWe for central tower systems, and 50MWe for parabolic trough systems. It is likely that the cost of individual parabolic dishes will fall, which will open the market for smaller single units with an estimated cost of 5 000 €/kWe.

For central towers systems and parabolic troughs, present system costs are already below 3 000 €/kWe, but the likely trend is towards larger installat ions of between 100MWe and 200MWe which would lead to a reduction of this cost. Future plants of 1GWe are feasible if modular designs are utilized; this is comparable to the size of a nuclear power plant and would require 17km2 of desert land area [2].

However, developments in the technology will also ensure that the system costs decrease and cost reductions of up to 50% are expected as a result of a combination of several factors. The costs of a CSP system can, broadly speaking, be split into solar costs and nonsolar costs. Reduction in relation to solar costs lies in mass production leading to economies of scale and in the development of innovative mirror systems, the solar collectors which currently constitute 3040 % of the present plant investment costs, along with the development of novel optical systems. Nonsolar costs will be reduced by the development of simpler and more efficient heat transport schemes, more efficient power cycles, direct steam generation, integration with conventional systems, and increases in steam temperature to improve the efficiency of the steam cycle for electricity generation [7] .

VI. Future Challenges

Solar technology has made huge technological and cost improvements, but more research and development remains to be done to make it cost-competitive with fossil fuels. Costs can be reduced by increasing demand for this technology worldwide, as well as through improved component design and advanced systems.

Concentrating solar power technologies currently offer the lowest-cost solar electricity for large-scale power generation (10 MW-electric and above). Current technologies cost around $3 per watt or 12¢ per kilowatt-hour (kWh) of solar pow er. New innovative hybrid systems that combine large concentrating solar power plants with conventional natural gas combined cycle or coal plants can reduce costs to $1.5 per watt and drive the cost of solar power to below 8¢ per kWh. Advancements in the technology and the use of low-cost thermal storage will allow future concentrating solar power plants to operate for more hours during the day and shift solar power generation to evening hours. Future advances are expected to allow solar power t o be generated for 4¢5¢ per kWh in the next few decades. Researchers are developing lower cost solar concentrators, high-efficiency engine/generators, and high-performance receivers [3,5]. The goal is to further develop the technology to increase acceptance of the systems and help the systems penetrate growing domestic and international energy markets.

VII. Future Opportunities

Developing countries in Asia, Africa, and Latin Americawhere half the population is currently without electricity and sunlight is usually abundant represent the biggest and fastest growing market for power producing technologies. A number of projects are being developed in India, Egypt, Morocco, and Mexico. In addition, independent power producers are in the early stages of design and development for potential parabolic trough power projects in Greece (Crete) and Spain. If successful, these projects could open the door for additional project opportunities in these and other developing countries. The southwestern United States can also bene fit from the use of these systems. Because the Southwest gets up to twice as much sunlight as the rest of the country, many southwestern states (California, Nevada, Arizona, and New Mexico) are exploring the use of concentrating solar power, especially for

use in public utilities [5,6].

One key competitive advantage of concentrating solar energy systems is their close resemblance to most power plants. Concentrating solar power technologies use many of the same technologies and equipment used by conventional power plants; they simply substitute the concentrating power of the sun for the combustion of fossil fuels to provide the energy for conversion into electricity. DOE analysts predict the opening of specialized niche markets in this country for t he solar power industry between 2005 and 2010. DOE estimates that by 2020, more than 20 gigawatts of concentrating solar power systems could be installed throughout the world [7].

REFERENCES

Stoddard, L and J. Abiecunas, R. O'Connell. "Subcontract Report: Economic, Energy, and Environmental Benefits of Concentrating Solar Power in California." Black & Veatch, http://social.csptoday.com/content/bv- economic- energy-and-env- benefits- csp- ca, April 2006.

"A Short History of Solar Thermal Energy." Acquasol Water & Power, http://www.solardesalination.com.au/content/Parabolic- Trough- Solar- Power-History.html, 2009.

"The Total Solar Solution." Sopogy, http://sopogy.com/solutions,2009.

"Dish/Engine Research and Development." Solar Energy Technologies Program, Energy Efficiency and Renewable Energy, U.S. Department of Energy, http://www.eere.energy.gov /solar/dish_engine_rnd.html, Nov 2008.

Bullis, Kevin. "Cheaper Solar Thermal Power." Technology Review, http://www. technologyreview.com/energy/23079/, 28 July 2009.

"Press Release: Stirling Energy Systems and Tessera Solar Introduce Optimized SunCatcherTM Solar Power System." Stirling Energy Systems/Tessera Solar, http://www.stirlingenergy.com/ pdf/2009 -06 - 23.pdf, June 2009.

"Concentrating Solar Power: Energy from Mirrors." National Renewable Energy Laboratory, U.S. Department of Energy, http://www.nrel.gov/docs/fy01osti/28751.pdf, March 2001.

DESIGN AND IMPLEMENTATION OF AN ILLUMINATION SUPERVISOR

B. Nkom, IEEE member#, P. M. Gani-Ikilama*
#Engineering and Instrumentation Design Section, Centre for Energy Research and Training (CERT), Ahmadu Bello University, Zaria, Nigeria.
e-mail: bgnkom@abu.edu.ng

ABSTRACT
This paper describes the design and implementation, in hardware and software, of a microcontroller-based illumination supervisor. The system essentially functions by sensing the ambient illumination of a designated indoor or outdoor area via a light dependent resistor network connected to one of the comparator inputs of a PIC 16F628A microcontroller from Microchip™, in order to provide discrete (ON/OFF) control of two artificial illumination sources. A further degree of illumination control was added to the system, which functions by specifying timing loop values on the keyboard of any IBM-clone PC which are transmitted on-the fly as ASCII characters via a suitable terminal program to the microcontroller connected to the PC's RS 232 port. This dual control mechanism was purposely implemented in the system to increase the reliability of the system; thus providing an efficient, low-cost solution for avoiding energy waste by artificial illumination of areas already illuminated to a pre-determined level. This formed the motivation for the research that resulted in the design and implementation of this device. A supervisory function was further implemented using two additional light dependent resistor networks connected to two more comparator inputs of the microcontroller to monitor the illumination sources and provide an indication via visual and aural means when either of them fails.

Keywords- microcontroller; energy saving device; low cost smart light switch; real-time clock; PIC assembler firmware.

I. Introduction

It is expected that as the world population increases, the demand for energy should also increase. However, a crucial factor in this equation further complicates issues. This factor is the tremendous advances in technologies that make life more comfortable and convenient for humans [1,2,3]. Most of these technologies require electricity to power them, resulting in an ever-increasing level of demand of the commodity per capita [4,5,6]. This undoubtedly puts tremendous pressure on electricity supply, prompting worldwide campaigns for energy conservation spearheaded mainly by environmentalists and highly supported by the electricity suppliers themselves, in order to avoid repercussions from nature [7,8,9].

Amongst several other recommended good practices, energy conservation requires that artificial lighting by electricity be optimum to the space being considered in order to avoid waste of electricity [10,11]. It thus follows that when such a space does not require illumination, either due to the presence of sunlight or other reasons, the lights should be switched off. Unfortunately, the task of determining when such lights should be switched on or off is left to humans in virtually all cases, often resulting in electricity waste due to forgetfulness, carelessness, or other human factors.

The illumination supervisor described in this paper is an attempt to address the issues previously discussed by removing, to a large degree, the human factor element from the control of lighting switches. It is a device that automatically turns two artificial light circuits on or off, depending either on the ambient light level within a space crossing a pre-determined threshold, or on the time of the day; whichever occurs first. In addition, the device monitors the status of the artificial lights when turned on, in order to provide fault indication by both visual and aural means, thereby ensuring

prompt maintainability and improving the likelihood of such a space being constantly illuminated. The device is thus best suited for security or high-priority lighting applications.

II. Research Context

The Centre for Energy Research and Training (CERT) was established by the Federal Government of Nigeria as a centre of excellence for multi-disciplinary training and research in general energy systems, with particular bias to nuclear energy systems and methods; with a view to improve vital sectors of the economy such as energy, power, health, agriculture, and water resources [12]. Amongst other terms of references, it is required to explore practical ways to conserve electrical energy at the utilization end and inform the general public about such findings, under its energy studies mandate. This forms the main motivation for the research that resulted in the design of the illumination supervisor. CERT is also mandated to carry out applied research in general measurement, control, and instrumentation systems; with a view to develop devices and systems for possible commercialization, after being verified by using them for our own purposes. This forms the further motivation for the practical implementation of the illumination supervisor.

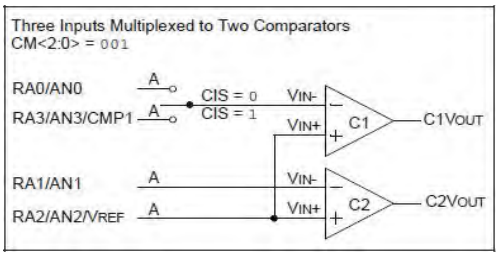
The primary challenge to the authors was to physically implement a system that will conform to some requirements, according to similar things being done presently [13,14]. The primary objective was to make it low-cost, power-efficient, reliable, and simple but effectiv e. On account of this, one of the first decisions made was to use a microcontroller chip as the control and data processing centre for the device [15,16]. This is because a microcontroller combines the versatility and convenience of digital programmable logic systems such as flash memory and digital I/O ports with a number of analogue modules. An example of an analogue module is a comparator, which comes handy for threshold applications. This can be used in conjunction with light dependent resis tors (LDRs) to control a switch via the microcontroller's digital circuitry, as was done in our device [17,18]. A simple LDR/relay set-up can achieve the same switching result, but there lies an advantage in using microcontrollers generally. It can be programmed to perform a number of other tasks concurrently, depending on the peripheral modules on board. In our case, amongst other functions, we specifically used a timer/counter module to provide real-time clock information for our device. Very importantly, a microcontroller can be interfaced with a PC for the purpose of data transfer. Also, a typical microcontroller is a small-sized, lightweight, low-power device, which is important for modern devices.

The choice of which microcontroller to use is influenced by popularity of the general family and particular devi ce, performance history, suitability for intended application, availability in locality, cost, device architecture, and the device manufacturer, which also has a bearing on its ease of use [19]. By taking these factors into consideration, we focused on microcontrollers from Microchip™, particularly the PIC 16Fxxx mid-range family, which are extremely popular and easy to use [20], and can be found even in a small “third-world” city such as Zaria, Nigeria. With not less than 400 types of microcontrollers in their latest catalogue, finding one suitable for implementing our device was not difficult [21]. After duly consulting the catalogue, we narrowed down to the PIC 16F628A microcontroller [22].

III. Design Preliminaries

The predominant reasons for choosing the PIC 16F628A microcontroller were because it has analogue comparator modules and is available in many local electronic component retailers. We desired to use one master LDR to sense the ambient illumination, and as many auxiliary LDR's as possible to monitor the status of an equal number of lamps, when they are switched on. From studying the 16F628A data sheet, which specifies a number of configurations for using the comparator module, we realized we could connect a maximum of two auxiliary LDR's only, by toggling between comparator mode 001 for auxiliary LDR's and mode 110 for master LDR. We specifically needed mode 110 for the master LDR because in this mode, it is possible to get an indication of the comparator switching action by connecting a LED to pin RA4/CMP2 of the microcontroller. This is very important for troubleshooting purposes. A graphic description of the configuration of the two modes is given in figure 3.1 below.

The number of auxiliary LDR's limited the number of lamps to be supervised to two. To switch these two lamps, we needed two mechanical relays with



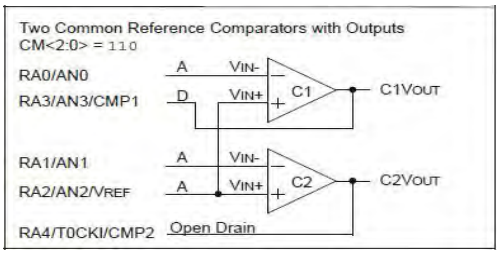


Figure 3.1: Graphic Descriptions of 16F628A Comparator Configurations

250V mains AC contacts and 5V DC coils.

As previously mentioned, we needed an additional degree of control for switching the lamps, which we achieved by creating a real-time clock loop within the firmware. We decided that the "on" and "off" time values be specified by transmitting data from a PC to the microcontroller, in order to keep our device as portable as possible. This necessitated the introduction of a "function" switch to enable the user to initiate communication between the device and the PC. In addition, an RS-232 interface chip was needed as an interface between the microcontroller and PC.

The design process started with the identification and procurement of the needed components. Three LDRs manufactured by Silonex ™ inc.[23] with electrical and resistance versus illumination characteristics as shown in table 3.1 and figure 3.2 were obtained.
In addition, the relays and all other components required to drive them, a simple spring-loaded non-latching button switch, three high-i ntensity LED's, and a 5V DC buzzer were also obtained. It was necessary to first obtain these components because they are always required in the firmware development process, to establish the best firmware routines needed to run them, and the best output pins to dedicate to them, by using them to run experiments with the microcontroller [24].

Table 3.1: LDR Electrical Characteristics

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
R_L	Light Resistance	5.4		12.6	kΩ	1 ftc, (2)
R_D	Dark Resistance	1.0			MΩ	15 sec. after removal of test light.
λ_P	Spectral Peak		550		nm	

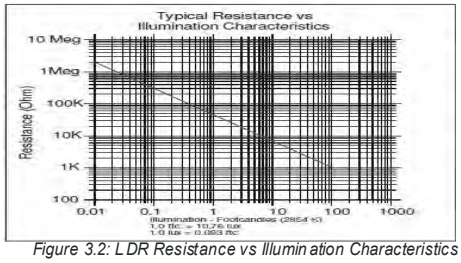


Figure 3.2: LDR Resistance vs Illumination Characteristics

The PIC 16F628A has 16 I/O ports; five are dedicated to the comparator module, two are dedicated to the USART module, two are used for connecting crystal oscillator s if desired, and one is used for the master reset if desired [22]. Even though we intended to use the microcontroller's internal precision oscillator, we decided to leave ports RA6/OSC 2 and RA7/OSC 1 free in case a system re-design becomes necessary. We also needed a master reset, which left us with six free ports, all on port B, i.e. 0, 3, 4, 5, 6, and 7. These were used up by our I/O interfaces, indicating that our choice of microcontroller was optimal [24].

We arbitrarily allocated the funct ion switch to RB 0, lamp 1 to RB 3, lamp 2 to RB4, LED 1 to RB5, LED 2 to RB6, and the buzzer to RB7; to be verified in the experimental process.

IV. Firmware Design Considerations

Due to our desire for an accurate real-time clock/calendar function to be incorporated into our device, it was decided that the firmware be developed on the basis of a continuous time counting and incrementing loop, with all other functions being handled by subroutine calls and other routines within the timing loop [25]. This arrangement dictated a reasonably high clock speed, which will ensure that the microcontroller processes a large number of instructions per second, thereby increasing the probability of the elapse of a second to be decoded in the timing loop

by the firmware. We thus opted for the internal precision oscillator speed of 4MHz, which enables one million instructions to be processes per second [22].

Algorithms were created, tested, and modified, resulting in a flowchart from which the firmware was developed and blown into the microcontroller to make it a functional piece of hardware [26]. The flowchart is given in figure 4.1. Text appearing next to decision boxes and in parenthesis inside process boxes refer to register bits that influenc e the decision, or are being affected by the action, respectively. Some of these register bits are preprogrammed in the microcontroller's special purpose registers, but most of them are flag bits designated by the authors, which are grouped in a general purpose register named “user_status”. The description “register hex test” and “register zero test” appearing next to some decision boxes refer to standard tests in the assembler firmware to determine if a register contains a particular hex value, or is clear (all zeroes), respectively. These are shown below.

```
HexTest1   movlw   09h              ;09h=0000 1001 is moved to W.
           bcf     status,2         ;the zero flag bit is cleared.
           xorwf   date_units,0     ;the "date units" register is bitwise XORED with W.
           btfss   status,2         ;the zero flag bit is tested,
           (action for -ve outcome) ;if it is set, this instruction is skipped.
           (action for +ve outcome) ;

ZeroTest1  movlw   0FFh             ;FFh=1111 1111 is moved to W.
           bcf     status,2         ;the zero flag bit is cleared.
           andwf   date_units,0     ;the "date units" register is bitwise ANDED with W.
           btfss   status,2         ;the zero flag bit is tested,
           (action for -ve outcome) ;if it is set, this instruction is skipped.
           (action for +ve outcome) ;
```

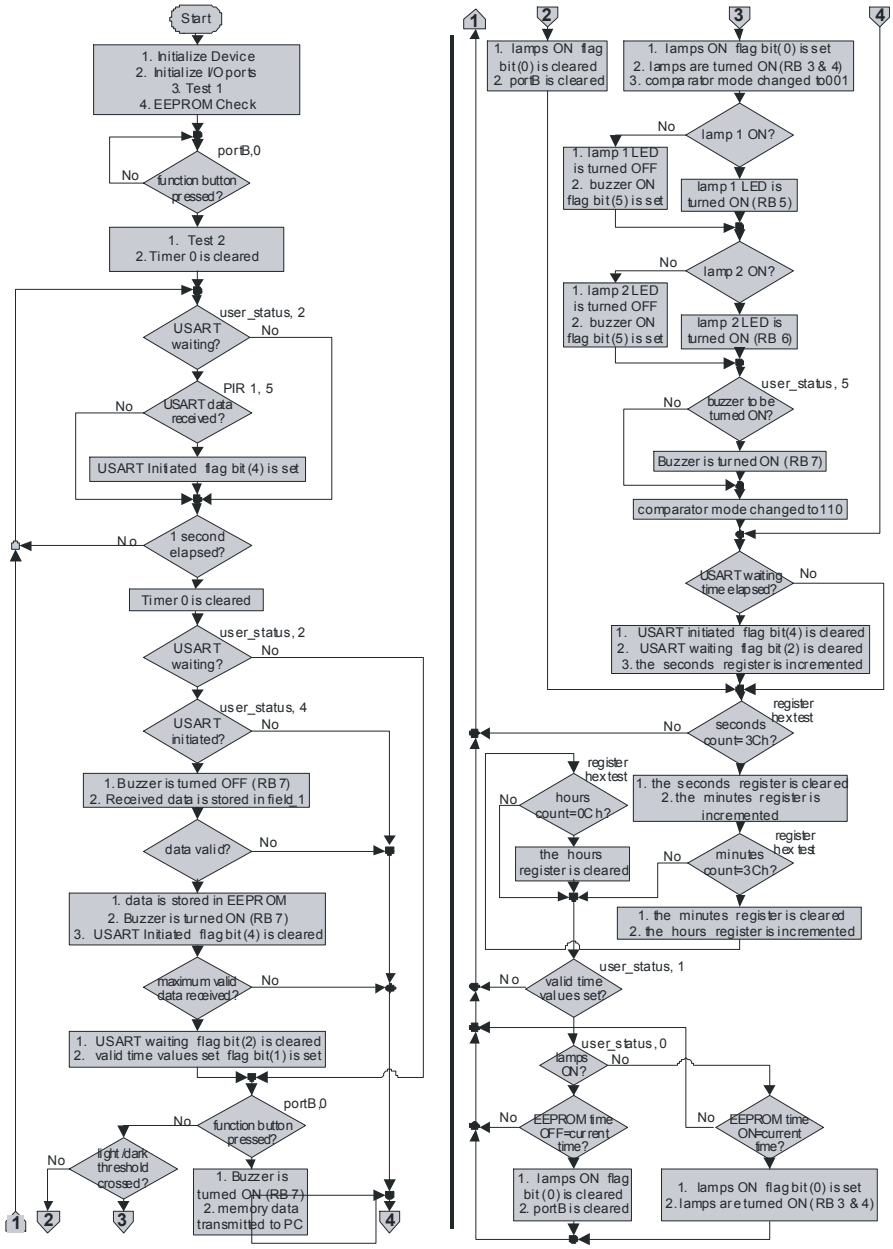


Figure 4.1: Flowchart for the device firmware

On power-up, the firmware initializes the device with the necessary code to enable/disable peripherals as required, to select options, and to initialize general purpose registers designated for processes as well as the input/output ports. It then takes the device through a test of its output user interfaces where the LEDs and buzzer are energized. The contents of the EEPROM memory are then checked to ensure that they contain valid time values for time ON and time OFF. If the EEPROM data is inval id, as will be the case the first time the device is being used, the time switch control will not function, leaving only the LDR switch control operational.

Once valid time data is downloaded from a PC, the time switch will work and there will be no need to repeat the process except if the values need to be changed, since the data is stored in non-volatile memory. However, if a loss of power is encountered by the microcontroller, a firmware safeguard has been put in place to also disable the tim e switch control. This is because even though the current time, time for lamps to go ON, and time for lamps to go OFF are all input via the PC, the current time is stored directly into the volatile general purpose registers that store the minutes and hours count, together with a special flag bit that is set when “pm” rather than “am” is specified. Thus, a loss of power will invariably wipe out the current time values and render incorrect the time ON/OFF values stored, prompting a re-download of the current time only. This is possible because the current time value is input first, and after doing so, allowing the input time window of about 10 seconds to elapse will leave what is in EEPROM unaffected.

The LEDs and buzzer will remain energized until the function button is pressed, whereby the buzzer is de-energized and the two lamps are energized to check their status. The timer 0 register is then cleared in order to streamline its timing function. Before one second elapses, there is a loo p that checks for the presence of data received via USART, if the USART function has been enabled by pressing the function switch momentarily. If data has been received, a flag is set to enable the data to be checked and possibly stored after the second elapses.

Enabling USART prompts the data currently stored in the “minutes” and “hours” registers, as well as the time ON/OFF, to be sent to the PC to be viewed in the terminal program. This forms a means of checking that all is in order. As soon as the USART time window elapses, the timing loop continues. The time window is refreshed every time a valid time value is inputted, until the maximum number of values (18; 2 for hours, 2 for minutes, 2 for am/pm; for the three values) is inputted.

The LDR routine and the USART function are mutually exclusive. The LDR routine starts by checking the ambient light levels, and switches the lamps ON or OFF accordingly. It then checks the status of each lamp and indicates a loss of illumination by the buzzer and LED associated with the faulty lamp.

Just before the timing loop returns to the top, a routine checks the “lamps ON” flag bit and compares the current time with the EEPROM time ON or time OFF, according to the value of this flag. Any positive match prompts the action associated with the routine.

Pressing and holding down the function switch for more than three seconds at any time switches the lamps, LED's, and buzzer all OFF, effectively shutting down the entire device. This is necessary for lamp servicing and other maintenance work.

V. Hardware Design and Implementation

The consideration of a number of issues in general hardware design and implementation were necessary to ensure functional harmony between the programmed microcontroller and all other hardware components specified for the illumination supervisor on integration; first on a breadboard for hardware troubleshooting purposes, and then onto a PCB [27, 28]. A few of these considerations in turn required the use of additional hardware components, for overall system effectiveness and efficiency.

