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A study of application of Data Mining in Demonstrating Business Intelligence

A.Mohammed Khalid Kaleem, B .Mohammed Iquebal Akhter

Abstract-- Business intelligence (BI) has been referred to as the process of making better decisions through the use of people, processes, data and related tools and methodologies. Data mining is the extraction of hidden stating information from large databases. It is a powerful new technology with large potential to help the company's to focus on the most necessary information in the data warehouse. This study gives us an idea of how data mining is applied in exhibiting business intelligence thereby helping the organizations to make better decisions.

Keywords-- Business intelligence, data mining, database, information technology, management information system

I. INTRODUCTION

Data mining, is the extraction of hidden stating information from large databases, is a powerful new technology with large potential to help the company's to focus on the most necessary information in the data warehouse [Quinlan J R, 1993]. The tools of Data mining predict the future behaviours and trends and allow the business to make knowledge driven and proactive decisions. The prospective and automated analysis offered by data mining moves beyond the analysis of past events provided by contemplating tools of decision support systems. The tools of data mining can answer the questions of business that were traditionally too much consumption of time to solve. The tools of data mining clean the databases for the hidden patterns, and find the stating information that the experts may miss because it lies outside the expectations. Most of the companies already refine and collect the large quantities of data. Techniques of data mining is implemented rapidly on the hardware platforms and existing software to enhance the value of the consisting resources of information that is integrated with the new systems and products as they are brought online [Fayyad U, 1996].

II. FOUNDATIONS OF DATA MINING

The figure below shows the knowledge extraction process

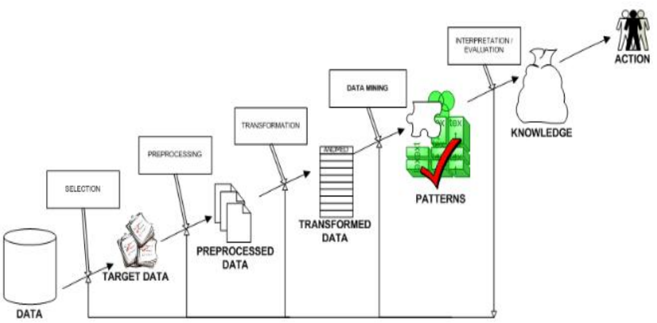

Figure 1: Knowledge Extraction Process

from the available data by application of data mining techniques [Srikant R, 1997].

Data mining techniques are a result of long process of product and research development. This evolution started when the business data was 1st stored in the computers, continued with the improvements in access of data and recently, the generated technologies allow the users to navigate through their data in real time. Data mining takes the evolutionary process beyond the contemplating access of data and navigates to proactive and prospective delivery of information [Berry M, 1997]. Data mining is ready for the application in the community of business because it is supported by 3 technologies that are now adequately developed as the:

- Powerful multiprocessor computers.
- Massive collection of data.
- Algorithms of Data mining [Liu B, 1996]

III. INTRODUCTION TO BUSINESS INTELLIGENCE

Business intelligence is used to refer the number of company activities, which may undertake to collect information about their competitors or their market. Some areas are always included under the heading of business intelligence are: industry analysis, competition analysis and market analysis. Some people also consider the industrial espionage to operate for collection of information purposes to be a form of business intelligence. In most cases, the company will create their own dedicated group of business intelligence or hire outside agency. The business intelligence group will collect information from inside the company about how the company is performing and where the improvements are made. A business intelligence group then looks for outside sources, which include the public records of other business in the same sector, customer survey information and analysis of market by

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third parties. A business intelligence group will drive further into particular competitors, both by examining the business model and public information, in some cases an industrial spy is used to collect the information [Weiss S M, 1998].

The systems of business intelligence are contrasted to more classic forms of collection of information by their interdepartmental focus and their general overview towards the performance of business. They are also different in their use of advanced techniques and technology to crunch and mine the data in most optimal manner. A business intelligence group change the analysis of market have a strong understanding of the specific sector of the market in which business operates, their lack of same detailed understanding about the inner management of the company and particular competitors make their information useful. In the model of business intelligence all the various forms of improvement of business are tied together so that the communication is easy and quick and each segment helps to inform the other segments to be more valuable than they would be their own [Shafer J C, 1996].

A. Importance of Business Intelligence in Organisations

When the companies are seeking cut in cost to regain the margins of profit the intelligent system of software provide better insight of the critical statistics of the data of company, which may be proven as a useful tool to build the future strategies of gain in profit. A company cannot analyze the data within the organization but can perform research market by collecting external data from web interface to analyze the trend with the help of software of Business intelligence. The software for Business Intelligence is the future of any business because it is not only the software but its intelligent system for the business provide total information of the business like personal data, analyze database data, supply chain information, sales marketing activity and customer database etc [Ferias A, 1998].

Applications of Business Intelligence are one of the systems and tools that play the major role in the process planning of business strategy. In addition, it allows the corporation to analyze, store, collect and access the necessary corporate data, which is helpful in the strategy of decision-making. The software for Business Intelligence is covering the areas of business like market research, customer, market segmentation, statistical analysis, profiling, products profitability and customer support etc. Business Intelligence system uses the data from the data mart or data warehouse of business. The corporation or an organization can use the software solution of Business Intelligence for different purposes [Jain A K, 1988].

- Handle the consumer better
- To balance the expense streams and revenue
- Market Research
- Altering levels of staff
- Customer support
- To forecast the sales

Applications of Business Intelligence are used for different support of Management Information System. Business Intelligence helps top-level management for making strategies as the application of Business Intelligence provides some functions [Muller F, 1998]:

- Strategic planning process for an organization
- It performs optimal solution gathering, planning, data mining and data warehousing, financial analysis, etc [Mehta M, 1996].
- It provides critical Decision Support System for organization
- Gathers data from web interface along with Business Intelligence platform
- It runs against all Enterprise Resource Planning data sources

Typical software for Business Intelligence follows certain steps to carry out the meaningful information of data for an organization to use it for future decision-making and prediction.

- Analysis
- Planning
- Prediction
- Execution of reports
- Gathering of legends by AS

Software for Business Intelligence has not become very useful and important only for small organization but also for big software organizations like Microsoft, which admires and supports the support given by the applications of Business Intelligence [Chan P, 1993].

IV. Need for Applying Data Mining in Business Intelligence

Data mining is a process by which raw data or the computer programs analyze large amounts of information. The computer programs employ different types of criteria to decide which information is important, to show the trends and to sort the information. In business intelligence data mining is an essential tool, due to the fact that the understanding trends help the managers to improve the share of market by capitalizing certain trends and avoids negative trends [Augural R, 1993]. Examples of this are:

- Sales Analyzing as per Date: A business use techniques of data mining to maximize the sales by increasing the product availability that sells more during days of the week.
- Analyzing Website Traffic: Website owners analyze patterns of website traffic to determine which advertisements is more effective, based on overall success of the site, click patterns and time spent on each page. This allows the owners of site to remove the ads which improves the overall profitability of website

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ineffective and increases the effective ad campaigns [Haussler D, 1996].

- Analyzing patterns of Foot-Traffic: Owners of Casino uses analytic tools to find the patterns in choice of slot machines. If certain type of style of machine is picked up, regardless of placement, it is likely to be placed again. If certain location is favoured, regardless of the machine, the management uses that information to change the placement of the machines, and ensure that more traffic of gambling goes to more expensive machines. Retail establishment analyzes the patterns of foot-traffic in the store, compared with sales of various items in each location, to make decisions of placement of products [Chen M S, 1996].

The below figure shows the value created to an organization by the application of data mining in Business Intelligence:

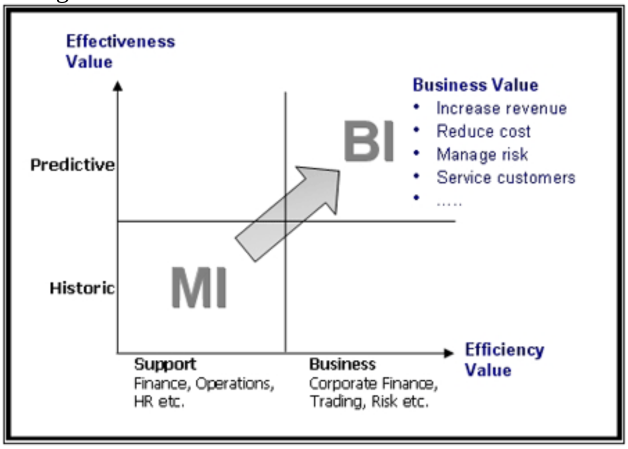

Figure 2: Value created by Business Intelligence

A. The process of using Data Mining for Business Intelligence

Business intelligence is information about company's past performance that is needed to predict the future performance of company. It reveals the evolving trends from which the company may get profit. Data mining allow users to put large amount of available information in data warehouses and it also put the process in which the gems of business intelligence are found [Hand D J, 1998].

Data mining is not a framework or intelligence tool. Business intelligence is drawn typically from an enterprise data warehouse, which is used to uncover and analyze the information about past performance in an aggregate level. Business intelligence and Data warehousing provides a method for the users to foresee future trends from analyzing past patterns in the organizational data. Data mining is more spontaneous, that allows increased insight beyond data warehouse. Implementation of data mining in an organization will serve as a guide to uncover inherent tendencies and trends in the historical information. It also allows for classifications of data, statistical predictions and groupings [Mitchell T M, 1997].

Most companies deduce, gather and refine large quantities of data. Techniques of data mining is implemented rapidly in the hardware platforms and existing software to enhance the value of existing resources of information and can be integrated with new systems and products as they become a part of the system. When it is implemented on high performance parallel processing computer or client/server, tools of data mining analyze large databases to deliver the answers to different types of twist questions [Madigan D, 1996].

Software of data mining allows the users to analyze large databases to solve the problems of business decision-making. The tools of data mining predict future behaviours and trends, allows the business to make knowledge driven and proactive decisions. Data mining is an extension of statistics with few machine learning twists and artificial intelligence thrown in. Like statistics, data mining is not a solution for business it is a technology [Stafford B, 1997].

V. Case Study- Netezza Performance Server

An infrastructure of the Business intelligence company is a great challenge with the demand for analyzing and storing information. It is a technology of patchwork that has piled up for different reasons over a long period. Many flavours of the Database Management System software, is implemented partially as middleware strategy or, as a collection of various assorted disk arrays, mid-tier Symmetric Multiprocessing server and myriad applications of end-user depending on various communication and database standards. Costly system administrators and databases that are fighting to keep up with the demands of user hold this technology of patchwork together. As much information is added to existing systems, they are becoming unreliable and decreasing dramatically. The initiatives of online such as analyzing and capturing click stream data, threatens to defeat the infrastructure entirely. As the demands of Business intelligence and customer growth of data the Vice President of the Netezza Company, the CIO and the Customer Knowledge Management are facing costly systems administrators and DBAs make multi-billion-dollar investments in software, networking and storage and hardware to lose battle to maintain the present levels of performance [Website. Download 101].

This situation is common for 2000 companies across many industries. Over the past few decades, high profile initiatives of management strain the present infrastructure with their need for access to data across the enterprise are:

- Operations management
- Customer Relationship Management
- Enterprise Resource Planning
- Supply Chain Management
- Partner Relationship Management.

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With all these stresses on the present infrastructure of Business intelligence it is not surprised that many technical pain points and business has evolved:

- Slow access of information inhibits spontaneous queries, which results in lost opportunities.
- Complex reports and queries require days or even hours to process.
- Speeds up processing, and the data are summarized and sampled limited analysis of depth.
- Collecting useful information requires training. A person who needs the data are not the same people who runs the queries. This results in lost opportunities and creates bottlenecks in the organization.
- Produces predictive models that is critical and often requires statistician's staff.
- Scalability suffers growth in databases beyond 100s of gigabytes.
- Costs increases discontinuously and unpredictably and the performance remains poor.
- Loading of data is painful and slow and requires medley of tools of Extract Transform Load tools;
- Queries run on outdated information yielding inaccurate and misleading results.
- Combining or standardizing data is difficult and time-consuming because data is held on different legacy systems and formats [Website. Download 101]..
- Analysis of data marts from large warehouse data extract data is critical to achieve in an acceptable frame of time.
- Teams of system administrators and database are required to tune queries and systems to achieve acceptable performance.

The below figure shows the multiple sources which contributes to the stresses of infrastructure of Business intelligence:

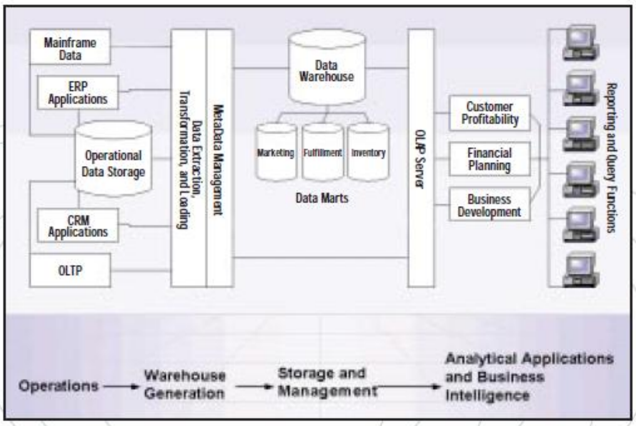

Figure 3: Existing BI Infrastructure

VI. Future infrastructure of Business intelligence

Today, new platform of Business intelligence is needed to revitalize and rationalize the existing infrastructure. In today's business environment this new platform of Business intelligence provides a foundation for the growth of exponential data. It merges large parallel software and hardware and storage, which focus directly to provide optimal scalability and response times at the terabyte level. The new platform of Business intelligence eliminates yesterday's patchwork of storage, hardware and software, and enables optimized access to information. As technical and business demands continue to change and grow in the new century, the new platform of Business intelligence is designed to scale with the need, scope and performance and size of data. And it does all this in a predictable and affordable price [Website, Netezza].

The below figure shows the Netezza Performance server:

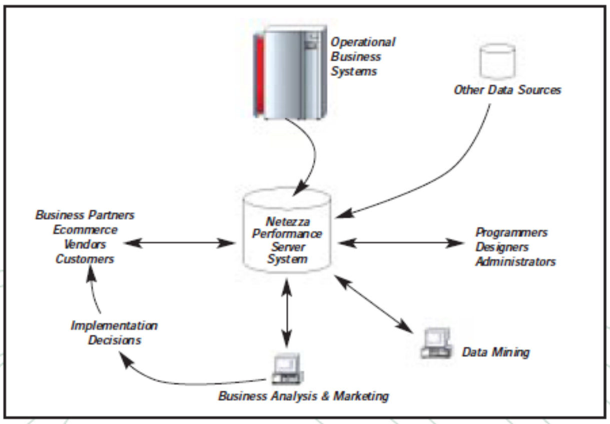

Figure 4: Netezza Performance Server Architecture

The new platform of Business intelligence offers large parallel processing, scalability and open architecture and allows growing without painful integrations of new systems or complex upgrades.

The Netezza Performance server of 7000 series is the realization of the new platform of Business intelligence. The Netezza Performance server system is an enterprise-class data warehouse appliance that delivers ease-of-use and breakthrough performance in a fraction of cost of traditional data warehouse. The Netezza Performance server appliance offers:

- 20 to 60 times the performance of existing data warehouse systems is half the price and finally affordable solution to users of business performance needs.
- Tight integration of database components, storage and server is largely parallel architecture that provides complex analysis and reports and rapid optimized execution of interactive queries.
- Extreme reliability and ease-of-use and a part-time DBA that requires to manage the system.
- Self-tuning data storage, real-time data loading and high throughput on complex and large workloads.

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- Straightforward integration, through open Application Programming Interfaces with all main elements of the Business intelligence environment: Business intelligence tools and applications, Enterprise Application Integration and Extract Transform Load tools, data sources and legacy systems [Website, Download 101].

ACKNOWLEDGMENT

We are thankful to our Professors with whom we had useful discussions regarding data mining and business intelligence. Any suggestions to further improvement of this topic are most welcome.

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Design and Implementation of Mobile and Internet Product Access Information and Its Administration System

Yoong Cheah Huei, Lim Chin Wee, Koh Zheng Kang and Nelson Chin Rong Jie

Abstract - Internet has become a ubiquitous access to information. Mobile smart phones are becoming popular today as well in the area of interactive information retrieval. Many applications are developed on these mobile intelligent machines. This paper presents the design and implementation of a seamless distributed product access information system that can be accessed through Internet and/or Google Android smart phones. The system uses a hybrid approach of master-slave and peer-to-peer communication models. This system may help to increase business activities in an area because consumers can access to more information about products that they are interested to purchase anywhere with Internet connection and any time. In addition, these customers are able to know about shops that sell a particular product, including the price and the shops addresses. This might help to save their shops hunting time. The main purpose of the administration system is to help the administrator manage the system.

Keywords: Distributive product access information system, Google Android smart phones, Internet access

1. INTRODUCTION

INTTERNET can be accessed through desktops, notebooks, smart phones, and other electronic equipment. Recent advancement in mobile and wireless technologies has made possible the creation of applications on smart phones that were not possible ten years ago. Smart phones have become ubiquitous as latest and less expensive models with more and advanced features are built into the phones. Smart phones have become pervasive as people can always access information, anytime and anywhere. Hence, useful application will continue to be developed on them, especially those that can help to increase business activities and improve human life.

At present, it is easier to develop software applications on platforms supported by vendors like Google, Apple, Microsoft, and Nokia. The mobile product access information (PAI) distributed system reported in this paper is developed on Google's Android platform because the platform adopts an open source strategy which gives more flexibility to developers. This distributed system can also be access through Internet via smart phones, desktops, or notebooks.

Some research work on mobile phones like software test framework [1], middleware for building mobile applications [2], enhance mobile phone usability through personalization at user interface [3] and integration of different technologies [4], mobile applications in education [5], performance study of mobile applications [6], and applying context-aware technique in mobile applications [7] have been reported in the literature. In addition, specific software applications on mobile phones, for example SMS on demand [8], a type of wafer packaging system [9], and a wireless news browsing application [10] were developed. On Android platform, location-based mobile service [11], safety functions in vehicles [12],

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and global positioning system [13] were implemented.

A lot of research has been done in the area of web based information system like in manufacturing [14-15], shopping [16-18], education [19] and shares [20]. In the area of web based distributed system, there are work published in web service [21-27], in particular the mobile transaction management system in a distributed environment [26], where heterogeneous of computer systems and synchronization and control of operations are issues, and mobile agent-based Internet commerce system [27] that analyses number of agents to contact for price comparisons.

In this paper, we present the design and implementation of mobile PAI distributed system developed on Google's Android and Internet platform and its administration system, which resides in the server. Our system employs a hybrid approach of master-slave and peer-to-peer communication models. The main purpose of the PAI system is to assist consumers make an informed decision whether to purchase a particular product. Furthermore, this system helps consumers, in particular mobile consumers to search for shops that sell a particular product so that they can save product hunting time. The administration system is to help the administrator manage the PAI system.

A typical scenario is described as follows. Every year millions of visitors visited Singapore. One of the main tourist attractions is the shopping paradise of Orchard Road which offers major departmental stores like Paragon, Ngee Ann City, and Far East Shopping Center, and many retail outlets that sell wide variety of electronic goods. Very often, tourists require more information about a product before making an informed decision to buy it or would wish to know shops that sell a particular product. Assume that the PAI system is installed in a mobile phone that runs on Android platform. A tourist can then access the required information from a nearby server via a wireless router. If the requested information is not found in that server, the system will automatically communicate with an adjacent server via a wireless router. This continues to happen in the background until the information is located. Once the information is found, it is transferred back to the original server and then to the requestor. Another scenario is that a tourist carrying any smart phone can access the PAI through Internet.

The rest of the paper is organized as follows. Section 2 presents the tools, development languages, and overview network architecture. Section 3 briefly describes the design method used which includes the high level framework of PAI distributed system and its administration functions. Section 4 briefly explains the implementation of the entire system. Section 5 concludes this paper.

2. TOOLS, DEVELOPMENT LANGUAGES, AND OVERVIEW NETWORK ARCHITECTURE

The following software tools are employed to develop the distributed database systems: Eclipse 3.5 Galileo Integrated Development Environment with Android ADT plug-in, including Dalvik Debug Monitor Server, Adobe Fireworks, Droid Draw, Dreamweaver, Photoshop, and XAMPP. The system is written with the use of JAVA, XML, HTML, and PHP programming languages.

Figure 1 depicts the overview distributed network architecture for the systems. The clients can be Android phones, notebooks or desktops that run a Google smart phone simulator, Internet Explorer, or Firefox

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software. Each client is able to access the XAMPP database located in any of the three servers via a wireless router or a switch. The client may be connected to a wireless router using a wired or non-wired connection. Every client can access to Internet through the server which is connected to the Ngee Ann Polytechnic network center, located a few floors below of an adjacent building.

A gateway is given a unique Service Set Identifier (SSID) or unique network name in order to prevent duplicate names from nearby wireless router. This is to prevent consumers from joining the wrong network. The default gateway Internet Protocol (IP) address is of class B which is 192.xxxx.xxxx.xxxx. In the wireless router, the broadcast of SSID is set to enable (Refer to Figure 2) so that mobile users are able to search and then join the network. In order not to degrade the performance of the network, the maximum number of users connected simultaneously to the network is configured. The server IP address is reserved so that it does not have a different address each time the network is build up. However, Dynamic Host Configuration Protocol can be initiated to get automatic IP address for the server.

.

3. DESIGN

3.1 High Level Framework of Android Phone Access

Figure 3 shows the high level framework of PAI and its administration system. The system is divided into two main parts. The first part is the PAI software that resides in a smart phone that runs on Google's Android platform. This software consists of three main functions – bookmark, browse, and search. The bookmark feature gives users the flexibility to mark frequent or important information so that it can be retrieve quickly and easily. The browse function allows users to list all the items or shops. The search function gives users the option to perform a full or partial name information retrieval from the database via the wireless router. Users can then select the particular item and more information about it is displayed like the price, background information, and shops that sell it. Users may do a shop search to get a list of shops and their addresses and contact numbers that sell a product in that shopping area. Feedback to the administrator can be generated through the administration function in the search module.

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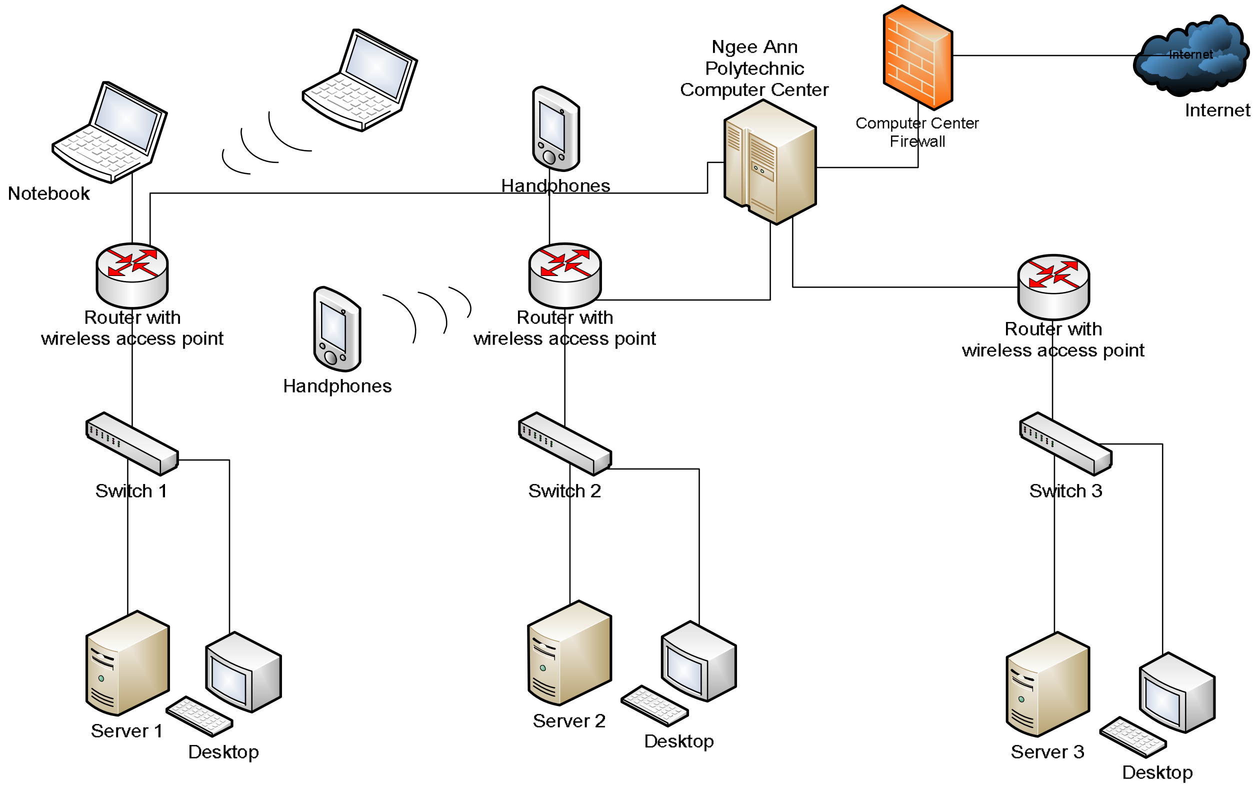

Figure 1. Overview Distributed Network Architecture

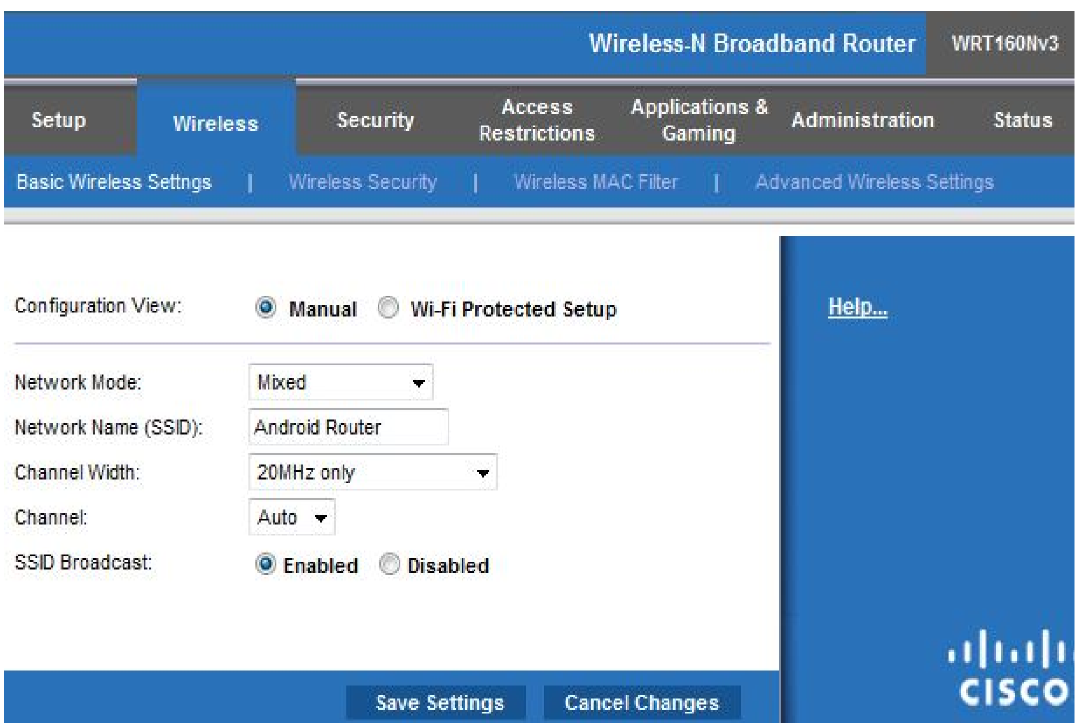

Figure 2. Set SSID to Broadcast Mode

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The second part is the PAI administration system which is installed in the server. The administration module allows the administrator to add, delete, and update products information to the database. The inventory module allows the number of stock of a product to be updated when necessary. This information gives clues for reordering of a product. One of the functions of the account module is to provide total revenue generated for a particular product during a given period. The search module provides a full or partial search for a particular product. The shop module lists shops that sell a particular product.

The XAMPP is located in the server but the SQL Lite database resides in the phone that runs on Android platform. If the information is not found in a XAMPP database, a search is conducted in an adjacent database via a wireless router.

3.2 High Level Framework of Internet Access

The high level framework (Figure 4) is similar to Figure 3 except the user features reside in a server and can be accessed by any smart phone, desktop or notebook through Internet.

3.3 Some Parts of Overview Design and Process Flow Access by Android Phone or by Smart Phones/Desktops/Notebooks

The main modules for PAI and its administration systems were identified and relationships among them were known.

Figure 5 gives the overview of the PAI Design. The XML scripts are generated to present the user interface and capture commands from users. Then the commands are configured so that the correct database is accessed through the activation of relevant PHP script files.

Figure 6 illustrates the process flow of browse shops. The user interface displays the list of shops. If a user selects a shop and the system will depict information about it, in particular the address and contact number. Otherwise, continue interaction with the user is activated.

Figure 7 displays the overview of administrative management system design. The GUIs are written in HTML, specifically to capture user inputs. The command initiates the correct PHP script files so that the database access may be invoked.

Figure 8 exhibits the administration process flow. A user has the option to add product records, update existing product records or delete an existing product record.

Figure 9 shows the high level distributed database query processing. The communication between servers and databases is built using a hybrid model of master-slave and peer-to-peer communication models.

The master-slave similarity procedures are explained as follows. Every time a device request information from the system, the request is only sent to one of the many servers, in this context the master server. Residing in the master server is also a complete list of all the servers and databases that is in the domain of the system, the slave servers. Every time the request is received by the master server, it would call its own database and process the request, adding all the results found into a result set. After which the master server will proceed to call the slave servers according to the list and pass on the request. Currently this procedure uses a linear

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algorithm to process the list as the list is small and it is a product in development. It can be edited to use a parallel algorithm to speed up the processing if the server list is large. All the search results found will be accumulated to the same result set. Once the list is exhausted, the result set will then be returned to the device that sends the request for further processing.

Next, the P2P similarity procedures are described. Some components of the system such as the server scripts and the news bars are not dependent on databases but instead store their information directly on the server. As the system final design is centered on efficiency, the closest server to the client will be deemed as the master server, the rest slaves. Thus changes made on one server will be required to be reflected on all servers as the master server will change depending on where the system is being accessed. As the system will be broad and servers scattered over different areas and each having different administrators, the easiest and cost/resource efficient method to deploy updates and changes would be to use P2P model. As per the client's request, the database will still be isolated from each other but scripts and web pages updates will be deployed in this manner. When changes are made in one of the servers, it will send out the new copy to servers closest to it. Upon receiving the new files, the servers will pass on to the next closest server and this continues till all the servers have the new files and the files are synchronized with one another. This deployment saves bandwidth and manpower resources as it is dynamic and changes made will be reflected within the entirety of the system in the shortest time possible.

4. IMPLEMENTATION

The top down approach is used to write the software codes for the whole system. First, the user interface was developed and tested. Then the main module was coded. The scripts files were parsed by the application modules. The key obstacle was passing correct information between modules, especially between databases. Figure 10 presents the access to the PAI system through Android phone. The smart phone can access to Internet by clicking the browser button. Figure 11 depicts the front page of the PAI system which we call Android Search-A-Ble. This system is coded using JAVA and resides in the phone. The coding Search-A-Ble by Internet is similar to Android Search-A-Ble except that it is developed using PHP instead of JAVA and resides in a server. Figure 12 shows the main page of the Android Search-A-Ble administration management system which resides in a server. This system and the communication between databases are developed using PHP. There were about 1000 lines of code written and complied for the entire system. System testing was carried out successfully. The response time of a user request using Search-A-Ble that resides in the Android phone is much faster than the Search-A-Ble that stores in the server. The reason is because the software is already being processed and ready to execute user commands. However, the Search-A-Ble software for Internet access does not constraint to Android phone only but can be used by any smart phones, notebooks, and desktops that run Internet Explorer or Firefox software.

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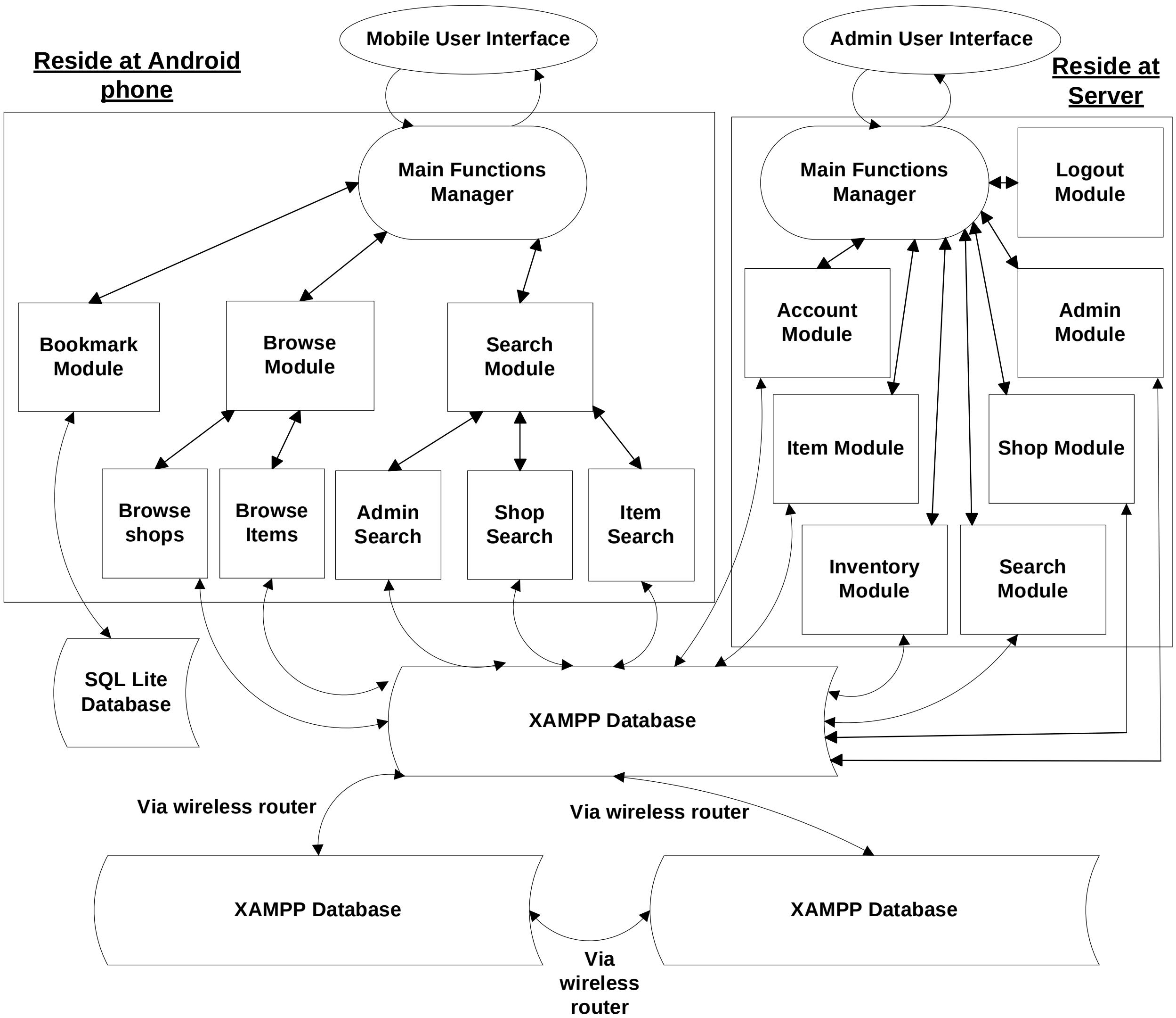

Figure 3. High Level Framework of PAI and its Administration System Access by Android Mobile Phone

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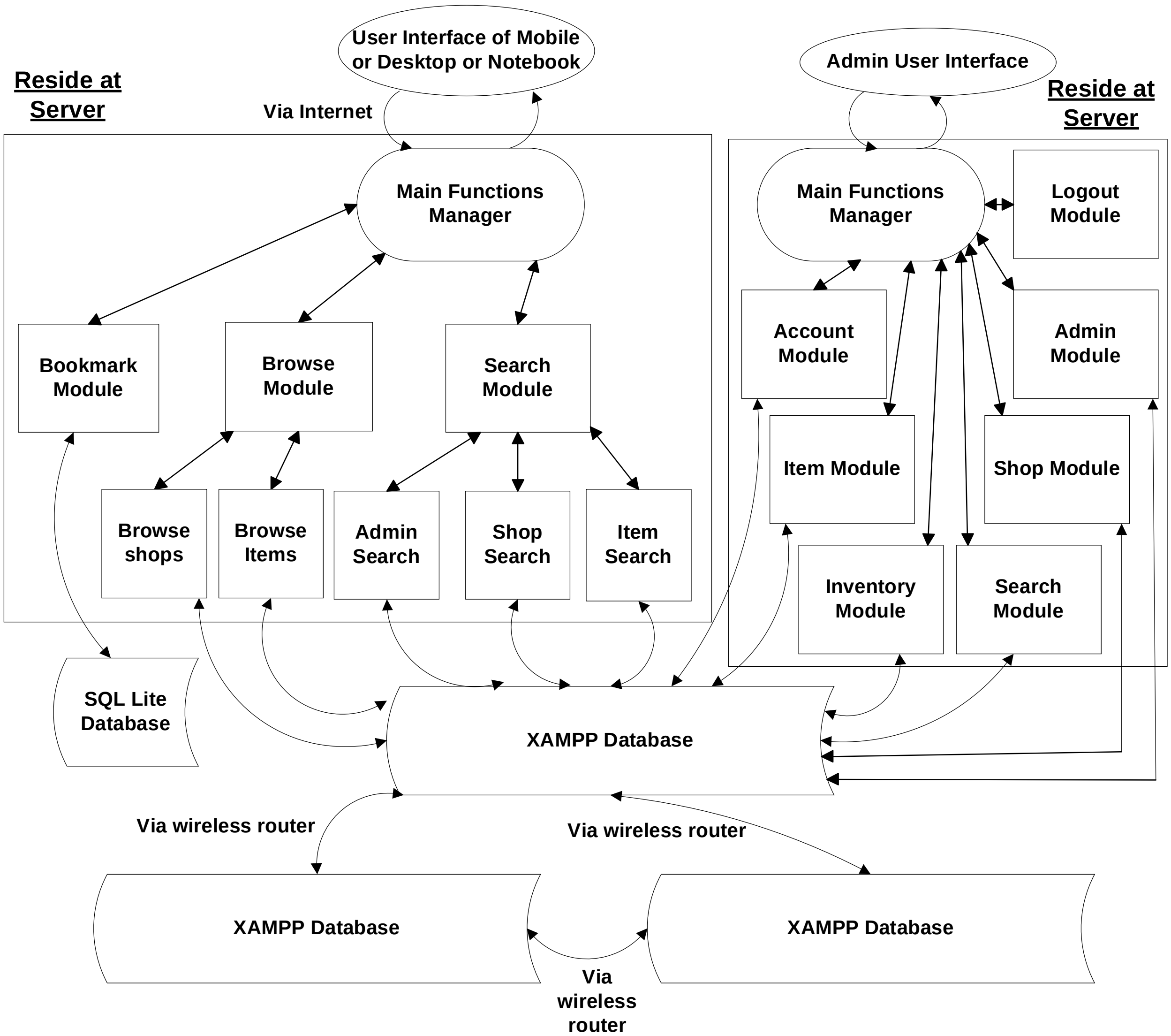

Figure 4. High Level Framework of PAI and its Administration System Access by Smart Phones, Desktops or Notebooks via Internet

