



International Journal of Advanced Computer Science and Applications

Volume 2 Issue 2

February 2011



ISSN 2156-5570(Online)

ISSN 2158-107X(Print)



www.ijacsa.thesai.org



INTERNATIONAL JOURNAL OF
ADVANCED COMPUTER SCIENCE AND APPLICATIONS



A Publication of
The Science and Information Organization



IJACSA Editorial

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We hope to continue exploring the always diverse and often astonishing fields in Advanced Computer Science and Applications

Thank You for Sharing Wisdom!

Managing Editor

IJACSA

Volume 2 Issue 2, February 2011

editorijacsa@thesai.org

ISSN 2156-5570(Online)

ISSN 2158-107X(Print)

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Building XenoBuntu Linux Distribution for Teaching and Prototyping Real-Time Operating Systems

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Abstract- This paper describes the realization of a new Linux distribution based on Ubuntu Linux and Xenomai Real-Time framework. This realization is motivated by the eminent need of real-time systems in modern computer science courses. The majority of the technical choices are made after qualitative comparison. The main goal of this distribution is to offer standard Operating Systems (OS) that include Xenomai infrastructure and the essential tools to begin hard real-time application development inside a convivial desktop environment. The released live/installable DVD can be adopted to emulate several classic RTOS Application Program Interfaces (APIs), directly use and understand real-time Linux in convivial desktop environment and prototyping real-time embedded applications.

Keywords- Real-time systems, Linux, Remastering, RTOS API, Xenomai

I. INTRODUCTION

Real-Time embedded software become an important part of the information technology market. This kind of technology previously reserved to very small set of mission-critical applications like space crafts and avionics, is actually present in most of the current electronic usage devices such as cell phones, PDAs, sensor nodes and other embedded-control systems [1]. These facts make the familiarization of graduate students with embedded real-time operating systems very important [2]. However, many academic computer science programs focus on PC based courses with proprietary operating systems. This could be interesting for professional training, but inappropriate to the academicians because it limits students to these proprietary solutions.

In the RTOS market, there are some predominant actors with industry-adopted standards. Academic real-time systems courses must offer to the students the opportunity to use and understand the most common RTOSs APIs. Actually, we assist to the growing interest of the real-time Linux extensions. In fact, they must be considered with great interests since each real-time Linux extension offers a set of advantages [3]. Xenomai real-time Linux extensions have the main advantages to emulate standard RTOS interfaces, compatibility with non-real-time Linux. Such adoption can be very cost-effective for the overall system.

In this paper, we present the interest of using Xenomai and Ubuntu as live installable DVD for teaching real-time operating systems and rapid real-time applications prototyping. Technical choices and benefits of the chosen solutions will be discussed.

The remainder of this paper is organized as follows. Section 2 presents a survey of RTOS market and discusses both of the classic solution and the Linux-based alternatives. The Remastering solutions and available tools are detailed in Section 3. Section 4 describes the realization of our live DVD. Conclusions and discussion are provided in Section 5.

II. SURVEY OF THE RTOS MARKET

A. Classic RTOS and Real-Time API

RTOS is an essential building block of many embedded systems. The most basic purpose of RTOS is to offer task deadline handling in addition to classic operating system functionalities. The RTOS market is shared between few actors. Each of them has its appropriate development tools, its supported target, its compiler tool-chain and its RTOS APIs. In addition, several RTOS vendors can offer additional services such as protocol stacks and application domain certification.

According to the wide varieties of RTOSs, the designers must choose the most suitable one for their application domain. In the following, we will present a brief description of traditional RTOS and real-time API available in the embedded market.

1) VxWorks

VxWorks [4] is a RTOS made and sold by Wind River Systems actually acquired by Intel. It was primarily designed for embedded systems use. VxWorks continues to be considered as the reference RTOS due to its wide range of supported targets and the quality of its associated IDE.

2) PSOS

This RTOS [5] was created in about 1982. It was widely adopted especially for Motorola MCU. Since 1999 PSOS has been acquired by Wind River Systems.

3) *VRTX*

VRTX [6] is an RTOS suitable for both traditional board-based embedded systems and System on Chip (SoC). It was widely adopted for RISC microprocessors.

4) *POSIX*

POSIX [7] (**P**ortable **O**perating **S**ystem **I**nterface for **C**omputer **E**nvironments), is a set of a standardized interface that provides source level compliance for RTOS services.

B. Real Time Linux Alternatives

According to the reference study [4], the market place of embedded Linux becomes more and more important. In 2007 their part was about 47% of the total embedded market. The same study anticipates that the market place of embedded Linux will be 70% in 2012. These facts can be justified by the growing availability resources in modern embedded hardware, the maturity of actual Linux kernels and applications and the cost reduction needs. Actually, there are many existing open source implementations of real-time extensions for Linux kernel, but we must note that various existing industrial solutions are based on those extensions with an additional value of support quality. Real-time Linux variants are actually successfully used in different applications [5]. Due to the increasing Linux popularity in the embedded systems' field, many efforts were spent and proposed to transform Linux kernel into a real-time solution. These works resulted in several implementations of real-time Linux. Actually, there are many existing implementations of real-time extension for Linux kernel extension [6]. They can be classified in two categories according to the approach used to improve their real-time performance of the Linux kernel. The first approach consists of modifying the kernel behavior to improve its real-time characteristics. The second approach consists of using a small real-time kernel to handle real-time tasks and what can run the Linux kernel as a low priority task.

Actually, a lot of researches and industrial efforts are made to enhance the real-time capability of the various real-time Linux flavors' [3] for different perspectives and applications domain. These works can be classified in two categories. The first one is about scheduling algorithm and timer management. The second category is about application's domain such as Hardware-in-the-Loop simulation system, model based engineering [7] and real-time simulation. In Table I, we present some of the available open source many research Linux implementations.

TABLE I. LINUX OPEN SOURCE RTOS

Linux-based RTOS	Description
ADEOS	Adaptive Domain Environment for Operating Systems) [11], is a GPL nanokernel hardware abstraction layer created to provide a flexible environment for sharing hardware resources among many operating systems. ADEOS enables multiple prioritized domains to exist simultaneously on the same hardware.
ART Linux	Advanced Real-Time Linux [12], is a hard real-

	time Linux extension inspired from RTLinux and developed with robotics applications in mind. Real-Time is accessible from user level and does not require special device drivers. ART Linux is available for 2.2 and 2.6 Linux kernel.
KURT	Kansas University's Real-Time Linux is a real-time Linux [13] extension developed by the Kansas University for x86 platforms. It can allow scheduling of events with a 10µs resolution.
QLinux	QLinux [14] real-time Linux kernel, is a Linux extension that focus and provide Quality of Service (QoS) guarantees for "soft real-time" performance in applications such as multimedia, data collection, etc.
Linux/RK	Linux Resource Kernel [15] is a real-time extension which incorporates real-time extensions to the Linux kernel.
RTAI	Real-Time Application [16] Interface usable both for mono processors and symmetric multi-processors (SMPs), that allows the use of Linux in many "hard real-time" applications. RTAI is the real-time Linux that has the best integration with other open source tools scilab/scicos and Comedi. This extension is widely used in control applications.
Xenomai	Xenomai [17] is a real-time development framework that provides hard real-time support for GNU/Linux. It implements ADEOS (I-Pipe) micro-kernel between the hardware and the Linux kernel. I-Pipe is responsible for executing real-time tasks and intercepts interrupts, blocking them from reaching the Linux kernel to prevent the preemption of real-time tasks by Linux kernel. Xenomai provides real-time interfaces either to kernel-space modules or to user-space applications. Interfaces include RTOS interfaces (<i>pSOS+</i> , <i>VRTX</i> , <i>VxWorks</i> , and <i>RTAI</i>), standardized interfaces (<i>POSIX</i> , <i>uTRON</i>), or new interfaces designed with the help of <i>RTAI</i> (native interface). These features made that Xenomai was considered as the RTOS Chameleon for Linux. It was designed for enabling smooth migration from traditional RTOS to Linux without having to rewrite the entire application.
RT-Preempt	The RT-Preempt patch [18] converts Linux into a fully preemptible kernel. It allows nearly the entire kernel to be preempted, except for a few very small regions of code. This is done by replacing most kernel spinlocks with mutexes that support priority inheritance and are preemptive, as well as moving all interrupts to kernel threads. (Dubbed interrupt threading), which by giving them their own context allows them to sleep among other things.

C. Selecting real-time extension for educational purposes

Xenomai, RTAI and RT-Preempt are the most used real-time Linux extensions. According to the study [8], Xenomai and RTAI can provide interesting performances comparable to those offered by VxWorks in hard real-time applications. RTAI has the best integration with open source tools and can be remarkable for teaching control application. RT-Preempt has the privilege to be integrated to the mainline kernel. It offers the support of all drivers integrated into the standard kernel. Xenomai can provide the capability of emulating classic RTOS APIs with good real-time characteristics. It can be also fully compatible with RTAI. For these reasons, we focus on Xenomai to be the primary extension to integrate in our solution.

1) Xenomai technology and ADEOS

To make Xenomai tasks hard real-time in GNU/Linux, a real-time application interface (RTAI) co-kernel is used. It allows real-time tasks to run seamlessly aside of the hosting GNU/Linux system while the tasks of the “regular” Linux kernel are seen as running in a low-priority mode. This cohabitation is done using the previously presented ADEOS nanokernel and illustrated by figure 1.

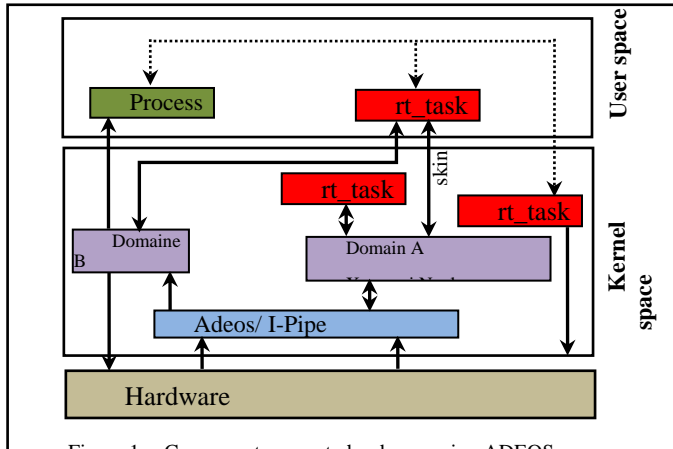


Figure 1. Concurrent access to hardware using ADEOS

Based on the behavioral similarities between the traditional RTOS, Xenomai technology aims to provide a consistent architecture-neutral and generic emulation layer taking advantages from these similarities. This emulation can lead to fill the gap between the very fragmented RTOS world and the GNU/Linux world.

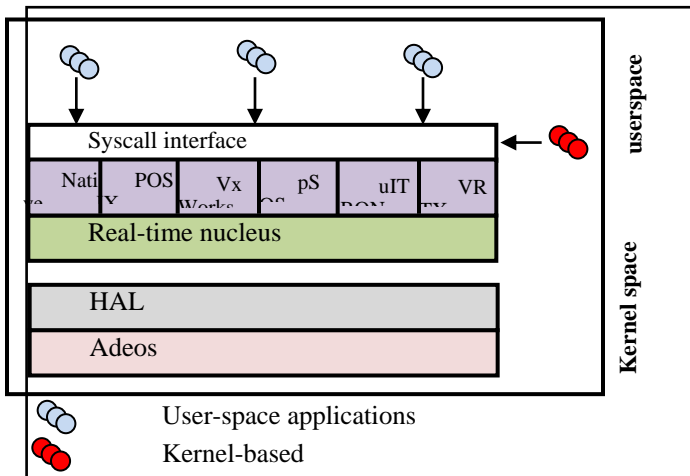


Figure 2. Xenomai Architecture

Xenomai relies on the shared features and behaviors [9] found between many embedded traditional RTOS, especially from the thread scheduling and synchronization standpoints. These similarities are used to implement a nucleus that offers a limited set of common RTOS behavior. This behavior is exhibited using services grouped in high-level interfaces that can be used in turn to implement emulation modules of real-

time application programming interfaces. These interfaces can mimic the corresponding real-time kernel APIs. Xenomai technology offers a smooth and comfortable way for real-time application migration from traditional RTOS to GNU/Linux.

2) RTOS emulation in the industrial field

The fact that Xenomai can offer real-time capabilities in a standard desktop environment can be very useful in control system prototyping [10]. In this case, the desktop system which is running Xenomai can be used as X-in-the-loop to emulate the standard controlled equipments (electrical motors, power plants, etc.) in different phases of product prototyping and testing.

Thus, since Xenomai can emulate the most classic RTOS API, we can easily port any application developed for this RTOS to it. Furthermore, it's covered by open-source license which has a very interesting cost advantage. Moreover, by Using Xenomai we can realize an easy migration to open-source solutions without having to rewrite previously developed RT applications for proprietary RTOS. Xenomai can also reduce the application price by offering the ability to cohabit them with standard time shared Linux applications, to benefit from all the software infrastructure of Linux combined to RT capability.

3) RTOS emulation in academic field

Real-Time students must have a clear idea about various RTOS APIs. The cost of buying a large collection of classic RTOS to use them in the education field is not feasible. Xenomai also offers the capability of using different RTOS APIs, understanding the abstraction concept of them, manipulating the kernel/user spaces and learning about virtualization technologies.

III. REMASTERING UBUNTU LINUX

A. Interest of remastering Linux distributions

A live CD or DVD allows any user to run different OS or applications without having to install them on the computer. To build a live CD/DVD, we must remaster an existing OS. Remastering is the process of customizing a software distribution. It is particularly associated with the Linux distribution world but it was extended to the majority of widely used OS. We can highlight that the most Linux distributions have been started by remastering another distribution. The term was popularized by Klaus Knopper, creator of the Knoppix Live Distribution, which has traditionally encouraged its users to modify his distribution in the way that satisfies their needs. Remastering OS can be used to make a full system backup including personal data to a live or installable CD, DVD or Flash disk that is usable and installable anywhere. It can also be exploited to make a distributable copy of an installed and customized operating system.

B. Existing remastering software for Ubuntu Linux

There are many remastering solutions of various Linux distributions. Our live/installable DVD is based on Ubuntu

because this OS has gained a growing place in different application areas. The most known remastering solutions are such as Remastersys, Ubuntu Customization Kit, Reconstructor, Builder, ulc-livecd-editor and Disc Remastering Utility.

Reconstructor and Ubuntu Customization Kit can make a personalized live system based on official image. The use of such approach is relatively complicated. The others' tools are focusing on the package installation and boot customizations. We adopted Remastersys since it is the most useful and powerful tool that we find in the available list of remastering solutions.

IV. THE INTEGRATION OF XENOMAI IN UBUNTU INFRASTRUCTURE

Xenomai is only related to the Linux kernel version. It's independent of the Linux distribution in which it will be run. The recent Ubuntu distributions integrate Xenomai as a default package. We have taken the choice of using Ubuntu as basic distribution because it inherits all the benefit of a Debian distribution in terms of reliability and the number of available packages. Ubuntu has also the best existing Multilanguage support. Many computer constructors propose Linux as an alternative operating system. This type of systems can be used as a framework for Model-Driven Engineering (MDE) in Control and Automation since the usage of a standard operating system such as Ubuntu can facilitate the integration of these tools. The realization of our Live DVD was conducted following the steps' bellow.

A. Adding Xenomai functionality to Linux kernel

In This step, we must firstly download the essential packages needed to configure and compile the Linux kernel. These packages are: build-essential, kernel-package, ncurses-dev. They can be installed using synaptic or apt-get. Secondly, we must download both Linux kernel and its compatible Xenomai framework, patch the Linux kernel using the prepare-kernel tool included in Xenomai package, configure, compile it and add this kernel to the boot choices. For the actual release, we used the xenomai-2.4.10 and the Linux-2.6.30.8. The compilation and installation must preferably be realized using make-kpkg tools designed especially for Debian based distributions. After realizing these steps, we can boot a system running Linux kernel using ADEOS.

B. Compiling Xenomai and running some samples

The second step must begin by creating a Xenomai group and adding to it the appropriate users (XenoBuntu and root). We can actually configure, compile and install Xenomai and their examples, customizing available software by adding development environments. We adopted CodeLite, which is an Integrated Development Environment (IDE) designed for C and C++ development and Scilab/Scicos which can be used for control systems prototyping and real-time code generation. After rebooting our running system, we can boot to a usable system based on Xenomai through it, we can test some real-time examples based on different standards API.

C. Transform our running system in a live DVD

The final step is to remaster our running real-time system using Remastersys package. Before we move to the explanation of this stage, we give a brief description of this tool. In fact, it's a Debian oriented remastering tool, controllable using command line or Graphic User Interface. It enables the creation of live installable CDs or DVDs, including all the software available in the installed system. We can choose to include or not our personal data by choosing between "dist" and "backup" parameters. We must add Remastersys repository, install and use it to remaster our system to obtain an ".iso" burnable image usable as live installable DVD. This phase is the easiest step in the realization thanks to the simplicity of Remastersys usage and the wide choice of parameters offered by this package.

D. Testing the real-time characteristics of our system

The realized system can be used as live DVD or installed in a standard PC architecture. The real-time performances may vary depending on the used architecture. To have a clear idea about reached performances by deployment platform, Xenomai offers a set of benchmarks able to test different real-time aspects of the system. The most important benchmarks are described in Table II.

TABLE II. XENOMAI ASSOCIATED BENCHMARKS

Benchmark	Description
Switchtest	Can test thread context switches.
Switchbench	Can measure the contexts switch latency between two real-time tasks.
Cyclictest	Can be used to compare configured timer expiration and actual expire time.
Clocktest	Can be used to repeatedly prints a time offset compared to reference gettymeofday().

These benchmarks can be used to familiarize students with real-time performance evaluation and their different associated metrics. Such can be illustrated by the evaluation of the impact of real-time enhancements into the overall system performances.

V. CONCLUSION

The realized live/installable DVD can be used both in education or system development. The main contribution of such solution is to have a ready to run system, which minimizes the time of selecting and including different needed software components. This system can be enhanced and remastered after its installation and can be tuned by inclusion of new components to meet specific application needs.

This kind of solution offers the possibility to work with real-time Linux without losing the contact with classic RTOS knowledge's. It can be a very interesting way to introduce real-time and embedded Linux word especially when considering that Xenomai is actually used by various companies such as Sysgo in their ELinOS solution.

Considering that this distribution does not take the advantage of the two other predominant real-time Linux extensions (RTAI and RT-PREEMPT). We plan to extend our distribution with these two extensions by including multi configuration boot capability, which can allow the user to choose between these three alternatives. In the other hand, we plan to include and explore other open-source components that can be used for real-time applications design and code generation such as Topcased, Openembedd and Beremiz.

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Design and Implementation of NoC architectures based on the SpaceWire protocol

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Abstract- The SpaceWire is a standard for high-speed links and networks used onboard spacecrafts, designed by the ESA, and widely used on many space missions by multiple space agencies. SpaceWire has shown a great flexibility by giving the space missions a wide range of possible configurations and topologies. Nevertheless, each topology presents its own set of tradeoffs such as hardware limitations, speed performance, power consumption, costs of implementation, etc. In order to compensate these drawbacks and increase the efficiency of the SpaceWire networks, many solutions are being considered. One of these solutions is the Network on Chip or NoC configuration which resolves many of these drawbacks by reducing the complexity of designing with a regular architecture improving speed, power, and reliability and guaranteeing a controlled structure. This paper presents the main steps for building Network on Chip based on the SpaceWire protocol. It describes the internal structure, the functioning and the communication mechanism of the Network's Nodes. It also exposes the software development and the validation strategy, and discusses the tests and results conducted on the adopted NoC topologies.

Keywords- NoC architectures; SpaceWire protocol; Codec IP; ,FPGA.

I. INTRODUCTION

The SpaceWire standard was developed to meet the electromagnetic compatibility (EMC) specifications of typical spacecraft. It is also easy to implement, has a great flexibility, and supports fault-tolerance by providing redundancy to networks [1,2]. In order to interpret and exploit the received data coming from space equipments correctly, the reliability and the protection from errors of these data are essential. To ensure reliability without jeopardizing the spacecraft operations neither its components, the Spacewire was quickly adopted in many space missions, not only in the ESA but also among the largest agencies world's space like NASA, JAXA, or RKA.

The financial constraint of these missions eventually led to many researches to elaborate new strategies of integration to reduce weight and improve configurability within a distributed satellite system (DSS) network. Among the solutions explored, the Network on Chip (NoC) is a recent solution paradigm adopted to increase the performance of multi-core designs [3, 4]. The key idea is to interconnect various computation modules (IP cores) in a network fashion and transport packets

simultaneously across them, thereby gaining performance [5,6]. In addition to improving performance by having multiple packets in flight, NoCs also present others advantages including scalability, power efficiency, and component re-use through modular design. The concept of Network-on-Chip or NoC is a new approach to design mechanisms for internal communications of a System On-a-Chip. The NoC-based systems can accommodate multiple asynchronous clock signals that use recent complex SoC [7, 8, 9].

The desired architecture built using NoC allows interconnecting different systems' types via a communications network, all integrated on a chip. This configuration gives the benefits of large scale integration, which leads to a reduction of power consumption and a significant decrease in wiring and noise. On the other hand, it allows the system to take advantage of techniques and theories of development network as the routing of data, parallelism and communication modularity.

In this context many works were conducted such as the SpaceWire based System-on-Chip (SoCWire) communication network. Designed to give enhanced dynamic reconfigurable processing module, the SoCWire provides a mean to reconfigure various parts of the FPGA during flight safely and dynamically. The SoCWire has a dynamic partial reconfigurable architecture with host system including SoCWire CODEC and PRMs (Partial Reconfigurable Modules) with SoCWire CODEC as well as an additional module for control and data generation [10]. Besides, Configurable System-on-Chip (SoC) solutions based on state-of-the art FPGA have successfully demonstrated flexibility and reliability for scientific space applications. Furthermore, in-flight reconfigurability and dynamic reconfigurable modules enhances the system with maintenance potential and at runtime adaptive functionality. To achieve these advanced design goals a flexible Network-on-Chip (NoC) is proposed which supports in-flight reconfigurability and dynamic reconfigurable modules [11, 12, 13, 14].

The INTA (Instituto Nacional de Técnica Aeroespacial) has made several successful missions and focuses on small satellites with NANOSAT and INTA μ SAT. In addition, the INTA has recently made a data architecture based on Spacewire protocol for the INTA μ SAT. This design includes

several subsystems including an On Board Data Handling (OBDH). Due to its importance as it ensures the best performances for data exchange on small satellites, the OBDH subsystem also comprises dedicated Remote Terminal Units (RTU) and a Mass Memory Unit (MMU). The ladder consists of a set of SDRAM memory banks and a Payload Processor as part of a System-on-Chip design. Together with the processor, the SoC will provide a Spacewire router, a low data rate interface with the payload and a CAN interface [15].

Moreover, recent researches discuss other possibilities and solutions to use the SoC technology. In fact, the similarities between the IEEE802.11 and the Spacewire standards were exploited in order to design a wireless link for Spacewire networks. The idea was to create a bridge to connect SpaceWire routers with an IEEE802.11 transceiver. This bridge was also capable of converting data from one standard format to the other and controlling information flow and had a mechanism to provide memory access to SpaceWire routers. The bridge was incorporated into a high performance SoC, which provides a communication platform enabling spacecraft with SpaceWire networks to communicate via inter-satellite links based on the IEEE 802.11 wireless network standard [16].

Additionally, other works present a design of a SpaceWire Router-network using CSP (Communication Sequential Processes) where an IEEE1355 network router is integrated as an Intellectual Property (IP) core [17]. The router design has been evaluated, refined and verified from the point of view of robustness and security using CSP method, one of the formal design methods [18]. The router was implemented in a Network on Chip (NoC) formed with several TPCOREs [19] an IP (Intellectual Property) core for the T425 Transputer where the same machine instructions as the transputer are executable in this IP core.

In this paper, we investigate the protocol SPW which is widely used to provide communications between devices in satellites and we propose to explore different implementation solutions in the form of NoC. After a brief presentation of the NoC solutions advantages of, we introduce the SpaceWire IP Codec we developed and its internal components. Then we discuss the adopted design strategy and present the structure of our SpaceWire node which is the unitary element of the discussed NoC solutions. Finally we expose the main studied NoC architectures, their performance/capability and the obtained testing results.

II. ADVANTAGE OF NOC ARCHITECTURES

The NoC solution can combine theories and methods used in networks communication mechanisms on chip. Compared to the communication bus conventional, they greatly improve the scalability of systems on chip, the exchange data and power consumption in complex systems. A network on chip is established from multiple type connections point-to-point interconnected by routers. The messages or frames can circulate throughout the network and reach all machines. The design of a NOC is similar to a telecommunication network-based modems and uses the switching digital bits or packets through links multiplexed [20].

Thanks to this architecture, the connections are shared by several signals that achieve a high level of parallelism since all links may convey different packets of data simultaneously. And more complex integrated networks increases, the size and performance NoC are improved over previous architectures communications [21].

Networks-on-chip (NoCs) are designed to provide high bandwidth and parallel communication, while minimizing the number of employed interconnect resources. However, NoC performance can significantly degrade in absence of an effective flow control mechanism. The flow control is responsible for preventing resource starvation and congestion inside the network. This goal is achieved by managing the flow of the packets that compete for resources, such as links and buffers [22, 23].

Due to the reduction in the construction's scale and the circuit's optimization, the NoCs tend to reduce design complexity and routing connections in a SoC, while ensuring low power consumption, minimal noise and high reliability. NoCs support modularity and allow distribution of data processing and communication. They are very suitable for test platforms and increased productivity.

III. THE SPACEWIRE NODE DESIGN AND VALIDATION

A. The Node Hardware Design

A SpW node is composed mainly of two modules, namely (1) the host based on the processor on which the user application will be implemented and (2) the SpW CODEC implementing the protocol interface "Fig. 1". The Host represents a processing unit that will execute tasks and eventually communicate with other nodes. While the SpW interface plays the role of the modem and enables interfacing with the SpW network "Fig. 2".

The designed SpW CODEC IP in "Fig. 1", is composed of the following main modules:

- Transmitter module: responsible for emissions. Its role is to synchronize the reception of data arriving from the host, build frames Spacewire (FCTS, NULLS, N-CHARS and Times Codes) and send coded "DATA-STROBE".
- Receiver module: responsible for receiving data. Unlike the transmitter module, it decodes the incoming frames, classifies them by type, and synchronizes the delivery of N-CHARS and time codes with the host.
- FSM module: is the state machine responsible for connection and communications management. This is the heart of the interface that controls the operation of all other modules.
- Timer module: has the task of ensuring the necessary synchronization for initializing a connection.

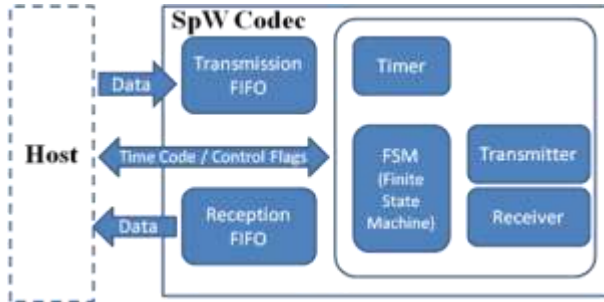


Figure 1. Overview of the SpaceWire CODEC architecture

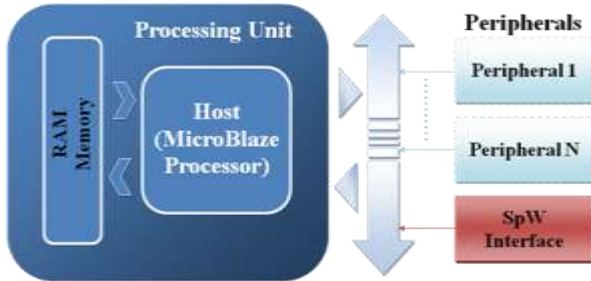


Figure 2. Overview of the SpaceWire node architecture

For the processing unit, a Xilinx MicroBlaze microprocessor (soft-core clocked at 100 MHz) is used and connected to:

- A RAM Memory bloc of 64 Kbits with its controllers.
- An OPB bus controller for OPB peripherals.
- An UART to control, monitor and debug the functioning of the node with a computer.
- An interrupt controller for the management of priority signals.

The HOST communicates with its devices on the OPB Bus. Data exchange is made via formatted requests and responses through the bus and in its native form. The SpaceWire Interface's IP is only usable with low-level binary signals. It is far from being equipped to be directly plugged into the OPB peripherals bus. To overcome this inability, an OPB IPIF (Intellectual Property InterFace) was added; so we can transform our "raw IP" into an OPB interface device that can communicate not only with our processor but can also serve in any other project involving this bus.

The concept of the IPIF is to regroup the different I/O into registers interposed between the OPB bus and the IP. The exploitation of the device (formerly binary) is achievable through loading and unloading register's driver-functions targeted by the address of the device in question. So in order to command or read any I/O of the interface, we have just to load the bits of the register covering that I/O while identifying the interface on which the changes will be brought.

B. The Node Software Development

The programming of host was made in C language with EDK environment. We wrote a function for each elementary

operation of the interface: initialization, sending and receiving data, sending and receiving time codes and the display on the output stream. This facilitates the programming, avoids cluttering our source code and facilitates the errors localization when debugging.

With these functions we created a library dedicated to our device. So the host's main program will be less loaded and the update or the summoning of a function in several source codes does not require its "full" presence / reissue in each code. That was very handy in a NOC programming or any multiprocessor configuration.

C. Tests and validation

In order to validate the functioning of the designed node; we have established a checklist that includes the main criteria for compliance with the standard. We made an experimental plan that runs through scenarios putting in trial : The proper connection, the proper sending and receiving of data (Chars, control codes, time codes) and the proper functioning of the FiFos (Indicators, limitations and good management).