Our desire for a master reset line, specified for the PIC 16F628A in its firmware configuration word, necessitated the addition of a spring-loaded, non-latching, NO/NC switch to our hardware; which was connected to the ground and +5V rails of our breadboard. To avoid noise from the function switch port if left floating [22,24], a simple buffering arrangement using a 1K resistor was employed, as is shown in the illumination supervisor's schematic diagram given in figure 5.1. Normally, this port is at

a LOW logic state, but when the function switch is pressed, it takes the port to a HIGH logic state.

A basic resistor network consisting of an ordinary resistor and a LDR in series is all that is needed to achieve a light to voltage transducer [17,18]. However, by looking at figure 3.2, it is clear that a typical LDR's resistance is inversely proportional to the illumination incident on it. Thus, total darkness represents a high resistance of above 1 M?. With the arrangement shown in the schemati c diagram i.e. 5 volts connected to LDR and zero volts connected to an ordinary resistor, with the voltage output tapped from the connection between the LDR and the resistor, the voltage at the tap point will be directly proportional to the illumination incident on the LDR. Swapping the 5 and zero volt connections will give a voltage inversely proportional to illumination. By experiments we determined that a resistance of not more than 10 K? will be adequate to form a complete resistor network in series with a LDR. We thus added three 10 K ? resistors to our components.

Figure 3.1 shows that an external voltage reference, or threshold vo ltage, is required for both of the comparator configurations used for the illumination supervisor. This was provided for by a

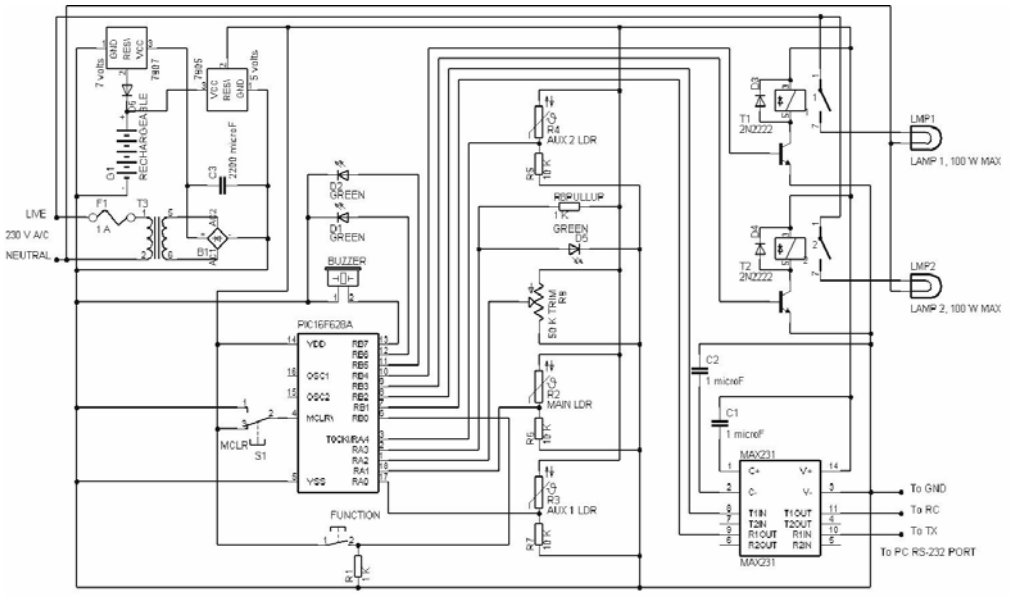


Figure 5.1: Schematic Diagram of the Illumination Supervisor

simple variable resistor of 50 K ?in order to enable the threshold, applicable to all LDRs used in the device, to be fine tuned.

For communicating with PCs, the USART module of the 16F628A requires an interface circuit to convert signals to and from RS-232 voltage levels to what is acceptable to it [22]. This is available in the form of numerous RS-232 interface chips such as the MAX 231 from Maxim ™[29], which together with two 1 µF capacitors, was used in our device.

With a clock speed of 4 MHz, the best communications was achieved by specifying a low speed (BRGH=0) baud rate of 300, with 8 data bits, 1 stop bit, no parity, and flow control disabled.

A rechargeable battery power system was deemed an ideal choice for the device because of the previous issues raised concerning the current time count. This necessitated the addition of a transformer power supply (230 volts to 7.5 volts D.C., regulated to 7 volts D.C., then 5 volts D.C.)

with a diode clamp for charging a 6 volt battery when mains power is available, which continues to power the data logger in the event of a mains failure [28].

In regards to the type of casing to be provided for the illumination supervisor, it was considered good practice to separate the D.C. circuit from the power circuit, which consists of the transformer, rectifier, battery and two lamp relays that are used in switching the A.C. lamp loads. Thus, two PCBs were prepared, with a 4-gang PCB connector acquired to provide power to the D.C. board from the A.C. board (5volt and ground) and provide a connection from the two switching transistors on the D.C. board to the relays on the A.C. board.

A 3-gang PCB connector was also acquired to provide connectivity to a PC for RS-232 data transfer, while electrical screw binding posts, similar to what can be found on any domestic electrical installation fitting, were used to provide connections for the 230 volt power input and lamp outputs.

The illumination supervisor went through some basic tests for functionality, durability, power consumption, and safety [27]. Power consumption was found to be about 28 mA while running. Heat dissipation was barely noticeable, thus no heat sink and/or fan was required for the device; however vent slots are necessary in any casing considered for the power circuit in order to cool the transformer by air convection. Our data transfer speed of 300 baud was also found to be satisfactory, with no errors encountered during transfers. At this stage, the device was considered to be verified [19].

V. Conclusion

The concept of designing and implementing an automatic lamp switch provided the authors with a number of challenges; the major one being how to bring the concept to reality in a manner consistent with global advances in electrical/electronics engineering [30], while also considering other factors such as cost, efficiency, versatility, multi-tasking, future technological advances, and functionality/ease of use. These issues pointed us in the direction of the use of a microcontroller as our control/data processing centre, which in turn enabled us to explore ways of increasing the sophistication of our concept, resulting in a device that switches lamps ON and OFF by two degrees of control and goes further to continuously check the status of the switched lamps. Thus, by applying embedded system design principles and methods [31] to the illumination supervisor, the issues of miniaturization, component count, power consumption, cost, and reliability were also positively addressed.

In embedded systems design, the issue of efficiency is a function of the quality and suitability of the chosen components and how well the firmware integrates with the overall hardware. In our case, our efforts were concentrated at achieving the most out of our choice of microcontroller, thereby achieving a low component count. Miniaturization, reliability issues, power requirements, and development costs are a few of the reasons for desiring a low component count in any embedded system design; but from the perspective of most electronics design engineers operating on a tight budget, the principal factor dictating their choice of components is obviously cost. All the components that make up the illumination supervisor cost approximately $ 28 US [32]. The work presented in this paper has thus tried to show that a desired function can be obtained efficiently just by using a suitable low or mid-range microcontroller running firmware which has been deftly and ingeniously developed, in conjunction with carefully selected hardware components.

A few recommendations for further work on the illumination supervisor are given below. Most of them are suggestions to keep the final size of the device as small as possible, in order for it to fit into standard domestic electrical installations.

1) The PIC 16F628A microcontroller also has a capture/compare/pulse width modulator (CCP) module. This may be used to extend the concept of the illumination supervisor further by creating routines for fading in and out of the lamps in accordance with the ambient light levels in a given area (i.e. a dimmer control).
2) An occupancy sensing routine may also be created, in conjunction with a PIR detector, in the microcontroller. This effectively enables the lamps to be switched on only if the indoor space is occupied.
3) The power supply may be replaced with a switch-mode type; which is smaller, and more reliable.

4) A primitive battery charge controller in the form of a diode was used in our application; this may be replaced by a more sophisticated one to prolong battery life.
5) The battery used in our application, for prototyping, was a 6 volt, 4.5 Ah sealed lead-acid battery, with dimensions of 100mm by 50mm by 70mm, and weighing 600 grams. Other battery types, such as lithium-ion, which have good storage and recharge characteristics with the added advantage of higher Ah rating per size and weight than the aforementioned type, may be considered.
6) Some hardware components may be replaced with surface mount equivalents; for size reduction.
7) A double-sided PCB for the electronics board may be considered for further size reduction.
8) The communication scheme for data transfer between the data logger and a PC may be replaced both in firmware and hardware by something more convenient; such as USB or Bluetooth. This will most probably require the microcontroller to be changed.
9) A dedicated software p rogram to download, store, and process data from the illumination supervisor may be developed for the PC.
10) The number of lamps to be controlled may be increased; this may require a change of microcontroller.

REFERENCES

(2010) *What Are the Uses of Electricity ?,* Wikipedia website. [Online]. Available: http://wiki.answers.com/Q/What_are_the_uses_of_electricity

(2010) *Consumers,* Teachnet website. [Online]. Available: http://www.teachnet.ie/pcoakley/consumers.htm

C. Brackett, *Electricity in Daily Life: A Popular Account of the Applications of Electricity to Every Day Uses*, Kessinger Publishing, 2007.

(2010) J. Wells, *Meeting Energy Demand in the 21st Century: Many Challenges and Key Questions,* a report to the subcommittee on energy and resources, committee on government reform, United States House of Representatives, 2005. [Online]. Available: http://www.gao.gov/new.items/d05414t.pdf

Electricity in Economic Growth, a report by the committee on Electricity in Economic growth, Energy Engineering Board, Commission on Engineering and Technical Systems, and the National Research Council; National Academy Press, 1986.

(2010) *Electricity Demand,* Electropaedia website. [Online]. Available: http://www.mpoweruk.com/electricity_demand.htm

A. Bejan, *Energy and the Environment*, Kluwer Academic Publishers, 1999.

(2010) *EPA Energy Conservation Series: Pollution Prevention (P2) Education Toolbox,* EPA website. [Online]. Available: http://www.epa.gov/reg5rcra/wptdiv/p2pages/energy.pdf

(2010) *Austin Seeks a New Blueprint for Power Utilities,* New York Times Energy and Environment Blog. [Online]. Available: http://www.nytimes.com/cwire/2010/04/07/07climatewire-austin-seeks-a-new-blueprint-for-power-utili-89818.html

(2010) *Lighting Application,* lecture note from the Indian Institute of Technology website. [Online]. Available: http://nptel.iitm.ac.in/courses/ Webcourse-contents/IIT%20Kharagpur/Illumination%20Engg/Illumination%20%20Engineering/Lesson-20/pdf/L-20(NKK)(IE)%20((EE)NPTEL).pdf

OPERATION OF A DUAL-STATOR WINDING INDUCTION GENERATOR AT UNITY POWER FACTOR

Jibril Yusuf Olorunfemi Ojo; Bajoga Buba*.**
**Department of electrical engineering, Ahmadu Bello University, Zaria, Nigeria.*
***Department of Electrical and Computer Engineering, Tennessee Technological University, Cookeville, TN38505, USA.*

ABSTRACT
This paper seeks to investigate the steady state performance of a dual stator winding induction machine. The machine under consideration has a standard squirrel cage rotor and a stator with two separate windings wound for the same number of poles. One of the major draw backs of induction machine is the fact that it requires reactive power for its operations. An attempt has been made here to derive a mathematical model for the effective capacitance required to operate the machine at unity power factor thereby increasing the efficient utilization of electrical energy and decrease installation cost of the system. The capacitor bank is connected to one winding set called the control winding whereas the other winding set called the power winding is connected to the voltage source. A constant phase capacitor value can achieve unity power factor at a specific slip. To ensure that the power winding operates at a unity power factor under all load conditions, a three-phase DC/AC converter is connected to the winding with a DC capacitor connected to the converter input. Pulse width modulating the inverter delivers effective but variable three-phase capacitors. A 3 horse power induction machine redesigned as a dual stator winding machine was used for the experimental implementation and verification of analysis.

Keywords: dual stator, winding, reactive, power.

I. Introduction

Recent years have seen public interest in issues related to efficient utilization of energy especially in the industry where cost of production is of great concern. In industry, two-third of electrical energy consumption is accounted for by electrical machineries [1]. They are therefore of central importance when it comes to efficient energy utilization. The most widely used among the electric machineries in industries is induction machineries. Induction machineries offer the advantage of been robust, relatively cheap and can work for a very long period of time unattended to [1].

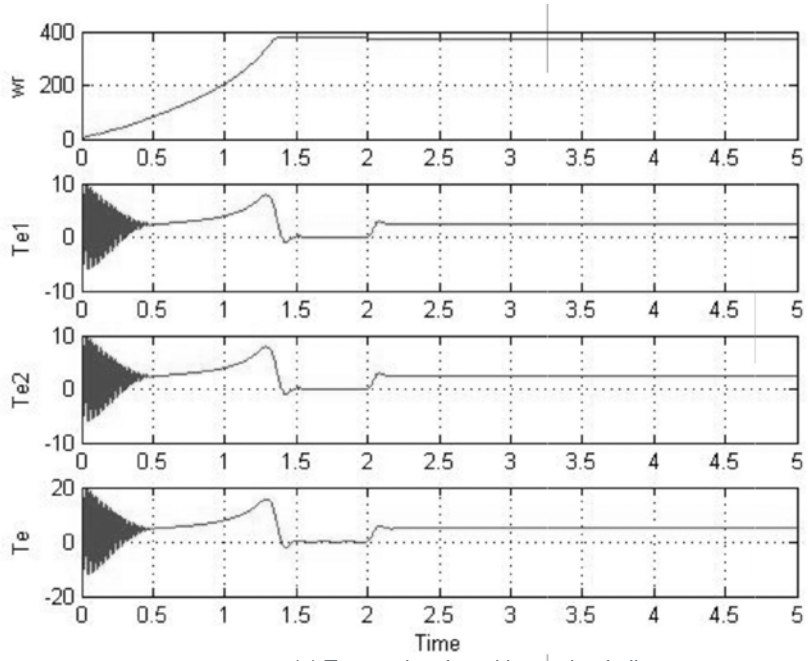
Despite all the above mentioned advantages credited to induction machineries, they consume reactive power for their excitation [2]. This demand for reactive power causes the machine to operate with a lagging power factor which leads to incomplete utilization of electrical power and thereby making the system in-efficient and costly [3-5].

Although the idea of reactive power compensation is not new and has been reported by so many researchers the use a dual stator winding induction machine for this purpose is still at its infancy stage. In this novel machine there are two-three phase star connected windings on the stator [6-9]. The neutral of both windings are kept isolated in order to prevent propagation of physical fault from one three-phase set to another and to prevent the flow of triplen harmonics [7,8].

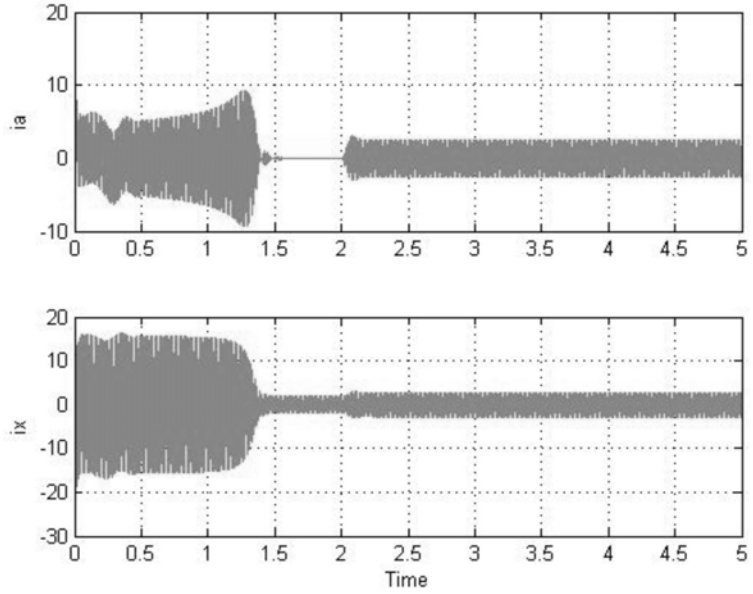
A bank of capacitors is connected across “control winding” while the ot her winding is connected to the source of voltage and is termed “power winding” [9].
The parameters of the machine used are:

Stator resistances: $R_1 = R_2 = 1.5$ohms; Rotor resistance $R_r = 0.56$ ohms; Stator leakage inductances: $L_1 = L_2 = 3.5 * 10^{-3}$mH; Magnetizing inductance $L_m = 0.38$ mH.

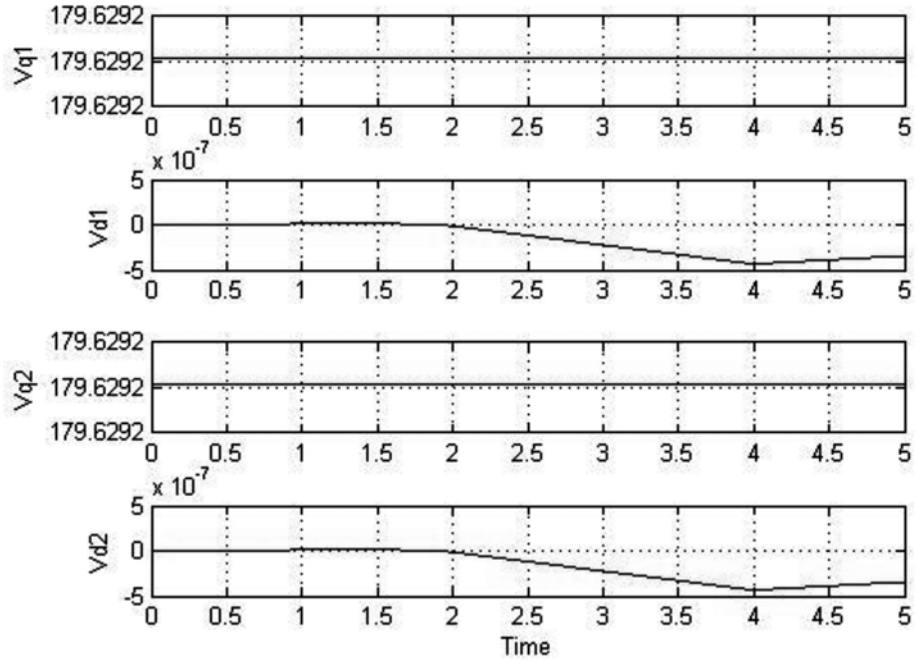
Subscripts 1, 2 and r stand for power, control and rotor windings respectively. The simulation results when both windings are excited by sinusoidal voltage sources are as shown in figure 1(a) (d).



(a) Torque developed by each winding



b) One phase currents from each stator winding



(d) dq voltages of the machine

II Steady State Analysis Of A Dual Winding Induction Machine

This section considers steady state analysis of the proposed machine. In this case one of the windings is shorted by a capacitor bank. The expression of the capacitor required to give a unity power factor (pf) is derived.

A. Derivation Of The D-Q Voltage Equations Of The Dual Stator Winding Machine For Unity Pf Operation Using 3-Phase Capacitor Bank In One Winding

The dq equations at steady state in complex form can be written as:

$$V_{qd1} = Z_{11}I_{qd1} + Z_{12}I_{qd2} + Z_{13}I_{qdr}$$
$$V_{qd2} = Z_{21}I_{qd1} + Z_{22}I_{qd2} + Z_{23}I_{qdr} \quad (1)$$
$$V_{qdr} = Z_{31}I_{qd1} + Z_{32}I_{qd2} + Z_{33}I_{qdr}$$

Where,

$$Z_{11} = r_1 - j\omega_e L_{s1}; Z_{12} = Z_{13} = Z_{21} = Z_{23} = -j\omega_e L_m;$$
$$Z_{22} = r_2 - j(\omega_e L_{s2} + X_c); Z_{31} = Z_{32} = -j(\omega_e - \omega_r)L_m$$
$$Z_{33} = r_r - j(\omega_e - \omega_r)L_r$$

Where

$X_c = \frac{1}{\omega_e C}$ is the reactance of the capacitor bank with capacitance, C connected across the terminals of control winding.

With squirrel cage rotor and capacitor excitation in the control winding, $V_{qdr}=V_{qd2}=0$.

Thus,

$$V_{qd1} = Z_{11}I_{qd1} + Z_{12}I_{qd2} + Z_{13}I_{qdr}$$
$$0 = Z_{21}I_{qd1} + Z_{22}I_{qd2} + Z_{23}I_{qdr} \quad (2)$$

And

$$0 = Z_{31}I_{qd1} + Z_{32}I_{qd2} + Z_{33}I_{qdr}$$

This at steady state yields;

$$CpV_{qdc} - j\omega_e CV_{qdc} = I_{qd2} \quad (3)$$

From the above equation it's seen that

$$I_{qd2} = -j\omega_e CV_{qdc} \quad (4)$$

Or,

$$\begin{aligned} Z_{22}I_{qd2} + Z_{23}I_{qdr} &= Z_{21}I_{qd1} \\ Z_{32}I_{qd2} + Z_{33}I_{qdr} &= Z_{31}I_{qd1} \end{aligned} \quad (5)$$

$$\begin{bmatrix} Z_{22} & Z_{23} \\ Z_{32} & Z_{33} \end{bmatrix} \begin{bmatrix} I_{qd2} \\ I_{qdr} \end{bmatrix} = \begin{bmatrix} -Z_{21}I_{qd1} \\ -Z_{31}I_{qd1} \end{bmatrix} \quad (6)$$

$$I_{qd2} = \begin{vmatrix} -Z_{21}I_{qd1} & Z_{23} \\ -Z_{31}I_{qd1} & Z_{33} \end{vmatrix} \frac{1}{\Delta} \quad (7)$$

Where,

$$I_{qdr} = \begin{vmatrix} Z_{22} & -Z_{21}I_{qd1} \\ Z_{32} & -Z_{31}I_{qd1} \end{vmatrix} \frac{1}{\Delta} \quad (8)$$

$$\Delta = Z_{22}Z_{33} - Z_{32}Z_{23}$$

Where,

$$I_{qd2} = \frac{1}{\Delta}(-Z_{21}Z_{33} + Z_{31}Z_{23})I_{qd1} = AI_{qd1}$$

$$I_{qdr} = \frac{1}{\Delta}(Z_{32}Z_{21} - Z_{22}Z_{31})I_{qd1} = BI_{qd1}$$

Substituting (8) in (4) yields;

$$A = \frac{1}{\Delta}(-Z_{21}Z_{33} + Z_{31}Z_{23})$$

Where,

$$B = \frac{1}{\Delta}(Z_{32}Z_{21} - Z_{22}Z_{31})$$

Define

$$V_{qd1} = Z_{11}I_{qd1} + AZ_{12}I_{qd1} + BZ_{13}I_{qd1} = Z_1 I_{qd1} \quad (9)$$

it follows;

$$Z_1 = Z_{11} + AZ_{12} + BZ_{13}$$

$$= \frac{1}{\Delta}(Z_{11}\Delta + Z_{13}Z_{23}Z_{12} - Z_{21}Z_{33}Z_{12} + Z_{32}Z_{21}Z_{13} - Z_{22}Z_{31}Z_{13}) \quad (10)$$

Where,

$$Z_{22} = Z_{22}^{\wedge} + jX_c$$

$$\Delta = Z_{22}Z_{33} - Z_{32}Z_{23} = (Z_{22}^{\wedge} + jX_c)Z_{33} - Z_{32}Z_{23} \quad (11)$$

Let,

$$= Z_{22}^{\wedge}Z_{33} - Z_{32}Z_{23} + jX_cZ_{33} = \Delta_1 + jX_cZ_{33}$$

Then

$$\Delta_1 = Z_{22}^{\wedge}Z_{33} - Z_{32}Z_{23}$$

$$k_1 = Z_{31}Z_{23}Z_{12} - Z_{21}Z_{33}Z_{12} + Z_{32}Z_{21}Z_{13}$$

Where,

$$Z_1 = \frac{1}{\Delta}[Z_{11}(\Delta_1 + jX_cZ_{33}) + k_1 - Z_{13}Z_{31}(Z_{22}^{\wedge} + jX_c)]$$

$$= \frac{1}{\Delta}[Z_{11}\Delta_1 + k_1 - Z_{13}Z_{31}Z_{22}^{\wedge} - jX_c(Z_{13}Z_{31} - Z_{11}Z_{33})] \quad (12)$$

$$= \frac{1}{\Delta}(\gamma - jX_c\Sigma)$$

Where,

$$\gamma = Z_{11}\Delta_1 + k_1 - Z_{13}Z_{31}Z_{22}^{\wedge}$$

$$\Sigma = Z_{13}Z_{31} - Z_{11}Z_{33}$$

$$\Delta = \Delta_1 + jX_cZ_{33} = (\Delta_{11} - X_cX_{33}) + j(\Delta_{12} + X_cR_{33}) = n_1 + jn_2$$

Therefore Z_1 becomes;

$$\Delta_1 = \Delta_{11} + j\Delta_{12}$$

$$Z_{33} = R_{33} + jX_{33}$$

In order to eliminate the complex number from the denominator, the numerator and the denominator of the above equation are multiplied by the conjugate of the denominator. After simplification we get;

$$Z_1 = \frac{\gamma - jX_c\Sigma}{n_1 + jn_2} \quad (13)$$

Where k is a real number.