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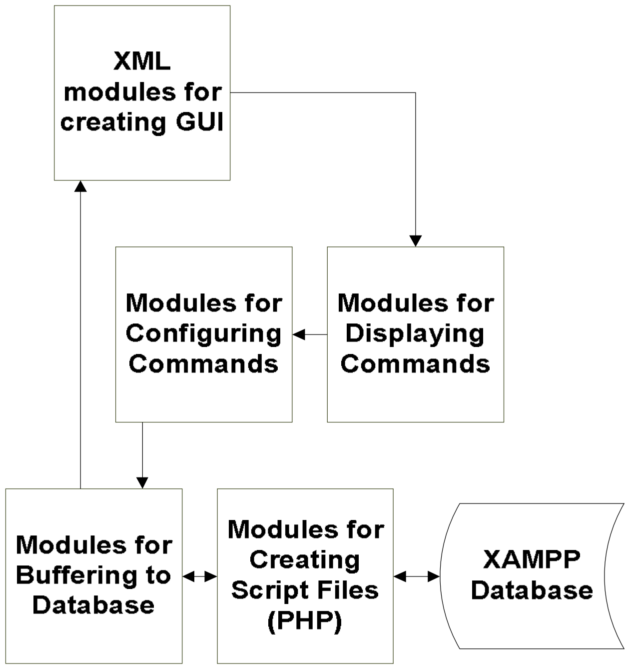

Figure 5. Overview of PAI Design

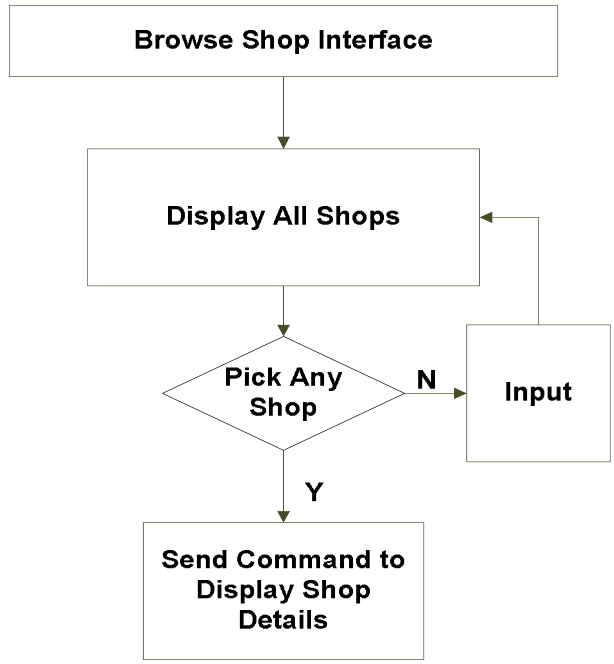

Figure 6. Browse Shop Process Flow

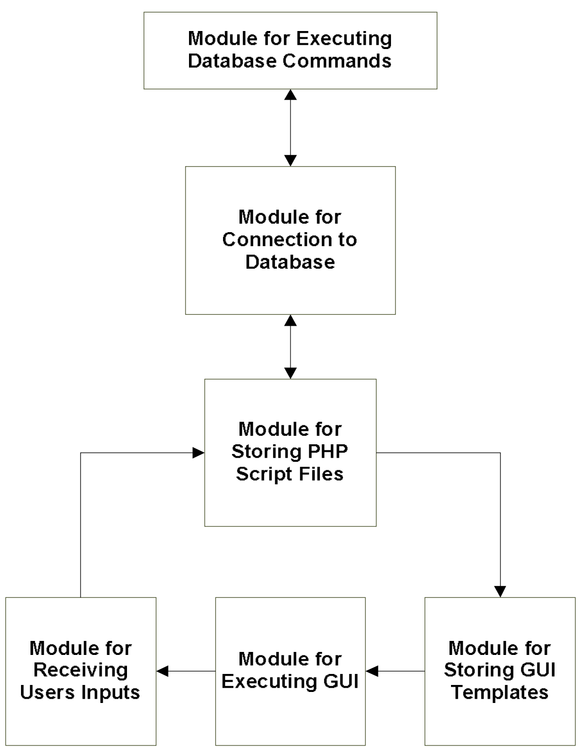

Figure 7. Overview of Administrative Management System Design

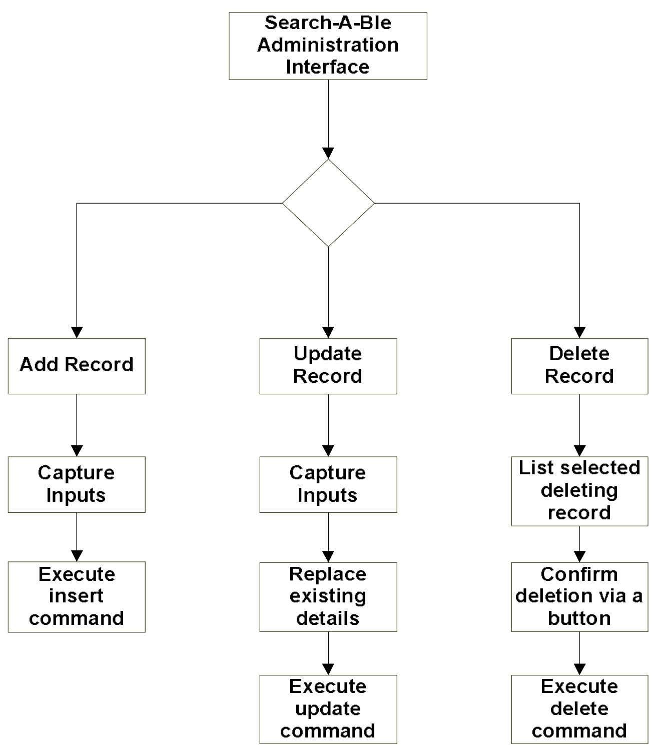

Figure 8. Administration Process Flow

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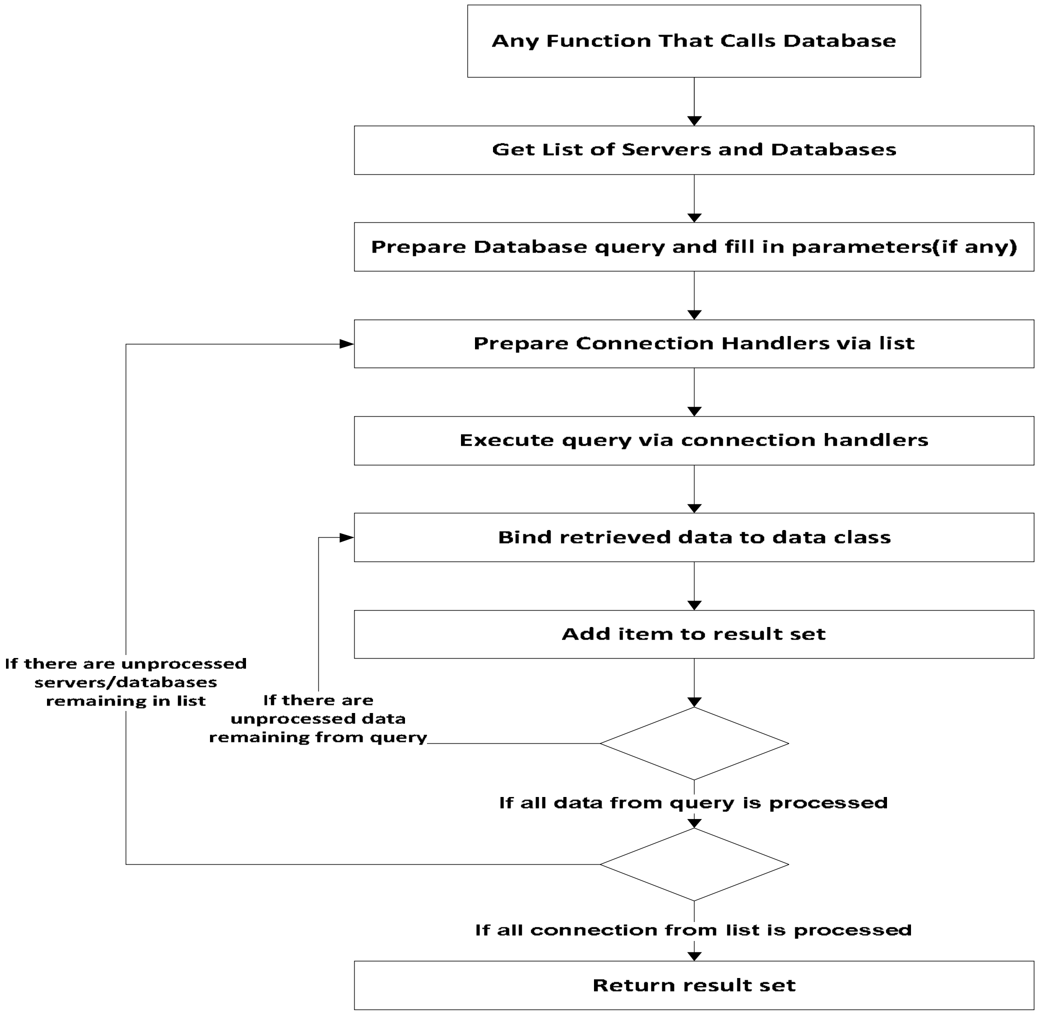

Figure 9. Overview of Distributive Database Query Processing

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Figure 10. Access to PAI system

Figure 11. PAI system functions

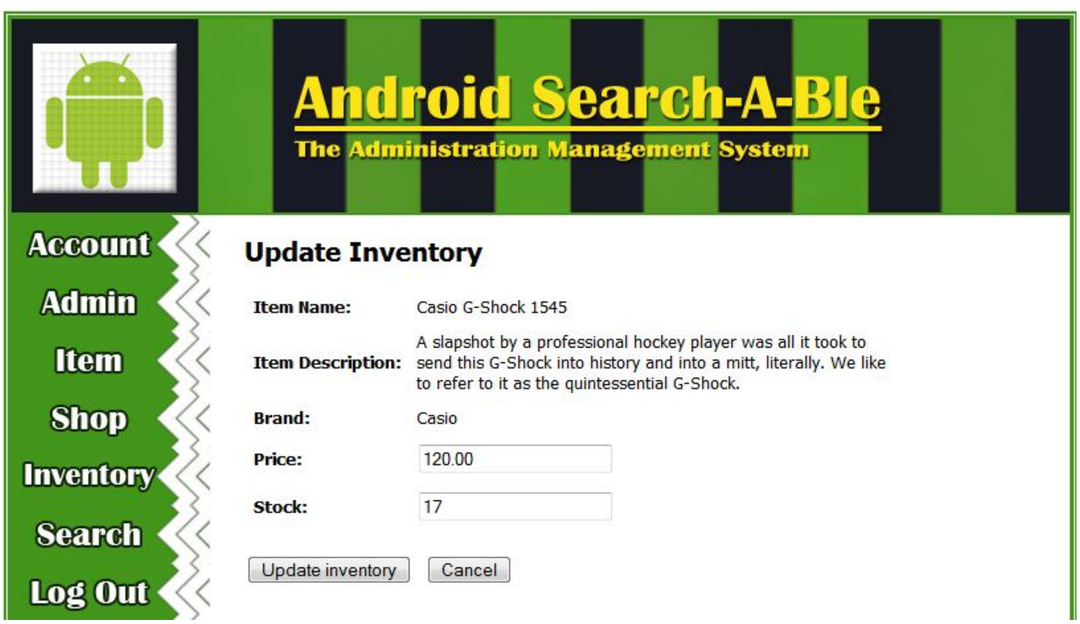

Figure 12. Administration Management System Features

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5. CONCLUSION

In this paper, the design and implementation of the PAI distributed system and its administration system that can be accessed by any smart phones, desktops or notebooks have been presented. The systems were written in Java, PHP, XML, and HTML programming languages.

The main purpose of the PAI distributed system is to help increase business activities in an area because consumers can access to more information about products that they are interested to buy before making a purchase decision. Furthermore, this system can help these consumers to save their shopping time as they can locate the places which sell particular goods. The major objective of the administration system is to assist the administrator manage the PAI system.

Acknowledgement

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Optimized AES Rijndael implementation on embedded controller R8C

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Abstract— Advanced Encryption Standard (AES) Rijndael algorithm has gained popularity as it is deployed in various embedded systems. Realization of AES algorithm on microcontroller with minimum memory will be useful for deploying it in low cost applications. R8C microcontroller from Renesas is one of the popular microcontrollers in industrial application, being low cost and versatile processor having all peripherals like three UART, three timers, SSU, I^2C, LIN, USB, 10 channels ADC with operating frequency at 20MHz. This paper discusses the implementation of AES on R8C controller its speed and memory requirement for the same.

Index Terms—R8C microcontroller, AES Rijndael, optimization.

1 Introduction

Microcontroller can be used in a wide range of applications, such as industrial control, monitoring, communication interface in wireless sensor network for environment monitoring and battle field ad-hoc network [1]. The 8/16 bit microcontroller with their limited ability in computation and power, the security is the one of the most important issue for these applications. With limited computational ability the cryptography algorithm when implemented not only consumes CPU time but also the precious memory area both program and data memory. The AES Rijndael algorithm is one algorithm which can be implemented on all types of microprocessor because of its basic design flexibility in block, key size and number of rounds. Rijndael's internal round structure has instruction-level parallelism and hence implementing on hardware is very easy [1, 2].

1.1 What is Rijndael?

AES is a block cipher developed to address the threatened key size of Data Encryption Standard (DES). AES-Rijndael was developed by Joan Daemen and Vincent Rijmen, Rijndael [4, 5] and was selected from five finalists namely; 1. Mars Developed by the IBM team that developed Lucifer; 2. RC6 Developed by the RSA Laboratories; 3. Rijndael Developed by Joan Daemon and Vincent Rijmen; 4. Serpent Developed by Ross Anderson, Eli Biham, and Lars Knudsen; 5. Two fish Developed by Counterpane Systems (upon the parameters such as security, performance, efficiency, flexibility, and implementability) by NIST as the Advanced Encryption Standard (AES) replacing DES and published as FIPS 197 in November 2001 [5]. It is a symmetric block cipher that can process 128 bits message blocks and 128, 192, and 256 bits key lengths. Both hardware and software implementation of AES-Rijndael are more attractive.

Following is the convention used to describe the operations in this paper.

- **Nb**: input block length divided by 32
- **Nk**: key length divided by 32
- **Nr** : number of rounds
- **State**: the intermediate cipher result
- **Sub state**: 8 bit, divided unit of state, if block length is 128-bit, it has 16 sub state of 8-bit
- **GF**: finite field, Galois field

	Block size in words N_b	Key length in words N_k	Number of round N_r
128-bits key	4	4	10
192-bits key	4	6	12
256-bits key	4	8	14

Table1. Number of key bits v/s number of round

The block length of plain message is 128 bits divided by 32 results in 4 words and key length can be extended by multiples of 32 bits. Moreover the operation is based on 8 bits size of sub state, which gives 8/16 bit processor the highest advantage to implement it by writing algorithm

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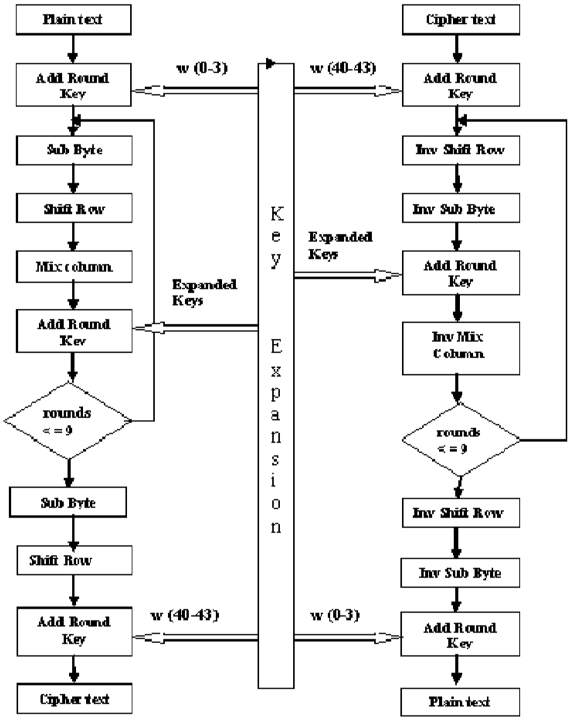
in both assembly and high level langue. The AES algorithm basically consists of four byte oriented transformation for encryption and inverse transformation for decryption process namely [1],

a) Byte substitution using substitution box table. (S-box):

b) Shifting rows of the state array using (Row transformation)

c) Mixing the data within each column of the state array. (Mixing columns)

d) Adding a round key to the state. (Add round key)



Encryption Decryption

Figure 1 Structure of AES Rijndael algorithm

The figure 1 shows AES Rijndael Encryption and Decryption structure, where plain text input to the encryption and cipher text input to the decryption algorithm is 128 bit block. The key provided is expanded into an array of forty - four 32bit words, w[i]. Four distinct words forming 128 bits serve as a key for each round in both encryption and decryption. In encryption process first four words w(0 – 3) are used as key in the first round but for decryption last four words w(40 – 43) are used in the first round.

1.2 BASIC OPERATION OF AES RIJNDAEL

1.21 Byte sub operation

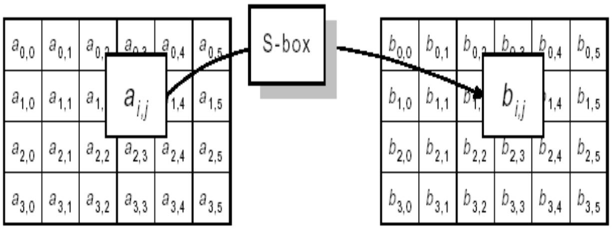


Fig2. Sub Byte operation

The ByteSub transformation is a non-linear operation which takes 8-bit sub state as its input and produce same size next sub state. The output is predetermined value defined at S-box which takes 16 by 16 byte of memory [1].

1.22 ShiftRow operation

In ShiftRow, the rows of the State are cyclically shifted over different offsets. Row 0 is not shifted; Row 1 is shifted over C1 bytes, row 2 over C2 bytes and row 3 over C3 bytes. The ShiftRow transformation is individual to every last 3 rows of the state. Each of the three rows shifts by all different bits which decided by block length [1].

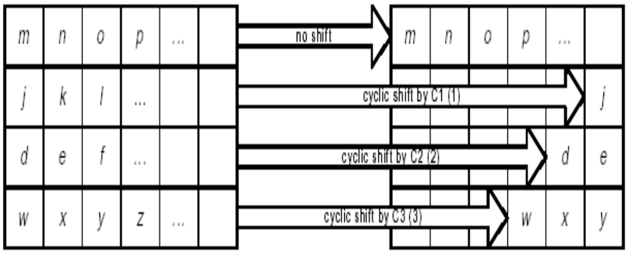


Fig3. ShiftRow operation

1.23 MixColumn operation

In MixColumn, the columns of the State are considered as polynomials over GF (2^8) and multiplied modulo $x^4 + 1$ with a fixed polynomial c(x) [1]. The MixColumn transformation operates independently on every column of the state and treats each sub state of the column as term of a(x) in the equation $b(x)=c(x)\otimes a(x)$, where c(x)= '03'X^3+'01'X^2+'01'X+'02'.This polynomial is coprime to (X^4 + 1) For example, in the fig4. a(x) is $a_{0,j}X^3+a_{i,j}X^2+a_{2,j}X+a_{3}j$ and it is used as multiplicand of operation.

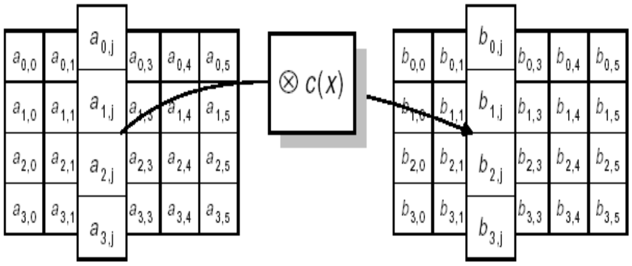


Fig4. MixColumn operation

1.24 AddRoundKey operation

The AddRoundKey operation is simply a bitwise EXOR of roundkey and state. The Round Key is derived from the Cipher Key by means of the key schedule. The Round Key length is equal to the block length **Nb**. The figure 5 shows Add round key operation.

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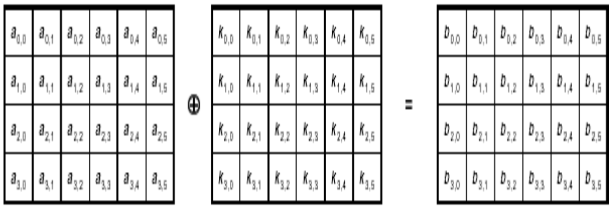

Fig5. AddRoundKey operation

2 RELATED WORK

Rijndael can also be implemented very efficiently on a wide range of processors and in hardware. Rafael R. Sevilla implemented by 80186 assembly and Geoffrey keating's Motorola 6805 implementation is also available on Rijndael site **[3].** During the evaluation process the all five finalist algorithms were evaluated for the hardware implementation including 8 bit processor 8051. Number of works has been published in this regard by various people. R8C micro controller an industrial standard processor was not used for AES Rijndael implementation. This paper discusses implementation of AES with optimized memory without compromising on speed of the system.

3 IMPLEMENTATION

3.1 Renesas R8C Controller

The R8C/Tiny Series of single-chip microcomputers was developed for embedded applications by Renesas. The R8C/Tiny Series supports instructions tailored for the C language, with frequently used instructions implemented in one-byte op-code. It thus allows development of efficient programs with reduced memory requirements when using either assembly language or C. Furthermore, some instructions can be executed in a single clock cycle, enabling fast arithmetic processing.

R8C has features like CPU core operating at 20MHz, on chip ROM,RAM, and data Flash memories, programmable I/O ports, 9 interrupts with 7 priority levels, 14 bit watch dog timer, 3 timers, 4 UARTs, synchronous communication port, I^2C bus, LIN module, USB, 10 channel 10 bit ADC and 2 comparators which makes it most preferred industrial application microcontroller.

For implementation on R8C microcontroller, Renesas High performance Embedded workshop V.4.07.01 with simulator version 4.1.04.00 which is provided by Renesas was chosen for convenience. It provides integrated development environment composed of compiler and simulator also. Every cycle number and code size output depends on embedded workshop. Every design decision is tradeoff between speed and code size.

3.2 ByteSub operation

Byte substitution can be done in the two different ways. First, taking the multiplicative inverse in GF (2^8) and '00' is mapped onto itself. Then, applying an affine (over GF(2)) transformation defined by 8 by 8 matrix, produces the output. This approach needs sacrificing of speed because of several numbers of extra operations. Whereas the other way using S-box gains speed but loses the code size for storing S-box on the memory. In this implementation S-box approach was chosen.

3.3 MixColumn operation

MixColumn operation needs a certain number of multiplication operations on GF (2^8). Every finite field multiplication can be done using tables, Logs and Antilog tables. Like ByteSub operation, using table need more memory space while increasing speed. Especially, in MixColumn operation, multiplicand is confined as '01', '02', and '03', which means '01' and '02' multiplication can provide the clue for '03' multiplication. Therefore to exploit this special feature, direct multiplication approach was chosen instead of using tables.

3.4 Storing state

Repeated round comprises 4 different transformation. Each transformation need state as its input and produce output as new state. Such data transaction between each state and register executed very frequently. Also for arithmetic and logic operation the operand, each sub state should stay at register. Therefore the storing state issue is very critical. If the state stays at memory it is easier to fetch each 8-bit sub state from memory to register with indirect address register A0 and A1. However this approach need more cycle consumption because from/to memory to/from register transaction need 2 cycles each, which is twice as much as from/to register to/from register scheme. If all sub state can be stored at registers, the memory will be referenced only for round key and S-box, which is impossible to be stored at registers.

4. SIMULATION RESULT

Code was run on the Renesas High performance embedded workshop V.4.07.01 with simulator version 4.1.04.00 with test vector from Brian Gladman's technical paper [5]. The implementation was optimized many times. From many versions of implementation, two simulation results are proposed depending on the storing state issue. The one stores the state at memory and the other at registers.

Module	Cycle	Code (Byte)
Precomputation	2178	1649
ByteSub	115	32
ShiftRow	51	256
MixColumn	201	134
AddRoundKey	127	48
branch	19	12
Total	8276	2135
(round0-10)	5917	784

Table2. Simulation result of memory version

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The total number includes consideration of the number of rounds. In this implementation, the block and key length are 128-bit each. Therefore 10 rounds constitute one encryption procedure. In the 10 rounds of encryption procedure, precomputation is executed just once which gives weight factor 1, and other modules have all different execution times as in Cycle column of the Table2. Whereas, code length weight factor is irrelevant with cycle number weight factor because some modules are reused every time while the other modules are not. For example, AddRoudKey module executed at round0, round1-9 and round10 but MixColumn executed only at round1-9, which makes the different code weight factor 3 and 1 respectively.

Module	Cycle	Code (Byte)
Precomputation	1	1
ByteSub	10	2
ShiftRow	10	2
MixColumn	9	1
AddRoundKey	11	3
branch	1	1

Table2. Weight factor of each module

With weight factor total number of cycle and code are computed by equation below.

Total cycle number =
$\sum$ Cycle number(i) * weight factor(i)

Total code size =
$\sum$ Code number(i) * weight factor(i)
Where i is every module

The round0-10 number is pure execution number, which excluding precomputation feature. Because precomputation is composed of S-box input to memory, key input to memory, key expansion and data block input, these phases happens just once in the whole life time of sensors. Once done precomputation can be reused afterward if there is no key update and S-box update. For data block input, it can be assumed as initially staying at special function register, beforehand.

The Table3 shows much improved result after storing state at registers. The improvement is 44% and 41.9% in the cycle number and code size respectively.

Module	Cycle	Code (Byte)
Precomputation	2178	1649
ByteSub	42	56
ShiftRow	15	28
MixColumn	196	96
AddRoundKey	45	60
branch	36	10
Total	5863	1552
(round0-10)	2615	329

Table3. Simulation result of Register version

5. Evaluation

The fully registered implementation produced remarkably improved output as at table4 and table5. Trivially increased time consumption at branch module stems from complicated register assignment scheduling. This sacrifice makes utilization percent of register nearly full, which means most of the data transactions happen between register and register. The MixColumn module is still takes much part of cycle number. This module is also the critical part for register scheduling because it need four multiplication with four different sub state at the same time while keeping their initial state. Therefore indirect address registers was used temporarily for normal operations. For other modules the utilization of register is slightly over 50%, which gives more possibility to improve the efficiency. Table5 shows size improvement after storing state in the register.

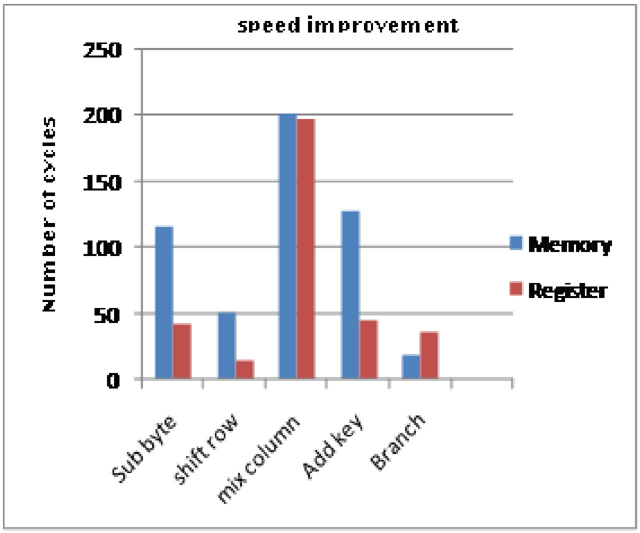

Table4. Speed improvement by register

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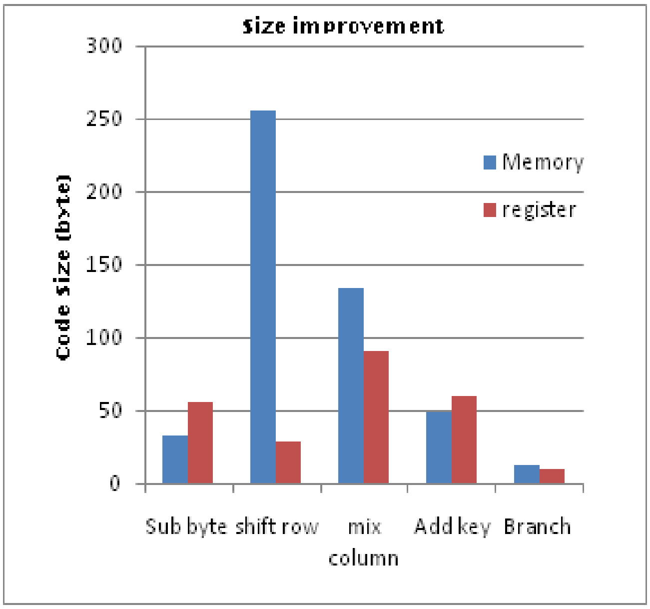

Table5. Size improvement by register

Comparing with other implementations the output is obviously better. The Table6 and 7 are from Rijndael proposal **[1]** and they show execution time and code size of other implementation depending on key and block length.

Key/Block length	Number of cycles	Code length
(128, 128) a)	4065 cycles	768 byte
(128, 128) b)	3744 cycles	826 byte
(128, 128) c)	3168 cycles	1016 byte
(192, 128)	4512 cycles	1125 byte
(256, 128)	5221 cycles	1041 byte

Table6. Execution time and code size Rijndael in Intel 8051 assembler

In case of Intel 8051 assembler, as code size increase, the speed decreases, this improvement in speed while sacrificing size can be also done at AVR microcontroller by executing multiplication by tables.

Key/Block length	Number of cycles	Code length
(128, 128) a)	8390 cycles	919 byte
(192, 128)	10780 cycles	1170 byte
(256, 128)	12490 cycles	1135 byte

Table7. Execution time and code size Rijndael in Motorola 68HC08 assembler

6 CONCLUSION

Rijndael implementation using registers for storing state improves the efficiency over 40% in both speed and code size. Hence implementation using register will be more optimal when the processor is less loaded with other works which not only increases the speed but also reduces memory usage.

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Use of Frequency Modulation Technique to improve security system

Shaikh Md. Rubayiat Tousif, Shaiyek Md. Buland Taslim

Abstract— A wireless fire alarm and other passive circuit elements has been designed and implemented. The designed alarm circuit could detect any kind of smoke and generate an alarm signal that would be sent to the control room by frequency modulation technique. The designed transmitter could operate around 100 MHz. A monopole antenna has been used for transmitting the signal carrying the information in the free space. An antenna length of 41cm has been used for the design convenience. The transmitting signal has been successfully received at a distance of 53 feet without any disturbance by FM receiver. The operating frequency of the transmitter was found out to be 97 MHz and comparison shows a very good agreement between the measured value and the calculated value. The designed wireless fire alarm has been very dynamic in terms of performance and the transmitter part successfully demonstrates the basic principle of FM transmitter.

Index Terms— Frequency modulation, FM Transmitter, Monopole antenna, Range, Smoke detector

1 INTRODUCTION

THIS project has been designed to build a device that would detect any presence of fire and immediately send signal to the control room to take necessary actions. The project also involved developing a mechanism that would allow the sensitivity and hence the power of the transmitted signal to be controlled. As a part of this project a FM transmitter has been designed that would transmit signal at a particular frequency and could be received easily with a FM receiver. Most importantly design and build a cost effective wireless fire alarm that would work under any condition and be easily set up in commercial and residential areas.

2 BASIC WORKING PRINCIPLE

The operation of a wireless fire alarm is very simple and generally follows the sequence shown on the figure. When there is a fire or smoke in the room the detector which is very sensitive quickly detects it and generates a signal or alarm which is transmitted by FM radio transmission and received at the control room.

A frequency generator is used to generate a frequency radio signal with a particular band range, and for mixing the frequency radio signal with the transmission data, to make a transmission signal having a particular frequency; and a transmitter for amplifying the transmission signal having the particular frequency up to a predetermined level and for transmitting the same through an antenna.

The receiver receives the transmission signal via a second antenna and filters the transmission signal to acquire desire data including the identification code and location data and compares the identification code with registered codes.

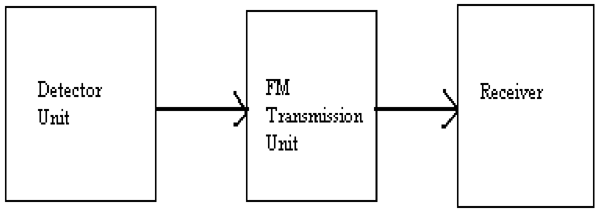

Fig. 1 Block Diagram of a Wireless Fire Alarm

2.1 Detection Unit

The detection unit in any kind of fire alarm circuit is the most important part. The successful operation of the circuit depends on how well this portion functions, so this portion is of great interest for the circuit designers. It should be sensitive, less complex, fast and reliable. There are various components in the smoke detection scheme where each component plays a significant role in proper functioning of the overall circuit.

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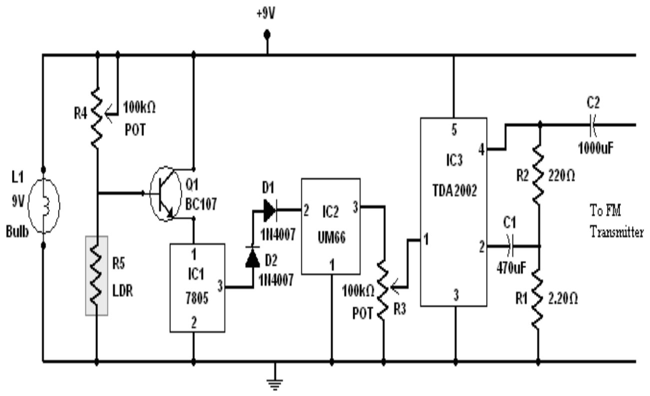

Fig. 2 Smoke Detector Circuit

Here is a simple fire alarm circuit based on a LDR and lamp pair for sensing the fire. The alarm works by sensing the smoke produced during fire. The circuit produces an audible alarm when the fire breaks out with smoke.

When there is no smoke the light from the bulb will be directly falling on the LDR. The LDR resistance will be low and so the voltage across it (below 0.6V).The transistor will be OFF and nothing happens. When there is sufficient smoke to mask the light from falling on LDR, the LDR resistance increases and so do the voltage across it. Now the transistor will switch to ON. This gives power to the IC1 and it outputs 5V.This powers the tone generator IC UM66 (IC2) to play music. This music will be amplified by IC3 (TDA 2002).

The diode D1 and D2 in combination drops 1.4 V to give the rated voltage (3.5V) to UM66. UM 66 cannot withstand more than 4V.

Potentiometer (POT) R4 can be used to adjust the sensitivity of the alarm, which means turning it up towards more resistance makes the circuit less sensitive to light, while turning it down towards less resistance makes the circuit more sensitive to light. By adjusting the POT, it is possible to turn the alarm on and off just by passing shadow over it.

POT R3 can be used for varying the volume of the alarm. That is it can be used to control the amplifier TDA2002's gain. This sound will be transmitted by the FM transmitter. So before being transmitted, this audio signal should be amplified to optimum level.

2.2 FM Transmission Unit

Frequency modulation is a type of modulation where the frequency of the carrier is varied in accordance with the modulating signal. The amplitude of the carrier remains constant. The information-bearing signal (the modulating signal) changes the instantaneous frequency of the carrier. Since the amplitude is kept constant, FM modulation is a low-noise process and provides a high quality modulation technique which is used for music and speech in hi-fidelity broadcasts. In addition to hi-fidelity radio transmission; FM techniques are used for other important consumer applications such as audio synthesis and recording the luminance portion of a video signal with less distortion. There are several devices that are capable of generating FM signals, such as a VCO or a reactance modulator. Frequency Modulation is abbreviated FM.

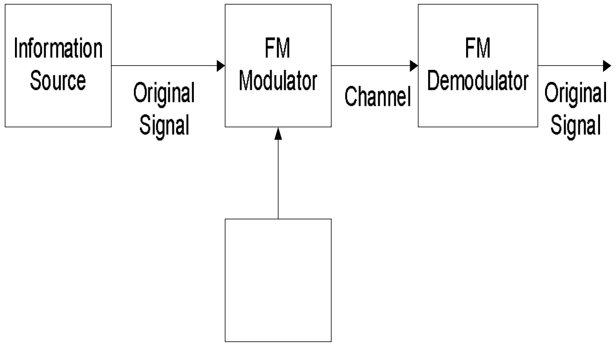

Fig.3 FM System Block Diagram

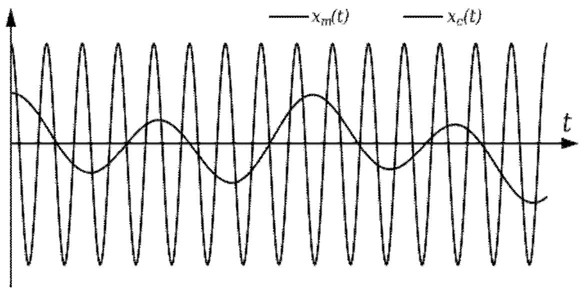

Fig. 4 An example of frequency modulation. This diagram shows the modulating, or message, signal, $x_m(t)$, superimposed on the carrier wave, $x_c(t)$.

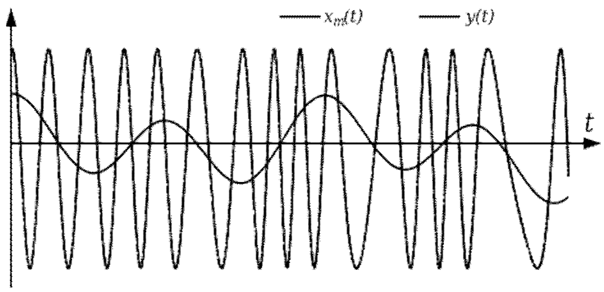

Fig. 5 The modulated signal, y(t), produced from frequency-modulating $x_c(t)$ with $x_m(t)$.

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2.3 FM Transmitter

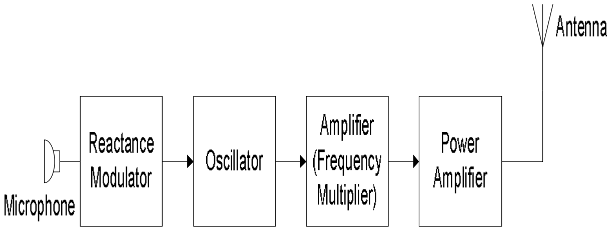

Fig. 6 General FM transmitter block diagram

In the figure the voice frequencies from the microphone are fed to special type of modulator called reactance modulator. The output of the modulator causes the frequency of oscillator to change. Output of the oscillator is amplified and the frequency is multiplied in the next section of transmitter.

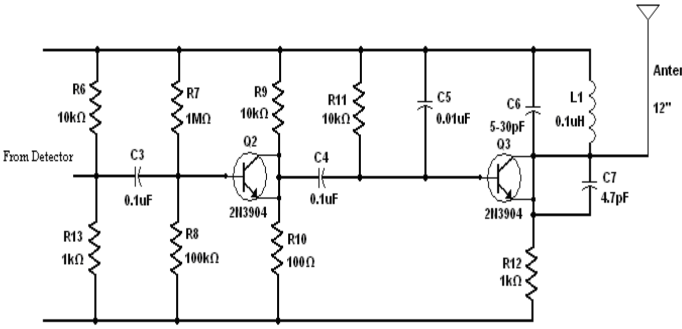

Fig.7 Circuit diagram of FM transmitter

The FM transmitter's input is the audio signal generated by the alarm circuit. The first transistor Q2 works as an audio amplifier, which amplify the audio signal even more. The second transistor works as an oscillator circuit. The inductor L1 and capacitor C6 works together as an oscillator and generate a frequency in FM band. Therefore it transmits the signal at a particular frequency, which, if tuned properly will be received at the receiver. Capacitor C3 is DC blocking capacitor and C4 is coupling capacitor.

Antenna tuning is done by adjusting inductance L1 and capacitance C6 combined with the active antenna (but distinct and separate from the active antenna). The inductance and capacitance provides the reactance which combines with the inherent reactance of the active antenna to establish a resonance in a circuit including the active antenna. The established resonance is at a frequency other than the natural electrical resonant frequency of the active antenna. Adjustment of the inductance or capacitance changes this resonance. The signal is transmitted at this resonant frequency.