The tests were conducted on a self-looped Node and on a host equipped with two interconnected interfaces.

IV. THE SPACEWIRE NOC DESIGNED ARCHITECTURES

A. The double Nodes Network:

We first began with a double node network-on-chip that consists of two nodes connected to each others. We have doubled the material of a single node, so each Node has its own processor, working memory and peripherals. The only exclusive device to one of the nodes is the serial interface that does not support multi-drive and is used to debug the program and the functioning of the network.

We could use an OPB Bridge to interconnect the processor's OPB buses on and provide simultaneous access to the UART, but it goes against our main objective which is to route two separate nodes connected only by Data-Strobe signals for SpaceWire communication. The node equipped with UART will perform the monitoring of the network and inform us of its status. If need dictates, it is possible to supervise each node individually by connecting it to the UART, but with each change, a new synthesis and a new routing is required.

Concerning the software layer, the two processors have their own individual programming source, headers and libraries (dual-processor configuration) and exploit the SpaceWire library we created.

To test this setup, we used a simple source code, exchanging data. The test's scenario consists on sending X data and time / control codes from the first node to the second and the second node sends fully the received data to the first one as shown in the flowchart diagrams of "Fig. 3" and "Fig. 4". The tests were positive: Whether in data, control codes or time codes exchange, the dual node architecture meets the standards of Spacewire protocol. Using this architecture, a parallel processing could be made with an exchange of data at high speed and very low error rate.

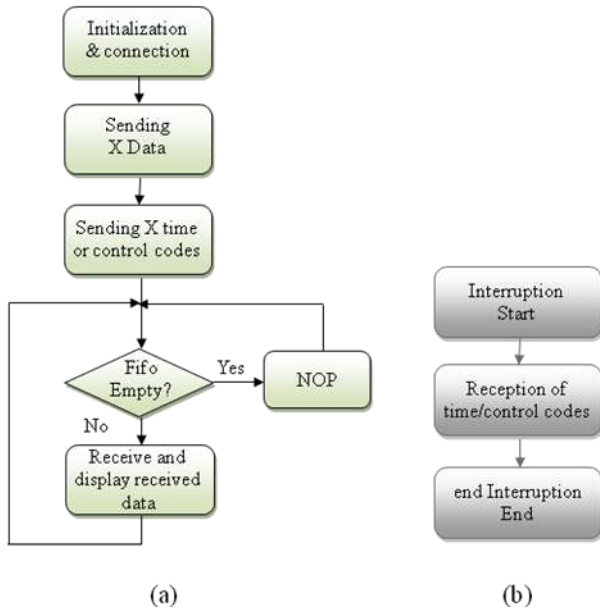


Figure 3. Node A flowcharts: (a) Main Program; (b) Interruption

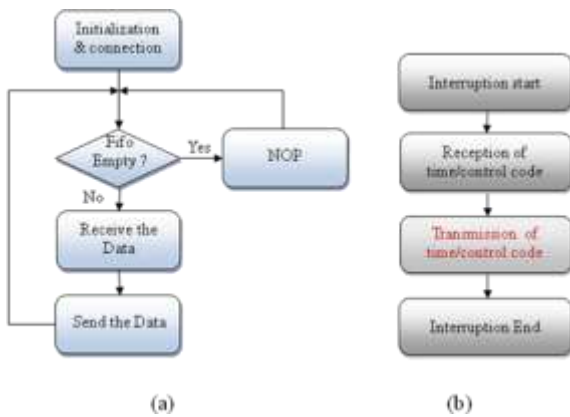


Figure 4. Node B flowcharts: (a) Main Program; (b) Interruption

B. The triple Nodes Network

In the fully meshed networks, the nodes are linked together by direct connections (without any intermediary node). When a node needs to communicate with another it refers directly to it (no data carrying or intermediate machine). This direct communication provides the mesh network the highest possible performance in terms of communications: It minimizes the loss of data, errors and data transfer time. Unfortunately fully meshed networks suffer from a major handicap which is the high number of links and communications interfaces necessary for their establishment. Indeed, the number of interface is double the number of connections which is $N \times (N-1) / 2$. That is costly in terms of hardware (special cables, shielding, interfaces ...), size and weight.

At our level of integration, the problems related to the scale are resolved; the only persisting limitation is the capacity of the FPGA. The space probe intended to explore Venus has

received a Virtex 4 with a Spacewire network and feedback over this mission are very good! That's why we decided to explore this kind of Networking Method on Chip.

In the same way as the dual node architecture, we tripled the number of components. The only difference compared to the dual node architecture lies in the number of interfaces in each node. We provided every Spacewire node with two interfaces: One for each channel. So when Node A needs to transfer data to Node B or C, it sends them through the interface linking it with the Node in question.

The network architecture is as follows:

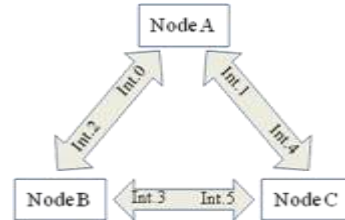


Figure 5. Triple nodes Architecture

As for the dual network node, each of our three nodes must be programmed separately. The testing scenario we executed consists on sending data through the network and make it returns back to its issuers: We send data and time / control codes from the first node to the second, the second node sends them to the 3rd which will forward them back to the first (that supervises the network and displays the data movement on the serial connection).

According to the original node and the destination node, the data are sent threwh the interfaces linking to the two concerned nodes.

The programs of each node are illustrated by the flowcharts diagrams shown on "Fig. 6" and "Fig. 7":

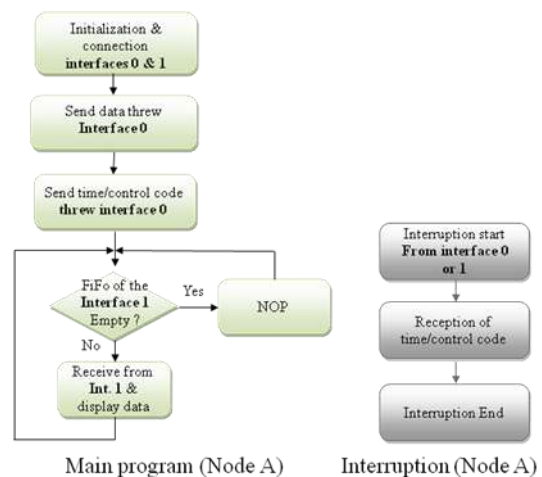


Figure 6. The Node A distributed program

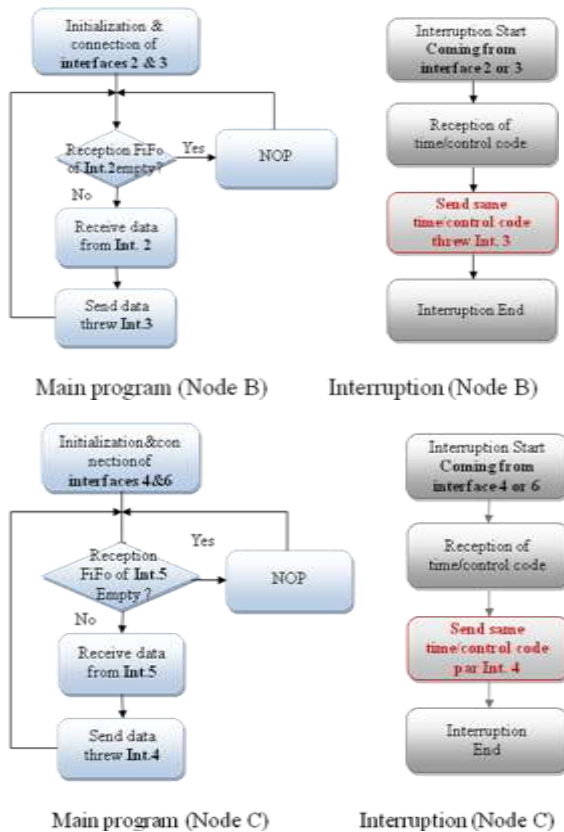


Figure 7. The Node B and C distributed programs

As for the dual nodes network, the transmission and reception of data takes place properly. The nodes communicate correctly. The transmitted data does a complete turn and returns back to its issuer. The Network is well operational.

V. TESTS AND VALIDATION OF DESIGNED SYSTEMS

In this work, we have developed NoC architectures based on the SpW communication protocol which is widely used as a proved reliable interface standard on-board spacecrafts. Our work focused on implementing a SpW CODEC and its integration into point to point networks architectures.

The designed IP has several features such as:

- It operates at a frequency of 100 MHz while maintaining the standard (flow and exchange time of silence);
- It is synthesizable and routable;
- It does not load its FiFo Randomly (total synchronization with the host);
- It connects and operates normally when it is associated to a host.

In order to test the SpW CODEC IP, we have programmed various codes that emulate a HOST connection with a specific behaving scenario. After each execution of a test, the temporal evolution of signals has been visualized. So we could conclude on the smooth running of the script and compliance behavior of the interface.

In addition, this IP has been associated with a host and tested with different configurations of NoCs. The obtained results showed the efficiency and flexibility of the proposed solution for systems based on FPGA circuits.

The digital clock manager DCM of the used FPGA (Virtex II Pro) is limited to 100 MHz, which limits our communication rate to 50 Mbits/s. The use of more recent FPGA circuits such as the Virtex 6 would increase the number of nodes and the transmission frequencies.

VI. CONCLUSION

In this paper, we study various NoC architectures based on the SpW protocol. These solutions integrate the SpW IP codec developed as part of this work and are achieved by the introduction of point to point interconnections between different nodes. Each node consists of a host processor associated with one or more SpW interfaces (IP codec).

Compared to other related works like SoCwire Or MARC architecture, we built simple but versatile and intelligent nodes that can be used to develop more complex applications. In fact, the main benefits of the proposed architectures are modularity, flexibility and usability. Since the Nodes are all connected directly to each other through the dedicated IP codec, (without any intermediate units) communication speed is increased, routing errors are reduced, and in case of an error or a disconnection between two nodes occurs, alternate way to transmit data through other nodes is always possible.

The number of necessary links and communications interfaces may appear significant In case of a large Network establishment but in reality it is not a consequent problem in front of the performance of the new generations of FPGA platform like Virtex 5 or Virtex 6.

Another advantage of our design is the SpaceWire Codec peripheral which is an OPB Peripheral. It can be easily integrated in any design or mechanism that includes that bus and establish a SpaceWire Communication.

Once the initial tests done, it is possible to carry out more optimizations and improvements of the designed NoC architectures. In addition, some bits of the frame are reserved for future extension: they may be used for example to implement additional techniques to manage messages priorities and or to generate distributed interruptions between nodes.

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A Study on Cross Layer MAC design for performance optimization of routing protocols in MANETs

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Abstract— One of the most visible trends in today's commercial communication market is the adoption of wireless technology. Wireless networks are expected to carry traffic that will be a mix of real time traffic such as voice, multimedia conferences, games and data traffic such as web browsing, messaging and file transfer. All of these applications require widely varying and very diverse Quality of Service (QoS) guarantees. In an effort to improve the performance of wireless networks, there has been increased interest in protocols that rely on interactions between different layers. Cross-Layer Design has become the new issue in wireless communication systems as it seeks to enhance the capacity of wireless networks significantly through the joint optimization of multiple layers in the network. Wireless multi-hop ad-hoc networks have generated a lot of interest in the recent past due to their many potential applications. Multi-hopping implies the existence of many geographically distributed devices that share the wireless medium which creates the need for efficient MAC and routing protocols to mitigate interference and take full advantage of spatial reuse. Cross-Layer Design is an emerging proposal to support flexible layer approaches in Mobile Ad-hoc Networks (MANETs). In this paper, we present few Cross-Layer MAC design proposals by analyzing the ongoing research activities in this area for optimizing the performance of routing protocols in MANETs.

Keywords- *cross-layer, routing, MAC, MANET, multi-hop networks;*

I. INTRODUCTION

An ad-hoc network is a local area network (LAN) that is built spontaneously as devices connect. It is self-creating, self-organizing and self-administrating network. Each node acts as a host and router and forwards each other's packet to enable the communication between nodes. The network topology changes frequently because of node mobility and power limitations. Multi-hopping in ad-hoc networks implies the existence of many geographically distributed devices that share the wireless medium. Efficient routing is the fundamental issue in multi-hop wireless ad-hoc networks [1, 2].

A layered architecture, like the seven-layer open systems interconnect (OSI) model [3, p.20], divides the overall networking task into layers and defines a hierarchy of services to be provided by the individual layers. The services at the layers are realized by designing protocols for the different

layers. The architecture forbids direct communication between non adjacent layers; communication between adjacent layers is limited to procedure calls and responses. It is repeatedly argued that although layered architectures have served well for wired networks, they are not suitable for wireless networks. The complexity and time-varying attributes of the wireless channel call for cross-layer design [4]. Protocols can be designed by violating the reference architecture, for example, by allowing direct communication between protocols at nonadjacent layers or sharing variables between layers. Such violation of a layered architecture is called cross-layer design with respect to reference architecture [5].

It is argued that while designing efficient routing protocols for multi-hop wireless ad-hoc networks to meet the QoS requirements, we also need to consider the influence of MAC protocol in finding the optimal routes. Researchers analyzed the interaction between routing and the MAC layer protocols and confirmed that the MAC protocols can significantly affect the performance of routing protocols and vice versa.

Thus, a central challenge in the design of ad-hoc networks is the development of efficient MAC and dynamic routing protocols that can efficiently find routes between the communicating nodes. In this paper, we focus on cross layer design proposals based on the coupling between network layer and MAC layer for optimizing the performance of routing protocols in MANETs.

Widely used routing protocols for Ad-hoc networks are the two major categories:

A. *Pro-active (table-driven) Routing Protocols:*

This type of protocols maintains fresh lists of destinations and their routes by periodically distributing routing tables throughout the network.

The DSDV and OLSR are well-known proactive routing protocols.

B. *Reactive (on-demand) Routing Protocols:*

This type of protocols finds a route on demand by flooding the network with Route Request (RREQ) packets.

The AODV and DSR are representatives of on-demand routing protocols.

The fundamental MAC technique of IEEE 802.11 based WLAN standard is the Distributed Coordination Function (DCF). DCF employs a CSMA/CA with Binary exponential back-off algorithm. This algorithm is used to space out repeated retransmissions of the same block of data, often as part of network congestion avoidance.

II. AN OVERVIEW OF THE PROPOSALS

The layered architecture can be violated by creating new interfaces between the layers or by merging of adjacent layers [5]. The new interfaces are used for information sharing between the layers at runtime. Depending on the direction of information flow along the new interfaces, we classify the different proposals in the literature under consideration into the following categories:

1. The cross-layer proposals in which some information from the MAC layer is passed onto network layer for optimized routing in MANETs.
2. The cross-layer proposals in which some parameter of the network layer is passed onto the MAC layer to improve the performance of routing protocols.
3. The cross-layer proposals in which some information is passed back and forth between the two layers for efficient routing.

The adjacent layers are merged by designing a new sublayer such that the services provided by the new sublayer is the union of the services provided by the constituent layers.

4. Novel routing protocols based on cross-layer coupling between MAC and network layer.

The route maintenance overhead in AODV increases as the network mobility is high and the topology changes frequently. The established routes are to be changed as the nodes move away. It results in low performance as many packets are dropped when some active router node on the path moves away significantly. The performance of AODV protocol is improved by adopting a cross-layer approach and position based forwarding technique [6]. Here the MAC layer calculates the received power of the packets from the nodes and informs network layer if it is below the threshold value for efficient transmission. (Category 1). The network layer removes those nodes from the routing table and finds an alternate path.

A. Implementation of AODV-PF:

AODV-PF is an update over on-demand routing protocol.

In position-based forwarding, every node maintains a list of neighbors nearest to the position of the destination. At the time of route establishment, only these nodes will be selected. Hence the route lifetime improves. A forwarding region is either a circular or a Box like virtual area drawn around the destination node.

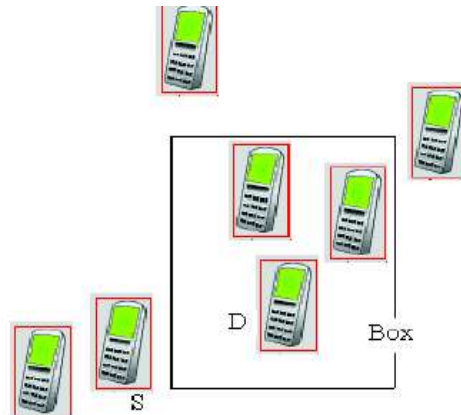


Figure 1: Sample PF Box forwarding region. A route between source node S and destination node D is found by flooding the forwarding region.

When a node, S, needs a route to a destination, D, it floods a route request (RREQ) through the forwarding region/ entire network attempting to find the destination. In PF Box, a neighbor of S determines whether it is within the forwarding zone by using the location of S and the expected zone for D.

Once the path is established, source transmits data packets to the destination. There may be some nodes which may be in the same direction as of the destination, but may not have sufficient energy to forward the packets further. Such nodes must notify their predecessors about the energy constraint. Energy is a physical layer feature, which is measured at the MAC layer. If the estimated energy is below the threshold value for efficient transmission, then the routing layer is notified about the energy fall. Accordingly routing layer initializes route maintenance by notifying its neighbors about the problem and removes those nodes from the routing table.

AODV-PF outperforms on-demand routing protocols (AODV) in various constraints such as control overhead, throughput, latency when simulated with pause time and different loads. AODV-PF sustains high packet delivery rates. In terms of routing overhead, AODV-PF has scalable routing overhead for mobility, random packet loss, and traffic load, thus utilizing the channel efficiently.

A strategy of cross-layer algorithm AODV- SPF (Scheduling Priority Flow) is proposed in [7] to address the *Intra-Flow contention problem* in chain topology where the source, could actually inject more packets into the chain than the subsequent nodes can forward.

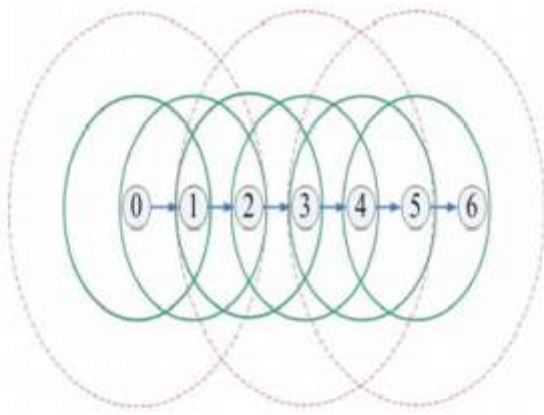


Figure 2: MAC layer interference among a chain topology. Small circle denotes node's valid transmission range. Large circles denote node's interference range. Node 0 is the source, 6 is the destination.

These packets are eventually dropped at the two subsequent nodes. In the shared channel environment of multi-hop ad hoc network, intra-flow contention is widespread and result in collision and congestion at some nodes. This not only greatly decreases the end-to-end throughput but also increase the probability of link failure during data transmission in network layer. Here the total hop count parameter is transmitted from network layer to MAC layer (Category 2) which is used to recalculate the contention window of the nodes along the routing path. This approach avoids collision in the MAC layer and results in getting better performances of data transmission in the network layer.

B. Implementation of AODV-SPF:

The AODV-SPF includes two major mechanisms. The first one is to assign a higher probability of channel access to the downstream node. This could achieve optimum packet scheduling for chain topology and avoid severe intra-flow contentions in each flow. The second one is to limit the data/fragment outgoing rate of source node in MANET, not to allow the source node to occupy the whole outgoing queue and bandwidth. This could efficiently prevent the irresponsible applications from injecting more packets than the network could handle, and leave more queue space and bandwidth for other flows passing through network, which further alleviates the unfairness problem between moderate and greedy source flows. One way to prevent the first node on the path from injecting more packets than what the succeeding nodes can forward is to assign the lowest channel access probability to source node and higher channel access probability to intermediate nodes along the downstream path. This can achieve optimum scheduling for one-way traffic in the regular chain topology.

Extensive simulations verify that compared to IEEE 802.11 DCF, this scheme, AODV -SPF, in most of the cases could achieve better performance metrics of data transmission in network layer, e.g., stable and higher throughput, packet delivery ratio, lower normalized routing load, decreasing the number of control messages such as Route Request and Route Error.

A mobile station that experiences bad channel tends to transmit at a low rate in order to decrease the bit error rate (BER). In [8], a cooperative MAC protocol is used to improve the performance of the routing protocol (DSDV) in the network layer. In the cooperative MAC protocol, a station would use a neighboring helper station for MAC layer forwarding, if the two-hop relaying yields to a better performance than a direct single-hop transmission. A cross-layer approach is followed here where the DSDV routing protocol finds a multi-hop path from the source to destination while the cooperative MAC scheme, eventually selects two-hop forwarding for each routing layer hop (category 3), to boost the performance of the routing protocol.

C. Implementation of Cooperative Routing MAC protocol:

Every station maintains information about its candidate helpers in a table called *CoopTable*. Corresponding to a particular helper station, each row in the *CoopTable* stores the MAC address of the helper and the transmission rates that this helper could provide for the two hop transmission (i.e., from the transmitter to the helper, and from the helper to the intended destination).

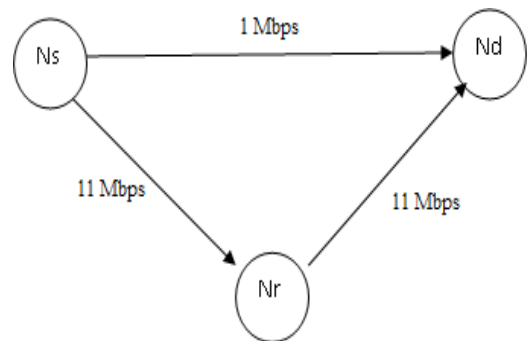


Figure 3: Represents a simple network consisting of a source node (N_s), a destination node (N_d), and a helper node (N_r).

In a real environment, every station could be considered as a candidate helper by its neighboring stations. The authors have implemented a broadcasting scheme using a *hello* packet in each station. The *hello* packet is generated directly by the MAC layer and is broadcasted on a periodic basis, and it indicates the sustainable rates between the particular station and its neighbors. A mobile station updates its *CoopTable* based upon the received *Hello* messages, in order to be aware of candidate helpers, and revokes timely an enlisted helper once the helper becomes inactive.

The extensibility of the cooperative MAC protocol into multi-hop ad-hoc networks, where in conjunction with the routing protocol can achieve superior performance, compared to the legacy 802.11g.

Due to the highly complicated nature of medium access control (MAC) layer in wireless networks, MAC protocol has been implemented as software. This is different from a wired network situation where MAC is implemented in hardware. Due to the software implementation of MAC protocol, the traditional routing structure in multi-hop wireless ad hoc networks results in long processing delays for forwarding packets in every intermediate/relay node. The authors in [9]

propose a solution to alleviate this issue based on cross-layer MAC design, which improves the coordination between MAC and routing layers using an idea called "virtual link". Experimental results show that the proposed cross-layer design significantly improves the performance in terms of reduced round trip time(RTT), reduced processing time in the intermediate relay/forwarding nodes and increased throughput compared to a legacy architecture.

D. Implementation of cross layer MAC enabling Virtual Link:

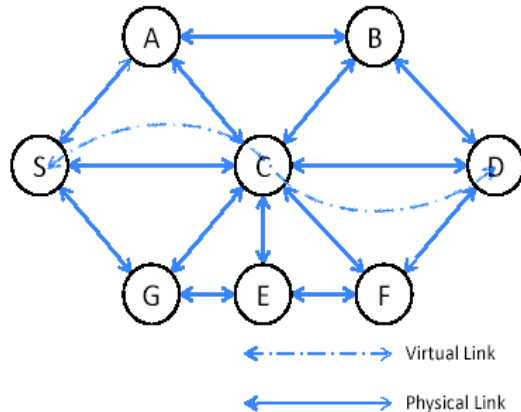


Figure 4: A multi-hop ad-hoc network example

In the proposed cross-layer MAC architecture, the authors introduce two extra modules: *Inbound Monitor* module and *Self-Learning* module. The steps for creating a virtual link are then as follows. When the wireless MAC starts to run in a node, its IP address is noted and the Inbound Monitor also starts to run. The Inbound Monitor of this node checks for the destination IP address on each frame. If the destination IP is equal to its own IP address, this is treated as a normal frame. Otherwise, the Inbound Monitor will look up the corresponding virtual link entry for this frame. If a suitable virtual link is located successfully, this frame will be re-encapsulated according to this virtual link entry and sent to the physical layer immediately for relay/forwarding purpose.

If no corresponding virtual link is found, the self-learning module will be triggered. From now on, this monitor module will work on the outbound direction of the IEEE 802.11 MAC. After routing layer re-encapsulates the frame, which triggers the self-learning module, this frame will be shown again on the outbound direction. The self-learning module will create a suitable virtual link according to the new MAC header of this frame. When other data frames arrive at this node, the Inbound Monitor will re-encapsulate the MAC header according to corresponding Virtual Link entry.

The tests performed clearly demonstrate that cross-layer MAC design employing the proposed virtual link concept reduces the processing time at the intermediate nodes approximately by 50% while the throughput increases by 7–10% when compared with the legacy routing algorithm.

LEss remaining hop More Opportunity (LEMO) algorithm was proposed to improve the packet delivery ratio and fairness among flows for multi-hop ad hoc networks through cross-layer interaction between MAC and the routing layer. The

routing information about the total hops and the remaining hops required by a packet to reach its destination is exploited by the MAC layer (Category 2) in order to give priority to the packets that are closer to their destination. Reference [10] compares the performance of LEMO algorithm by using DSR and AODV protocols at the routing layer and varying the mobility and the load conditions. With the help of performance metrics like packet delivery ratio, average end-to-end delay and normalized routing load, it is shown that cross-layering between DSR and IEEE 802.11 DCF performs better than cross-layering between AODV and IEEE 802.11 DCF.

E. Implementation of LAODV and LDSR:

LAODV algorithm is implemented by applying cross-layered approach between AODV protocol at the routing layer and IEEE 802.11 DCF at the MAC layer. In order to achieve this, the information about the total number of hops between the source and the destination nodes, and the number of remaining hops from the forwarding node is collected from the routing layer and is sent to the MAC layer. The IEEE 802.11 DCF used at the MAC layer is modified to process the received information from the routing layer and change the value of CW_{min} accordingly. LDSR algorithm is implemented in a similar manner by using DSR as the routing layer protocol instead of AODV.

It is concluded from the simulation results that LAODV and LDSR have better packet delivery ratio. Both have shown significant improvement in performance in terms of average end-to-end delay and normalized routing load. Cross layering between DSR and IEEE 802.11 DCF has shown better results than cross-layering between AODV and IEEE 802.11 DCF. LDSR has shown an increase in packet delivery ratio up to 2% whereas with LAODV marginal increase can be seen.

In [11], the authors propose a novel Cross-layer Synchronous Dynamic Token Protocol (CLSDTP) in single channel that is based on token-passing scheme (Category 4). The protocol introduces a token relay algorithm which is fast and adaptive to topology variation, presents a collision avoidance algorithm which solves the exposed and hidden terminal problem. The CLSDTP improves the spatial multiplexing compared with the RTS/CTS access mechanism. The results of the simulation show that CLSDTP can significantly improve the system performance.

F. Implementation of CLSDTP:

In CLSDTP, the Time Slot is defined as the time need to send a token and a data packet. Every node synchronizes with each other through monitoring messages transferred by its neighbors. A node begins to transfer token at the time T_0 , send data packet at the time T_1 . Node sends one data packet in one time slot. If a node hears a token transferred by its neighbor, it will realize it is the beginning of a slot. If a node hears a data packet sent by its neighbor, it will realize it is the time T_1 of a slot. There should be no worry about the timeslot synchronization because the Time Slot is long and the guard interval. Same as WDTP, each node should maintain a token passing queue (TPQ) to record its neighbor nodes. The nodes not holding the token listen to the channel. If they find a node processed the token transfer, they push the node to the rear of

their TPQs. The node holding the token transfers the token to the front node in its TPQ. Successful token transmission relies on implicit acknowledgment which is the successor's token transmission. A node will consider that the connection with its successor is broken, if the successor does not transfer token in the beginning of the next timeslot, which indicates that the transfer was unsuccessful. It should delete the node from its TPQ and transfer the token again to the new front node of its TPQ.

The most important feature of CLSDTP is the sharing of net information by MAC and routing layer, which reduces the system overhead significantly. The protocol inherits the advantage of the token passing scheme under which the probability of collision is very low, which effects the performance of network dramatically. The results of Spatial-multiplexing analysis and the simulation demonstrate that CLSDTP outperforms 802.11 RTS/CTS-AODV protocol in terms of system throughput and delay.

A novel cross-layer efficient routing protocol (CLERP) is presented in [12]. CLERP adopts cross-layer design to establish backup route to reduce the packet losses when link breaks occur. To decrease the unnecessary overhead of hello packets, adaptive links connectivity is employed to improve connectivity and coverage when the nodes are far away from the primary route. The simulation results demonstrate that CLERP yields lower route discovery frequency, higher packet delivery fraction, better average end-to-end delay and lower routing load.