Let,

And,

$$Z_1 = \frac{1}{k}(\gamma - jX_c\Sigma)(n_1 - jn_2) \quad (14)$$

Then,

$$jX_c\Sigma = m_1 + jm_2 \quad (15)$$

In order for the machine to operate with unity power factor the imaginary part of Z_1 in the above equation must be equal to zero.

Hence,

$$(\gamma - jX_c\Sigma)(n_1 - jn_2) = (m_1n_1 + m_2n_2) + j(m_2n_1 - m_1n_2) \quad (16)$$

By substituting m_1, m_2, n_1 and n_2 we get;

$$[\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad] \quad (17)$$

The above equation can be expressed in a

general quadratic expression as:

$$m_2 n_1 - m_1 n_2 = 0 \qquad (18)$$

Where,

$$(\Sigma_2 R_{33} - \Sigma_1 X_{33}) X_c^2 - (\Sigma_2 \Delta_{12} + \gamma_1 R_{33} + \Delta_{11} \Sigma_1 + \gamma_2 X_{33}) X_c + (\gamma_1 \Delta_{12} - \gamma_2 \Delta_{11}) = 0 \qquad (19)$$

X_c can thus be evaluated as:

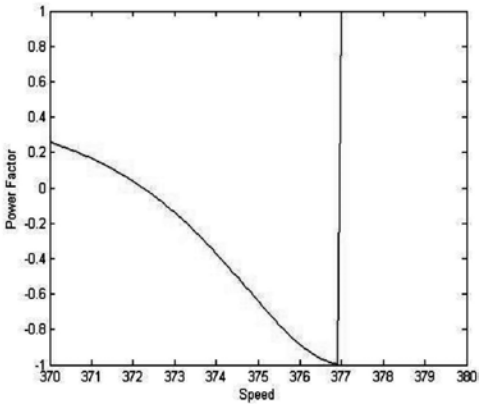
$$aX_c^2 + bX_c + c = 0 \qquad (20)$$

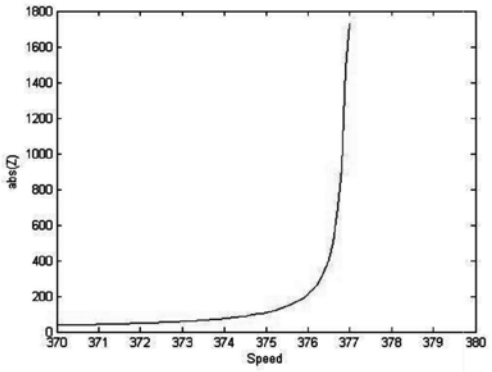
And the required capacitor can be calculated from the relationship:

$$b = -(\Sigma_2 \Delta_{12} + \gamma_1 R_{33} + \Delta_{11} \Sigma_1 + \gamma_2 X_{33})$$

The simulation results of the capacitors required for full reactive power compensation is as shown in fig 2; while fig 3 shows the simulation of the absolute value of the machine's impedance as a function of speed. Fig. 4 shows phase 'a' voltage and current in phase.

$$X_c = 1/\omega C \qquad (22)$$





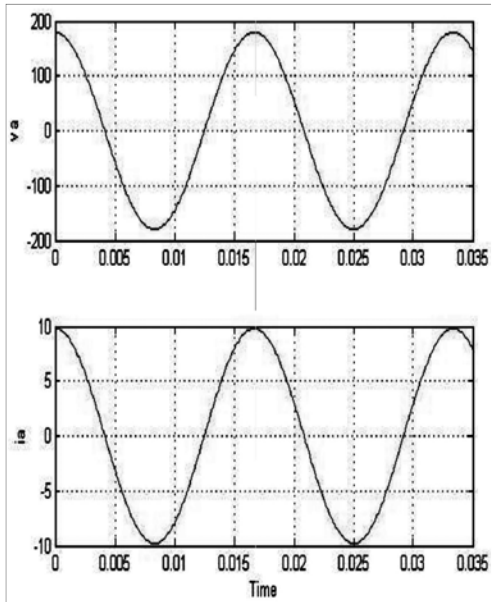


Fig. 4: Voltage and Current of Phase 'a' with 0 phase shift between them as a function of time

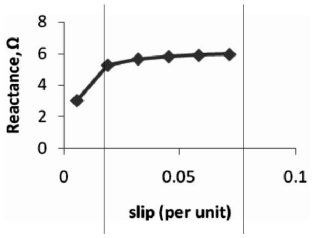


Fig. 5 Reactance that gives unity p.f. vs. Slip

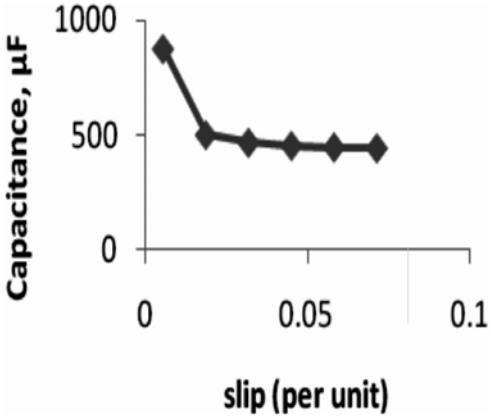


Fig. 6. Capacitance that gives unity p.f. vs. Slip

III. Conclusion

Induction machines find wide applications in various aspects of human endeavour especially in industries (where they consume about 70% of electric power been supplied to the industries). Though they have been shown to have superior performance characteristics (as compared to other machines) nonetheless their reactive power requirement for excitation limits their widespread application especially in a standalone system.

Researchers have attempted in various ways to find solutions to this impending problem. One of the approaches was to connect a synchronous condenser in parallel with the induction machine for the purpose of supplying reactive power. In another method static capacitor bank was used to supply the reactive power. These capacitors are normally connected either in series, parallel or combined series/parallel.

The proposed system (though employs the same technique for reactive power compensation) offers the advantage of separating control winding from power winding. This gives n ot only more degree of flexibility to the control scheme and as a result better performance characteristics but also higher reliability in some applications.

REFERENCES

McPHERSON G. An introduction to Electrical Machines and Transformers, John Wiley and Sons, 1998

O. Ojo and I.E. Davidson, " PWM-VSI inverter-assisted stand-alone dual stator winding generator," IEEE *Transactions on Industry Applications* Vol. 36, No. 6 pp.1604-1611, Nov./Dec. 2000.

Z.Wu and O. Ojo, "Coupled circuit model simulation and air gap field calculation of a dual stator winding induction machine," IEEE *Proceedings Electric power Applications,* Vol.153, No.3, pp387-400, May 2006.

Z. Wu. O. Ojo and J. Sastry, "Control of a dual stator winding induction machine as a sourc e of DC power," conference record of IEEE *Industry Applications Conference,* Vol. 2, pp. 1089-1096, 2-6 Oct. 2005.

Z. Wu and O. Ojo, "High performance of a dual winding induction generator with series connected boost rectifiers," Conference of 37th IEEE *Power Electronics Specialists Conference* ,Jun. 18-22, Korea, 2006.

Levy D. (1986), "Analysis of a double- stator induction machine used for a variable-speed /constant-frequency small-scale hydro/wind electric power generator", Electric power Systems research, vol.11, pp.205-223.

Bansal R.C., Kothari D.P. and Bhatti T.S. (20 04), " A novel mathematical modelling of induction generator for reactive power control of isolated hybrid power systems," Int. J. of modeling Simulation, vol.24, no.1, pp. 1-7.

Quazene L. and Mcpherson Jr. G. (1983), "Analysis of an isolated induction generator," IEEE Trans. Power App. Syst., vol. 102, no. PAS-8, pp. 2793-2798, Aug.1983.

Rajakaruna S. and Bonert R. (1993), " A Technique for the steady state analysis of an induction generator with variable speed, " IEEE Trans. Energy Conversion, vol. 8, no. 4, pp.757 761, Dec. 1993.

SMART METERING TECHNOLOGIES ADOPTION: PROSPECTS AND CHALLENGES

Eronu Emmanuel Majiyebo
Faculty of Engineering, Dept. of Electrical and Electronics Engineering
University of Abuja, Abuja, Nigeria
Email: eronume@ejosytechconsult.com

ABSTRACT
The Nigerian Electricity power sector is plague with a number of challenges that has made it quite ineffective in recent years. These problems look quite insurmountable. However a new technology-Smart Metering which is fast gaining momentum might just be the right solution if effectively adopted. In this paper we provide an overview of Smart Metering technologies and further illustrate how some of these problems can be easily addressed by the proposed concept. More also, like most new innovations, the Smart metering technology comes along with its challenges. We examine these challenges and also assess the economics of using Smart meters by focusing on its cost and benefits. We conclude by affirming that the cost of meeting these challenges is highly justifiable when compared to the benefits of adopting the Smart Metering technology.

Keyword*:* Smart Metering , Power Supply and Remote Meter Management

I. Introduction

One of the cardinal points of the seven point agenda of the Federal government of Nigeria is to ensure that electricity energy is made available and affordable to all. Several efforts has been made in order to achieve these goals, however none has been able to yield any appreciable result. This problem is a complex one and it spans over the process of generating power, to its distribution and finally consumption, none seems to be without a serious challenge. Some of the problems have been attributed to lack of maintenance, non replacement of obsolete components parts or equipment, inability to generate revenue or non effective billing systems, vandalisms, corruption and several others. Information available in figure 1, and figure 2 from the Nigerian Electricity Regulatory Commission (NERC) website attest to this. The total debt owed by customers outweighs the revenue realized for the same period under review.

Investigations as to why there is so much debt being owed by customers reveals that the metering and billing system in use are grossly inefficient. Most of the meters used at the customer end are either the electromehanical energy type of meter or the traditional prepaid electronic meters. These meters are susceptible to manipulations and counterfeiting. Also of note are the infrequent visits to residential premises to take meter readings, this in the long run discourages the customer from paying bills promptly. There are also cases of customer bypassing the meter and other vices which subsequently results into unaccounted use of electricity.

All these deficiencies can be effectively curtailed by adopting Smart metering technology. In adopting the Smart metering technology a number of questions easily comes mind. What are the exact tasks performed by these Smart meters and what are the benefits? What is the current state of the technology? In what ways can the Smart meters proffer solutions to the many problems facing the Nigerian electricity power sector? Are there any barriers for its implementation and what is the nature of these?

This paper will provide all the answer to these questions and also present the economics of using Smart metering technology with emphasis on cost and the benefits.

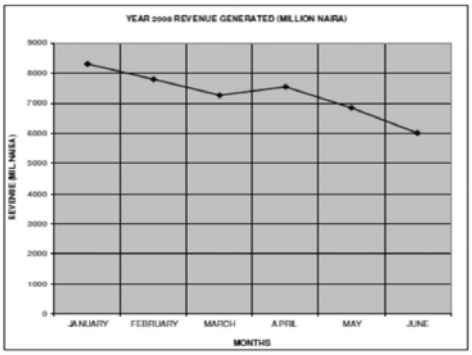


Figure 1: Year 2008 Revenue Generated [1]

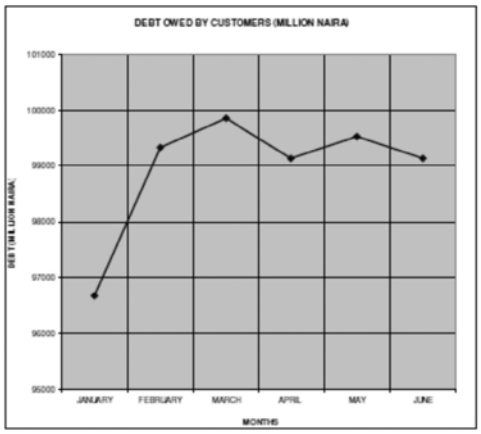


Figure 2: Debt owed by customers [1]

II. Smart Metering Technology

Smart metering technology is build around the Smart meter device, communication and IT infrastructure which connects the meter and customer and also the meter and the (central) meter control centre, where meter data is administrated and meters are remotely operated. Smart metering therefore refers to the entire meter infrastructure, fulfilling or partly fulfilling the following main specifications:

? Interval meter data (load profile measurement)

? Remote meter reading, data processing to market players.

? Remote meter management (power reduction, disconnection, demand management, etc.)

? Measurement of consumption and generation by distributed units.

? Remote meter parameterization such as tariff structures, contractual power, meter interval, etc.

? Remote message transfer from market players to the customer (consumer/generator) as e.g. price signals.

? Information display on the meter and/or communication port for external display.

? Main communication port (e.g. GPRS, GSM, PLC, etc).

? Power quality measurement (incl. continuity of supply and voltage quality).

? Communication port for collection and transmission of other metered data (e.g. gas, heat).

These specifications are usually referred to as Automated Meter Management (AMM) [3]:

Smart meter (as shown in figure 3) is a type of advanced and innovative meter which offers consumers information about consumption in more detail than a traditional meter, and optionally interacts with local utility suppliers via some network for monitoring and billing purposes [2]. Smart meters have the follo wing capabilities [4]:

? real-time or near-time registration of electricity use

? offers the possibility to relay meter readings locally and remotely (on demand);

? remote limitation of the throughput through the meter (in the extreme case cutting of the electricity to the customer)

? interconnection to premise-based networks and devices (e.g., distributed generation)

? Provide a more effective way for consumers to understand their energy consumption via a prominent display unit which includes:
  - Cost in NAIRA/KOBO
  - Indicator of low/med/high use,
  - Comparison with historic/average consumption patterns,
  - Function to allow data to be accessed via PCs/mobile phones [5].

Communications technology is vital to all current metering systems. Smart meters with communications capabilities provide an enhanced level of functionality that and allows for

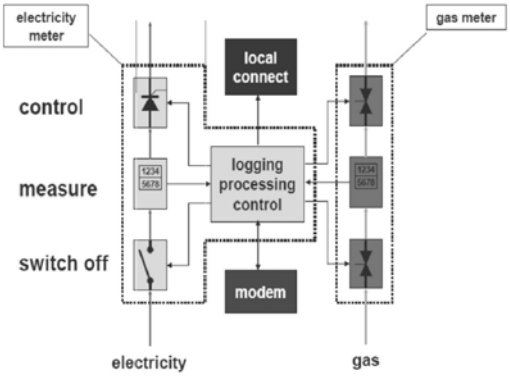


Figure 3: Schematic overview of a typical Smart meter configuration [4]

a greater level of interaction between the various actors in the supply chain. Advanced Metering Infrastructure (AMI) refers to the entire infrastructure of meters, communication networks and data management systems required for advanced information to be measured, collected and subsequently used.

Figure 4 shows a simplified picture of how the various communication networks link parts of the AMI together. There are three main types of network: the Home Area Network (HAN), Local Area Network (LAN) and the Wide Area Network (WAN). The meter can act as a platform for coordinating with other devices in the home (display devices, appliances, lights, thermostats, HVAC systems) and with the customer through the HAN and with the rest of the electricity system through the LAN and WAN. There are two main categories of advanced metering systems that are differentiated by their levels of communication: Automated Meter Reading (AMR) and Automated Metering Management (AMM) [3].

automated meter reading (amr)- amr allows for readings to be collected without the need for physical access to the meter. the simplest form of amr connects the meter temporarily via a radio link to an electronic meter reading device.

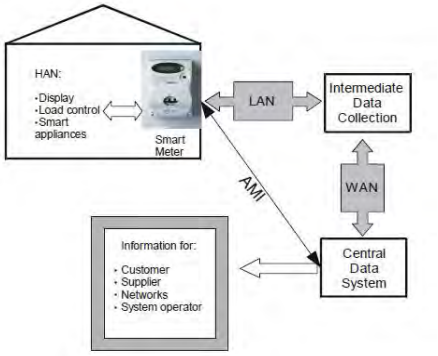


Figure 4: Advanced metering infrastructure and the Home Area Network [3]

various forms of wireless and wired communications technologies can be employed for this purpose. automated meter management (amm) amm goes a step beyond amr and refers to the process of two-way communication between the meter and the rest of the network. this type of remote management allows for commands/messages to be uploaded to the meters as well as data to be downloaded. remote management of the meter includes the capability for remote connection/disconnection and remote changes in contracted power or price schemes. in general, electronic interval meters are used as part of an amm system [3].

For most communications solutions, the LAN connects the meters to intermediate data concentrators and the WAN transmits the data further to a central data system. Power Line Carrier (PLC) for the LAN and the public telecommunications network for the WAN are also being used. PLC communications send signals over power lines between zone substations and meters. Distribution Line Carrier (DLC) communications can also be used for the LAN; in this case the low voltage distribution network is used as a communication medium. Mesh radio is an alternative to both PLC and DLC and is a private network radio technology which uses meters as repeaters in a mesh configuration before the data is transmitted to a concentrator.

I. Benefits Of Smart Metering Technology

Smart metering technology offers a lot of benefits which entails provision of detail information and efficient control of electricity energy usage. This

translates into lower metering cost, energy savings for residential customers, more reliability of supply, variable pricing schemes to attract new customers and easier detection of fraud [6]. Additional benefits are foreseen in relation to distributed generation (DG). The Smart meter can be used to separately measure electricity delivered by the DG to the grid and the Smart metering communication infrastructure can be used to remotely control DG (e.g., in a virtual power plant concept) [6].

Other benefits that Smart meters bring to different stakeholders are further explained below'

A. Energy Efficiency

Smart meters are designed to relay energy consumption accurately in local currencies even to the lowest units thereby providing consumers with vital economic information that can assist them in making cost saving decisions. More advanced Smart meters exist that can interact with electrical appliances around the home and relay the exact amount of energy they use, or even control the amount of energy use in a house [6].

A significant body of evidence has proven that consumers' behavior would change if they were regularly informed of the cost of energy they consume [7]. For example, they may try to find ways of saving money by cutting back on the amount of overall energy they consume, or by reducing energy consumption at peak times. As a result, consumers with Smart meters could be more energy efficient.

B. Ruggednes and Reliabilty

The absence of moving parts is a clear advantage of the electronic solution (also referred to as a "solid state solution"), therefore, electronic meters can be designed to withstand higher levels of mechanical stress. While it is true that electronic components are sensitive to temperature variations, these can be easily taken into account and compensated.

C. Automated Meter Reading

Considerable savings can be achieved by the utility companies by removing the need for a visual inspection of the meter at each billing term. The process is labor intensive, prone to (human) error and a source of inconvenience for the user w hen the meter is actually located inside the user premises.

Smart meters can be read and communicated to automatically through mechanisms such as:

- Radio Frequency (RF) short and long-range
- Data Modem via a telephone line
- Power Line Carrier (PLC) short to medium range
- Broadband

Part of the advantage of automated reading it eliminates the need for an operator to visit each location, it ensures that the readings are accurately relayed and thereby speeding up the entire process considerably.

D. Security

As the metering process automation increases, so does the need for secure communication technology. Privacy and integrity of the data being collected by the utilities is of great importance. Solutions available to ensure a secured communications employ advanced cryptographic algorithms, such as triple DES and AES (up to 256-bit keys) for data encryption, as well as low-cost proprietary solutions (KEELOQ ®security ICs) for user authentication and access control.

E. Anti-Tampering Protection

Smart meters use several, simple methods to detect tampering and theft. it is possible to det ect a number of "typical" conditions. For example:

- Asymmetrical loads (closing the loop with the ground to avoid metering)
- Temporary meter disconnect (or bypassed)
- Use of permanent magnets to saturate current transformers or stop the counter
- Vandalism

Upon detection of these attacks, the Smart meter can, in some cases, adopt specific "work arounds", or simply raise a flag, and if connected to a reading network send an immediate alert to the utility company.

F. Improving Billing Performance

Poor billing is by far the largest source o f complaints by consumers. Consumers lack confidence in the accuracy of estimated bills sent to them and quite a large percentage of Nigerians receive estimated bills frequently. Most customers believe that the estimated bills they received are very or fairly inaccurate. And almost a large

percentage customer accuses the relevant authorities of pushing them into debt. However, with a suitable information network and infrastructure, Smart meters can send accurate real time meter readings directly to the energy suppliers. Hence, the adoption of Smart meters can potentially eliminate the need for manual meter reading and estimated billing. The automatic and remote meter reading and accurate billing will lead to a substantial reduction in energy suppliers' back office costs related to complaint resolution [5].

II. Challenges To Adoption Of Smart Metering Technology

The adoption of Smart Metering technology might not be an easy one under certain circumstances. The challenges that could prevent Smart metering technology from taking off in the energy consumer market can be summarized in three aspects: economic, technical and regulatory [6].

A. Economic

The production and deployment of Smart meters involves a lot of expenses as such they become inevitably costlier than the conventional meters, and the more sophisticated the model, the higher the price. On the one hand, for consumers, the cost of a Smart meter might be up to three times the cost of a conventional meter. Therefore, high absolute cost of replacement of existing conventional meters with Smart meters remains a significant economic barrier preventing Smart meters from being adopted [2].