2.4 FM Receiver

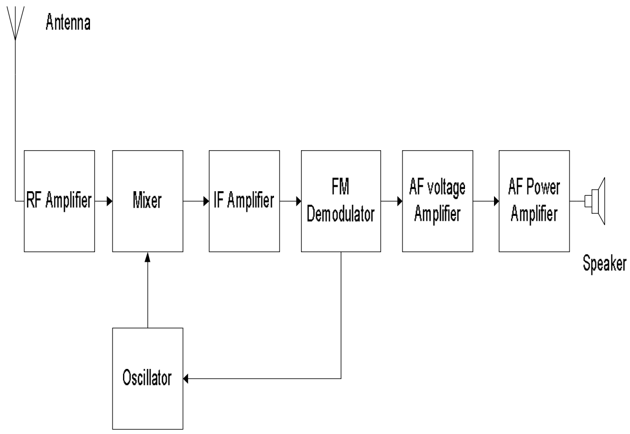

Fig.8 Block diagram of FM Receiver.

The RF amplifier selects and amplifies the desired station from the many. It is adjustable so that the selection frequency can be altered. This is called tuning. In cheaper receivers the tuning is fixed and the tuning filter is wide enough to pass all signals in the FM band. The selected frequency is applied to the mixer. The output of an oscillator is also applied to the mixer. The mixer and oscillator form a frequency changer circuit. The output from the mixer is the intermediate frequency (IF). The IF is a fixed frequency of 10.7 MHz. No matter what the frequency of the selected radio station is, the IF is always 10.7 MHz. The IF signal is fed into the IF amplifier. The advantage of the IF amplifier is that its frequency and bandwidth are fixed, no matter what the frequency of the incoming signal is. This makes the design and operation of the amplifier much simpler. The amplified IF signal is fed to the demodulator. This circuit recovers the audio signal and discards the RF carrier. Some of the audio is fed back to the oscillator as an automatic frequency control voltage. This ensures that the oscillator frequency is stable in spite of temperature changes. The audio signal voltage is increased in amplitude by a voltage amplifier. The power level is increased sufficiently to drive the loudspeaker by the power amplifier.

3 EXPERIMENTAL CALCULATIONS AND FINDINGS

3.1 Inductor

Let,
Frequency = 95MHz
Capacitance = 30pF

We know,

Resonant frequency for oscillator, $F_r = \dfrac{1}{2\Pi\sqrt{LC}}$

From here, using the above values for frequency and

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capacitance, inductance, L was found to be 94nH

Assuming length, l = 1cm

Total number of turns, $n = \sqrt{\frac{L \times (90 \times r + 10 \times l)}{r^2}}$

From here, n was found to be 13 turns.

3.2 Antenna

Assuming free space propagation, $C = f \times \lambda$
Therefore,

$$\lambda = \frac{3 \times 10^{10} cm.s^{-1}}{95MHz} \approx 316 \text{ cm}$$

Antenna length = $\lambda/8$ = 41cm has been used for design convenience.

3.3 Practical data obtained

The transmitting frequency was found to be 97MHz.

The range of the transmitter circuit was found to be more than 53 feet on the same floor.

3.4 Antenna Designing

In our design a monopole antenna was used, though any sort of antenna such as dipole antenna could have been used in the design for signal transmission in the free space. Folded dipole antenna has high radiation impedance and its radiation pattern was found to be better than monopole antenna, though in practical cases monopole antenna is used for FM transmission. We have chosen antenna length to be $\lambda/8$, which is almost 41cm.

3.5 Range of the circuit

The range of the transmitter circuit was determined by placing the receiver at different distances up to which the audio signal is clearly heard. The range was found to be more than 50 feet on the same floor. The signal could not be received clearly at different floor from the transmitter as harmonics effect there was too strong. The received power reduces with the increment in distance as expected. The range was found to be more at night and the sound quality of the signal was better too. This was due to less amount of electrical equipment working at night reducing the overall interference.

3.6 Suggestions for Future Work

Design improvements that could be considered in future are listed bellow:

More sensors, such as temperature sensor, humidity sensor and pressure sensor can be added for better prediction and detection of fires.

The musical IC could be replaced by a custom made IC which will generate signal giving out the address of the particular fire affected room.

The transmitted signal can data signal transmitting time, location and origin of the fire.

Coding the signal before transmission will enhance the security, reduce multi-path fading, and allow many transmitters to use the same channel.

A speaker could be attached to the TDA2002 audio amplifier's output for alarm to sound in the room of the fire.

4. Conclusion

Wireless fire alarm is a very effective safety device, its application and use have been increasing day by day and in most cases radio transmission is used to send the signal. FM is used because of its superiority over other analog modulation schemes such as AM and PM. It shows good sound quality, better reception and more immune to noise and signal distortion. This project included a two transistor low power FM transmitter which gave us the opportunity to learn precisely the basic principle of frequency modulation, transmitter circuit, and various its components. While designing the smoke or fire detector we learnt the various methods by which smoke or fire is detected and different components in the fire alarm circuit were discussed extensively as well.

Acknowledgment

We would like to thank all our group members for the help and support.

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Design of Low-Power CMOS Cell Structures Using Subthreshold Conduction Region

Vishal Sharma, Sanjay Kumar

Abstract— Subthreshold (leakage or cut-off) currents are a necessary evil in traditional VLSI design methodologies. These currents increase exponentially as threshold voltage scales, creating a serious problem for traditional design approaches. This work is based on the exclusive use of subthreshold conduction currents to perform circuit operations, turning this problem into an opportunity. It yields a dramatic improvement in power consumption compared to traditional circuit design approaches. This improvement makes it feasible to design extreme low-power circuits with such an approach. The CMOS digital circuits for this work have been designed using standard TSMC 0.18 *μm* Technology.

Index Terms—Low-Power, Leakage Current, Subthreshold Conduction.

1 Introduction

With the growing scale of integration, more and more sophisticated signal processing systems need to be implemented on a VLSI chip. For these signal processing applications, power consumption has become a critical concern in today's VLSI system design. The need for low-power VLSI systems arises from two main forces. First, with the steady growth of processing capacity per chip, large current has to be delivered and the heat due to large power consumption must be removed by proper cooling techniques. Second, battery life in portable electronic devices is limited. Low-power design directly leads to prolonged operation time in these portable devices.

Also, with shrinking technology sizes, energy efficiency has become a critical aspect of designing digital circuits. Traditionally, voltage scaling, a mechanism in which the supply voltage is varying and the threshold voltage is constant, has been an effective solution in meeting stringent energy requirements. However, voltage scaling does come at a cost of reduction in performance. The limits of voltage scaling, and therefore energy minimization, can be explored by operating a circuit at subthreshold [1]. In subthreshold circuits, the supply voltage is reduced well below the threshold voltage of a transistor. Due to the quadratic reduction in power with respect to the supply voltage, subthreshold circuits are classified as *ultra low-power circuits*.

Specifically in application areas where performance can be sacrificed for low-power, subthreshold circuits are an ideal fit. Some of the applications include devices such as digital wrist watches, radio frequency identification (RFID), sensor nodes, pacemakers and battery operated devices such as, cellular phones.

2 Why To Reduce The Power

Up until now, the power consumption has not been of great concern because of the availability of large packages and other cooling techniques having the capability of dissipating the generated heat. However, continuously increasing density as well as the size of the chips and systems might cause to difficulty in providing adequate cooling and hence, might either add significant cost to the system or provide a limit on the amount of the functionality that can be provided [2].

Another factor that fuels the need for low-power chips is the increased market demand for portable consumer electronics powered by batteries. For these high performance portable digital systems, running on batteries such as-laptops, cellular phones and personal digital assistants (PDAs), low-power consumption is a prime concern because it directly affects the performance by having effects on battery longevity.

Hence, low-power VLSI design has assumed great importance as an active and rapidly developing field. Due to their extreme low-power consumption, subthrehsold design approaches are appealing for a widening class of applications which demand low-power consumption and can tolerate larger circuit delays.

3 Subthreshold Conduction For Low Power VLSI Design

In traditional digital VLSI design, the subthreshold region of operation is avoided, since it contributes toward leakage power consumption when the device is in stand-by. But the power can be reduced significantly by exclusively utilizing this subthreshold leakage current to implement circuits. This is achieved by actually setting the

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circuit power supply V_{dd} to a value less than or equal to V_{th}. The subthreshold current is exponentially related to gate voltage giving the exponential reduction in power consumption, but also an increase in circuit delay [3]. So, we use the circuits operating in subthreshold conduction region where the power is main concern and large delay can be tolerated.

The MOS transistor conducting below the threshold voltage V_{th} is called subthreshold conduction. Fig. 1 shows that the current I_d has linear dependency in the strong inversion region while in the moderate inversion region it shows quadratic dependency on gate voltage. The current in subthreshold conduction region changes exponentially, similar to BJT operation.

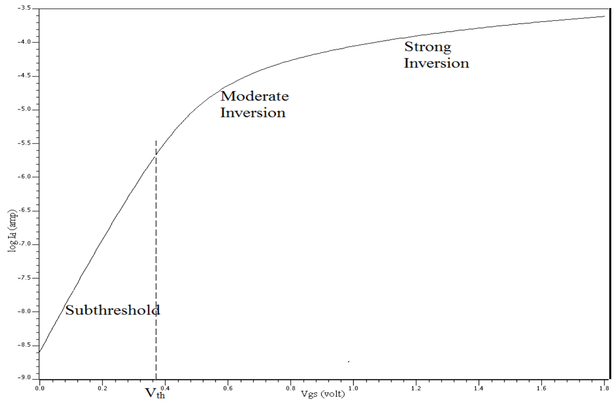

Fig. 1 CMOS Conduction region for an NMOS with V_{ds}= 1.8 V and V_{gs}varying from 0 V to 1.8 V.

Unlike moderate and strong inversion, in which the drift component of current dominates, subthreshold conduction is dominated by diffusion current [4].

3.1 Modelling of subthreshold current

In subthreshold conduction, the channel of the transistors is not inverted and current flows by diffusion. Subthreshold current can be expressed by the following basic equation:

$$I_{on-sub} = I_0 \, exp\left(\frac{V_{gs}-V_{th}}{nV_T}\right) \quad (1)$$

Equation (2) shows the same basic equation with low V_{ds} roll-off:

$$I_{on-sub} = I_0 \, exp\left(\frac{V_{gs}-V_{th}}{nV_T}\right)\left(1 - exp\left(\frac{-V_{ds}}{V_T}\right)\right) \quad (2)$$

where I_0 is the drain current when V_{gs}= V_{th} given below:

$$I_0 = \mu_{eff} C_{ox} \frac{W}{L_{eff}} (n-1) V_T^2 \quad (3)$$

As expected for the diffusion current, (1) shows that I_{on-sub} depends exponentially on V_{gs}. Here, W is the width of the transistor, L_{eff} is the effective length, μ_{eff} is the effective mobility, C_{ox} is the oxide capacitance, n is the subthreshold slope factor $\left(n = 1 + \frac{C_d}{C_{ox}}\right)$, V_{th} is the transistor threshold voltage and V_T is the thermal voltage,V_T =(*kT/q*).

4 Minimum Energy Point Model

In this section, we will discuss a closed form solution for the optimum V_{dd} and V_{th} for a given frequency and technology operating in the subthreshold region means (V_{dd} V_{th}).

The total energy per operation of a digital CMOS circuit consists of two components: switching and leakage energy [6]. Here, we will discuss in terms of an inverter.

Hence, total energy per operation can be expressed as:

$$E_{Total} = E_{SW} + E_L$$

$$= V_{dd}^2\left(C_{eff} + W_{eff} K C_g \, L_{DP} exp\left(\frac{-V_{dd}}{nV_T}\right)\right) \quad (4)$$

where, C_{eff} is the average effective switched capacitance per operation, K is a delay fitting parameter, C_g is the output capacitance of the inverter and L_{DP} is the depth of the critical path.

To define the V_{dd} at which the *minimum energy point* should occur, the derivative of (4) is taken with respect to V_{dd}, setting it equal to zero, and applying a number of rearrangements, we find:

$$\left(2 - \frac{V_{dd}}{nV_T}\right) exp\left(2 - \frac{V_{dd}}{nV_T}\right) = \frac{-2C_{eff}}{W_{eff} K C_g \, L_{DP}} exp(2) \quad (5)$$

Now according to Lambert function [5],

If $y = xe^x$, then x = lambert W(y)

So, the analytical solution for $V_{dd,opt}$ from (5) is given as:

$$V_{dd,opt} = nV_T\left(2 - \text{lambert W}\left(\frac{-2C_{eff}}{W_{eff} K C_g L_{DP}} exp(2)\right)\right) \quad (6)$$

Also, we can find the optimum value of V_{th} = $V_{th,opt}$ for a given frequency $f$as:

$$V_{th,opt} = V_{dd,opt} - nV_T \, log_e\left(\frac{f K C_g \, L_{DP} V_{dd,opt}}{I_0}\right) \quad (7)$$

If the argument to the natural log in (7) exceeds 1, then the assumption of subthreshold operation no longer holds because $V_{th,opt}$ $V_{dd,opt}$. This constraint shows that there is a maximum achievable frequency for a given circuit in the subthreshold region [6].

Swanson and Meindl analysed the VTC of an inverter and showed that the inverter operation could be simulated down to 100 mV [7]. The VTC curves for different supply voltages for an inverter are shown in Fig. 2. To find the minimum voltage, Swanson equated the *off* current of NMOS and PMOS and calculated the inverter gain

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in subthreshold. Since an inverter must have sufficient gain at $V_{dd}/2$, the minimum voltage which can be used was estimated to be 8(*kT*/*q*) or 0.2 V [7].

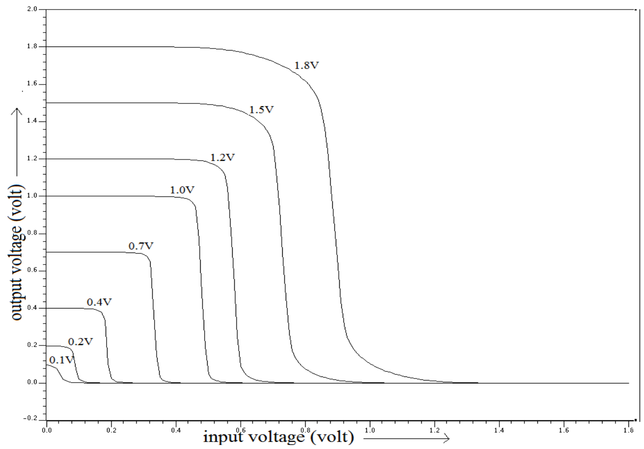

Fig. 2 Inverter VTC showing operation down to 100 mV in a 0.18 μm process.

5 Designing Of Different CMOS Cells

This section describes the design of various digital CMOS cells in subthreshold. First, the basic CMOS Inverter, shown in Fig. 3, is analyzed in detail and then, based on this analysis, the NAND and the NOR gates are designed and after that other circuits can also be designed by calculating the values of *W*/*L* with the help of these *W*/*L* values of Inverter which has been designed for symmetric output and equal charging and discharging current.

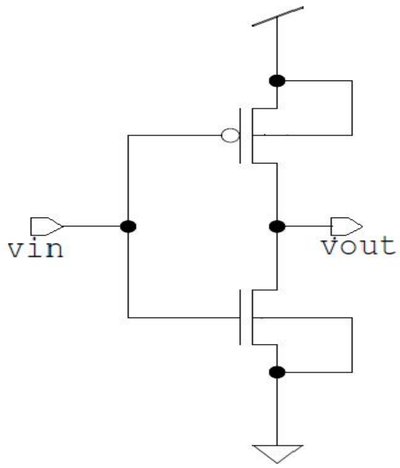

Fig. 3 Basic CMOS Inverter

By simulating this CMOS Inverter using TSMC 0.18 μm technology, the Inverter's values of *W*/*L* for PMOS = (1.2 μm/0.18 μm) and *W*/*L* for NMOS = (0.27 μm/0.18 μm) were obtained for strong inversion operation. While the Inverter's values of *W*/*L* for PMOS = (3.0 μm /0.18 μm) and *W*/*L* for NMOS = (0.27 μm/0.18 μm) were obtained for subthreshold operation.

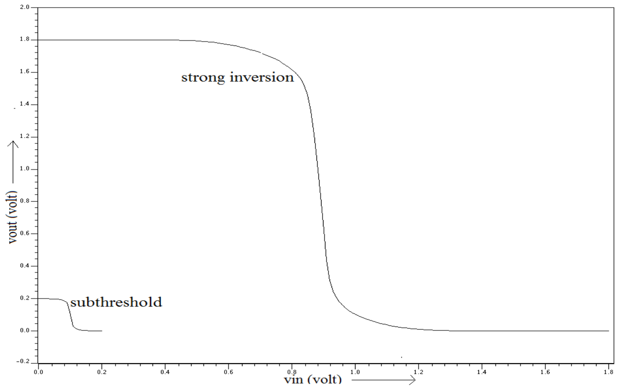

Fig. 4 VTC curves for Inverters operating in strong inversion and subthreshold.

By using these values of *W*/*L* of basic Inverter, other circuits can be designed having the equivalent *W*/*L* values equal to that of this basic Inverter.

6 Design And Simulation Results Of Different Cmos Circuits

6.1 CMOS Inverter

The load capacitance, for the inverter described in previous section, for strong inversion region is 5 *fF* while the load capacitance for subthreshold conduction is 11 *fF*.

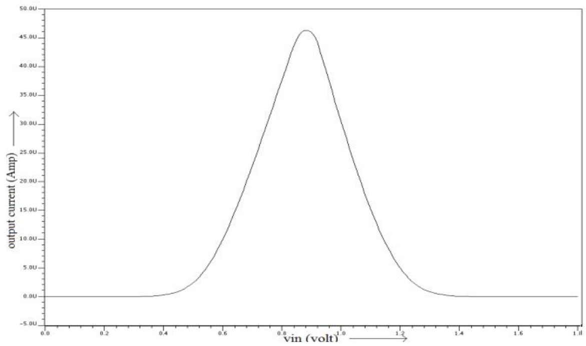

Fig. 5 Output current variation with input voltage in strong inversion region with V_{dd} = 1.8 V.

From Fig. 5 and 6, it is clear that the current depends on input (gate) voltage linearly in strong inversion region and exponentially in subthreshold region.

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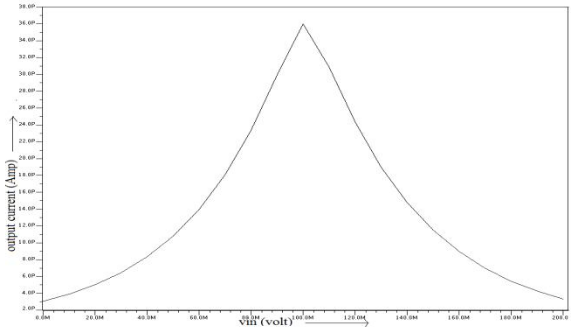

Fig. 6 Output current variation with input voltage in subthreshold region with = 0.2 V.

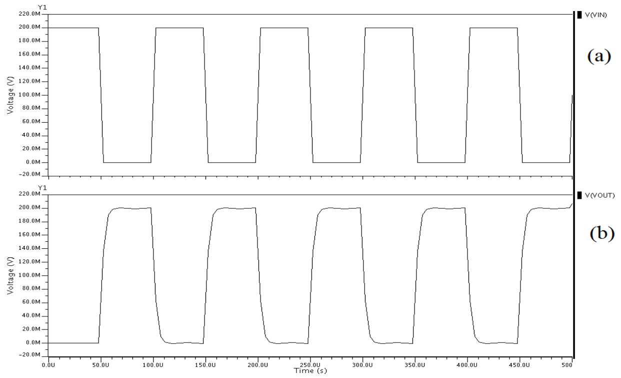

Fig. 7 Simulation result of transient analysis for CMOS Inverter in subthreshold region: (a) Input Signal, (b) Voltage waveform of Output Signal.

6.2 Two-input CMOS NAND Gate

Two-input CMOS NAND Gate can be designed having the equivalent *W/L* value equal to that of the Inverter.

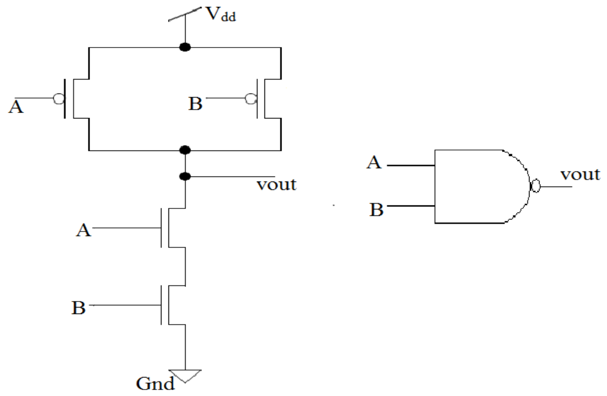

Fig. 8 Basic Structure of a 2-input CMOS NAND Gate

The load capacitance, for the NAND Gate designed, for strong inversion is 10 *fF* while for subthreshold conduction is 18 *fF*.

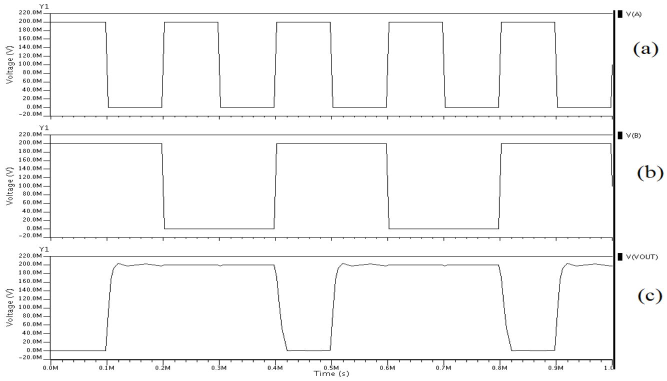

Fig. 9 Simulation result of transient analysis for a 2-input CMOS NAND Gate in subthreshold conduction region: (a) Input Signal (A), (b) Input Signal (B), (c) Voltage waveform of Output Signal (VOUT).

6.3 Two-to-One CMOS Multiplexer

The basic structure and its simulation result of a 2-to-1 CMOS Multiplexer are shown in Fig. 10 and 11.

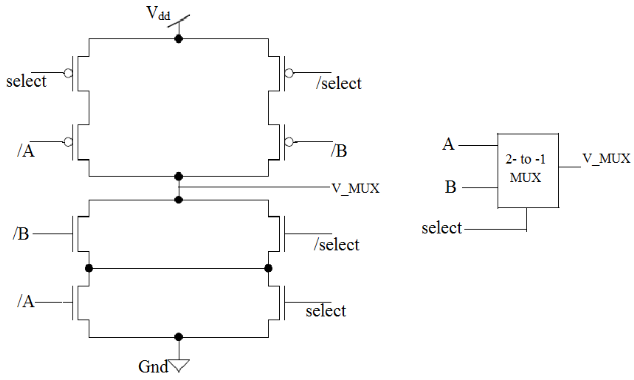

Fig. 10 Basic Structure of a 2-to-1 CMOS Multiplexer

The load capacitance, for the 2-to-1 CMOS Multiplexer designed, for strong inversion is 13 *fF* while for subthreshold conduction is 30 *fF*.

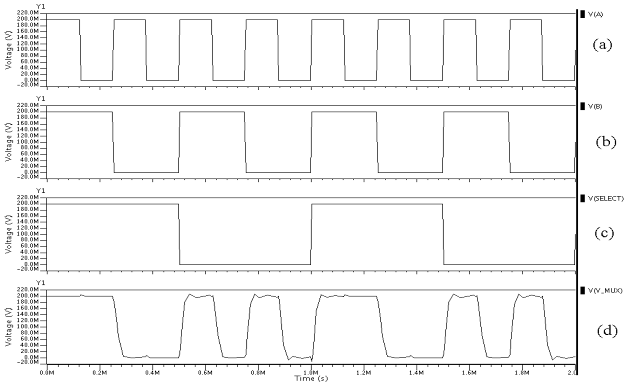

Fig. 11 Simulation result of transient analysis for a 2-to-1 CMOS Multiplexer in subthreshold conduction region: (a) Input Signal (A), (b) Input Signal (B), (c) Input Signal (SELECT) (d) Voltage waveform of Output Signal (V_MUX).

6.4 One-Bit CMOS Full Adder

Full Adder is basic structure for any arithmetic circuit, so the design of a Full Adder is also necessary. The basic

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structure and simulation result for a One-Bit CMOS Full Adder are shown in figures given below.

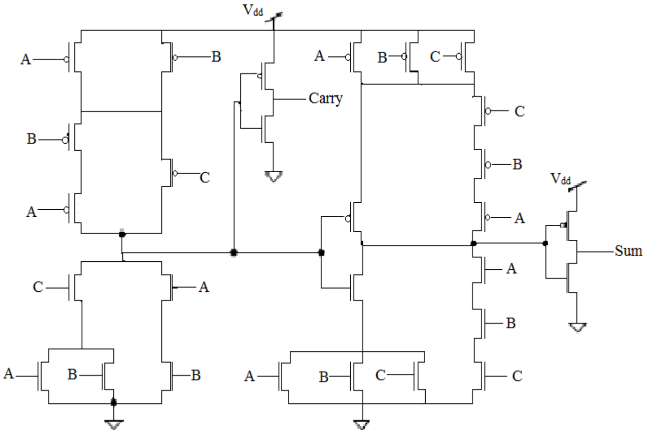

Fig. 12 Basic Structure of a One-Bit CMOS Full Adder

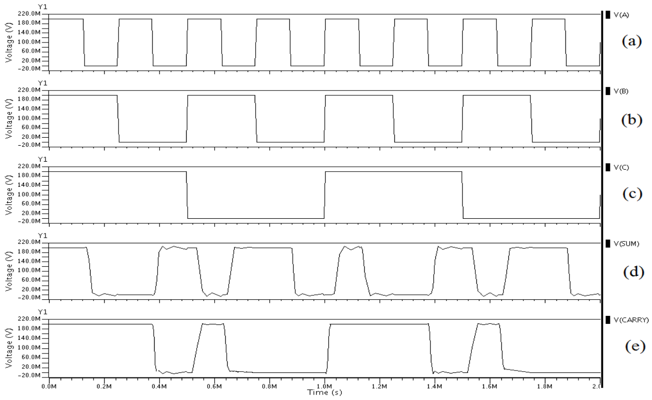

Fig. 13 Simulation result of transient analysis for a One-Bit CMOS Full Adder in subthreshold conduction region: (a) Input Signal (A), (b) Input Signal (B), (c) Input Signal (C), (d) Voltage waveform of Output (SUM) Signal, (e) Voltage waveform of Output (CARRY) Signal.

TABLE I
POWER DISSIPATION IN DIFFERENT CMOS CIRCUITS

		Power (nW)	
		f = 4 kHz	f = 5 kHz
CMOS Inverter	Superthreshold	389.54 n	486.93 n
	Subthreshold	0.002107 n	0.002576 n
2-input NAND	Superthreshold	366.56 n	442.54 n
	Subthreshold	0.002732 n	0.003382 n
2:1 MUX	Superthreshold	869.55 n	1038.58 n
	Subthreshold	0.004995 n	0.005414 n
Full Adder	Superthreshold	971.15 n	1100.94 n
	Subthreshold	0.024413 n	0.027932 n

Fig. 14 shows the dynamic power variation with different clock frequencies for a 1-bit Full Adder operating in subthreshold conduction region.

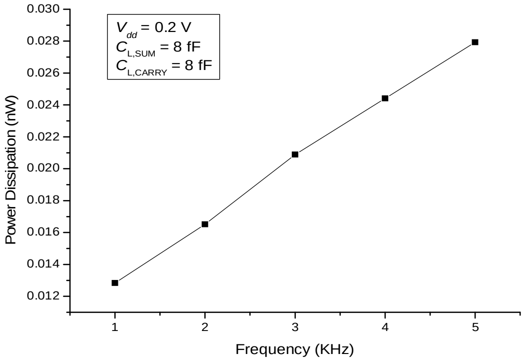

Fig. 14 Power dissipation results for a 1-bit Full Adder operating in subthreshold conduction region.

7 LAYOUT DESIGN AND POST-LAYOUT SIMULATION RESULT FOR A 1-BIT CMOS FULL ADDER

For a 1-bit Full Adder operating in subthreshold conduction resgion, layout and post-layout simulation results are shown in Fig. 15 and 16 respectively.

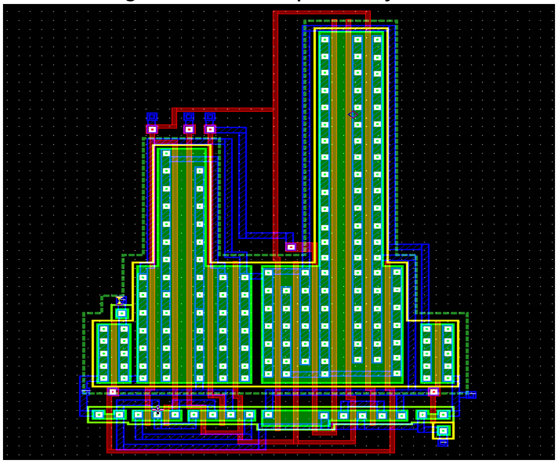

Fig. 15 Layout of 1-bit CMOS Full Adder operating in subthreshold conduction region.

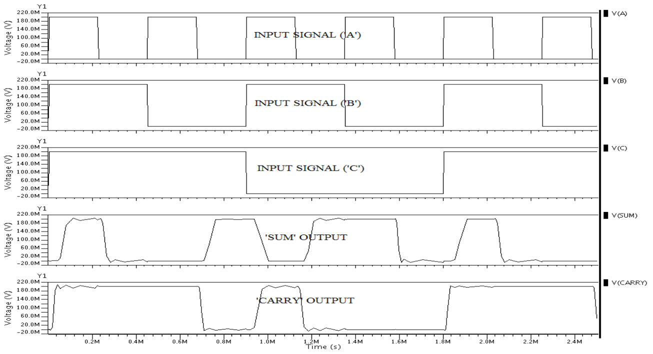

Fig. 16 Post-Layout Simulation – Transient analysis for 1-bit CMOS Full Adder operating in subthreshold conuction region.

8 CONCLUSIONS

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Based on the subthreshold conduction, the designing of various digital circuits have been done. The supply voltage used for the circuits operating in subthreshold conduction region is 0.2 V. The power analysis also has been carried out for the circuits, operating in subthreshold conduction region and in superthreshold conduction region. It is found that the circuits operating in subthreshold conduction region provide the significant power reduction than the superthreshold conduction region.

It can be found that subthreshold conduction region is advantageous in applications where power is the main concern and performance can be sacrificed to achieve the low-power because the speed of a circuit operating in subthreshold conduction region becomes significantly slow.

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Shake-down Satellites on core-level regions of the XPS for Europium (III) Compounds

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Abstract— We have observed “shake-down” and “shake-up” satellites evidenced on core-level regions of the XPS binding energy data base for europium(III) compounds, in which Eu cation have various chemical environments: simple oxide Eu2O3 , Eu mixed oxides with organic oxalate, acetylacetonate [Eu(CH3COOCH3)3] or inorganic sulfate [Eu2(SO4)3] , Nitrate [Eu(NO3)3] , carbonate [Eu2(CO3)3 , Eu2(C2O4)3] ligands.

Index Terms— Surface Plasmon Satellites, Relative Intensity & Energy Separation

INTRODUCTION

In the characteristic X-ray Spectra, Diagram as well as non Diagram lines are present. Those lines which fit in the conventional energy level diagram are called Diagram lines. & those lines which do not fit in the conventional energy level diagram are called non diagram lines. It is also known as “Satellites or Second order lines”. Satellites are generally of weak intensity lines & are found close to more intense parent line. The satellites which are observed on higher energy side are called high energy satellites (HES) whereas those are observed on lower energy side are called lower energy satellites (LES). First Siegbahn & Stenstroem observed these satellites in the K-Spectra of element from Cr (24) to Ge (32) while coster theraeus & Richtmyer in the L-Spectra of element from Cu (29) to Sb (51) & Hajlmar, Hindberg & Hirsch in the M-Spectra of elements from Yb (70) to U (92). Several theories were proposed from time to time to explain the origin of these satellites. Out of these theories the plasmon theory is found to be the most suitable theory especially for those satellites.

Plasmon theory was first proposed by Bohm & pines which are extended by Housten, Ferrel, Noziers & Pines. According to this theory the low energy plasmon satellites are emitted when valence electron excites a plasmon during the annihilation of core hole conversely if Plasmon pre exists, its energy add up to the energy of diagram line.The radiation less reorganization of electronic shell of an atom is known as Auger effect. Auger satellites have also been observed by Korbar and Mehlhorn [1] Haynes et at. [2] Edward and Rudd [3]. Theoretical explanation for K series Auger spectrum was given by Burhop and Asaad [4] using intermediate coupling. Later on more refined theory, using relativistic and configuration interaction has been used by Listengarter [5] and Asaad [6]

In Auger primary spectra, one can also observe secondary electron peaks close to the primary peaks are produced by incident electrons which have undergone well energy losses. The most common source of such energy loss in the excitation of collective plasma oscillations of the electrons in the solid. This gives rise to a series of plasma peaks of decreasing magnitude spaced by energy $\hbar\omega_p$ where ω_p is the frequency of plasma oscillation.

Auger peaks are also broadened by small energy losses suffered by the escaping electrons. This gives rise to a satellite on the low energy of the Auger peak. Energy loss peaks have well defined energy with to primary energy.

The involvement of Plasmon oscillation in the X-ray emission or absorption spectra of solids has been widely studied during the last few decades and has been recognized that the electron –electron interaction has played an important role.

This Paper is devoted to Plasmon theory to explain the Energy Satellites and relative intensity of “shake-down” and “shake-up” satellites evidenced on core-level regions of the XPS binding energy data base for europium(III) compounds, in which Eu cation have various chemical environments: simple oxide Eu_2O_3 , Eu mixed

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oxides with organic oxalate, acetylacetonate **[$Eu(CH_3COOCH_3)_3$]** or inorganic sulfate **[$Eu_2(SO_4)_3$] ,** Nitrate **[$Eu(NO_3)_3$]** , carbonate [**$Eu_2(CO_3)_3$, $Eu_2(C_2O_4)_3$]** ligands.

According to Plasmon theory , if the valence electron , before filling the core vacancy , also excites a Plasmon ,then the energy $\hbar\omega_p$ needed for the excitation of Plasmon oscillation is taken from the transiting valence electron so that the emitted radiation will be derived off an energy $\hbar\omega_p$ and a low energy satellites will emitted whose sepration from the main X-ray line will correspond to $\hbar\omega_p$. On the other hand if the Plasmon pre exists , during the X-ray emission process , then , on its decay it can give its energy to the transiting valence electron before it annihilates the core vacancy . Thus the energy of emitted X-ray photon will be higher than the main emission line and by an amount $\hbar\omega_p$ giving rise to high energy satellite .

MATHEMATICAL CALCULATION –

In order to confirm the involvement of Plasmon in the emission of X-ray satellites the relative intensity of single Plasmon satellites must be calculated . In this process first we deal with mathematical details of canonical transformation carried out over the model Hamiltonian of the system . Thus the energy separation ΔE of the low and high energy Plasmon satellite from the corresponding main line should be equal to the quantum of Plasmon energy $\hbar\omega_p$ which is given by [10]

$$\Delta E = \hbar\omega p = 28.8 \sqrt{\left(\frac{Z.\sigma}{w}\right)} \text{ ev} \qquad \textbf{1}$$

Where Z = No.of unpaired electrons , σ = Specific gravity & ω = Molecular Weight

This equation can be derived as given below .

From the classical consideration , we get the frequency of Plasmon oscillation as

$$\omega p = \left(\frac{4\pi n e^2}{m}\right)^{1/2} \qquad \textbf{2}$$

Hence the amount of energy given to Plasmon becomes

$$E_p = \hbar\omega_p = \hbar \left(\frac{4\pi n e^2}{m}\right)^{1/2}$$

In this equation we can write $\mathbf{n} = \frac{L\sigma Z}{w}$

Where σ , Z and W are defined above and L is the Avogadro number .By putting the numerical value of constant , we get the Plasmon energy as

$$\Delta E = \hbar\omega p = 28.8 \sqrt{\left(\frac{Z.\sigma}{w}\right)} \text{ ev} \qquad \textbf{3}$$

Our calculated values of ΔE have been compared with the Scrocco's experimental value. And We have also calculated the relative intensity of plasmon satellites, which is different in different processes. If the excitation of plasmon occurs during the transport of the electron through the solid, it is known as extrinsic process of plasmon excitation. The plasmon can also be excited by another method known as intrinsic process. In this process, excitation of plasmon takes place simultaneously with creation of a hole. Bradshaw et al have further divided core hole excitation into two classes,

1 - Where the number of slow electrons are conserved.

2 - Where the number of slow electrons are not conserved

The Author has calculated relative intensity in both the cases with new modification in the light of Bradshaw [12] and Lengreth [13] work, which explains that not only intrinsic process but extrinsic process and their relative contribution may also contribute in relative intensities. The combined effect of intrinsic and extrinsic plasmon excitation intensity variation was suggested by Lengreth as**:**

$$i = \frac{Is}{Im} = \alpha^n \sum_{m=0}^{n} \frac{\left(\frac{\beta}{\alpha}\right)^m}{m!} \qquad \textbf{4}$$

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The value of β is taken as β = $0.12r_s$ which is purely intrinsic, $r_s = (47.11/\hbar w_s)^{2/3}$ is dimensionless parameter and $\alpha = 0.47\ r_s^{1/2}$ in the place of $\alpha = (1+l/L)^{-1}$ used by Pardee et. al.(14) . The equation (3) contains a series of terms. The first term of the equation is purely extrinsic, while second term is purely intrinsic. The other terms are containing the relative contributions of both extrinsic and intrinsic. The specialty of this formula is that each term alone or simultaneously with other terms is able to give the relative intensity. This formula also includes both the categories mentioned by Bradshaw and gives better results as compared than traditional methods for calculation of the relative intensity. Using the values of α, β and rs in equation (4)

Using the equation (4), the author has for the first time, calculated the relative intensity of Shake down satellites in Europium (III) compounds and Our calculated and estimated values are in agreement with the calculated values of F. Mercier & its associate [15,16] (2005)

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Table -1 Energy sepration ΔE of Eu4d photoelectron peak, of its associated shake-down Kα Satellite

S.No.	Compounds	Z	σ	ω	Author's Calculated Plasmon Energy Separation (ΔE_s)	Experimental value of Energy Separation Ref. [133,134]
1	Eu_2O_3	2	351.93	7.40	5.91	6.4
2	$Eu(CH_3COOCH_3)_3$	3	374.2	7.89	7.24	7.1
3	$Eu_2(C_2O_4)_3$	3	567.99	11.98	7.24	7.1
4	$Eu_2(CO_3)_3$	3	483.95	10.21	7.24	7.4
5	$Eu_2(SO_4)_3$	4	592.12	12.49	8.36	9
6	$Eu(NO_3)_3$	5	592.12	12.49	9.35	10.2
7	EuF_3	4	208.96	4.41	8.36	9.9
8	$EuCl_3$	5	258.32	5.45	9.35	9.60

Table – 2 Relative Intensity of Eu4d photoelectron peak, of its associated shake-down Kα Satellite

S.No.	Compounds	ΔE_s	R_s	Alpha (α)	Beta (β)	Author Calculated Relative Intensity	Experimental value of Relative Intensity Ref.	Intensity assignment
1	Eu_2O_3	4.18	5.03	1.054	0.6035	0.2785903	0.24	$\beta-0.1-\beta^2/2\alpha-\beta^3/6\alpha^2$
2	$Eu(CH_3COOCH_3)_3$	5.12	4.39	0.984	0.5267	0.2650213	0.29	$\beta-0.1-\beta^2/2\alpha-\beta^3/6\alpha^2$
3	$Eu_2(C_2O_4)_3$	5.12	4.39	0.984	0.5267	1.3770302	1.43	$2*(\beta+\beta^2/2\alpha+\beta^3/6\alpha^2)$
4	$Eu_2(CO_3)_3$	5.12	4.39	0.984	0.5267	0.1650213	0.19	$\beta-0.2-\beta^2/2\alpha-\beta^3/6\alpha^2$
5	$Eu_2(SO_4)_3$	5.91	3.99	0.938	0.4786	0.1503615	0.13	$\beta-0.2-\beta^2/2\alpha-\beta^3/6\alpha^2$
6	$Eu(NO_3)_3$	6.61	3.7	0.904	0.4442	0.1371624	0.11	$\beta-0.2-\beta^2/2\alpha-\beta^3/6\alpha^2$
7	EuF_3	5.91	3.99	0.938	0.4786	0.1503615	0.19	$\beta-0.2-\beta^2/2\alpha-\beta^3/6\alpha^2$
8	$EuCl_3$	6.61	3.7	0.904	0.4442	0.2371624	0.27	$\beta-0.1-\beta^2/2\alpha-\beta^3/6\alpha^2$

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An Efficient Key Management Scheme for Wireless Network

Yogendra Kumar Jain, Vismay Jain

Abstract-Sensor networks have great potential to be employed in mission critical situations like battlefields but also in more everyday security and commercial applications such as building and traffic surveillance, habitat monitoring and smart homes etc. However, wireless sensor networks pose unique security challenges. While the deployment of sensor nodes in an unattended environment makes the networks vulnerable to a variety of potential attacks, the inherent power and memory limitations of sensor nodes makes conventional security solutions unfeasible. Key Management is a major challenge to achieve security in wireless sensor networks. In most of the schemes presented for key management in wireless sensor networks, it is assumed that the sensor nodes have the same capability. This research presents a security framework WSNSF (Wireless Sensor Networks Security Framework) to provide a comprehensive security solution against the known attacks in sensor networks. The proposed framework consists of four interacting components: a secure triple-key (STKS) scheme, secure routing algorithms (SRAs), a secure localization technique (SLT) and a malicious node detection mechanism. Singly, each of these components can achieve certain level of security. However, when deployed as a framework, a high degree of security is achievable. WSNSF takes into consideration the communication and computation limitations of sensor networks. While there is always a tradeoff between security and performance, experimental results prove that the proposed framework can achieve high degree of security, transmission overheads and perfect resilience against node capture.