G. Implementation of CLERP:

CLERP is presented by sharing the cross-layer cache information while still maintaining separation between the MAC layer 802.11 and the route layer AODV in protocol design. Cross-layer cache is used to enhance the connectivity of the network. Node updates its cross-layer cache if any communication is heard from any neighbor (Category 1). If a node receives any messages from its neighbors, the neighbors' link status is set to active and the timeout is reset to the current time plus active timeout. If active timeout passes without any messages from a neighbor, the neighbor's link status changes to inactive. Once in the inactive state, if there is still no sign of the neighbor during the delete interval, the neighbor is deleted from the cross-layer cache. Cross-layer cache can be used to establish backup route to reduce the packet losses due to link break. The backup routes are established during the RTS/CTS/DATA/ACK exchange procedure. When a node that is not part of the route overhears RTS messages transmitted by a neighbor, it records MAC address of the receiver and the sender of the packet. When the node overhears the CTS messages, it checks if the recorded sender of the RTS is the receiver of the CTS. If it is, the receiver of the RTS is a neighbor and should be inserted in the cross-layer cache. Meanwhile, it records that neighbor as the next hop to the destination in its backup route table. Using this method, backup route can be conducted. When a node detects a link break, it caches the packets transmitted to it and then broadcasts a one hop Route Request (RREQ) to candidate for backup routes. After receiving this RREQ, nodes that have a routing to the destination in their alternate route table, forward the packet to

their next hop node. Data packets therefore can be delivered through one or more alternate routes and are not dropped when link breaks occur. If no backup route can be constructed with the downstream node, an RERR message is propagated toward the source node to initiate a route rediscovery after a timeout value.

Simulation results prove that CLERP increases the packet delivery fraction, reduces the route discovery frequency, average end-to-end delay and normalized routing load.

III. CONCLUSION AND FUTURE RESEARCH

In accordance with the review performed, we propose to combine the strategies followed in more than one literature in the following manner to further improve the performance of the routing protocols in MANETs. 1. AODV-PF and AODV-SPF can be combined with the Cooperative Routing MAC protocol to further improve the performance of routing protocols. 2. AODV-SPF considers only the chain topology. We can focus on how this AODV-SPF can be extended on networks with other topologies and can analyze the results through simulation. 3. To reduce packet processing delay at every node the concept of virtual link can be incorporated along with other strategies for performance improvement of routing protocols. 4. AODV-SPF can be combined with LEMO algorithm to further improve the performance of routing protocols in MANETs. We also suggest modifying the existing approach in the literatures with the new one and analyzing whether it could be possible to bring out the best outcome. 5. In CLSDTP, a token passing scheme is used through which MAC and network layer share net information. This idea of token passing can be combined with AODV-PF to pass information about the weak nodes to network layer. In CLERP, AODV is used at the routing protocol in the network layer. Instead other on-demand routing protocol such as DSR can be used and the results can be analyzed through simulation. Also we plan to introduce more parameters other than the existing parameters and try to analyze the results through simulation.

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Churn Prediction in Telecommunication Using Data Mining Technology

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Abstract—Since its inception, the field of Data Mining and Knowledge Discovery from Databases has been driven by the need to solve practical problems. In this paper an attempt is made to build a decision support system using data mining technology for churn prediction in Telecommunication Company. Telecommunication companies face considerable loss of revenue, because some of the customers who are at risk of leaving a company. Increasing such customers, becoming crucial problem for any telecommunication company. As the size of the organization increases such cases also increases, which makes it difficult to manage, such alarming conditions by a routine information system. Hence, needed is highly sophisticated customized and advanced decision support system. In this paper, process of designing such a decision support system through data mining technique is described. The proposed model is capable of predicting customers churn behavior well in advance.

Keywords- churn prediction, data mining, Decision support system, churn behavior.

I. INTRODUCTION

The biggest revenue leakages in the telecom industry are increasing customers churn behavior. Such customers create an undesired and unnecessary financial burden on the company. This financial burden results in to huge loss of the company and ultimately may lead to sickness of the company, detecting such customers well in advance is an objective of this research paper.

II. DATA MINING IN TELECOMMUNICATION

In telecommunication sector data mining is applied for various purposes. Data mining can be used in following ways:

A. Churn prediction:

Prediction of customers who are at risk of leaving a company is called as churn prediction in telecommunication. The company should focus on such customers and make every effort to retain them. This application is very important because

it is less expensive to retain a customer than acquire a new.

B. Insolvency prediction:

Increasing due bills are becoming crucial problem for any telecommunication company. Because of the high competition in the telecommunication market, companies cannot afford the cost of insolvency. To detect such insolvent customer's data mining technique can be applied. Customers who will refuse to pay their bills can be predicted well in advance with the help of data mining technique.

C. Fraud Detection:

Fraud is very costly activity for the telecommunication industry; therefore companies should try to identify fraudulent users and their usage patterns.

III. CHURN PREDICTION IN TELECOMMUNICATION

Major concern in customer relationship management in telecommunications companies is the ease with which customers can move to a competitor, a process called "churning". Churning is a costly process for the company, as it is much cheaper to retain a customer than to acquire a new one.

The objectives of the application to be presented here were to find out which types of customers of a telecommunications company is likely to churn, and when.

In many areas statistical methods has been applied for churn prediction. But in the last few years the use of data mining techniques for the churn prediction has become very popular in telecom industry. Statistical approaches are often limited in scope and capacity. In response to this need, data mining techniques are being used providing proven decision support system based on advanced techniques.

The BSNL. Satara like other telecom companies suffer from churning customers who use the provided services without paying their dues. It provides many services like the Internet, fax, post and pre-paid mobile phones and fixed phones, the researchers would like to focus only on postpaid phones with respect to churn prediction, which is the purpose of this research work.

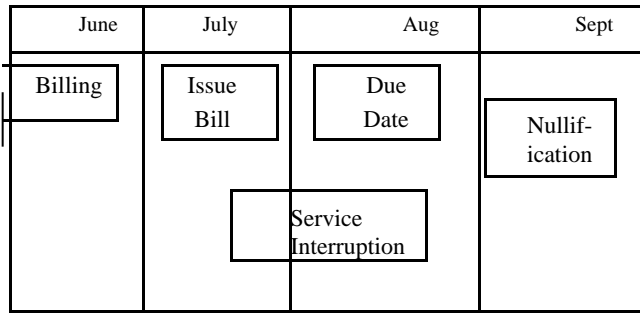


Figure 1

As described in above figure1, customers use their phone for a period of one month, called the billing period. The bill is issued two weeks after the billing period. The due date for the payment is normally two weeks after the date of issue. If a bill is not paid in this period, the company takes action on such a customer's. The company disconnects the phone one way, two week after payment due date for 30 days. That means the customer can only receive incoming calls and can't make outgoing calls during these 30 days.

If the customer pays their bill, connection is reestablished. If the customer doesn't pay in this 30 days period the companies nullify the contract and uncollected amount will be passed to custody. The amount that customer owes is transferred to uncollectible debts and the company considers the money most probably lost. Telecommunication companies face considerable loss of revenue, because some of the customers who are at risk of leaving a company. As one can see the measures that the company takes against churn customers come quite late Predicting such customers well in advance who are at risk of leaving a company. Detection of as many such customers well in advance is the main objective of this research paper.

A. Data collection

Following are the different sources used for collecting the data.

In house customer databases- It has major fields such as phone number, address category, type of security deposit and cancellation.

External sources- Call detail record of every call made by the customer i.e. call no, receiver no., call date, call time and duration of each call. In addition data was identified from billing sections.

Research survey- Data is collected through previous research survey.

In order to make study more precise customers from various categories such as government, businesses and private were included. The following table shows the number of records from various categories were included.

Category	Number of records
Government	35
Business	125
Private	735

Total	895
-------	-----

Table 1: category wise records

B. Data Preparation

Before data can be used for data mining they need to be cleaned and prepared in required format. Initially multiple sources of data is combined under common key. Typical missing values on the call detail records like call_date, call_time, and call_duration was found, it forced to ignore such records in the study. At this stage, two attributes such as late_pay, and extra_charges were eliminated since records in these attributes were not complete even though they were playing significant role in the problem of churn. In order to perform above tasks SQL server were used.

Attribute	Data Type	Description
category_Id	Text	Category id of phone account.
Category	Text	Category of phone account.
Sec_dep	Currency	Security deposit

Table 2: Attributes from customer file

Attribute	Data Type	Description
Late_pay	Number	Count of late pay
Extra_charges	Number	Count of bills with extra charges.

Table 3: Attributes from billing information section

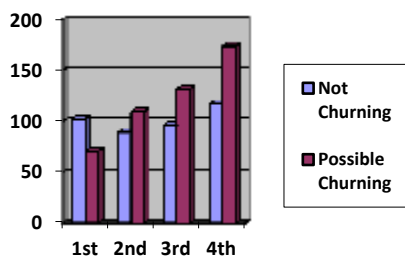
Attribute	Data Type	Description
Max_Units	Currency	Maximum no of units charged in any two week period during the study period.
Min_Units	Currency	Minimum no of units charged in any two week period during the study period.
Max_dur	Number	Maximum total duration for the calls in any two week period during the study period.
Min_dur	Number	Minimum total duration for the calls in any two week period during the study period.
Max_count	Number	Maximum no. of calls in any two week period during the study period.
Min_count	Number	Minimum no. of calls in any two week period during the study period.
Max_dif	Number	Maximum no. of different numbers are called in any two week period during the study period.
Min_dif	Number	Minimum no. of different numbers are called in any two week period during the study period.

Table 4: Attributes from call detail record

C. Defining data mining function

Churn prediction can be viewed as a classification problem, where each customer is classified in one of the two classes such as most possible churning or not. Even though there were many

churning customers reported, it was difficult to get a significant number of them during study period. As a result, the distribution of customers between the two classes was very uneven in the original dataset. Approximately 82.33% were not churning and 17.67% churning customers during research period. Classification problem with such characteristics are difficult to solve. Hence new dataset had to be created especially for the data mining function. For every phone call made by a customer, the data had to be aggregated. Aggregation is done with the aim of creating a customer profile that reflects the customer’s phoning behavior over the last five months. The details of this aggregation process are complex, interesting and important, but cannot be described here due to space limitations. In essence, many aggregated attributes containing the lengths of calls made by every customer in these five months were created.



	1 st week	2 nd week	3 rd week	4 th week
Not Churning	102.5	89.2	96.1	117.2
Possible Churning	71	109.5	131.5	174

Figure 2: Difference between Churning and not churning customers

From the above figure the difference between the not churning and possible churning customers can see clearly. On an average, the not churning customers were using their phone approximately for the same number of times during all periods ranging from 102 to 117. On the contrary, the possible churning customers on the average were using their phone for less number of times for the first few days and then their behavior changed resulting to high number of calls than not churning customers, ranging from 71 to 174.

D. Model Building and Evaluation

The major task to be performed at this stage was creating

and training a decision support system that can discriminate between churning and not churning customers. For the proposed, we had a choice of several data mining tools available, and METALAB was found to be the most suitable for this purpose, because it supports with many algorithms. It has neural network toolbox. The algorithm that is used for this research work is Back propagation algorithm. While building a model whole dataset was divided into three subsets. These subsets were the training set, the validation set, and the test set. The training set is used to train the network. The validation set is used to monitor the error during the training process. The test set is used to compare the performance of the model.

IV. CONCLUSION

This research report is about to predicting customers who are at risk of leaving a company, in telecommunication sector. Using this report company will be able to find such kind of customers. The model can be employed in its present state. With further work, the scope of model can be widened to include insolvency prediction of telecommunication customers.

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Knowledge-Based System's Modeling for Software Process Model Selection

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Abstract—This paper depicts the knowledge-based system named as ESPMS (Expert System for Process Model Selection) through various models. A questionnaire was developed to identify important parameters, which were evaluated through domain experts in about all the universities of Pakistan. No exact system was found, which could guide Software Engineers for selection of a proper model during software development. This paper shows that how various technologies like Fuzzy Logic, Certainty Factors, and Analytical Hierarchy Process (AHP) can be adopted to develop the Expert System. Priorities assignments to critical factors have been shown for decision making in the model selection for a problem domain. This research work will be beneficial to both students and researchers for integrating Soft Computing Techniques and Software Engineering.

Keywords- ESPMS, Expert System, Analytical Hierarchy Process, Certainty Factors, Fuzzy Logic, Decision-Making.

I. INTRODUCTION

This article presents a conceptual framework for selection of an appropriate software process model showing the whole work through various models. The main goal of this research work is to guide the Software Engineer for decision making about selection and evaluation of software process model through implementation of Soft Computing Technology. Expert system named as ESPMS (Expert System for Process Model Selection) was developed using ESTA (Expert System Shell for Text Animation) as a development tool.

A software process defines the approach that is taken as software is engineered. But software engineering also encompasses technologies that populate the process – technical method and automated tools [1]. Professional system developers and the customers they serve share a common goal of building information systems that effectively support business process objectives. In order to ensure that cost-effective, quality systems are developed which address an organization's business needs, developers employ some kind of system development process model to direct the project's lifecycle [2].

Software process is a framework to build high quality software [1]. The most difficult task in software engineering is to select an appropriate software process model, which

completely suits for the particular situation. If a particular software process model is not selected then it will become a bottleneck for the software product; takes more time, higher budget than the estimated one. Mostly software projects fail due to inappropriate modeling. That is why care must be taken during a selection of software process model. As, most of the times domain experts (software engineers) are few in numbers, are much busy and/or not available in time, so such types of systems are much important to novice users.

This research aims to devise a theoretical framework for software process model selection, which will help Knowledge Engineer and Software Engineer in developing high quality, cost-effective software, well in time within the available resources.

II. STUDY DOMAIN

A. Software Engineering and Artificial Intelligence

The integration of matured AI methods and techniques with conventional software engineering remains difficult and poses both implementation problems and conceptual problems [3]. Artificial Intelligence and Software engineering both disciplines have many commonalities. Both deal with modeling real world objects from the real world like business processes, expert knowledge, or process models. Recently several research directions of both disciplines come closer together and are beginning to build new research areas. Some of these research areas are the following; Software Agents play an important role as research objects in Distributed AI (DAI) as well as in agent-oriented software engineering (AOSE). Knowledge-Based Systems (KBS) are being investigated for learning software organizations (LSO) as well as knowledge engineering. Ambient Intelligence (AmI) is a new research area for distributed, non-intrusive, and intelligent software systems both from the direction of how to build these systems as well as how to design the collaboration between ambient systems. Last but not least, Computational Intelligence (CI) plays an important role in research about software analysis or project management as well as knowledge discovery in databases or machine learning [4].

An expert system is a computer program which captures the knowledge of a human expert on a given problem, and uses this knowledge to solve problems in a fashion similar to the expert [5]. Computer programs using Artificial Intelligence (AI) techniques to assist people in solving difficult problems involving knowledge, heuristics, and decision-making are called expert systems, intelligent systems, or smart systems [6]. Software development process is a very complex process that, at present, is primarily a human activity. Programming, in software development, requires the use of different types of knowledge: about the problem domain and the programming domain. It also requires many different steps in combining these types of knowledge into one final solution. One of my key observations is that expert programmers rely heavily on a large body of standard implementation methods and program forms [7]. Software Engineering is a highly dynamic field in terms of research and knowledge, and it depends heavily upon the experience of experts for the development and advancement of its methods, tools, and techniques [4]. Learning is based on knowledge and experiences related to the different processes, products, tools, techniques and methods applied to the software development process. The overall objective of a Learning Software Organization (LSO) is to improve software processes and products according to the strategic goals of the organization [8]. Literature study reveals that there is a great intersection between Software Engineering and Artificial Intelligence. The knowledge of experts of related fields can be captured, elicited and copied into computer to work just like commitment to users.

B. Background and Related Work

Literature study shows that research has been taken on different aspects of software process models but there is no standard criteria being developed for evaluation and selection of software process model. To select an appropriate software process model, which completely suits for a particular situation is very difficult task as much of the problems as well as process models cannot be separated among each other due to their mixed characteristics. Process modeling is a rather young and very active research area during the last few years, new languages and methods have been proposed to describe software processes [9]. Lonchamp [10] focused some framework conceptual issues and terminology of process, such as; framework for Process, Process Models, Meta-process, and process centered software engineering environment. Yu & Mylopoulos, [11] presents a model which captures the intentional structure of a software process and its embedding organization. The model is embedded in the conceptual modeling language Tools. The expert systems could advise the domain engineer in programming without the detailed experience in programming languages, Integrate with the help of deductive database and domain knowledge, the previously developed software components to new complex functionalities [12]. Canfora [13] describe the results and lessons learned in the application of the Framework for the Modeling and Measurement of Software Processes in a software company dedicated to the development and maintenance of software for information systems. LSO is an organization that learns within the domain of software development, evolution and application

[8]. Modeling concept is well accepted in software engineering discipline. However, there is still a lacking integration of software process modeling and software process measurement by software engineers. This paper aims to portray the idea and result of integrating measurement in software process modeling [14]. Kim & Gil [15] propose a complementary approach, KANAL (Knowledge Analysis) which helps users and check process models. Liao et al, [16] described an ontology-based approach to express software processes at the conceptual level. Software process is viewed as an important factor to deliver high quality products. Although there have been several Software Process Models proposed, the software processes are still short of formal descriptions.

Literature study reveals, the integration of matured AI methods and techniques with conventional software engineering remains difficult and poses both implementation problems and conceptual problems [3]. Lonchamp [10] focused some framework conceptual issues and terminology of process. Raza [7] stated software development problems includes conceptual specifying, designing, testing the conceptual construct and representation problems that comprising representing software and testing the reliability of a representation. A basic problem of software engineering is the long delay between the requirements specification and the delivery of a product. This long development cycle causes requirements to change before product arrival. Canfora [13] described, modeling and measurement are two key factors to promote continuous process improvement. Turban [17] stated expert system may contain components of knowledge acquisition subsystem, knowledge base, inference engine, user interface, explanation subsystem, and knowledge refinement system. Awad [18] described four components of AI systems: a knowledge base, an inference engine, justifier/scheduler, and user interface. Durkin [5] stated that Expert systems solve problems using a process which is very similar to the methods used by the human expert. Knowledge base, working memory, inference engine, and Explanation Facility are the components of Expert System.

Knowledge base is core component of expert system in AI. Durkin [5] described, the knowledge base contains specialized knowledge on a given subject that makes the human a true expert on the subject. This knowledge is obtained from the human expert and encoded in the knowledge base using one of several knowledge representation techniques. One of the most common techniques used today for representing the knowledge in an expert system is rules. Turban [17] described a system which emulates human intelligence in system by capturing knowledge and expertise from knowledge sources is known as artificial intelligent system. Hence it is the need of the day to develop a Knowledge base System to work just like a consultant for Software Engineers for selection of a proper process model for software development.

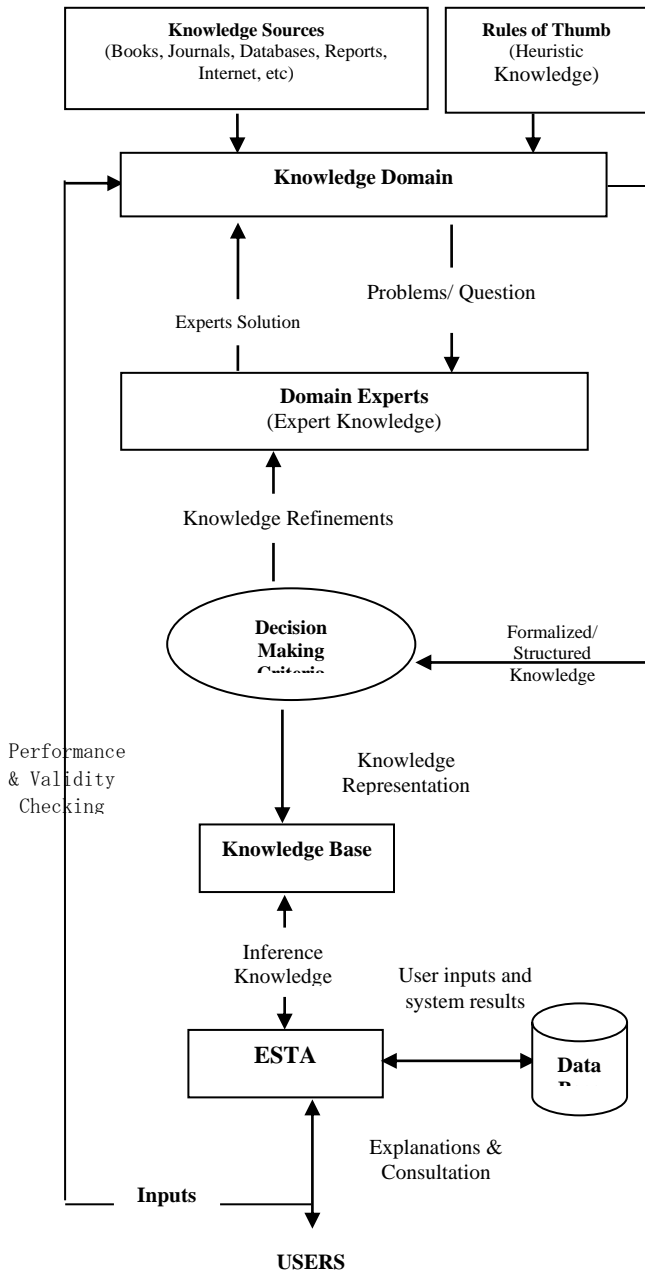
III. PROBLEM MODELING

In this research work critical factors were identified to select a process model for a specific problem through a questionnaire, which were verified by domain experts and were analyzed using SPSS. These factors were assigned weights using AHP. Decision making process in the proposed research

work has been shown through various models and tables. Following paragraphs describes various models to depict the problem domain:

A. Conceptual Modeling of Prototype ESPMS

This model depicts the whole process of knowledge acquisition through decision making using ESPMS. See Fig 1.



(Novice Software Engineers and Designer)

Figure 1. Conceptual Model of the ESPMS

B. Decision Making Model

The questionnaire (i.e. knowledge acquisition tool) was sent to about 100 domain experts of 124 universities (both public and private) in the country. Expert opinions were analyzed through using SPSS and weights of the critical factors were known. The analysis resulted that project team, project type & risk management, and Validation & verification were on the top among the parameters [19]. See Figure 2 and Appendix-I for detail.

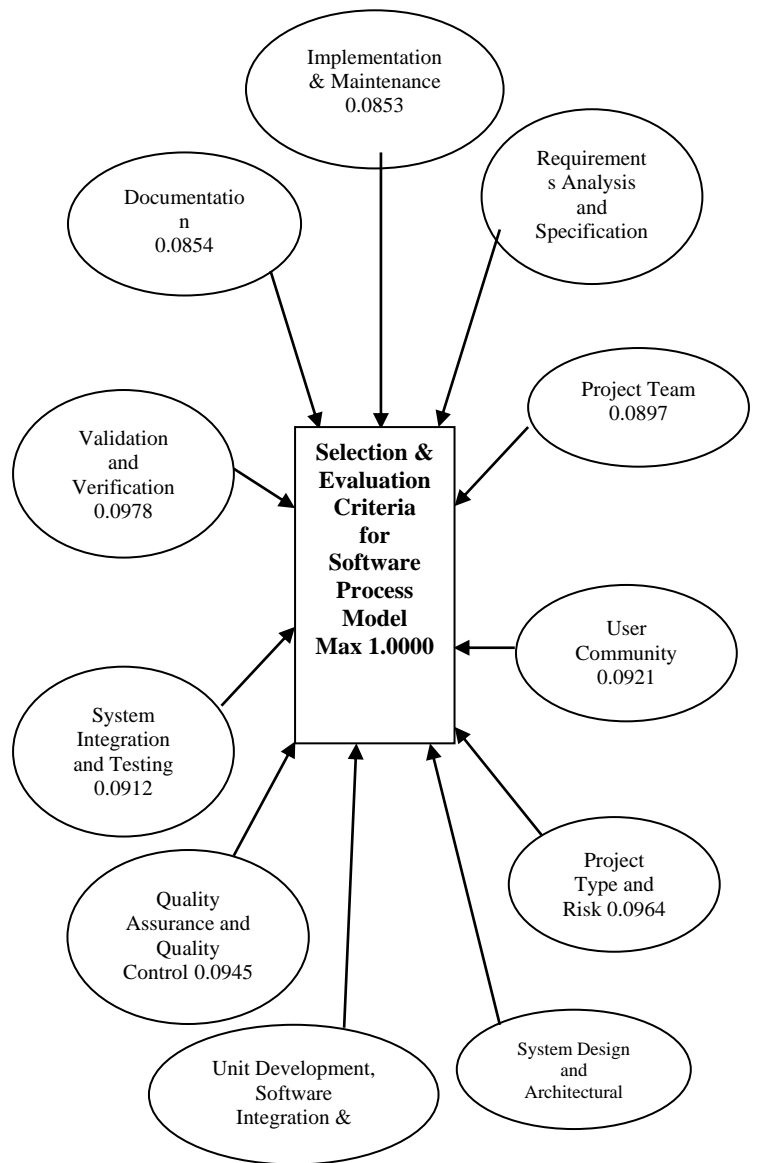


Figure 2. Decision Making by Priorities Assignments to Parameters

C. Expert System Model

Expert System model represents how the Expert System will be developed. Expert Systems are developed either through using expert system languages (i.e. PROLOG, LISP etc) or through using expert system shells (i.e. ESTA, EXSYS

etc). We adopted ESTA (Expert System for Text Animation) as development tool for expert system development [20].

ESTA was combined with the knowledge-base to develop the ESPMS, shown as below:

$$ESPMS = ESTA + Knowledge Base$$

D. Dialogue Mechanism of ESPMS

ESTA has a special DDE (Dynamic Data Exchange) component, which can share knowledge with the external environment (i.e. other software and databases). Figure 4 represents how Expert System exchanges information with its environment.

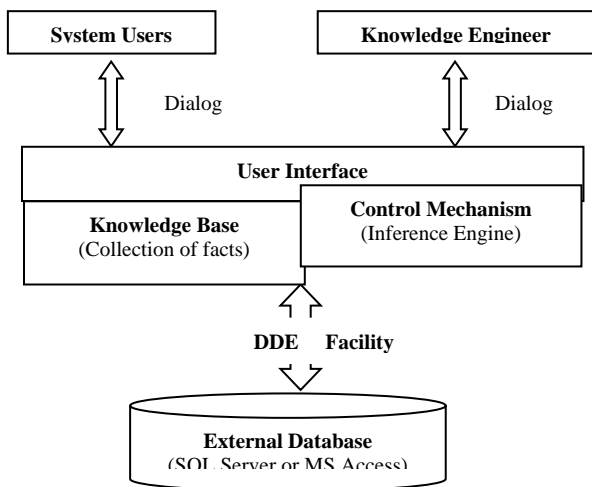


Figure 3: ESTA Dialogue Mechanism of Expert System

E. Production Rules

Rules represent the major elements of a modular knowledge representation scheme, especially when using shells. Rules are conditional statements that are easy to understand and write; they specify an action to be taken if a certain condition is true. They also express relationship between parameters or variables. In expert systems vocabulary, production rules are also called premise-action, cause-effect, hypothesis-action, condition-action, IF... THEN, or IF THEN ELSE, [18].

The basic idea of using rules is to represent the expert’s knowledge in the form of premise-action pairs as follows:

Syntax: IF (premise) THEN (action)

e.g. IF X < 0.20 THEN “Prototype Process Model”

The above example shows that if the value of “X” is less than “0.20” then “Prototype Process Model” will be selected.

F. Symbolic Modeling

For proposed intelligent framework, analytical hierarchy process (AHP) has been used for decision making process in selection and evaluation factors in the software process model. The AHP is a structured technique for handling with complex decision problem, developed by Thomas L. Saaty in 1970s, which is based on Mathematics & Psychology. It provides a framework for solving decision problem and quantifying its

elements, for overall goals; also evaluating possible alternative solutions [21].

AHP was used to prioritize the decision making parameters in different levels. The weights of individual factors (i.e. levels) were summed up to level 2 and the weights of level 2 were summed up to get the value of level 1. See Appendix-I for detail.

Maximum weight is 1 and therefore the weight of main goal is 1.000, which is the sum of all the factors weights. To achieve the main goal, first of all we sum up the weights of sub items which become the weight of their groups’ parameter, and at the end sum of the weight of groups’ parameters become the weight of the goal. The level wise weight assignments to main groups & sub-criteria elements are shown in Appendix-I. To calculate the score of sub-hierarchy the following formula is used.

The following mathematical model evaluates the final value of the objective function. The weight of concerned parameter is multiplied with its assigned weight and summed up together. See equation (1) through equation (4).

$$Kq = \sum_{q=1}^n C_q \times W_q \dots\dots\dots (1)$$

Where
Kq = qth main criteria.
n = number of sub-criteria in the qth Criteria.
C_q = Fuzzy value of qth parameter
W_q = Weight of the relative parameter.

To calculate the overall score of the decision hierarchy, the equation is re-defined as:

$$Total Score = K_1 + K_2 + K_3 + \dots + K_{11} \dots (2)$$

It implies that:

$$Total Score = \sum_{i=1}^{11} Ki \dots\dots\dots (3)$$

Where,
Wi= Expert weight of the ith main criteria.
Ki= Calculation obtained from equation (1) or value of main criteria obtained through equation (1).

From equation (1) and (3), we derived equation (4) as below:

$$Total Score = \sum_{i=1}^{11} (\sum_{q=1}^n Cq \times Wq) \dots\dots\dots (4)$$

Process’s evaluation score could not be achieved efficiently through using yes/no, i.e. 1 or 0; as the values of parameters are qualitative in nature. For these qualitative parameters we use fuzzy logic. Zadeh [22] used fuzzy logic to measure the continuous values.

Since, through out in the decision making process parameters’ weight assigned from experts’ opinion is constant, final decision ranking score computed from the overall decision

hierarchy is varied due to the input parameters values entered by users. The value of parameters, might be 0 or 1 [22], if a special parameter is present then the parameter weight is multiplied by 1, else by 0 if not present.

According to Zadeh [22, 24] variables words or sentences as their values is called linguistics variables and the variables that represents the gradual transition from high to low, true to false is called fuzzy variables and a set containing these variables is the fuzzy set. Their degree of membership is [1, 0], where '1' represents highest membership and '0' represents no membership.