B. Technical

The lack of standardization of types of Smart meters can create risk for energy suppliers: a consumer installing a Smart meter from one energy supplier may switch to another energy supplier because its new Smart meters appear to offer more advanced services [7] Additionally, the lack of standardization of Smart metering technology means that large number of Smart meters of different types will work (e.g. collect and dispatch data and instructions, keep track of meter errors, validate and transform the data and store data) under different communication protocols. Currently, this issue remains a big technical challenge for energy suppliers [7]. The standardization of Smart meter tec hnology can overcome this technical barrier and enable energy suppliers to boost the deployment of Smart meters in large scale.

C. Regulat ory

With the current regulatory framework as proposed by the Nigerian Electricity Regulatory Commission (NERC) , little or virtual noting is being said as regards to Smart metering technology. And since most of the energy meters remain the assets of the Power Holding Company of Nigeria (PHCN), the Federal government of Nigeria through NERC should take a critical look at the new trend in the use of Smart metering Technology and subsequently come up with regulations that will encourage private utilities companies to invest in the deployment of Smart metering Technology. The regulation can incentivize network operators or new entrants to deliver their existing services as efficiently as possible in order to maintain t profitability. The electricity network operators are reluctant to risk developing innovative services, especially those t hat can render their current assets (existing working meters) obsolete [7].

III. Assessing The Costs And Benefits Of The Smart Metering Technology

A general experience is that costs are most often easier to quantify than benefits. Given th is, there is a higher likelihood of positive net benefits when taking into account the issues which can only be evaluated qualitatively.

The main driver in several countries is the hope that exposing consumers to a time varying cost of electricity will lead to a reduction in consumption and to a reduction of peak demand, reducing the need for additional investments in networks and generation. In turn, increased energy efficiency will translate into savings for consumers and the system as a whole . A need for improved billing accuracy is the main driver, consumer heavily criticize estimated electricity bills for being both unclear and inaccurate. The most cost effective way distribution companies could meet this requirement is to invest in remote meter reading technology. Some of the benefits of investing into the Smart Metering Technology enterprise are better appreciated in the light of a number of

business driven reasons:

- Limiting the large number of meter reading visits per year.
- Reducing bad debts.
- Provision of good statistic information that will be helpful to both customers and utilities companies.

In carrying out cost analysis one will look into the costs of purchasing, installing and operating the meters as well as managing the entire communication system. Whatever the outcome of the analysis it's obvious that the range of benefits from adopting the Smart metering technology clearly outweighs the cost. Some of these benefits can be categories as follows [5]:

- **System benefits**: efficiency gains resulting from consumer responding to price signals provided by the Smart meter;
- **Customer benefits:** efficiency gains from demand response, increased competition and other services, security of supply;
- **Network and metering operational savings**: efficiency gains in the operation and development of distribution networks and metering systems;
- **Retailer opportunities**: efficiency gains in the retailing business.

REFERENCES

NERC Electricity industry 3 rd Quarter Reports. Available: http://www.nercng.org/docs/scorcard.htm .

Smart Meter, Notes from Wikipedia. Available: http://en.wikipedia.org/wiki/Smart_meter.htm

Aoife, Tooraj and Micheal (2009). Smart Metering and Electricity Demand: Technology, Economics and International Experience, Cambrigde Working paper in Economics CWPE0905/Electricity Policy Research Group Working paper EPRG 0903.

Gerwen, R.J.F., Jaarsera.S. and Koenis,F., Domme meters worden slim? Kostenbatenanalyse Slimme meetinfrastructuur. Arnhem. 30 augustus 2005.

Get Smart: Bringing meters in to the 21 st Century, EnergyWatch, August 2005..

Zhang, Tao and Nutall, William(2007). An Agent Based Simulation of Smart Metering technology Adoption.Cambrigde Working paper in Economics CWPE0760/Electricity Policy Research Group Working paper EPRG 0727.

Vasey, G.(2007) "Smart Metering Requires SMART Technology", Issue Alert(European Edition). Available:

OPTIMAL LOCATION OF FACTS DEVICES IN POWER SYSTEM NETWORK USING PARTICLE SWARM OPTIMIZATION

Y. S. Haruna, U. O. Aliyu, G. A. Bakare and T. S. G. Wudil*
Electrical/Electronics Engineering Programme, A. T. B. U., Bauchi, Nigeria and
**Nigerian Electricity Regulatory Commission, Abuja, Nigeria*
yhshuaibu@yahoo.ca ,uoaliyu@yahoo.com, bakare_03@yahoo.com and twudil@ieee.org

ABSTRACT
A modern power system typically comprises of several generators, transformers, transmission lines, switch gears, active and reactive compensators interconnected with loads. In order to ensure security, generation infrastructures has to be improved, this require considerable investment and sometimes takes long time to implement. In recent years, the introduction of Flexible AC Transmission System (FACTS) devices in to the system has led to the reduction of power flow in heavily loaded lines, thereby resulting in an increased loadability, reduction in the power losses, as well as improvement in stability and the voltage profile of the system. In this paper, an algorithm for the optimal allocation of FACTS devices based on Particle Swarm Optimization (PSO) for loss minimization and voltage profile improvement is presented. Herein, for the selected FACTS devices, their location, type and their value are considered and modeled for the steady state studies using modified Matpower software in the MATLAB environment. The proposed algorithm has been tested on a standard Institute of Electrical and Electronics Engineers (IEEE) 14 bus system. Simulation results revealed that significant percentage power loss reductions are obtained for the network different loading scenarios. It is also established that system voltage profile was improved appreciably with the incorporation of FACTS devices in to the case study system.
Keywords- PSO, FACTS Devices, Optimal Location and Nigerian Grid System.

I. INTRODUCTION

The power system is an interconnection of generating units to load centers through high voltage electric transmission lines. It can be divided into three subsystems: generation, transmission and distribution systems. Electric power demand continues to grow and also building of the new generating units and transmission circuits is becoming more difficult because of economic and environmental reasons. Therefore, power utilities are forced to rely on utilization of existing generating units and to load existing transmission lines close to their thermal limits. However, stability has to be maintained at all times. Nigeria had nine (9), sixteen (16) and twenty (20) total system collapses in 2007, 2008 and 2009 respectively. These problems of the Nigerian grid system arise not only due to generation deficiencies alone, but also inadequate transmission and distribution facilities. In some parts of the network, the bus voltage limits are violated. It has continue to suffer due to the numerous system collapses.

In order to ensure the system reliability and security, generation infrastructures have to be improved which require considerable investment and sometimes takes long time to implement. In recent years, the introduction of Flexible AC Transmission System (FACTS) devices into the power system has led to reduction of power flow in heavily loaded lines, thereby resulting in an increased loadability, reduction in the power losses, as well as improvement in stability and the voltage profile of the system. The placement of these emerging FACTS devices in suitable location is central to controlling line flow and maintaining bus voltages at desired level so as to achieve improvement in power system security and reliability [1].

In the late 1980's, the development of the semiconductor technology by the Electric Power Research Institute (EPRI) has led to the use of power electronics in electric power devices, particularly in Flexible AC Transmission Systems (FACTS) devices [2]. FACTS devices can be utilized to control power flow and enhance s ystem

OPTIMAL LOCATION OF FACTS DEVICES IN POWER SYSTEM NETWORK USING PARTICLE SWARM OPTIMIZATION

Y. S. Haruna, U. O. Aliyu, G. A. Bakare and T. S. G. Wudil*
Electrical/Electronics Engineering Programme, A. T. B. U., Bauchi, Nigeria and
**Nigerian Electricity Regulatory Commission, Abuja, Nigeria*
yhshuaibu@yahoo.ca ,uoaliyu@yahoo.com, bakare_03@yahoo.com and twudil@ieee.org

ABSTRACT
A modern power system typically comprises of several generators, transformers, transmission lines, switch gears, active and reactive compensators interconnected with loads. In order to ensure security, generation infrastructures has to be improved, this require considerable investment and sometimes takes long time to implement. In recent years, the introduction of Flexible AC Transmission System (FACTS) devices in to the system has led to the reduction of power flow in heavily loaded lines, thereby resulting in an increased loadability, reduction in the power losses, as well as improvement in stability and the voltage profile of the system. In this paper, an algorithm for the optimal allocation of FACTS devices based on Particle Swarm Optimization (PSO) for loss minimization and voltage profile improvement is presented. Herein, for the selected FACTS devices, their location, type and their value are considered and modeled for the steady state studies using modified Matpower software in the MATLAB environment. The proposed algorithm has been tested on a standard Institute of Electrical and Electronics Engineers (IEEE) 14 bus system. Simulation results revealed that significant percentage power loss reductions are obtained for the network different loading scenarios. It is also established that system voltage profile was improved appreciably with the incorporation of FACTS devices in to the case study system.
Keywords- PSO, FACTS Devices, Optimal Location and Nigerian Grid System.

I. INTRODUCTION

The power system is an interconnection of generating units to load centers through high voltage electric transmission lines. It can be divided into three subsystems: generation, transmission and distribution systems. Electric power demand continues to grow and also building of the new generating units and transmission circuits is becoming more difficult because of economic and environmental reasons. Therefore, power utilities are forced to rely on utilization of existing generating units and to load existing transmission lines close to their thermal limits. However, stability has to be maintained at all times. Nigeria had nine (9), sixteen (16) and twenty (20) total system collapses in 2007, 2008 and 2009 respectively. These problems of the Nigerian grid system arise not only due to generation deficiencies alone, but also inadequate transmission and distribution facilities. In some parts of the network, the bus voltage limits are violated. It has continue to suffer due to the numerous system collapses.

In order to ensure the system reliability and security, generation infrastructures have to be improved which require considerable investment and sometimes takes long time to implement. In recent years, the introduction of Flexible AC Transmission System (FACTS) devices into the power system has led to reduction of power flow in heavily loaded lines, thereby resulting in an increased loadability, reduction in the power losses, as well as improvement in stability and the voltage profile of the system. The placement of these emerging FACTS devices in suitable location is central to controlling line flow and maintaining bus voltages at desired level so as to achieve improvement in power system security and reliability [1].

In the late 1980's, the development of the semiconductor technology by the Electric Power Research Institute (EPRI) has led to the use of power electronics in electric power devices, particularly in Flexible AC Transmission Systems (FACTS) devices [2]. FACTS devices can be utilized to control power flow and enhance s ystem

stability. A better utilization of the existing power systems to increase their capacities and controllability by installing FACTS devices becomes imperative. Other benefits of FACTS devices are summarized in [3] and [4]. In general, FACTS devices can be connected in series, shunt or combination of series and shunt [5] and [6].

The main aim of this paper is to optimally locate the selected FACTS devices in an interconnected network so as to minimze the power losses and improve the voltage profile . The FACTS devices considered in this paper are Static Var Compensator (SVC), Thyristor Controlled Series Capacitor (TCSC) and Unified Power Flow Controller (UPFC) which are located optimally in order to control the power flows in the power system network. Particle Swarm Optimisation was used for the analysis which is explained in [6]; [7]; [8]; [9]; [10]; and [11].

A number of papers have been published proposing FACTS devices to be used for regulating power flow and for enhancing power system stability [3]; [4] and [5]. In particular, various methods on how to modeled and optimally locate FACTS devices had been proposed [5]; [6]; [8]; [9]; and [10] .

II. Problem Formulation

The optimal choice and location of FACTS devices so as to increase loadability and improve the voltage profile seeks to minimize power loss while keeping the voltage levels within an acceptable limit. This can be mathematically formulated as:

$$\text{Min } P_{loss}(X,U) \quad (1)$$

$$\text{Subject to } G(X,U) = 0 \quad (2)$$

$$H(X,U) - \sigma \quad (3)$$

Where is in real power losses in the j , *n* is the number of transmission lines, *X* is the vector of dependent variables comprises of load bus voltages V_L, generator reactive power outputs Q_g. *U* is the vector of control variables comprising of generator voltages V_g and FACTS devices. G(X, U) = 0 is a typical power flow equation. This is solved using a modified version of the MATLAB power simulation package, Matpower 2.0 [13].

I. Realiazation Of PSO-Based Tool

In PSO, each individual in the swarm flies in the search space with a velocity which is far: This value is called the *pbest* Another best value that is tracked by the global version of the particle swarm optimizer is the overall best value, and its location, obtained so far by any particle in the population. This is called the *gbest* The basic concept of PSO technique lies in accelerating each particle towards its *pbest* and *gbest* locations at each time step. The computational steps of the PSO based tool are:

Step 1: Read the relevant PSO parameters. Also the relevant power system data for computational process are actualized from the data files. Run the power flow to obtain the initial power loss and voltage profiles.

Step 2: Initial swarm of particles with random positions corresponding to location, type and value of the FACTS devices and velocities are randomly generated. Each candidate solution should be within the feasible decision variable space.

Step 3: For each individual comprising the population, with the FACTS devices lo cated and appropriate values set, solve the power flow equation using Newton Raphson to obtain power loss and voltage profiles. Compute the fitness value of the initial particles in the swarm using:

Where is the penalty factor and

$$f_{obj} = P_{loss} + \lambda_v \sum_{j=1}^{n} \left(V_i - V^{\lim}\right)^2 \quad (4)$$

λ_v

Set the initial *gbest* to current position f each particle and the initial best evaluated value among the swarm is set to *gbest*.

Step 4: Increase the generation number.

Step 5: Update the velocities and positions according to (6) and (7):

Where; rand, $rand_1$ and $rand_2$: the uniformly random numbers between 0 and 1.

v_{ij}^{k+1}: current velocity of individual i at iteration k. (6)
v^{k+1}: modified velocity of individual i at iteration k.
$x_{ij}^{(k+1)}$: current position of individual i at iteration k.
$pbest_i$: pbest of individual i; $gbest$ gbest of the group.
c_1 and c_2 : cognition constant and social constant respectively.
w^k: inertia weight factor obtain from (8).

Where; $iter^{max}$: maximum number of iteration;
$iter$: current iteration number;
w^{max} : maximum inertia weight;
w^{min} : minimum inertia weight;

$$w^k = w^{\max} - \frac{w^{\max} - w^{\min}}{iter^{\max}} * iter \quad (8)$$

Step 6: Compute the fitness value of the new particles in the swarm using (4). Update the *pbest* with the new positions if the particle present fitness is better than the previous ones. Also update the *gbest* with the best particle in the swarm.

Step 7: Repeat steps 3 to 5 until the preset convergence criterion: maximum number of generations is achieved.

Step 8: The parameters of the *gbest* at the end of the run are returned as the desired optimum location and sizing of the FACTS devices. Solve the final power flow equation using Newton Raphson to obtain the power loss, voltage profile and sum square of error (SSE) using:

$$SSE = \sum_{i=1}^{n} (V_i^{sp} - V_i)^2 \quad (9)$$

The PSO parameter settings used are as shown in Table 1.

Table 1: Optimal Parameter Settings for PSO
Maximum generation, $iter^{max}$: 100
Particle Size, np: 20
Penalty factors : 7
Cognition constant c_1: 2
Social constant c_2: 2
Maximum inertia weight, w^{max}: 0.9
Minimum inertia weight w^{min}: 0.2
Maximum velocity v^{max} resolution N: 6

I. Simulation Results And Discussion

Optimizations were carried out with a tool developed using a modified version of the MATLAB power simulation package, Matpower 2.0. Simulation studies were carried out on IEEE 14 bus test system.

A. CASE STUDY: IEEE 14 Bus Test Network

In order to verify the effectiveness of the proposed method, the modified IEEE 14 bus test system whose data obtained from [12] was used. The summary of the simulations results obtained are shown in Tables 2 - 7;

Table 2: Simulation Results Considering Single FACTS Device

FACTS Device	SVC	TCSC	UPFC
Location	Bus 5	Line 1	Line5 & 8
Value	-27.932 Mvar	0.2 p u	-180°& -180°
Initial Power Loss (MW)	34.232	34.232	34.232
Final Power Loss (MW)	13.313	13.295	13.393
Loss Reduction (%)	61.109	61.162	60.875
Sum Square Error without FACTS Device (pu)	0.1193	0.1193	0.1193
Sum Square Error with FACTS Device (pu)	0.0397	0.0390	0.0397
Generation to convergence	18	20	10

Table 3: Simulation Results Considering SVC and TCSC

FACTS Device	**SVC**	**TCSC**
Location	-	Line 4
Value	-	0.2 p u
Initial Power Loss (MW)	34.232	
Final Power Loss (MW)	13.253	
Loss Reduction (%)	61.285	
Sum Square Error without FACTS Device (pu)	0.1193	
Sum Square Error with FACTS Device(pu)	0.0390	
Generation to convergence	7	

Table 4: Simulation Results Considering SVC and UPFC

FACTS Device	**SVC**	**UPFC**
Location	-	Line 4, 5 & 7
Value	-	-180°, -180° & -180°
Initial Power Loss (MW)	34.232	
Final Power Loss (MW)	13.295	
Loss Reduction (%)	61.162	
Sum Square Error without FACTS Device (pu)	0.1193	
Sum Square Error with FACTS Device(pu)	0.0390	

Table 5: Simulation Results Considering TCSC and UPFC

FACTS Device	**TCSC**	**UPFC**
Location	Line 2 and 14	-
Value	-0.12pu & -0.233pu	-
Initial Power Loss (MW)	34.232	
Final Power Loss (MW)	13.289	
Loss Reduction (%)	61.179	
Sum Square Error without FACTS Device (pu)	0.1193	
Sum Square Error with FACTS Device(pu)	0.0403	
Generation to convergence	45	

Table 6: Simulation Results considering all FACTS Devices

FACTS Device	**SVC**	**TCSC**	**UPFC**
Location	-	Line 4	Lines 8 & 11
Value	-	0.2p u	-180° & -180°
Initial Power Loss (MW)	34.232		
Final Power Loss (MW)	13.329		
Loss Reduction (%)	61.062		

From Table 2, it can be seen that TCSC has the highest percentage power loss reduction of 61.162% followed by SVC and UPFC. Likewise the real power loss, TCSC has the least of 13.295MW; while UPFC and SVC has higher real power loss has 13.313MW and 13.393MW respectively. For the voltage improvement, SVC and UPFC has equal capability to with sum square error (SSE) of 0.0397 higher than that of TCSC.

Tables 3 to 5 depict the simulation results when considering two FACTS devices optimally located in the network. SVC and TCSC as a group has the highest percentage of real power loss reduction of 61.285%, followed by TCSC and UPFC, and lastly SVC and UPFC with 61.162% and 60.875% respectively. For the real power loss, SVC and UPFC has the highest value of 13.395MW, followed by SVC and TCSC, and TCSC and UPFC with 13.253MW and 13.289MW. For the voltage improvement, SVC and TCSC, and SVC and UPFC has the same SSE of 0.039, whilst TCSC and UPFC has 0.0403.

In Table 6, all the three selected FACT S devices were optimally located in the network and the overall percentage loss reduction is 61.062% and the SSE is 0.0390. This result is similar to the one obtained when SVC and UPFC as a group, and when SVC and TCSC are located seperately in the network. From figures 7 to 9, UPFC appeared to have undergone few generations (less than 10) to reach the final real power loss. SVC and TCSC on the other hand reached the final real power loss within the first 20 generations. The overall average percentage loss reduction is 61.119%, the average power loss 13.31MW and the average SSE is 0.0393.

A sample of the graph of the voltage profile improvement considering all the three FACTS devices optimally located in to the network is as shown in Fig. 1. The corresponding plot of real power loss in pu against the number of generations is shown in Fig. 2.

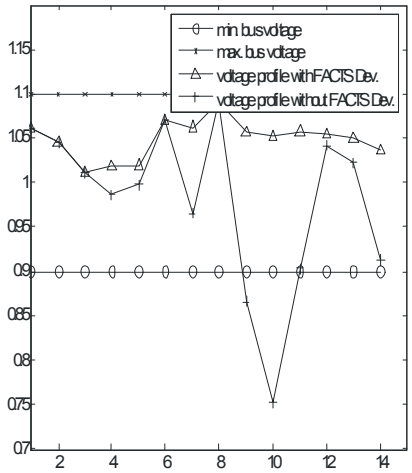


Fig.1: Voltage profiles improvement with all the devices

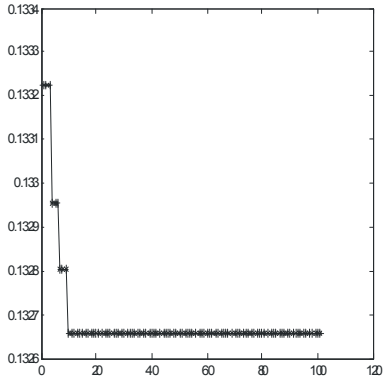


Fig. 2: Convergence characteristics

V. Summary And Conclusions

In this paper a tool for the optimal allocation of FACTS devices for real power loss minimization and voltage profile improvement is presented. The feasibility and effectiveness of the proposed tool were demonstrated on the IEEE 14 bus test system. The average percentage power loss reduction for the IEEE 14 bus test system is 61.12%, and the average real power loss is 13.31MW. Also, the average SSE is 0.0393. The optimal location of FACTS devices greatly

improves the voltage profile of the network. To reduce the computational time of the algorithm, a small population based PSO is proposed. This method will be applied to the Nigerian Grid System with possible loss reduction of about 7%. This will be pursued in our next research thrust.

REFERENCES

Mechenbier, J., Ellis, A., Curtner, R. and Ranade, S. (2004). Design of an Under Voltage Load Shedding Scheme. IEEE Publication.

Gerbex, S., Cherkaoui, R. & Germond, A. J.(2001). *"Optimal Location of Multi-Type FACTS Devices in a Power System by Means of Genetic Algorithms"*. IEEE Transactions on Power Systems, Vol.16, No.3, pp 537-544.

Paserba, J. J. (2004). How FACTS Controllers Benefit AC Transmission Systems, IEEE Power Engineering Society Meeting.

Mubeen, S. E., Nema, R. K. &Agnihotri, G.(2008). *"Power Flow Control with UPFC in Power Transmission System"*. Proceedings of World Academy of Science, Engineering and Technology. Vol. 30.

Cai, L. J. (2004). "Robust Coordinated Control of FACTS Devices in Large Power Systems". Ph. D. Dissertation, University Duisburg-Essen Germany. Verlag Berlin.

Cai, L. J. & Erlich, I.(2004). *"Optimal Choice and Allocation of FACTS Devices Using Genrtic Algorithms"*. IEEE Power Engineering Society Meetin g.

Baskaran, J., & Palanisamy, V. (2005). *"Genetic Algorithm Applied to Optimal Location of FACTS Devices in a Power System Network Considering Economic Saving Cost"*. Academic Open Internet Journal, Vol. 15.

Hernandez, J. C., Valle, Y. D., Venayagamoorthy, G. K. & Harley, R. G. (2006). "*Optimal Allocation of a STATCOM in a 45 bus Section of the Brazilian Power System Using PSO".* IEEE Transactions on Power Systems.

Radu, D. & Besanger, Y. (2006). " *A Multi-Objective Genetic Algorithm Approach to Optimal Allocation of Multi-Type FACTS Devices for Power Systems Security*". IEEE Power Engineering Society Meeting.