Keywords- Wireless Sensor Networks, Secure triple key, Routing algorithms, Localization technique.

1. INTRODUCTION

Wireless Sensor Networks (WSNs) have recently attracted much attention because of their wide range of application, such as military, environmental monitoring, and heath care industry. Unlike wired and Mobile Ad hoc Networks, wireless sensor networks are infrastructure-less and can operate in any environment as compared to the traditional networks. Wireless sensor networks mainly consist of large number of tiny and simple nodes that are randomly deployed in operating areas unattended. In hierarchical WSNs, sensor nodes are clustered and a gateway or cluster head is allocated for each cluster. Gateway nodes are more powerful in computational capability, memory storage, life time, and communication range as compared to other nodes [1]. In this paper, we propose a framework for key management in cluster based WSNs using a hybrid technique of public key and symmetric key cryptography. A symmetric key is assigned dynamically to sensor nodes to establish a secure link with their neighbors. A public key is pre-loaded to the sensor nodes and gateways for communicating with each other. Because gateway nodes are powerful, using Elliptic Curve Cryptography (ECC) as a lightweight public key cryptography would not provide overhead in the network. Advancements in Micro Electro Mechanical Systems (MEMS) and wireless networks have made possible the advent of tiny sensor nodes sometimes referred as "motes". These are mini, low-cost devices with limited coverage having low power, smaller memory sizes and low bandwidth. Wireless sensor networks consist of a large number of such sensor nodes and are able to collect and disseminate data in areas where ordinary networks are unsuitable for environmental and/or strategic reasons. As such, they have a promising future in many applications, such as smart houses, smart farms, smart parking, smart hospitals, habitat monitoring, building and structure monitoring, distributed robotics, industry and manufacturing, national security etc. The sensors' low cost has made wireless sensor networks more viable and have contributed to their increasing popularity as potential low-cost solutions to a variety of real life challenges. While all networks are subject to common threats, remote wireless sensor networks are additionally vulnerable to security breaches because they are physically more accessible to possible adversaries. The memory and energy limitations of sensor nodes are a major obstacle to implementing traditional security solutions. The fact that wireless sensor networks utilise unreliable communication media and are left

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unattended once deployed makes the provision of adequate security countermeasures even more difficult [2], [3], [7] and [13].

2. BACKGROUND

Wireless sensor networks have unique constraints as compared to traditional networks making the implementation of existing security measures not practicable. In broader terms, these constraints are the result of limitations regarding the sensor nodes' memory, energy, transmission and processing power as well as due to the ad-hoc and wireless channel. These constraints, which make the design of security procedures more complicated, have been categorised into node constraints and network constraints. The security solutions require high computation, memory, storage and energy resources which creates an additional challenge when working with tiny sensor nodes. Typical sensor nodes are tiny devices which come with very limited memory and storage capacity. Berkeley's MICA2 possess 4-8 MHz, 4KB of RAM, 128KB flash and ideally 916 MHz of radio frequency .This means any security solution designed for sensor networks should be smaller in code. Energy is another important factor to consider when designing security measures for sensor nodes. Given the sensor network topology which makes accessing them after deployment impracticable, it is very important to limit the energy consumption and thereby extend the battery life. However, adding security measures to sensor networks necessarily has a significant impact on its energy consumption, for example, to perform the encryption and decryption functions, to store, manage and send the encryption keys etc. Sensor networks inherit all the constraints of mobile ad hoc networks such as unreliable network communication, collision related problems and their lack of physical infrastructure. Wireless communication is inherently unreliable and can cause packets to be damaged or dropped. This unreliability in communication poses additional threats to the nodes if dropped packets are taken over by adversaries. The networks utilise a dense arrangement of nodes potentially deploying hundreds of thousands of nodes in a sensitive application. This raises the likelihood of collision and latency in packets. However, unlike in traditional networks, the energy limitations of sensor nodes makes it impracticable to resend packets in case of collision [2], [12] and [13].

Setting security goals for sensor networks will depend on knowing what it is that needs protecting. Sensor networks share some of the features of mobile ad hoc networks but also pose the unique challenges discussed in the previous. Therefore the security goals encompass both those of the traditional networks and goals suited to the unique constraints of sensor networks. The four security goals for sensor networks are determined as Confidentiality, Integrity, Authentication and Availability (CIAA) [4], [9] and [10].

Recently, the probabilistic key pre-distribution scheme where each sensor node receives a random subset of keys from a large key pool before deployment. To agree on a key for communication, two nodes find one common key within their subsets and use that as their shared key. To extend this idea with three key pre-distribution schemes: a q-composite scheme, multi-path reinforcement, and a random-pair-wise key scheme [6], [14] and [15].

Probabilistic model using random key assignment and two protocols 'direct' and 'cooperative' to establish pair-wise communication between sensors by assigning a small set of random keys to each sensor. This idea is later converged into the pseudo random generation of keys which is more energy efficient compared to previous key management schemes. General framework for establishing pair-wise keys between sensors on the basis of a polynomial-based key pre-distribution protocol . They later present two instantiations of the general framework: a random subset assignment key pre-distribution scheme, and a hypercube-based key pre-distribution scheme. Finally, they also propose a technique to reduce the computation at the sensors so that their scheme could be implemented efficiently [3], [5] and [11].

In previous, a pair-wise key pre-distribution is an effort to improve the resilience of the network by lowering the initial payoff of smaller scale network attacks and pushing the adversary towards a larger scaled attack to compromise the network.

In later work present a key scheme based on deployment knowledge. This key management scheme takes advantage of the deployment knowledge where the sensor's position is known prior to deployment. Because of the randomness of deployment, it is not feasible to know the exact location of neighbours, but it is realistic to know the set of likely neighbours. This issue is addressed using the random key pre-distribution [2], [8] and [16].

The secure localization technique based on the use of directional antennas. Referring to

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applications where the sensor nodes need to be disguised, having directional antennas is not feasible, use explicit RF distance bounding in order to obtain a verifiable location in the presence of attackers. This scheme utilises the known position of certain nodes as "landmarks". However, since these landmarks are placed across the network in an organized manner, this could pose some difficulty in applications such as on a battlefield where the nodes are deployed by being dropped from aircrafts. In such cases, determining the landmarks' positions may not be practical then [1].

3. PROPOSED TECHNIQUE

3.1 Secure Triple Key Scheme (STKS):

Based on the argument that no single keying method provides adequately secure communication in sensor networks, a secure triple-key (STKS) scheme is proposed consisting of three keys: two pre-deployed keys in all nodes and one in-network generated cluster key which addresses the hierarchical nature of sensor network. The network key K_n is generated by the base station, pre-deployed in each sensor node, and shared by the entire sensor network. The nodes use this key to *encrypt* the data before passing it on to the next hop. The sensor key K_s is generated by the base station, pre-deployed in each sensor node, and shared by the entire sensor network. The base station uses this key to *decrypt* and process the data, and the cluster leader uses this key to *decrypt* the data and send it to the base station. The cluster key K_c is generated by the cluster leader, and shared by the nodes in that particular cluster. Nodes from a cluster use this key to *decrypt* the data and forward to the cluster leader. Nodes will only use this key when they are serving as a cluster leader, otherwise they do not need to decrypt messages received from other nodes thus saving the energy and processing power. This triple key serves the purpose of confidentiality and authentication, and the following section describes how the scheme works.

3.2 Terms and Notations Used:

The following terms and notations are used in the secure triple key scheme (STKS).

ID# → The unique ID of the sensor node.
TS → An encrypted time stamp for beacon authentication.
Aggr Message → Message aggregated by a cluster leader.
CL→ Cluster leader – a node randomly elected as a leader for a given group of sensors through an election process.
BS→ Base station, a node assumed to be very powerful with extraordinary computation resources.
MAC_k (M) → Message authentication code for message *m*, generated using key *k*.
K_n → Network key (Kn) – generated by the base station, broadcast and shared throughout the network.
K_s → Sensor key (Ks) – generated by the base station, based on a seed and sensor ID, pre-deployed in each sensor node and shared by the sensor nodes and base station.
K_c → Cluster key (Kc) – generated by the cluster leader and shared by the nodes in that particular cluster.

3.3 Base Station to Node Key calculation:

The base station uses its network key K_n to encrypt and broadcast data. When a sensor node receives this message, it decrypts it using its sensor key K_s. This proceeds as follows: The base station encrypts its own ID, a time stamp *TS* and its network key K_n. The packet contains following fields:

K_n	MAC	ID	TS	Message

The sensor node decrypts the message received from the base station using its sensor key K_s whereby the MAC is the authentication code for a message (*m*).

3.4 Proposed Secure Routing Algorithms (SRAs):

In the proposed secure routing mechanism all the nodes have a unique ID# to uniquely identify the sensor nodes. Once the network is deployed, the base station builds a table containing ID#s of all the nodes in the network. After a self-organizing process the base station knows the topology of the network. The nodes use the proposed secure triple-key scheme (STKS) to encrypt and authenticate the collected data, and then forward it to the cluster leader which aggregates and sends the data to the base station. The energy efficient secure data transmission algorithms were adapted and modified with the secure triple-key scheme (STKS) to make transmission resilient against attacks. The two algorithms used to securely transfer the data from the nodes to the base station and vice versa are the sensor node algorithm and the base station algorithm. These are presented below.

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3.4 Node algorithm performs the following functions:

→Sensor node uses the *Kn* to encrypt and transmit the data.

→Transmission of encrypted data from nodes to cluster leader

→Appending ID# to data and then forwarding it to higher level of cluster leaders. (In hierarchical topology, cluster leaders closer to the base station is known as a high level cluster leader)

→Cluster leader uses *Kc* to decrypt and then uses its *Kn* to encrypt and send the data to next level of cluster leaders, eventually reaching the base station

3.5 Base station algorithm is responsible for following tasks:

→Broadcasting of *Ks* and *Kn* by the base station

→Decryption and authentication of data by the base station

Node Algorithm:
The node algorithm performs the following functions:

Step 1: If Sensor Node *i* wants to send data to its cluster leader, it goes to Step 2; if not, it exits the algorithm.

Step 2: Sensor Node *i* requests the cluster leader to send *Kc*.

Step 3: Upon receipt, Sensor Node *i* uses *Kc* and its own *Kn* to compute the encryption key.

Step 4: Sensor Node *i* encrypts the data with *Kn*, appends its ID# and the *TS* to the encrypted data and then sends this to the cluster leader.

Step 5: The cluster leader receives the data, uses *Ks* to decrypt it and aggregates the data. It then appends its own ID#, adds the *TS* and encrypts the data using *Kc*, whereupon it sends it to the higher-level cluster leader or to the base station if directly connected. Thereafter it begins again at Step 1.

Figure1 below demonstrates how this algorithm proceeds and illustrates the communication between Sensor Node *i* and the cluster leader.

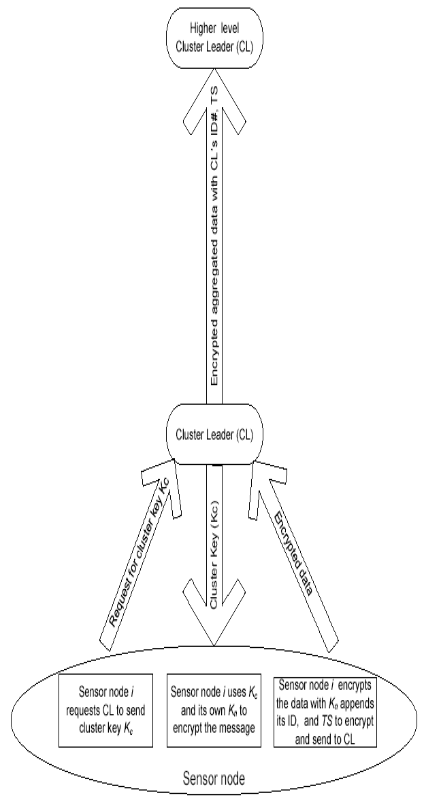

Figure1 Sensor Node *i* to cluster leader and base station communication.

Base Station Algorithm:

According to the suggested algorithm the base station performs these steps:

Step 1: Check if there is any need to broadcast a message. If so, broadcast the message encrypting it with *Kn*.
Step 2: If there is no need to broadcast a message then check if there are any incoming messages from the cluster leaders. If there is no data being sent to the base station return to step 1.

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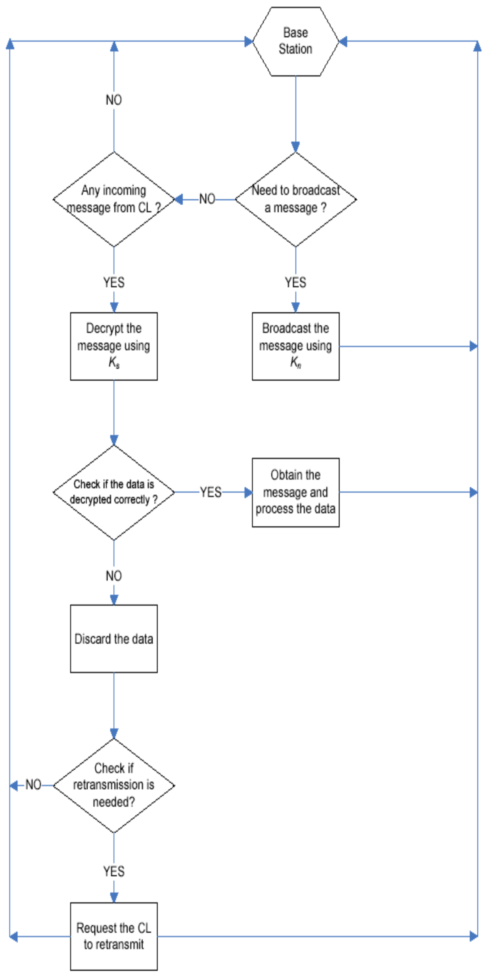

Figure 2 Base stations to cluster leader and sensor node communication.

Step 3: If there is any data coming in to the base station then decrypt it using *Ks*, the ID# of the node and the TS within the data.

Step 4: Check if the decryption key *Ks* has decrypted the data perfectly by checking the credibility of the TS and the ID#. If the decrypted data is not perfect, discard the data and go to Step 6.

Step 5: Process the decrypted data and obtain the message sent by the cluster leaders and sensor nodes.

Step 6: Decide whether to request all sensor nodes for retransmission of data. If deemed not necessary, return to Step 1.

Step 7: If a request is necessary, send one to the sensor nodes asking them to retransmit the data. Once this session is finished, return to Step 1.

This routing technique using the secure triple-key management scheme provides a strong resilience against the spoofed routing information attacks, selective forwarding, sinkhole attacks, Sybil attacks, wormholes, and HELLO flood attacks.
The Figure 2 illustrates the base station to node algorithm:

4. RESULTS

The level of this scheme's security depends entirely on the application. The percentage of neighbours being awake all the time could be providing complete security. Instead, in order to be more energy efficient, the topology works by letting each node go to sleep when it is not sending or receiving a packet. As seen from the experimental results shown in Figure below, the time required to detect a malicious node decreases when the number of nodes in the network is increased. This is because in dense network, the probability of node detection is higher and faster because there are more neighbours monitoring the nodes. The results in Figure are an average of 10 runs.

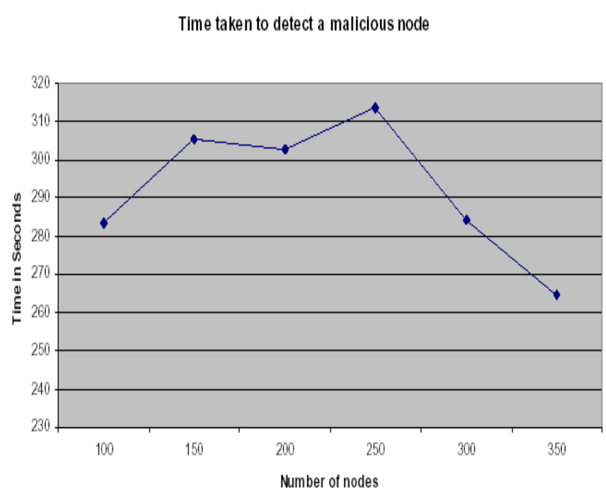

Figure 3 Time taken to detect a malicious node.

5. CONCLUSION AND FUTURE WORK

Traditional security measures require heavy communication and computational resources which are beyond the resource starved sensor nodes. In this research, it has been argued that

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cryptographically complex security solutions for sensor networks are not viable for many reasons: firstly, the energy, memory and transmission range limitations; secondly, the wireless channel limitations; thirdly, the deployment nature of sensor nodes being left unattended after deployment; and fourthly, the need to keep costs low to enable dense deployment. Instead, sensor networks need a balanced and comprehensive solution, which is efficient, effective and has low security overheads. Bearing these factors in mind, a novel security framework for wireless sensor networks has been proposed. We are heading towards a future of miniature station and wireless connectivity and sensor networks have the ability to deliver both at very low cost. For future research we propose extending this security framework to include trust establishment and trust management in sensor networks. Besides this we have an interest in exploring and solving security issues in multimedia and biometric security, cyber security and information assurance, protection against identity theft, and forensic computing.

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A novel fast version of particle swarm optimization method applied to the problem of optimal capacitor placement in radial distribution systems

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Abstract— Particle swarm optimization (PSO) is a popular and robust strategy for optimization problems. One main difficulty in applying PSO to real-world applications is that PSO usually needs a large number of fitness evaluations before a satisfying result can be obtained. This paper presents a modified version of PSO method that can converge to the optima with less function evaluation than standard PSO. The main idea is inserting two additional terms to the particles velocity expression. In any iteration, the value of the objective function is a criterion presenting the relative improvement of current movement with respect to the previous one. Therefore, the difference between the values of the objective function in subsequent iterations can be added to velocity of particles, interpreted as the particle acceleration. By this modification, the convergence becomes fast due to new adaptive step sizes. This new version of PSO is called Fast PSO (FPSO). To evaluate the efficiency of FPSO, a set of benchmark functions are employed, and an optimal capacitor selection and placement problem in radial distribution systems is evaluated in order to minimize cost of the equipment, installation and power loss under the additional constraints. The results show the efficiency and superiority of FPSO method rather than standard PSO and genetic algorithm.

Index Terms— convergence speed, fast PSO, capacitor placement, particle swarm optimization, radial distribution system

1 INTRODUCTION

In recent years, many optimization algorithms are introduced. Some of these algorithms are traditional optimization algorithms. Traditional optimization algorithms use exact methods to find the best solution. The idea is that if a problem can be solved, then the algorithm should find the global best solution. Large search spaces increases the evaluation cost of these algorithms. Therefore the complex large spaces slow down the convergence rate of the algorithm to find the global optimum. Linear and nonlinear programming, brute force or exhaustive search and the divide and conquer methods are some of the exact optimization methods.

Other optimization algorithms are stochastic algorithms, consisted of intelligent, heuristic and random methods. Stochastic algorithms have several advantages compared to other algorithms as follows [1]:

1. Stochastic algorithms are generally easy to implement.
2. They can be used efficiently in a multiprocessor environment.
3. They do not require the problem definition function to be continuous.
4. They generally find optimal or near-optimal solutions.

Two well known intelligent stochastic algorithms are Particle swarm optimization (PSO) and genetic algorithm (GA). PSO is a population-based searching technique proposed in 1995 [2] as an alternative to GA [3]. Its development is based on the observations of social behavior of animals such as bird flocking, fish schooling, and swarm theory. Compared with GA, PSO has some attractive characteristics. First of all, PSO has memory, that is, the knowledge of good solutions is retained by all particles, whereas in GA, previous knowledge of the problem is destroyed ones the population is changed. Secondly, PSO has constructive cooperation between particles, i.e. particles in the swarm share their information.

In today's power system, there is a trend to use nonlinear loads such as energy-efficient fluorescent lamps and solid-state devices. Distribution systems provide power to a wide variety of load types. Resistive loads (power factor = 1.0) require no reactive power at all, while induc-

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tive loads (power factor < 1.0) require both active and reactive power. Inductive loads (e.g. motors) are always present so that the line current consists of a real (or resistive) component and an inductive component. Both components contribute to the MW losses (which are proportional to the square of the current magnitude), voltage drop and line loading (measured in A or MVA) reactive currents increased ratings for distribution components. The resistive component of the current cannot be substantially reduced as this is the part of the current that actually performs work (defined by demand). The reactive component of the current can be reduced by installation of capacitors "close" to the loads. This has the effect that the reactive power needed is generated locally and the distribution circuits are relieved from the reactive power transfer. Effective placement of the shunt capacitors (depending on the situation) can improve the voltage profile and can greatly reduce the losses and the line loading. The capacitor sizing and allocation should be properly considered, or else they can amplify harmonic currents and voltages due to possible resonance at one or several harmonic frequencies. This condition could lead to potentially dangerous magnitudes of harmonic signals, additional stress on equipment insulation, increased capacitor failure and interference with communication system. Thus, the problem of optimal capacitor placement consists of determining the locations, sizes, and number of capacitors to install in a distribution system such that the maximum benefits are achieved while operational constraints at different loading levels are satisfied [4].

Optimal capacitor placement has been investigated since the 60's. Early approaches were based on heuristic techniques applied to relaxed versions of the problem (some of the more difficult constraints were dropped). In the 80's, more rigorous approaches were suggested as illustrated by the paper by Grainger [5], [6]. Baran-Wu [7] have formulated the capacitor placement problem as a mixed integer nonlinear program: the problem then has been approximated by a differentiable function that allowed the solution by Benders decomposition. In the 90's, combinatorial algorithms were introduced as a means of solving the capacitor placement problem: simulated annealing has been proposed in [8], genetic algorithms in [9], and tabu search algorithms in [10]. Delfanti et. al. [11] have introduced a genetic algorithm (GA) approach in VAR planning of a small CIGRE system of the Italian transmission and distribution network in order to determine the minimum investment required to satisfy suitable reactive power constraints. Unfortunately the introduced GA algorithm had the problem of a large number of simplex iterations leading to very long computation time.

However, in this paper, a modified PSO, named fast PSO (FPSO) is proposed which asserts fast convergence property and consequently lower the number of function evaluation. FPSO possesses two additional terms added to the standard PSO velocity updating formula. These statements cause FPSO to move to the optimal solution faster than the standard PSO, adaptively. Therefore, these modifications speed up the PSO convergence rate. The effectiveness and efficiency of the proposed FPSO is first examined using some well-known optimization benchmarks. Then, it is applied to the problem of optimal capacitor placement in radial distribution systems. Numerical simulations are presented to validate the applicability and efficiency of our modified optimization scheme.

The rest of this paper is preceded as follows. Section 2 presents the standard PSO algorithm. Section 3 introduces FPSO. In Section 4, first the efficiency of FPSO algorithm is verified using some standard test functions. Then, the problem of optimal capacitor placement is solved using proposed FPSO method. Finally, some conclusions are given in section 5.

2 The Standard PSO Algorithm

2.1 Review Stage

A particle swarm optimizer is a population based stochastic optimization algorithm modeled based on the simulation of the social behavior of bird flocks. PSO is a population-based search process where individuals initialized with a population of random solutions, referred to as particles, are grouped into a swarm. Each particle in the swarm represents a candidate solution to the optimization problem, and if the solution is made up of a set of variables, the particle can correspondingly be a vector of variables. In PSO system, each particle is "flown" through the multidimensional search space, adjusting its position in the search space according to its own experience and that of neighboring particles. The particle, therefore, makes use of the best position encountered by itself and that of its neighbors to position itself toward an optimal solution. The performance of each particle is evaluated using a predefined fitness function, which encapsulates the characteristics of the optimization problem [12].

The core operation of PSO is the updating formulae of the particles, i.e. the equation of velocity updating and the equation of position updating. The global optimizing model proposed by Shi and Eberhart is as follows [12]:

$$v_{i+1}=w\times v_i+RAND\times c_1\times(P_{best}-x_i)+rand\times c_2\times(G_{best}-x_i) \quad (1)$$

$$x_{i+1}=x_i+v_{i+1} \quad (2)$$

where w is the inertia weight factor, vi is the velocity of particle i, xi is the particle position and C_1 and C_2 are two positive constant parameters called acceleration coefficients. RAND and rand are the random functions in the range [0, 1], Pbest is the best position of the ith particle and Gbest is the best position among all particles in the swarm.

3 Fast PSO Algorithm

The main drawback of PSO approach is slow convergence specifically prior to providing an accurate solution, close-

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ly related to its lack of any adaptive acceleration terms in the velocity updating formulae. In equation 1, c1 and c2 determine the step size of the particles movements through the Pbest and Gbest positions, respectively. In the original PSO, these step sizes are constant and for the all particles are the same.

In any iteration, the value of the objective function is a criterion that presents the relative improvement of this movement with respect to the previous one. Thus the difference between the values of the objective function in consequent iterations can represent the particle acceleration.

Therefore, velocity updating formulae turns to the following form.

$$v_{i+1} = w \times v_i + (f(P_{best}) - f(x_i)) \times RAND \times c_1 \times (P_{best} - x_i) + (f(G_{best}) - f(x_i)) \times rand \times c_2 \times (G_{best} - x_i) \quad (3)$$

where $f(P_{best})$ is the best fitness function that is found by i^{th} particle and $f(G_{best})$ is the best fitness function that is found by swarm up to now and other parameters are chosen the same as section A. These two terms, i.e. $(f(P_{best}) - f(x_i))$ and $(f(G_{best}) - f(x_i))$ cause to have an adaptive movement.

The steps of FPSO algorithm are as follows:

1. Initialize particles positions and velocities, randomly.
2. Calculate the objective functions values of particles.
3. Update the global and local best positions and their objective function values.
4. Calculate new velocities using equation (3).
5. Update the positions.
6. If stop condition is attained stop otherwise go to step 2.

Remarks:

1. *The term $(f(P_{best}) - f(x_i))$ and $(f(G_{best}) - f(x_i))$ are named local and global adaptive coefficients, respectively. In any iteration, the former term defines the movement step size in the best position's direction which is found by ith particle, and the later term defines adaptive movement step size in the best optimum's direction point which ever have been found by the swarm. In other words, the adaptive coefficients decrease or increase the movement step size relative to being close or far from the optimum point, respectively. By means of this method, velocity can be updated adaptively instead of being fixed or changed linearly. Therefore, using the adaptive coefficients, the convergence rate of the algorithm will be increased rather than performed by the proportional large or short steps.*
2. *Stochastic optimization approaches suffer from the problem of dependent performance. This dependency is usually because of parameter initializing. Thus, we expect large variances in performance with regard to different parameter settings for FPSO algorithm. In general, no single parameter setting exists which can be applied to all problems. Therefore, all parameters of FPSO should be determined optimally, by trial and error.*
3. *There are three stopping criteria. The first one is related to the maximum number of allowable iterations set for the algorithm. The second one is when no improvement has been made for a certain number of iterations in the best solution, and the third one is when a satisfactory solution is found.*
4. *The fast version of PSO is proposed for continuous variable functions. Moreover, the main idea of speeding up can be applied to the discrete form of the PSO [13]. We take this into our consideration as a future work.*
5. *Increasing the value of the inertia weight, w, would increase the speed of the particles resulting in more exploration (global search) and less exploitation (local search). On the other hand, decreasing the value of w will decrease the speed of the particle resulting in more exploitation and less exploration. Thus, an iteration-dependent weight factor often outperforms a fixed factor. The most common functional form for this weight factor is linear, and changes with step i as follows:*

$$w_{i+1} = w_{max} - \frac{w_{max} - w_{min}}{N_{iter}} \quad (4)$$

where N_{iter} is the maximum number of iterations and W_{max} and W_{min} are selected to be 0.8 and 0.2, respectively.

6. *Lastly, the proposed FPSO is still a general optimization algorithm that can be applied to any real world continuous optimization problems. In the next section, we will apply FPSO approach to several benchmark functions and compare the results with standard PSO and GA algorithms.*

4 RESULTS OF SIMULATIONS

In this section, first the efficiency of FPSO is tested using a set of test functions. Then, the FPSO algorithm is applied to solve the problem of optimal capacitor placement.

4.1 Evaluating FPSO using benchmarks

Here, some well-known benchmark functions (listed in Appendix A) are used to examine the effectiveness and convergence speed of the proposed FPSO technique. To avoid any misinterpretation of the optimization results, related to the choice of any particular initial populations, we performed each test 100 times, starting from various randomly selected solutions, inside the hyper rectangular search domain specified in the usual literature.

The performance of FPSO is compared to continuous GA and PSO algorithms using 15 functions listed in Appendix A. The experimental results obtained for the test functions, using the 3 mentioned different methods, are given in Table 1. In our simulations, each population in GA has 10 chromosomes and a swarm in FPSO and PSO

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has 10 particles. Other parameters of the three algorithms are selected optimally by trial and error. For each function, we give the average number of function evaluations for 100 runs. The best solution found by 3 methods was similar, so there are not given here.

Note that the FPSO has shown drastically better results in convergence and evaluation costs compared with GA and PSO, as it utilizes adaptive movements to reach to the optima, while GA and PSO do not have such an element. Fig. 1 shows a typical diagram of three algorithms convergence rates for B2 function, starting from a same initialization point. As it can be seen, although, all algorithms can find the optima, but FPSO is dramatically faster than the others. Therefore, in many real world applications where real time computations and less CPU time consumption are necessary, FPSO may work better than GA and PSO.

TABLE 1

AVERAGE NUMBER OF OBJECTIVE FUNCTION EVALUATIONS USED BY THREE METHODS

Function/Method	FPSO	PSO	GA
RC	38	42	48
ES	67	90	92
GP	31	39	41
B2	27	33	32
SH	44	61	57
R_2	45	63	65
Z_2	50	62	62
DJ	38	55	60
$H_{3,4}$	39	68	71
$S_{4,5}$	55	82	91
$S_{4,7}$	51	74	76
$S_{4,10}$	53	81	79
R_5	159	244	251
Z_5	123	194	171
$H_{6,4}$	132	212	195

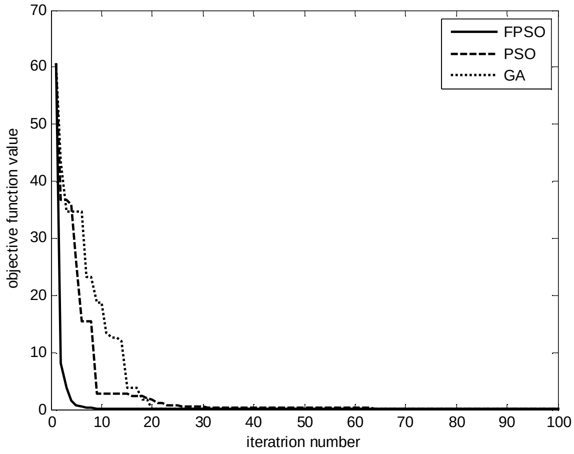

Fig. 1. Convergence rate of three algorithms for B2 function

5 SOLVING OPTIMAL CAPACITOR PLACEMENT USING FPSO

Now that the efficiency and high speed convergence property of the proposed FPSO algorithm has been revealed by simulation results of benchmark functions, the next step is to solve the problem of optimal capacitor placement with FPSO method.

The optimal capacitor placement problem has many variables including the capacitor size, capacitor location and capacitor equipment and installation costs. In this section we consider a distribution system with nine possible locations for capacitors and 27 different sizes of capacitors. Capacitor values are often assumed as continuous variables whose costs are considered as proportional to capacitor size in past researches [14-16]. However, commercially available capacitors are discrete capacities and tuned in discrete steps. Moreover, the cost of capacitor is not linearly proportional to the size. Hence, if the continuous variable approach is used to choose integral capacitor size, the method may not result in an optimum solution and may even lead to undesirable harmonic resonance conditions [17]. However, considering all variables in a nonlinear fashion will make the placement problem very complicated. In order to simplify the analysis, only fixed-type capacitors are considered with the following assumptions: (1) balanced conditions; (2) negligible line capacitance; and (3) time-invariant loads. The objective function of this problem is to minimize f. It is composed of two parts: (1) the cost of the power loss in the transmission branch and (2) the cost of reactive power supply. Therefore, the fitness function is defined as [18].

$$f = K_p \times p_{loss} + \sum_{n=1}^{m} Q_{cj_n} K_{cj_n} \qquad (5)$$

where K_p is the equivalent annual cost per unit of power loss ($/KWatt), n is the bus number, Kcj_n is the equiva-

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lent capacitor cost installed in bus n ($/KVar), $Q_{cj_n} = j \times K_S$ is the size of the capacitor, K_s is the capacitor bank size (KVar) (here K_s=150), and j= the number of banks used in any bus.

Here, a radial distribution feeder is used as an example to show the effectiveness of this algorithm. The testing distribution system is shown in Fig. 2.

This feeder has nine load buses with rated voltage of 23 kV. Tables 2 and 3 show the loads and feeder line constants. Kp is selected to be US$ 168/kW. The base value of voltage and power is 23 kV and 100 MW respectively [18]. Possible choice of capacitor sizes and costs are shown in Table 4 by assuming a life expectancy of 10 years (the placement, maintenance, and running costs are assumed to be grouped as total cost). The main procedure of finding optimal capacitor placements with FPSO method is illustrated in Fig. 3.

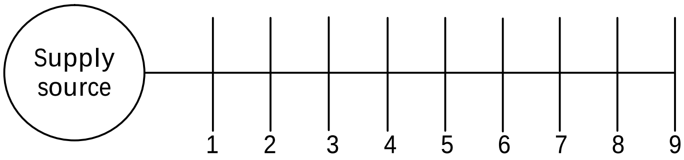

Fig. 2. Testing distribution system with nine buses

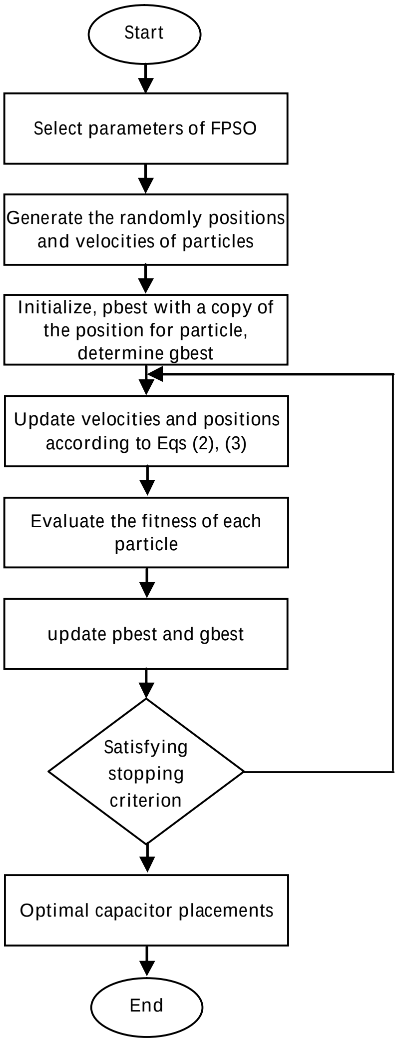

Fig. 3. Flow chart of optimal capacitor placements with FPSO

TABLE 2
LOAD DATA OF THE TEST SYSTEM

Bus	1	2	3	4	5	6	7	8	9
P(kW)	1840	980	1790	1598	1610	780	1150	980	1640
Q(Var)	460	340	446	1840	600	110	60	130	200

TABLE 3
FEEDER DATA OF THE TEST SYSTEM

From bus i	From bus j	R	X
0	1	0.1233	0.4127
1	2	0.0140	0.6051
2	3	0.7463	1.2050
3	4	0.6984	0.6084
4	5	1.9831	1.7276
5	6	0.9053	0.7886
6	7	2.0552	1.1640
7	8	4.7953	2.7160
8	9	5.3434	3.0264

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TABLE 4

POSSIBLE CHOICE OF CAPACITOR SIZES AND COSTS

j	1	2	3	4	5	6	7	8	9
Q_{cj}	150	300	450	600	750	900	1050	1200	1350
K_{cj}	0.500	0.350	0.253	0.220	0.276	0.183	0.228	0.170	0.207
j	10	11	12	13	14	15	16	17	18
Q_{cj}	1500	1650	1800	1950	2100	2250	2400	2550	2700
K_{cj}	0.201	0.193	0.187	0.211	0.176	0.197	0.170	0.189	0.187
j	19	20	21	22	23	24	25	26	27
Q_{cj}	2850	3000	3150	3300	3450	3600	3750	3900	4050
K_{cj}	0.183	0.180	0.195	0.174	0.188	0.170	0.183	0.182	0.179

The effectiveness of the method is illustrated by a comparative study of the following two cases: Case 1 is without capacitor installation and Case 2 use the FPSO approach for optimizing the size and the placement of the capacitor in the radial distribution system.

The capacitor sizes, power loss and the total cost are shown in Table 5. Fig. 4 depicts the minimum value of cost function in any iteration for 100 iterations. Before optimization (Case 1), the power loss is 775 kW and total cost is 1.302e5 \$. After optimization (Case 2), the power loss becomes 667.5 kW and the total cost becomes 1.130e5 \$.

TABLE 5

SUMMARY RESULT OF THE APPROACH

	Capacitor size (kVar)										P_{loss} (kW)	total cost (\$)
Bus	0	1	2	3	4	5	6	7	8	9		
Case 1	0	0	0	0	0	0	0	0	0	0	775	1.302e5
Case 2	0	1500	1500	1500	1500	400	450	300	150	300	667.5	1.130e5

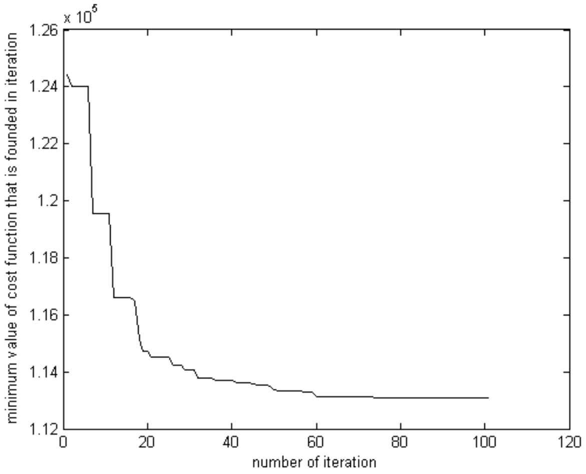

Fig. 4. Minimum value of cost function in each iteration

5 CONCLUSIONS

In this paper, a modified optimization technique based on PSO algorithm is introduced and it is called fast PSO (FPSO). Using adaptive coefficients, the step sizes of particles movements are changed appropriately to reach the optima, rapidly. The important characteristics of FPSO are: less function evaluation and high convergence rate. Consequently in real time processes, FPSO seems to outperform both the standard PSO and the genetic algorithm. The efficiency of the proposed FPSO algorithm is shown using several well-known benchmark functions. Then, the proposed FPSO method is used to successfully solve the problem of optimal capacitor selection and placement problem in radial distribution systems.