We defined a fuzzy variable set for conceptual framework model as:

Fuzzy Set = {Extremely Strong, Strong, Moderate, Weak, Extremely Weak}

Their fuzzy membership values are as: Fuzzy membership value = {1.0, 0.75, 0.5, 0.25, 0}

Table I depicts the fuzzy variables with respective degree of membership value. In the following table, from top to bottom a gradual transition is represented from extremely strong to extremely weak in the fuzzy variables and the respective degree of membership values.

TABLE I. PARAMETERS OF FUZZY VALUES

Fuzzy variable	Degree of Membership
Extremely Strong	1.0
Strong	0.75
Moderate	0.50
Weak	0.25
Extremely Weak	0

These fuzzy values are input parameters' values provided by the users during consultation and the final ranking score of a particular process's evaluation is calculated by the system at run time, but here an example of computation in the decision making score is depicted. If qualitative value of a parameter is extremely strong, then related numeric value 1.0 will be multiplied with parameter's weight.

Let, suppose a parameter risk analysis is assigned a weight 0.046 by experts then the fuzzy decision score can be calculated as shown in the Table II.

The overall weights of all the parameters are calculated by Equation (4), and the resultant score will be the final score for decision making.

Decision score calculated by linguistic mapping, which is the output of the intelligent system and also description for a selection of software process model ranking is depicted in the Table III.

IV. CONCLUSION

This research is promising to solve the problems associated with the existing approach to intelligent framework modeling. These models will become a base for selection of an

appropriate process model for Expert systems development (i.e. **ESPMS**). Neither there exist any strict rules to be followed to select a software process model nor any consultative system to guide novice user. This an attempt to integrate various technologies, like Expert Systems, AHP, Fuzzy Logic and Decision Making to solve real world problems.

TABLE II. FUZZY SCORE CALCULATION

Parameter's fuzzy value	Membership value	* Parameter's weight	Fuzzy score
Extremely Strong	1.0	0.046	0.046
Strong	0.75	0.046	0.034
Moderate	0.5	0.046	0.023
Weak	0.25	0.046	0.011
Extremely Weak	0	0.046	0

TABLE III. LINGUISTIC DESCRIPTION OF PROPOSED SYSTEM WITH OUTPUT (X)

System Output	Linguistic Description
$X < 0.20$	Prototyping Process Model
$0.20 \leq X \leq 0.40$	RAD Process model
$0.40 \leq X \leq 0.60$	Evolutionary Process Models (Incremental, Spiral, Win-Win Spiral & Concurrent Development Model)
$0.60 \leq X \leq 0.80$	Waterfall Process Model
$X \geq 0.80$	Component-Based Development

V. FUTURE SCOPE

Following the decision issues and the accompany models presented in this paper, a prototype ESPMS can easily be developed. This prototype ESPMS can be linked with external database and other software to develop a full-fledge Expert System for final decision making in selection of a process model for a particular software project. This work may become a base for solving other similar problems.

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Modelling & Designing Land Record Information System Using Unified Modelling Language

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Abstract - Automation of Land Records is one of the most important initiatives undertaken by the revenue department to facilitate the landowners of the state of Punjab. A number of such initiatives have been taken in different States of the country. Recently, there has been a growing tendency to adopt UML (Unified Modeling Language) for different modeling needs and domains, and is widely used for designing and modelling Information systems. UML diagramming practices have been applied for designing and modeling the land record information system so as to improve technical accuracy and understanding in requirements related with this information system. We have applied a subset of UML diagrams for modeling the land record information system. The case study of Punjab state has been taken up for modelling the current scenario of land record information system in the state. Unified Modeling Language (UML) has been used as the specification technique. This paper proposes a refined software development process combined with modeled process of UML and presents the comparison study of the various tools used with UML.

Keywords - Information system, Unified Modeling Language (UML), software modelling, software development process, UML tools.

I. INTRODUCTION

Computerization of Land Records is one of the most important initiatives undertaken by the Revenue Department to facilitate the landowners of the State. A number of such initiatives have been taken in different States of India. The paper proposes a UML based approach, where non-functional requirements are defined as reusable aspects to design and analysis. UML offers vocabulary and rules for communication and focus on conceptual and physical representations of a system. UML uses an object oriented approach to model systems which unifies data and functions (methods) into software components called objects. Various diagrams are used to show objects and their relationships as well as objects and their responsibilities (behaviors). UML is Standard for object-oriented modeling notations endorsed by the Object Management Group (OMG), an industrial consortium on object technologies. UML has become a standard after combining and taking advantage of a number of object oriented design methodologies (Kobryn, 1999) and is currently posed as a modeling language instead of a design

process.

A. Process of Data Digitisation

The automation of the projects related with information systems is underway in many Govt. sectors. With the use of the funds, 153 Fard kendras will be established in the Tehsils of the State to provide certified copies of the Revenue Records to the general public. Some farad centres have been already opened in few tehsils and sub-tehsils, for to be used by public. The land records (Jamabandi etc.), generally are updated after every 5 years. The legacy land records to be digitized are: Jamabandi, Mutation, Roznamcha Waqiyati, Khasra Girdawari and Field Book. Lack of faith and undefined procedures regarding services being provided to the citizens. This implementation of changing the paper record into digital records will lead to facilitation of the farmers, maintaining better transparency of the revenue records, lead to drastic reduction of fraudulent practices, level of corruption and procedural hassles relating to the management of the land records, will lead to reduction in time delay and will also work as a faith building measure, providing service to citizens.

II. UNIFIED MODELLING LANGUAGE

UML (Unified Modelling Language) is a complete language for capturing knowledge(semantics) about a subject and expressing knowledge(syntax) regarding the subject for the purpose of communication. It applies to modeling and systems. Modeling involves a focus on understanding a subject (system) and being able to communicate in this knowledge. It is the result of unifying the information systems and technology industry's best engineering practices (principals, techniques, methods and tools). It is used for both database and software modeling. UML attempts to combine the best of the best from: Data Modeling concepts (Entity Relationship Diagrams), Business Modeling (work flow), Object Modeling and Component Modeling. UML is defined as: "UML is a graphical language for visualizing, specifying, constructing, and documenting the artifacts of a software intensive system" [Booch]. Software architecture is an area of software engineering directed at developing large, complex applications in a manner that reduces development costs, increases the quality and facilitates evolution[8]. A central and critical problem software architects face is

how to efficiently design and analyze software architecture to meet non-functional requirements. UML offers vocabulary and rules for communication and focus on conceptual and physical representations of a system.

The various structural things in UML are Class, Interface, Collaboration, Use-case, behavioral things comprise of Interaction, State machine, Grouping things comprise of packages and notes.

a) Things: important modeling concepts.

b) Relationships: tying individual things (i.e., their concepts).

c) Diagrams: grouping interrelated collections of things and relationships.

The artifacts included in standard UML consist of: Use case diagram, Class diagram, Collaboration diagram, Sequence diagram, State diagram, Activity diagram, Component diagram and Deployment diagram (OMG, 1999). There are different ways of using UML in terms of design methodologies to accomplish different project objectives.

III. SYSTEM ANALYSIS & DESIGN

Unified Modeling Language (UML) is used as a specification technique for the system analysis and design process involved in the software development life cycle.

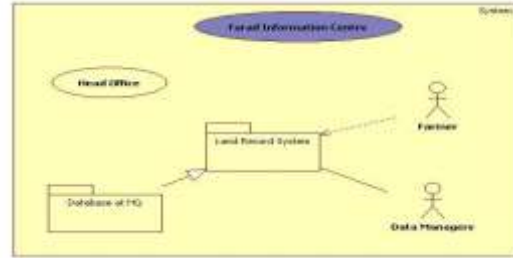
A. Modelling & Designing Using UML

1) Case Scenario : Land Record Information System

UML is built upon the MOF™ metamodel for OO modeling. A modeling method comprises a language and also a procedure for using the language to construct models, which in this case is Unified Modeling Language (UML). Modeling is the only way to visualize one's design and check it against requirements before developers start to code. The land record information system is modeled using use-case, sequence, class, and component diagrams offered by the Unified Modeling Language.

a) *Use-Case Diagram*: Use case diagrams describe what a system does from the standpoint of an external observer [17]. Use Case Diagrams describe the functionality of a system and users of the system. And contain the following elements:

- Actors, which represent users of a system, including human users and other systems.
- Use Cases, which represent functionality or services provided by a system to users.



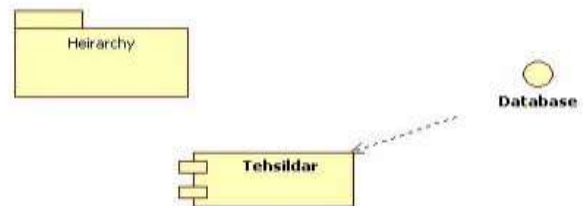
{ *as modeled in StarUML }

b) *Class Diagrams & Object Diagrams*: Being the most important entity in modeling object-oriented software systems, it is used to depict the classes and the static relationships among them [3]. Class Diagrams describe the static structure of a system, or how it is structured rather than how it behaves. These diagrams contain the following elements:

- Classes, which represent entities with common characteristics or features. These features include attributes, operations and associations.
- Associations, which represent relationships that relate two or more other classes where the relationships have common characteristics or features.

c) *Object Diagrams*: describe the static structure of a system at a particular time. Whereas a class model describes all possible situations, an object model describes a particular situation. Object diagrams contain the following elements:

- Objects, which represent particular entities. These are instances of classes.
- Links, which represent particular relationships between objects. These are instances of associations.



{ *as modeled in StarUML }

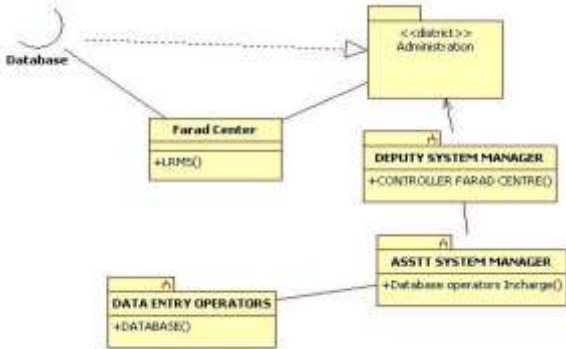
d) *Collaboration Diagrams & Component Diagrams*: Component diagram is one of UML's architectural diagrams used to effectively describe complex architectures as a hierarchy of components (subsystems) communicating through defined interfaces [6]. Collaboration Diagrams describe interactions among classes and associations. These interactions are modeled as exchanges of messages between classes through their associations. Collaboration diagrams are a type of interaction diagram. Collaboration diagrams contain the following elements:

i) Class roles, which represent roles that objects

may play within the interaction.

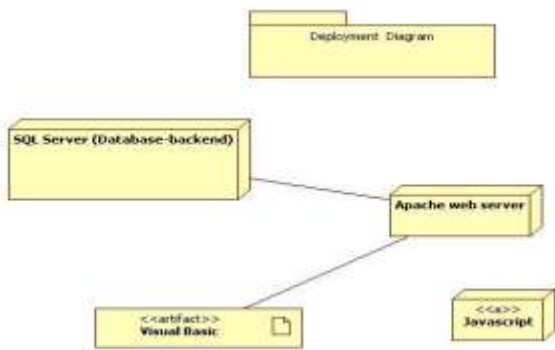
ii) Association roles, which represent roles that links may play within the interaction.

iii) Message flows, which represent messages sent between objects via links. Links transport or implement the delivery of the message.



{*as modeled in StarUML }

e) *Deployment Diagrams* : Deployment diagrams describe the configuration of processing resource elements and the mapping of software implementation components onto them. These diagrams contain components and nodes, which represent processing or computational resources, including computers, printers, etc. Each cube icon is known as a node representing a physical system. All the system requirements are shown in the architecture which is used for the land record information system. All the modules of the information system have been developed using Visual Basic with SqlServer at the backend. The web components are hosted on Apache web server and use Java Servlets. The modeled components* are shown in the deployment diagram.



{*as modeled in StarUML }

IV. MODELLING TOOLS USED IN UML

The various types of tools used for modelling in Unified

Modeling Language(UML) are:

a) Modeling Tools : Rational Rose, ArgoUML, Together,

Umbrello

b) Drawing Tools : Visio, Dia

c) Metamodels: Eclipse UML2, NSUML, OMF

d) Renderers: Graphviz, UMLDoc

e) IDEs: Visual Studio 2005, XCode 2,

Rational XDE

A. Comparison of UML Tools

The Unified Modelling Language(UML) tools used for modeling the design of various information systems are compared by taking some vital parameters which distinguish each one of them; giving fairly the advantage of one tool over the other.

TABLE I. COMPARISON OF UML TOOLS

Tools	Strength/Stability	Cost	Additional Features	Current Status
Rational Rose	Full-strength modeling suite	expensive	Office for UML, add-ons, plug-ins, scripting interface, plug-in to MS Visual Studio and Eclipse	Re-developed Rational XDE
Together	Supports most UML diagrams	Mid-range cost	Can reverse engineer with C++,Java • Generate source code for C++, Java	Exports to PNG
ArgoUML	Open source UML modeling application written in Java	Free to download	Supports most diagram types, reverse engineering and code generation for Java	Forked into commercial product Poseidon
Umbrello	Open source modeling application for KDE, written in C++	Free to download	Supports data modeling for SQL, reverse engineering and code generation	Under development
MS Visio	Fairly compliant with UML metamodel	Not interoperable	used for creating 2D schematics and diagrams	

Dia	Open source graphics drawing Program form GNOME	Free	Supports the creation of some UML diagram types	Used frequently by open Source developers
Graphviz and UMLDoc	AT&T Graphviz graph specification input, generates PNG, PDF layouts of graphs UMLDoc - parses Java comments to produce diagrams	mid-range	generates PNG, PDF layouts of graphs Actually uses graphviz to create diagrams	
MS-Visual Studio	Supports UML-like diagrams for .NET languages (i.e., C#)	New part in VS 2005	Provides support for roundtrip engineering,	New part in VS 2005
XCode2	Claims support for C, C++, and Java		Provides UML-like class diagrams for Objective-C, Can be used for roundtrip engineering	Provides UML-like class diagrams for Objective-C
Rational XDE	Visual modeling suite for UML	Costly	Plugs in to many different IDE's (Visual Studio .NET, Eclipse, IBM WebSphere), Supports roundtrip engineering	Provides Rational Rose

V. UML IN INFORMATION SYSTEMS: ITS APPLICATIONS

- Any type of application, running on any type and combination of hardware, operating system, programming language, and network can be modeled in UML.
- UML Profiles (that is, subsets of UML tailored for specific purposes) help to model Transactional, Real-time, and Fault-Tolerant systems in a natural way.
- UML is effective or modeling large, complex software systems.
- It is simple to learn for most developers, but provides advanced features for expert analysts, designers and architects.

- It can specify systems in an implementation-independent manner.
- Structural modeling specifies a skeleton that can be refined and extended with additional structure and behavior.
- Use case modeling specifies the functional requirements of system in an object-oriented manner. Existing source code can be analyzed and can be reverse-engineered into a set of UML diagrams.
- UML is currently used for applications other than drawing designs in the fields of Forward engineering, Reverse engineering, Roundtrip engineering and Model-Driven Architecture (MDA). A number of tools on the market generate Test and Verification Suites from UML models.

VI. CONCLUSION & FUTURE SCOPE

UML tools provide support for working with the UML language for the development of various types of information systems. From the paper, it is concluded that each UML tool is having its own functionality and can be used, according to the need of the software development cycle for the development of information systems. The three different views of using UML are: Documenting design up front, maintaining design documentation after the fact and generating refinements or source code from models. This paper has concluded with the aspect that information system can be modeled using UML due to its flexibility and inherent nature & the tools tend to add to its ever-increasing demand for the use of development of information systems. UML can still further be considered as part of mobile development strategy and further planning can also be done to conceive the unified modeling principles for later stages of enhancement of land record information system.

Future work that could be pursued includes applying the software process to large scale m-commerce application systems and generating the model diagrams with UML, for them to be made specially tailored for the software development process; providing backbone to the analysis and design phases associated in the SDLC.

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An Algorithm to Reduce the Time Complexity of Earliest Deadline First Scheduling Algorithm in Real-Time System

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Abstract—To this paper we have study to Reduce the time Complexity of Earliest Deadline First (EDF), a global scheduling scheme for Earliest Deadline First in Real Time System tasks on a Multiprocessors system. Several admission control algorithms for earliest deadline first are presented, both for hard and soft real-time tasks. The average performance of these admission control algorithms is compared with the performance of known partitioning schemes. We have applied some modification to the global earliest deadline first algorithms to decrease the number of task migration and also to add predictability to its behavior. The Aim of this work is to provide a sensitivity analysis for task deadline context of multiprocessor system by using a new approach of EFDF (Earliest Feasible Deadline First) algorithm. In order to decrease the number of migrations we prevent a job from moving one processor to another processor if it is among the m higher priority jobs. Therefore, a job will continue its execution on the same processor if possible (*processor affinity*). The result of these comparisons outlines some situations where one scheme is preferable over the other. Partitioning schemes are better suited for hard real-time systems, while a global scheme is preferable for soft real-time systems.

Keywords- Real-time system; task migration, earliest deadline first, earliest feasible deadline first.

I. INTRODUCTION (HEADING 1)

Real-time systems are those in which its correct operation not only depends on the logical results, but also on the time at which these results are produced. These are high complexity systems that are executed in environments such as: military process control, robotics, avionics systems, distributed systems and multimedia.

Real-time systems use scheduling algorithms to decide an *order of execution* of the tasks and an *amount of time* assigned for each task in the system so that no task (for hard real-time systems) or a minimum number of tasks (for soft real-time systems) misses their deadlines. In order to verify the fulfillment of the temporal constraints, real-time systems use different exact or inexact *schedulability tests*. The schedulability test decides if a given task set can be scheduled such that no tasks in the set miss their deadlines. Exact

schedulability tests usually have high time complexities and may not be adequate for online *admission control* where the system has a large number of tasks or a dynamic workload. In contrast, inexact schedulability tests provide low complexity sufficient schedulability tests.

The first schedulability test known was introduced by Liu and Layland with the Rate Monotonic Scheduling Algorithm [Liu, 1973] (RM). Liu and Layland introduced the concept of *achievable utilization factor* to provide a low complexity test for deciding the schedulability of independent periodic and preemptable task sets executing on one processor.

In Earliest Deadline First scheduling, at every scheduling point the task having the shortest deadline is taken up for scheduling. The basic principle of this algorithm is very intuitive and simple to understand. The schedulability test for EDF is also simple. A task is schedule under EDF, if and only if it satisfies the condition that total processor utilization (U_i) due to the task set is less than 1.

With scheduling periodic processes that have deadlines equal to their periods, EDF has a utilization bound of 100%. Thus, the schedulability test for EDF is:

$$U = \sum_{i=1}^n \frac{C_i}{T_i} \leq 1$$

Where the $\{C_i\}$ are the worst-case computation-times of the n processes and the $\{T_i\}$ are their respective inter-arrival periods (assumed to be equal to the relative deadlines).

The schedulability test introduced by Liu and Layland for RM states that a task set will not miss any deadline if it meets the following condition: $U \leq n(2^{1/n} - 1)$. Liu and Layland provided a schedulability tests that fails to identify many schedulable task sets when the system is heavily overloaded. After the work of Liu and Layland, many researchers have introduced improvements on the schedulability condition for RM for one and multi processors. These improvements include the introduction of additional timing parameters in the schedulability tests and transformations on the task sets. It is a well-known fact that when more timing parameters are

introduced in the schedulability condition better performance can be achieved.

For example let us Consider 3 periodic processes scheduled using *EDF*, the following acceptance test shows that all deadlines will be met.

Table 1: Task Parameters

Process	Execution Time = C	Period = T
P1	1	8
P2	2	5
P3	4	10

The utilization will be:

$$\frac{1}{8} + \frac{2}{5} + \frac{4}{10} = 0.925 = 92.5\%$$

The theoretical limit for any number of processes is 100% and so the system is schedulable.

EDF has been proven to be an optimal uniprocessor scheduling algorithms [8]. This means that if a set of tasks is unschedulable under *EDF*, then no other scheduling algorithm can feasible schedule this task set. The *EDF* algorithm chooses for execution at each instant in the time currently active job(s) that have the nearest deadlines. The *EDF* implementation upon uniform parallel machines is according to the following rules [2], No Processor is idled while there are active jobs waiting for execution, when fewer than *m* jobs are active, they are required to execute on the fastest processor while the slowest are idled, and higher priority jobs are executed on faster processors.

A formal verification which guarantees all deadlines in a real-time system would be the best. This verification is called feasibility test.

Three different kinds of tests are available:-

- Exact tests with long execution times or simple models [11], [12], [13].
- Fast sufficient tests which fail to accept feasible task sets, especially those with high utilizations [14], [15].
- Approximations, which are allowing an adjustment of performance and acceptance rate [1], [8].

For many applications an exact test or an approximation with a high acceptance rate must be used. For many task sets a fast sufficient test is adequate.

EDF is an appropriate algorithm to use for online scheduling on uniform multiprocessors. However, their implementation suffers from a great number of migrations due to vast fluctuations caused by finishing or arrival of jobs with relatively nearer deadlines. Task migration cost might be very high. For example, in loosely coupled system such as cluster of workstation a migration is performed so slowly that the overload resulting from excessive migration may prove unacceptable [3]. Another disadvantage of *EDF* is that its behavior becomes unpredictable in overloaded situations. Therefore, the performance of *EDF* drops in overloaded condition such that it cannot be considered for use. In this

paper we are presenting a new approach, call the Earliest Feasible Deadline First (*EFDF*) which is used to reduce the time complexity of earliest deadline first algorithm by some assumptions.

II. BACKGROUND AND REVIEW OF RELATED WORKS

Each processor in a uniform multiprocessor machine is characterized by a speed or Computing capacity, with the interpretation that a job executing on a processor with speed *s* for *t* time units completes (*s * t*) units of execution. The Earliest-Deadline First scheduling of real-time systems upon uniform multiprocessor machines is considered. It is known that online algorithms tend to perform very poorly in scheduling such real-time systems on multiprocessors; resource-augmentation techniques are presented here that permit online algorithms in general (*EDF* in particular) to perform better than may be expected given these inherent limitations.

Generalization the definition of utilization from periodic task to nonperiodic tasks has been studies in [23] and [24]. In deriving the utilization bound for rate monotonic scheduler with multiframe and general real time task models, Mok and Chen in [25] and [26] proposed a *maximum average utilization* which measures utilization in an infinite measuring window. To derive the utilization bound for nonperiodic tasks and multiprocessor system, the authors in [23] and [24] proposed a utilization definition that is based on relative deadlines of tasks, instead of periods. It is shown that *EDF* scheduling upon uniform multiprocessors is robust with respect to both job execution requirements and processor computing capacity.

III. SCHEDULING ON MULTIPROCESSOR SYSTEM

Meeting the deadlines of a real-time task set in a multiprocessor system requires a scheduling algorithm that determines, for each task in the system, in which processor they must be executed (*allocation problem*), and when and in which order, with respect to other tasks, they must start their execution (*scheduling problem*). This is a problem with a difficult solution, because (i) some research results for a single processor not always can be applied for multiple processors [17], [18], (ii) in multiple processors different scheduling anomalies appear [19], [21], [20] and (iii) the solution to the allocation problem requires of algorithms with a high computational complexity.

The scheduling of real-time tasks on multiprocessors can be carried out under the *partitioning scheme* or under the *global scheme*. In the partitioning scheme (Figure 1.a) all the instances (or jobs) of a task are executed on the same processor. In contrast, in the global scheme (Figure 1.b), a task can migrate from one processor to another during the execution of different instances. Also, an individual job of a task that is preempted from some processor, may resume execution in a different processor. Nevertheless, in both schemes parallelism is prohibited, that is, no job of any task can be executed at the same time on more than one processor.

On both schemes, the *admission control* mechanism not only decides which tasks must be accepted, but also it must create a feasible allocation of tasks to processors (i.e., on each

processor, all tasks allocated must met their deadlines). For the partitioning and global schemes, task sets can be scheduled using static or dynamic schedulers. In any case, the computational complexity associated to the admission control must remain as low as possible, especially for the dynamic case.

The partitioning scheme has received greater attention than the global scheme, mainly because the scheduling problem can be reduced to the scheduled on single processors, where at the moment a great variety of scheduling algorithms exist. It has been proved by Leung and Whitehead [18] that the partitioned and global approaches to static-priority scheduling on identical multiprocessors are *incomparable* in the sense that (i) there are task sets that are feasible on μ identical processors under the partitioned approach but for which no priority assignment exists which would cause all jobs of all tasks to meet their deadlines under global scheduling on the same μ processors, and (ii) there are task sets that are feasible on μ identical processors under the global approach, which cannot be partitioned into μ distinct subsets such that each individual partition is feasible on a single static-priority uniprocessor.

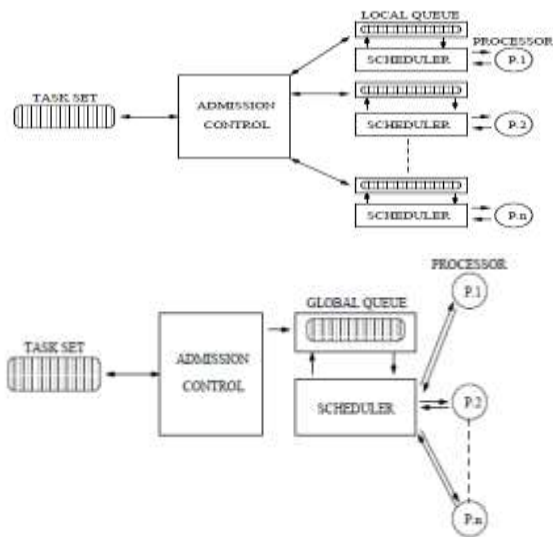


Fig. 1. (a). Partitioning and (b). Global Scheduling Schemes

IV. OUR PROPOSED GRID APPROXIMATION STRATEGY

We have applied some modification to the global Earliest Deadline First algorithms to decrease the number of task migration and also to add predictability to its behavior. In order to decrease the number of migrations we prevent a job from moving to another processor if it is among the m higher priority jobs. The scheduling algorithms can be classified in static and dynamic. In a static scheduling algorithm, all scheduling decisions are provided a priori. Given a set of timing constraints and a schedulability test, a table is constructed, using one of many possible techniques (e.g., using various search techniques), to identify the start and completion times of each task, such that no task misses their deadlines. This is a highly predictable approach, but it is static in the sense that when the characteristics of the task set change the system must be re-started and its scheduling table re-computed.

In a dynamic scheduling algorithm, the scheduling decision is executed at run-time based on task's priorities. The dynamic scheduling algorithms can be classified in algorithms with *fixed* priorities and algorithms with *variable* priorities. In the scheduling algorithms with fixed priorities, the priority of each task of the system remains static during the complete execution of the system, whereas in an algorithm with variable priorities the priority of a task is allowed to change at any moment.

The schedulability test in static scheduling algorithms can only be performed *off-line*, but in dynamic scheduling algorithms it can be performed off-line or *on-line*. In the *on-line* scheduling test, there are complete knowledge of the set of tasks executing in the system, as well as the restrictions imposed to each one of the tasks (deadlines, precedence restrictions, execution times), before the start of their execution. Therefore no new tasks are allowed to arrive in the system. Therefore, a job will continue its execution on the same processor if possible (*processor affinity*¹).

A. The Strategy

In Earliest Deadline First scheduling, at every scheduling point the task having the shortest deadline is taken up for scheduling. The basic principle of this algorithm is very intuitive and simple to understand. The schedulability test for Earliest Deadline First is also simple. A task is schedule under *EDF*, if and only if it satisfies the condition that total processor utilization due to the task set is less than 1. For a set of periodic real-time task $\{T_1, T_2, T_n\}$, *EDF* schedulability criterion can be expressed as:-

$$\sum_{i=1}^n \frac{e_i}{p_i} = \sum_{i=1}^n U_i \leq 1$$

Where e_i is the execution time, p_i is the priority of task and u_i is the average utilization due to the task T_i and n is the total number of task in set. *EDF* has been proven to be an optimal uniprocessor scheduling algorithm [8]. This means that if a set of task is unschedulable under Earliest Deadline First, then no other scheduling algorithm can feasible schedule this task set. In the simple schedulability test for *EDF* we assumed that the period of each task is the same as its deadline. However in practical problem the period of a task may at times be different from its deadline. In such cases, the schedulability test needs to be changed. If $p_i > d_i$, then each task needs e_{we} amount of computing time every $\min(p_i, d_i)$ duration time. Therefore we can write:

$$\sum_{i=1}^n \frac{e_i}{\min(p_i, d_i)} \leq 1$$

However, if $p_i < d_i$, it is possible that a set of tasks is *EDF* schedulable, even when the task set fail to meet according to expression

B. Mathematical Representation

Our motivation for exploiting *processor affinity* drive from the observation that, for much parallel application, time spent bringing data into the local memory or cache is significant source of overhead, ranging between 30% to 60% of the total execution time [3]. While migration is unavoidable in the

global schemes, it is possible to minimize migration caused by a poor assignment of task to processors.

By scheduling task on the processor whose local memory or cache already contains the necessary data, we can significantly reduce the execution time and thus overhead the system. It is worth mentioning that still a job might migrate to another processor when there are two or more jobs that were last executed on the same processor. A migration might also happen when the numbers of ready jobs become less than the number processors. This fact means that our proposed algorithm is a work conserving one.