Ali, T. A., Abdel-Magid, Y. L. & Abido, M. A. (2007). *"A Particle-Swarm-Based Approach of Power System Stability Enhancement with Unified Power Flow Controller"*. Science Direct, Electric Power and Energy Systems, Vol. 29, pp 251-259. Retrieved from www.sciencedirect.com .

Bakare, G. A. & Kunduli, M. (2008). " *Application of Meta-Heuristic Techniques to Power System Optimization Problems"*, National Engineering and Technology Conference ABU Zaria.

L'Abbate, A., Trovati, M., Becker, C. & Handschin, E.(2002). "Advanced Steady-State Models of UPFC for Power System Studies". IEEE Publications, pp 449-454.

Zimmermann, R. D., Zurillo-Sanchez, C. E., & Gan, D. (2005). "MATLAB Power System Simulation Package", Version 3.0.0.

PREDICTABLE POWER SUPPLY: A SMART TRANSITORY OPTION FOR NIGERIA'S ELECTRICITY SUPPLY

Ikechukwu Nwosu
Electrical Maintenance Engineer
Shell Petroleum Development Company of Nigeria, Warri, Nigeria.
Ikejnwosu@ieee.org

ABSTRACT
Nigeria's epileptic electricity supply problem is well written of and spoken of all over the world. Many solutions have been proffered both in formal and informal settings. Yet, despite efforts by governments at both state and federal levels in this last 10 years, the situation is still very appalling. It is now clear that there is no quick-fix panacea for the problem such as just buying new transformers or just building new power plants. The entire system - generation, transmission and distribution- needs to be worked on. And this requires lots of resources, including time. The time it will take to achieve reliable uninterrupted power supply is not known, but without wastages due to incompetence and/or corruption, the most optimistic time it will take from the time a clear plan and commitment is made is 24months. During this incubation period, a possible sedative option is to adopt the Predictable Power Supply strategy, which is achievable in less than 6 months. It is "non-epileptic" and will significantly reduce the cost due to lack of reliable energy since consumers can plan to make best use of the period of power supply. And since it is SMART, it will make it easier for Nigerians to track progress made towards Reliable Uninterruptible Power Supply.

Keywords: Predictable Power Supply, Smart transitory, Uninterruptible

I. Introduction

Nigeria is estimated to have about 150million people [1]. However, only about 40% of the population is estimated to have access to electricity. And although 70% of the population is believed to be living in the rural areas, accessibility to electricity drops to 15% in these rural areas [2]. This means that majority of Nigerians currently do not have access to public electricity.

Despite the lack of access to electricity for majority of Nigerians, those who have access receive very epileptic power supply. The lack of certainty about when power will be available makes planning impossible. Even when public electricity is available, it may be almost unusable as the voltage may be outside the nominal 220 to 240V phase to neutral and 380 415V phase to phase voltages. Many companies have thus had to switch to much more expensive private generators and those who cannot afford to do so have closed shop.

Worse still, the country's population is increasing and there is an increase in rural-urban migration with an increase in the number of people with access to electricity. Also, the power outages have led to reduced productivity and economic loss to the country. An estimate by The Council for Renewable Energy in Nigeria (CREN) puts the loss due to power outages at about 126 billion naira (US$984.38 million) annually to the country [3].

Currently, several Nigerians are calling for a "State of Emergency" to be declared on Electricity. Although there are different perceptions of what that entails, this calls show how deep the frustrations are getting. Predictable Power Supply can help reduce the frustrations by providing reliable power. And since it is SMART (Specific, Measurable, Achievable, Realistic and Time-bound), it can be used to track progress of the country towards Reliable Uninterrupted Power Supply.

II. Definition Of Terms

Reliability, according to BS EN 13306, is the ability of an item to perform a required function under given conditions for a given time interval. Consequently, for a system to reliable, it should fulfill two conditions:

1. It should function within specifications. For example, public supply in Nigeria is specified to be 220-240V phase to neutral, 50Hz frequency. Any supply outside this range is not reliable.
2. It should function within the expected time interval. Thus, if it is expected for power to be available from 6am to 6pm, for it to be reliable, it must be available throughout the designated period.

Hence, **Reliable Power Supply** means power supply that meets the power supply specifications within the designated interval of avai lability. If Power supply is available 24/7, 356 days a year, except for planned downtime (and very occasional "acts of God"), then it is **Uninterrupted Power Supply.** Uninterrupted Power Supply may or may not reliable. For uninterrupted power to be reliable, it must be within the specification. For instance, if power supply to a single phase consumer in Nigeria is available 24/7 but is not within the specified 220 240V voltage range, then it is not reliable. But if it is within 220-240V, then it is **Reliable Uninterrupted Power Supply**.

Predictable Power Supply is a form of Reliabl e Power Supply in which the designated period of supply may not be 24/7, 365days a year. For example, if the electricity distributor communicates to a single phase consumer in an area that power will be available from 7pm to 9am every week day and the distributor succeeds in supplying 220-240V throughout this specified period, then the supply is predictable power supply. If power is still supplied beyond the designated period, it is a welcomed plus but the key thing is that power must be availab le throughout the designated period and meet the prescribed specifications.

III. The Bitter Truths About Nigeria's Current Electricity Supply

A. Current Power Generation is grossly inadequate

Nigeria's power generation has been between 2500MW and 4000MW within the last 10years. Using the generation of 4000MW and assuming that a lower population estimate of 80 million, the per capita power generated is a meager 50W. Using the scenario that only the estimated 40% that currently have access to electricity need to be catered for, the per capita power generated is just 125W. And this is far less than what is generated by the 750VA generator popularly known as "I better pass my neighbor".

Therefore, current power generation is grossly inadequate for Reliable Uninterrupted Power Supply in Nigeria. Even the much touted 6000MW generation translates to 188.5W per capita using the same best case scenario of only catering for 40% of an 80 million population.

B. Current transmission capacity may not be adequate for Reliable Uninterrupted Power Supply.

Transmission is arguably the most forgotten component of public power supply in Nigeria. This is probably becaus e the transmission lines have not been as troublesome as the generating stations or the distribution networks. But then with the anticipated increase in power generation, there is need to ensure the capacity of the transmission lines is adequate to handle the generated power reliably and without causing congestion. Because, electrical power supply is a supply chain whose capacity is the capacity of the link in the chain that has the least capacity.

There are 2 main concerns about the current transmission lines. First, even though the transmission grid has handled 4,000MW, it may not be able to reliably handle 6,000 - 10,000MW. Secondly and most importantly, there are concerns over the current grid design, which appears to be inefficient and does not have redundancies to carter for failures of primary links. For example, according to C. O. Ahiakwo, "Rivers State gets its electricity supply from Ala-Oji Aba (National grid) to Port Harcourt. But recall that Afam Station located in Rivers State generates electricity and supply it to the National grid (Aba), which is then transmitted back to Rivers State. The question is why not Afam direct to cities in Rivers State"? [4]. By inference, if there is a failure in the link between Aba and Port Harcourt, then Port Harcourt will be without electricity till the fault is rectified.

For reliable power supply, transmission grids must be able to carter for all the power generated and there should be some form of redundancy that ensures that failure of primary transmission links does not equate to black-out in the supplied areas.

C. The Distribution Network cannot sustain any

form of Reliable Power Supply

Nigeria's distribution network can be described to be shambolic. Wires are untidily flying from the electric poles to the final consumer, transformer yards are bushy and unkempt and the fuses in feeder pillars are in some cases replaced by solid metallic bars. Lots of arching occurs in transformers and feeder pillars without being attended to and the distribution sub-stations have very old and dysfunctional switchgears. The result is that in many areas, it is common to have fluctuating voltage outside the specified voltage and frequency range.

There is no way power can be reliable with the current condition of distribution networks across the nation. The distribution networks need professional rehabilitation to ensure they work efficiently.

D. The tarriff structure and methods employed are also a big part of the problem.

Electricity metering is a big issue in Nigeria. For the utility company, costumers keep trying to evade tariffs by by-passing meters or tampering with meters or by refusing to pay their bills. For many of their customers, the utility company is charging fictitious bills as there are cases where power is not supplied and yet customers are charged. This occurs because the utility company often uses estimation instead of meter reading in charging customers. In most cases, this estimation can technically be regarded as "extortion" as the amount cannot be justified if the period of availability of power is taken to account.

The use of pre-paid meters has significantly reduced the extortive nature of estimation. However, so many consumers are still using post-paid meters. Also, pre-paid meters do not guarantee that customers will not by-pass meters. The utility company needs to find a way to properly secure the connections to their meters to reduce the possibility of tariff evasion. They can also employ smart metering to face this menace.

But until the metering issue is resolved, it will be difficult to set up a tariff structure that is fair to both consumer and power distributor. And until such a tariff structure is put in place, the power supply system in Nigeria will remain inefficient.

E. Reliable Uninterruptable Power Supply is not likely to be achieved within the next 2 years.

With all these problems with power supply in Nigeria, it does not look feasible that Reliable Uninterrupted Power Supply can be achieved within the next 2 years for those who currently have access to electricity. Universal Reliable Uninterrupted Power Supply will take much longer. This is building new power plants and transmission lines are both cost and time intensive.

For instance, the shortest time it takes to build a combustion turbine generating station is about 18 months. While for the less maintenance prone steam turbines, it takes three to five years [5]. Then, building a generating station requires Front-End Engineering and Design for the station and building infrastructure for tying the power to existing grid. It also requires sourcing for fuel, securing fuel supply agreements and building infrastructure for fuel supply. And since the materials required for these infrastructures are not made in Nigeria or anywhere in Africa, there will be delays due to importation of materials. Therefore, the 2 years timeline is extremely optimistic. Likewise, the work required in transmission and distribution will also take a lot of time.

And of course, all these have to be funded. And the more expediently the tasks are carried out, the more funds will be required.

F. Privatisation and Deregulation are not short term solutions to the power problem.

Some have called for either the privatization or deregulation of the Nigeria's power supply system. The belief is that privatization will bring in the efficiency inherent in the private sector while deregulation will bring about competition. Some have also cited the successes of deregulation in the telecoms and banking sectors [6].

Although deregulation or even privatization of the electricity supply sector may or may not work on the long run, currently, it is not the immediate solution to Nigeria epileptic power supply. This is because private sector efficiency comes with true competition. Monopolies and manipulated markets do not usually lead to efficiency. For deregulation and privatization to work in any sector, the market should be such that true competition is possible.

Looking at the Nigerian telecoms sector, when GSM debuted, the prices were extremely high. But by May 2004, prices dropped significantly when

new entrants Globacom, keen on having a foothold in the market, brought competition to the market. Currently, prices have stabilized. But with the profits the companies recently declared for 2009, it can be inferred that the prices are still relatively high not only because of they have to foot the bill of using diesel to generate their electricity, but also because the participants are now comfortable with their market share and so true competition no longer exists.

Currently, people complain th at the GSM networks are relatively unreliable as the number of dropped calls remains high. That means that privatization and deregulation has not translated to reliability. And unlike in telecoms where the "busy" ring tone may be tolerable, in electricity market, a single fluctuation event could lead to collapse of the network and to huge economic losses as critical loads such as hospital equipments and industrial loads could fail.

If this can happen in telecoms, then for electricity, it will lik ely be worse. This is because electricity has many of the elements of a "natural monopoly". There are no good substitutes, it is difficult to store, one provider can efficiently distribute it, market entry barriers are high, and hence demand does not respond to price increase in the same way as many other commodities.

For instance, as noted by Theo MacGregor in an IEEE Spectrum article, " *In Britain, as in California and everywhere else market pricing of electricity has been tried, theory is bumping up against reality. In Rio de Janeiro, Brazil, for example, prices following privatization shot up 400 percent, 40 percent of electricity workers lost their jobs, and the lights went out'*[7]. Another example is that in the USA, only 22 out of the 50 states have adopted deregulation and handing over the electricity market to private hands. As of January 2010, eight of these states have suspended deregulation activities. [8]

Therefore, if Nigeria desires Reliable Power Supply, deregulation and privatization in the present situation will not achieve it.

IV. Suggestions On Predictable Power Supply Implementation In Nigeria

A. Set up Quarterly Electricity Schedules

The utility supplier should every quarter, prepare supply schedules for their customers based on expected generation, scheduled maintenance and class of customer. This schedule must be communicated directly to the customers and also available on the internet for all to see.

For instance, electricity schedule for January 2011 can be prepared by November 2010. Since it is known that it will be dry season in Q1 of 2011 in Niger State and so it is likely that the dams will have low water level and th is should be factored into the schedule. This provisional schedule can be distributed to customers via internet and by hand delivery for customers to comment prior to finalization. By first week of December, a final schedule can be prepared and then distributed.

Thus, an entrepreneur that owns a factory can use this schedule to optimize his or her energy means. If the entrepreneur notices that public supply will be available only at night, then the factory may decide to operate night shifts only.

B. Consumer Classification

For an efficient power supply schedule, there is need to classify consumers based on load characteristics and need. Different types of customers have different periods when they most need electricity supply. For example, residential consumers are likely going to need electricity at night, in the early hours of the day and at weekends. Industrial consumers will tend to need electricity during the day of weekdays. Some consumers like hospitals and heavy industries will need electricity throughout .

Classification will make it easier to decide how much time electricity will be supplied to a consumer. Of course, since power is not enough to go round 24/7, no consumer will have Uninterruptable Power Supply.

Another advantage of classification is that it could improve pricing efficiency. For instance, those who are giving higher priority in the scheduling could be made to pay more for electricity to whom much is given, much is expected.

C. Refurbishment of Distribution Networks

Nigeria's current distribution network cannot sustain *reliable* p ower. Even the utility company prepares schedules and keeps to them, the network cannot ensure that the supplied power

will be within the specified 220-240V for single phase customers not to mention 380-415V for three phase customers.

Many distribution substations require major rehabilitation switchgears, transformers and feeder pillars need upgrading, those that do not require upgrading need major maintenance such as changing transformer oils, busbar maintenance and feed pillar refurbishment.

To a large extent, the time it takes to get the distribution network fixed will determine how quickly Predictable Power Supply can be achievable, since it is the most time consuming part of the requirements for achieving Predictable Power Supply.

D. Other suggestions

- Personnel of the supplying company should be trained or retrained as applicable. Measures have to be in place to ensure professionalism. Without personnel acting professionally, Predictable Power Supply will remain a mirage.
- Electricity supplying company should pay compensation to customers whenever they deviate from the announced schedule to the detriment of the consumer. This does not need to be cash but can be converted to kilowatt-hours and included in the bills. This will likely deter them from deviating from the schedule.
- All non-industrial customers should be provided with pre-paid meters. Since meters belong to the supplying companies, they should directly bear the cost of installation and maintenance of the meter.
- Installation of meters should only be by trained personnel of the supplying company. The company should also provide all necessary accessories like cables from pole to the meter. Cables between pole and meter should not be joined anywhere in between while meters should be locked with tamper proof protection. However, provisions should be made for safe private installation of private generators, inverters, UPS and other consumer devices.
- Once predictable power is achieved, it will be easier to detect electricity theft. Stiffer penalties should be imposed by law on those who steal electricity by bypassing or tampering with meters.
- For Predictable Power Supply to be sustained, the performance of the entire electricity supply chain should be monitored and disseminated. This will help measure how far away the country is from the ultimate goal of reliable uninterrupted power supply.
- Nigerians need to be wary of complacency towards the drive for reliable uninterrupted power supply when Predictive Power Supply is achieved. The main objectives of Predictive Power Supply are to allow for consumer to plan their activities and to se rve as a fore-runner for Reliable Uninterrupted Power Supply.

V. Potential Challenges In Implementation Of Predictive Power Supply

A. Public acceptance

It is human to desire for the best. Nigerians desire and deserve reliable uninterrupted power supply. Therefore, they may not be keen on accepting any sedative alternative.

However, Predictable Power Supply is not an alternative to Reliable Uninterrupted Power Supply. Rather it is a fore-runner. It will allow the supplying company to practice supplying reliable power. It will allow consumers to plan efficiently. As one entrepreneur noted about epileptic power supply, "The worst part is not knowing when the blackouts will hit. When you least expect it, everything comes to a standstill". [9]

Thus, consumers are likely going to accept Predictable Power Supply once they start reaping the benefits. Especially because it is much better than the current epileptic and unreliable power supply.

B. Classification of Consumers

Often, various classes of users are supplied on the same distribution network especially if they are within the same vicinity. Thus, classificatio n in such circumstances becomes difficult. In Nigeria, this is exacerbated by the relatively unplanned nature of many urban areas, which has led to mingling of residential and industrial areas together.

One solution to this challenge should be to use the original government plan for the town to decide whether an area will be treated as industrial or residential or something in between. In that way Predictable Power Supply will help governments to implement town plans.

C. Training
Since a lot of the concepts involved are new to the executors. There will be need to train Operators, Maintainers, Planners, Managers and all those that will be involved in executing Predictive Power Supply.

D. Funding
All the activities to be carried out towards achieving and sustaining Predictive Power Supply will require funding. However, apart from the schedule preparation, all other activities would still have been done for Reliable Uninterruptable Power Supply. And these activities are not the biggest ticket items in the activities required for Reliable Uninterrupted Power Supply. Therefore, it is much easier to fund Predictive Power Supply than reliable uninterrupted power supply.

VI. Conclusion

Nigeria's current electricity power supply is very epileptic and unreliable. In order to obtain Reliable Uninterrupted Power Supply in the country, there is need to work on several aspects of the power supply chain. These include increasing generation, expanding transmission capacity and rehabilitating distribution networks across the country. Also, there is need to ensure equitable tariff and key to this is to solve the metering challenges in the country.

But all these will take a long time two years at the least. Therefore, within this period, the gulf can be filled using Predictable Power Supply strategy. This involves having publicly declared schedules for power supply and keeping to these schedules. It also involves supplying power within the prescribed voltages and frequency. This will help reduce the losses incurred by individuals, corporate bodies and the country due to epileptic power supply since all can efficiently plan to use power efficiently when available.

Predictable Power Supply is SMART because the goals are specific, measurable, achievable, realistic and time-bound. It does not preclude the quest for reliable uninterrupted power supply. Rather, it is a step away from the ultimate goal of Reliable Uninterrupted Power Supply.

REFERENCES

International Energy Agency (IEA), "Key world energy statistics 2009," http://www.iea.org/Textbase/nppdf/free/2009/key_stats_2009.pdf, p. 51.

A.S. Sambo, "Renewable energy resources in nigeria: the way forward," Renewable Electricity Policy Conference, Abuja, December 2006. Http://www.energy.gov.ng/index.php?option=com_docman&task=doc_view&gid=34

Xinhua News Agency, "Why electricity shortage hangs over nigeria," April 2007 http://china.org.cn/english/international/206687.htm

C. O. Ahiakwo, "Electricity survey of Rivers State", IEEE Nigeria Sectional Technical Meeting, June 2008, http://ewh.ieee.org/r8/nigeria/gold/docs/Electricity%20Survey%20of%20Rivers%20State%20%20-%20Engr%20Dr%20Chris%20Ahiakwo.pdf, p.3

G. Zorpette, "Re-engineering Iraq," IEEE Spectrum, Feb. 2006. Http://spectrum.ieee.org/energy/fossil-fuels/reengineering-iraq/0

O. I. Okoro and E. Chikuni, "Power sector reforms in Nigeria: opportunities and challenges," Journal of Energy in Southern Africa, vol 18, no 3, August 2007 http://www.erc.uct.ac.za/jesa/volume18/18-3jesa-okoro.pdf

T. MacGregor," Electricity restructuring in Britain: not a model to follow," IEEE Spectrum, June 2001. Http://spectrum.ieee.org

US Energy Information Administration,"Status of electricity restructuring by State," January 2010 http://www.eia.doe.gov/cneaf/electricity/page/restructuring/restructure_elect.html,.

I. Madomombe, "Energy key to Africa's prosperity: challenges in West Africa's quest for electricity,"Africa Renewal, vol 18, no 4, January 2005,http://www.un.org/ecosocdev/geninfo/afrec/vol18no4/184electric.htm ,

SHORT-TERM LOAD FORECASTING USING SEASONAL ARTIFICIAL NEURAL NETWORK

Christopher Ahiakwo[1], Anthony Ekedegwa[2] , Sunny Orike[3]
Department of Electrical/Computer Engineering
Rivers State University of Science and Technology
Port Harcourt, Nigeria
[1]chrisahias@yahoo.com, [2]onyeig@yahoo.com, [3]orike.sunny@ust.edu.ng

ABSTRACT:
This paper presents a Seasonal Artificial Neural Network (SANN) approach in forecasting the short-term load for the National Control Centre (NCC) Oshogbo of the Power Holding Company of Nigeria (PHCN) Limited. SANNs are sets of ANNs that are trained with data for particular seasonal and hourly time durations. Unlike the conventional ANN configuration, the networks in SANNs are entirely independent of each other with each network fully dedicated to data on similar features for a specific duration. The proposed SANNs consist of four modules. Each module is assigned to a particular season, and includes three ANNs, each of which is fully dedicated to a particular time period. The time periods include 00:00 08:00, 09:00 15:00, and 16:00 24:00. Three types of variables are used as inputs to the neural networks: (1) time-related input, (2) electric load-related inputs, and (3) national and religious event input. Data from the year 2006 to 2009 were used as test cases. By applying the SANN good results were obtained.

Keywords: Neutral Network, Load to recasting, MLP Network

1. INTRODUCTION

In Nigeria the supply of high quality electric energy to customers in a secure and economic manner has been a Herculean task for the Power Holding Company of Nigeria (PHCN), this is due largely to the many economical and technical problems facing the company especially in operation, planning and control. For the purpose of optimal planning and operation of this large scale power system, modern theories and optimization techniques are being applied with the expectation of considerable cost saving s. In achieving this goal, the knowledge of future power system load is the first prerequisite; therefore, long and short-term load forecasts are very important subjects [1].

Electric load forecasting is an essential procedure for any electric utility. Forecasts of hourly, daily or weekly loads are necessary for scheduling functions, such as transaction evaluation and maintenance, and for network analysis procedures such as dispatcher power flow, optimal power flow, and auxiliary energy analysis. Based on the load forecasts and depending on the operational security objectives of a specific utility, operators would then undertake prevention or corrective actions needed to operate the power system securely and economically [2].

Load forecasting provide the primary and most important steps in power delivery planning, also they are used by energy management systems to establish operational plans for power stations and their generating units. In essence it is an essential part of an efficient power system planning and operation. It is well known that STLF plays an important role in the traditional monopolistic power systems.

In a restructured or deregulated power system, the Independent Power Producer (IPP) would have to forecast the system demand and its corresponding price in order to make an appropriate market decision. The line of demarcation separating the good investment from the investment that is likely to end up as stranded assets rests on the quality of the decision, based on careful analysis of growth patterns. Different forecasting models have been employed in power systems for achieving forecasting accuracy. However, several key issues must be addressed before reliable forecast may be developed. Among them are:
The relevant variables with strong correlation to

the electric loads such as temperature, humidity and winds must be identified.

A reliable feature extraction technique to capture the dominant information related to load patterns and profiles must be developed. Accuracy of the weather forecasting can have great impact on the accuracy of load forecasting.