6 END SECTIONS

6.1 APPENDIX A

Some well-known benchmark functions of optimization problems [19].

Branin RCOS (*RC*) (2 variables):

$$RC(x_1,x_2)=\left(x_2-\left(\frac{5}{4\pi^2}\right)x_1^2+\left(\frac{5}{\pi}\right)x_1-6\right)^2+$$

$$10\left(1-\left(\frac{1}{8\pi}\right)\right)cos(x_1)+10;$$

Search domain: $-5 < x_1 < 10$, $0 < x_2 < 15$

no local minimum; 3 global minima

B2 (2 variables):

$$B2(x_1,x_2)=x_1^2+2x_2^2-0.3\cos(3\pi x_1)-0.4\cos(4\pi x_2)+0.7;$$

Search domain: $-100 < x_j < 100$, j=1, 2;

several local minima; 1 global minimum

Easom (*ES*) (2 variables):

$$ES(x_1,x_2)=-cos(x_1)cos(x_2)exp(-((x_1-\pi)^2+(x_2-\pi)^2));$$

Search domain: $-100<x_j<100$, j=1, 2;

several local minima, 1 global minimum

Goldstein and Price (*GP*) (2 variables):

$$GP(x_1,x_2)=$$

$$\begin{bmatrix}1+(+x_1+x_2+1)^2\\ \times(19-14x_1+3x_1^2-14x_2+6x_1x_2+3x_2^2)\end{bmatrix}\times$$

$$\begin{bmatrix}30+(2x_1-3x_2)^2\times\\ (18-32x_1+12x_1^2+48x_2-36x_1x_2+27x_2^2)\end{bmatrix};$$

Search domain: $-2 < x_j < 2$, j=1, 2;

4 local minima; 1 global minimum

Shubert (*SH*) (2 variables):

$$SH(x_1,x_2)=\left\{\sum_{j=1}^{5} j\cos[(j+1)x_1+j]\right\}$$

$$\times\left\{\sum_{j=1}^{5} j\cos[(j+1)x_2+j]\right\};$$

Search domain: $-10 < x_j < 10$, j=1, 2;

760 local minima; 18 global minimum

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De Joung (*DJ*) (3 variables):

$$DJ(x_1, x_2, x_3) = x_1^2 + x_2^2 + x_3^2$$

Search domain: -5.12 < x_j < 5.12, j=1, 2, 3;
1 single minimum (local and global)
Hartmann (H3, 4) (3 variables):

$$H_{3,4}(x_1, x_2, x_3) = -\sum_{j=1}^{4} c_i \exp[-\sum_{j=1}^{3} a_{ij}(x_i - p_{ij})^2];$$

Search domain: 0 < x_j < 1, j=1, 2, 3;
4 local minima1 global minimum
Shekel ($S_{4,n}$) (3 variables):

$$S_{4,n}(X) = -\sum_{j=1}^{n} [(X - a_i)^T \times (X - a_i) + c_i]^{-1};$$

$$X = (x_1, x_2, x_3, x_4)^T; a_i = (a_i^1, a_i^2, a_i^3, a_i^4)^T;$$

Search domain: 0 < x_j < 10, j=1, 2, 3,4;
n local minima; 1 global minimum
Rosenbrock (R_n) (n variables):

$$R_n(X) = -\sum_{j=1}^{n} -[100(x_j^2 - x_{j+1})^2 + (x_j - 1)^2;$$

Search domain: -5 < x_j < 10, j=1, …, n;
several local minima;1 global minimum
Zakharov (Z_n) (n variables):

$$Z_n(X) = \left(\sum_{j=1}^{n} x_j^2\right) + (\sum_{j=1}^{n} 0.5 j x_j)^2 + (\sum_{j=1}^{n} 0.5 x_j)^4;$$

Search domain: -5 < x_j < 10, j=1, …, n;
several local minima; 1 global minimum.

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An Effiecient Modeling Technique for Heart Sounds and Murmurs

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Abstract— Cardiac auscultation is highly subjective and a cognitive process and the amount information that can be obtained by listening heart sounds largely depends on the expertise, experience and acuity of the ear of the physician. In general, the classification and interpretation of heart sounds and murmurs is based on a adjective 0-6/6 grade scale and described by using "faint", "soft", "loud", " high pitch", "clear", "thrill", "tremor", "musical" and others terms. These terms are not well-defined and suitable mathematical models are not available. Apart from that, the adjective scales vary among the doctors and difficult to derive a standard model for heart sound quality and correct clinical interpretation.

In this research paper, we propose a novel framework based on psychoacoustic principles and derive psychoacoustic models for the heart sounds and murmurs. We discuss the theoretical foundations, psychoacoustic principles and derive the mathematical models for the psychoacoustic features such as loudness, sharpness, intensity, strength, roughness, tonality etc. for a set of heart sounds and murmurs. The proposed framework helps in deriving heart sound quality and also used for the comparison and correlation with normal and pathologic murmurs and enhances clinical decisions.
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Index Terms— psychoacoutic principles, psychoacoutic models, heart sounds, auscultation, phonocardiography

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1 Introduction

Heart sounds and murmurs are acoustic phenomenon caused by the mechnical events of cardiac system. Auscultation or hearing of heart sounds using conventional stethscope or electronic stehoscope is not purely a mechnical phenomenon of sound wave propagation, but also auditory, sensory, cognative and perceptual event. Digital cardiac auscultation is an art and science of interpreating hearts sounds and murmurs used for clinical diagnostics. Congnitive process that paly significant role heart sound perception and clinical interpreatation. The phonocardiography (PCG) — the art and science of recording and interpreting of heart sounds using latest digital technology has significantly helped to understand and interpret the complex heart sounds (normal, abnormal sounds including murmurs). The PCG is a display of the heart sound signal with respect time (time domain) and frequency components or spectral properties (frequency domain) and plotting the heart sounds and murmurs can provide useful information to the physician by complementing cardiac auscultation Phonocardiography techniques are used for the effective clinical investigations and corrective diagnostic heart related diseases and in particular valvular heart diseases. When a heart valve is stenotic or damaged, the abnormal blood flow patterns produce a series of audible vibratory sounds known as murmurs [3]. Doctors and physicians detect these disorders by listening to heart sounds at different locations across the torso. Murmurs heared during routine physical exminations offer important clues to the presence of undetected and asymptomatic cardiac disease. The process of interpreating heart sounds is called cardiac auscultation. It is a simple, non-invasive tec niques helps in early detection of cardiac disorders. Different cardiac ailments produce a potentially overwhelming set of acoustic pathological events and correctly identfying a disorder requires discrimination of subtle variations in the timing characteristics and spectral properties of heart sounds. The analysis and interpretation is complicated by the natural variations in heart sounds introduced by factors such as the gender, age, habitus and dynamic state of the patients. Even in adults, anixiety, stress, fever, anemia etc. may also cause benign murmurs. Typically, these cases are distinguished by examining the intensity of sounds, in addition to their timing and frequency content. Sounds that are interesting from the perspective of auscultation are often short lived (less than 20 millseconds) and seperated from one another by less than 30 milliseconds. Pathological signals indicative of cardiac diseases are also often much quieter than other heart sounds and their audibility varies across sucessive heart beats. Even with extensive experience, physicians may often disagree about sounds, in particular with brief heart sounds. These inaccuracies are attributed to human auditory limitations which include insensitivity to frequencies, slow response to rapidly occurring

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changes in acoustic signals and an inability to unmask soft sounds in the promixity of loud ones. Murmurs are extra heart sounds that are produced as a result of turbulent blood flow which is sufficient to produce audible noise. Murmurs may be present in normal hearts without any heart diseases are called innocent murmurs. The murmurs due to valvular heart diseases are called pathologic murmurs and needs to evaluate by the cardiologists. In general, the murmurs [3, 4] can be classified by seven different physical characteristics: timing, shape, location, radiation, intensity, pitch and quality. It may also include psychoacuostic characteristics such as loudness, heart sound intensity, heart sound pressure, sharpness and fluctuations. Timing refers to whether the murmur is a systolic or diastolic murmur depending on the S1 and S2 sounds of a standard heart sound cycle and plays vital role in clinical decisions.

Shape refers to the intensity of the heart sounds over time. We can derive the intensity contours and can be described in musical note such as “cresccendo”, “decrescendo”, or “crescendodecrescendo”.

Radiation refers to where the sound of the heart sounds and murmurs radiates and normally radiates in the direction of the blood flow. The radiated sound can be captured and displayed as radiation patterns and helps in specific characterizations of murmurs.

Intensity refers to the loudness of the murmur, and is graded on a scale from 0-6/6 adjective scale as shown in the following Table I. The terms such as “soft”, “faint”, “loud” ,”blowing”, “harsh”, “rumbling”and others have a subjective meaning and needs to be modeled precisely

Pitch of a murmur is low, medium or high and is determined by whether it can be auscultated best with the bell or diaphragm of a stetchscope. Pitch mainly refers to the fundmental frequency of the heart sounds and murmurs.
From the above discussios, it clear that the physical characteristics such as timing, shape, pitch, loudness, radiation, sound intensity, sound pressure and other parameters are clinically important and and described using a adjective scales as shown in table 1.

Table 1: Gradings on a scale from 0-6/6

Grade	Description
Grade 1	Very faint
Grade 2	Soft
Grade 3	Heared clearly on pericardium.
Grade 4	Loud with palpable thrill sound. May also be vibratory or tremor on palpatation.
Grade 5	Loud, clear with thrill.
Grade 6	Very loud with thrill

In order to address the above challenges, we derive psychoacoustics principlaes for the hearts sounds and murmurs in a novel way and specfic contributions of the research work. We propose and derive psychoacoutsic models based on the psychoacoustics principles for heart sounds and murmurs.We derive psychoacoutsic models and map them to the psychoacustic features such as loundness, pitch, sound intensity, sharpness, etc. with mathematical equations.We also discuss the classifciation of murmurs and adjective scales and also try to relate them into the psychoacoustic features. For example, the grade 4 murmur which is loud and thrill and derive the loundness contour and characterize the thrill by observing the contour of loudness pattern.We highlight the usage of psychoacuostic model for the heart sound qualities.

2. PSYCHOACOUSTIC PRINCIPLES AND MODLES

Psychoacoustics is the study of the subjective human perception of sounds [1]. Alternatively it can be described as the study of psychological correlates of the physical parameters of acoustics [1]. The field of psychoacoustic aims to model parameters of auditory sensation in terms of physical signal parameters and provide a framework and modeling capabilities for the acoustic sounds. The psychoacoustic models of sound perception exploiting the imperceptable sounds are used in the audio compression such as MP3 standards; non-linear response of the ear is exploited in the noise reduction systems and communication networks. The human ear can nominally hear sounds in the range 20 HZ to 20,000 Hz (20 kHz). Frequency reso lution of the ear is 0.36 Hz within the octave of 1,000–2,000 Hz. That is, changes in pitch larger than 0.36 Hz can be perceived in a clinical setting. Other scales have been derived directly from experiments on human hearing

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perception, such as the Mel scale and Bark scale and these are approximately logarithmic in frequency at the high-frequency end, but nearly linear at the low-frequency end. Ear drums are sensitive only to variations in the sound pressure, but can detect pressure changes as small as 2×10–10 ATM and as great or greater than 1 ATM. The sound pressue level (SPL) is also measured logarithimically, with all pressures referenced to 1.97385×10–10 ATM. The lower limit of audibility is therefore defined as 0 dB, but the upper limit is not as clearly defined. By measuring this minimum intensity for testing tones of various frequencies, a frequency dependent absolute threshold of hearing (ATH) curve may be derived. Typically, ear shows a peak of sensitivity (i.e., its lowest ATH) between 1 kHz and 5 kHz, though the threshold changes with age, with older ears showing decreased sensitivity above 2 kHz. Equal-loudness contours indicate the sound pressure level (dB), over the range of audible frequencies, which are perceived as being of equal loudness and may be ploted. We use classical reference [5] which represents a set of algorithms for calculating auditory sensations including loudness, sharpness, roughness, softness, sound strength and intensity, and fluctuation strength and extend it for the heart sounds and murmurs. The classification of murmurs is characterized by using the psychoacoustic features and derives mathematical equations.

3. PROPOSED MODELS

3.1 Loudness of heart sound and murmurs

The loudness is modeled by the following equation, where N is loudness, N' is the loudness of a given critical band or also know as specific loudness, and dz is the increment in the critical band scale.

$$N = \int_0^{24} N' dz \qquad (1)$$

The unit of loudness, the sone, is a ratio scale referenced against the sensation produced by a 1 kHz sine tone with a sound pressure level of 40 dB. The models draw on data gained from subjective testing and from a physiological understanding of the auditory periphery. The "loudness" property of heart sounds and murmurs helps in characterization, classification and discrimination of various murmurs in clinical investigations. We can plot the loudness contour using above equations and derive deep insight in the heart sound analysis and interpretations. The complexity of the loudness of complex heart sound needs to be investigated in multistages and becomes complicated for time varying sounds, dynamical effects like forward masking and temporal loudness integration [2, 6, 5] have to be considered When the physician hears the heart sounds and murmurs, the loudness is a clinically significant feature and can be measured in sone and be mapped to the vertical axis of the Figure 1 in terms of the adjective scales of murmur classifications.

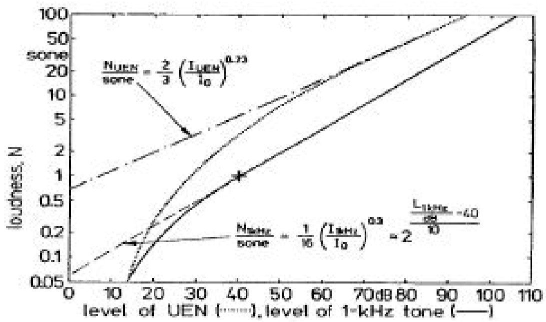

Figure 1. Loudness function of a 1- kHz tone (solid) and of Uniform Exciting Noise (dotted), broken and dashed-dotted lines with corresponding equations (adopted from [5])

3.2 Sharpness of heat sound and murmurs

Sharpness or brightness is one of the most prominent features of timbre. Timbre is more complicated, being determined by the harmonic content of the signal. The hearing is based on the amplitude of the frequencies and is very insensitive to their phases. The shape of hearts sounds and murmurs in time domain waveform is only indirectly related to hearing and poses serious challenges in correct interpretation of heart sounds. The models are based on the centroid (signal spectrum or loudness pattern) of the heart sounds and murmurs. The sharpness is modeled as a weighted centroid of the specific loudness pattern. The unit is acum, referenced to a band of noise 1 critical band wide, centered on 1 kHz at 60 dB. It is also referred to the perception that the sound is "sharp", "harsh" or "soft" when used in the context of heart sound perception and clinical interpretations. It is related to the proportion of high frequency energy present in the sound, weighted towards energy in the region above 3 kHz. For harmonic tones, sharpness can be controlled through distribution of the harmonic spectral envelope. The model used [5, 9, 7] for the calculating the sharpness of tones is summarized by the Equation 2.

$$s = 0.11 \frac{\int_0^{24\,Bark} N' g(z) z dz}{\int_0^{24} N' dz} \qquad (2)$$

where the S is sharpness, N' is specific loudness, z is the bark scale of auditory filters and g(z) is a weighting func-

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tion that emphasis z for the critical band rates. It was found that the sharpness of narrow band noises increases proportionally with the critical band rate for center frequencies below about 3 kHz. At higher frequencies, however, sharpness increases more strongly, an effect that has to be taken into account when the sharpness S is calculated using a formula that gives the weighted first momentum of the specific loudness pattern: In equation (2), the denominator gives the total loudness, while the upper integral is the weighted momentum mentioned. The psychoacoustic feature - sharpness can be used for the following murmurs.

Early systolic ejection click murmur is a high frequency, early systolic sound occurring 0.03- 0.07 second after S1 [4]. The sound is generated either by the sudden upward doming of an abnormal semilunar valve (aortic or plutonic) and sharp click sounds.

Opening Snap murmur is a high frequency, early diastolic sound that is associated with MS [3]. It occurs 0.04-0.12 second after S2 and may or may not be associated with a late peaking or rumbling diastolic murmur of varying sharpness with peaking at specific temporal patterns.

3.3 Pitch of heart and murmurs

A psycho acoustical pitch ratio scale is a difficult concept due to the complexity of pitch perception and cognition. Reference [6, 10] describes some of the complexity of pitch structures for harmonic tones (such as pitch height, octave equivalence and cycle of fifths) through multidimensional geometric figures. In addition to complex structures of pitch height, pitch has the dimension of pitch strength, also known as “tonalness”. The harmonic series is of great importance in pitch perception, and mainly pitched sounds in everyday experience exhibit harmonic spectra. In general, it is usually determined by the fundamental frequency as a pitch percept. A model of pitch perception is analyzed using template matching or autocorrelation techniques. Pitch is used to describe the tonal quality of the murmur be it high pitched or low pitched. For those of us not musically inclined, a simple way to distinguish pitch is to determine whether the sound is heard best with the diaphragm of the stethoscope, i.e., high pitched, or with the bell, i.e., low pitched. Murmurs of mitral or tricuspid stenosis are best heard with the bell. Some of other hearts sounds that can characterize the pitch are: *S3 sound* is a low frequency, mid diastolic sound occurring 0.14-0.22 second after S2. The frequency components of low frequency heart sounds are difficult to hear and can be modeled and uniquely find pitch features of the heart sounds and murmurs [3]. *S4 sound* is also a low frequency, late diastolic sound occurring 0.08-0.20 second prior to S1. It is generated during presystolic ventricular filling due to atrial contraction, hypertension and diastolic dysfunction. The sequencing and ordering with respect to the S1 and S2 in a standard cardiac cycle and obtain pitch pattern and frequency components using spectral techniques will assist the doctor for the better clinical decisions [3].

3.4 Roughness of heart sounds and murmurs

Roughness is a sensation caused by quite rapid amplitude modulation within auditory filters. This modulation can be caused by beats between two pure tone components, or by a signal with amplitude or frequency modulation. Beating within an auditory filter channel has been used to explain the acoustic component of tonal dissonance and represent roughness of the heart sounds [5]. The unit of roughness is the asper, which is referenced to a 1 kHz tone at 60 dB with 100% amplitude modulation at 70 Hz. The model presented in [5,8] by for calculating the roughness of modulated tones having a single modulation frequency is given in Equation 5, where R is roughness, fmod is the modulation frequency, and L_E is the excitation level within an auditory filter. This uses the time-varying excitation pattern of the ear (similar to the specific loudness pattern, except that the magnitude is in decibels rather than sones/bark), with the difference between maximum and minimum excitation levels integrated across auditory filters used to determine roughness.

$$R = 0.3 \frac{f_{\text{mod}}}{kHz} \int_{0}^{24Bark} \frac{\Delta L_E(z)dz}{dB/Bark} asper \quad (3)$$

The roughness of the heart sound can be used for the modeling aortic insufficiency (AI) may be congenital rheumatic, and collagen vascular disease. The murmur is a high frequency (blowing) decrescendo murmur beginning in early cardiac cycle and uniquely radiates to the top of the head. The roughness of the murmurs can be uniquely characterized using the above equation and needs further investigations. Mitral regurgitation (MR) is associated with endocarditis, and ischemic heart diseases [4]. The murmur is typically a high frequency, holosystolic, plateau murmur that is best heard at the apex. The murmur often radiates to the left axilla and back. There is no appreciable change in murmur intensity with cycle length (as with AS). MR may be associated with S3 in more severe cases. Here we have to use intensity, high frequency and radiation patterns in a consistent way and need further investigation and clinical validations.

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4. CONCLUSIONS

The cardiac auscultation is an effective diagnostic technique used in the early detection of cardiac diseases in particular the valvular diseases, including the murmurs. It is argued that the most of the doctors and physicians depend on their experience and make subjective interpretations of heart diseases. In this paper, we proposed psychoacoustic models based on a psychoacoustic principles and mathematical foundations and discussed the psychoacoustic features (pitch, intensity, timbre, loudness, power, intensity and other clinically important psychoacoustic features) that can be modeled, analyzed and provide effective aid of clinical decisions related to heart diseases, and in particular murmurs. These models offer a reasoning framework for the subjective reasoning of heart sounds and derived psychoacoustical models. It is also used to model the quality of heart sounds for many standardization efforts and can be used as an effective teaching aid for the cardiac auscultations. Our preliminary investigations and experimental results on our psychoacoustic models are quite encouraging and provide a deeper insight into the perception and interpretation of cardiac auscultations. The visualization tools for the psychoacoustic models are in progress and will help in clinical decisions. Further investigations and validation of the proposed psychoacoustic models are planned for the future work.

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Oscillation Properties of Solutions for Certain Nonlinear Difference Equations of Third Order

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Abstract : In this paper some sufficient conditions for the oscillation of all solutions of certain difference equations are obtained. Examples are given to illustrate the results.

Key words: Linear, Nonlinear, Difference equations, Oscillations and Non-oscillation.

AMS Subject Classification: 39 A 11.

1 Introduction

We are concerned with the oscillatory properties of all solutions of third order nonlinear difference equations of the form

$$\Delta^2\left(\frac{q_n}{a_n}\Delta\left(x_n+c_n x_{n-\sigma}\right)\right)+p_n\Delta x_n+q_n f(x_{n+1})=0; n=0,1,2,\ldots \tag{1.1}$$

$$\Delta^2\left(\frac{q_n}{a_n}\phi(x_n)\Delta\left(x_n+c_n x_{n-\sigma}\right)\right)+p_n\Delta x_n+q_n f(x_{n+1})=0; n=0,1,2,\ldots \tag{1.2}$$

$$\Delta^2\left(\frac{q_n}{a_n}\Delta\left(x_n+c_n x_{n-\sigma}\right)\right)+q_n f(x_{n+1})=0; n=0,1,2,\ldots \tag{1.3}$$

$$\Delta^2\left(\frac{q_n}{a_n}\phi(x_n)\Delta\left(x_n+c_n x_{n-\sigma}\right)\right)+p_n\Delta x_n+q_n f(x_{n+1})=0; n=0,1,2,\ldots \tag{1.4}$$

Where the following conditions are assumed to hold.

(H1) $\{a_n\},\{p_n\},\{q_n\}$ and $\{c_n\}$ are real positive sequence and $q_n \neq 0$ for infinitely many values of n.

(H2) $f: R \to R$ is continues and $xf(x)>0$ for all $x \neq 0$.

(H3) there exists a real valued function g such that

$f(u_n)-f(v_n)=g(u_n,v_n)[(u_n+c_n u_{n-\sigma})-(v_n+c_n v_{n-\sigma})]$, for all $u_n \neq 0, v_n \neq 0, c \geq 0, n>\sigma>0$ and

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$g(u_n, v_n) \geq L > 0 \in R.$

(H4) $\phi : R \to R$ is continues for all $x \neq 0, \phi(x_n) > 0$.

(H5) $\sum_{n=M}^{\infty} (n+1) p_n^{\ 2} < \infty.$

(H6) $\sum_{n=0}^{\infty} \frac{q_n^{\ 2}}{a_n^{\ 2}} < \infty.$

(H7) $\sum_{n=0}^{\infty} (n+1) q_n = \infty.$

(H8) $\sum_{n=0}^{\infty} \frac{a_n}{n q_n} = \infty.$

By a solution of equation (1.1) –(1.4), we mean a real sequence $\{x_n\}$ satisfying (1.1)-(1.4) for

$n = 0,1,2,....$A solution $\{x_n\}$ is said to be oscillatory if it is neither eventually positive nor eventually negative. Otherwise, it is called non-oscillatory. The forward difference operator Δ is defined by

$\Delta x_n = x_{n+1} - x_n$

In recent years, much research is going in the study of oscillatory behavior of solutions of third order difference equations. For more details on oscillatory behavior of difference equations, one may refer [1-22].

2 Main Results

In this section, we present some sufficient condition for the oscillation of all the solutions of (1.1)-(1.4). We begin with the following lemma.

Lemma 1

Let $P(n,s,x)$ be defined on $N \times N \times R^+, N = \{0,1,2,...\}, R^+ = [0,\infty)$ such that for fixed n and s , the function $P(n,s,x)$ is non-decreasing in x .Let $\{r_n\}$ be a given sequence and the sequences $\{x_n\}$ and $\{z_n\}$ be defined on N satisfying , for all $n \in N$,

$$x_n \geq r_n + \sum_{s=0}^{n-1} P(n,s,x_s), \qquad (2.1)$$

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And $$z_n = r_n + \sum_{s=0}^{n-1} P(n, s, z_s), \tag{2.2}$$

respectively. Then $z_n \le x_n$ for all $n \in N$.

This proof can be found in [18].

Theorem 1

In addition to (H1), (H2) and (H3).assume that (H5), (H6), (H7) and (H8) hold and let $z_n = x_n + c_n x_{n-\sigma}$. Then, every solution of (1.1) is oscillatory.

Proof:

Suppose the contrary. Then we may assume that $\{x_n\}$ be a non oscillatory solution of (1.1), such that $x_n > 0 (or x_n < 0)$ for all $n \ge M - 1, M > 0$ is an integer and let $b_n = \frac{q_n}{a_n}$.

Equation (1.1) implies

$$\Delta\left(b_{n+1}\Delta z_{n+1}\right) - \Delta\left(b_n \Delta z_n\right) + p_n \Delta x_n + q_n f(x_{n+1}) = 0 \tag{2.3}$$

Multiplying (2.3) by $\frac{n+1}{f(x_{n+1})}$ and summing from M to $(n-1)$, we obtain

$$\sum_{s=M}^{n-1} \frac{s+1}{f(x_{s+1})} \Delta\left(b_{s+1}\Delta z_{s+1}\right) - \sum_{s=M}^{n-1} \frac{s+1}{f(x_{s+1})} \Delta\left(b_s \Delta z_s\right) + \sum_{s=M}^{n-1} \frac{s+1}{f(x_{s+1})} p_s \Delta x_s + \sum_{s=M}^{n-1} (s+1) q_s = 0. \tag{2.4}$$

But

$$\sum_{s=M}^{n-1} \frac{s+1}{f(x_{s+1})} \Delta\left(b_{s+1}\Delta z_{s+1}\right) = \frac{(n+1) b_{n+1} \Delta x_{n+1}}{f(x_{n+1})} - \frac{(M+1) b_{M+1} \Delta x_{M+1}}{f(x_{M+1})} - \sum_{s=M}^{n-1} \frac{b_{s+2}\Delta z_{s+2}}{f(x_{s+2})} + \sum_{s=M}^{n-1} \frac{(s+1) b_{s+2} g(x_{s+2,} x_{s+1}) \Delta z_{s+1} \Delta z_{s+2}}{f(x_{s+1}) f(x_{s+2})} \tag{2.5}$$

Also,

$$\sum_{s=M}^{n-1} \frac{s+1}{f(x_{s+1})} \Delta\left(b_s \Delta z_s\right) = \frac{(n+1) b_n \Delta x_n}{f(x_{n+1})} - \frac{(M+1) b_M \Delta x_M}{f(x_{M+1})} - \sum_{s=M}^{n-1} \frac{b_{s+1}\Delta z_{s+1}}{f(x_{s+2})} + \sum_{s=M}^{n-1} \frac{(s+1) b_{s+1} g(x_{s+2,} x_{s+1}) (\Delta z_{s+1})^2}{f(x_{s+1}) f(x_{s+2})} \tag{2.6}$$

Substituting (2.5) and (2.6) in (2.4), we have

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$$\left(\frac{(n+1)b_{n+1}\Delta z_{n+1}}{f(x_{n+1})}-\frac{(n+1)b_n\Delta z_n}{f(x_{n+1})}\right)+\sum_{s=M}^{n-1}\left(\frac{(s+1)b_{s+2}g(x_{s+2},x_{s+1})\Delta z_{s+1}\Delta z_{s+2}}{f(x_{s+1})f(x_{s+2})}-\frac{(s+1)b_{s+1}g(x_{s+2},x_{s+1})(\Delta z_{s+1})^2}{f(x_{s+1})f(x_{s+2})}\right)$$

$$-\sum_{s=M}^{n-1}\left(\frac{b_{s+2}\Delta z_{s+2}}{f(x_{s+2})}-\frac{b_{s+1}\Delta z_{s+1}}{f(x_{s+2})}\right)+\sum_{s=M}^{n-1}\frac{s+1}{f(x_{s+1})}p_s\Delta x_s+\sum_{s=M}^{n-1}(s+1)q_s=\left(\frac{(M+1)b_{M+1}\Delta z_{M+1}}{f(x_{M+1})}-\frac{(M+1)b_M\Delta z_M}{f(x_{M+1})}\right) \quad (2.7)$$

Using Schwarz's inequality, we have

$$\sum_{s=M}^{n-1}\left(\frac{b_{s+2}\Delta z_{s+2}}{f(x_{s+2})}\right)\le\left(\sum_{s=M}^{n-1}(b_{s+2})^2\right)^{1/2}\left(\sum_{s=M}^{n-1}\left(\frac{\Delta z_{s+2}}{f(x_{s+2})}\right)^2\right)^{1/2} \quad (2.8)$$

$$\sum_{s=M}^{n-1}\left(\frac{b_{s+1}\Delta z_{s+1}}{f(x_{s+2})}\right)\le\left(\sum_{s=M}^{n-1}(b_{s+1})^2\right)^{1/2}\left(\sum_{s=M}^{n-1}\left(\frac{\Delta z_{s+1}}{f(x_{s+2})}\right)^2\right)^{1/2} \quad (2.9)$$

$$\sum_{s=M}^{n-1}\left(\frac{(s+1)b_{s+2}g(x_{s+2},x_{s+1})\Delta z_{s+1}\Delta z_{s+2}}{f(x_{s+1})f(x_{s+2})}\right)\le\left(\sum_{s=M}^{n-1}(b_{s+2})^2\right)^{1/2}\left(\sum_{s=M}^{n-1}\left(\frac{(s+1)g(x_{s+2},x_{s+1})\Delta z_{s+1}\Delta z_{s+2}}{f(x_{s+1})f(x_{s+2})}\right)^2\right)^{1/2} \quad (2.10)$$

$$\sum_{s=M}^{n-1}\left(\frac{(s+1)b_{s+1}g(x_{s+2},x_{s+1})(\Delta z_{s+1})^2}{f(x_{s+1})f(x_{s+2})}\right)\le\left(\sum_{s=M}^{n-1}(b_{s+1})^2\right)^{1/2}\left(\sum_{s=M}^{n-1}\left(\frac{(s+1)g(x_{s+2},x_{s+1})(\Delta z_{s+1})^4}{f(x_{s+1})f(x_{s+2})}\right)^2\right)^{1/2} \quad (2.11)$$

And

$$\sum_{s=M}^{n-1}\left(\frac{(s+1)p_s\Delta x_s}{f(x_{s+1})}\right)\le\left(\sum_{s=M}^{n-1}(s+1)(p_s)^2\right)^{1/2}\left(\sum_{s=M}^{n-1}(s+1)\left(\frac{\Delta x_s}{f(x_{s+1})}\right)^2\right)^{1/2} \quad (2.12)$$

In view of (2.8), (2.9), (2.10),(2.11) and (2.12), the summation in (2.7) is bounded , we have

$$\left(\frac{(n+1)b_{n+1}\Delta z_{n+1}}{f(x_{n+1})}-\frac{(n+1)b_n\Delta z_n}{f(x_{n+1})}\right)-\left(\sum_{s=M}^{n-1}(b_{s+2})^2\right)^{1/2}\left(\sum_{s=M}^{n-1}\left(\frac{\Delta z_{s+2}}{f(x_{s+2})}\right)^2\right)^{1/2}+\left(\sum_{s=M}^{n-1}(b_{s+1})^2\right)^{1/2}\left(\sum_{s=M}^{n-1}\left(\frac{\Delta z_{s+1}}{f(x_{s+2})}\right)^2\right)^{1/2}$$

$$+\left(\sum_{s=M}^{n-1}(b_{s+2})^2\right)^{1/2}\left(\sum_{s=M}^{n-1}\left(\frac{(s+1)g(x_{s+2},x_{s+1})\Delta z_{s+1}\Delta z_{s+2}}{f(x_{s+1})f(x_{s+2})}\right)^2\right)^{1/2}-\left(\sum_{s=M}^{n-1}(b_{s+1})^2\right)^{1/2}\left(\sum_{s=M}^{n-1}\left(\frac{(s+1)g(x_{s+2},x_{s+1})(\Delta z_{s+1})^4}{f(x_{s+1})f(x_{s+2})}\right)^2\right)^{1/2}$$

$$+\left(\sum_{s=M}^{n-1}(s+1)(p_s)^2\right)^{1/2}\left(\sum_{s=M}^{n-1}(s+1)\left(\frac{\Delta x_s}{f(x_{s+1})}\right)^2\right)^{1/2}\le\left(\frac{(M+1)b_{M+1}\Delta z_{M+1}}{f(x_{M+1})}-\frac{(M+1)b_M\Delta z_M}{f(x_{M+1})}\right)-\sum_{s=M}^{n-1}(s+1)q_s \quad (2.13)$$

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In view of (H5), (H6) and (H7), we get from (2.13) that $\dfrac{(n+1)\Delta(b_n\Delta z_n)}{f(x_{n+1})} \to -\infty$ as $n \to \infty$.

Hence there exists $M_1 \geq M$ such that $\Delta(b_n\Delta z_n) < 0$ for $n \geq M$, which implies $\Delta(b_n\Delta z_n) < -k, k > 0$

Summing the last inequality from m to $(n-1)$, we obtain

$$\sum_{s=m}^{n-1} \Delta(b_s\Delta z_s) < \sum_{s=m}^{n-1}(-k)$$

That is $b_n\Delta z_n < -k(n-m) + b_m\Delta z_m$

Therefore $b_n\Delta z_n \to -\infty$ as $n \to \infty$. Hence there exists $M_2 \geq M_1$ such that $\Delta z_n < 0$ for $n \geq M_2$ (2.14)

Rewriting (2.7), we have

$$\frac{(n+1)b_{n+1}\Delta z_{n+1}}{f(x_{n+1})} + \sum_{s=M_2}^{n-1} \frac{(s+1)b_{s+2}g(x_{s+2},x_{s+1})\Delta z_{s+1}\Delta z_{s+2}}{f(x_{s+1})f(x_{s+2})} = \frac{(n+1)b_n\Delta z_n}{f(x_{n+1})} + \frac{(M+1)b_{M+1}\Delta z_{M+1}}{f(x_{M+1})} - \frac{(M+1)b_M\Delta z_M}{f(x_{M+1})}$$

$$-\sum_{s=M}^{n-1}(s+1)q_s + \sum_{s=M_2}^{n-1} \frac{(s+1)b_{s+1}g(x_{s+2},x_{s+1})(\Delta z_{s+1})^2}{f(x_{s+1})f(x_{s+2})} - \sum_{s=M}^{M_2-1} \frac{(s+1)b_{s+2}g(x_{s+2},x_{s+1})\Delta z_{s+1}\Delta z_{s+2}}{f(x_{s+1})f(x_{s+2})} - \sum_{s=M}^{M_2-1} \frac{s+1}{f(x_{s+1})} p_s\Delta x_s$$

$$+\sum_{s=M}^{M_2-1} \frac{(s+1)b_{s+1}g(x_{s+2},x_{s+1})(\Delta z_{s+1})^2}{f(x_{s+1})f(x_{s+2})} + \sum_{s=M}^{M_2-1}\left(\frac{b_{s+2}\Delta z_{s+2}}{f(x_{s+2})} - \frac{b_{s+1}\Delta z_{s+1}}{f(x_{s+2})}\right) + \sum_{s=M_2}^{n-1}\left(\frac{b_{s+2}\Delta z_{s+2}}{f(x_{s+2})} - \frac{b_{s+1}\Delta z_{s+1}}{f(x_{s+2})}\right) - \sum_{s=M_2}^{n-1} \frac{s+1}{f(x_{s+1})} p_s\Delta x_s$$

(2.15)

From (H1), (H7), (2.14) and (2.15), there exists an integer $M_3 \geq M_2$, such that

$\dfrac{(n+1)b_{n+1}\Delta z_{n+1}}{f(x_{n+1})} + \displaystyle\sum_{s=M_2}^{n-1} \dfrac{(s+1)b_{s+2}g(x_{s+2},x_{s+1})\Delta z_{s+1}\Delta z_{s+2}}{f(x_{s+1})f(x_{s+2})} \leq -l, l \geq M_3$ where l is a positive integer.

$$-\frac{(n+1)b_{n+1}\Delta z_{n+1}}{f(x_{n+1})} - \sum_{s=M_2}^{n-1} \frac{(s+1)b_{s+2}g(x_{s+2},x_{s+1})\Delta z_{s+1}\Delta z_{s+2}}{f(x_{s+1})f(x_{s+2})} \geq l \quad (2.16)$$

Let $u_{n+1} = -(n+1)\Delta z_{n+1}$, (2.16) becomes

$$\frac{u_{n+1}b_{n+1}}{f(x_{n+1})} \geq l + \sum_{s=M_3}^{n-1} \frac{(s+1)b_{s+2}g(x_{s+2},x_{s+1})\Delta z_{s+1}\Delta z_{s+2}}{f(x_{s+1})f(x_{s+2})}; n \geq M_3$$

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(i.e) $u_{n+1} \geq l\dfrac{f(x_{n+1})}{b_{n+1}} + \sum_{s=M_3}^{n-1} \dfrac{b_{s+2} f(x_{n+1}) g(x_{s+2}, x_{s+1})(-\Delta z_{s+2}) u_{s+1}}{b_{n+1} f(x_{s+1}) f(x_{s+2})}$ (2.17)

Also, Let $v_{n+1} = l\dfrac{f(x_{n+1})}{b_{n+1}} + \sum_{s=M_3}^{n-1} \dfrac{b_{s+2} f(x_{n+1}) g(x_{s+2}, x_{s+1})(-\Delta z_{s+2}) v_{s+1}}{b_{n+1} f(x_{s+1}) f(x_{s+2})}$ (2.18)

Using lemma 1, we have, from (2.17) and (2.18)

$$\Rightarrow u_{n+1} \geq v_{n+1} \qquad (2.19)$$

(2.18) implies $v_{n+1} = \dfrac{f(x_{n+1})}{b_{n+1}} \left(l + \sum_{s=M_3}^{n-1} \dfrac{b_{s+2} g(x_{s+2}, x_{s+1})(-\Delta z_{s+2}) v_{s+1}}{f(x_{s+1}) f(x_{s+2})} \right)$

This implies that $v_{n+1} \geq \dfrac{lf(x_{M_3})}{b_{n+1}}; n \geq M_3$ (2.20)

From (2.19) and (2.20), we have $-(n+1)\Delta z_{n+1} \geq \dfrac{lf(x_{M_3})}{b_{n+1}}$

$$\Rightarrow \Delta z_{n+1} \leq \frac{-lf(x_{M_3})}{(n+1)b_{n+1}} \qquad (2.21)$$

Summing (2.21) from M_3 to $(n-1)$, we have $\sum_{s=M_3}^{n-1} \Delta z_{n+1} \leq -lf(x_{M_3}) \sum_{s=M_3}^{n-1} \dfrac{1}{(n+1)b_{n+1}}$

That is $z_{n+1} - z_{M_3+1} \leq -lf(x_{M_3}) \sum_{s=M_3}^{n-1} \dfrac{1}{(n+1)b_{n+1}}$

$$\Rightarrow z_{n+1} \leq z_{M_3+1} - lf(x_{M_3}) \sum_{s=M_3}^{n-1} \frac{1}{(n+1)b_{n+1}}$$

$\Rightarrow z_n = (x_n + c_n x_{n-\sigma}) \leq 0$ For sufficiently large n,

Which is a contradiction to the fact that x_n is eventually positive. The proof is similar for the case when x_n is eventually negative. Hence the theorem is completely proved.

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Examples

Example 1

Consider the difference equation

$$\Delta^2\left(\frac{n}{n+1}\Delta\left(x_n+nx_{n-3}\right)\right)+\frac{9n^2+18n+5}{2n^2(n+1)(n+2)}\Delta x_n+\frac{x_{n+1}}{n(n+1)}=0 \qquad \text{(E1)}$$

All the conditions of Theorem 1 are satisfied. Hence every solution of equation (E1) is oscillatory.