In order to give the scheduler a more predictable behavior we first perform a *feasibility check* to see whether a job has a chance to meet its deadline by using some exiting algorithm like Yao's [16]. If so, the job is allowed to get executed. Having known the deadline of a task and its remaining execution time it is possible to verify whether it has the opportunity to meet its dead line. More precisely, this verification can be done by examining a *task's laxity*³. The *laxity* of a real-time task T_i at time t , $L_i(t)$, is defined as follows:-

$$L_i(t) = D_i(t) - E_i(t)$$

Where $D_i(t)$ is the dead line by which the task T_i must be completed and $E_i(t)$ is the amount of computation remaining to be performed. In other words, Laxity is a measure of the available flexibility for scheduling a task. A laxity of $L_i(t)$ means that if a task T_i is delayed at most by $L_i(t)$ time units, it will still has the opportunity to meet its deadline.

A task with zero laxity must be scheduled right away and executed without preemption or it will fail to meet its deadline. A negative laxity indicates that the task will miss the deadline, no matter when it is possible picked up for execution. We call this novel approach the *Earliest Feasible Deadline First (EFDF)*

C. EFDF Scheduling Algorithm

Let m denote the number of processing nodes and n , ($n \geq m$) denote the number of Available tasks in a uniform parallel real-time system. Let s_1, s_2, \dots, s_m denote the computing capacity of available processing nodes indexed in a non-increasing manner: $s_j \geq s_{j+1}$ for all j , $1 \leq j < m$. We assume that all speeds are positive i.e. $s_j > 0$ for all j . In this section we are presenting five steps of *EFDF* algorithm. Obviously, each task which is picked for up execution is not considered for execution by other processors. Here we are giving following methods for our new approach:

1. Perform a feasibility check to specify the task which has a chance to meet their deadline and put them into a set A , Put the remaining tasks into set B . We can partition the task set by any existing approach.
2. Sort both task sets A and B according to their deadline in a non-descending order by using any of existing sorting algorithms. Let k denote the

number of tasks in set A , i.e. the number of tasks that have the opportunity to meet their deadline.

3. For all processor j , ($j \leq \min(k, m)$) check whether a task which was last running on the j^{th} processor is among the first $\min(k, m)$ tasks of set A . If so assign it to the j^{th} processor. At this point there might be some processors to which no task has been assigned yet.
4. For all j , ($j \leq \min(k, m)$) if no task is assigned to the j^{th} processor, select the task with earliest deadline from remaining tasks of set A and assign it to the j^{th} processor. If $k \geq m$, each processor have a task to process and the algorithm is finished.
5. If $k < m$, for all j , ($k < j \leq m$) assign the task with smallest deadline from B to the j^{th} processor. The last step is optional and all the tasks from B will miss their deadlines.

D. Experimental Evaluation

We conducted simulation-based experimental studies to validate our analytical results on *EFDF* overhead. We consider an SMP machine with four processors. We consider four tasks running on the system. Their execution times and periods are given in Table 2. The total utilization is approximately 1.5, which is less than 4, the capacity of processors. Therefore, LLREF can schedule all tasks to meet their deadlines. Note that this task set's α (i.e., $\max^N \{u_i\}$) is 0.818, but it does not affect the performance of *EFDF*, as opposed to that of global EDF [22].

Table 2: Task Parameters (4 Task Set)

Process P_i	Execution Time C_i	Period T_i	U_i
P1	9	11	0.818
P2	5	25	0.2
P3	3	30	0.1
P4	5	14	0.357

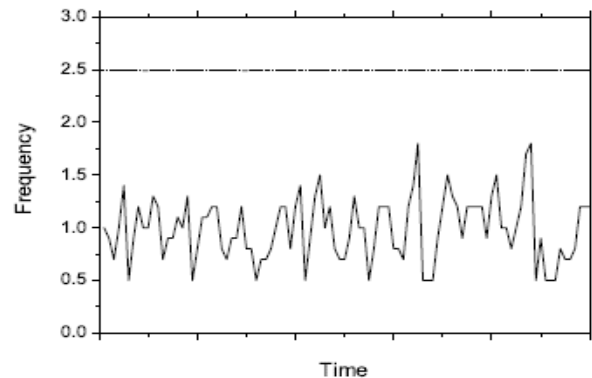


Figure 1: Scheduler Invocation Frequency with 4 Tasks

In Figure 1, the upper-bound on the scheduler invocation frequency and the measured frequency are shown as a dotted

line and a fluctuating line, respectively. We observe that the actual measured frequency respects the upper bound.

Table 3: Task Parameters (8 Task Set)

Process P_i	Execution Time C_i	Period T_i	U_i
P1	3	7	0.429
P2	1	16	0.063
P3	5	19	0.263
P4	4	5	0.8
P5	2	26	0.077
P6	15	26	0.577
P7	20	29	0.69
P8	14	17	0.824

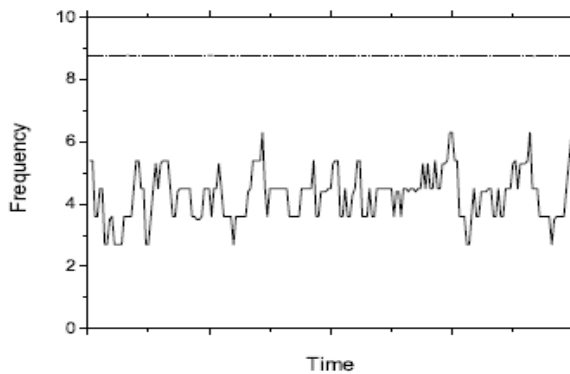


Figure 2: Scheduler Invocation Frequency with 8 Tasks

Figure 2 shows the upper-bound on the invocation frequency and the actual frequency for the 8-task set. Consistently with the previous case, the actual frequency never moves beyond the upper-bound. We also observe that the average invocation frequencies of the two cases are approximately 1.0 and 4.0, respectively. As expected the number of tasks proportionally affects *EFDF* overhead.

E. Complexity and Performance of the Partitioning Algorithms

In Table 2 we are taking the compression of given standard and simulated complexities of different algorithms given below and we are comparing these complexities to our purposed algorithm, the complexity and performance of the partitioning algorithms is introduced. Note that the algorithms with lowest complexity are RMNF-L&L, RMGT/M, and EDF-NF, while the algorithm with highest complexity is RBOUND-MP. The rest of the algorithms have complexity $O(n \log n)$. The algorithms with best theoretical performance are RM-FFDU, RMST, RMGT, RMGT/M, EDF-FF and EDF-BF.[16]

TABLE 2 : COMPLEXITY AND PERFORMANCE OF THE MULTIPROCESSOR

PARTITIONING ALGORITHMS			
Algorithm	Condition	Complexity	\mathfrak{R}_A
RMNF [14]	IP	$O(n \log n)$	2.67
RMFF [35]	IP	$O(n \log n)$	2.33
RMBF [35]	IP	$O(n \log n)$	2.33
RM-FFDU [33]	UO	$O(n \log n)$	5/3
FFDUF [12]	L&L	$O(n \log n)$	2.0
RMST [10]	PO	$O(n \log n)$	$1/1-\alpha$
RMGT [10]	PO and Le	$O(n \log n)$	7/4
RBOUND-MP [21]	RBOUND	$O(n(m + \log n))$	N/A
RMNF-L&L [34]	L&L	$O(n)$	2.88
RMFF-L&L [34]	L&L	$O(n \log n)$	2.33
RMBF-L&L [34]	L&L	$O(n \log n)$	2.33
RMGT/M [9]	PO	$O(n)$	$\frac{1}{(1-\alpha)} + \frac{1}{1-(m^2)/M}$
EDF-FF [15]	$U \leq 1$	$O(n \log n)$	1.7
EDF-BF [15]	$U \leq 1$	$O(n \log n)$	1.7
EDF-WF [31]	$U \leq 1$	$O(n \log n)$	N/A
EDF-NF [31]	$U \leq 1$	$O(n)$	N/A

F. Complexity Analysis

The Earliest Deadline First algorithm would be maintaining all tasks that are ready for execution in a queue. Any freshly arriving task would be inserted at the end of queue. Each task insertion will be achieved in $O(1)$ or constant time, but task selection (to run next) and its deletion would require $O(n)$ time, where n is the number of tasks in the queue. *EDF* simply maintaining all ready tasks in a sorted priority queue that will be used a heap data structure. When a task arrives, a record for it can be inserted into the heap in $O(\log_2 n)$ time where n is the total number of tasks in the priority queue. Therefore, the time complexity of Earliest Deadline First is equal to that of a typical sorting algorithm which is $O(n \log_2 n)$. While in the *EFDF* the number of distinct deadlines that tasks in an application can have are restricted.

In our approach, whenever a task arrives, its absolute deadline is computed from its release time and its relative deadline. A separate first in first out (*FIFO*) queue is maintained for each distinct relative deadline that task can have. The schedulers insert a newly arrived task at the end of the corresponding relative deadline queue. So tasks in each queue are ordered according to their absolute deadlines. To find a task with the earliest absolute deadline, the scheduler needs to search among the threads of all *FIFO* queues. If the number of priority queue maintained by the scheduler in n , then the order of searching would be $O(1)$. The time to insert a task would also be $O(1)$. So finally the time complexity of five steps of Earliest Feasible Deadline First (*EFDF*) are $O(n)$, $O(n \log_2 n)$, $O(m)$, $O(m)$, $O(m)$, respectively.

V. CONCLUSION AND FUTURE WORK

This work focused on some modification to the global Earliest Deadline First algorithms to decrease the number of task migration and also to add predictability to its behavior. Mainly Earliest Feasible Deadline First algorithms are presented the least complexity according to their performance analyzed. Experimental result of Earliest Feasible Deadline First (*EFDF*) algorithm reduced the time complexity in compression of Earliest Deadline First algorithm on real time system scheduling for multiprocessor system and perform the feasibility checks to specify the task which has a chance to meet their deadline.

When Earliest Feasible Deadline First is used to schedule a set of real-time tasks, unacceptable high overheads might have to be incurred to support resource sharing among the tasks without making tasks to miss their respective deadlines, due to this it will take again more time. Our future research will investigate other less complexity Algorithm and also reduced the overhead for different priority assignments for global scheduling which will, consequently, lead to different bounds.

We believe that such studies should be conducted regularly by collecting data continuously so that skill demand patterns can be understood properly. This understanding can lead to informed curricula design that can prepare graduates equipped

with necessary skills for employment. Once such studies are carried out, students can use the findings to select courses that focus on those skills which are in demand. Academic institutions can use the findings so that those skills in demand can be taken into account during curriculum design.

As an advance to our work, in future, we have desire to work on different deployment approaches by developing more strong and innovative algorithms to solve the time complexity of Earliest Deadline First. Moreover, as our proposed algorithm is a generalized one, we have planned to expand our idea in the field of Real Time System existing Rate Monotonic Algorithm for calculating minimum Time Complexity. Moreover, we have aim to explore some more methodologies to implement the concept of this paper in real world and also explore for Fault Tolerance Task Scheduling Algorithms to finding the Task Dependency in single processor or multiprocessor system for reducing the time for fault also reduce the risk for fault and damage.

ACKNOWLEDGMENTS

The authors thank the reviewers of drafts of this paper. It is profound gratitude and immense regard that we acknowledge to Dr. S.P. Panda, Chairman, GGI, Prof. N.V.J. Rao Dean (Admin), GGI for their confidence, support and blessing without which none of this would have been possible. Also a note to all professors here in GIET for the wisdom and knowledge that they given us, all of which came together in the making of this paper. We express our gratitude to all my friends and colleagues as well for all their help and guidance.

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Analysis of Software Reliability Data using Exponential Power Model

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Abstract—In this paper, Exponential Power (EP) model is proposed to analyze the software reliability data and the present work is an attempt to represent that the model is as software reliability model. The approximate MLE using Artificial Neural Network (ANN) method and the Markov chain Monte Carlo (MCMC) methods are used to estimate the parameters of the EP model. A procedure is developed to estimate the parameters of the EP model using MCMC simulation method in OpenBUGS by incorporating a module into OpenBUGS. The R functions are developed to study the various statistical properties of the proposed model and the output analysis of MCMC samples generated from OpenBUGS. A real software reliability data set is considered for illustration of the proposed methodology under informative set of priors.

Keywords- EP model, Probability density, function, Cumulative density function, Hazard rate function, Reliability function, Parameter estimation, MLE, Bayesian estimation.

I. INTRODUCTION

Exponential models play a central role in analyses of lifetime or survival data, in part because of their convenient statistical theory, their important 'lack of memory' property and their constant hazard rates. In circumstances where the one-parameter family of exponential distributions is not sufficiently broad, a number of wider families such as the gamma, Weibull and lognormal models are in common use. Adding parameters to a well-established family of models is a time honoured device for obtaining more flexible new families of models. The Exponential Power model is introduced by [14] as a lifetime model. This model has been discussed by many authors [4], [9] and [12].

A model is said to be an Exponential Power model with shape parameter $\alpha > 0$ and scale parameter $\lambda > 0$, if the survival function of the model is given by

$$R(x) = \exp\left\{1 - e^{(\lambda x)^\alpha}\right\}, (\alpha, \lambda) > 0 \text{ and } x \in (0, \infty).$$

A. Model Analysis

For $\alpha > 0$ and $\lambda > 0$ the two-parameter Exponential Power model has the distribution function

$$F(x; \alpha, \lambda) = 1 - \exp\left\{1 - e^{(\lambda x)^\alpha}\right\}; (\alpha, \lambda) > 0, x \geq 0 \quad (1)$$

The probability density function (pdf) associated with eq (1) is given by

$$f(x; \alpha, \lambda) = \alpha \lambda^\alpha x^{\alpha-1} e^{(\lambda x)^\alpha} \exp\left\{1 - e^{(\lambda x)^\alpha}\right\}; (\alpha, \lambda) > 0, x \geq 0 \quad (2)$$

We shall write $EP(\alpha, \lambda)$ to denote Exponential Power model with parameters α and λ . The parameter α is named as 'shape parameter' by [4] and [14]. The R functions `dexp.power()` and `pexp.power()` given in `SoftreliaR` package can be used for the computation of pdf and cdf, respectively.

Some of the typical EP density functions for different values of α and for $\lambda = 1$ are depicted in Figure 1. It is clear from the Figure 1 that the density function of the Exponential Power model can take different shapes.

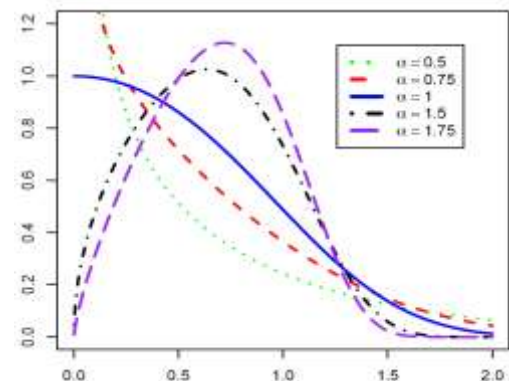


Figure 1 Plots of the probability density function of the Exponential Power model for $\lambda=1$ and different values of α

1) Mode

The mode can be obtained by solving the non-linear equation

$$(\alpha - 1) + \alpha (\lambda x)^\alpha \left\{1 - e^{(\lambda x)^\alpha}\right\} = 0. \quad (3)$$

2) The quantile function

For a continuous distribution $F(x)$, the p percentile (also referred to as fractile or quantile), x_p , for a given p , $0 < p < 1$, is a number such that

$$P(X \leq x_p) = F(x_p) = p. \quad (4)$$

The quantile for $p=0.25$ and $p=0.75$ are called first and third quartiles and the $p=0.50$ quantile is called the median(Q_2). The five parameters

Minimum(x), Q_1 , Q_2 , Q_3 , Maximum(x)

are often referred to as the five-number summary or explanatory data analysis. Together, these parameters give a great deal of information about the model in terms of the centre, spread, and skewness. Graphically, the five numbers are often displayed as a boxplot. The quantile function of Exponential Power model can be obtained by solving

$$1 - \exp\left\{1 - e^{(\lambda x)^\alpha}\right\} = p$$

$$\text{or, } x_p = \frac{1}{\lambda} \log\left\{1 - \log(1-p)\right\}^{1/\alpha} ; 0 < p < 1. \quad (5)$$

The computation of quantiles the R function `qexp.power()`, given in `SoftreliaR` package, can be used. In particular, for $p=0.5$ we get

$$\text{Median}(x_{0.5}) = \frac{1}{\lambda} \left(\log\{1 - \log(0.5)\}\right)^{1/\alpha} . \quad (6)$$

3) The random deviate generation

Let U be the uniform (0,1) random variable and $F(\cdot)$ a cdf for which $F^{-1}(\cdot)$ exists. Then $F^{-1}(u)$ is a draw from distribution $F(\cdot)$. Therefore, the random deviate can be generated from $EP(\alpha, \lambda)$ by

$$x = \frac{1}{\lambda} \log\left\{1 - \log(1-u)\right\}^{1/\alpha} ; 0 < u < 1 \quad (7)$$

where u has the $U(0, 1)$ distribution. The R function `rexp.power()`, given in `SoftreliaR` package, generates the random deviate from $EP(\alpha, \lambda)$.

4) Reliability function/survival function

The reliability/survival function

$$S(x; \alpha, \lambda) = \exp\left\{1 - \exp(\lambda x)^\alpha\right\}, (\alpha, \lambda) > 0 \text{ and } x \geq 0 \quad (8)$$

The R function `sexp.power()` given in `SoftreliaR` package computes the reliability/ survival function.

5) The Hazard Function

The hazard function of Exponential Power model is given by

$$h(x; \alpha, \lambda) = \alpha \lambda^\alpha x^{\alpha-1} \exp(\lambda x)^\alpha, (\alpha, \lambda) > 0 \text{ and } x \geq 0 \quad (9)$$

and the allied R function `hexp.power()` given in `SoftreliaR` package. Since the shape of $h(x)$ depends on the value of the shape parameter α . When $\alpha \geq 1$, the failure rate function is increasing. When $\alpha < 1$, the failure rate function is of bathtub shape. Thus the shape parameter α plays an important role for the model.

Since differentiating equation (9) w.r.to x , we have

$$h'(x) = \frac{1}{x} \left\{(\alpha - 1) + \alpha(\lambda x)^\alpha\right\} . \quad (10)$$

Setting $h'(x) = 0$ and after simplification, we obtain the change point as

$$x_0 = \frac{1}{\lambda} \left(\frac{1-\alpha}{\alpha}\right)^{1/\alpha} . \quad (11)$$

It easily follows that the sign of $h'(x)$ is determined by $(\alpha - 1) + \alpha(\lambda x)^\alpha$ which is negative for all $x \leq x_0$ and positive for all $x \geq x_0$.

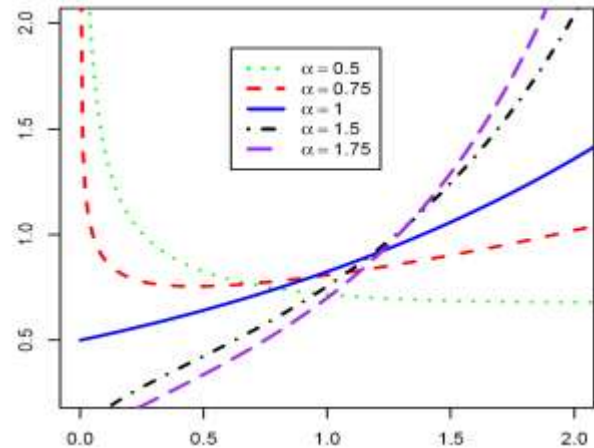


Figure 2 Plots of the hazard function of the Exponential Power model for $\lambda=1$ and different values of α

Some of the typical Exponential Power Model hazard functions for different values of α and for $\lambda = 1$ are depicted in Figure 2. It is clear from the Figure 2 that the hazard function of the Exponential Power model can take different shapes.

6) The cumulative hazard function

The cumulative hazard function $H(x)$ defined as

$$H(x) = -\{1 - \log F(x)\} \quad (12)$$

can be obtained with the help of `pexp.power()` function given in `SoftreliaR` package by choosing arguments `lower.tail=FALSE` and `log.p=TRUE`. i.e.

- `pexp.power(x, alpha, lambda, lower.tail = FALSE, log.p = TRUE)`

7) Failure rate average (fra) and Conditional survival function(crf)

Two other relevant functions useful in reliability analysis are failure rate average (fra) and conditional survival function (crf) The failure rate average of X is given by

$$\text{FRA}(x) = \frac{H(x)}{x} , x > 0, \quad (13)$$

where $H(x)$ is the cumulative hazard function.

The survival function (s.f.) and the conditional survival of X are defined by

$$R(x) = 1 - F(x)$$

and $R(x | t) = \frac{R(x+t)}{R(x)}$, $t > 0, x > 0, R(\cdot) > 0$, (14)

respectively, where $F(\cdot)$ is the cdf of X. Similarly to $h(x)$ and $FRA(x)$, the distribution of X belongs to the new better than used (NBU), exponential, or new worse than used (NWU) classes, when $R(x | t) < R(x)$, $R(t | x) = R(x)$, or $R(x | t) > R(x)$, respectively.

The R functions *hra.exp.power()* and *crf.exp.power()* given in *SoftReliaR* package can be used for the failure rate average (*fra*) and conditional survival function (*crf*), respectively.

II. MAXIMUM LIKELIHOOD ESTIMATION AND INFORMATION MATRIX

Let $x=(x_1, \dots, x_n)$ be a sample from a distribution with cumulative distribution function (1). The log likelihood function of the parameter $L(\alpha, \lambda)$ is given by

$$\log L(\alpha, \lambda) = n \log \alpha + n \alpha \log \lambda + (\alpha - 1) \sum_{i=1}^n \log x_i + \lambda^\alpha \sum_{i=1}^n x_i^\alpha + n - \sum_{i=1}^n \exp\{(\lambda x_i)^\alpha\}$$
 (15)

Therefore, to obtain the MLE's of α and λ we can maximize eq.(15) directly with respect to α and λ or we can solve the following two non-linear equations using iterative procedure [2] and [4]:

$$\frac{\partial \log L}{\partial \alpha} = \frac{n}{\alpha} + n \log \lambda + \sum_{i=1}^n \log x_i + \sum_{i=1}^n (\lambda x_i)^\alpha \log(\lambda x_i) \{1 - \exp(-\lambda x_i)^\alpha\} = 0$$
 (16)

$$\frac{\partial \log L}{\partial \lambda} = \frac{n \alpha}{\lambda} + \sum_{i=1}^n \alpha \lambda^{\alpha-1} x_i^\alpha \{1 - \exp(-\lambda x_i)^\alpha\} = 0$$
 (17)

Let us denote $\hat{\theta} = (\hat{\alpha}, \hat{\lambda})$ as the MLEs of $\underline{\theta} = (\alpha, \lambda)$. It is not possible to obtain the exact variances of $\hat{\theta} = (\hat{\alpha}, \hat{\lambda})$. The asymptotic variances of $\hat{\theta} = (\hat{\alpha}, \hat{\lambda})$ can be obtained from the following asymptotic property of $\hat{\theta} = (\hat{\alpha}, \hat{\lambda})$

$$(\hat{\theta} - \underline{\theta}) \rightarrow N_2\left(0, (I(\underline{\theta}))^{-1}\right)$$
 (18)

where $I(\underline{\theta})$ is the Fisher's information matrix given by

$$I(\underline{\theta}) = - \begin{bmatrix} E\left(\frac{\partial^2 \ln L}{\partial \alpha^2}\right) & E\left(\frac{\partial^2 \ln L}{\partial \alpha \partial \lambda}\right) \\ E\left(\frac{\partial^2 \ln L}{\partial \alpha \partial \lambda}\right) & E\left(\frac{\partial^2 \ln L}{\partial \lambda^2}\right) \end{bmatrix}$$
 (19)

In practice, it is useless that the MLE has asymptotic variance $(I(\underline{\theta}))^{-1}$ because we do not know $\underline{\theta}$. Hence, we approximate the asymptotic variance by "plugging in" the estimated value of the parameters. The common procedure is to use observed Fisher information matrix $O(\hat{\theta})$ (as an estimate of the information matrix $I(\underline{\theta})$) given by

$$O(\hat{\theta}) = - \begin{bmatrix} \frac{\partial^2 \ln L}{\partial \alpha^2} & \frac{\partial^2 \ln L}{\partial \alpha \partial \lambda} \\ \frac{\partial^2 \ln L}{\partial \alpha \partial \lambda} & \frac{\partial^2 \ln L}{\partial \lambda^2} \end{bmatrix}_{(\hat{\alpha}, \hat{\lambda})} = -H(\underline{\theta})|_{\underline{\theta}=\hat{\theta}}$$
 (20)

where H is the Hessian matrix, $\underline{\theta}=(\alpha, \lambda)$ and $\hat{\theta}=(\hat{\alpha}, \hat{\lambda})$. The observed Fisher information is evaluated at MLE rather than determining the expectation of the Hessian at the observed data. This is simply the negative of the Hessian of the log-likelihood at MLE. If the Newton-Raphson algorithm is used to maximize the likelihood then the observed information matrix can easily be calculated. Therefore, the variance-covariance matrix is given by

$$(-H(\underline{\theta})|_{\underline{\theta}=\hat{\theta}})^{-1} = \begin{bmatrix} \text{Var}(\hat{\alpha}) & \text{cov}(\hat{\alpha}, \hat{\lambda}) \\ \text{cov}(\hat{\alpha}, \hat{\lambda}) & \text{Var}(\hat{\lambda}) \end{bmatrix}$$
 (21)

Hence, from the asymptotic normality of MLEs, approximate 100(1- γ)% confidence intervals for α and λ can be constructed as

$$\hat{\alpha} \pm z_{\gamma/2} \sqrt{\text{Var}(\hat{\alpha})} \quad \text{and} \quad \hat{\lambda} \pm z_{\gamma/2} \sqrt{\text{Var}(\hat{\lambda})}$$
 (22)

where $z_{\gamma/2}$ is the upper percentile of standard normal variate.

III. BAYESIAN ESTIMATION IN OPENBUGS

The most widely used piece of software for applied Bayesian inference is the OpenBUGS. It is a fully extensible modular framework for constructing and analyzing Bayesian full probability models. This open source software requires incorporation of a module (code) to estimate parameters of Exponential Power model.

A module *dexp.power_T(alpha, lambda)* is written in component Pascal, enables to perform full Bayesian analysis of Exponential Power model into OpenBUGS using the method described in [15] and [16].

A. Implementation of Module - *dexp.power_T(alpha, lambda)*

The developed module is implemented to obtain the Bayes estimates of the Exponential Power model using MCMC method. The main function of the module is to generate

MCMC sample from posterior distribution under informative set of priors, i.e. Gamma priors.

1) Data Analysis

We are using software reliability data set *SYS2.DAT* - 86 time-between-failures [10] is considered for illustration of the proposed methodology. In this real data set, Time-between-failures is converted to time to failures and scaled.

B. Computation of MLE and Approximate ML estimates using ANN

The Exponential Power model is used to fit this data set. We have started the iterative procedure by maximizing the log-likelihood function given in eq.(15) directly with an initial guess for $\alpha = 0.5$ and $\lambda = 0.06$, far away from the solution. We have used *optim()* function in R with option Newton-Raphson method. The iterative process stopped only after 7 iterations. We obtain $\hat{\alpha} = 0.905868898$, $\hat{\lambda} = 0.001531423$ and the corresponding log-likelihood value = -592.7172. The similar results are obtained using *maxLik* package available in R. An estimate of variance-covariance matrix, using eq.(22), is given by

$$\begin{pmatrix} \text{Var}(\hat{\alpha}) & \text{cov}(\hat{\alpha}, \hat{\lambda}) \\ \text{cov}(\hat{\alpha}, \hat{\lambda}) & \text{Var}(\hat{\lambda}) \end{pmatrix} = \begin{bmatrix} 7.265244e-03 & -1.474579e-06 \\ -1.474579e-06 & 1.266970e-08 \end{bmatrix}$$

Thus using eq.(23), we can construct the approximate 95% confidence intervals for the parameters of EP model based on MLE's. Table I shows the MLE's with their standard errors and approximate 95% confidence intervals for α and λ .

TABLE I MAXIMUM LIKELIHOOD ESTIMATE, STANDARD ERROR AND 95% CONFIDENCE INTERVAL

Parameter	MLE	Std. Error	95% Confidence Interval
alpha	0.905868	0.085236	(0.7388055, 1.0729322)
lambda	0.001531	0.000112	(0.0013108, 0.0017520)

An approximate ML estimates based on Artificial Neural Networks are obtained by using the *neuralnet* package available in R. We have chosen one hidden-layer feedforward neural networks with sigmoid activation function [1]. The results are quite close to exact ML estimates.

C. Model Validation

To study the goodness of fit of the Exponential Power model, we compute the Kolmogorov-Smirnov statistic between the empirical distribution function and the fitted distribution function when the parameters are obtained by method of maximum likelihood. For this we can use R function *ks.exp.power()*, given in *SoftreliaR* package. The result of K-S test is $D = 0.0514$ with the corresponding p-value = 0.9683, Therefore, the high p-value clearly indicates that Exponential Power model can be used to analyze this data set, and we also plot the empirical distribution function and the fitted distribution function in Figure 3. From above result and

Figure 3, it is clear that the estimated Exponential Power model provides excellent fit to the given data.

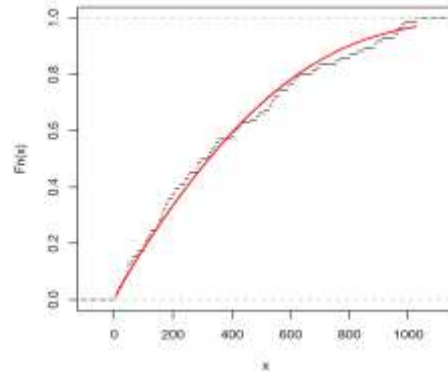


Figure 3 The graph of empirical distribution and fitted distribution function.