The forecasting model must be able to extrapolate with reasonable degree of accuracy during unfavourable weather conditions, or pick up loads. The forecasting model must also adapt to the system's thermal inertia. It must also handle load growth.

For the electric utility to be able to supply high quality electric energy to the consumer in a secure and economic manner, the system owner must be able to anticipate the need for power delivery; how much power must be delivered and when, the above key issues play crucial roles in the achievement of the overall objective.

Over the years several methods of load forecasting models has evolved and a lot of them have been well researched and appro priately documented. Some of these load models includes Box-Jenkins, auto-regressive and moving average (ARAMA), expert systems, state-space models using Kalman filters, and artificial neural networks [3][4][5][6][7][8][9].

One of the prominent setbacks of the Box-Jenkins, ARAMA, and the state-space models is that these models cannot adapt easily to rapid changes in load variation pattern. The inability of the adaptive updating procedures to completely eliminate the bias introduced by a large his torical database has often made the adaptive algorithm less fanciful in application in making accurate forecasts. However, adaptive algorithms can update model parameter estimates.

In addition, artificial intelligence-based algorithms have been introduced based on expert system, evolutionary programming, fuzzy system, artificial neural network (ANN), and a combination of these algorithms. The expert systems approach relies on human experience in making accurate forecasts which in turn can be co-o pted into the system. However, it is a common knowledge how very difficult it is to transform human knowledge into a set of mathematical rules. ANN, on the other hand, attempts to extract the implicit nonlinear relationships from historical electric data rather than rely on human experience. Moreover, they can adapt to a changing forecasting environment through self-learning. The forecasting efficient of any ANN strongly depends on the selection of the training data and the network architecture [2].

In this work, we attempt to explore the use of the Seasonal Artificial Neural Network (SANN) approach to forecast the short-term load for the National Control Centre Oshogbo of the Power Holding Company of Nigeria (PHCN) Limited.

II. Artificial Neural Network

The artificial neural network (ANN) refers to a class of models inspired by biological nervous systems. In general, it is a computing system consisting of a number of simple, and highly interconnected processing elements called neurons. The neuron processes information by its dynamic response to external inputs (stimuli). Fig. 1 shows the schematic diagram of a feed forward network.
The elements (neurons) are connected by synaptic weights, which are allowed to adapt through a learning process. Note each neuron can have multiple inputs; while there can be only one

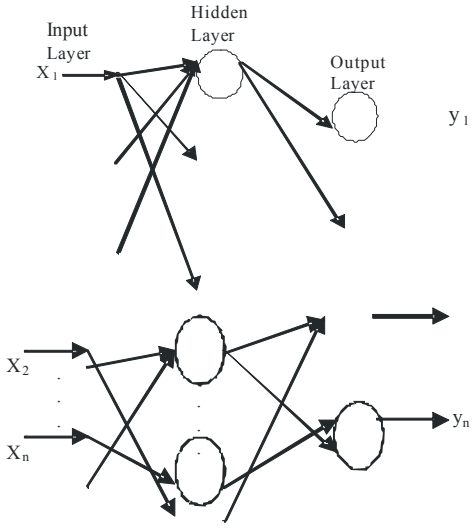


Fig. 1. A Three-layer MLP network

output. Inputs to a neuron could be from external source or could be from output of the other neurons. Neural networks can be interpreted as adaptive machines, which can store knowledge through the learning process. Today, neural networks have applications, for example in pattern recognition, speech recognition, and classification, vision, and control systems.

There are many types of neural network models. The models can be categorized in many ways. One possibility is to classify them on the basi s of the learning principle or algorithm. A neural network uses either supervised or unsupervised learning. In supervised learning, the network is provided with example cases and desired responses (inputs). The network weights are then adapted in order to minimize the difference between network outputs and desired outputs. In unsupervised learning the network is given only input signals, and the network weights changes through a predefined mechanism, which usually group the data into clusters ofsimilar data.

The learning algorithm is a recursive process that adapts the connecting weights the neurons and the offsets (biases) to minimize the square errors between the network outputs and the desired outputs for training. In this paper the learning algorithm proposed as a methodology for electric load forecasting is the back propagation algorithm.

The back propagation algorithm is a generalization of the Widrow-Hoff error correction rule. The original Widrow-Hoff technique formed an error signal, which is the difference between what the output is and what it was supposed to be, i.e., the reference or target output. Synaptic weights, were changed in proportion to the error times the input input signal, which diminishes the error in the direction of the gradient [1].

The most common network type using supervised learning is a feed-forward (signal transfer) network. The network is given an input signal, which is transferred forward through the network. Eventually, an output signal is produced. The network can be understood as a mapping from the input space to the output space, and this mapping is defined by the free parameters of the model, which are the synaptic weights connecting the neurons. The most popular of all neural networks, Multi-Layer Perceptron network (MLP), is of this type.

The attraction of multi-layer perceptron (MLP) has been explained by the ability of the network to learn complex relationships between input and output patterns, which would be difficult to model with conventional algorithmic methods. In the models, inputs to the network are generally present and past load values and outputs are future load values. The network is trained using actual load data from the past.

ANN Configuration

The configuration of the ANN is implemented such that it is consistent with the annual and daily power demand profiles for the years 2006 2009. The annual power demand profile can be subdivided into four main zones. Seasons zones S1, S2, S3, and S4 include power demand for the durations: January 1st March 31st and November 1st December 31st, April 1st April 30th, May 1st September 31st, and October 1st October 31st, respectively.

The daily power demand can also be subdivided into three hourly time zones. Time zones T1, T2, and T3 include the power demand of the hourly time durations: 00:00 08:00, 09:00 15:00, and 16:00 24:00. Within each time zone, the load forecasting is carried out for the day ahead at discrete times. Upon entering a following time zone from a preceding time zone, a different ANN would be in effect. For instance, considering a network that is assigned to T1, the forecasting is discontinuously performed at the hours 00:00, 01:00… 08:00. Then, after the forecasting is completed for the hour 08:00, a different network will be in effect to forecast for the day ahead at the discrete times 09:00, 10:00, and so on.

Having four seasonal zones and three hourly times zones within each season leads to a total of 12 separate time durations. Each data segment associated with the 12 time durations has its own features that distinguish it from the others. A particular MLP ANN is trained with data of particular time duration. The purpose of training a particular ANN with a particular data segment of specific time duration is that the data segment elements share similar features, and thus, the ANN performs better. The overall ANN-based

forecasting system consists of 12 separate MLP ANNs, each of which is assigned to a particular time duration [2].

For the purpose of this work, the load curve to be forecasted consists of hourly load values, which are in reality hourly averages. This means that the load curves can be seen as a time series of real numbers, each being the average load of one hour. Although, the number of observations is restricted to 24 per day, the models studied can be applied with slight modifications to cases w here the interval between observations is shorter. The hourly electric load demand of Power Holding Company of Nigeria (PHCN) is used throughout this work as the test case. The data ranges from January, 2006 to January, 2009.

III Short-Term Load Forecasting (Stlf): Modeling And Procedure

This section discusses the ANN model and the procedure used here for STLF.

Neuron Model

ANNs are made up of a number of simple and highly interconnected Processing Elements (PE), called neurons, as depicted in Fig. 1. Its mathematical model is expressed as:

1

Where:

= output of a neuron;

= transfer function;

= adjustable weight;

= input neuron.

Fig. 2 shows the diagrammatic representation of a typical neuron model.

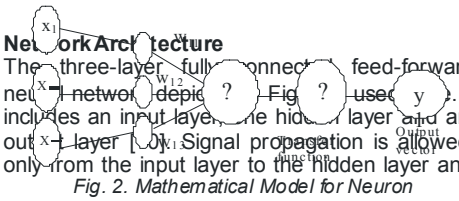


Fig. 2. Mathematical Model for Neuron

Network Architecture

The three-layer fully connected feed-forward network depicted in Fig. ? used. It includes an input layer, one hidden layer and an output layer [ ]. Signal propagation is allowed only from the input layer to the hidden layer and from the hidden layer to the output layer. Input variables come from historical data corresponding to the factors that affect the load. The outputs are the desired forecasting results, which in these case are m = 24, i.e., one for each hour of the day.

The number of input and hidden nodes, transfer functions, scaling schemes, and training methods affect the forecasting performance and hence need to be chosen carefully.

Training

ANN training basically consists of determining the network parameters such as w eights and others that allow achieving the desired objective based on the available training sets. Usually, multi-layer feed-forward neural networks are trained in a supervised manner. Back-propagation is used as the training method here [11], which is an iterative procedure. In each iteration, the back propagation algorithm has three steps:

Forward: The outputs are calculated for given inputs.

Backward: The errors at the output layer are propagated backwards toward the input layer, with the partial derivatives of the performance with respect to the weights and biases calculated in each layer.

Weight adjustment: A multivariate nonlinear numeric optimization algorithm finds the weight that minimizes the error based on the gradient.

Training stops when the performance has been minimized to the goal, the performance gradient falls below a minimum gradient, the maximum number of epochs is reached, or the maximum amount of time has been exceeded. The "generalized delta rule" is suggested by Rumelhart, et al, and gives a recipe for adjusting the weights on internal units based on the error at the output [7]:

Let be the overall measure of the error, where and are the target and actual outputs of the component of the output pattern for input pattern , respectively. The error function used in the back-propagation training process is the sum-squared error and can be written as:

$$E_p = \tfrac{1}{2}\sum (t_{pj} - o_{pj})^2 \qquad 2$$

$$E = \sum_p E_p$$

The network is specified as:

To obtain a rule for adjusting weights, the gradient of with respect to is used and it is represented as follows.

$$E = \tfrac{1}{2}\sum_p \sum_j (t_{pj} - o_{pj})^2 \qquad 3$$

$$o_{pj} = f_j(net_{pj}) \qquad 4$$

Where is defined in two ways. If a unit is an output unit, it is give by:

$$net_{pj} = \sum (w_{jk} o_{pk}) \qquad 5$$

For a unit in an arbitrary hidden layer:

$$\frac{\partial E_p}{\partial w_{jk}} = \delta_{pj} o_{pk} \qquad 6$$

Where is a derivative of.

The learning function used in the training process is a gradient descent with momentum weight/bias function, which allows calculating the weight change for a given neuron. It is expressed as:

$$\delta_{pj} = (t_{pj} - o_{pj}) f_j'(net_{pj}) \qquad 7$$

Where is the previous weight change, is the weight gradient with respect to the performance. is the le arning rate, and is the momentum. Different learning rates and momentum affect the convergence properties.

$$\delta_{pj} = f_j'(net_{pj}) \sum_k \delta_{pk} w_{jk} \qquad 8$$

Testing

In order to be sure of a proper generalization, the network model, like any mathematical model, has to be validated. This is a ste in system identification, which should follow th choosing of the model structure and estimating the parameters. The validation of a neural network model can be carried out on the principle of standard tool in statistics known as cross-validation. This means that a data set, which has not been used in parameter estimation (i.e. training the network), is used for evaluation of the performance of the model.

$$w_{jk}(n+1) = m\,w_{jk}(n) + (1-m)\,l_r\,\delta_{pj} \qquad 9$$

The determining of the model structure consists of selecting the input variables and deciding the network structure. The parameter estimation is carried out by training the network on load data of the history. This requires choices concerning the learning algorithm and appropriate training data. The model validation is carried out by testing on load data, which has not been used in training. However, the modeling with neural networks is different to modeling with linear system models.

FORECASTING PROCEDURE

1. Input Variable Selection

Input variables such as load, day type, temperature, etc of the previous day, and day type, temperature of the forecasting day are initially chosen.

2. Data Pre-processing

Improperly recorded data and observation error are inevitable. Hence, bad and abnormal data are identified and discarded or adjusted using a statistical method to avoid contamination of the model [3].

3. Scaling (Normalization of loads)

Since the variables have very different ranges, the direct use of network data may cause convergence problems. A scaling scheme is used, in this scheme the input and output variables are scaled to be in the [-c, c] range, where c is a positive number. The inputs and outputs in this case are scaled as follows:

Where:

= normalized load at hour on day

= load at hour on day

= valley load of day

= peak load of day

When the load shape has been predicted, the hourly load forecast can e calculated:

$$L_{nor(i,j)} = \frac{L_{(i,j)} - L_{\min(i)}}{L_{\max(i)} - L_{\min(i)}} \qquad 10$$

Where the indicate that the load values are forecass.

4. Training

Each layer's weights and biases are initialized when the neural net is set up. The network adjusts the connection strength among the internal network nodes until the proper transformation that

links past inputs and outputs from the training bases is learned. Data windows are fed and moved one day ahead.

5. Simulation

Using the trained neural network, the forecasting output is simulated using the input patterns.

6. Post-Processing

The neural network output need de-scaling to generate the desired forecasted loads. If necessary, special events can be considered at this stage.

7. Error Analysis

As characteristics of load vary, error observations are important for the forecasting process. Hence, the following Mean Absolute Percentage Error (MAPE) and Root Mean Square Error (RMSE) are used here for the after-the-fact error analysis:

Where:

= the number of cases to be forecasted;
= the actual load value,
= the forecasted load

12

In all the above error measurements, a lower value means a more precise model, with a value of 0 depicting the statistical perfect model.

13

Test Results

The historical data of Power Holding Company of Nigeria for 2006 2009 were used for testing the proposed ANN-based STLF. Neural networks with various inputs - hidden - output nodes, with the scaling scheme as previously described, were used. A tangent sigmoid function was chosen as the transfer function for the hidden layer, and a linear function for the output layer. These particular ANN structures were chosen based on several tests with different number of inputs, hidden nodes, transfer functions and scaling schemes.

The training performance for both a learning rate and a momentum set at 0.75 and 0.1. The fast convergence without oscillation is due to the relatively large values of lr and mc, which were chosen based on multiple tests carried out with different values of these two parameters.

The STLF results are tabulated in Tables 1 - 3, and depicted in various graphs in Figures 4 7. The graphs observe satisfactory forecasted results and adequate performance of the proposed STLF as illustrated in the absolute percentage errors both for hourly, daily of training and weekly basis. The temperature effects are not considered, hence, the number of iterations required to achieve the same forecasting accuracy practically could not be ascertain.

Conclusion And Recommendations

Several neural network models for short-term load forecasting were studied in the work. The techniques were divided into two classes: models for creating the forecast for one whole day at a time, and models utilizing the most recent load data and allowing hourly forecasting.

Forecasting the daily load profile was first studied using a MLP network to predict daily peak, valley and average load values. The shape of the load curve was predicted by averaging some daily shapes in the load history. The whole year was used as the training set for the MLP networks. The performance of the models was tested on the load data of a particular season within the year. The best results were obtained with the simplest input structure, which only uses the load data of the previous day as the predictor. The average errors of approximately 4 % for the peak load, less than 5 % for the valley load, and less than 3.5 % for the average load were obtained.

The work shows that the hourly MLP models have many of the required properties, and suited for an automatic application, and implementation to an energy management system is relatively easy. It can adapt well to different weather conditions. A particularly good property is the ability to forecast accurately for all lead-times from one hour to one week.

The study recommends an hourly forecasting for a real application, as it was shown that this clearly improves the accuracy for the closest hours. Another good feature is the ability to forecast for an arbitrary lead-time. Forecasting one week

ahead was tested, the accuracy was good.

REFERENCES

K. Y. Lee, J. H. Park, 1992, "Short-term Load Forecasting using an Artificial Neural Network", IEEE Transactions on Power Systems, vol. 7, no. 1, February 1992, pp. 124-130.

G. Karady, "Short-Term Load Forecasting using Neural Networks and Fuzzy Logic, ASU, Tempe, AZ-85281, 2001.

P. Vähäkyla, E. Hakonen and P. Léman, "Short-term Forecasting of Grid Load using Box-Jenkins techniques", International Journal of Electrical Power & Energy Systems, vol. 2, no. 1, 1980, pp. 29-34.

D. W. Bunn, E. D. Farmer (eds.), 1985, "Comparative models for electrical load forecasting", John Wiley & Sons, Belfast.

S. Rahman, R. Bhatnagar, "An Expert System Based Algorithm for Short Term Load Forecast", IEEE Transactions on Power Systems, vol.3, no. 2, May 1988, pp. 392-399.

S. Rahman, O. Hazim, "A generalized knowledge-based short-term load-forecasting technique", IEEE Transactions on Power Systems, vol. 8, no. 2, May 1993, pp. 508-514.

T. W. S., Chow, and C. T. Leung, "Neural Network Based Short-term Load Forecasting using Weather Compensation", IEEE Transactions on Power Systems, vol. 11, no. 4, November 1996, pp. 1736-1742.

P. K., Dash, H. P. Satpathy, A. C. Liew, and S. Rahman, "A Real-time Short-term Load Forecasting System using Functional Link Network", IEEE Transactions on Power Systems, vol. 12, no. 2, May 1997, pp. 675-680.

A. Asar, J. R. McDonald, "A Specification of Neural Network Applications in the Load Forecasting Problem", IEEE Transactions on control systems technology, vol. 2, no. 2, June 1994, pp. 135-141.

Y. Y. Hsu, C. C. Yang, "Design of Artificial Neural Networks for Short-term Load Forecasting. Part I: Self-organizing feature maps for day type selection", IEEE Proceedings C, vol. 138, no. 5, September 1991, pp. 407-413.

K. L. Ho, Y. Y. Hsu, C. C. Yang, "Short-term Load Forecasting using a Multilayer Neural Network with an Adaptive Learning Algorithm", IEEE Transactions on Power Systems, vol. 7, no. 1, February 1992, pp. 141-148.

FAULT TREE ANALYSIS AS A SOLUTION TO PROBLEMS IN THE AUTOMATION OF POWER DISTRIBUTION SYSTEMS

Joe-Uzuegbu Chijioke and Ogbogu S.O.E.
Department of Electrical/Electronics Engineering
Federal University of Technology Owerri
Imo State, Nigeria
E-mail: joskie23@yahoo.co.uk

ABSTRACT
Power providers constantly deal with demands to increase productivity and reduce costs. This translates into the need for administrators, engineers, operators, planners, field crews and others to collect and act on decision-making information. Power system vendors are following a trend to make devices smarter so they can create and communicate this information as is necessary in the automation of electrical power systems. Fault Tree Analysis (FTA) attempts to model and analyze failure processes of engineering systems. FTA can be used as a valuable design tool, can identify potential accidents, and can eliminate costly design changes. It can also be used as a diagnostic tool, predicting the most likely system failure in a system breakdown. FTA is applicable in safety engineering and in all major fields of engineering. This paper will focus mainly on the application of FTA as a strategy for improving Economics of Power Distribution and consumption.

Keywords- Accident, Event, Emergency, Restorative, Multi-function

I. Introduction

Fault tree analysis (FTA) is a failure analysis in which an undesired state of a system is analyzed using boolean logic to combine a series of lower-level events. This analysis method is mainly used in the field of safety engineering to quantitatively determine the probability of a safety hazard.

In the technique known as "fault tree analysis", an undesired effect is taken as the root ('top event') of a tree of logic. There should be only one Top Event and all concerns must tree down from it. Then, each situation that could cause that effect is added to the tree as a series of logic expressions. When fault trees are labeled with actual numbers about failure probabilities (which are often in practice unavailable because of the expense of testing), computer programs can calculate failure probabilities from fault trees.

The Tree is usually written out using conventional logic gate symbols. The route through a tree between an event and an initiator in the tree is called a Cut Set. The shortest credible way through the tree from fault to initiating event is called a Minima l Cut Set. Fault Tree Analysis usually involves events from hardware wear out, material failure or malfunctions or combinations of deterministic contributions to the event stemming from assigning a hardware/system failure rate to branches or cut sets. See Fig. 1.

Typically failure rates are carefully derived from substantiated historical data such as mean time between failure of the components, unit, subsystem or function. Predictor data may be assigned. Assigning a software failure rate is elusive and not possible. Since software is a vital contributor and inclusive of the system ope ration it is assumed the software will function normally as intended. There is no such thing as a software fault tree unless considered in the system context. Software is an instruction set to the hardware or overall system for correct operation. Since basic software events do not fail in the physical sense, attempting to predict manifestation of software faults or coding errors with any reliability or accuracy is impossible, unless assumptions are made. Predicting and assigning human error rate s is not the primary intent of a fault tree analysis, but may be attempted to gain some knowledge of what happens with improper human input or intervention at the wrong time.
Electric utilities, all around the world, have realized

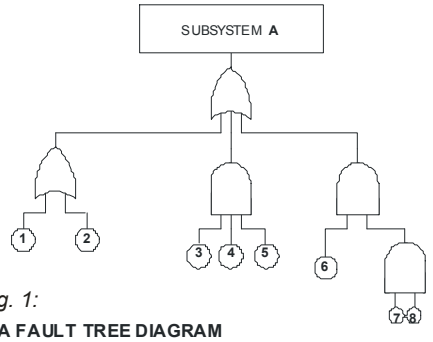


Fig. 1:
A FAULT TREE DIAGRAM

the problems associated with vertically integrated electric power systems and therefore they are moving towards unbundled model of generation companies (GENCOs), transmission companies (TRANSCOs), distribution companies (DISCOs), and energy service companies (ESCOs). In the past, all electric power distribution-related functions could be transparently coordinated along the complete supply chain. In the future, many distribution companies will manage third-party contacts by delivering bulk power from GENCOs and TRANSCOs to meters owned by ESCOs.

At the same time, many state regulatory commissions are considering the viability of retail wheeling (small generators connected to the distribution system selling electricity directly to customers). In addition to planning and operating difficulties, retail wheeling asks distribution systems to perform the functions for which they were not designed.

In view of the above, on-line information, remote control and efficient management system are required for power distribution utilities. Considering the extensive size of the network, these tasks can be effectively achieved through the intervention of information technology utilizing the available high-speed computer and communication technology. This system of monitoring and control of electric power distribution networks is also called as "Distribution Automation (DA)" system. [1]

II. History

Fault Tree Analysis was, initially developed for projects where errors are intolerable (e.g., an error in a nuclear reactor is not tolerated). Bell Telephone Laboratories started the development of FTA during the early 60's for the United States Air Force's Minuteman System (Intercontinental Ballistic Missiles and Bombers). Later, U.S. nuclear power plants and the Boeing Company used the system extensively.

On the other hand, the idea of Distribution Automation began in 1970s. The motivation at that time was to use the evolving computer and communications technology to improve operating performance of distribution systems. Since then, the growth of distribution automation has been dictated by the level of sophistication of existing monitoring, control, and communication technologies; and performance and cost of available equipment. Although distributio systems are a significant part of power systems, advances in distribution control technology have lagged considerably behind advances in generation and transmission control. Small pilot projects were implemented by a few utilities to test the concept of distribution automation in the 1970s. In the 1980s, there were several major pilot projects. By the 1990s, the DA technology had matured and that resulted in several large and many small projects at various utilities.[1]

III. Analysis

Automation allows utilities to implement flexible control of distribution systems, which can be used to enhance efficiency, reliability, and quality of electric service. Flexible control also results in more effective utilization and life-extension of the existing distribution system infrastructure. Many utilities are contemplating providing performance-based rates to their customers. They would be willing to pay compensation to the customers if the performance falls below a minimum level. Such actions will allow utilities to brace for the upcoming competition from other parties interested in supplying power to the customers.