Example 2

Consider the difference equation

$$\Delta^2\left(\frac{n+1}{n+2}\Delta\left(x_n+nx_{n-5}\right)\right)+\frac{1}{n^3}\sqrt{\frac{n}{n+1}}\Delta x_n+\frac{(x_{n+1})^3}{(n+1)(n+2)}=0 \qquad \text{(E2)}$$

All the conditions of Theorem 1 are satisfied. Hence every solution of equation (E2) is oscillatory

Theorem 2

In addition to (H1), (H2) ,(H3)and (H4).assume that (H5), (H6), (H7) and (H8) hold and let $z_n = x_n + c_n x_{n-\sigma}$. Then, every solution of (1.2) is oscillatory.

Theorem 3

In addition to (H1), (H2) and (H3).assume that (H6), (H7) and (H8) hold and let $z_n = x_n + c_n x_{n-\sigma}$. Then, every solution of (1.3) is oscillatory.

Theorem 4

In addition to (H1), (H2), (H3) and (H4).assume that (H6), (H7) and (H8) hold and let $z_n = x_n + c_n x_{n-\sigma}$. Then, every solution of (1.4) is oscillatory.

Proofs of Theorem 2, Theorem 3 and Theorem 4 are similar to the proof of Theorem 1 and hence the details are omitted.

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Modeling and Detecting Damage in Rails & Avoidance of Collision in the Tracks

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Abstract-- One of the major problems that railroads have faced since the earliest days is the prevention of service failures in track. As is the case with all modes of high-speed travel, Rail is manufactured in different weights; there are different rail conditions wear, corrosion etc. present there are a significant number of potential defects possible and the task has to be performed with some speed to reliably inspect the thousands of miles of track stretching across the land failures of an essential component can have serious consequences. The main problem about a railway analysis is detection of cracks in the structure. If these deficiencies are not controlled at early stages they might cause huge economical problems affecting the rail network unexpected requisition of spare parts, handling of incident and/or accidents. The main part of the work was to carry out a feasibility study on two methods for detection of cracks in the tracks and avoidance of the collision between the rails. The detection of cracks can be identified using the UVRays, CAN Controller & GSM. The avoidance of collision can be carried out using IR Rays.

Keywords-- Avoidance, Cracks, CAN Controller, Detection, GSM, IR & UV Rays

I. INTRODUCTION

Today, rail networks across the world are getting busier with trains travelling at higher speeds and carrying more passengers and heavier axle loads than ever before. The combination of these factors has put considerable pressure on the existing infrastructure, leading to increased demands in inspection and maintenance of rail assets. The expenditure for inspection and maintenance has thus, grown steadily over the last few years without however being followed by a significant improvement of the industry's safety records. As a direct consequence the immediate key challenges faced by the rail industry are: The improvement in the safety of the railway system, the development of new railways to accommodate the continued growth in demand, and Contributing to a more sustainable railway, in both environmental and financial terms, by delivering further efficiencies and exploiting technological innovation. High safety standards required in the management of railroad lines demand the inspection of railway wheels directly after production in order to detect the presence of surface cracks that could seriously affect the integrity of the railway, and therefore passengers' safety. During the last one year, we have been developing the proposed system for the detection of cracks. The main goal was to develop the highly reliable system based on detection of cracks using UV rays i.e., UV transmitter and receiver to avoid future accidents. The system is based on UV rays with signal lamp will acts as a UV receiver and it will be connect to the CAN Controller and to the GSM. By this technique the cracks are visible and they can easily see in the nearest railway station and as well as it will indicate to the engine also. So finally engine detects the alarm and engine driver will stop the train to prevent from the big Disaster. The avoidance of collision can be carried out using IR Rays. For example the two trains at different destinations i.e., from Tambaram to Chengalpattu in case two train start at different direction one train goes to Tambaram another for Chengalpattu but there is one single line so in this case severe clash will happen. In order to avoid this, our proposed model will save the train. Here we are going to pass the IR rays from the engine likewise opposite train engine also have the same rays at one particular distance the two rays will get collide and get reflected back to the engines so the alarm detects in the engine and driver will stop the train.

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II. DETECTION OF CRACKS FOUNDATIONS

The detection of Cracks can be identified using UV rays with the UV transmitter and receiver. UV receiver is connected to the Signal Lamp and it will acts as Sensor. CAN Controller is connected to the main node and it sends the information via GSM and transmits the message to engine and to the nearest station.

A. UV Rays

Ultraviolet (UV) radiation is electromagnetic radiation of a wavelength shorter than that of the visible region, but longer than that of soft X-rays. It can be subdivided into near UV (380–200 nm wavelength) and extreme or vacuum UV (200–10 nm). When considering the effects of UV radiation on human health and the environment, the range of UV wavelengths is often subdivided into UVA (380–315 nm), also called Long Wave or "backlight"; UVB (315–280 nm), also called Medium Wave; and UVC (280-10 nm), also called

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Short Wave or "germicidal”. The name means "beyond violet" (from Latin ultra, "beyond"), violet being the colour of the shortest wavelengths of visible light. Some of the UV wavelengths are colloquially called black light, as it is invisible to the human eye. The solar corona as seen in "deep" ultraviolet light at 17.1 nm by the Extreme ultraviolet Imaging Telescope instrument aboard the SOHO spacecraft. The Sun emits ultraviolet radiation in the UVA, UVB, and UVC bands, but because of absorption in the atmosphere's ozone layer, 99% of the ultraviolet radiation that reaches the Earth's surface is UVA. Some of the UVC light is responsible for the generation of the ozone. Ordinary glass is transparent to UVA but is opaque to shorter wavelengths. Silica or quartz glass, depending on quality, can be transparent even to vacuum UV wavelengths. The onset of vacuum UV, 200 nm, is defined by the fact that ordinary air is opaque below this wavelength. This opacity is due to the strong absorption of light of these wavelengths by oxygen in the air. Pure nitrogen less than about 10 ppm oxygen is transparent to wavelengths in the range of about 150–200 nm. This has wide practical significance now that semiconductor manufacturing processes are using wavelengths shorter than 200 nm. By working in oxygen-free gas, the equipment does not have to be built to withstand the pressure differences required to work in a vacuum. Some other scientific instruments, such as circular dichroism spectrometers, are also commonly nitrogen purged and operate in this spectral region. Soon after infrared radiation had been discovered, the German physicist Johann Wilhelm Ritter began to look for radiation at the opposite end of the spectrum, at the short wavelengths beyond violet. In 1801 he used silver chloride, a light-sensitive chemical, to show that there was a type of invisible light beyond violet, which he called chemical rays. At that time, many scientists, including Ritter, concluded that light was composed of three separate components: an oxidising or calorific component (infrared), an illuminating component (visible light), and a reducing or hydrogenating component (ultraviolet). The unity of the different parts of the spectrum was not understood until about 1842, with the work of Macedonia Melloni, Alexander-Edmond Becquerel and others.UV Light have many uses. Some of them are as follows:

Black lights

A black light is the name commonly given to a lamp emitting almost entirely UV radiation and very little visible light. Ultraviolet radiation itself is invisible, but illuminating certain materials with UV radiation prompts the visible effects of fluorescence and phosphorescence. Black light testing is commonly used to authenticate antiques and bank notes. The fluorescence it prompts from certain textile fibers is also used as a recreational effect.

Flourescent lamps

Fluorescent lamps produce UV radiation by the emission of low-pressure mercury gas. A phosphorescent coating on the inside of the tubes absorbs the UV and becomes visible. The main mercury emission wavelength is in the UVC range. Unshielded exposure of the skin or eyes to mercury arc lamps that do not have a conversion phosphor is quite dangerous. The light from a mercury lamp is predominantly at discrete wavelengths. Other practical UV sources with more continuous emission spectra include xenon arc lamps commonly used as sunlight simulators, deuterium arc lamps, mercury-xenon arc lamps, metal-halide arc lamps, and tungsten-halogen incandescent lamps.

Spectrophotometry

UV radiation is often used in visible spectrophotometry to determine the existence of fluorescence a given sample.

Photolithography

Ultraviolet radiation is used for very fine resolution photolithography, a procedure where a chemical known as a photo resist is exposed to UV radiation which has passed through a mask. The light allows chemical reactions to take place in the photo resist, and after development (a step that either removes the exposed or unexposed photo resist), a geometric pattern which is determined by the mask remains on the sample. Further steps may then be taken to "etch" away parts of the sample with no photo resist remaining.

UV radiation is used extensively in the electronics industry because photolithography is used in the manufacture of semiconductors, integrated circuit components and printed circuit boards.

Checking electrical insulation

A new application of UV is to detect corona discharge (often simply called "corona") on electrical apparatus. Degradation of insulation of electrical apparatus or pollution causes corona, wherein a strong electric field ionizes the air and excites nitrogen molecules, causing the emission of ultraviolet radiation. The corona degrades the insulation level of the apparatus. Corona produces ozone and to a lesser extent nitrogen oxide which may subsequently react with water in the air to form nitrous acid and nitric acid vapours in the surrounding air.

Sterilization

Ultraviolet lamps are used to sterilize workspaces and tools used in biology laboratories and medical facilities. Conveniently, low pressure mercury discharge lamps emit about 50% of their light at the 253.7 nm mercury emission lines which coincides very well with the peak of the germicidal effectiveness curve at 265 nm. UV light at this wavelength causes adjacent thymine molecules on DNA to dimerize, if enough of these defects accumulate on a microorganism's DNA its replication is inhibited, thereby

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rendering it harmless. Since microorganisms can be shielded from ultraviolet light in small cracks and other shaded areas, however, these lamps are used only as a supplement to other sterilization techniques.

Fire detection

Ultraviolet (UV) detectors generally use either a solid-state device, such as one based on silicon carbide or aluminium nitride, or a gas-filled tube as the sensing element. UV detectors which are sensitive to UV light in any part of the spectrum respond to irradiation by sunlight and artificial light. A burning hydrogen flame, for instance, radiates strongly in the 185 to 260 nanometre (1850 to 2450 angstrom) range and only very weakly in the IR region, while a coal fire emits very weakly in the UV band yet very strongly at IR wavelengths; thus a fire detector which operates using both UV and IR detectors is more reliable than one with a UV detector alone. Virtually all fires emit some radiation in the UVB band, while the Sun's radiation at this band is absorbed by the Earth's atmosphere. The result is that the UV detector is "solar blind", meaning it will not cause an alarm in response to radiation from the Sun, so it can easily be used both indoors and outdoors.

UV detectors are sensitive to most fires, including hydrocarbons, metals, sulphur, hydrogen, hydrazine, and ammonia. Arc welding, electrical arcs, lightning, X-rays used in non-destructive metal testing equipment (though this is highly unlikely), and radioactive materials can produce levels that will activate a UV detection system. The presence of UV-absorbing gases and vapours will attenuate the UV radiation from a fire, adversely affecting the ability of the detector to "see" a flame. Likewise, the presence of an oil mist in the air or an oil film on the detector window will have the same effect.

B. Signal Lamp

A signal is a mechanical or electrical device erected beside a railway line to pass information relating to the state of the line ahead to train drivers/engineers. The driver interprets the signal's indication and acts accordingly. Typically, a signal might inform the driver of the speed at which the train may safely proceed, or it may instruct the driver to stop.

(Fig2.1.Signal lamp)

C. Application and positioning of signals

Originally, signals displayed simple stop/proceed indications (Fig: 2.2). As traffic density increased, this proved to be too limiting, and refinements were added. One such refinement was the addition of distant signals on the approach to stop signals. The distant signal gave the driver/engineer warning that he was approaching a signal which might require a stop. This allowed for an increase in speed, since trains no longer needed to be able to stop within sighting distance of the stop signal. Under timetable and train order operation, the signals did not directly convey orders to the train crew. Instead, they directed the crew to pick up orders, possibly stopping to do so if the order warranted it.

Signals are used to indicate one or more of the following:

- That the line ahead is clear (free of any obstruction) or blocked.
- That the driver has permission to proceed.
- Those points (also called switch or turnout in the US) are set correctly.
- Which way points are set?
- The speed the train may travel.
- The state of the next signal.
- That the train orders are to be picked up by the crew.
- Signals can be placed:
- At the start of a section of track.
- On the approach to a movable item of infrastructure, such as points/switches or a swing bridge.
- In advance of other signals.
- On the approach to a level crossing.
- At a switch or turnout.
- Ahead of platforms or other places that trains are likely to be stopped.
- At train order stations.

'Running lines' are usually continuously signalled. Each line of a double track railway is normally signalled in one direction only, with all signals facing the same direction on either line. Where 'bi-directional' signalling is installed, signals face in both directions on both tracks (sometimes known as 'reversible working' where lines are not normally used for bi-directional working). Signals are generally not provided for controlling movements within sidings or yard areas.

D. Aspects and indications

A British lower quadrant semaphore stop signal with subsidiary arm below. Signals have aspects and indications. The aspect is the visual appearance of the signal the indication is the meaning. In American practice the indications have conventional names, so that for instance "Medium Approach" means "Proceed at not exceeding medium speed prepared to stop at next signal". Different railroads historically assigned different meanings to the same aspect, so it is common as a result of mergers to find that different divisions of a modern railroad may have different rules governing the interpretation of signal aspects. A Finnish distant signal at the western approach to Muhos station is displaying Expect Stop. In the background, express train 81 is pulling away from the station. It is important to understand that for signals that use colour aspects, the colour of each individual light is subsumed in the overall pattern. In the United States, for example, it is common to see a "Clear" aspect consisting of a green light above a red light. The red light in this instance does not indicate "Stop"; it is simply a component of a larger aspect. Operating rules normally specify that when there is some imperfection in the display of an aspect (e.g., an extinguished lamp), the indication should be read as the most restrictive indication consistent with what is displayed. Signals control motion past the point at which the signal stands and into the next section of track. They may also convey information about the state of the next signal to be encountered. Signals are sometimes said to "protect" the points/switches, section of track, etc. that they are ahead of. The term "ahead of" can be confusing, so official UK practice is to use the terms in rear of and in advance of. When a train is waiting at a signal it is "in rear of" that signal and the danger being protected by the signal is "in advance of" the train and signal.

(Fig2.2.Aspects & indications)

A distinction must be made between absolute signals, which can display a "Stop" (or "Stop and Stay") indication, and permissive signals, which display a "Stop & Proceed" aspect. Furthermore, a permissive signal may be marked as a Grade Signal where a train does not need to physically stop for a "Stop & Proceed" signal, but only decelerate to a speed slow enough to stop short of any obstructions. Interlocking ('controlled') signals are typically absolute, while automatic signals (i.e. those controlled through track occupancy alone, not by a signalman) are usually permissive. Drivers need to be aware of which signals are automatic. In current British practice for example, automatic signals have a white rectangular plate with a black horizontal line across it. In US practice a permissive signal typically is indicated by the presence of a number plate. Some types of signal display separate permissive and absolute stop aspects. Operating rules generally dictate that a dark signal must be interpreted as displaying its most restrictive aspect (generally "Stop" or "Stop and Proceed").

E. Signal form

Signals differ both in the manner in which they display aspects and in the manner in which they are mounted with respect to the track.


(Fig2.3.Signal form)

F. Mechanical signals

Mechanical semaphore signals at Kościerzyna in Poland. A British semaphore signal on the former Southern Region of British Railways. The oldest forms of signal displayed their different indications by a part of the signal being physically moved. The earliest types comprised a board that was either turned face-on and fully visible to the driver, or rotated away so as to be practically invisible. These signals had two or at most three positions. Semaphore signals were patented in the early 1840s by Joseph James Stevens, and soon became the most widely-used form of mechanical signal, although they are now decreasing in number. The semaphore arm consists of two parts: An arm or blade which pivots at different angles, and a spectacle holding coloured lenses which move in front of a lamp in order to provide indications at night. Usually these were combined into a single frame, though in some types (e.g. "somersault" signals in which the arm pivoted in the centre), the arm was separate from the spectacle. The arm projects horizontally in its most restrictive aspect; other angles indicate less restrictive aspects. Semaphores come in "lower quadrant" and "upper quadrant" forms. In lower quadrant signals, the arm pivots down for less restrictive aspects. Upper quadrant signals, as the name implies, pivot the arm upward. Either type may be capable of showing two or three indications depending on the application. For example, it was common in the United States for train order signals to point the arm straight down to indicate "Proceed". The colour and shape of the arm is commonly varied to show the type of signal and therefore type of indication displayed. A common pattern was to use red, square-ended arms for "stop" signals and yellow "fishtail" arms for "distant" signals. A third type with a pointed end extending outward (in the opposite direction from the fishtail shape) may indicate "proceed at restricted speed after stopping" (and indeed, stopping itself is often waived for heavy freight ("tonnage") trains already moving at slow speed).The first railway semaphore was erected by Charles Hutton Gregory on the London and Croydon Railway (later the Brighton) at New Cross, southeast London, in the winter of 1842-1843 on the newly enlarged layout also accommodating the South Eastern Railway. The semaphore was afterwards rapidly adopted as a fixed signal throughout Britain, superseding all other types in most uses by 1870. Such signals were widely adopted in the U.S. after 1908.Initially, railway semaphores were mounted on the roof of the controlling signal box, but gradually a system of wires and pulleys controlled through mechanical linkages was

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developed to control the signals at a distance. Signal boxes became controllers of interlocking, and came to be known as interlocking towers or simply signal towers in the United States, while retaining the name "signal box" in the United Kingdom. The signals protecting the station itself came to be called home signals, while signals some distance away giving advance warning came to be called distant signals. Mechanical signals may be operated by electric motors or hydraulically. The signals are designed to be fail-safe so that if power is lost or a linkage is broken, the arm will move by gravity into the horizontal position. For lower quadrant semaphores this requires special counterweights to cause the arm to rise rather than fall; this is one of the reasons for the widespread switch to upper quadrant signals. In the U.S., semaphores were employed as train order signals, with the purpose of indicating to engineers whether they should stop to receive a telegraphed order, and also as simply one form of block signalling. Mechanical signals worldwide are being phased out in favour of colour-light signals or, in some cases, signalling systems that do not require line side signals (e.g. RETB).


(Fig2.4.Semaphore signal)

G. Colour light signals

Network Rail (UK) two-aspect colour light railway signal set at 'danger 'The introduction of electric light bulbs made it possible to produce colour light signals which were bright enough to be seen during daylight. Many railways thus converted to colour light signals. The signal head is the portion of a colour light signal which displays the aspects. To display a larger number of indications, a single signal might have multiple signal heads. Some systems used a single head coupled with auxiliary lights to modify the basic aspect. Colour light signals come in two forms. The most prevalent form is the multi-unit type, with separate lights and lenses for each colour, in the manner of a traffic light. Hoods and shields are generally provided to shade the lights from sunlight which could cause false indications; coloured Fresnel lenses are used to focus the beam, though reflectors are often not used in order to prevent false indications from reflected sunlight. The lights may be mounted vertically or in a triangle; usually green is on top and red at the bottom. Signals with more than three aspects to display generally have multiple heads to display combinations of colours. Mechanism of a searchlight signal made by Union Switch & Signal, with the lamp and reflector removed to expose the colored roundels Searchlight signals were also used, although these have become less popular. In these, a single incandescent light bulb is used in each head, and a solenoid is used to position a colored spectacle (or 'roundel') in front of the lamp. In effect, this mechanism is very similar to the colour light signal that is included in an electrically operated semaphore signal, except that the omission of the semaphore arm allows the roundels to be miniaturized and enclosed in weather proof housing. Typically, an elliptical reflector focuses the lamp through the roundel a small lens and then a larger Fresnel lens. The viewing angle for the searchlight beam is frequently very narrow, so these signals have to be carefully sited and aligned in order for the light to be seen properly. Again, to display more than three aspects, multiple heads are used. Searchlight signals have the disadvantage of having moving parts in what can be a hostile location for mechanical equipment and thus need regular maintenance. Searchlight signals could be seen on the Colchester to Clacton line in the UK until their replacement with LED signals in 2009. A few searchlight signals remain in use at Clacton. A variant of this is the Unilens signal made by Safe ran Systems Corporation, which uses a single-lens system, fed by three or four individual halogen lamps with parabolic reflectors behind them. These lamps shine through coloured filters into individual fibre-optic elements, which join together at the focal point of the lens assembly. This makes it possible to show four different colours (usually red/yellow/green/lunar (white)) from a single signal head, which is impossible for the traditional searchlight mechanism.


(Fig2.5.Signal colours)

H. German railway signals showing aspect Hp0 (Stop)

More recently, clusters of LEDs have started to be used in place of the incandescent lamps, reflectors and lenses. They have a more even colour output, use less power and have a working life of around 10 years, significantly reducing long term costs. These are often arranged so that the same aperture is used for whichever colour light is required and are therefore sometimes referred to as modern searchlights. Operating rules generally dictate that a dark signal be interpreted as giving the most restrictive indication it can display (generally "stop" or "stop and proceed"). Obviously this greatly impedes traffic until repairs are made. Therefore many colour light systems have circuitry to detect failures in lamps or mechanism, allowing the signal to compensate for the failure by displaying

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an aspect which, while more restrictive than that set by the dispatcher or signalling equipment, still allows traffic to pass for example, if a green lamp is burned out, but the indication to be displayed is "clear", the signal can detect this and display a cautionary aspect using a different lamp or lamps, allowing traffic to proceed at reduced speeds without stopping. Approach lighting leaves the signal dark (or dimmed) when a train is not present. This may be applied for sighting reasons, or simply to extend the life of the lamp and save the batteries. In the UK, most filament-type colour light signals are equipped with lamps having two filaments. When the main filament fails, the auxiliary filament automatically comes into use. Failure of the main filament is indicated to the technician (but not the signalman), who will then arrange for the lamp to be replaced. Failure of both filaments, resulting in a 'dark' signal, is indicated to the signalman, inside the signal box, also the previous signal may also be restricted to no more than a yellow warning aspect.

I. Position light signals

A position light signal is one where the position of the lights, rather than their colour, determines the meaning. The aspect consists solely of a pattern of illuminated lights, which are the entire same colour (typically amber or white). In many countries, small position light signals are used as shunting signals, while the main signals are of colour light form. Also, many tramway systems (such as the Metro of Wolverhampton) use position light signals. On the Pennsylvania Railroad, lights were displayed in rows of three, corresponding to the positions of a semaphore blade. Multiple signal heads were used at interlocking where four aspects did not suffice. The Pennsylvania Railroad chose to use position lights to both replace the semaphores and their moving parts as well as because the intense amber light provided superior visibility in adverse weather conditions such as rain or fog. The prototype position lights used rows of 4 lamps in an asymmetric fashion in the style of semaphore blades, but this was later changed to the symmetric 3-lamp system. The first installation of 3-lamp semaphores occurred on the Main Line between Philadelphia and Paoli, in concurrence with the 1915 electrification. These first signals differed from the later ones in that the lamps were mounted separately in front of a tombstone shaped black painted metal backing. Later the lamps and backing were integrated into a single unit. The Norfolk and Western also adopted PRR type amber position lights, as the PRR had a 33% share in the N&W at the time. Furthermore, the Long Island Rail Road adopted position lights after it was bought outright by the PRR. After the Penn Central merger, the former all-amber position lights were modified with twin red lenses in the upper horizontal position to enhance recognition of Stop signals at interlocking. The N&W also modified its all-amber position lights to include colour in the 1950s, and Amtrak fully coloured its inherited position lights (replacing all the amber) starting in the 1980s.Two-head colour position signal on CSXT mainline at Savage, Maryland. The left head displays "Stop", the right head, "Clear".

J. Colour-position signals

A system combining aspects of the colour and position systems was developed on the Baltimore and Ohio Railroad in the 1920s and was also applied to the Chicago and Alton Railroad when the latter was under B&O control. The CPLs were first installed as a pilot on the Staten Island Railroad in New York City; a former B&O subsidiary later turned rapid transit line operated by the Metropolitan Transportation Authority. The B&O system used a central round head with pairs of lights mimicking the traditional semaphore positions using pairs of large coloured lights (green, yellow, red) with a lunar white also being present sometimes. The main head was surrounded by up to 6 so-called "orbitals" at the 12, 2, 4, 6, 8 and 10 o'clock positions. The function of the main head was block occupancy information with green representing 2 or clearer blocks, yellow 1 clear block and red/lunar white representing no clear blocks. The orbital's would then serve to provide speed information, 12 o'clock being full (authorized) speed, 6 being Medium speed (Limited speed if flashing), 10 being Full to Medium (Limited if flashing), 2 being Full to Slow, 8 being Medium to Medium, 4 being Medium to Slow and no lit orbital's being Slow to Slow. The B&O CPL system was, and continues to be, the most theoretically sound signalling system in North America. It is the only system of signal aspects used in North America which only displays the colour red for situations involving an obstructed block or interlocking. Also, it is the only system to use the same aspects on high signals as it does on dwarf signals. Despite its advantages in clarity and viability, due to higher maintenance and construction costs it was not adopted by other railroads, and in the 1990s and 2000s CSX was gradually replacing these signals with colour light signals, though as of 2006, clusters of them remained, especially on secondary main lines. When the Staten Island Railroad was re-signalled in 2005 the MTA decided to keep and upgrade the CPL system. The Norfolk and Western as well as Amtrak both used a system which altered former all-amber position lights to ones with coloured lenses for visibility purposes. These should not be referred to or mistaken with B&O Colour Position Lights. On Amtrak they are officially called Position Colour Light although colorized position light would also be accurate.

K. Signal mounting

A gantry of British semaphore signals seen from the cab of a steam locomotive Line side signals need to be mounted in proximity to the track which they control.

Post mounting

When a single track is involved, the signal is normally mounted on a post which displays the arm or signal head at some height above the track, in order to allow it to be seen at a distance. The signal is normally put on the engineer's or driver's side of the tracks (Fig 2.8)

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(Fig2.6.Post mounting signal)

Gantry mounting

When multiple tracks are involved, or where space does not permit post mounting, other forms are found. In double track territory one may find two signals mounted side by side on a bracket which itself is mounted on a post. The left hand signal then controls the left-hand track, and the right signal the right-hand track. A gantry or signal bridge may also be used. This consists of a platform extending over the tracks; the signals are mounted on this platform over the tracks they control.

Ground mounting

Dwarf signal at Utrecht Central, Netherlands, in some situations where there is insufficient room for a post or gantry, signals may be mounted at ground level. Such signals may be physically smaller (termed dwarf signals). Rapid transit systems commonly use nothing but dwarf signals due to the restricted space. In many systems, dwarf signals are only used to display 'restrictive' aspects such as low speed or shunt aspects, and do not normally indicate 'running' aspects.

Control and operation of signals

Signals were originally controlled by levers situated at the signals, and later by levers grouped together and connected to the signal by wire cables, or pipes supported on rollers (US). Often these levers were placed in a special building, known as a signal box (UK) or interlocking tower (US), and eventually they were mechanically interlocked to prevent the display of a signal contrary to the alignment of the switch points. Automatic traffic control systems added track circuits to detect the presence of trains and alter signal aspects to reflect their presence or absence.

Cab signalling

Some locomotives are equipped to display cab signals. These can display signal indications through patterns of lights in the locomotive cab, or in simple systems merely produce an audible sound to warn the driver of a restrictive aspect. Occasionally, cab signals are used by themselves, but more commonly they are used to supplement signals placed at line side. Cab signalling is particularly useful on high speed railways. In the absence of line side signals, fixed markers may be provided at those places where signals would otherwise exist, to mark the limit of a movement authority.

Signalling power

Usually, signals and other equipment (such as track circuits and level crossing equipment), are powered from a low voltage supply (varies with country and equipment). The reason behind this is that the low voltage allows easy operation from storage batteries, and indeed in some parts of the world, batteries are the primary power source, as mains power may be unavailable at that location. In urban built-up areas, the trend is now to power signal equipment directly from mains power, with batteries only as backup.

III. CAN CONTROLLER

Controller area network (CAN or CAN-bus) is a vehicle bus standard designed to allow microcontrollers and devices to communicate with each other within a vehicle without a host computer. CAN is a message based protocol, designed specifically for automotive applications but now also used in other areas such as industrial automation and medical equipment. Development of the CAN bus started originally in 1983 at Robert Bosch GmbH. The protocol was officially released in 1986 at the Society of Automotive Engineers (SAE) congress in Detroit, Michigan. The first CAN controller chips, produced by Intel and Philips, came on the market in 1987. Bosch published the CAN 2.0 specification in 1991.CAN is one of five protocols used in the OBD-II vehicle diagnostics standard. The OBD standard is mandatory for all cars and light trucks sold in the United States since 1996, and the EOBD standard, mandatory for all petrol vehicles sold in the European Union since 2001 and all diesel vehicles since 2004.

Automotive - A modern automobile may have as many as 70 electronic control units (ECU) for various subsystems. Typically the biggest processor is the engine control unit, which is also referred to as "ECU" in the context of automobiles; others are used for transmission, airbags, antilock braking, cruise control, audio systems, windows, doors, mirror adjustment, etc. Some of these form independent subsystems, but communications among others are essential. A subsystem may need to control actuators or receive feedback from sensors. The CAN standard was devised to fill this need. The CAN bus may be used in vehicles to connect engine control unit and transmission, or (on a different bus) to connect the door locks, climate control, seat control, etc. Today the CAN bus is also used as a field bus in general automation environments; primarily due to the low cost of some CAN Controllers and processors. Bosch holds patents on the technology, and manufacturers of CAN-compatible microprocessors pay license fees to Bosch, which is normally passed on to the customer in the price of the chip. Manufacturers of products with custom ASICs or FPGAs

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containing CAN-compatible modules may need to pay a fee for the CAN Protocol License.

Technology

CAN is a multi-master broadcast serial bus standard for connecting electronic control units (ECUs).Each node is able to send and receive messages, but not simultaneously. A message consists primarily of an ID usually chosen to identify the message-type or sender and up to eight data bytes. It is transmitted serially onto the bus. This signal pattern is encoded in NRZ and is sensed by all nodes. The devices that are connected by a CAN network are typically sensors, actuators, and other control devices. These devices are not connected directly to the bus, but through a host processor and a CAN controller. If the bus is free, any node may begin to transmit. If two or more nodes begin sending messages at the same time, the message with the more dominant ID (which has more dominant bits, i.e., zeroes) will overwrite other nodes' less dominant IDs, so that eventually (after this arbitration on the ID) only the dominant message remains and is received by all nodes. Each node requires a host processor. The host processor decides what received messages mean and which messages it wants to transmit itself. Sensors, actuators and control devices can be connected to the host processor. CAN controller (hardware with a synchronous clock).

Receiving

The CAN controller stores received bits serially from the bus until an entire message is available, which can then be fetched by the host processor (usually after the CAN controller has triggered an interrupt).

Sending

The host processor stores it's transmit messages to a CAN controller, which transmits the bits serially onto the bus.
Transceiver (possibly integrated into the CAN controller)

Receiving

It adapts signal levels from the bus to levels that the CAN controller expects and has protective circuitry that protects the CAN controller.

Sending

It converts the transmit-bit signal received from the CAN controller into a signal that is sent onto the bus. Bit rates up to 1 Mbit/s are possible at network lengths below 40 m. Decreasing the bit rate allows longer network distances (e.g., 500 m at 125 Kbit/s).The CAN data link layer protocol is standardized in ISO 11898-1. This standard describes mainly the data link layer composed of the logical link control (LLC) sub layer and the media access control (MAC) sub layer and some aspects of the physical layer of the OSI reference model. All the other protocol layers are the network designer's choice.

Data transmission

CAN feature an automatic 'arbitration free' transmission. A CAN message that is transmitted with highest priority will 'win' the arbitration, and the node transmitting the lower priority message will sense this and back off and wait. This is achieved by CAN transmitting data through a binary model of "dominant" bits and "recessive" bits where dominant is a logical 0 and recessive is a logical 1. This means open collector, or 'wired or' physical implementation of the bus (but since dominant is 0 this is sometimes referred to as wired-AND). If one node transmits a dominant bit and another node transmits a recessive bit then the dominant bit "wins" (a logical AND between the two).
Truth tables for dominant/recessive and logical AND

- Bus state with two nodes transmitting
- Dominant recessive
- Dominant dominant dominant
- Recessive dominant recessive

Logical AND

	0	1
0	0	0
1	0	1

A. GSM

GSM (Global System for Mobile Communications: originally from Groupe Spécial Mobile) is the most popular standard for mobile telephony systems in the world. The GSM Association, its promoting industry trade organization of mobile phone carriers and manufacturers, estimates that 80% of the global mobile market uses the standard. GSM is used by over 1.5 billion people across more than 212 countries and territories. Its ubiquity enables international roaming arrangements between mobile network operators, providing subscribers the use of their phones in many parts of the world. GSM differs from its predecessor technologies in that both signalling and speech channels are digital, and thus GSM is considered a second generation (2G) mobile phone system. This also facilitates the wide-spread implementation of data communication applications into the system.

Technical details

The longest distance the GSM specification supports in practical use is 35 kilometres (22 mi). GSM-R, Global System for Mobile Communications - Railway or GSM-Railway is an international wireless communications standard for railway communication and applications. A sub-system of European Rail Traffic Management System (ERTMS), it is used for communication between train and railway regulation control centres. The system is based on GSM and EIRENE - MORANE specifications which guarantee performance at speeds up to 500 km/h (310 mph), without any

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communication loss. The standard is the result of over ten years of collaboration between the various European railway companies, with the goal of achieving interoperability using a single communication platform. GSM-R is part of the new European Rail Traffic Management System (ERTMS) standard and carries the signalling information directly to the train driver, enabling higher train speeds and traffic density with a high level of safety.

B. GSM-R Uses

GSM-R permits new services and applications for mobile communications in several domains:

- transmission of Long Line Public Address (LLPA) announcements to remote stations down the line
- control and protection (Automatic Train Control/ETCS) and ERTMS)
- communication between train driver and regulation center,
- communication of on-board working people
- information sending for ETCS
- communication between train stations, classification yard and rail tracks

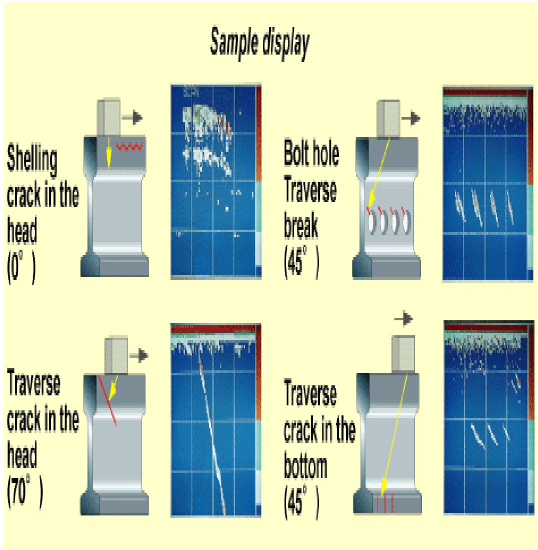
Main use

It is used to transmit data between trains and railway regulation centres with level 2 and 3 of ETCS. When the train passes over a Eurobalise, it transmits its new position and its speed, and then it receives back agreement (or disagreement) to enter the next track and its new maximum speed. In addition, trackside signals become redundant.

Railways using GSM-R

TGV POS, linking Paris to Germany and Switzerland ICE 3M at Gare de Est in Paris. A fully-functional GSM-R system is being trailed on the North Clyde Line in Scotland from 2007. For some years before these trials commenced however, GSM-R has been in use for voice-only purposes (known as the 'Interim Voice Radio System' (IVRS)) in some locations where axle counters are used for train detection, for example parts of the West Coast Main Line (WCML) between Crewe and Wembley. Britain's GSM-R network should be fully operational by 2013 at a cost of £1.2 billion. This cost though does not include the WCML.The first train (390 034 on the 09.15 Manchester Piccadilly service to London Euston) to use GSM-R on the south end of the West Coast Main Line ran on 27 May 2009. This is the first vehicle to run in passenger service with GSM-R outside of the Strathclyde trial. On 2nd Sept 09 the Rugby to Stoke section went live. Network Rail has fitted out a test train at Derby it purchased for RSV testing of the GSM-R network. The train is formed from ex Gatwick Express stock. At a cost of £5.9 million, this custom-built machine known as the RSV (Radio Signal Verification) train, has already started monitoring the Newport Synergy scheme and the Cambrian Line. The Cambrian Line ERTMSPwllheli to HarlechRehearsal commenced on 13 February 2010 and successfully finished on 18 February 2010. The driver familiarisation and practical handling stage of the Rehearsal has provided an excellent opportunity to monitor the use of GSM-R voice in operation on this route. The first train departed Pwllheli at 0853hrs in ERTMS Level 2 Operation with GSM-R voice being used as the only means of communication between the driver and the signaller. In France, the first commercial railway route opened with full GSM-R coverage is the LGV Esteuropenne linking Paris Gare de l'Est to Strasbourg. It was opened on the 10th of June 2007.On Sunday, June 10, 2007 at 0643, the first high speed train run on it was the ICE, the high speed train from the German passenger operator: DB. It linked the Gare de l'Est in Paris to Saarbrucken (Germany).On the same day, 0715; it was the opportunity of the TGV POS, the last generation high speed train from the French operator, SNCF. It linked Strasbourg to Paris (Gare de l'Est).In Norway, the GSM-R network was opened on all lines on 1 January 2007.In The Netherlands, there is coverage on all the lines and the old system called Telerail was abandoned in favour of GSM-R in 2006.As of 2008, in Italy more than 9000 km of railway lines are served by the GSM-R infrastructure: this number includes both ordinary and high speed lines, as well as more than 1000 km of tunnels. Roaming agreements with other Italian mobile operators allow coverage of line.

C. Types of Detects



(Fig3.1.Types of detection in cracks)

Types of Corrosion and its Prevention

There are different types of corrosion. Appropriate reasons are described. Corrosion is a natural phenomenon. Eminent scientists, engineers, and researchers have been successful over the years in overcoming this menacing problem. Nevertheless, periodical assessments are done to achieve the current level of protection.

Galvanic Corrosion

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Gradual decay of metal by electrochemical process or by chemical is corrosion. Galvanic corrosion is a generic form. An anode, cathode and an electrolyte are necessary to form galvanic corrosion. This combination is known as a galvanic cell. It is formed when two dissimilar metals are electrically connected by an aqueous solution that causes electron transfer. Chemical reduction forms when the current enters the electrode from the electrolyte. Electrical potential difference occurs when anode and cathode are separated in a conductive electrolyte. The charged cat-ions flow from anode to cathode via a conductive electrolyte. An electrical circuit is formed by this action, and corrosion occurs at the anode. The cathode may corrode to a lesser extent. Oxidation happens when anode loses electrons, which causes a positively charged metal surface. Cat-ions attract negative anions in electrolyte forming a new compound. It loses its former metal properties forming rust or iron oxide. Reduction refers to the gain of electrons at the cathode. Thus the cathode retains its metallic properties. The occurrence and magnitude of corrosion depends on the potential difference between anode and cathode. Metals of highest potentials generally appear at the anodic end of the galvanic series and those with lowest potentials are at the cathodic end of the galvanic series. As a general rule, metals at the farther end of the galvanic series are more susceptible to corrosion when put together in a solution. Galvanic corrosion is invariably due to an electrochemical process wherein incompatible metals are connected to an electrical field through an electrolyte. Non-compatible metals – examples are aluminium and copper and aluminium and iron. Aluminium has a high affinity with oxygen. It instantly forms a tough oxide film which retards further oxidation.Aluminum and steel components are protected by powder coating. They come with attractive colours and a thick coating gives long lasting protection from corrosion. If the coating is scratched, corrosion starts gradually peeling the coating.

Intergranular Corrosion

Oxides at grain boundaries have high electrical resistance. Mechanical properties are also affected. The yield strength declines. Cold working suffers damage. Microstructure study reveals spread and agglomerated distribution of unwanted oxides. Aluminium oxides always settle at grain boundary which is unavoidable. Aircrafts use aluminium alloys. Treating the molten alloys or pure aluminium with rare earth elements contains the oxides inside the grain boundaries. It makes the metal stronger and electrically efficient. Fatigue failures are avoided by containing oxides inside the grain boundaries.