The other graphical method widely used for checking whether a fitted model is in agreement with the data is Quantile-Quantile (Q-Q) plots.

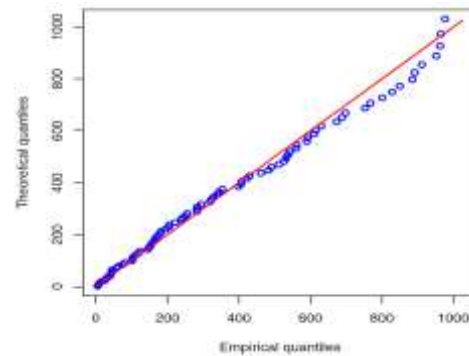


Figure 4 Quantile-Quantile(Q-Q) plot using MLEs as estimate.

The Q-Q plots show the estimated versus the observed quantiles. If the model fits the data well, the pattern of points on the Q-Q plot will exhibit a 45-degree straight line. Note that all the points of a Q-Q plot are inside the square

$$\left[\hat{F}^{-1}(p_{l:n}), \hat{F}^{-1}(p_{n:n}) \right] \times [x_{l:n}, x_{n:n}] .$$

The corresponding R function *qq.exp.power()* is given in *SoftreliaR* package. As can be seen from the straight line pattern in Figure 4, the Exponential Power model fits the data very well.

IV. BAYESIAN ANALYSIS UNDER INFORMATIVE PRIORS, I.E., GAMMA PRIORS

OpenBUGS code to run MCMC:

```

Model
{
  for(i in 1 : N)
  {
    x[i] ~ dexp.power_T(alpha, lambda)
  }
}
# Prior distributions of the Model parameters
    
```

```
# Gamma prior for alpha
alpha ~ dgamma(0.001, 0.001)
# Gamma prior for lambda
lambda ~ dgamma(0.001, 0.001)
}
```

Data

```
list(N=86, x=c(4.79, 7.45, 10.22, 15.76, 26.10, 28.59, 35.52, 41.49,
42.66, 44.36, 45.53, 58.27, 62.96, 74.70, 81.63, 100.71, 102.06, 104.83,
110.79, 118.36, 122.73, 145.03, 149.40, 152.80, 156.85, 162.20, 164.97,
168.60, 173.82, 179.95, 182.72, 195.72, 203.93, 206.06, 222.26, 238.27,
241.25, 249.99, 256.17, 282.57, 282.62, 284.11, 294.45, 318.86, 323.46,
329.11, 340.30, 344.67, 353.94, 398.56, 405.70, 407.51, 422.36, 429.93,
461.47, 482.62, 491.46, 511.83, 526.64, 532.23, 537.13, 543.06, 560.75,
561.60, 589.96, 592.09, 610.75, 615.65, 630.52, 673.74, 687.92, 698.15,
753.05, 768.25, 801.06, 828.22, 849.97, 885.02, 892.27, 911.90, 951.69,
962.59, 965.04, 976.98, 986.92, 1025.94))
```

Initial values

```
# chain 1
list(alpha=0.2, lambda=0.01)
# chain 2
list(alpha= 1.0, lambda=0.10)
```

We run the model to generate two Markov Chains at the length of 40,000 with different starting points of the parameters. The convergence is monitored using trace and ergodic mean plots, we find that the Markov Chain converge together after approximately 2000 observations. Therefore, burnin of 5000 samples is more than enough to erase the effect of starting point(initial values). Finally, samples of size 7000 are formed from the posterior by picking up equally spaced every fifth outcome, i.e. thin=5, starting from 5001. This is done to minimize the auto correlation among the generated deviates. Therefore, we have the posterior sample $\{\alpha_{1i}, \lambda_{1i}\}$, $i = 1, \dots, 7000$ from chain 1 and $\alpha_{2i}, \lambda_{2i}\}$, $i = 1, \dots, 7000$ from chain 2.

The chain 1 is considered for convergence diagnostics plots. The visual summary is based on posterior sample obtained from chain 2 whereas the numerical summary is presented for both the chains.

A. Convergence diagnostics

Sequential realization of the parameters α and λ can be observed in figure 5. The Markov chain is most likely to be sampling from the stationary distribution and is mixing well.

1) History(Trace) plot

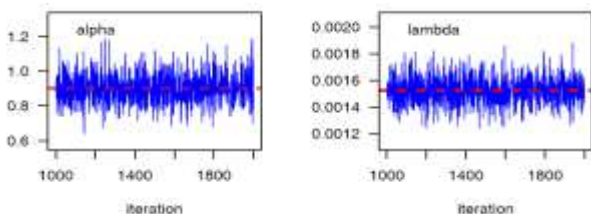


Figure 5 Sequential realization of the parameters α and λ .

There is ample evidence of convergence of chain as the plots show no long upward or downward trends, but look like a horizontal band, then we have evidence that the chain has converged.

2) Running Mean (Ergodic mean) Plot

The convergence pattern based on Ergodic average as shown in figure 6 is obtained after generating a time series (Iteration number) plot of the running mean for each parameter in the chain. The running mean is computed as the mean of all sampled values up to and including that at a given iteration.

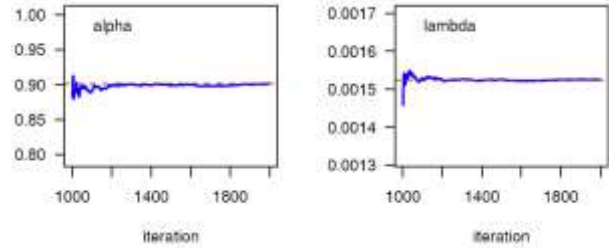


Figure 6 The Ergodic mean plots for α and λ .

3) Autocorrelation

The graph shows that the correlation is almost negligible. We may conclude that the samples are independent.

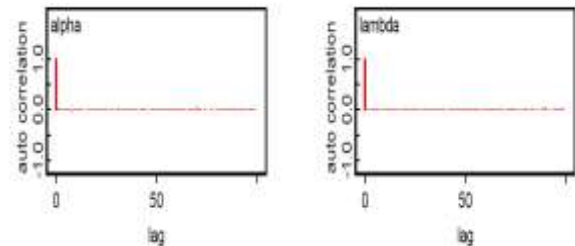


Figure 7 The autocorrelation plots for α and λ .

4) Brooks-Gelman-Rubin Plot

Uses parallel chains with dispersed initial values to test whether they all converge to the same target distribution. Failure could indicate the presence of a multi-mode posterior distribution (different chains converge to different local modes) or the need to run a longer chain (burn-in is yet to be completed).

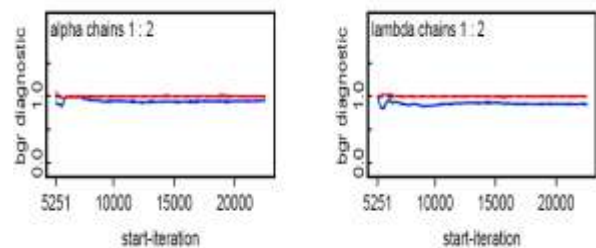


Figure 8 The BGR plots for α and λ .

From the Figure 8, it is clear that convergence is achieved. Thus we can obtain the posterior summary statistics.

B. Numerical Summary

In Table II, we have considered various quantities of interest and their numerical values based on MCMC sample of posterior characteristics for Exponential Power model under Gamma priors.

TABLE II NUMERICAL SUMMARIES UNDER GAMMA PRIORS

Characteristics	Chain 1		Chain 2	
	alpha	lambda	alpha	lambda
Mean	0.895628	0.001525208	0.8971537	0.001525661
Standard Deviation	0.08527441	0.0001170499	0.0841966	0.0001169336
Monte Carlo(MC) error	0.001108	1.322E-6	-9.216E-4	1.402E-6
Minimum	0.607600	0.001102000	0.5905000	0.001089
2.5th Percentile(P _{2.5})	0.733700	0.001307975	0.7332975	0.001385
First Quartile (Q ₁)	0.837400	0.001447000	0.8394750	0.001447
Median	0.893800	0.001522000	0.8952000	0.001523
Third Quartile (Q ₃)	0.949925	0.001600000	0.9522000	0.001603
97.5th Percentile(P _{97.5})	1.068000	0.001752000	1.0690000	0.001761
Maximum	1.234000	0.002138000	1.2510000	0.001989
Mode	0.8911972	0.001506012	0.8915055	0.001502559
95% Credible Interval	(0.7337, 1.0680)	(0.0013, 0.00176)	(0.7332975, 1.069)	(0.0013, 0.00176)
95% HPD Credible Interval	(0.7324, 1.0650)	(0.0013, 0.00176)	(0.7313, 1.0650)	(0.0012, 0.00174)

C. Visual summary

1) Box plots

The boxes represent inter-quartile ranges and the solid black line at the (approximate) centre of each box is the mean; the arms of each box extend to cover the central 95 per cent of the distribution - their ends correspond, therefore, to the 2.5% and 97.5% quantiles. (Note that this representation differs somewhat from the traditional.)

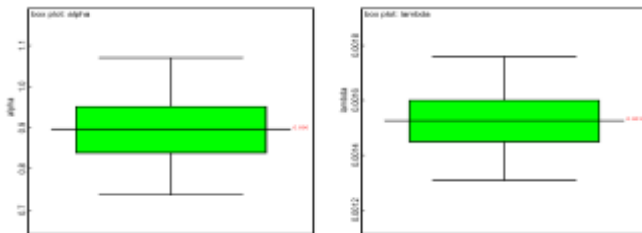


Figure 9 The boxplots for alpha and lambda.

2) Kernel density estimates

Histograms can provide insights on symmetric, behaviour in the tails, presence of multi-modal behaviour, and data outliers; histograms can be compared to the fundamental shapes associated with standard analytic distributions.

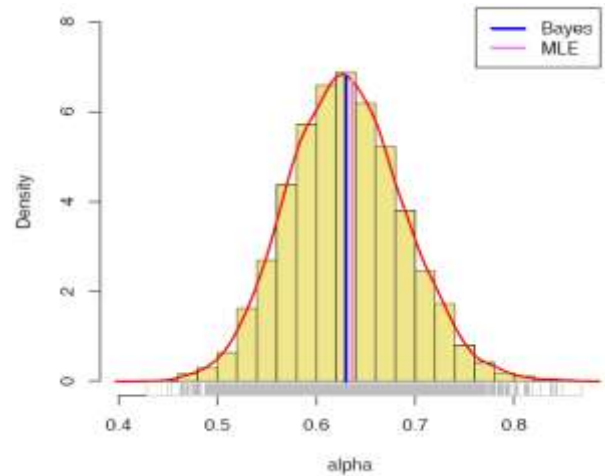


Figure 10 Kernel density estimate and histogram of α based on MCMC samples, vertical lines indicates the corresponding ML and Bayes estimates.

Figure 10 and 11 provide the kernel density estimate of α and λ respectively. It can be seen that α and λ both are symmetric.

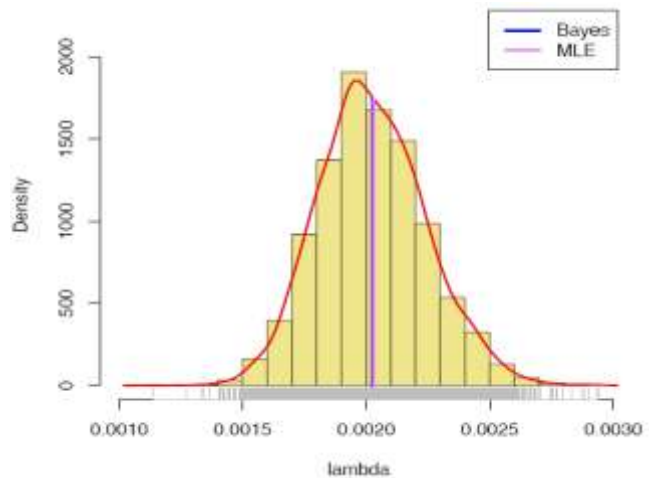


Figure 11 Histogram and kernel density estimate of λ based on MCMC samples

D. Comparison with MLE

For the comparison with MLE we have plotted two graphs. In Figure 12, the density functions $f(x; \hat{\alpha}, \hat{\lambda})$ using MLEs and Bayesian estimates, computed via MCMC samples under gamma priors, are plotted.

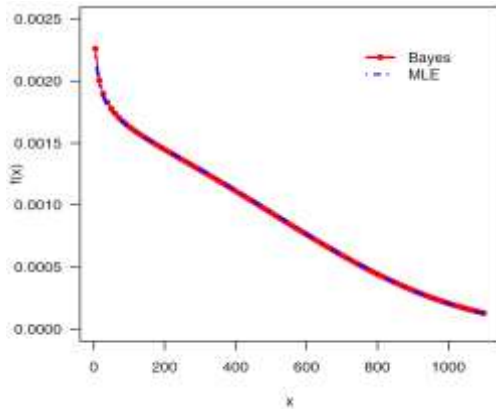


Figure 12 The density functions $f(x; \hat{\alpha}, \hat{\lambda})$ using MLEs and Bayesian estimates, computed via MCMC samples under gamma priors.

The Figure 13, exhibits the estimated reliability function(dashed line) using Bayes estimate under gamma priors and the empirical reliability function(solid line).

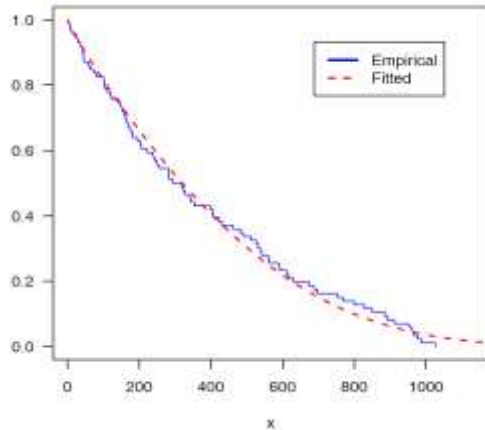


Figure 13 The estimated reliability function(dashed line) and the empirical reliability function (solid line).

It is clear from the Figures, the MLEs and the Bayes estimates with respect to the gamma priors are quite close and fit the data very well.

V. CONCLUSION

In this research paper, we have presented the Exponential Power model as software reliability model which was motivated by the fact that the existing models were inadequate to describe the failure process underlying some of the data sets.

We have developed the tools for empirical modelling, e.g., model analysis, model validation and estimation. The exact as well as approximate ML estimates using ANN of the

[15] Thomas, A. (2004). OpenBUGS, URL <http://mathstat.helsinki.fi/openbugs/>.

parameters alpha (α) and lambda (λ) have been obtained.

An attempt has been made to estimate the parameters in Bayesian setup using MCMC simulation method under gamma priors. The proposed methodology is illustrated on a real data set. We have presented the numerical summary and visual summary under different priors which includes Box plots, Kernel density estimates based on MCMC samples. The Bayes estimates are compared with MLE. We have shown that the Exponential Power model is suitable for modeling the software reliability data and the tools developed for analysis can also be used for any other type of data sets.

ACKNOWLEDGEMENT

Our thanks to Dr. Andrew Thomas, St. Andrew's University, UK, Prof. Uwe Ligges, TU Dortmund University, Germany and Prof R.S. Srivastava, DDU Gorakhpur University, Gorakhpur, for their valuable suggestions to make this work a success.

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Priority Based Dynamic Round Robin (PBDRR) Algorithm with Intelligent Time Slice for Soft Real Time Systems

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Abstract—In this paper, a new variant of Round Robin (RR) algorithm is proposed which is suitable for soft real time systems. RR algorithm performs optimally in timeshared systems, but it is not suitable for soft real time systems. Because it gives more number of context switches, larger waiting time and larger response time. We have proposed a novel algorithm, known as Priority Based Dynamic Round Robin Algorithm (PBDRR), which calculates intelligent time slice for individual processes and changes after every round of execution. The proposed scheduling algorithm is developed by taking dynamic time quantum concept into account. Our experimental results show that our proposed algorithm performs better than algorithm in [8] in terms of reducing the number of context switches, average waiting time and average turnaround time.

Keywords- Real time system; Operating System; Scheduling; Round Robin Algorithm; Context switch; Waiting time; Turnaround time.

I. INTRODUCTION

Real Time Systems (RTS) are the ones that are designed to provide results within a specific time-frame. It must have well defined fixed and response time constraints and the processing must be done within the defined constraints or the system will fail. RTS are basically divided into three types: hard, firm and soft. In hard real time systems, failure to meet deadline or response time constraints leads to system failure. In firm real time systems, failure to meet deadline can be tolerated. In soft real time systems, failure to meet deadline doesn't lead to system failure, but only performance is degraded[6]. Space research, weather forecast, seismic detection, audio conferencing, video conferencing, money withdrawal from ATM, railway and flight reservation etc are some of the applications of real time systems. The simple RR algorithm cannot be applied in soft real time systems as it gives longer waiting and response time. Yashuwanth and et. al. [8] have proposed a scheduling algorithm for soft real time systems where Intelligent Time Slice (ITS) for all the processes

has been calculated. The processes are scheduled using RR with ITS as time quantum. By taking dynamic time concept with ITS, we have proposed a new algorithm which gives improved performance than the algorithm proposed in [8].

A. Real Time Scheduling Algorithms

Some of the well known real-time scheduling algorithms are described as follows. **Rate Monotonic Algorithm (RM)** is a fixed priority scheduling algorithm which consists of assigning the highest priority to the highest frequency tasks in the system, and lowest priority to the lowest frequency tasks. At any time, the scheduler chooses to execute the task with the highest priority. By specifying the period and computational time required by the task, the behavior of the system can be categorized *a priori*. **Earliest-Deadline-First Algorithm (EDF)** uses the deadline of a task as its priority. The task with the earliest deadline has the highest priority, while the task with the latest deadline has the lowest priority. **Minimum-Laxity-First Algorithm (MLF)** assigns a *laxity* to each task in a system, and then selects the task with the minimum laxity to execute next. Laxity is defined as the difference between deadline by which the task must be completed and the amount of computation remaining to be performed. **Maximum-Urgency-First Algorithm (MUF)** is a combination of fixed and dynamic priority scheduling. In this algorithm each task is given an urgency which is defined as a combination of two fixed priorities, and a dynamic priority. One of the fixed priorities, called the criticality, has highest priority among the three, and then comes the dynamic priority which has precedence over the user priority (fixed priority). The dynamic priority is inversely proportional to the laxity of a task.

B. Related Work

In real time systems, the rate monotonic algorithm is the optimal fixed priority scheduling algorithm where as the earliest-deadline-first and minimum-laxity-first algorithms are the optimal dynamic priorities scheduling algorithms as

presented by Liu and Layland in their paper [1]. S. Baskiyar and N. Meghanathan have presented a survey on contemporary Real Time Operating System (RTOS) which includes parameters necessary for designing a RTOS, its desirable features and basic requirements[6]. A dynamically reconfigurable system can change in time without the need to halt the system. David B. Stewart and Pradeep K. Khosla proposed the maximum-urgency-first algorithm, which can be used to predictably schedule dynamically changing systems [2]. The scheduling mechanism of the maximum-urgency-first may cause a critical task to fail. The modified maximum urgency first scheduling algorithm by Vahid Salmani, Saman Taghavi Zargar, and Mahmoud Naghibzadeh resolves the above mentioned problem [7]. C.Yashuwaanth proposed a Modified RR(MRR) algorithm which overcomes the limitations of simple RR and is suitable for the soft real time systems [8].

C. Our Contribution

In our work, we have proposed an improved algorithm as compared to the algorithm defined in [8]. Instead of taking static time quantum, we have taken dynamic time quantum which changes with every round of execution. Our experimental results show that PBDRR performs better than algorithm MRR in [8] in terms of reducing the number of context switches, average waiting time and average turnaround time.

D. Organization of Paper

Section II presents the pseudo code and illustration of our proposed PBDRR algorithm. In section III, Experimental results of the PBDRR algorithm and its comparison with the MRR algorithm is presented. Section IV contains the conclusion.

II. OUR PROPOSED ALGORITHM

The early the shorter processes are removed from the ready queue, the better the turnaround time and the waiting time. So in our algorithm, the shorter processes are given more time quantum so that they can finish their execution earlier. Here shorter processes are defined as the processes having less assumed CPU burst time than the previous process. Performance of RR algorithm solely depends upon the size of time quantum. If it is very small, it causes too many context switches. If it is very large, the algorithm degenerates to FCFS. So our algorithm solves this problem by taking dynamic intelligent time quantum where the time quantum is repeatedly adjusted according to the shortness component.

A. Our Proposed Algorithm

In our algorithm, Intelligent Time Slice(ITS) is calculated which allocates different time quantum to each process based on priority, shortest CPU burst time and context switch avoidance time. Let the original time slice (OTS) is the time slice to be given to any process if it deserves no special consideration. Priority component (PC) is assigned 0 or 1 depending upon the priority assigned by the user which is

inversely proportional to the priority number. Processes having highest priority are assigned 1 and rest is assigned 0. For Shortness Component(SC) difference between the burst time of current process and its previous process is calculated. If the difference is less than 0, then SC is assigned 1, else 0. For calculation of Context Switch Component (CSC) first PC, SC and OTS is added and then their result is subtracted from the burst time. If this is less than OTS, it will be considered as Context Switch Component (CSC). Adding all the values like OTS, PC, SC and CSC, we will get intelligent time slice for individual process.

Let 'TQ_i' is the time quantum in round i. The number of rounds i varies from 1 to n, where value of i increments by 1 after every round till ready queue is not equal to NULL.

1. Calculate ITS for all the processes present in the ready queue.
 2. While(ready queue!= NULL)
{
For i=1 to n do
{
if (i ==1)
{
TQ_i = { ½ ITS, if SC= 0
ITS, otherwise
}
Else
{
TQ_i = { TQ_{i-1} + ½ TQ_{i-1}, if SC=0
2 * TQ_{i-1}, otherwise
}
If (remaining burst time -TQ_i) <=2
TQ_i = remaining burst time
} End of For
} End of while
 3. Average waiting time, average turnaround time and no. of context switches are calculated
- End

Fig-1: Pseudo Code of Proposed PBDRR Algorithm

C. Illustration

Given the CPU burst sequence for five processes as 50 27 12 55 5 with user priority 1 2 1 3 4 respectively. Original time slice was taken as 4. The priority component (PC) were calculated which were found as 1 0 1 0 0. Then the shortness component (SC) were calculated and found to be 0 1 1 0 1. The intelligent time slice were computed as 5 5 6 4 5. In first round, the processes having SC as 1 were assigned time quantum same as intelligent time slice whereas the processes having SC as 0 were given the time quantum equal to the ceiling of the half of the intelligent time slice. So processes P1, P2, P3, P4, P5 were assigned time quantum as 3

5 6 2 5. In next round, the processes having SC as 1 were assigned double the time slice of its previous round whereas the processes with SC equals to 0 were given the time quantum equal to the sum of previous time quantum and ceiling of the half of the previous time quantum. Similarly time quantum is assigned to each process available in each round for execution.

III. EXPERIMENTS AND RESULTS

A. Assumptions

The environment where all the experiments are performed is a single processor environment and all the processes are independent. Time slice is assumed to be not more than maximum burst time. All the parameters like burst time, number of processes, priority and the intelligent time slice of all the processes are known before submitting the processes to the processor. All processes are CPU bound and no processes are I/O bound.

B. Experimental Frame Work

Our experiment consists of several input and output parameters. The input parameters consist of burst time, time quantum, priority and the number of processes. The output parameters consist of average waiting time, average turnaround time and number of context switches.

C. Data set

We have performed three experiments for evaluating performance of our new proposed PBDRR algorithm and MRR algorithm. We have considered 3 cases of the data set as the processes with burst time in increasing, decreasing and random order respectively. The significance the performance metrics for our experiment is as follows. *Turnaround time(TAT)*: For the better performance of the algorithm, average turnaround time should be less. *Waiting time(WT)*: For the better performance of the algorithm, average waiting time should be less. *Number of Context Switches(CS)*: For the better performance of the algorithm, the number of context switches should be less.

D. Experiments Performed

To evaluate the performance of our proposed PBDRR algorithm and MRR algorithm, we have taken a set of five processes in three different cases. Here for simplicity, we have taken 5 processes. The algorithm works effectively even if it used with a very large number of processes. In each case, we have compared the experimental results of our proposed PBDRR algorithm with the MRR algorithm presented in [8].

Case 1: We assume five processes arriving at time = 0, with increasing burst time (P1 = 5, P2 = 12, P3 = 16, P4 = 21, p5= 23) and priority (p1=2, p2=3, p3=1, p4=4, p5=5).

TABLE-1 (MRR – Case 1)

Process id	Burst time	Priority	OTS	PC	SC	CSC	ITS
P1	5	2	4	0	0	1	5
P2	12	3	4	0	0	0	4
P3	16	1	4	1	0	0	5
P4	21	4	4	0	0	0	4
P5	23	5	4	0	0	0	4

TABLE-2 (PBDRR- Case 1)

Process id	SC	ITS	ROUNDS				
			1 st	2 nd	3 rd	4 th	5 th
P1	0	5	5	0	0	0	0
P2	0	4	2	3	7	0	0
P3	0	5	3	5	8	0	0
P4	0	4	2	3	5	8	3
P5	0	4	2	3	5	8	5

TABLE – 3 (Comparison between MRR and PBDRR)

Algorithm	Average TAT	Average WT	CS
MRR	51.2	35.8	19
PBDRR	46.4	31	17

The TABLE-1 and TABLE-2 show the output using algorithm MRR and our new proposed PBDRR algorithm. Table-3 shows the comparison between the two algorithms. Figure-2 and Figure-3 show Gantt chart for algorithms MRR and PBDRR respectively.



Fig. 2 : Gantt Chart for MRR(Case-1)

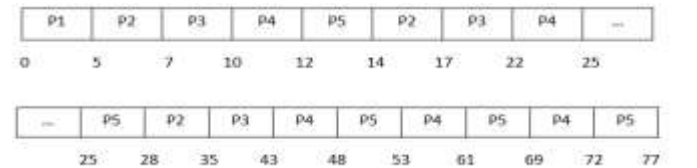


Fig. 3: Gantt Chart for PBDRR (Case-1)

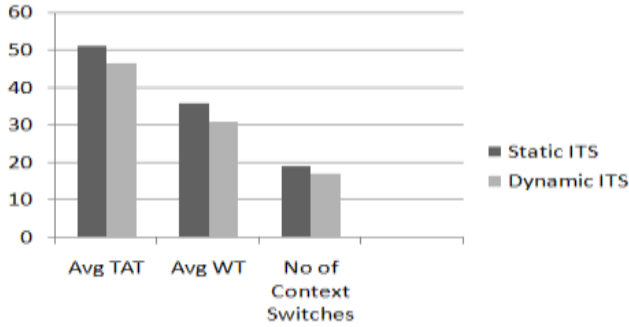


Fig.4 : Comparison of Performance of Algorithms - MRR with Static ITS and PBDRR with dynamic ITS (Case-1)

Case 2: We Assume five processes arriving at time = 0, with decreasing burst time (P1 = 31, P2 = 23, P3 = 16, P4 = 9, p5= 1) and priority (p1=2, p2=1, p3=4, p4=5, p5=3). The TABLE-4 and TABLE-5 show the output using algorithms MRR and PBDRR respectively. TABLE-6 shows the comparison between the two algorithms.

TABLE-4 (MRR- Case 2)

Process id	Burst time	Priority	OTS	PC	SC	CSC	ITS
P1	31	2	4	0	0	0	4
P2	23	1	4	1	1	0	6
P3	16	4	4	0	1	0	5
P4	9	5	4	0	1	0	5
P5	1	3	4	0	1	0	1

TABLE-5 (PBDRR- Case 2)

Process ID	Burst Time	SC	ITS	Rounds			
				1 st	2 nd	3 rd	4 th
P1	31	0	4	2	3	5	21
P2	23	1	6	6	12	5	0
P3	16	1	5	5	11	0	0
P4	9	1	5	5	4	0	0
P5	1	1	1	1	0	0	0

TABLE – 6 (Comparison between MRR and PBDRR)

Algorithm	Avg TAT	Avg WT	CS
MRR	54	38	18
PBDRR	50.4	34.4	12

Figure-5 and Figure-6 show Gantt chart for the algorithms MRR and PBDRR respectively.

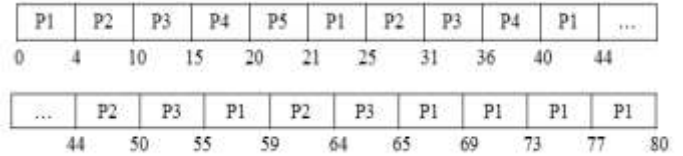


Fig. 5 : Gantt Chart for MRR(Case-2)

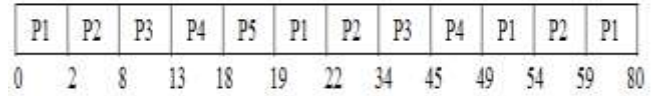


Fig. 6: Gantt Chart for PBDRR (Case-2)

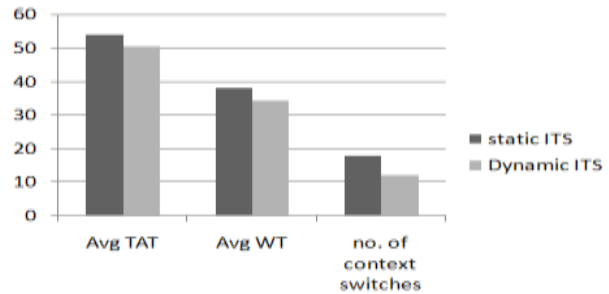


Fig. 7 : Comparison of Performance of Algorithms - MRR with Static ITS and PBDRR with dynamic ITS (Case-2)

Case 3: We assume five processes arriving at time = 0, with random burst time (P1 = 11, P2 = 53, P3 = 8, P4 = 41, p5= 20) and priority (p1=3, p2=1, p3=2, p4=4, p5=5). The TABLE-7 and TABLE-8 show the output using algorithms MRR and PBDRR respectively. TABLE-9 shows the comparison between the two algorithms. Figure-8 and Figure-9 show Gantt chart for both the algorithms.