Although higher reliability and quality are the goals of the utilities, they would like to accomplish this while optimizing the res ources. Another goal for a utility should be improvement in system efficiency by reducing system losses. The functions that can be automated in distribution systems can be classified into two categories, namely, monitoring functions and control functions [3],[4]. Monitoring functions are those needed to record meter

readings at different locations in the system, the system status at different locations in the system, and events of abnormal conditions. The data monitored at the system level are not only useful for day-to-day operations but also for system planning. Distribution supervisory control and data acquisition (DSCADA) systems perform some of these monitoring functions. The control functions are related to switching operations, such as switching a capacitor, or reconfiguring feeders. The function that is the most popular among the utilities is fault location and service restoration or outage management. This function directly impacts the customers as well as the system reliability.

Presently, worldwide research and development efforts are focused in following areas to make distribution automation more intelligent and cost effective in order to accomplish the objective of full-scale unbundling of power systems.

- Power system communication protocol to achieve interoperability
- Communication system to make it commercially viable
- Switchgears and transformers to make them self intelligent through IEDs
- Intelligent Remote Terminal Units (RTUs)
- Intelligent instrumentation system
- Power system algorithm to provide quick and accurate control decision

Some customer-related functions, such as remote load control, automated meter reading (AMR), and remote connect/disconnect may also be considered as distribution automation functions. However, AMR has evolved significantly itself as a separate area. In addition, system protection can also be a part of overall distribution automation schemes.

Many different approaches can be used to model a FTA, but the most common and popular way can be summarized in a few steps. Remember that a fault tree is used to analyze a single fault event and that one and only one event can be analyzed during a single fault tree. Even though the "fault" may vary dramatically, a FTA follows the same procedure for an event.
FTA analysis involves five steps:
1. Define the undesired event to study: Definition of the undesired event can be very hard to catch, although some of the events are very easy and obvious to observe. An engineer with a wide knowledge of the design of the system or a system analyst with an engineering background is the best person who can help define and number the undesired events. Undesired events are used then to make the FTA, one event for one FTA; no two events will be used to make one FTA.

3. Obtain an understanding of the system: Once the undesired event is selected, all causes with probabilities of affecting the undesired event of 0 or more are studied and analyzed. Getting exact numbers for the probabilities leading to the event is usually impossible for the reason that it may be very costly and time consuming to do so. Computer software is used to study probabilities; this may lead to less costly system analysis. System analysts can help with understanding the overall system. System designers have full knowledge of the system and this knowledge is very important for not missing any cause affecting the undesired event. For the selected even t all causes are then numbered and sequenced in the order of occurrence and then are used for the next step which is drawing or constructing the fault tree.

4. Construct the fault tree: After selecting the undesired event and having analyzed the system so that we know all the causing effects (and if possible their probabilities) we can now construct the fault tree. Fault tree is based on AND and OR gates which define the major characteristics of the fault tree.

5. Evaluate the fault tree: After the fault tree has been assembled for a specific undes ired event, it is evaluated and analyzed for any possible improvement or in other words study the risk management and find ways for system improvement. This step is as an introduction for the final step which will be to control the hazards identified. In short, in this step we identify all possible hazards affecting in a direct or indirect way the system.

6. Control the hazards identified: This step is very specific and differs largely from one system to another, but the main point will always be that after identifying the hazar ds all possible methods are pursued to decrease the probability of occurrence.

In order for fault tree analysis to be optimally

employed in Power Distribution Automation, it would be useful to consider probable contingency/accidental events and analysis. A contingency is an event that might occur in the future, especially a problem, emergency, or expense that might arise unexpectedly and therefore must be prepared for.

An accidental event is defined as the first significant deviation from a normal situation that may lead to unwanted consequences (e.g., gas leak, falling object, start of fire). An accidental event may lead to many different consequences.. The potential consequences may be illustrated by a consequence spectrum as seen in Fig. 2.

When defining an accident event, we should answer the following questions:

- What type of event is it? (e.g., leak, fire)
- Where does the event take place? (e.g., in the control room)
- When does the event occur? (e.g., during normal operation, during maintenance)

In practical applications there are sometimes discussions about what should be considered an accidental event (e.g., sho uld we start with a gas leak, the resulting fire or an explosion). Whenever feasible, we should always start with the first significant deviation that may lead to unwanted consequences.

An accidental event may be caused by:

- System or equipment failure
- Human error
- Process upset

The accidental event is normally "anticipated". The system designers have put in barriers that are designed to respond to the event by terminating the accident sequence or by mitigating the consequences of the accident.

For each accidental event we sho uld identify: The potential accident progression(s), System dependencies and Conditional system responses.[5]. For example,

A reliable power system maintains frequency and voltage excursions within acceptable limits under normal and abnormal operating conditions, without exceeding the thermal limits of the power system components (lines, transformers, generators, etc.). Typical frequency limits are fNOM ± 0.1 Hz; typical voltage limits are VNOM ±5%.The power

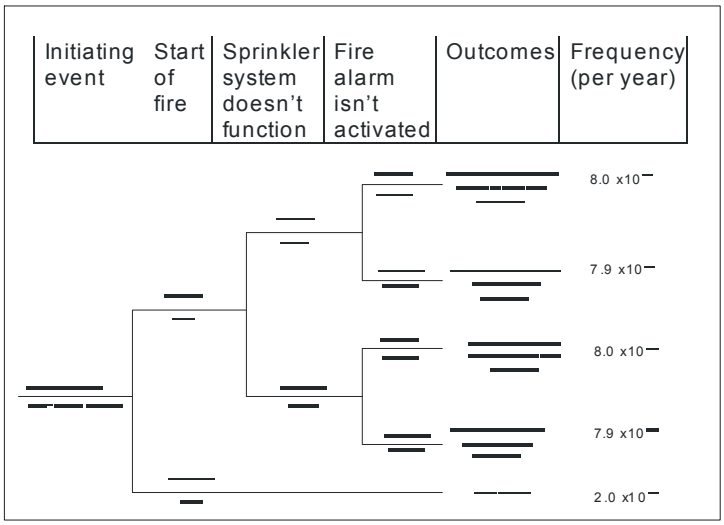


Fig 2: Example illustrating a typical accidental event

system operates in normal state when system frequency and voltages are close to their nominal values and there is sufficient generation and transmission reserve.

The system enters an alert state when generation and transmission reserve margins are reduced or eliminated, or there is a problem with one or several of the system components (one or several lines are overloaded). In the alert state, automated and manual controls of the system operate to restore the system to the normal state. Adequate power system monitoring and metering are necessary to promptly detect power system problems and accelerate system recovery.

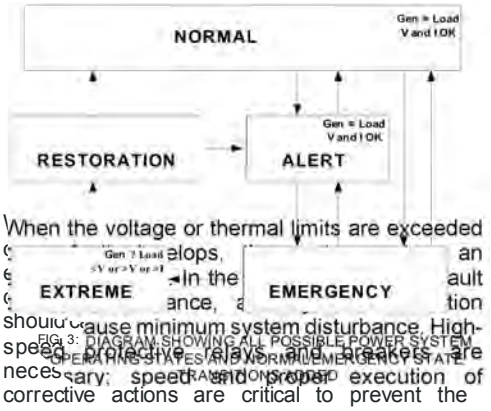


FIG 3: DIAGRAM SHOWING ALL POSSIBLE POWER SYSTEM OPERATING STATES AND NORMAL/EMERGENCY STATE TRANSITIONS ADOPTED

When the voltage or thermal limits are exceeded elops, an In the ault ance, a tion should cause minimum system disturbance. High-speed protective relays and breakers are necessary; speed and proper execution of corrective actions are critical to prevent the system from entering the extreme state. For example, high-speed transmission line protection with single-pole tripping with adaptive reclosing capabilities minimizes system disturbance. When entering the emergency state without a fault in the system, automated control (fast valving, static VAR compensation, etc.) is desirable to reestablish normal or alert operating state to avoid entering the extreme state. This is illustrated in Fig. 3

If the system cannot maintain the generation-load balance, the system enters the extreme state. In the extreme state, load shedding, generation shedding or system islanding occurs to balance generation and load. Under-frequency load shedding schemes operate to restore load-generation balance across the system; under-voltage load shedding schemes operate to avoid system voltage collapse. Remedial actior schemes that monitor power flows, system configuration, voltage levels, etc. actuate to separate the system in islands or shed generation to maintain the load generation balance to avoid total system collapse.

After load and/or generation shedding, the system enters a system recovery state. In this state, manual or automated reinsertion of generation and load occurs. The figure 4 below identifies tasks that multifunction protective relays can execute to improve system reliability in each of the system operating states. [5]

NORMAL AND ALERT STATES

In the normal and alert states, multifunction relays provide system monitoring. These devices obtain samples of the power system voltages and currents synchronized wi thin a time frame, (say 1is). We can use this capability to measure the state of the system in true real time instead of trying to estimate the system state using SCADA and traditional state estimation systems. Additional monitoring capabilities include the following:

- Fast open line monitors quickly detect system configuration changes.
- Comprehensive line, transformer and motor thermal models warn of dangerous system component operating conditions.
- Real time channel communications monitoring improves communication system availability and warns when communications errors occur.
- Load encroachment region definition avoids line protective relay misoperation during heavy load conditions.
- System frequency tracking allows relays to adapt to changes in system operating conditions.
- Out-of-step detection avoids unnecessary tripping of transmission lines.
- Breaker monitoring includes the following:

- Trip coil supervision alarm
- Breaker contact wear
- Electrical and mechanical operating time
- Pole discrepancy
- Interrupted current
- Motor running time
- Breaker inactivity time

? DC supply monitoring includes the following:
- DC ground detection
- Voltage level alarm
- Open current transformer detection
- Potential transformer monitor

Emergency State

In the emergency state, proper execution of corrective actions is key to restoring the system to normal or alert states. Actions that cause minimum system disturbance are required. Multifuncti on relays are capable of detecting system faults in less than one power system cycle and automatically restoring the system once the fault has been cleared. Because single-line-to- ground faults constitute the majority of all power system faults, single-pole-tripping and reclosing maximizes line power transmission capability by tripping only the faulted phase. Opening and closing of a single phase minimizes the system disturbance. Fast communications minimize fault-clearing times and accelerate control actions.[4]

Extreme State

In the extreme state, remedial action schemes can operate to reestablish generation-load balance. Multifunction relays include programmable logic capability and fast protection elements to implement complex remedial action schemes. We can describe a two-contingency remedial action scheme that prevents the system from near voltage collapse operation. In this description, the power system consists of three areas (see Fig below):

- Area A: Heavy load concentration
- Area B: Heavy generation concentration
- Area C: Light load concentration

Areas A and B are interconnected with three transmission links; Areas B and C are interconnected with two transmis sion links. The remedial action scheme to avoid voltage collapse is enabled when transmitted power from Area B to Area A is greater than 1100 MW, (See Figure 4).

If two lines open under these conditions, the scheme sheds excess generation in Area B in a timely manner (less than one second). Multifunction relays can execute these tasks to prevent the system from collapsing.

Restoration State

Rapid system restoration is critical to minimize blackout duration. Automated restoration schemes and accurate fault location can accelerate the restoration process. Multifunction relays include reporting capabilities that indicate fault location, breaker status, protective element operation, etc. These reports provide a summary of the event that the system operator can use to speed-up system restoration. The ability to synchronize events within 1 μs facilitates and accelerates event analysis.[5]

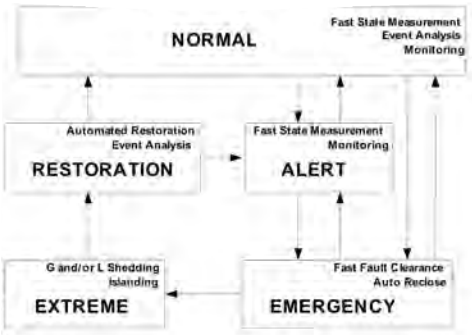


FIG. 3: Tasks that multifunction protective relays can exe improve System Reliability

IV. Conclusions

The power system goes through alert and/or emergency states before collapsing. Transition from one state to another is not instantaneous; with timely and accurate information, there is enough time to activate appropriate control systems to effectively operate the power system. Multifunction protective relays include comprehensive monitoring capabilities that can detect the alert and emergency states, minimize system disturbance and prevent system collapse.

REFERENCES

R.P Gupta, R.K Varma, Power Distribution Automation: Present Status. Vol 15, pp 2-11, March 2005, available at

www.acadjournal.com .

A. Guzmán, J. B. Mooney, G. Benmouyal, N. Fisher, "Transmission Line Protection for Increasing Power System Demands," 55th Annual Conference for Protective Relay Engineers, College Station, Texas, April 8-11, 2002.

[3] D. Bassett, K. Clinard, J. Grainger, S. Purucker, and D. Ward, "Tutorial Course: Distribution Automation", *IEEE Tutorial Publication* 88EH0280-8-PWR, 1988.

[4]J. B. Bunch, "Guidelines for Evaluating Distribution Automation", *EPRI Report EL-3728, 1984*.

[5.] G. Benmouyal, E. O. Schweitzer, A. Guzmán, "Synchronized Phasor Measurement in Protective Relays for Protection, Control, and Analysis of Electric Power Systems," 29 th Annual Western Protective Relay Conference, Spokane, Washington, October 2224, 2002.

ADVANCED NUMERICAL METHOD OF SOLVING MAGNETIC FIELD PROBLEM OF SALIENT POLE SYNCHRONOUS MACHINE

P. E. Okon, † C. C. Okoro and * E.N.C. Okafor
** Dept. of Electrical / Electronic Engineering,*
Federal University of Technology, Owerri
† Dept. of Electrical / Electronic Engineering,
University of Lagos, Akoka
**e-mail:peokon1@yahoo.co.uk*

ABSTRACT
The characteristics of a salient four pole synchronous alternator, commonly applied for bulk power generation, are obtained using advanced numerical method - the Finite Element Method. The method is most suited for dealing with the complicated internal structure of Electrical Machines, their non-linear magnetic characteristics and the numerical application of the electromagnetics of such machines to their design computations. The Finite Element Method Magnetic software version 4.0 is applied to a two dimensional structure of the Synchronous machine. The results provide a two dimensional magnetic field mapping of the flux patterns in the entire machine domain. The air gap flux distribution at a particular excitation current and the open circuit performance characteristics obtained agreed with standard curves for Synchronous Alternators.

Keywords: Finite Element Method Magnetic, Salient Pole Synchronous Machine, Partial Differential Equation with boundary conditions, Maxwell Equations, Poisson Equations.

1. Introduction

Analysis and prediction of salient pole synchronous machines magnetic field pattern and characteristics are difficult due to irregular geometry and non-linear magnetic materials associated with this machine. The machine may be the cylindrical rotor or salient pole construction. In order to obtain accurately the performance of this machine, the magnetic field mapping of the internal structure and performance characteristics are necessary. Different methods have been deployed over the years to han dle this task. These are the Finite Difference Method (FDM), Boundary Element Method (BEM) and the Finite Element Method (FEM). However the FEM is increasing being used by designers due to its ability to handle the complex internal structure and non-linear materials present in the machine structure.

In practice, electrical machines are saturated making its behaviours non linear. Consequently the machines calculations are based on approximation that typified the operating point. Inaccuracies resul ting from these approximations make it necessary to employ high precision analytical tool the finite element method.

The proposed methodology is to compute a flux patterns in a four pole, 50Hertz, 3 phase, 415Volts synchronous machine to open circuit characteristics and air gap flux density on no load.

2. Statement of Problem

The basic problem of the electromagnetic field computation that resulted in the magnetic field mapping/distribution in the salient pole synchronous machine cross section is modeled by the two dimensional Poisson Equation as follows:

$$\frac{\partial}{\partial x}\left[\frac{1}{\mu_o\mu_r}\frac{\partial \mathbf{A}}{\partial x}\right]+\frac{\partial}{\partial y}\left[\frac{1}{\mu_o\mu_r}\frac{\partial \mathbf{A}}{\partial y}\right]=-\mathbf{J}_z$$

$$\frac{\partial^2 \mathbf{A}}{\partial x^2}+\frac{\partial^2 \mathbf{A}}{\partial y^2}=-\mu\mathbf{J}_z \qquad (1)$$

Where:
μ_o = Permeability of free space
μ_r = Relative Permeability
μ = Absolute permeab ility = $\mu_o\mu_r$
A_z = Magnetic vector potential normal to the section of the machine
J_z = current density vector normal to the section

However, vector magnetic potential is of great

value when solving two-dimensional problems containing current carrying areas [6]. The equation (1) is reformulated by variational calculus, in the finite element method, and first-order triangular elements are used to discretize the field region, resulting in a set of linear algebraic equations [9]. These linear simultaneous equations are solved using Newton-Raphson technique to obtain the magnetic vector potential.

3. Mathematical Formulation

Finite Element Method as applied to this paper is used to solve derived electromagn etic field problems of Poisson's equation from basic magnetostatic Maxwell equations. The equations relate magnetic vector potential **A**, magnetic flux density **B** and magnetic field intensity **H** to obtain the Poisson's equation.

The basic steps used in solving this magnetic equation are discussed below.

A. Maxwell's Equation

$$\nabla \times \mathbf{H} = \mathbf{J} \qquad 2$$

$$\nabla \cdot \mathbf{B} = 0 \qquad 3$$

And the relationship

$$\mathbf{B} = \mu \mathbf{H}$$

Where **B** is the magnetic flux density, **H** is the magnetic field intensity, **J** is the current density and μ is the material absolute permeability.

If a vector field has no divergence, then vector field is the curl of some other vector fields [8]. Therefore, $\Delta \cdot \mathbf{B} = 0$ means that **B** is the curl of another vector field. Let that other vector field be **A**.

Since $\nabla \cdot \mathbf{B} = 0$, there exists a magnetic vector **A** such that $\mathbf{B} = \nabla \times \mathbf{A}$.

A current in the z direction produces $\mathbf{A}_z$ only, and x and y component of $\mathbf{B}$. $\mathbf{A}_z$ is then related to the flux circulating in the x, y plane, per unit length in the z direction: it has the units of Webers per metres length.

Thus for two-dimensional field, **A** can be treated as a scalar quantity. The magnetic flux flowing in a conducting material carrying current has its permeability μ greater than that of copper conductor of permeability μ_o. Solving for the magnetic vector potential **A**, the component of the magnetic flux density are obtained by finding the derivatives and as shown below.

$$\frac{\partial \mathbf{A}}{\partial y} \qquad \frac{\partial \mathbf{A}}{\partial x}$$

$$\mathbf{B} = \nabla \times \mathbf{A} \qquad (4)$$

$$\mathbf{B} = \mu_o \frac{\partial \mathbf{A}_z}{\partial x} - \mu_o \frac{\partial \mathbf{A}_z}{\partial y} \qquad (5)$$

With current densit $\mathbf{J}_z$ only, and hence $\mathbf{A}_z$ only, and no variation of these quantities in the z direction,

$$\mathbf{B}_x = \frac{\partial \mathbf{A}_z}{\partial y}, \quad \mathbf{B}_y = -\frac{\partial \mathbf{A}_z}{\partial x} \qquad (6)$$

$\mathbf{J}_x$ and $\mathbf{J}_y = 0$, do not exist

$$-\nabla \times \mathbf{H} = \mathbf{J} \quad \text{only} \quad \text{exist} \qquad (7)$$

Therefore

Using $\mathbf{B} = \mu \mathbf{H}$ and substituting equation 6 into the above equation gives

$$\mathbf{J}_z = \frac{\partial \mathbf{H}_y}{\partial x} - \frac{\partial \mathbf{H}_x}{\partial y}$$

And so for fixed μ

$$\frac{\partial}{\partial x}\left[\frac{1}{\mu_o \mu_r}\frac{\partial \mathbf{A}}{\partial x}\right] + \frac{\partial}{\partial y}\left[\frac{1}{\mu_o \mu_r}\frac{\partial \mathbf{A}}{\partial y}\right] = -\mathbf{J}_z$$

Which is Poisson's Equation

$$\frac{\partial^2 \mathbf{A}}{\partial x^2} + \frac{\partial^2 \mathbf{A}}{\partial y^2} = -\mu \mathbf{J}_z \qquad (8)$$

B. Shape Function And Discretization

Finite element method employs discretization of the solution domain into smaller regions called elements, and the solution is determined in terms of discrete values of some primary field variables **A** (example, vector magnetic potential in x, y, z directions) at the nodes. The number of unknown primary field variables at a node is the degree of freedom at that node. The discretized domain comprised of triangular shaped element as shown in figure 1(a) with each node having one degree of freedom as shown in the figure 1(b). The two-dimensional Cartesian coordinate system presented in this paper uses triangular element with nodes only at corners as shown in figure 1(a). Magnetic potentials $\mathbf{A}_i$, $\mathbf{A}_j$ and $\mathbf{A}_k$ are assumed to exist at the nodes. It is now necessary to define the variation of this magnetic potential over the

element, and this is known as Shape Function [6].

The shape function is represented by a polynomial approximation consistent with the number of nodes (and associated potentials) on each edge. The polynomial approximation for magnetic vector potential (**A**) used to model a four pole dc machine is expressed by the general term

, and are coefficients dependent on **A**$_i$, **A**$_j$ and **A**$_k$ and their associated coordinate. These equations are available to determine the three unknown , and

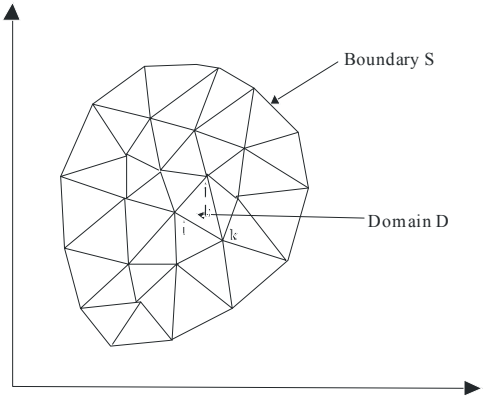


Figure 1(a): *Discretization of the field region by triangular finite element*

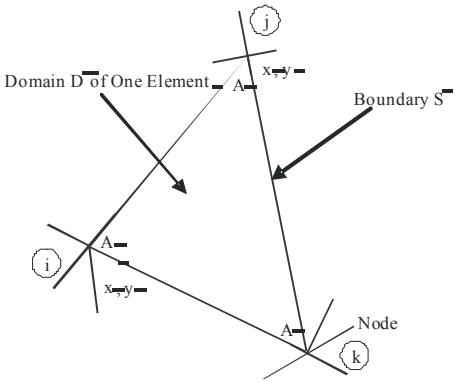


Figure 1(b): *A domain of One Element*

$$A = \alpha_1 + \alpha_2 x + \alpha_3 y \quad (9)$$

α_1 α_2 α_3

from which

α_1 α_2 α_3

$$\left.\begin{aligned} A_i &= \alpha_1 + \alpha_2 x_i + \alpha_3 y_i \\ A_j &= \alpha_1 + \alpha_2 x_j + \alpha_3 y_j \\ A_k &= \alpha_1 + \alpha_2 x_k + \alpha_3 y_k \end{aligned}\right\} \quad (10)$$

Where

$$\alpha_1 = \frac{(a_i A_i + a_j A_j + a_k A_k)}{2\Delta} \quad (11)$$

and area of element

$$\left.\begin{aligned} a_i &= (y_k x_j - y_j x_k) \\ a_j &= (y_i x_k - y_k x_i) \\ a_k &= (y_j x_i - y_i x_j) \end{aligned}\right\} \quad (12)$$

Where

$$\Delta = = \frac{(a_i + b_i x_i + c_i y_i)}{2} \quad (13)$$

and

$$\alpha_2 = \frac{(b_i A_i + b_j A_j + b_k A_k)}{2\Delta} \quad (14)$$

$$\left.\begin{aligned} b_i &= (y_j - y_k) \\ b_j &= (y_k - y_i) \\ b_k &= (y_i - y_j) \end{aligned}\right\} \quad (15)$$

Substituting for , and in equation 9

$$\alpha_3 = \frac{(c_i A_i + c_j A_j + c_k A_k)}{2\Delta} \quad (16)$$

$$\left.\begin{aligned} c_i &= (x_i - x_j) \\ c_j &= (x_k - x_i) \\ c_k &= (x_i - x_j) \end{aligned}\right\} \quad (17)$$

where summation m = i, j, k indicates the summation is m takes the values i, j, k in turn and N etc are the Shape Functions.