Uniform Corrosion

All types of corrosion are generally correlated though they may take different forms. Corrosion may spread over uniformly or concentrated at a localized area. This is distinguished by uniformity of corrosion distribution caused by movement of anodic and cathodic areas of the metallic surfaces. This tendency is more precarious than a failure case. The uniform spread of corrosion is usually seen at the base of railway track is a classic example. The track is of I section and it is mechanically strong. Failures do not happen at the base since it is always under compressive loads. It makes no difference whether it is electric engine or diesel engine. Fatigue failure happens only at the joint interface under tensile stress.

Localized Corrosion

Localized corrosion creates tiny holes or pits in the metal surface. It is most dangerous like small pox. These pits are known as pitting effect. These are not readily visible. They may be concealed by corrosion debris. The dangerous subsurface damage gives rise to fatigue cracks if the metal is under tensile stress. Fortunately, pitting on the railway track is not serious problem because the high compressive rolling force does not allow pits to happen. This action is like shot blasting effect. The track faces are always shiny when there is constant traffic.

Stress Corrosion

Combinations of corrosive conditions under the application of tensile stress which have lower yield strength are prime reasons for failure. It is a time-based failure tendency.

Hydrogen Embrittlement

Whenever hydrogen gas is absorbed by metals at lower temperatures, the metals are susceptible to brittleness.

Passivation

Electroplated steel parts with zinc plating are passivated to prevent corrosion. After zinc plating is done with a zinc coat thickness of few microns, the component is dipped into chromic acid solution for a few seconds. It is rinsed in water and dried immediately to remove water traces. The surface attains a bright golden yellow colour finish which lasts in long use. Hot drying is done with temperature controlled electrically heated air blower. Please note that hot air temperature should not exceed 600C. If done at higher temperature, the attractive surface finish loses its luster and eventually becomes pretty dull. This is because the required bright finish which is a zinc chromate surface becomes zinc chromite. Zinc chromite and zinc chromate can be easily detected by X ray Diffraction analysis. Zinc chromite surface fades fast and becomes patchy with rust formation.

Anodizing

Aluminium has natural surface oxide protection. Increasing this oxide layer is known as anodizing. In

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anodizing, aluminium parts are connected to an electrode and the electrolyte is sulphuric acid. This gives higher corrosion and wears resistance. It has a crystalline structure surface and its thermal conductivity is less than aluminium. If the anodized parts are subjected to temperatures beyond 700C the surface layer will crack due to thermal stress. The thick anodized aluminium oxide layer with powder coating provides electrical protection against lighting- particularly for airplanes.

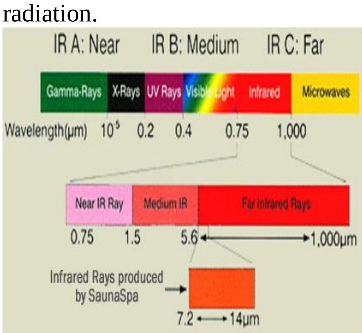
Powder Coating

Cleaned metal parts free from oil and grease are passivated with chromates or phosphates and powder coated with colour powder with an electrostatic gun. Passivating improves bonding. Powder coating comes in different attractive colours, and it has a lasting aesthetic appeal.

IV AVOIDANCE OF COLLISION

A. IR Rays

Infrared (IR) light is electromagnetic radiation with a wavelength between 0.7 and 300 micrometres, which equates to a frequency range between approximately 1 and 430 THz.IR wavelengths are longer than that of visible light, but shorter than that of terahertz radiation microwaves. Bright sunlight provides an irradiance of just over 1 kilowatt per square meter at sea level. Of this energy, 527 watts is infrared radiation, 445 watts is visible light, and 32 watts is ultraviolet radiation.



(Fig4.1.IR rays)

Different regions in the infrared

Objects generally emit infrared radiation across a spectrum of wavelengths, but only a specific region of the spectrum is of interest because sensors are usually designed only to collect radiation within a specific bandwidth. As a result, the infrared band is often subdivided into smaller sections.

CIE division scheme

The International Commission on Illumination (CIE) recommended the division of infrared radiation into the following three bands:

IR-A: 700 nm–1400 nm (0.7 µm – 1.4 µm)
IR-B: 1400 nm–3000 nm (1.4 µm – 3 µm)
IR-C: 3000 nm–1 mm (3 µm – 1000 µm)
A commonly used sub-division scheme is:

Near-infrared (NIR, IR-A DIN)

0.75-1.4 µm in wavelength, defined by the water absorption, and commonly used in fiber optic telecommunication because of low attenuation losses in the SiO2 glass (silica) medium. Image intensifiers are sensitive to this area of the spectrum. Examples include night vision devices such as night vision goggles.

Short-wavelength infrared (SWIR, IR-B DIN)

1.4-3 µm, water absorption increases significantly at 1,450 nm. The 1,530 to 1,560 nm range is the dominant spectral region for long-distance telecommunications.

Mid-wavelength infrared (MWIR, IR-C DIN) also called intermediate infrared (IIR)

3-8µm. In guided missile technology the 3-5 µm portion of this band is the atmospheric window in which the homing heads of passive IR 'heat seeking' missiles are designed to work, homing on to the IR signature of the target aircraft, typically the jet engine exhaust plume.

Long-wavelength infrared (LWIR, IR-C DIN)

8–15µm. This is the "thermal imaging" region, in which sensors can obtain a completely passive picture of the outside world based on thermal emissions only and requiring no external light or thermal source such as the sun, moon or infrared illuminator. Forward-looking infrared (FLIR) systems use this area of the spectrum. Sometimes also called the "far infrared."

Far infrared (FIR) 15 - 1,000 µm (see also far infrared laser):

NIR and SWIR is sometimes called "reflected infrared" while MWIR and LWIR is sometimes referred to as "thermal infrared." Due to the nature of the blackbody radiation curves, typical 'hot' objects, such as exhaust pipes, often appear brighter in the MW compared to the same object viewed in the LW.

ISO 20473 scheme

Designation	Abbreviation	Wavelength
Near Infrared	NIR	0.78 - 3 µm
Mid Infrared	MIR	3 - 50 µm
Far Infrared	FIR	50 - 1000 µm

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Astronomy division scheme

Astronomers typically divide the infrared spectrum as follows

Designation	Abbreviation	Wavelength
Near Infrared	NIR	(0.7-1) to 5 µm
Mid Infrared	MIR	5 to (25-40) µm
Far Infrared	FIR	(25-40)to(200-350) µm.

These divisions are not precise and can vary depending on the publication. The three regions are used for observation of different temperature ranges, and hence different environments in space.

B. Communications

IR data transmission is also employed in short-range communication among computer peripherals and personal digital assistants. These devices usually conform to standards published by IrDA, the Infrared Data Association. Remote controls and IrDA devices use infrared light emitting diodes (LEDs) to emit infrared radiation which is focused by a plastic lens into a narrow beam. The beam is modulated, i.e. switched on and off, to encode the data. The receiver uses a silicon photodiode to convert the infrared radiation to an electric current. It responds only to the rapidly pulsing signal created by the transmitter, and filters out slowly changing infrared radiation from ambient light. Infrared communications are useful for indoor use in areas of high population density. IR does not penetrate walls and so does not interfere with other devices in adjoining rooms. Infrared is the most common way for remote controls to command appliances. Free space optical communication using infrared lasers can be a relatively inexpensive way to install a communications link in an urban area operating at up to 4 gigabit/s, compared to the cost of burying fibre optic cable. Infrared lasers are used to provide the light for optical fiber communications systems. Infrared light with a wavelength around 1,330 nm (least dispersion) or 1,550 nm (best transmission) are the best choices for standard silica fibers.IR data transmission of encoded audio versions of printed signs is being researched as an aid for visually impaired people through the RIAS (Remote Infrared Audible Signage) project.

C. Transmitted Rays

In optics, a ray is an idealized narrow beam of light. Rays are used to model the propagation of light through an optical system, by dividing the real light field up into discrete rays that can be computationally propagated through the system by the techniques of ray tracing. This allows even very complex optical systems to be analyzed mathematically or simulated by computer. Ray tracing uses approximate solutions to Maxwell's equations that are valid as long as the light waves propagate through and around objects whose dimensions are much greater than the light's wavelength. Ray theory does not describe phenomena such as interference and diffraction, which require wave theory (involving the phase of the wave).

Special rays

There are many special rays that are used in optical modelling to analyze an optical system. These are defined and described below, grouped by the type of system they are used to model. Interaction with surfaces, Diagram of rays at a surface, an incident ray is a ray of light that strikes a surface. The angle between this ray and the perpendicular or normal to the surface is the angle of incidence. The reflected ray corresponding to a given incident ray, is the ray that represents the light reflected by the surface. The angle between the surface normal and the reflected ray is known as the angle of reflection. The Law of Reflection says that for a specular (non-scattering) surface, the angle of reflection always equals the angle of incidence. The refracted ray or transmitted ray corresponding to a given incident ray represents the light that is transmitted through the surface. The angle between this ray and the normal is known as the angle of refraction, and it is given by Snell's Law. Conservation of energy requires that the power in the incident ray must equal the sum of the power in the transmitted ray, the power in the reflected ray, and any power absorbed at the surface. If the material is birefringent, the refracted ray may split into ordinary and extraordinary rays, which experience different indexes of refraction when passing through the birefringent material.

D. Reflected Rays

In optics, a ray is an idealized narrow beam of light. Rays are used to model the propagation of light through an optical system, by dividing the real light field up into discrete rays that can be computationally propagated through the system by the techniques of ray tracing. This allows even very complex optical systems to be analyzed mathematically or simulated by computer. Ray tracing uses approximate solutions to Maxwell's equations that are valid as long as the light waves propagate through and around objects whose dimensions are much greater than the light's wavelength. Ray theory does not describe phenomena such as interference and diffraction, which require wave theory (involving the phase of the wave).

E. Time and Distance Calculation

The Time and distance can be calculated by using the following ways.
If energy get waste means,

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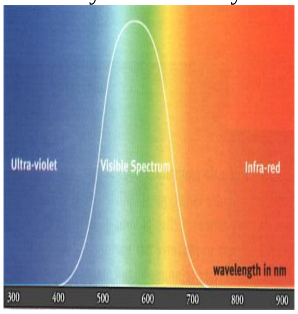
Incident rays = reflected rays.
If energy get now waste means,
Incident rays =/ reflected rays.
From the rays we can calculate the distance from the calculated distance we can set the time.

V UV & IR RAYS SENSING

Almost everything emits, reflects, or transmits some kind of light. The Electromagnetic (EM) Spectrum is the measurement of the frequency range of EM radiation of an object. The frequency is measured in wavelengths. The wavelength ranges can extend from the size of an atom to thousands of kilometres. The long wavelengths are low frequency and are the Radio, Microwave, and Infrared waves. The short wavelengths are the high frequency Ultraviolet, X-ray and Gamma Rays. The Visible Spectrum, or Optical Spectrum, is the range of the Electromagnetic Spectrum that is visible by the human eye.



(Fig5.1.spectrum waves)

A. Electromagnetic Spectrum

The Visible Spectrum has no clear boundaries from one colour to the next but is generally described in the following ranges:

- Violet 380-450nm (nanometres)
- Blue 450-495nm
- Green 495-570nm
- Yellow 570-590nm
- Orange 590-620nm
- Red 620-750nm

B. CAN CONTORLLER TO GSM INTERFACING

The base station subsystem (BSS) is the section of a traditional cellular telephone network which is responsible for handling traffic and signalling between a mobile phone and the network switching subsystem. The BSS carries out transcoding of speech channels, allocation of radio channels to mobile phones, paging, transmission and reception over the air interface and many other tasks related to the radio network.

Base transceiver station

Two GSM base station antennas disguised as trees in Dublin, Ireland. A solar-powered GSM base station on top of a mountain in the wilderness of Lapland

Base transceiver station

The base transceiver station, or BTS, contains the equipment for transmitting and receiving radio signals (transceivers), antennas, and equipment for encrypting and decrypting communications with the base station controller (BSC). Typically a BTS for anything other than a picocell will have several transceivers (TRXs) which allow it to serve several different frequencies and different sectors of the cell (in the case of sectorised base stations).A BTS is controlled by a parent BSC via the "base station control function" (BCF). The BCF is implemented as a discrete unit or even incorporated in a TRX in compact base stations. The BCF provides an operations and maintenance (O&M) connection to the network management system (NMS), and manages operational states of each TRX, as well as software handling and alarm collection. The functions of a BTS vary depending on the cellular technology used and the cellular telephone provider. There are vendors in which the BTS is a plain transceiver which receives information from the MS (mobile station) through the Um (air interface) and then converts it to a TDM (PCM) based interface, the Abis interface, and sends it towards the BSC. There are vendors which build their BTSs so the information is pre-processed, target cell lists are generated and even intracellular handover (HO) can be fully handled. The advantage in this case is fewer loads on the expensive Abis interface. The BTSs are equipped with radios that are able to modulate layer 1 of interface Um; for GSM 2G+ the modulation type is GMSK, while for EDGE-enabled networks it is GMSK and 8-PSK.Antenna combiners are implemented to use the same antenna for several TRXs (carriers), the more TRXs are combined the greater the combiner loss will be. Up to 8:1 combiners are found in micro and Pico cells only. Frequency hopping is often used to increase overall BTS performance; this involves the rapid switching of voice traffic between TRXs in a sector. A hopping sequence is followed by the TRXs and handsets using the sector. Several hopping sequences are available, and the sequence in use for a particular cell is continually broadcast by that cell so that it is known to the handsets. A TRX transmits and receives according to the GSM standards, which specify eight TDMA timeslots per radio frequency. A TRX may lose some of this capacity as some information is required to be broadcast to handsets in the area that the BTS serves. This information allows the handsets to identify the network and gain access to it. This signalling makes use of a channel known as the broadcast control channel (BCCH).

Sectorisation: Sector antenna

By using directional antennae on a base station, each pointing in different directions, it is possible to sectorise the base station so that several different cells are served from the same location. Typically these directional antennas have a

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beam width of 65 to 85 degrees. This increases the traffic capacity of the base station (each frequency can carry eight voice channels) whilst not greatly increasing the interference caused to neighbouring cells (in any given direction, only a small number of frequencies are being broadcast). Typically two antennas are used per sector, at spacing of ten or more wavelengths apart. This allows the operator to overcome the effects of fading due to physical phenomena such as multipath reception. Some amplification of the received signal as it leaves the antenna is often used to preserve the balance between uplink and downlink signal

Base station controller

GSM transmitter

The base station controller (BSC) provides, classically, the intelligence behind the BTSs. Typically a BSC has tens or even hundreds of BTSs under its control. The BSC handles allocation of radio channels, receives measurements from the mobile phones, and controls handovers from BTS to BTS (except in the case of an inter-BSC handover in which case control is in part the responsibility of the anchor MSC). A key function of the BSC is to act as a concentrator where many different low capacity connections to BTSs (with relatively low utilisation) become reduced to a smaller number of connections towards the mobile switching centre (MSC) (with a high level of utilisation). Overall, this means that networks are often structured to have many BSCs distributed into regions near their BTSs which are then connected to large centralised MSC sites.

The BSC is undoubtedly the most robust element in the BSS as it is not only a BTS controller but, for some vendors, a full switching centre, as well as an SS7 node with connections to the MSC and serving GPRS support node (SGSN) (when using GPRS). It also provides all the required data to the operation support subsystem (OSS) as well as to the performance measuring centres BSC is often based on a distributed computing architecture, with redundancy applied to critical functional units to ensure availability in the event of fault conditions. Redundancy often extends beyond the BSC equipment itself and is commonly used in the power supplies and in the transmission equipment providing the Ater interface to PCU. The databases for all the sites, including information such as carrier frequencies, frequency hopping lists, power reduction levels, receiving levels for cell border calculation, are stored in the BSC. This data is obtained directly from radio planning engineering which involves modelling of the signal propagation as well as traffic projections.

Transcoder

The transcoder is responsible for transcoding the voice channel coding between the coding used in the mobile network, and the coding used by the world's terrestrial circuit-switched network, the Public Switched Telephone Network. Specifically, GSM uses a regular pulse excited-long term prediction (RPE-LTP) coder for voice data between the mobile device and the BSS, but pulse code modulation (A-law or μ-law standardized in ITU G.711) upstream of the BSS. RPE-LPC coding results in a data rate for voice of 13 kbit/s where standard PCM coding results in 64 kbit/s. Because of this change in data rate for the same voice call, the transcoder also has a buffering function so that PCM 8-bit words can be recoded to construct GSM 20 ms traffic blocks. Although transcoding (compressing/decompressing) functionality is defined as a base station function by the relevant standards, there are several vendors which have implemented the solution outside of the BSC. Some vendors have implemented it in a stand-alone rack using a proprietary interface. In Siemens' and Nokia's architecture, the transcoder is an identifiable separate sub-system which will normally be co-located with the MSC. In some of Ericsson's systems it is integrated to the MSC rather than the BSC. The reason for these designs is that if the compression of voice channels is done at the site of the MSC, the number of fixed transmission links between the BSS and MSC can be reduced, decreasing network infrastructure costs. This subsystem is also referred to as the transcoder and rate adaptation unit (TRAU). Some networks use 32 kbit/s ADPCM on the terrestrial side of the network instead of 64 kbit/s PCM and the TRAU converts accordingly. When the traffic is not voice but data such as fax or email, the TRAU enables its rate adaptation unit function to give compatibility between the BSS and MSC data rates.

Packet control unit

The packet control unit (PCU) is a late addition to the GSM standard. It performs some of the processing tasks of the BSC, but for packet data. The allocation of channels between voice and data is controlled by the base station, but once a channel is allocated to the PCU, the PCU takes full control over that channel. The PCU can be built into the base station, built into the BSC or even, in some proposed architectures, it can be at the SGSN site. In most of the cases, the PCU is a separate node communicating extensively with the BSC on the radio side and the SGSN on the GB side.

BSS interfaces

Image of the GSM network, showing the BSS interfaces to the MS, NSS and GPRS Core Network

UM

The air interface between the mobile station (MS) and the BTS.

ABIS

The interface between the BTS and BSC. Generally carried by a DS-1, ES-1, or E1 TDM circuit.

ATER

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The interface between the BSC and transcoder. It is a proprietary interface whose name depends on the vendor (for example Ater by Nokia), it carries the A interface information from the BSC leaving it untouched.

GB

Connects the BSS to the SGSN in the GPRS core network.

VI NATURE OF WORK

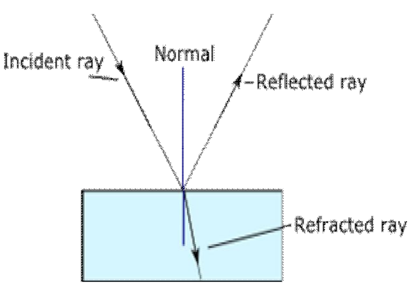
Here we are going to discuss about the proposed model for Detection and Avoidance of collision in the railway network. The detection can be done by UV rays i.e., UV transmitter & UV receiver. Avoidance can be done by the IR rays.

A. Detection of Cracks

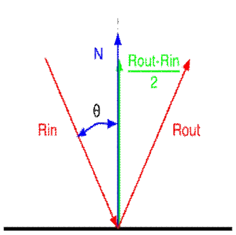
The detection of Cracks can be identified using UV rays with the UV transmitter and UV receiver. UV receiver is connected to the Signal Lamp and it will acts as Sensor. CAN controller is connected to the main node and it sends the information via GSM and transmit the message to engine and to the nearest station.

B. Avoidance of Collision

The avoidance of collision can be carried out by the IR rays. For example the two trains at different destinations i.e., from Tambaram to Chengalpattu in case two train start at different direction one train goes to Tambaram another for Chengalpattu but there is one single line so in this case severe clash will happen. In order to avoid this, our proposed model will save the train. Here we are going to pass the IR rays from the engine likewise opposite train engine also have the same rays at one particular distance the two rays will get collide and get reflected back to the engines so the alarm detects in the engine and driver will stop the train.



(Fig6.1.Rays incident on medium)



(Fig6.2.Reflected rays)

VII. RESULTS AND DISCUSSIONS

The main result for this paper is to avoid the detection of cracks and avoidance of collision between the rails. A collision avoidance technique based on short-distance train-to-train transmission is under test at the Wegberg-Wildenrath test centre near Düsseldorf in Gernamy.The trials are being led by aerospace research agency Deutches Zentrum für Luft- und Raumfahrt (DLR), which is providing researchers from its institutes for transportation systems and robotics & mechatronics. DLR partnered with train operator Bayerischen Oberlandbahn (BOB) for the trials – BOB offered use of an Integral dmu and crew. The other vehicle used was DLR's own "Rail Drive" road-rail unit.

(Fig7.1Detection of cracks)

"RCAS is a system for preventing train collisions that operates independently of other safety technology deployed alongside the railway track", Professor Dr Thomas String, project director at DLR explains. The DLR researchers delivered lectures and showed models to participants during a day of demonstration on 11 May. Observers were able to travel on the Integral, which was equipped with RCAS to communicate with the road-rail vehicle.

The two trains simulated three scenarios:

- One where the two were running alongside each other, simultaneously approaching a section of single-track line.
- In the second, one train headed for a set of points beyond which one route was occupied and the other clear, but the setting of the points was unclear.
- In a third test run, a train was left stationary near a set of points but did not constitute a hazard, and the system successfully recognised this. In all cases, RCAS assesses the situation automatically.

If it detects a conflicting move, the RCAS onboard interface prompts the driver to apply the brakes. "RCAS is initially intended for routes and situations where, at present, no other protection systems are employed – for example, routes with very low volumes of traffic, industrial railways, construction sites or shunting areas", according to Dr Michael

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Meyer zu Hörste, a DLR rail transport researcher. RCAS is in no way intended to replace ERTMS, he added. “It is an add-on system – RCAS can act as a safety overlay in places where conventional technology is not being employed.”According to DLR, the existing prototype is based on “standard commercial hardware and software”, which in its existing form does not hold official approval for safety-critical fields of operation, and this will not be sought. In order to avoid these types of cracks we are used the proposed model of UV rays with CAN controller. Anyway, the presented results, which also can be considered as preliminary results, are very encouraging and they suggest the possibility of increasing and generalizing the UV rays set up, i.e., UV transmitter & receiver.

CONCLUSION

Our proposed model is facing a new challenge to further improve the reliability of rail testing techniques, while seeking for new and emerging technologies in UV and IR rays or that aid the detection of rail defects. With the UV rays test equipment, focus has been on better understanding of the UV receiver at the signal lamp and the interaction of with the can controller with the defects through the main CAN node to the GSM. Further results, such as the crack location, depth, type etc. can be deduced through the analysis of the GSM Ongoing work is under way to develop improved automated rail testing techniques, mostly in the field of employing the proposed model for detection of cracks. Development of new processing algorithms (e.g. pattern/signature recognition) to detect defects has become the major focus of most research activities to detect defects quickly and reliably, aiming to reduce the incidents of false alarms. In most cases, data recording capability of the rail testing equipment allows the inspector to download the data for off-line signal analysis. But our concept is mainly to detects the cracks and avoid the collision in the tracks both will be carried out successfully.

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Comparative Study of Scheduling Algorithms in WiMAX

Mohammed Sabri Arhaif

Abstract— In recent years, telecommunication operators are constantly seeking more efficient wireless broadband service, while telecommunication technology is continuously upgrading its access network technologies to cope with the high demands for high-speed internet access and multimedia service by end-users. WiMAX seems to be the solution as it is able to provide easy deployment, high speed data rate and wide range coverage. Most importantly, WiMAX provides Quality of Service (QoS) that can support all kinds of real-time application in wireless networks that includes priority scheduling and queuing for bandwidth allocation that is based on traffic scheduling algorithms within wireless networks.

This paper aims to evaluate the implementation of the various types of scheduling algorithms of WiMAX wireless network technology namely: Diffserv-Enabled (Diffserv), Round Robin (RR), Self-Clocked-Fair (SCF), Strict-Priority (SP), Weighted-Fair Queuing (WFQ) and Weighted-Round Robin (WRR). A detailed simulation study via the QualNet 5.0 simulator evaluation version was carried out with the aim to analyze and evaluate the performance of each scheduler to support the different QoS classes. The results of the simulation showed that effective scheduling algorithm can provide high service standards to support the QoS requirements to meet the different types of demands by the various end-users.

Index Terms— Scheduling Algorithms, WiMAX, QoS, QualNet

1 Introduction

The demand for high speed broadband wireless systems, internet access and multimedia service has increased tremendously as these applications are used in all sectors; trade and commerce, education and research, communications, and even leisure and entertainment. Consequently, the need for broadband wireless access (BWA) has grown significantly due to the increase in the number and types of users. Due to their mobility and need for data access at all times, an efficient broadband connectivity is much sought after. Hence, WiMAX, (Worldwide Interoperability for Microwave Access) which is a trade name used to group a number of wireless technologies have emerged from IEEE (Institute of Electrical and Electronics Engineers) to meet the demands of the various end-users. It is deployed to serve all the end-users. Moreover WiMAX technology is based on a Standard that is IEEE 802.16 which is (BWA) that offers mobile broadband connectivity.

WiMAX provides Quality of Service (QoS) that supports five different categories of services namely: Unsolicited grant services (UGS), Real-time polling services (rtPS), Non- real-time polling service rate (nrtPS), Extended real-time polling service (ertPS) and Best-Effort services (BE). As such, scheduling class services must ensure there is efficiency and fairness in meeting the various QoS requirements.

The scheduling class services in wireless networks includes priority scheduling and queuing for bandwidth allocation based on traffic scheduling algorithms within wireless networks. Since the scheduling algorithm is still an undefined territory, designing an efficient scheduling algorithm that can provide high throughput with minimum delay is indeed a challenging task for system developers.

Although there are various studies on scheduling algorithms, there is a clear absence of a comprehensive performance study that provides a unified platform for comparing such algorithms. Therefore, this research paper is aimed to investigate and compare several scheduling algorithms in terms of performance and abilities to support multiple classes of service. Besides that, the paper intends to identify significant scheduling algorithms for the Uplink and Downlink channels that use QualNet-5.0. Finally it aims to measure the important metrics of the scheduling algorithms.

1.1 WiMAX Architecture

The basic IEEE 802.16 architecture consists of one Base Station (BS) and one or more Subscriber Station (SS). BS acts as a central entity to transfer all the data from SSs through two basic operational modes: mesh and point-to-multipoint (PMP). Meanwhile, transmissions take place through two independent channels: Downlink Channel (from BS to SS) and Uplink Channel (from SS to BS). The Uplink Channel is shared among all SSs, while the Downlink Channel is used only by BS [1].

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In the mesh mode, subscriber stations (SS) can communicate with each other as well as with the base station (BS). This means that traffic can be routed through other SSs. Also the traffic can occur directly among SSs. Therefore, within the mesh mode, uplink and downlink channels are defined as traffic in the direction to and from the BS, respectively.

In the PMP mode, the SSs are only allowed to communicate through the BS. In this way, the provider can control the environment to ensure that the Quality of Service (QoS) meets the requirements of its customers. In the PMP mode, traffic only occurs between the Base Station (BS) and Subscriber Stations (SS).

1.2 WiMAX Quality of Services

WiMAX standard defines 5 service classes to support its wide range of applications as endorsed by IEEE 802.16.

1.2.1 Unsolicited grant services (UGS):

This class of service is designed to support fixed-sized data packets at a constant bit rate (CBR) such as E1/T1 lines that can sustain real-time data stream applications. This service provides guaranteed throughput, latency and jitter to the necessary levels as TDM services. UGS is used mainly to support Constant Bit Rate (CBR) services found in voice applications such as voice over IP [2,3,4,5,6].

1.2.2 Real-time Polling Services (rtPS):

This class of service is designed to support real-time service flow that generates variable-sized data packets on a periodic interval with a guaranteed minimum rate and guaranteed delay. The mandatory service flow parameters that define this service are inclusive of minimum reserved traffic rate, maximum sustained traffic rate, maximum latency and request/transmission policy. rtPS is used extensively in MPEG video conferencing and streaming [2,3,4,5,6].

1.2.3 Non-real-time Polling Service (nrtPS):

This class of service is designed for non-real-time traffic with no delay guaranteed. The delay tolerant data stream consists of variable-sized data packets. The applications provided by this service are time-insensitive and a minimum amount of bandwidth. This service is especially suitable for critical data application such as in File Transfer Protocol (FTP) [2,3,4,5,6].

1.2.4 Extended real-time Polling Service (ertPS):

This class of service provides real-time applications which generate variable-sized data packets periodically that require guaranteed data rate and delay with silence suppression. This service is only defined in IEEE 802.16e-2005. During the silent periods, no traffic is sent and no bandwidth is allocated. However, there is a need to have a BS poll during the MS to determine the end of the silent periods. ertPS is featured in VoIP with silence suppression [2,3,4,5,6,7].

1.2.4 Extended real-time Polling Service (ertPS):

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1.2.5 Best-Effort Services (BE):

This class of service provides support for data streams whereby no minimum service-level guarantee is required. The mandatory service flow parameters that define this service include maximum sustained traffic rate, traffic priority and request/transmission policy. BE supports data streams found in Hypertext Transport Protocol (HTTP) and electronic mail (e-mail) [2,3,4,5,6].

2 SHEDULING ALGORITHMS

The main focus of this research study is to examine the scheduling schemes in WiMAX network. In order to specify high network performance, an efficient scheduling algorithm is essential as it manages and controls the provision of an efficient level of QoS support.

Although many scheduling algorithms have been proposed in the literature for WiMAX network, the design of the algorithms are challenged by having to support different levels of services, fairness and implementation complexity. Many researchers have compared their proposal schemes on different scheduling schemes, but there is no common, simple and standardized packet scheduling to make their comparisons with.

In this study, six carefully selected scheduling algorithms in WiMAX wireless network are investigated. These algorithms which are considered the most dominant and popular include Diffserv-Enabled (Diffserv), Round-Robin (RR), Self-Clocked-Fair (SCF), Strict-Priority (SP), Weighted-Fair Queuing (WFQ) and Weighted Round Robin (WRR). Furthermore, these common packet scheduling schemes provides QoS support for real time applications in IEEE 802.16 system.

2.1 Diffserv-Enabled: Diffserv is a simple, scalable and measurable mechanism for classifying and managing network traffic. Besides, it provides low-latency with guaranteed service to critical network traffic as well as to non-critical services. It relies on the principle of traffic classification by involving the 6-bit Differentiated Services Code Point (DSCP) field in the header of IP packets to classify the packet and indicate the per-hop behavior (PHB). DSCP replaces the outdated IP precedence in classifying and prioritizing types of traffic. Every router on the Diffserv network is configured to differentiate traffic

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based on class so that each traffic class can be managed differently, ensuring preferential treatment for higher-priority traffic on the network [8].

2.2 Round-Robin (RR): It is designed for a time-sharing system whereby the scheduler assigns time slots to each queue in equal portions without priority. It starts with the highest priority queue with packets, services a single packet, then visits the next lower priority queue with packets, and continues servicing every single packet from each queue. This is carried on until each queue with packets has been serviced once. Every queue is allocated with the same portion of system resources regardless of the channel condition, ultimately utilizing the same resources. However, the RR scheduler has the same bandwidth efficiency as a random scheduler, so it cannot guarantee different QoS requirements for each queue [9, 14].

2.3 Self-Clocked-Fair (SCF): It is an efficient queuing scheme which satisfies the quality of services (QoSs) in broadband implementation. The algorithm is based on the concept of virtual time that adopts the concept of an internally generated virtual time as the index of work in progress. It links virtual time to the work progress in the fluid-flow fair queuing (FFQ). As virtual time function is involved in determining the order of which packet should be served next, the virtual time that is produced depends very much on the progress of work in the actual packet-based queuing system. This scheme is efficient for the internal generation of virtual time as it involves negligible overhead. This is because virtual time is easily computed from the packet situated at the head of the queue. In addition, the SCFQ algorithm can accomplish easier implementation and it can maintain the fairness attribute in virtual time function. [10, 11,15].

2.4 Strict-Priority (SP): In Strict-Priority algorithm, the selection order is based on the priority of weight order. The packets are first categorized by the scheduler depending on the quality of service (QoS) classes and then allocated into different priority queues. The algorithm services the highest priority queue until it is empty, after which, it moves to the next highest priority queue. Thus, strict-priority algorithm may not be suitable in WiMAX network. This is because there is no compensation for inadequate bandwidth. Also this technique is only appropriate for low-bandwidth serial lines that currently uses static configuration which does not automatically adapt to changing network requirements. Finally, this process may result in bandwidth starvation for the low priority QoS classes whereby the packets may not even get forwarded and no guarantee is offered to one flow [6].

2.5 Weighted-Fair-Queuing (WFQ): This algorithm is employed for uplink traffic in WiMAX with different size packets. As it caters to different size packets, it emphasizes on providing fair scheduling for the different flows by assigning finish times to the packets. The finish times are based on the size and weight of the packets. In general, the WFQ algorithm outperforms the WRR due to variable size packets. However, the weaknesses of WFQ algorithm are, the start time of a packet is not taken into consideration, and it can lower the scheduler system if many packets occur in the priority region [12, 13].

2.6 Weighted Round Robin (WRR): It is a scheduling algorithm implemented for resource sharing in a computer or network. In fact, WRR is an extension of the Round Robin (RR) algorithm. In a network, WRR serves a number of packets that are computed by normalizing weight of data divided by the average of packet size from non-empty connection queue. It begins by classifying packets into a variety of service classes followed by assigning a queue that is determined by the different percentage of bandwidth. Finally, it is serviced in round robin order. Since the bandwidth is assigned according to the weights, the algorithm will not provide good performance in the presence of variable size packets. However, WRR method makes certain that all service classes have access to at least some configured amount of network band width to avoid bandwidth starvation [2,6,7].

3 Simulation Model

The purpose of this simulation study is to investigate and evaluate different types of scheduling techniques in order to determine the one that is most efficient in WiMAX network. The simulations are performed using QualNet simulation. This simulation provides an intuitive model set up capability that includes core components such as animator, packet tracer analyzer, protocol designer and protocol stack.

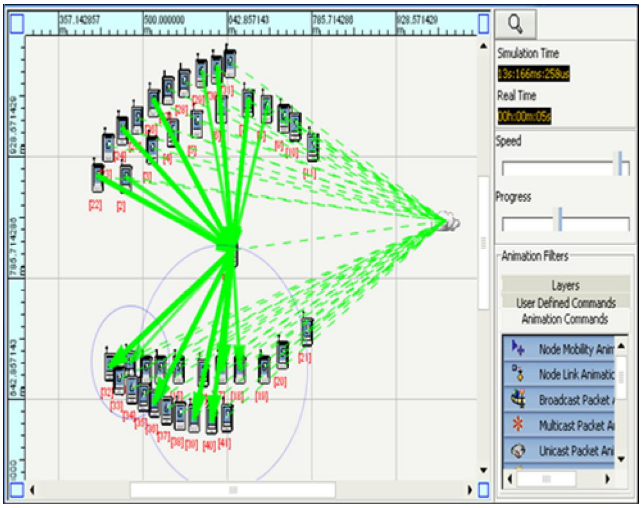

Fig.1.System Model Implementation by QualNet

The system parameter used in this simulation study consists of a single cell with a BS, and a number of MS that

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varies from 10 to 50 MS. Table 1 summaries the simulation parameters used in the experiments with 20MS.

TABLE 1.SIMULATION PARAMETERS

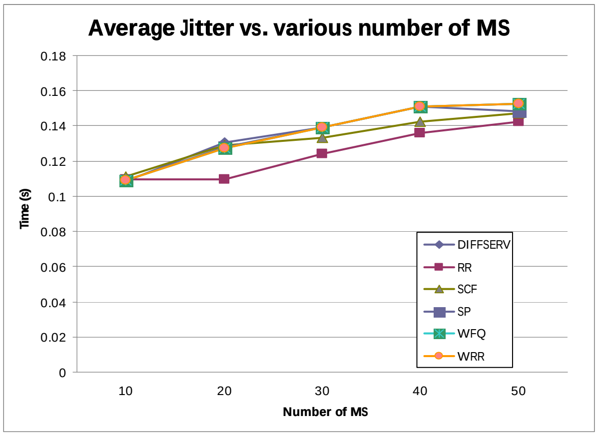
Parameter	Value
BS range radius (m)	1000
MS range radius (m)	500
Frequency band (GHz)	2.4
Channel bandwidth (MHz)	20
Frame duration (ms)	20
FFT size	2048
Number of MS	10-50
Number of BS	1
BS transmit power P_t $dBm/height$ (m)	20/5
MS transmit power P_t $dBm/height$ (m)	15/1.5
Services types (QoS)	BE, nrtPS, rtPS, ertPS, UGS
Simulation time (s)	30

4 SIMULATION RESULTS

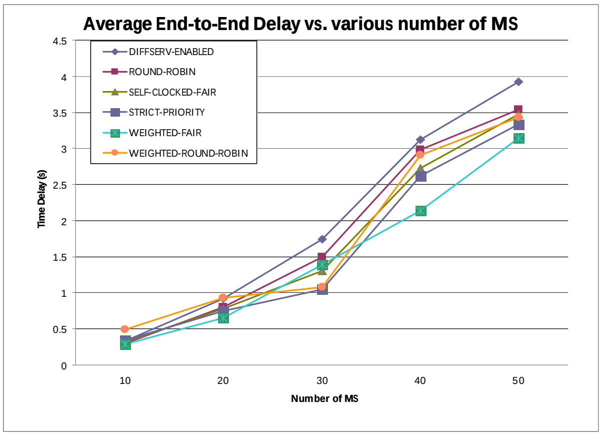
Six experiments with varying simulation parameters were carried out and the findings show varying results.
The results of experiment 1 are shown in Figure 4.1 that SP, WRR, and WF are the best scheduling techniques in WiMAX network with respect to the end-to-end time delay.

The results of experiment 2 are shown in Figure 4.3 indicate that there is much difference between all algorithms when the number of mobile stations (MS) is small (10MS). This happens as MS produces the shortest amount of time for packet latency. Another result obtained is RR outperforms the other techniques when the number of MS becomes more (20-50MS). The results also indicate that SCF performs better than Diffserv, WRR, SP, and WFQ when the number of mobile stations (MSs) is increased (30-40MS).

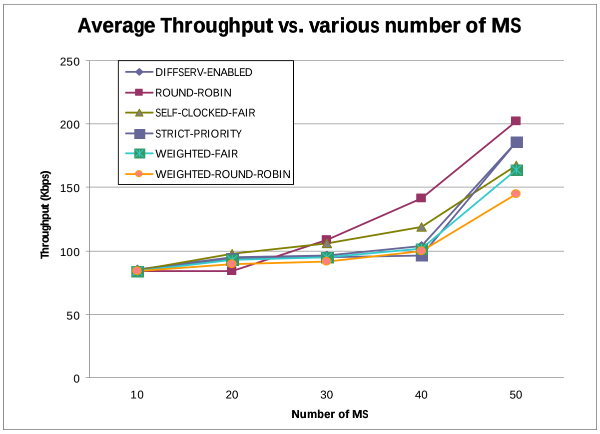
The result of experiment 3 are shown in Figure 4.5 clearly shows that RR technique has achieved the highest value of throughput for different numbers of MS (20-50) compared to the other five techniques. However, RR technique shows the same amount of throughputs as the others when the number of MS ranges between 10-20. Furthermore, most of the algorithms have the same performance when the numbers of MS are fewer than 30.



EXPERIMENT 1: FIGURE 4.1: THE AMOUNT OF END-TO-END DELAY



EXPERIMENT 2: FIGURE 4.3: THE PACKET LATENCY (JITTER)



EXPERIMENT 3: FIGURE 4.5: THE THROUGHPUT OF NETWORK

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Meanwhile the results tabulated in Figure 4.2 shows that Diffserv has the lowest performance in producing the highest amount of end-to-end delay time. On the other hand, WF shows the best performance as the average end-to-end time delay has the lowest reading. Finally, it can be concluded that there is much difference in terms of the average end-to-end delay time among RR, SCF and WRR.

From the figure 4.4, it is noted that RR technique shows the most favourable results as the average jitter has low reading (0.124s), while Diffserv shows the most unfavourable result as the average jitter has higher reading (0.137s). The results also show that WF and WRR produce almost the same amount of average jitter (0.136s). However, there is no big gap between the two algorithms, WF and WRR, in terms of overall average jitter and SP.