TABLE-7 (MRR- Case 3)

Process id	Burst time	Priority	OTS	PC	SC	CSC	ITS
P1	11	3	4	0	0	0	4
P2	53	1	4	1	0	0	5
P3	8	2	4	0	1	3	8
P4	41	4	4	0	0	0	4
P5	20	5	4	0	1	0	5

TABLE-8 (PBDRR- Case 3)

Process id	SC	ITS	ROUNDS					
			1 st	2 nd	3 rd	4 th	5 th	6 th
P1	0	4	2	3	6	0	0	0
P2	0	5	3	5	8	12	18	7
P3	1	8	8	0	0	0	0	0
P4	0	4	2	3	5	8	12	11
P5	1	5	5	10	5	0	0	0

Algorithm	Avg TAT	Avg WT	CS
MRR	80.8	54.2	29
PBDRR	76	49.4	18



Fig. 8 : Gantt Chart for MRR(Case-3)



Fig. 9 : Gantt Chart for PBDRR (Case-3)

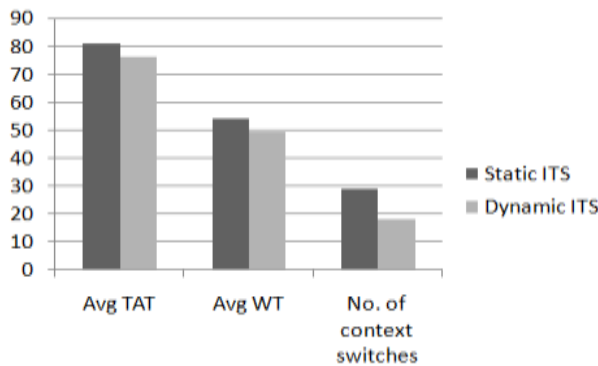


Fig.10 : Comparison of Performance of Algorithms - MRR with Static ITS and PBDRR with dynamic ITS (Case-3)

IV. CONCLUSION

From the above comparisons, we observed that our new proposed algorithm PBDRR is performing better than the algorithm MRR proposed in paper [8] in terms of average waiting time, average turnaround time and number of context switches thereby reducing the overhead and saving of memory spaces. In the future work, deadline can be considered as one of the input parameter in addition to the priority in the proposed algorithm. Hard Real Time Systems have hard deadline, failing which causes catastrophic events. In future

work, a new algorithm in hard real time systems with deadline can be developed.

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Application of Expert System with Fuzzy Logic in Teachers' Performance Evaluation

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Abstract— This paper depicts adaptation of expert systems technology using fuzzy logic to handle qualitative and uncertain facts in the decision making process. Human behaviors are mostly based upon qualitative facts, which cannot be numerically measured and hardly to decide correctly. This approach is an attempt to cope with such problems in the scenario of teachers' performance evaluation. An Expert System was developed and applied to the acquired knowledge about the problem domain that showed interesting results providing a sketch for students and researchers to find solutions of such types of problems. Through Fuzzy Logic we numerically weighted the *linguistic terms*, like; very good, good, bad, or high, medium, low or satisfied, unsatisfied by assigning priorities to these qualitative facts. During final decision making, key parameters were given weights according to their priorities through mapping numeric results from uncertain knowledge and mathematical formulae were applied to calculate the numeric results at final. In this way this ES will not only be useful for decision-makers to evaluate teachers' abilities but may also be adopted in writing Annual Confidential Reports (ACR) of about all the employees of an organization.

Keywords— Expert System, Fuzzy Random Variables, Decision Making, Teachers' Performance, Qualitative & Uncertain Knowledge.

I. INTRODUCTION

Computer programs using Artificial Intelligence (AI) techniques to assist people in solving difficult problems involving knowledge, heuristics, and decision-making are called expert systems, intelligent systems, or smart systems [18]. An expert system can be designed based on a set of rules to determine what action to set off when a certain situation is encountered [24]. In other words expert system is such a technology that able the human being to collect & control the human experts' knowledge and expertise in a particular problem domain for further use to solve similar problems through computer system.

Experts of any fields are always few in numbers, expensive to consult and they have short time due to much work to do. So there is an urgent need of storing the expert's knowledge in the computer in such a way that have a great extent of knowledge of problem domain solving problems of the users and sparing experts for others works "unpublished" [2]. In this paper we discuss the teachers' performance evaluation through AI technology at higher education

institutions of Pakistan. The proposed Fuzzy Expert System considering various aspects of teachers attributes, like research & publication, teaching learning process, personal skills & abilities, compensation, achievements & recognition etc that have deep influence on the teachers' performance in universities investigated by [1].

In this paper a fuzzy expert system's model is designed to combine the knowledge and expertise of human experts with reasoning capabilities that will provide a great support to executives for decision-making in educational institutions. This paper is organized as: the *section II* discusses the applications of expert system & fuzzy logic in teachers' assessment and education, *section III* briefly describes the teachers' evaluation, and *section IV* explains the proposed approach for the solution of the entitled problem.

II. STUDY BACKGROUND

From last few decades, academics and researchers began to recognize the importance of expert system and its related concepts became one of the most popular topics related to decision making and knowledge management. From the beginning, expert systems have been developed in divers areas, like agriculture, chemistry, computer science, engineering, geology, medicine, space technology etc. [14]; and widely applied to various studies and issues, including performance assessment [3; 26; 27], commercial loan underwriting [19], logistics strategy design [11], farm productivity [25], mergers and acquisitions [28], defence budget planning [29], earthquake design [6], system dynamics [32], conveyor equipment selection [15], customer service management [9] and knowledge inertia [20]. For example, in [13] used the development and implementation of an educational tool based on knowledge based technology employing an expert system shell— a knowledge base system for postgraduate engineering courses. In [17] extract project WBS from the obtained mind map of brainstorming project team by artificial intelligence (AI) tools which is Prolog programming language. In [5] used expert system technology for providing developmental feedback to individuals from different ethnic minority groups. Melek and Sadeghian, [22] developed a theoretic framework for intelligent expert systems in medical encounter evaluation. Shen et al., [31] constructed an intelligent assessment system model and compared with the current assessment in education, this new intelligent assessment system expands the range of objects

for evaluation and takes some AI technologies to give more heuristic and intelligent assessments.

According to Zadeh [33, 34] variables words or sentences as their values is called linguistics variables and the variables that represents the gradual transition from high to low, true to false is called fuzzy variables and a set containing these variables is the fuzzy set. Fuzzy logic can be incorporated into expert system to enhance the performance and reliability of expert system in decision making. Fuzzy logic principals with expert system form a fuzzy expert system which is able to implement human knowledge & expertise with imprecise, ambiguous and uncertain data. Recently, many researchers worked on the applications of fuzzy logic in education & assessments. Chiang and Lin [10] presented a method for applying the fuzzy set theory to teaching assessment. Bai and Chen [4] presented a new method for evaluating students' learning achievement using fuzzy membership functions and fuzzy rules. Chang and Sun [8] presented a method for fuzzy assessment of learning performance of junior high school students. Chen and Lee [7] presented two methods for students' evaluation using fuzzy sets. Ma and Zhou [21] presented a fuzzy set approach to the assessment of student-centered learning. In [30] presented a method for applying the fuzzy set theory and the item response theory to evaluate the learning performance of students. In "unpublished" [2] proposed an intelligent framework for teachers' performance evaluations in higher education.

The literature reveals that there is a vast potential of expert system and fuzzy logic in education as general and performance assessment, as a special.

III. TEACHERS' PERFORMANCE EVALUATION

The world is divided into developed and developing countries; the division is their capacity of educational and scientific attainment and its applications for economic progress and prosperity [16]. In developing countries, higher education is seen as an essential means for creation and development of resources and for improving the life of people to whom it has to serve. The problem with developing countries including Pakistan is that they have given a relatively low priority to higher education [23]. There are many reasons behind the poor status of Pakistan higher education. One of the top issues regarding the quality of higher education is the faculty (teachers) [23].

Permanent hired teachers in higher education's institutions especially in colleges did not update their knowledge and courses. They did the teaching as a routine activity and follow some particular books from years. Thus, students could not get updated knowledge and so fails to compete in market "unpublished" [2].

To put the existing teachers on track, it is very necessary to evaluate their performance, may be in quarterly, in semester or annually, depends upon the resources universities posses. Unfortunately, there exists no standard method for evaluating teachers' performance in higher education institutions or computerized solution that covers all factors affecting directly or indirectly the performance of university teachers. Although, the Higher Education Commission (HEC) has did lot of regarding quality assurance by establishing an idea of the Quality Enhancement Cells (QEC) in universities;

but is rarely followed by universities due to time consuming manual process and availability of funds.

IV. METHOD

In this research, expert system was adopted using fuzzy logic principals for teachers' evaluation process. In [2] they have developed the knowledge acquisition tool for the teachers' assessment problem in the development of intelligent expert system. They have extracted a set of 99 attributes from literature that have influence on teachers' performance by any means in higher education; the extracted attributes were divided in to 15 groups.

TABLE I
GROUPS OF ATTRIBUTES (SOURCE: AMIN & KHAN (2009))

S. No	Main Groups of Attributes	Weights
1	Research Orientation	0.0753
2	Publication	0.0742
3	Teaching Learning Process	0.0729
4	Personal Abilities	0.0727
5	Responsibility & Punctuality	0.0726
6	Compensation & Rewards	0.0726
7	Professional Ethics	0.0720
8	Job Security & Environment Factors	0.0706
9	Supervision	0.0677
10	Administrative Skills	0.0674
11	Awards & Achievements	0.0605
12	Promotion Factors	0.0602
13	Organization Evaluation Policy	0.0577
14	Needs & Requirements	0.0550
15	Background Factors	0.0490
	Total weight:	1.0000

They have received responses from 25 highly qualified and well experienced subject experts from 11 different universities of Pakistan about the various factors that affect teachers' performance and also the experts' ranked these factors. The initial results and priority assigned to those factors are shown in Table-I.

The *Research Orientation* is ranked highest weight (0.0753) which indicates that research work is much more important than any other task in higher education. See Figure 1 for detail.

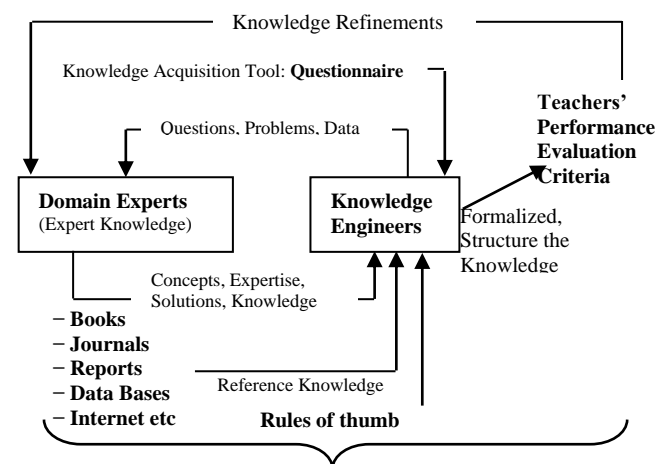


Fig. 1 Knowledge Acquisition Process [source: Amin & Khan (2009)]

In [33] developed an important logic concept that able researchers to measure the linguistic variables with ambiguous & uncertain knowledge into numeric values in decision making process for decision makers in real world problems. In this research, the author used the concept of fuzzy set and the membership functions to map the linguistic characteristics of teachers' performance that are either ranked High, Medium, or Low by the academic evaluators in higher education institutions. The degree of membership in fuzzy set is [1, 0], where '1' represents highest membership and '0' represents no membership. A fuzzy variable set and their membership value is defined as shown in Table-II.

TABLE II
FUZZY VARIABLES FOR INPUT PARAMETERS

Fuzzy variable	Degree of Membership
Very High	1.0
High	0.8
Medium	0.6
Low	0.4
Very Low	0.2
Null	0

The inputs data for a particular teacher's evaluation comes from various sources that may be research productivity & publications, academics awards & achievements, students' satisfactions, immediate head satisfaction, colleagues' opinions, and annual confidential report. Most of these inputs are in non-numeric or linguistic form. Therefore, a model is designed to process these inputs through fuzzy concept to support decision makers in teachers' performance assessment at higher education institutions.

As shown in Figure 2; the extracted knowledge is weighted according to the assigned priorities assigned by subject experts in the knowledge acquisition process and fuzzy concepts are then applied to handle the qualitative knowledge for efficient decision making possibility. All the fuzzy expert system components interact among each other to perform their functionalities achieving results. Let's take one group of attributes from Table-I with all its sub-factors along with assigned weights and compute the result for a particular case. Now observe Table-III, the maximum weight of all the teachers' performance criteria is 1.0000 and the selected main attribute got maximum weight as 0.0729; while its sub factors along with their weights are shown.

TABLE III
MAIN ATTRIBUTE ALONG WITH SUB-FACTORS

Teachers' Performance Evaluation in Higher Education Max Weight 1.0000	
Main Attribute	Sub Factors
TEACHING LEARNING PROCESS Weight 0.0729	Proficiency in teaching 0.0054
	Personal Interest In Teaching 0.0075
	Presentation & Communications skills 0.0063
	Speaking Style & Body language 0.0050
	Content knowledge 0.0059
	Lecture preparation 0.0067
	Language command 0.0059
	Response to Student queries 0.0067

Question Tackling	0.0050
Courses taught	0.0038
Students Performance	0.0029
Work load	0.0046
Fairness in marking	0.0071

The knowledge representation of the above main attribute with its sub-factors in fuzzy rules takes the following form.

```

IF proficiency_teaching is Very High THEN W= 0.0054
IF proficiency_teaching is High THEN W= 0.0043
IF proficiency_teaching is Medium THEN W=0.0032
IF proficiency_teaching is Low THEN W= 0.0022
IF proficiency_teaching is Very Low THEN W= 0.0011

IF personal_interest_teach is Very High THEN W= 0.0075
IF personal_interest_teaching is High THEN W= 0.0060
IF personal_interest_teaching is Medium THEN W=0.0045
IF personal_interest_teaching is Low THEN W= 0.0030
IF personal_interest_teaching is Very Low THEN W=
0.0015

IF present_Comm_skill is Very High THEN W= 0.0063
IF present_Comm_skill is High THEN W= 0.0050
IF present_Comm_skill is Medium THEN W=0.0038
IF present_Comm_skill is Low THEN W= 0.0025
IF present_Comm_skill is Very Low THEN W= 0.0013

IF style_body_language is Very High THEN W= 0.0050
IF style_body_language is High THEN W= 0.0040
IF style_body_language is Medium THEN W=0.0030
IF style_body_language is Low THEN W= 0.0020
IF style_body_language is Very Low THEN W= 0.0010

IF content_knowledge is Very High THEN W= 0.0059
IF content_knowledge is High THEN W= 0.0047
IF content_knowledge is Medium THEN W=0.0035
IF content_knowledge is Low THEN W= 0.0024
IF content_knowledge is Very Low THEN W= 0.0012

IF lecture_preparation is Very High THEN W= 0.0067
IF lecture_preparation is High THEN W= 0.0054
IF lecture_preparation is Medium THEN W=0.0040
IF lecture_preparation is Low THEN W= 0.0027
IF lecture_preparation is Very Low THEN W= 0.0013

IF language_command is Very High THEN W= 0.0059
IF language_command is High THEN W= 0.0047
IF language_command is Medium THEN W=0.0035
IF language_command is Low THEN W= 0.0024
IF language_command is Very Low THEN W= 0.0012

IF response_student_queries is Very High THEN W=
0.0067
IF response_student_queries is High THEN W= 0.0054
IF response_student_queries is Medium THEN W=0.0040
IF response_student_queries is Low THEN W= 0.0027
IF response_student_queries is Very Low THEN W= 0.0013

IF question_tack is Very High THEN W= 0.0050
IF question_tack is High THEN W= 0.0040
IF question_tack is Medium THEN W=0.0030
IF question_tack is Low THEN W= 0.0020
IF question_tack is Very Low THEN W= 0.0010

IF courses_taught is Very High THEN W= 0.0038
IF courses_taught is High THEN W= 0.0030
IF courses_taught is Medium THEN W=0.0023
IF courses_taught is Low THEN W= 0.0015
IF courses_taught is Very Low THEN W= 0.0008

IF student_perform is Very High THEN W= 0.0029
IF student_perform is High THEN W= 0.0023
IF student_perform is Medium THEN W=0.0017
IF student_perform is Low THEN W= 0.0012
IF student_perform is Very Low THEN W= 0.0006

IF workload is Very High THEN W= 0.0046
IF workload is High THEN W= 0.0037
IF workload is Medium THEN W=0.0028
    
```

IF workload is Low THEN W= 0.0018
IF workload is Very Low THEN W= 0.0009
IF fairness_marking is Very High THEN W= 0.0071
IF fairness_marking is High THEN W= 0.0057
IF fairness_marking is Medium THEN W=0.0043
IF fairness_marking is Low THEN W= 0.0028
IF fairness_marking is Very Low THEN W= 0.0014

The terms *Very High, High, Medium, Low, Very Low* are fuzzy variables on the basis the weight W varies. This is because the fuzzy membership function application which able the system to map qualitative variables as numeric one. Before entering input case to the fuzzy expert system, let's discuss the computational formula which was applied in fuzzy expert system for calculating decision making score.

To calculate the decision score of any single main attribute with its all sub factors the following summation formula is defined and used.

$$C_i = \sum_{n=1}^m P_n W_n \dots\dots\dots (1)$$

Where, C_i = i^{th} main attribute.
 M = number of sub-factors in the i^{th} attribute.
 P_n = Fuzzy value of n^{th} input parameter
 W_n = Expert weight of the relative input parameter

TABLE IV
EXAMPLES OF INPUT CASES

Three different examples as input cases to the Fuzzy Expert system				
All Sub Factors		Case A	Case B	Case C
Proficiency in teaching	0.0054	H	M	L
Personal Interest In Teaching	0.0075	H	M	L
Presentation & Comm. Skills	0.0063	VH	H	L
Speaking Style & Body lang.	0.0050	M	L	M
Content knowledge	0.0059	M	L	M

Lecture preparation	0.0067	H	M	H
Language command	0.0059	VH	H	VH
Response to Student queries	0.0067	VH	VH	H
Question Tackling	0.0050	M	L	M
Courses taught (nature)	0.0038	M	M	L
Students Performance	0.0029	VH	M	M
Work load	0.0046	H	H	H
Fairness in marking	0.0071	M	M	M

The above input data (Table-IV) is entered to the Fuzzy Expert System; through a built-in interface of the system for computing decision score as shown in Figure-3. Numbers 5, 4, 3, 2, 1 entered as input representing 5=Very High, 4=High, 3=Medium, 2=Low, 1=Very Low. In Figure 3, the interface two buttons have also shown, i.e., *Explain* and *Why* which are available for explanation of inputs and reasoning capabilities respectively.

After completion of the input data the Fuzzy Expert System used the scale in Table-V, to rank the three cases A, B, C respectively.

TABLE V
DECISION MAKING SCALE TO A LINGUISTIC DESCRIPTION
(MAX WEIGHT 0.0729)

Fuzzy Expert system output	Linguistic Description
$X < 0.0109$	Poor
$0.0109 \leq X < 0.0218$	Satisfied
$0.0218 \leq X < 0.0328$	Good
$0.0328 \leq X < 0.0437$	Very Good
$0.0437 \leq X < 0.0546$	Excellent
$X \geq 0.0546$	Outstanding

According to the developed scale in Table-V, the Fuzzy Expert System mapped the calculated numeric results of the three cases from qualitative input data into linguistic output description, as shown in Table-VI.

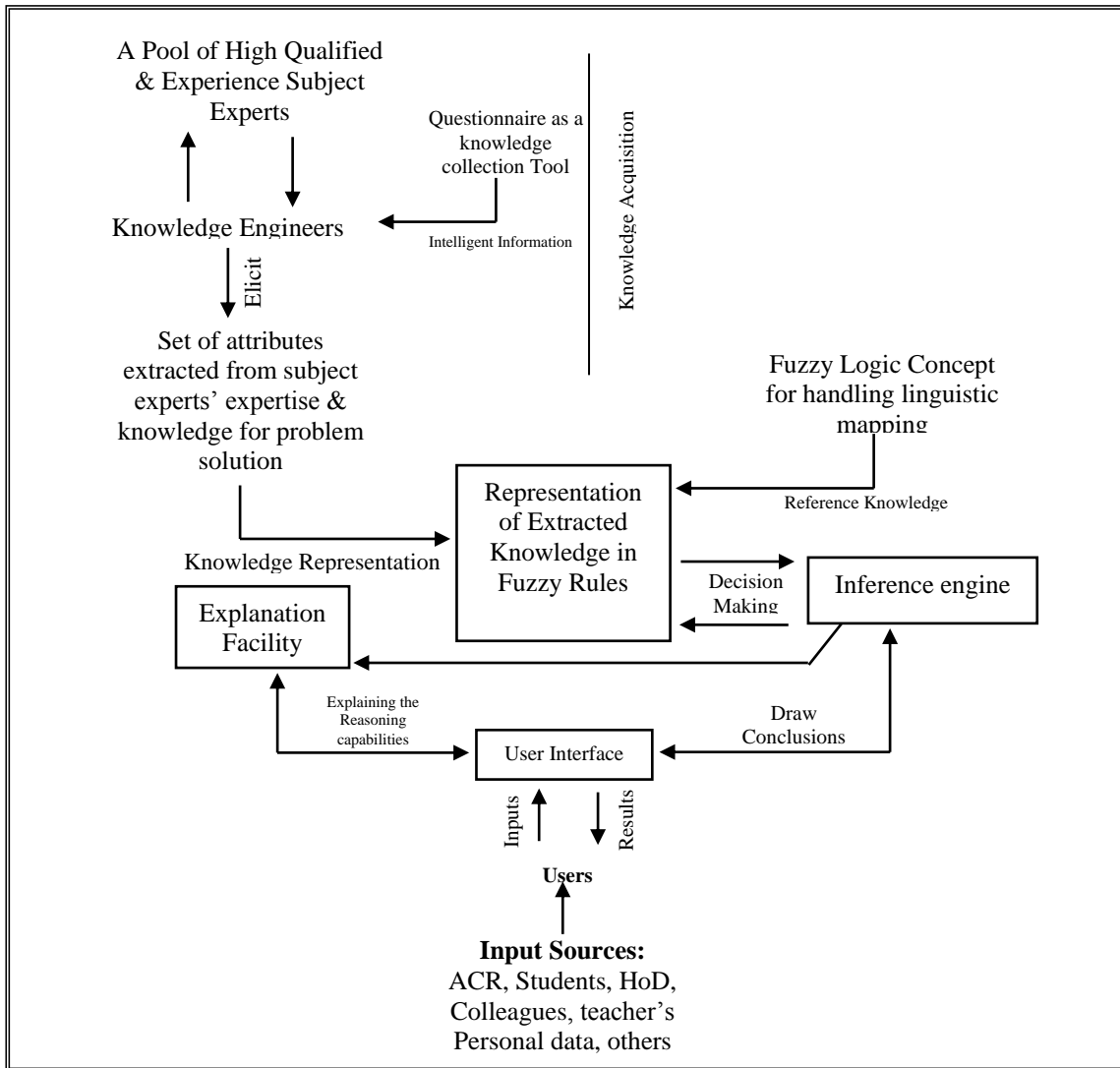


Fig. 2 Fuzzy Expert System Model

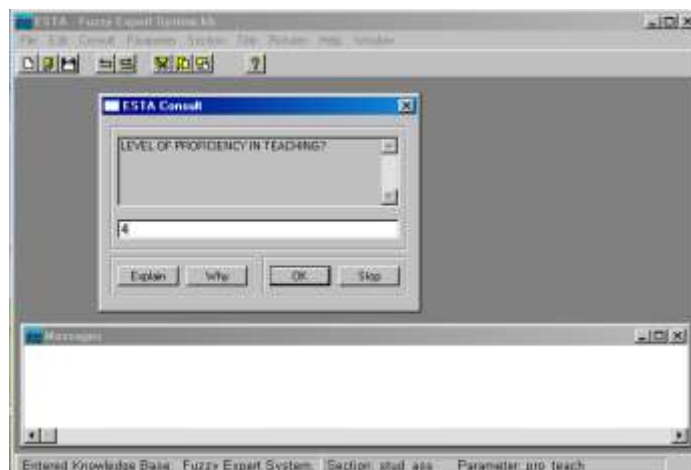


Fig. 3 User Interface

TABLE VI
THREE CASES RANKING

A	0.0573	Outstanding
B	0.0465	Excellent
C	0.0451	Excellent

Case	System Calculation	Description
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V. CONCLUSION & FUTURE DIRECTION

Regular teachers' assessment is suggested to maintain quality in higher education; literature clearly depicts that there is a vast potential of the applications of fuzzy logic & expert system in teachers' assessment. Expert system technology using Fuzzy Logic is very interesting for qualitative facts evaluation. A model of fuzzy expert system is proposed to evaluate teachers' performance on the basis of various key performance attributes that have been validated previously through subject experts. The fuzzy scale has been designed to map & control the input data values from absolute truth to absolute false. The qualitative variables are mapped into numeric results by implementing the fuzzy expert system's model through various input examples and provided a basis to use the system ranking for further decision making. Thus, the uncertain and qualitative knowledge of the problem domain have been handled absolutely through integration of expert system technology with fuzzy logic concept.

The proposed model produced significant bases for performance assessment and adequate support in decision making, so the research on the issue can be continued. Important aspect of this issue that could focus on in the future is the fuzzy expert system's model that could be extended to all type of employees' assessment in universities as well as in others government & private organizations.

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Dynamic Approach to Enhance Performance of Orthogonal Frequency Division Multiplexing (OFDM) In a Wireless Communication Network

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Abstract—In the mobile radio environment, signals are usually impaired by fading and multipath delay phenomenon. This work modeled and simulates OFDM in a wireless environment, it also illustrates adaptive modulation and coding over a dispersive multipath fading channel whereby simulation varies the result dynamically. Dynamic approach entails adopting probabilistic approach to determining channel allocation; First an OFDM network environment is modeled to get a clear picture of the OFDM concept. Next disturbances such as noise are deliberately introduced into systems that are both OFDM modulated and non-OFDM modulated to see how the system reacts. This enables comparison of the effect of noise on OFDM signals and non-OFDM modulated signals. Finally efforts are made using digital encoding schemes such as QAM and DPSK to reduce the effects of such disturbances on the transmitted signals. In the mobile radio environment, signals are usually impaired by fading and multipath delay phenomenon. In such channels, severe fading of the signal amplitude and inter-symbol-interference (ISI) due to the frequency selectivity of the channel cause an unacceptable degradation of error performance. Orthogonal frequency division multiplexing (OFDM) is an efficient scheme to mitigate the effect of multipath channel.

Keywords- OFDM, Inter-Carrier Interference, IFFT, multipath, Signal.

I. INTRODUCTION

Mobile radio communication systems are increasingly demanded to provide a variety of high- quality services to mobile users. To meet this demand, modern. mobile radio transceiver system must be able to support high capacity, variable bit rate information transmission and high bandwidth efficiency. In the mobile radio environment, signals are usually impaired by fading and multipath delay phenomenon. In such channels, severe fading of the signal amplitude and inter-symbol-interference (ISI) due to the frequency selectivity of the channel cause an unacceptable degradation of error performance. Orthogonal frequency division multiplexing (OFDM) is an efficient scheme to mitigate the effect of multipath channel. Since it eliminates ISI by inserting guard interval (GI) longer than the

delay spread of the channel [1], [2]. Therefore, OFDM is generally known as an effective technique for high data rate services. Moreover, OFDM has been chosen for several broadband WLAN standards like IEEE802.11a, IEEE802.11g, and European HIPERLAN/2, and terrestrial digital audio broadcasting (DAB) and digital video broadcasting (DVB) was also proposed for broadband wireless multiple access systems such as IEEE802.16 wireless MAN standard and interactive DVB-T [3]. In OFDM systems, the pilot signal averaging channel estimation is generally used to identify the channel state information (CSI) [5]. In this case, large pilot symbols are required to obtain an accurate CSI. As a result, the total transmission rate is degraded due to transmission of large pilot symbols. Recently, carrier interferometry (CI) has been proposed to identify the CSI of multiple-input multiple-output (MIMO). However, the CI used only one phase shifted pilot signal to distinguish all the CSI for the combination of transmitter and receiver antenna elements.[3,4]

In this case, without noise whitening, each detected channel impulse response is affected by noise [6]. Therefore, the pilot signal averaging process is necessary for improving the accuracy of CSI [7]. To reduce this problem, time, frequency interferometry (TFI) for OFDM has been proposed. [8] – [10].

The main problem with reception of radio signals is fading caused by multipath propagation. There are also inter-symbol interference (ISI), shadowing etc. This makes link quality vary. As a result of the multipath propagation, there are many reflected signals, which arrive at the receiver at different times. Some of these reflections can be avoided by using a directional antenna, but it is impossible to use them for a mobile user. A solution could be usage of antenna arrays, but this technology is still being developed.