α_1 α_2 α_3

$$\frac{1}{2\Delta}[(a_i + b_i x + c_i y)\mathbf{A}_i + (a_j + b_j x + c_j y)\mathbf{A}_j + (a_k + b_k x + c_k y)\mathbf{A}_k]$$

$$= \sum_{m=i,j,k} \frac{1}{2\Delta}(a_m + b_m x + c_m y)\mathbf{A}_m \quad (18)$$

$$= \sum_{m=i,j,k} \frac{1}{2\Delta} N_m \mathbf{A}_m$$

C. Variational Method

The variational method is essentially an energ method; it is useful to consider what is meant by the term energy and its associated co-energy in relation to magnetic device [6].

In general, magnetic materials are non linear and the magnetic energy needed to generate a flux density B in the material, corresponds to the figure below

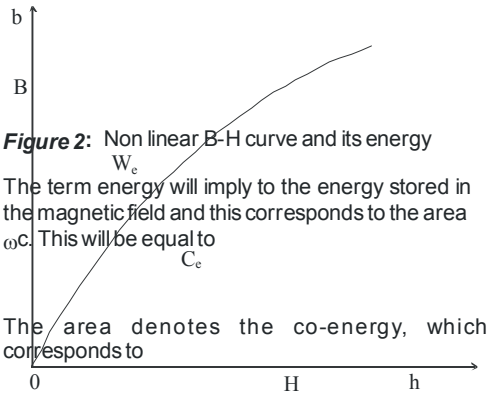


Figure 2: Non linear B-H curve and its energy

The term energy will imply to the energy stored in the magnetic field and this corresponds to the area ωc. This will be equal to

The area denotes the co-energy, which corresponds to

The magnetic stored energy is equal to the net energy supplied by the source. The total area will be equal to the integration over the exciting coil of **JA**

Where **J** is the final current density and **A** final flux levels.6]

Therefore co-energy density may be written locally as

$$\int_0^h b\,dh \qquad (20)$$

In formulating problems in terms of vector magnetic potential **A**, coil currents are usually known and the appropriate energy functional to be minimized is the co-energy quantity

Since reluctivity, equation 22 can be written as

$$C_e = \mathbf{JA} - \int \mathrm{h}\,\mathrm{db} \qquad (21)$$

Two-dimensional case is considered in two dimensional structure . The term containing flux density is expressed in terms of the vector magnetic potential **A**. As before it will be assumed that the reluctivity at any point can be assigned a value related to the final flux density **B** Thus the functional becomes

$$C_e = \int_v [\mathbf{JA} - \int_0^B \nu(b)\,b\,db]\,dx\,dy\,dz \qquad (23)$$

Comparing equation 24 with a parabola
Whose minimum is at $x = f$
Considering one element only as before

Hence, the contribution to the rate of change of F with A from the variation of potential of node i in element e only

$$= \int_e [\mathbf{JA} - \frac{\nu}{2}\{(\frac{\partial A}{\partial x})^2 + (\frac{\partial A}{\partial y})^2\}]dxdy \qquad (24)$$

$$f(x) = \frac{1}{2}x^2 - xf$$

$$F_e = \int_e [\mathbf{JA} - \frac{\nu}{2}\{(\frac{\partial A}{\partial x})^2 + (\frac{\partial A}{\partial y})^2\}]dxdy \qquad (25)$$

Substitute shape function equation derived from figure 1(b) and equation 9

$$\frac{\partial F_e}{\partial A_i} = \int_e \frac{\partial}{\partial A_i}[\mathbf{JA} - \frac{\nu}{2}\{(\frac{\partial A}{\partial x})^2 + (\frac{\partial A}{\partial y})^2\}]dxdy$$

Substitute equation 27 into equation 26
So, Equation 26 can also be written in the form up to m node

$$= \int_e [\mathbf{J}\frac{\partial}{\partial A_i} - \frac{\nu}{2}\{2(\frac{\partial A}{\partial x}).\frac{\partial}{\partial A_i}(\frac{\partial A}{\partial x}) + 2(\frac{\partial A}{\partial y}).\frac{\partial}{\partial A_i}(\frac{\partial A}{\partial y})\}]dxdy \qquad (26)$$

Or

$$\mathbf{A} = \sum_{m=i,j,k} \frac{[(a_i + bx + cy)\mathbf{A}_i]}{2\Delta} \quad (27)$$

and

$$\frac{\partial F_e}{\partial A_i} = \sum_{m=i,j,k} \left[\frac{1}{2\Delta}(a_i + bx + cy)\right] \quad (28)$$

The equation 29 can further be expressed with respect to each of the nodal potential. The integral equation 29 can be readily evaluated for the two-dimensional basic functions defined by equation 27 by using the expression of equation 30 [2]

$$\frac{\partial F_e}{\partial A_i} = \frac{1}{2\Delta}\int J[(a_i + bx + cy) - \frac{\nu}{2\Delta}\{b_i(b_iA_i + b_jA_j + b_kA_k) + c_i(c_iA_i + c_jA_j + c_kA_k)\}]dxdy \quad (29)$$

With J which is constant within the element, it can be shown that

The integral over the area of the element can be shown to be

$$\int_e \frac{\alpha^p \beta^q \gamma^r}{(p+q+r+2)!} 2\Delta \quad (30)$$

The minimization of the equation 29 is carried out for all the triangles of the field region on the cross section of the generator, the matrix equation 32 is obtained, the solution determines the unknown vector potential **A**.

$$\frac{1}{2\Delta}\int_e J[(a_i + bx + cy) = \frac{J\Delta}{3}$$

where , the source term with constant J within the element

$$\frac{\partial F_e}{\partial A_i} = \frac{J\Delta}{3} - \frac{\nu}{4\Delta}[(b_i^2 + c_i^2 + b_ib_j + c_ic_j + b_ib_k + c_ic_k)A_i + (b_ib_i + c_jc_i + b_j^2 + c_j^2 + b_jb_k + c_jc_k)A_j + (b_kb_i + c_kc_i + b_kb_j + c_kc_j + b_k^2 + c_k^2)A_k] \quad (31)$$

S = Non-linear matrix. The non-linear equation 32 is first quasi-linearized by a Newton-Rapson method, and the resulting in a set of equations solving directly - [S][A] iteratively using (32) digital computers

$$\frac{\partial F_e}{\partial A} = [T_e][S_e][A] \quad (32)$$

$$[T_e] = \frac{J\Delta}{3}$$

$$[S] = \frac{\nu}{4\Delta}\begin{bmatrix} S_{ii}S_{ij}S_{ik} \\ S_{ji}S_{jj}S_{jk} \\ S_{ki}S_{kj}S_{kk} \end{bmatrix} \quad (33)$$

Equation 34 is know as magnetic vector potential at the three nodes of the triangular element

$$[A] = \begin{bmatrix} A_i \\ A_j \\ A_k \end{bmatrix} \quad (34)$$

B. Boundary Conditions

The numerical equations considered above have to be solved subject to the relevant boundary conditions. The types of boundary conditions considered in this paper are summarized below:

Dirichlet: A Dirichlet boundary condition set the unknown function to a known on the boundary of the partial differential equation. This is the boundary condition that the value of the potential **A** is explicitly defined on the boundary, example **A**=0. The most common use of Dirichlet-type boundary conditions in magnetic problem is to define **A**=0 along a boundary to keep magnetic flux from crossing the boundary [5].

Neumann: Neumann boundary condition specifies the normal derivative of the potential along the boundary. In magnetic problem, the homogeneous Neumann boundary condition, is defined along a boundary to force flux to pass the boundary at exactly 90 ° to the boundary. This sort of boundary condition is consistent with an interface with a very highly permeable metal [5].

IV. Solution of the Problem

There are three unknown vector potential at each node of the triangular elements. The complete solution of the field problem consists of the solution of the system in equation 30 for each finite element that belongs to the domain. It is necessary to pass from the local matrix [S] that refers to the single m^{th} element (i.e. from the three value A_i, A_j and A_k only) to the global matrix that refers to the complete domain (i.e., to all the value of the nodes).

Since the potential is vector magnetic potential **A** the flux density **B** depends on the potential gradient and the flux density remain constant within the element.

$$\frac{\partial \mathbf{A}}{\partial n} = 0$$

The governing differential equation is now applied to the domain of a single element. At the element level, the solution to the governing equation is replaced by continuous function approximating the distribution of **A** over the element domain, expressed in terms of the unknown nodal value A_i, A_j and A_k of the solution **A** A system of equations in terms of the A_i, A_j and A_k will then be formulated for the element. Once the element equations are determined, the elements are assembled to form the entire domain of the problem. The solution **A**(x,y) to the problem becomes a polynomial approximation, expressed in terms of the nodal values of **A** A system of linear algebraic equations results, which may be solved by means of common numerical algorithms.

V Synchronous Machine Field Computation And Solution

Finite Element Method Magnetics (FEMM) is a suite of programs for solving low frequency electromagnetic problem on two-dimensional planar and axi-symmetric domain [5].

The procedure for implementing this numerical computation of magnetic field problems is by using the finite element method which is divided into three main steps:

A. Pre-processing: This processor is used for drawing the problems geometry, defining materials and defining boundary conditions.

The derivation of the finite element model of this machine under consideration involves defining conduction materials, electromagnetic materials and their properties and boundary conditions and eventually resulted in mesh generation. The machine is made up of two sections, the rotor and stator. The materials properties and boundary conditions are input into various defined region/section of the computation space. These values are used for computation within the defined boundary of the region.

Figure 3(a): Section of Computational Space

The figure 3(b) is part of pre-processing that shows a typical representation of mesh generation in synchronous machine computation space generated by FEMM. This entire synchronous machine solution region defined by materials, circuit properties, and boundary conditions broken down into 8420 triangular elements and 4,268 nodes before mathematical computation carried out to obtain magnetic field distribution within the cross section of the machine.

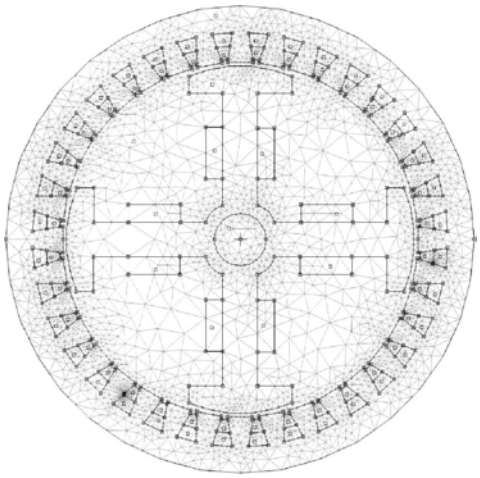
Figure 3(b): Generated Mesh in the Synchronous Machine Computation Space

B. Processing: Solving the problem by the relevant Maxwell's equations and obtaining the field distribution in the analyzed domain of the geometry for the synchronous machine at arbitrary chosen excitations and loading conditions.

C. Post Processing: This section of FEMM is used to view the solutions generated by FEMM solver. This is the process of calculating and presenting a synchronous machine flux pattern and deducing some results as well as parameters from the analyzed model. Figure 3(c) is the flux pattern obtained from the computations. Finite Element Method Magnetic solver that takes a set of data that describe the problem from the region and solves relevant Maxwell's equations to obtain field values which are translated to field distribution in the analyzed domain for this machine.

In order to obtain the desired result Finite Element Method Magnetic will then be run at arbitrary condition which is determine by value of the excitation.

Figure 3(c): Magnetic Flux Pattern of Synchronous Machine by Finite Element Magnetic



Method

VI. Structural Data and Material Properties of the Synchronous Machine

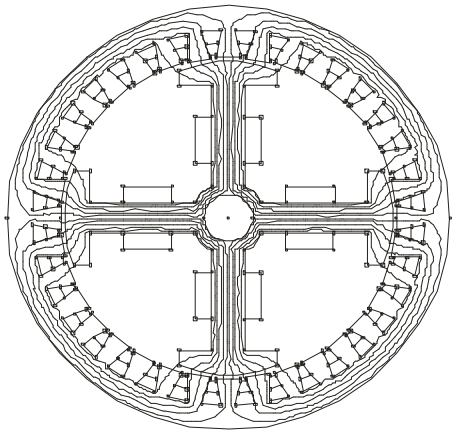
This paper is used to show, determine and predict operational characteristic of a small salient pole three phase synchronous generator using a software called FEMM 4.0 version.

Finite Element Method has been widely proved to be efficient when dealing with complicated geometries such as the one in this work.

The configuration of this machine is considered such that the stator produced MMF rotates at synchronous speed. Since the rotor is also rotating at synchronous speed in the steady state an observer on the rotor experiences a constant field i.e. . Therefore,

there are no eddy currents on the rotor. An observer on the stator experiences a time varying field whose fundamental is at the system frequency [7].

Poisson's Equation and a magneto static method are adopted for the analysis. By performing static analysis the following are neglected:



i. Effects of space harmonics of stator winding on the rotor surface losses
ii. Effects of tooth permeance losses

Due to single position analysis effect of rotor and stator teeth is not considered

A. Synchronous Machine Data

(i) Air Gap length: 0.5mm
(ii) Rotor diameter: 26cm
(iii) Stator External diameter: 35cm
(iv) Number of Stator Slots : 36 slots
(v) Terminal Voltage: 415 Volts
(vi) Frequency : 50 Hz
(vii) Phase: 3 μ
(viii) Poles: 4

B. Material Properties

The materials for this machine modeling can be user defined or can be obtained from FEMM material library. The material property list below are obtained using FEMM material library

(i) Rotor Material: M-19 Steel
(ii) Stator Material: 1006 Steel $\frac{\partial \mathbf{B}}{\partial t} = 0$
(iii) Stator conductor / Field Coil: Copper
(iv) Electrical conductivity: 58MS/m
(v) Field Coil number of turns: 1250 turns.

VII. Results Analysis

Presented here are some of the Synchronous Machine performance characteristics determine in step of post processing when using Finite Element Method. The results are obtained using the software package FEMM version 4.0 are:

? Magnetic field pattern in s ynchronous machine cross section on no load and load conditions.

? Air gap field distribution at no load
? Open circuit characteristics of the salient four pole synchronous machine

The magnetic flux density presented in figure 4(a) is assumed to vary sinusoidal with time around the machine cross section. Figure 4 shows the magnetic flux vector direction emanating from the one pole section to the other forming a loop. This loop will remain fixed in the machine section while the rotor which is attached to shaft will rotate inducing voltage in the stator winding. Figu re 4 shows magnetic flux distribution at the steady stead synchronous operation. Though the load condition is simulated under static mode, but the armature reaction in this case is (cross-magnetizing) i.e. the flux density on the opposite side of the pole to the direction of rotation is higher than that on the other side of the pole. This distribution of force produces the torque acting on the rotor that is opposite to the direction of rotation. The angle ä° between the two vectors also correspond to the angle between the central axis of the pole (direct axis) and the shifted axis of zero flux line shown in figure 4.1 (b). This angle is called load torque angle.

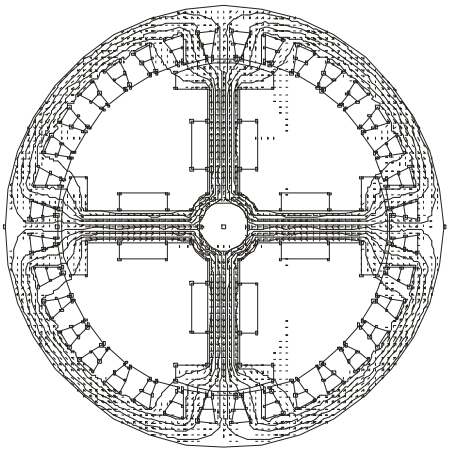


Figure 4(a): *Equipotential (Magnetic flux distribution) at no load, field current I_f = 0.6 Amps. P.u*

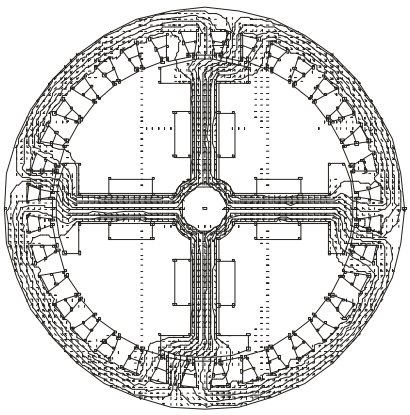


Figure 4(b): *Magnetic Flux Distribution at load condition I_f = 0.6 p.u Amps, Ia = 10 Amps. p.u, Ib = Ic = 5 Amps. p.u*

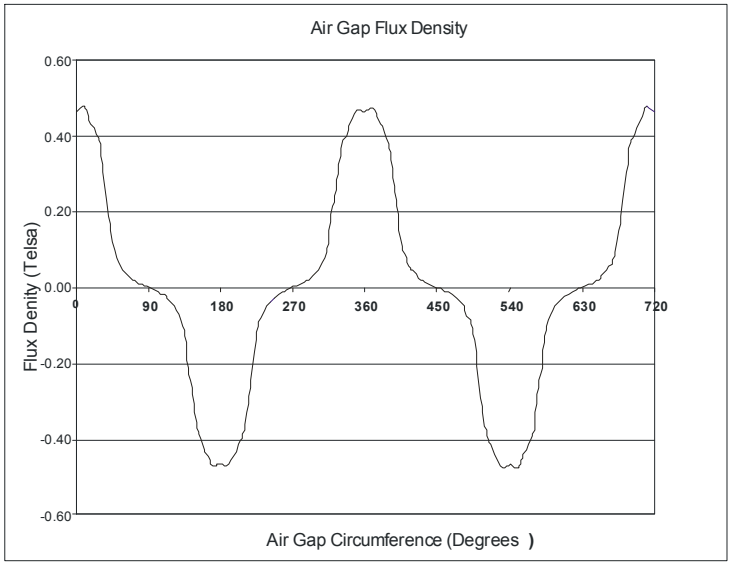


Figure 4c: No-Load Normal Magnetic Flux Density component variation in the air gap at field current I = 0.6A p.u)

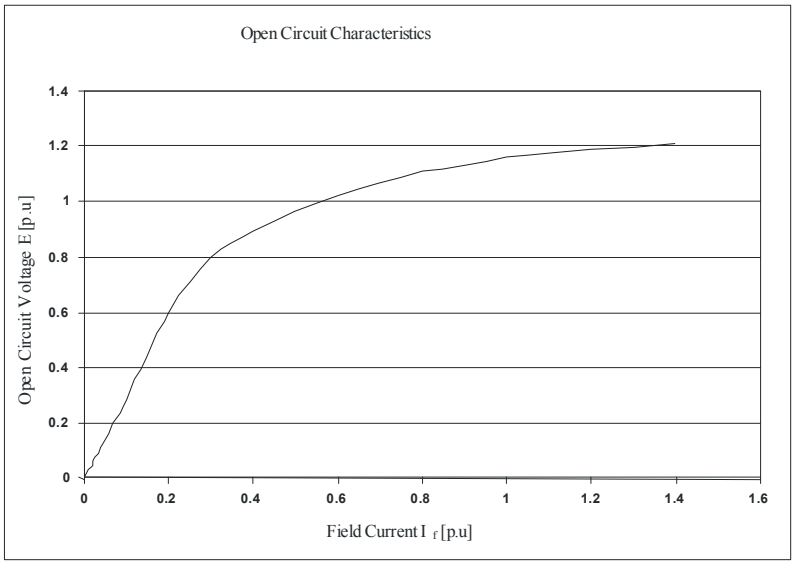


Figure 4d: *Open Circuit Characteristic of Salient Pole Synchronous Machine*

VIII. Conclusion

Computational procedure for finite element method and its application to solve magnetic field problems in salient synchronous machine is presented. The variational formulation for Poisson's equation, which govern the approximating function and functional minimization are presented by using first order triangular finite elements. The result obtained shows two dimensional magnetic field model of salient pole synchronous machine which include normal magnetic flux component variation in the air gap; magnetic field distribution in across section of the synchronous machine on no load and load conditions; open circuit characteristics of salient pole synchronous machine. The open circuit characteristics curve plotted correspond with the conventional curve obtained from typical synchronous machine.

Therefore FEM is an excellent tool for electromagnetic field mapping, which one could obtain electrical machine variables easily, quickly and accurately as compared to other method. Another advantage of FEM is also its ability to deal with complicated geometries such as the magnetic circuit of salient pole synchronous machines.

REFERENCES

Bastos Joao Pedro A. and Sadowski, N., Electromagnetic Modeling by Finite Element Methods, Marcel Dekker, New York, 2003.

Lawrenson, K. J. Binns and Trowbridge, C. W., The Analytical and Numerical Solution of Electric and Magnetic Fields, John Wiley and Sons, England, 1994.

McPherson, G., An Introduction To Electrical Machines and Transformers, John Willey and Sons, New York, 1981

Meeker, D., Finite Element Method Magnetics Version 4.0 User's Manual, 2004.

Okon, P. E., Two Dimensional Electromagn etic Field Mapping of A Salient Four Pole Synchronous Machine, M. Eng. Thesis, 2008

Reece, A. B. J., and Preston T. W, Finite Element Methods in Electrical Power Engineering, Oxford University Press, New York, 2000.

Salon, S. J., Finite Element Analysis of Electrical Machines, Kluwer Academic Publishers, Boston, 1995.

Skilling, H. H. Fundamentals of Electric Waves, Second Edition, John Wiley, New York, 1948.

Tandon, S. C., Richter, E. and Chari, M. V. K, Finite Elements and Electrical Machine Desig n, page 1020-1022, IEEE Transaction on Magnetics, Vol. MAG-16, No. 5 Sept. 1980.