From the figure 4.6, it is noted that RR algorithm outperforms the other five algorithms in terms of the overall throughput 125Kbps. The results of the experiment shows that WRR is a poor scheduling technique as it produces the lowest amount of average throughput 100Kbps. Diffserv, SCF, and SP produce almost the same amount of overall average for the throughput 110Kbps, while WF is ranked after these algorithms as the average throughput is 103Kbps.

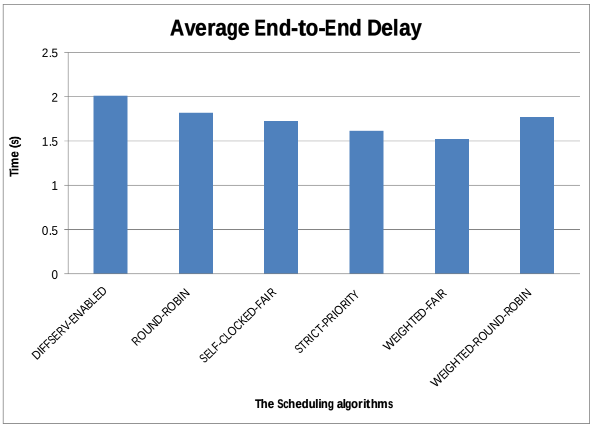

FIGURE 4.2: THE TOTAL AVERAGE OF END-TO-END DELAY TIME

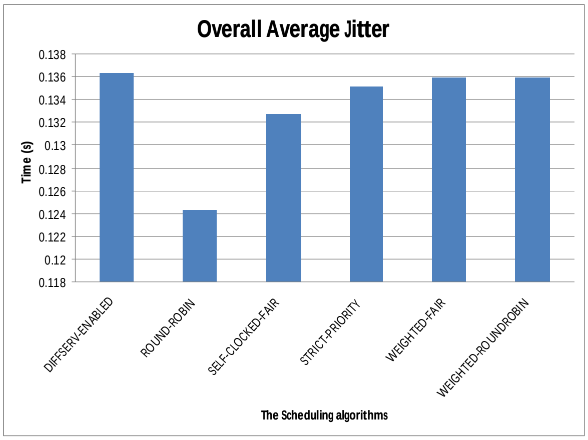

FIGURE4.4: THE AVERAGE OF PACKET LATENCY (JITTER)

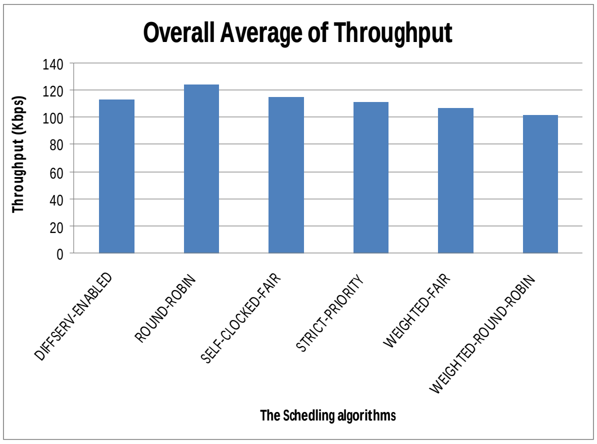

FIGURE 4.6: THE OVERALL AVERAGE OF THROUGHPUT

The results of experiment 4 are shown in Figure 4.7 that WF outperforms SP and WRR as it achieves the shortest amount of end-to-end delay time for all the classes of QoS. However, WF achieves the same amount of end-to-end delay time for the class BE and nrtPS. It is also noted that BE achieves the shortest amount of end-to-end delay time for the three algorithms, while UGS produces the longest amount of end-to-end delay time for all the three algorithms.

The results of experiment 5 are shown in Figure 4.8 the observations of the average throughput for the best three scheduling algorithms; SP, WF, WRR with respect to the classes of the quality of services (QoSs). In Figure 4.7, it is clear that WF is the best algorithm as produces BE, nrtPS, rtPS, ertPS, and UGS class. However, the performance of SP is not favorable compared to the performance of WRR and WF. These three algorithms are selected due to the fact that they achieve the best performance with respect to different scenarios and various numbers of factors in the simulation experiments.

The results of experiment 6 are shown in Figure 4.9 reveal that the classes of the QoSs positively influence the

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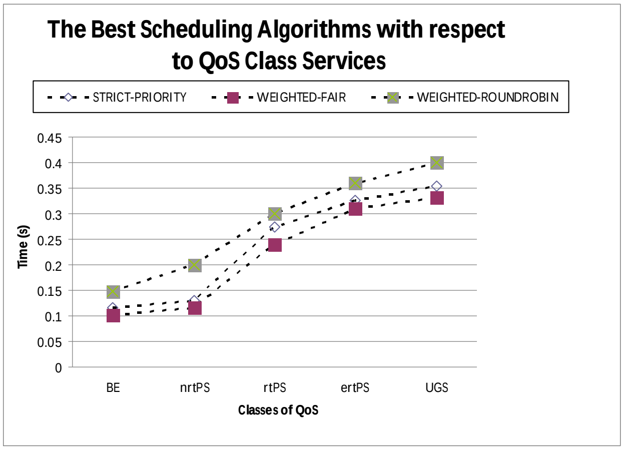
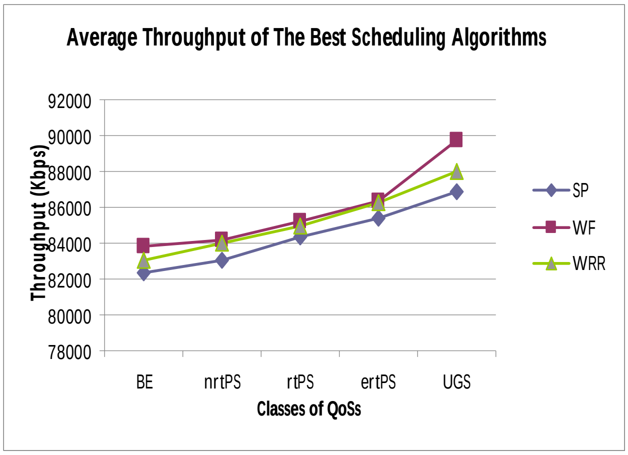
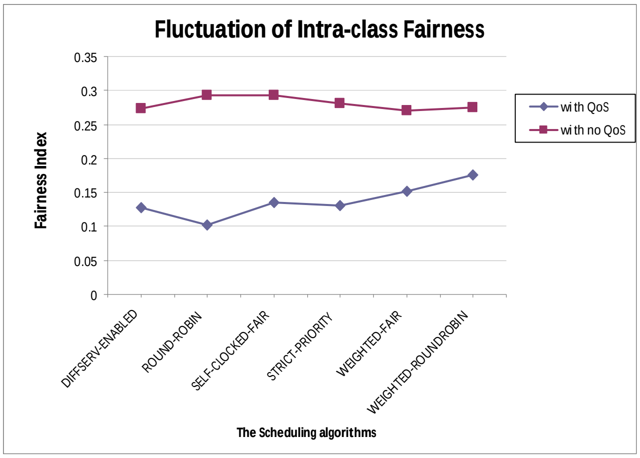
percentage of the fairness index for each scheduling technique. It is also noted that RR scheduling technique with QoS achieves the best percentage of fairness index, while WRR with QoS shows the highest percentage of fairness index. However, RR technique with no QoS achieves higher percentage of fairness index, while WRR with no QoS shows the lowest percentage of fairness index. Finally, from Figure 4.8, it can be concluded that the QoS class services have a high impact on the percentage of the fairness index.



EXPERIMENT 4: FIGURE 4.7: THE AMOUNT OF DELAY TIME FOR THE BEST SCHEDULING ALGORITHMS



EXPERIMENT 5: FIGURE 4.8: THE AVERAGE OF THROUGHPUT FOR THE BEST SCHEDULING ALGORITHMS



EXPERIMENT 6: 4.9: THE FLUCTUATION OF INTRA-CLASS FAIRNESS

6 CONCLUSIONS AND FUTURE WORK

In conclusion, the investigation of the behaviors of several wireless scheduling algorithms namely Diffserv, RR, SCF, SP, WFQ, WRR has shown the strengths of some of the scheduling algorithms that were under study. One of the best scheduling algorithms is WF, in terms of the amount of end-to-end delay. The other is RR, in terms of packet latency (Jitter). Finally WRR outperforms the rest by producing the highest rate of throughput of data packet in the network. As to the best scheduling algorithms in terms of the amount of delay time with respect to QoSs classes are WF, SP, and WRR respectively. Finally, it is clear that there is not a single scheduling scheme that provides superior performance with respect to all the QoS requirements and characteristics of the IEEE 802.16 MAC layer. This is because issues such as the amount of information required by the grant scheduler at the BS and the allocation of time-slots and sub-channels to different SSs require attention.

As the scheduling in WiMAX wireless network is a challenging topic, future works should include further investigation on scheduling algorithms under different bandwidth request mechanisms and CAC schemes.

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UTILITY OF PSO FOR LOSS MINIMIZATION AND ENHANCEMENT OF VOLTAGE PROFILE USING UPFC

A.S Kannan, R. Kayalvizhi

Abstract - The loss minimization is a major role in Power System (PS) research. Transmission line losses in a PS can be reduced by Var compensation. After the establishment of power markets with transmission open access, the significance and use of Flexible AC Transmission Systems (FACTS) devices for manipulating line power flows to relieve congestion and maximize the overall grid operation have been increased. This paper presents a method to provide simultaneous or individual controls of basic system parameters like transmission voltage, impedance and phase angle, which are controlling by using Unified Power Flow Controller (UPFC). The Particle Swarm Optimization (PSO) method is used to compute the power flow in optimum value. The performance of this technique is tested using IEEE - 14 bus system through the MatLab/Simulink simulation software package. The simulation results of test power system show that the location of the UPFC has been able to enhance the voltage level of the test power system and also minimize the transmission line losses.

Keywords - Flexible AC Transmission Systems (FACTS), Particle Swarm Optimization (PSO), Real and Reactive Power, Unified Power Flow Controller (UPFC).

1. INTRODUCTION

Most of the large power system blackouts, which occurred worldwide over the last twenty years, which are caused by heavily stressed system with large amount of real and reactive power demand and low voltage condition. When the voltages at power system buses are low, the losses will also to be increased. This study is devoted to develop a technique for improving the voltage and minimizing the losses and hence eliminate voltage instability in a power system [4]. State estimation is the process of estimating the values to an unknown system variable based on the measurement system according to some criterion. The basic idea was to "fine-tune" state variables by minimizing the sum of the residual squares. This is the well-known least squares (LS) method; State estimation is a widely used tool in power system energy management systems. The essence of state estimation is that the measurements are taken of active and reactive power, and system voltage magnitudes and phase angles (i.e, the 'states') are estimated [1]-[2]. Application of FACTS devices are currently pursued very intensively to achieve better control over the transmission lines for manipulating power flows.

State estimation in power system can be formulated as a nonlinear weighted least squared errors (WLSE) problem representing the zero injections of buses and the zero active power exchange between the power system and FACTS devices. There are several kinds of FACTS devices. Thyristor-Controlled Series Capacitors (TCSC), Thyristor Controlled Phase Shifting Transformer (TCPST) and Static Var Compensator (SVC) can exert a voltage in series with the line and, therefore, can control the active power through a transmission line[3][15]. On the other hand UPFC has a series voltage source and a shunt voltage source, allowing independent control of the voltage magnitude, and the real and reactive power flows along a given transmission line. The UPFC was proposed for real-time control and dynamic compensation of ac transmission systems, providing the necessary functional flexibility required to solve many of the problems facing the utility industry. The UPFC consists of two switching converters, which in the implementations considered are voltage sourced inverters using Gate Turn-Off (GTO) thyristor switch [5]. Particle swarm optimization (PSO) is a population based stochastic optimization technique inspired by social behavior of bird flocking or fish schooling. PSO is related to evolution-inspired problem solving techniques such as genetic algorithms [9].

In this paper Particle Swarm Optimization (PSO) technique is introduced to optimize the measurement error vector. The proposed technique was tested on the IEEE 14 bus system and UPFC can be installed at any of the weakest voltage at load buses. For practical and economic considerations, the number of UPFC units is limited to one. Here UPFC is connected in between 9 in IEEE 14 bus system to perform the test.

2. BASIC CIRCUIT OF UPFC

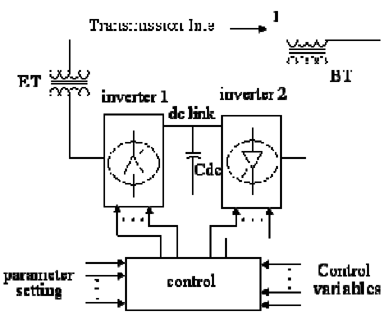

Fig. 1.Power Circuit of the Unified Power Flow Controller.

Fig.1 shows the power circuit of a UPFC which is composed of an Excitation Transformer (ET), a Boosting transformer (BT), two three phase GTO based voltage source converters (VSCs), and a dc link capacitor. This arrangement functions as an ideal ac to ac power converter in which the real power can freely flow in either direction between the ac terminals of the two inverters and each inverter can independently generate (or absorb) reactive power at its own ac output terminal . Inverter 1 can also generate or absorb controllable reactive power, if it is desired, and thereby it can provide independent shunt reactive compensation for the line. Inverter 2 provides the main function of the UPFC by injecting an ac voltage V_w with controllable magnitude V_m and phase angle (θ) at the power frequency, in search with line via an insertion transformer. This injected voltage *can* be considered essentially as a synchronous ac

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voltage source [6]. The transmission line current flows through this voltage source resulting in real and reactive power exchange between it and the ac system. The real power exchanged at the ac terminal (i.e., at the terminal of the insertion transformer) is converted by the inverter into dc power which appears at the dc link as positive or negative real power demand. The reactive power exchanged at the ac terminal is generated internally by the inverter [7].

3. STEADY STATE MODEL OF UPFC

A UPFC can be represented in the steady-state by two voltage sources representing fundamental components of output voltage waveforms of the two converters and impedances being leakage reactances of the two coupling transformers. Figure 2 depicts a two voltage-source model of UPFC [5].

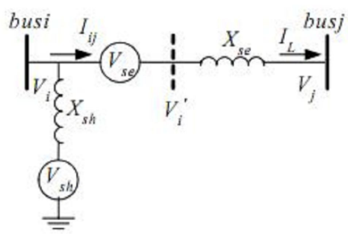


Figure 2. Two voltage-source model of UPFC

Voltage of bus i is taken as reference vector, $V_i = V_i <0$' and $V_i' = Vse + V_i$. The voltage sources, V_{se} and $V_{sh,}$ are controllable in both their magnitudes and phase angles. The values of r and γ are defined within specified limits given by Equation (1).

$0 \le r \le r_{max}$ and $0 \le \gamma \le 2\pi$. (1)

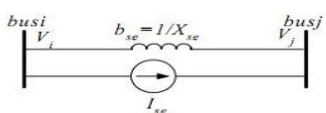
V_{se} should be defined as:

$V_{se} = rV_i e^{j\gamma}$ (2)

The steady-state UPFC mathematical model is developed by replacing voltage source V_{se} by a current source I_{se} parallel with the transmission line, where $b_{se} = 1/X_{se}$.

$I_{se} = -jb_{se}V_{se}$ (3)

The current source I_{se} can be modeled by injection powers at the two auxiliary buses i and j as shown in Figure 3.



$S_{is} = V_i (-I_{se})^*$ (4)

$S_{js} = V_j (-I_{se})^*$ (5)

Figure 3. Replacement of series voltage source by a current source

The injected powers Sis and Sjs can be simplified according to the following operations, by substituting Equation (2) and (3) into Equation (4).

$S_{is} = V_i (jb_{se}\, rV_i e^{i}\gamma)^*$ (6)

By using the Euler Identity, ($ej\gamma = \cos\gamma + J\ \mathrm{SIN}\,\gamma$), Equation (6) takes the form:

$S_{is} = V_i (e^{-j(\gamma+90)} b_{se} r V_i^*)$ (7)

$S_{is} = V_i^2 b_{se} r [\cos(-\gamma-90) + j \sin(-\gamma-90)]$. (8)

By using trigonometric identities, Equation (8) reduces to:

$S_{is} = -rb_{se}V_i^2 \sin\gamma - jrb_{se}V_i^2 \cos\gamma$ (9)

Equation (9) can be decomposed into its real and imaginary components,

$S_{is} = P_{is} + jQ_{is}$, where

$P_{is} = -rb_{se}V_i^2 \sin\gamma$ (10)

$Q_{is} = -rb_{se}V_i^2 \cos\gamma$ (11)

Similar modifications can be applied to Equation (5); the final equation takes the form:

$S_{js} = V_iV_jb_{se}\, r \sin(\theta_i - \theta_j + \gamma) + jV_iV_jb_{se}\, r \cos(\theta_i - \theta_j + \gamma)$ (12)

Equation (12) can also be decomposed into its real and imaginary parts,

$S_{js} = P_{js} + jQ_{js}$, where

$P_{js} = V_iV_jb_{se}r \sin(\theta_i - \theta_j + \gamma)$ (13)

$Q_{js} = V_iV_jb_{se}r \cos(\theta_i - \theta_j + \gamma)$ (14)

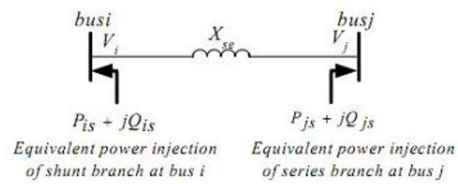


Figure 4. Equivalent power injections of series branch

In UPFC, the shunt branch is used mainly to provide both the real power, P_{series}, which is injected to the system through the series branch, and the total losses within the UPFC. The total switching losses of the two converters is estimated to be about 2% of the power transferred, for thyristor based PWM convertors [12]. If the losses are to be included in the real power injection of the shunt connected voltage source at bus i, P_{shunt} is equal to 1.02 times the injected series real power P_{series} through the series connected voltage source to the system [9 - 10].

$P_{shunt} = -1.02P_{series}$ (15)

The apparent power supplied by the series converter is calculated as

$S_{series} = V_{se}I_{ij}^* = re^{j\gamma}V_i \left(\frac{V_i - V_j}{jX_{se}}\right)$ (16)

Active and reactive power supplied by the series converter can be calculated from Equation (16):

$S_{series} = re^{j\gamma}V_i ((re^{j\gamma}V_i - V_j)\, jX_{se})^*$ (17)

$S_{series} = rV_ie^{j}(\theta_i+\gamma)\, ((rV_ie^{-j(\theta i+\gamma)} + V_ie^{-j\theta i} - V_je^{-j\theta j})l\text{-}jX_{se})$ (18)

$S_{series} = jb_{se}r^2V_i^2 + jb_{se}rV_i^2e^{j\gamma} - jb_{se}V_iV_je^{j(\theta i-\theta j+\gamma)}$ (19)

The steady state model of UPFC consists of two ideal voltage sources, one in series and one in parallel with the associated line. Neglecting UPFC losses, during steady-state operation it neither absorbs nor injects real power into the system. No real-power is exchanged between the UPFC and the system. The two sources are mutually dependent. The real and reactive power going through line can be formulated by the equation (3).

4. PARTICLE SWARM OPTIMIZATION TECHNIQUE

PSO is basically developed through simulation of bird flocking in two dimension space. The position of each agent is represented by XY-axis position and the velocity is expressed by v_x (the velocity of X-axis) and v_y (the velocity of Y-axis). Modification of the agent

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position is realized by the position and velocity information. PSO procedures based on the above concept can be described as follows. Namely, bird flocking optimizes a certain objective function. Each agent knows its best value so far (p_{best}) and its XY position. Moreover, each agent knows the best value in the group (g_{best}) among p_{bests}. Each agent tries to modify its position using the current velocity and the distance from p_{best} and g_{best}. The modification can be represented by the concept of velocity. Velocity of each agent can be modified by the following equation.[9]-[10] Vi=Vi + rand x (p_{best} i – Si) + rand x (g_{best} – Si)

where, Vi : velocity of agent i,
rand : uniformly distributed random number between 0 and 1,
Si : current position of agent i,
p_{best} i : p_{best} of agent i,
g_{best} : g_{best} of the group.

Using the above equation, a certain velocity that gradually gets close to p_{best} and g_{best} can be calculated. The current position (searching point in the solution space) can be modified by the following equation.

$$s_i^{-} = s_i + v_i \qquad (20)$$

The particle swarm optimization concept consists of, at each time step, regulating the velocity and location of each particle towards its p_{best} and g_{best} locations according to the following two equations respectively.

$$V_{id}^{n}+1 = wv_{id}^{n} + c_1 r_1^{n} (p_{id}^{n} - X_{id}^{n}) + c_2 r_2^{n} (p_{id}^{n} - X_{id}^{n}) \qquad (21)$$

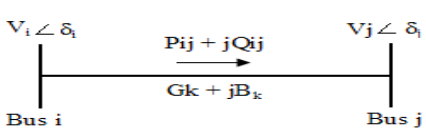
$$X_{id}^{n+1} = X_{id}^{n} + V_{id}^{n}+1 \qquad (22)$$

where w is inertia weight; c_1, c_2 are two positive constants, called cognitive and social parameter respectively ;d=1, 2, …, D; i=1, 2, …, m, and m is the size of the swarm; r_1, r_2 are random numbers, uniformly distributed in [0,1]; and n=1, 2, …, N, denotes the iteration number, N is the maximum allowable iteration number.

4.1.Particle Swarm Optimization Technique for Reactive Power and Voltage Control

Reactive Power and Voltage Control (Volt/Var Control: VVC) determines an on-line control strategy for keeping voltages of target power systems considering varying loads in each load point and reactive power balance in target power systems. VVC can be formulated as a mixed-integer nonlinear optimization problem with continuous state equipment. The objective function can be varied according to the power system condition. For example, the function can be loss minimization of the target power system for the normal operating condition [9]-[10].

Active and reactive power losses occur in transmission lines depending upon the power to be transmitted. The active power loss equation of the kth line, between buses i and j (fig 2). can be written as (14),



P_{L-}

Fig 5.Transmission line

$$_k = G_k(V_i^2+V_j^2-2V_iV_j\cos(\delta_i-\delta_j)) \qquad (23)$$

The series reactive power loss equation of the kth line, between buses i and j can be written as,

$$Q_{L-k}=B_k(V_i^2+V_j^2-2V_iV_j\cos(\delta_i-\delta_j)) \qquad (24)$$

Where,
G_k; is kth line conductance
B_k; is kth line susceptance
V_i;voltage magnitude of ith bus
δ_i;phase angle of ith bus

In power system, the total active power loss of all the lines of the system is

$$P_L=\sum P_{L-k} \qquad k=1\ldots\ldots\ldots\ldots nl \qquad (25)$$

and the total series reactive power loss of all the lines is

$$Q_L=\sum Q_{L-k} \qquad k=1\ldots\ldots\ldots\ldots nl \qquad (26)$$

Where, nl is the total number of lines.

4.2. VVC Algorithm using PSO

The proposed VVC algorithm using PSO is expressed as follows:

Step 1. Initial Searching points (agents) and velocities are generated using the above-mentioned state variables randomly.
Step 2. Pl_{oss} to the searching point for each agent is calculated using load flow. If the constraints are violated, penalty is added to the loss (evaluation value of agent).
Step 3. p_{best} is set to each initial searching point. The initial best evaluated value (loss with penalty) among p_{bests} is set to g_{best}.
Step 4. Velocities are calculated using (2).
Step 5. New searching points are calculated using (3).

Step 6. P_{loss} to the new searching point and the evaluation value is calculated.
Step 7. If the evaluation value of each agent is better than the previous p_{best}, the value is set to p_{best}. If the best p_{best} is better than g_{best}, the value is set to g_{best}. All of g_{bests} are stored as candidates for the final control strategy.
Step 8. If the iteration number reaches to the maximum iteration number, then exit otherwise, go to Step 4.

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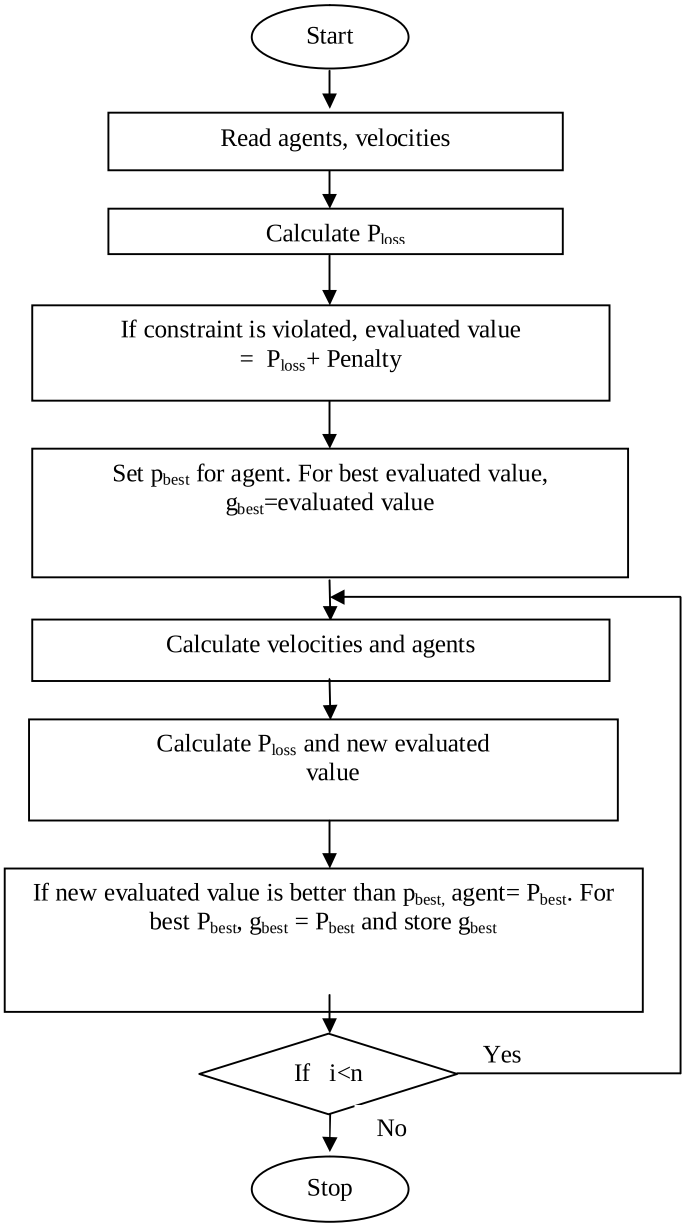
4.3 VVC Flowchart using PSO



4.4 PSO Parameter Control

The following parameters are subjected to vary and their values are given in Table I.

Table -1 Various parameters and their values

Sl. No	Parameter	Value
1.	Number of particles	50-110
2.	Dimension of particles	6
3.	Range of particles	0.1-0.7
4.	Maximum velocity	25
5.	Learning factors C_1 & C_2	1.6
6.	Inertia weight W_{min} & W_{max}	0.5 & 0.95

5. RESULTS AND DISCUSSION

Fig. 7 show the IEEE 14-bus system. UPFC has been included between the buses 4 and 9 in IEEE 14 bus system. Table 2 show the state variables without and with UPFC. Table 3and 4 show power flow results of IEEE 14 bus system without and with UPFC. Table 5 shows the comparative results of proposed system. From the tables it is concluded that the system voltages have been improved and the losses are reduced when UPFC is installed.

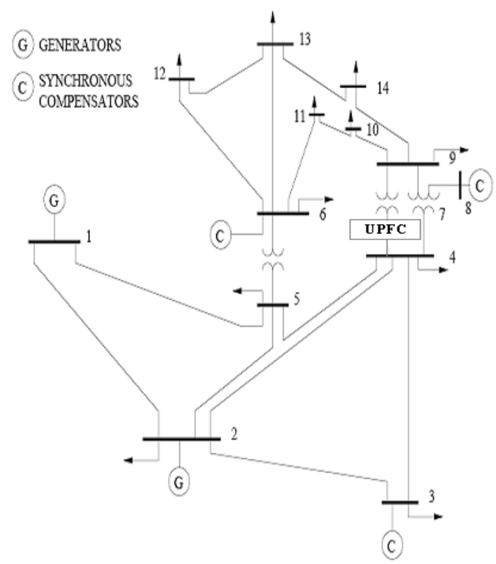


Fig.7 IEEE 14 bus system.

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Table -2 State Variables of IEEE 14-Bus System.

Bus No	Without UPFC		With UPFC	
	Voltage (pu)	Angle (deg)	Voltage (pu)	Angle (deg)
1	1.06	0.00	1.06	0.0
2	1.004	-5.762	1.010	-5.612
3	0.970	-12.268	0.973	-11.843
4	0.973	-10.279	0.981	-9.848
5	0.979	-8.944	0.986	-8.882
6	1.032	-14.716	1.050	-14.449
7	1.022	-13.769	1.020	-13.490
8	1.066	-13.893	1.050	-13.273
9	1.006	-15.054	1.013	-14.901
10	1.003	-15.468	1.006	-15.334
11	1.016	-15.220	1.018	-15.003
12	1.010	-15.660	1.032	-15.335
13	1.004	-15.362	1.023	-15.313
14	0.996	-16.616	0.997	-16.185

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Table - 3 Power Flows without UPFC.

Branch	From	To	From bus injection		To bus injection		Loss(I^2Z)	
			P(MW)	Q(MVAr)	P(MW)	Q(MVAr)	P(MW)	Q(MVAr)
1	1	2	154.37	-51.43	-149.3	61.63	5.079	15.51
2	1	5	67.84	-4.11	-65.35	9.56	2.488	10.27
3	2	3	57.33	4.38	-55.78	-2.11	1.552	6.54
4	2	4	45.15	2.88	-43.96	-2.60	1.187	3.60
5	2	5	32.88	2.84	-32.26	-4.34	0.623	1.90
6	3	4	-16.96	5.01	17.18	-5.64	0.227	0.58
7	4	5	-51.75	2.97	52.13	-1.77	0.379	1.20
8	4	7	29.59	-12.00	-29.59	14.16	0.000	2.15
9	4	9	52.13	-14.53	-52.13	-11.57	0.000	4.21
10	5	6	41.28	9.46	-41.28	-5.36	0.000	4.10
11	6	11	7.520	5.09	-7.450	-4.93	0.074	0.15
12	6	12	10.53	4.00	-10.39	-3.69	0.146	0.30
13	6	13	18.71	13.21	-18.39	-12.57	0.326	0.64
14	7	8	-5.340	-25.29	5.340	26.42	0.000	1.13
15	7	9	18.48	14.61	-18.48	-14.02	0.000	0.58
16	9	10	11.80	0.00	-11.76	0.12	0.044	0.12
17	9	14	10.60	-1.05	-10.46	1.35	0.142	0.30
18	10	11	-6.100	-4.21	6.150	4.31	0.045	0.10
19	12	13	0.220	2.97	-0.200	-2.95	0.019	0.02
20	13	14	6.170	-0.75	-6.100	0.88	0.065	0.13
Total							12.396	53.53

Table -4 Power Flows with UPFC.

Branch	From	To	From bus injection		To bus injection		Loss(I^2Z)	
			P(MW)	*Q(MVAr)*	*P(MW)*	*Q(MVAr)*	*P(MW)*	*Q(MVAr)*
1	1	2	148.19	-59.80	-143.30	69.40	4.889	14.93
2	1	5	67.13	-7.00	-64.69	12.25	2.446	10.10
3	2	3	55.90	6.28	-54.43	-4.38	1.473	6.21
4	2	4	42.79	2.11	-41.74	-2.29	1.052	3.19
5	2	5	33.94	2.15	-33.29	-3.61	0.652	1.99
6	3	4	-18.33	2.20	18.58	-2.80	0.243	0.62
7	4	5	-38.05	2.17	38.25	-1.54	0.201	0.64
8	4	7	31.10	-7.12	-31.10	9.23	0.000	2.11
9	4	9	16.73	0.76	-16.73	0.76	0.000	1.52
10	5	6	44.79	5.43	-44.79	-0.84	0.000	4.59
11	6	11	10.36	11.80	-10.14	-11.35	0.212	0.44
12	6	12	6.60	4.21	-6.53	-4.06	0.068	0.14
13	6	13	16.35	13.91	-16.07	-13.37	0.276	0.54
14	7	8	4.27	-17.08	-4.27	17.61	0.000	0.52
15	7	9	25.63	7.39	-25.63	-6.63	0.000	0.75
16	9	10	7.78	5.01	-7.76	-4.94	0.027	0.07
17	9	14	8.32	2.01	-8.22	-1.82	0.091	0.19
18	10	11	-3.24	-5.09	3.27	5.16	0.030	0.07
19	12	13	2.57	2.11	-2.55	-2.09	0.023	0.02
20	13	14	6.37	4.40	-6.28	-4.20	0.098	0.20
Total							11.781	48.84

Table 5 Comparative Results.

Power loss	P(MW)	Q(MVAr)
Without UPFC (IEEE 14 Bus System)	12.396	53.53
With UPFC (IEEE 14 Bus System)	11.781	48.84

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6. CONCLUSION

This paper presents the application of particle swarm optimization technique in power system state estimation with and without UPFC. The unified power flow controller provides simultaneous or individual controls of basic system parameters like transmission voltage, impedance and phase angle, there by controlling the transmitted power. The Particle Swarm Optimization technique is used to compute the power flow. The power loss occurring in the various branches and state variables of IEEE 5 bus and IEEE 14-bus systems are evaluated using PSO. From the results it is concluded that the system performs better when the UPFC is connected .ie the state variables are improved and the total losses are minimized.

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Theory of Infinite Dimensions & Parallel Universe

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Abstract- Theory of universe is an ultimate topic of debate since past centuries, its beginning, and existence and how it will going to end is remained a question, without any concrete evidence to prove it. Parallel universe is also a nice topic for brainstorming and its proof. I have deducted many innovative Ideas and concrete proofs to solve this problem and developed a satisfactory theory underlying the universe.

Keywords- unifying quantum & gravity, quantum Universe , Infinite dimensions, parallel universe, time and space constraints.

I. INTRODUCTION

For years Scientists and physicists are trying to unifying the quantum and gravity to determine an ultimate theory of the universe that suggest the beginning and end of it.

Through this paper ,I have tried to solve some the mysteries with my logics supported by principles and psychology perspective.

A. STRUCTURE OF UNIVERSE

A lot of research has been done before to determine the structure of the Universe but yet we have no concrete model to describe it.

According to my model the Universe has got various levels, at each level is defined under in its space and time constraints and living being perceive it within those constraints.

If we imagine ourselves at one of the level we have other universe at lower level that we observe as atoms, particles and quarks which forms a separate universe and exhibits the properties of quantum physics, defined under 3D space with Time for that level our level is completely unimaginable and out of reach as they can't get out of their dimensions while the level above our universe ,we are just as subatomic particles and exhibits the properties that of quantum physics and force to that we call it gravity.

At each level total energy is Zero and each lower level is at quantum level for next upper universe similarly we can't get out or even imagine our next upper world, for them we are at quantum levels for their level quantum; atomic force is gravity for us. This implies space and time has boundary define under visibility level.

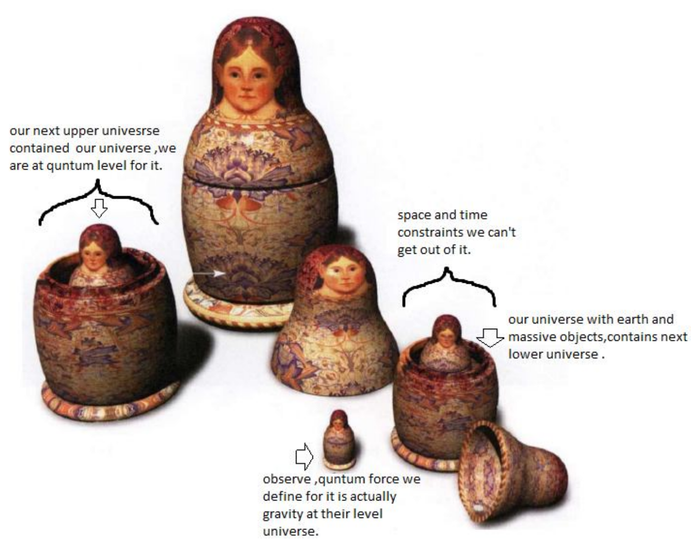
Source: "Universe in nutshell"-,Stephen hawking

B. DIMENSIONS

Each world is defined under three space dimensions (since two dimensions is not possible to support objects) **[1].**Plus the time dimension responsible for occurrence of events .i.e.Universe has its own space; it must have their relative time too.

We know that time actually appears to move slower near massive objects (clock runs slow on earth surface than sky).because time space wrapped by the weight, which implies time appears to increase with large magnitude with going up each level of the universe and this is known by theory of relativity that time is not absolute it is relative).**[1]**

Example:-The events taking place in our world are just momentary in next upper world like we observe the excitation of electron from one energy level to other is 10^{-8}.



II. MODIFIED SOURCE: "UNIVERSE IN NUTSHELL"-,STEPHEN HAWKING[2].

C.PARALLEL WORLD

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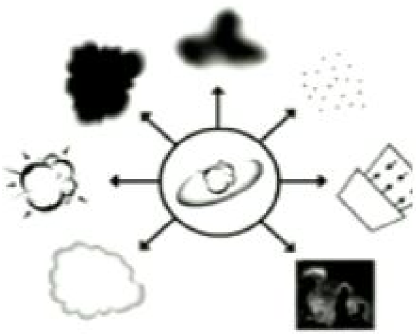
The Heisenberg uncertainty principle suggested that by observing quantum matter we affect the behaviour of the matter interpreted by the Neils bohr ,he said that quantum levels don't exist in one state or other state but all possible states at once and the sum of all possible states of quantum states called is wave function.(we can't observe our self as wave but next upper level can).This implies that we are at quantum level our universe would have many possible states and wave function too so there exist different parallel universe at each level (quantum states) within the time constraints.

When a physicist measures the universe into two distinct universes to accommodate each possible outcomes. This means if we ever find our self in situation where death is the possible outcome then in parallel universe, we are dead**[3].**

These parallel universes, set of all possible states that would triggered with some life changing event if defined as fifth dimension...that is parallel universe exists at each level of the universe with their respective relative time.



from big bang to all possible endings of the universe(quantum levels) forms 5th dimension. source:http://www.stumbleupon.com/su/26OeyR/www.geekarmy.com/Science/The-Tenth-Dimension.html

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D. INTEGARTING QUANTUM PHYSICS AND PSYCOLOGY

Since in quantum mechanics, each state is the possible universe. Dreams and thoughts shows that our unconscious mind is active and we imagine certain spaces (+time) what had happened and what would happen after, actually we are thinking of the fifth dimension (one of the possible quantum state) i.e. we are mentally transact to the 5th dimension and fantast the space that really exists somewhere, if there are space there must be time associated with it. For example if we go on telling an imagine the some fake event or (just like brain wash of man and make him think and imagine his own set of realities) we actually believe and sure about that fact that it had really happened once.

I.e. figments of the imagination three are the parallel universe (both past and future) with all possible outcomes that we can imagine for certain events. (Déjà vu).

"**We are what we think all that we arise with our thoughts we make our world**".

---------Buddha

A simple atom radiates an EMF .a molecule radiates much greater EMF, large molecules forms a cell which mind contain 200M such cells. These radiations, atomic waves include emotions and thoughts are be superimposed within the EMF frequencies. These vibrations are sent out of the physical worlds extending outwards.

A historian Arther Koestler refer that this capacity of the human psyche to act as a "cosmic resonator".

It has also been determined by the encephalograph that all reasoning process are actual waveform transmission.

Additionally wave function of the brain is not completely random and seems to have a phase difference.

Thoughts and feelings manifest itself into reality, quantum physics even suggest that by redirecting our focus and our attention we can bring a course of events in action**[5].**

III. Conclusions

I conclude my paper as our gravity is just a weak quantum force for next upper world with each world having 4 observable dimensions (three space and time(relative to each worlds)) and set of all realities(quantum states) we call it as parallel worlds underlining the 5th dimensions. Each worlds having own space and time constraints i.e. set of small particles, atoms, quantum force gravity for our below level) forms the small universe for just lower level for our universe.

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