This is why this research and development of the OFDM have received considerable attention and have made a great deal of progress in all parts of the world. OFDM is a wideband modulation scheme that is specifically able to cope with the problems of the multipath reception. This is achieved by transmitting many narrowband overlapping digital signals in parallel, inside one wide band. [5]

A. Objective of Project

The aim of this project is to simulate the physical layer of an OFDM system. It investigates the OFDM system as a whole and provides a simple working model on which subsequent research can be built. Hence the successful completion of this work shall involve;

- 1) *Practical description of the OFDM system.*
- 2) *Algorithm development based on mathematical analysis of the OFDM scheme.*
- 3) *Modeling of the algorithm and a software test based on the MATLAB/Simulink environment.*

Thus a typical OFDM system modeling the data source, the transmitter, the air channel and the receiver side of the system is simulated.

This project is intended to model and simulate an OFDM network environment. A simple data source is provided to serve as the input; likewise the transmitter, channel and receiver are modeled using appropriate block-sets in the Simulink. A simple representation of the OFDM system is modeled, though with little deviation from the real implementation. But all efforts had been taken in this work to reduce the effects of such deviations.[6]

B. OVERVIEW

Orthogonal Frequency Division is where the spacing between carriers is equal to the speed (bit rate) of the message. In earlier multiplexing literature, a multiplexer was primarily used to allow many users to share a communications medium like a phone trunk between two telephone central offices. In OFDM, it is typical to assign all carriers to a single user; hence multiplexing is not used with its generic meaning.

Orthogonal frequency division multiplexing is then the concept of typically establishing a communications link using a multitude of carriers each carrying an amount of information identical to the separation between the carriers. In comparing OFDM and single carrier communication systems (SCCM), the total speed in bits per second is the same for both, 1 Mbit/sec (Mbps) in this example. For single carrier systems, there is one carrier frequency, and the 1 Mbps message is modulated on this carrier, resulting in a 1 MHz bandwidth spread on both sides of the carrier. For OFDM, the 1,000,000 bps message is split into 10 separate messages of 100,000 bit/sec each, with a 100 KHz bandwidth spread on both sides of the carrier.[7]

To illustrate how frequencies change with time, we can use the analogy of the sounds of an orchestra or band. One carrier wave is analogous to one instrument playing one note, whereas many carriers is analogous to many instruments playing at once. Single carrier systems using a high speed message is analogous to a drum roll where the sticks are moving fast.

A more detailed understanding of Orthogonal arises when we observe that the bandwidth of a modulated carrier has a so called sinc shape ($\text{sinc}(x)$) with nulls spaced by the bit rate. In OFDM, the carriers are spaced at the bit rate, so that the carriers fit in the nulls of the other carriers.

II. CHOICE OF APPROACH

The bottom-up design approach is chosen for this work because of its concise form and ease of explanation.

A. Modeling the OFDM system

For the simulation, the Signal Processing and the Communication Block-sets are used. The OFDM network can be divided into three parts i.e. the transmitter, receiver and channel. A data source is also provided which supplies the signal to be transmitted in the network. Thereafter, the bit error rate can be calculated by comparing the original signal at the input of the transmitter and the signal at the output of the receiver.

Transmitter

Convolutional encoder. In order to decrease the error rate of the system, a simple convolution encoder of rate 1/2 is used as channel coding.

Interleaver.

The interleaver rearranges input data such that consecutive data are split among different blocks. This is done to avoid bursts of errors. An interleaver is presented as a matrix. The stream of bits fills the matrix row by row. Then, the bits leave the matrix column by column. The depth of interleaver can be adjusted.

Modulation.

- A modulator transforms a set of bits into a complex number corresponding to a signal constellation. The modulation order depends on the subcarrier.
- Bits flow through an interleaver with high SNR will be assigned more bits than a subchannel with low SNR. Modulations implemented here are QPSK, 16QAM and 64QAM.
- Symmetrical IFFT. Data are transformed into time-domain using IFFT. The total number of subcarriers translates into the number of points of the IFFT/FFT. A mirror operation is performed before IFFT in order to get real symbols as output
- Cyclic Prefix (CP). To preserve the orthogonality property over the duration of the useful part of signal, a cyclic prefix is then added. The cyclic prefix is a copy of the last elements of the frame.
- D/A. Convert digital symbols to analog signals. This operation is done using the AIC codec inside the DSP.
- Channel[8]
- The channel must have the same characteristics as the pair of twisted wires found in the telephone network. In order to achieve this, we use a telephone line emulation hardware. Also, we have the possibility to use the adjustable filter ZePo and the noise generator. This can be very useful to test the system performance.

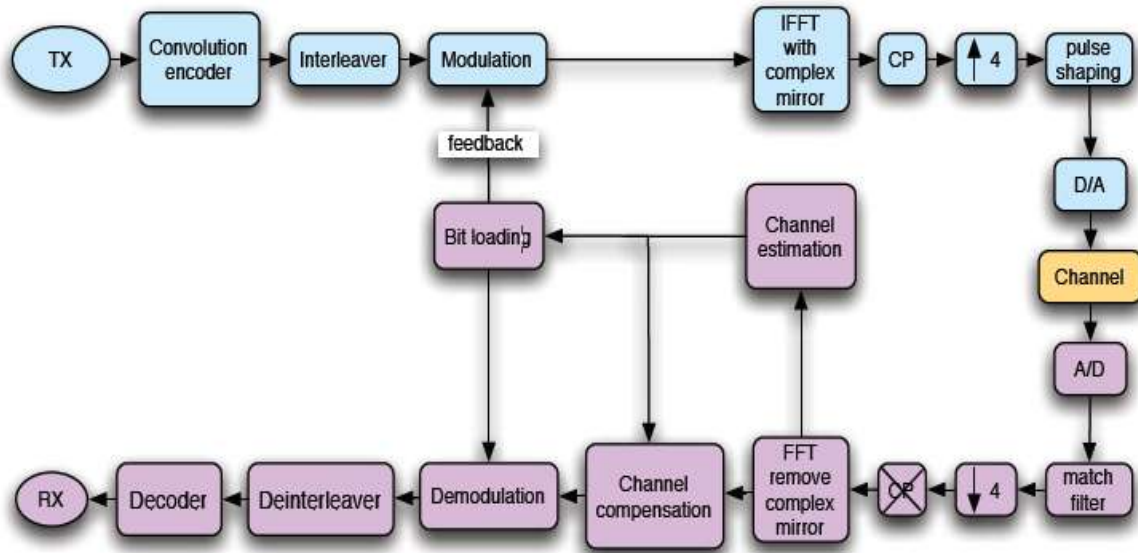


Fig. 2.0 OFDM system

B. Receiver

- A/D. Convert analog signals to digital symbols for processing.
- Synchronization. Due to the clock difference between transmitter and receiver, a synchronization algorithm is needed to find the first sample in the OFDM frame.
- Remove cyclic prefix. This block simply removes the cyclic prefix added in the transmitter.
- Symmetrical FFT. Data are transformed back to frequency-domain using FFT. Then the complex conjugate mirror added in the transmitter is removed.
- Channel estimation. The estimation is achieved by pilot frames.
- Channel compensation. The channel estimation is used to compensate for channel distortion.
- Bit loading. The receiver computes the bit allocation and send it to the transmitter.[9]
- Demodulation. Symbols are transformed back to bits. The inverse of the estimated channel response is used to compensate the channel gain.
- Deinterleaver (Interleaving inverse operation). The stream of bits fills the matrix column by column. Then, the bits leave the matrix row by row.
- Convolution decoder. The decoder performs the Viterbi decoding algorithm to generate transmitted bits from the coded bits.

We assume that a propagation channel consists of L discrete paths with different time delays. The impulse response $h(\tau, t)$ is represented as

$$h(\tau, t) = \sum_{l=0}^{L-1} h_l(\tau) \delta(\tau - t) \dots(2.1)$$

where h_l and τ_l are complex channel gain and the time delay of l th propagation path, respectively,

The channel transfer function $H(f, t)$ is the Fourier transform of $h(\tau, t)$ and is given by

$$H(f, t) = \int_0^{\infty} h(\tau, t) \exp(-j2\pi f\tau) dt \dots(2.2)$$

$$= \sum_{l=0}^{L-1} h_l \exp(-j2\pi f\tau_l) \dots(2.3)$$

$$g(t) = \begin{cases} 1 & \text{for } -T_g < t < T_s \\ 0 & \text{otherwise} \end{cases} \dots(2.4)$$

The guard interval T_g is inserted in order to eliminate the ISI due to the multi-path fading, and hence, we have

$$T = T_s + T_g \dots 2.5$$

In OFDM systems, T_g is generally considered as $T_s/4$ or $T_s/5$. Thus, we assume $T_g = T_s/4$ in this paper. In (3), $g(t)$ is the transmission pulse which gives $g(t)$

C. The Simulation Process

The simulation process is carried out in stages using different digital modulators, and considering different effects of the wireless interface. Hence, the wireless channel effects are varied, as well as the type of digital modulators used for the OFDM modulation. The effect of additive white Gaussian noise (AWGN), is considered on a signal which is QAM modulated. Finally, the combined effect of Phase noise and AWGN on QAM modulated OFDM signal is modeled and simulated. This enables comparison of the effect of noise on OFDM signals using QAM modulation.[11]

D. Mathematical analysis of OFDM system.

This system compares the Error Rates of an OFDM modulated signal with that of a non-OFDM modulated signal. The error rates of an OFDM modulated are expected to be lower than those of non-OFDM

$$s_c(t) = A_c(t)e^{j[\omega_c t + \phi_c(t)]} \dots\dots\dots (2.6)$$

Where

$$\omega_n = \omega_0 + n\Delta\omega \dots\dots\dots (2.7)$$

This is of course a continuous signal. If we consider the waveforms of each component of the signal over one symbol period, then the variables $A_c(t)$ and $\phi_c(t)$ modulated signals which be written as equation 2.8.

OFDM spectrum

- (a) A single Sub-channel
- (b) Five carriers

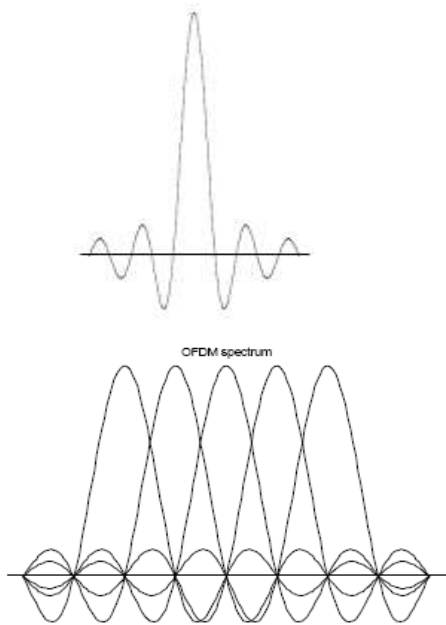


Fig 2.1 Examples of OFDM spectrum

Mathematically, each carrier can be described as a complex wave; [3] take on fixed values, which depend on the frequency of that particular carrier, and so can be rewritten as:

$$\begin{aligned} \phi_n(t) &\Rightarrow \phi_n \\ A_n(t) &\Rightarrow A_n \dots (2.8) \end{aligned}$$

If the signal is sampled using a sampling frequency of $1/T$, then the resulting signal is represented by:

$$s_s(kT) = \frac{1}{N} \sum_{n=0}^{N-1} A_n e^{j[(\omega_0 + n\Delta\omega)kT + \phi_n]} \dots (2.9)$$

At this point, we have restricted the time over which we analyze the signal to N samples. It is convenient to sample over the period of one data symbol. Thus we have a relationship

$$\tau = NT \dots\dots\dots (2.10)$$

If we now simplify eqn. (2.9), without a loss of generality by letting $\omega_0=0$, then the signal becomes:

$$s_s(kT) = \frac{1}{N} \sum_{n=0}^{N-1} A_n e^{j\phi_n} e^{j(n\Delta\omega)kT} \dots\dots\dots (2.10)$$

Now Eq. (2.10) can be compared with the general form of the inverse Fourier transform:

$$g(kT) = \frac{1}{N} \sum_{n=0}^{N-1} G\left(\frac{n}{NT}\right) e^{j2\pi nk/N} \dots\dots\dots (2.11)$$

In eq. (2.10) and (2.11), the function $s(kT)$ is no more than a definition of the signal in the sampled frequency Domain, and $A_n e^{j\phi_n}$ is the time domain representation. Eqns. (2.10) and (2.11) are equivalent if:

$$\Delta f = \frac{\Delta\omega}{2\pi} = \frac{1}{NT} = \frac{1}{\tau} \dots\dots\dots (2.12)$$

E. Factors influencing the control system

1) Signal- To- noise Ratio

AWGN is additive, which means that the noise signal adds to the existing signal, resulting in a distorted version of the original signal.

It is possible to determine the quality of a digitally modulated signal influenced by AWGN using the probability density function and the standard deviation signal. The signal

to- noise ratio is defined as the ratio [4] of the power of the signal to the noise power.

$$SNR = (S_{power} / N_{power}) = (S_{rms}(t, f_c) / n_{rms}(t, f_c))^2 \quad (2.13)$$

Or in decibel;

$$SNR_{dB} = 10 \text{Log}_{10}(SNR) \dots\dots (2.14)$$

F. Probability of Error in QPSK modulation

Because of the randomness of AWGN, it is impossible to predict the exact locations of incorrectly decoded bits, it is however possible to theoretically predict the amount of incorrectly decoded bits in the long run, and from that calculate error probabilities like the symbol- error rates and bit- error rates.

$$P(U_{00} / S_{10}) = P(- < x < 0) = \int_{-\infty}^0 \frac{1}{\sqrt{2\pi}} e^{-(x-(4.92))/(2\sqrt{2}dx)} \dots (2.15)$$

QPSK encodes two data bits into a sinusoidal carrier wave by altering the sinusoidal carrier wave's phase. The probability that a QPSK decoder will incorrectly decode a symbol U_{00} given that the correct transmitted symbol was S_{10} is given as [5].

$$SNR_{QPSK-Db} = [10 \text{Log}_{10} QPSK \text{ signal power} / \text{Noise Power}] + 10 \text{Log}_{10}(52) \dots\dots 2.16$$

TABLE 2.1 : THE OFDM SYMBOL DECODING PROCESS

SNR	BER	SER
2	.11	.05
4	.33	.28
6	.55	.45
8	.69	.63
10	.75	.70
12	.80	.74
14	.85	.76
16	.89	.79
18	.91	.80

Unfortunately, this function is not directly solvable and look up tables are used to determine the results.

There exists a function, though that is closely related to p, The Q- function [5]

The total symbol error rate of a QPSK decoder can finally be calculated as the average symbol error probability of $p(U_{00} / S_{10})$, $p(U_{01} / S_{01})$, $p(U_{10} / S_{10})$

and $p(U_{11} / S_{10}) \dots\dots(2.16.1)$

The SER is given as

$$SER = [2Q(A/\sqrt{2})] \dots\dots\dots (2.17)$$

The Bit- Error- Rate of a QPSK decoder is given as:

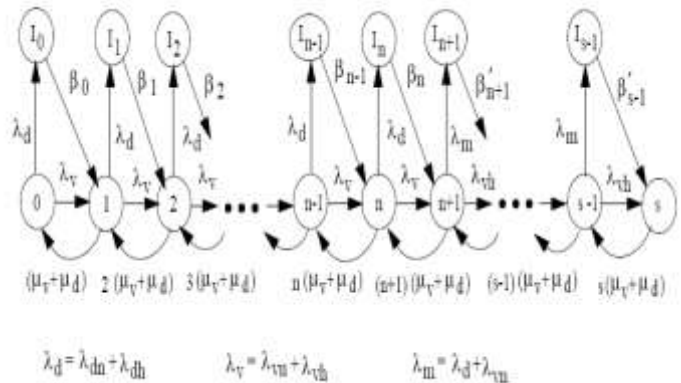
$$BER = [Q(A/\sqrt{2})] \dots\dots\dots (2.18)$$

Expressing the SER and BER as a function of SNR, we have:

$$SER = [2Q(\sqrt{SNR})] \dots\dots\dots(2.19)$$

$$BER = [Q(\sqrt{SNR})] \dots\dots\dots (2.20)$$

From the above relationships of eqns (2.19) and (2.20), the plot for the BER & SER of a QPSK modulated signal is as



shown below

Figure 2.2: shows the state transition diagram for the model of a cell operating under the proposed algorithm.

$$SNR_{QPSK - dB} = [10 \text{Log}_{10} QPSK \text{ signal power} / \text{Noise Power}] \dots\dots 2.21$$

Since IEEE 802.11a OFDM signal has $N_{st} = 52 \dots 2.22$

QPSK sub – carriers, the signal has 52 times more power

$$: SNR_{dB - OFDM} = SNR_{dB - QPSK} + 17.6dB \quad (4.99d)..$$

2.23

G. STATE TRANSITION DIAGRAM

It is a very useful pictorial representation that clearly shows the protocol (rule) operation.

Thus, it's a tool to design the electronics that implements the protocol and troubleshoots communication problems. In a state diagram, all possible activity states of the system are shown in nodes. At each state node, the system must respond to some event occurring and then proceed to the appropriate next state. [9]

H. Probabilistic Channel Allocation in OFDM

For a cell having S channels, the model has 2s+1 states, namely 0, 1, 2, 3, S, I₀, I₁,.....I_{S-1}.

A cell is defined as cold cell if it is in state K, for 0 ≤ K ≤ n, whereas a cell is called hot cell if it is not a state greater than n. If a data call with rate λd (respectively, a voice call with rate λv) arrives in a cold cell with state K, then the cell enters state I_K (respectively, state K+1). On the other hand, if a data call with rate λm or a new voice call with rate λvn arrives in a hot cell in state j for j>n, then the cell enters state I_j. A handoff voice call is always assigned a whole channel. However, a new voice is assigned a whole channel if the cell is a cold cell.

Let P_j denote the steady state probability that the process is in state j, for j =0; 1; 2; _ _ _; S. Assuming that all channel holding times are exponentially distributed.

For j = 0 (i.e., states 0 and I₀):

$$(\lambda d + \lambda v)P_0 = P_1 (\mu d + \mu v) \dots\dots\dots (2.24)$$

$$\lambda d P_0 = P I_0 \beta_0 \dots\dots\dots (2.25)$$

It follows from (1) that

$$P_1 = \frac{\lambda d + \lambda v P_0}{\mu v + \mu d} = \rho P_0 \dots\dots\dots (2.26)$$

For j = 1; 2; n

$$(\lambda d + \lambda v)P_j + j(\mu v + \mu d)P_j = \lambda v P_{j-1} + (j + 1)(\mu v + \mu d)P_{j+1} + P I_{j-1} \beta_{j-1} \dots\dots\dots (2.27)$$

$$\lambda d P_j = P I_j \beta_j \dots\dots\dots (2.28)$$

Eq. (1.5) implies that λd P_{j-1} can be substituted for P I_{j-1} β_{j-1} in (4.4). Hence, Eq. (4.4) can be rewritten as

$$(\lambda d + \lambda v)P_j + j(\mu v + \mu d)P_j = \lambda v P_{j-1} + (j + 1)(\mu v + \mu d)P_{j+1} + \lambda d P_{j-1} = (\lambda d + \lambda v)P_{j-1} + (j + 1)(\mu d + \mu v)P_{j+1} \dots\dots\dots (4.6)$$

By solving (1.6) recursively by letting j = 1; 2; 3 and n-1 in order to obtain

$$P_2 = 1/2! \rho^2 P_0$$

$$P_3 = 1/3! \rho^3 P_0$$

$$P_4 = 1/4! \rho^4 P_0$$

$$P_5 = 1/5! \rho^5 P_0 \text{ and}$$

$$P_n = 1/n! \rho^n P_0 \text{ respectively.}$$

Therefore, for 0 ≤ j ≤ n, we obtain

$$P_j = 1/j! \rho^j P_0 \dots\dots\dots (2.29)$$

For j = n+1, n+2,..... S-1, we have the following balance equation in the equilibrium case

$$(\lambda m + \lambda v h)P_j + j(\mu v + \mu d)P_j = \lambda v h P_{j-1} + (j + 1)(\mu v + \mu d)P_{j+1} + \lambda m P I_{j-1} (\lambda d + \lambda v) P_j + j(\mu d + \mu v)P_j = (\lambda d + \lambda v) P_{j-1} + (j+1)(\mu d + \mu v) P_{(j+1)} \dots\dots\dots (2.30)$$

Where λd + λv = λm + λvh

Note that Equation (10) is the same as Equation (1.6) therefore Equ. (4.7) also holds for j= n+1, n+2,.....S-1.

For j = S

$$S(\mu v + \mu d)P_s = \lambda v h P_{s-1} + P I_{s-1} \beta'_{j-1} = \lambda v h P I_{s-1} = (\lambda v h + \lambda m)P_{s-1} = (\lambda d + \lambda v)P_{s-1} \dots\dots\dots (2.31)$$

$$P_s = 1/S! \rho^s P_0 \dots\dots\dots (2.32)$$

Thus for 0 ≤ J ≤ S, the steady state probability, P_j is

$$P_j = 1/J! \rho^j P_0 \dots\dots\dots (2.33)$$

The P₀ for handoff dropping probability, P_{od}, and new call blocking probability, P_{ob} are equal to the same steady-state probability P_{0s}, that is,

$$P_0 \text{ for } P_d = P_b = P_s \dots\dots\dots (2.34)$$

If a handoff calls requests a free packet slots of a channel and is available. Then based on the algorithm proposed

$$P_d = 1/3j! \rho^j P_0 \dots\dots\dots (2.35)$$

When a new call is assigned a channel, the call is also assigned a channel holding time, which is generated by an exponential distribution function with a mean value of 15 time slots. Call arrival is modeled with Markov Chain as a Poisson process with different mean arrival rates, and the call duration is exponentially distributed with a mean value of 15 time slots. The traffic is characterized by the arrival rate of new calls and by the transition probabilities of handoff calls. It is assumed that base station has a buffer with a substantially large buffer capacity to avoid significant packet loss.

III. SYSTEM IMPLEMENTATION

A. Software Subsystem Implementation

The OFDM system was modeled and simulated using MATLAB & Simulink to allow various parameters of the system to be varied and tested, including those established by the standard as shown in fig 5.1 the simulation includes all the stages for transmitter, channel and receiver, according to the standard. Because of the MATLAB sampling time, the transmission was implemented in baseband to avoid long periods of simulation. Considering additive white gaussian noise (AWGN) and multipath path Rayleigh fading effect, a good approximation to the real performance can be observed,

over all in the degradation of the BER. At the transmitter, OFDM signals are generated by Bernoulli Binary and mapped by one of the modulation techniques. Then by using a Sequence Generation, The transmitter section converts digital data to be transmitted, into a mapping of sub carrier amplitude and phase. It then transforms this spectral representation of the data into the time domain using an Inverse Fast Fourier Transform (IFFT). The OFDM symbol is equal to the length of the IFFT size used (which is 1024) to generate the signal and it has an integer number of cycles. The Cyclic Prefix and Multiple Parameters were added before the signal conversion from Parallel to Serial mode. The addition of a guard period to the start of each symbol makes further improvement to the effect of ISI on an OFDM signal. For generation an OFDM signal, all the model variables parameters were setting in suitable values in order to have smooth generated signal to be transmitted. The channel simulation will allow for us to examine the effects of noise and multipath on the OFDM scheme. By adding small amount of random data of AWGN to the transmitted signal, noise can be simulated. Generation of random data at a bit rate that varies during the simulation. The varying data rate is accomplished by enabling a source block periodically for a duration that depends on the desired data rate.

The result above denotes the effect of noise (AWGN) on a non-OFDM modulated signal. This result is to be compared with the result of fig (4.3) so as to draw a comparison between the effect of noise on a non-OFDM modulated data signals and that of an OFDM modulated signal.

It is expected that OFDM performs better in noisy and disturbed environment than any other modulation technique compared with it here. It is also expected that the Bit Error Rate (BER) and Symbol Error Rate (SER) of OFDM modulated signals is always less than that of a non-OFDM modulated signals. The theoretical symbol error probability of PSK is Where erfc is the complementary error function, E_s / N_o is the ratio of energy in a symbol to noise power spectral density, and M is the number of symbols.

$$P_E(M) = \text{erfc} \left(\sqrt{\frac{E_s}{N_o}} \sin \left(\frac{\pi}{M} \right) \right) \dots(3.1)$$

To determine the bit error probability, the symbol error probability, P_E , needs to be converted to its bit error equivalent. There is no general formula for the symbol to bit error conversion. Upper and lower limits are nevertheless easy to establish. The actual bit error probability, P_b , can be shown

to be bounded by

$$\frac{P_E(M)}{\log_2 M} \leq P_b \leq \frac{M/2}{M-1} P_E(M) \dots(3.2)$$

The lower limit corresponds to the case where the symbols have undergone Gray coding. The upper limit corresponds to the case of pure binary coding. Because increasing the value of E_b/N_o lowers the number of errors produced, the length of each simulation must be increased to ensure that the statistics of the errors remain stable

Using the sim command to run a Simulink simulation from the MATLAB Command Window, the following code generates data for symbol error rate and bit error rate curves. It considers E_b/N_o values in the range 0 dB to 12 dB, in steps of 2 dB.

IV. SIMULATION RESULT

The importance of modulation using (OFDM) can be seen in the above simulations, since the un-modulated signal always performs poorer than the modulated signal. Hence, modulation makes a signal more conducive for transmission over the transmission medium (in this case, the wireless channel). It is also observed that appropriate choice of modulation techniques could either increase or decrease the error rates of the signals. Hence, a DPSK-modulated OFDM signal fig (4.6) is much more conducive for transmission over the wireless channel than any other type of modulation tested. The effect of the Additive White Gaussian Noise (AWGN) is observed by modeling a signal passing through a noisy channel without any form of modulation. Afterwards, OFDM modulated signals (using digital modulators such as QAM) are passed through the same channel. The error rate is then compared.

A matlab file (see Appendix A) is written to vary the signal-to-noise ratio (SNR) and plot the graph of the Bit Error Rate (BER). The BER of the un-modulated signal is found to be constant at 0.4904. The effect of a noisy channel on a QAM signal is modeled as shown in fig 4.4. It is observed that an un-modulated signal has a BER of about 50%, whereas OFDM modulation reduces the BER significantly. It was also observed that the DPSK-modulated OFDM signal reduces the BER significantly, graph on Fig 4.7 shows a probabilistic approach on the Comparison of the outage probability with the signal to interference ratio of CCI, Appendix 1 and Appendix 2 represent a classical representation of how OFDM and QPSK simulation.

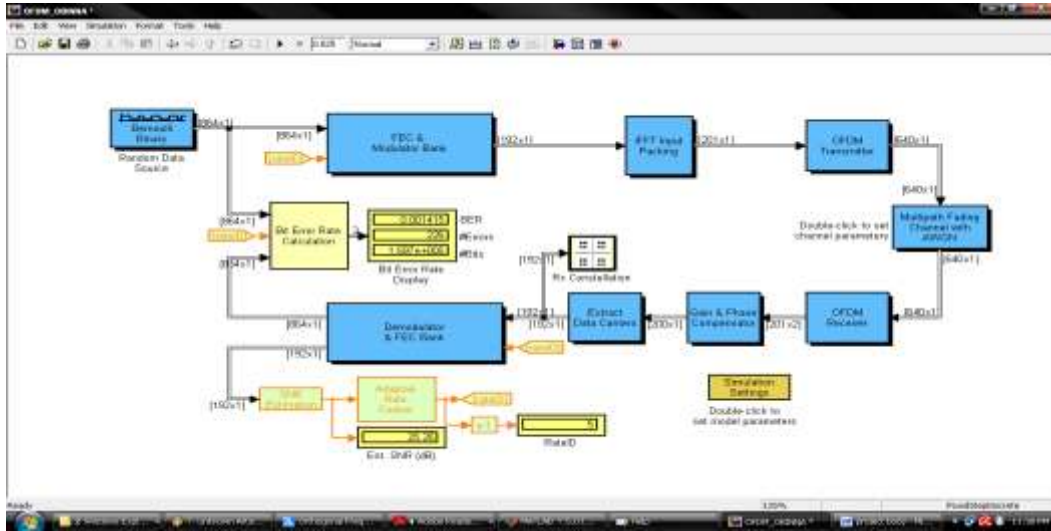


Fig 4.1 Modeling an OFDM network environment

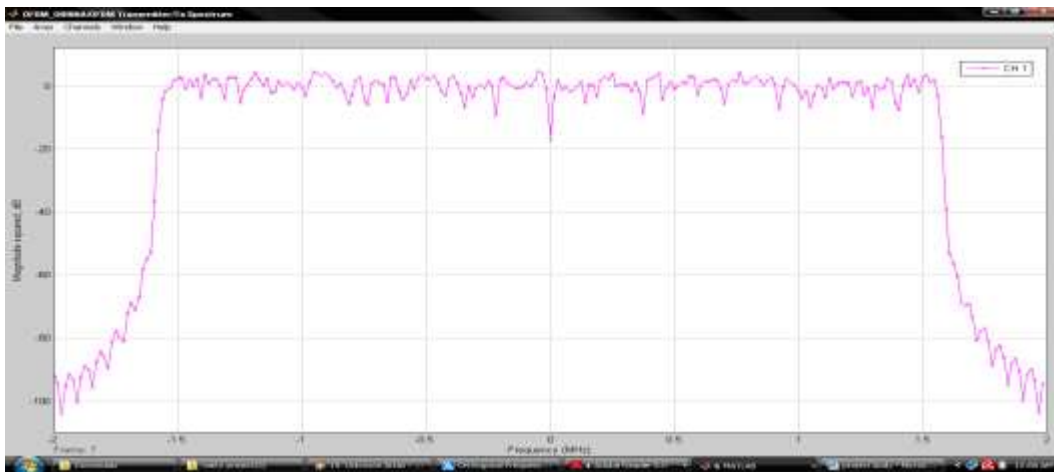


Fig 4.2 Graph of Transmission spectrum

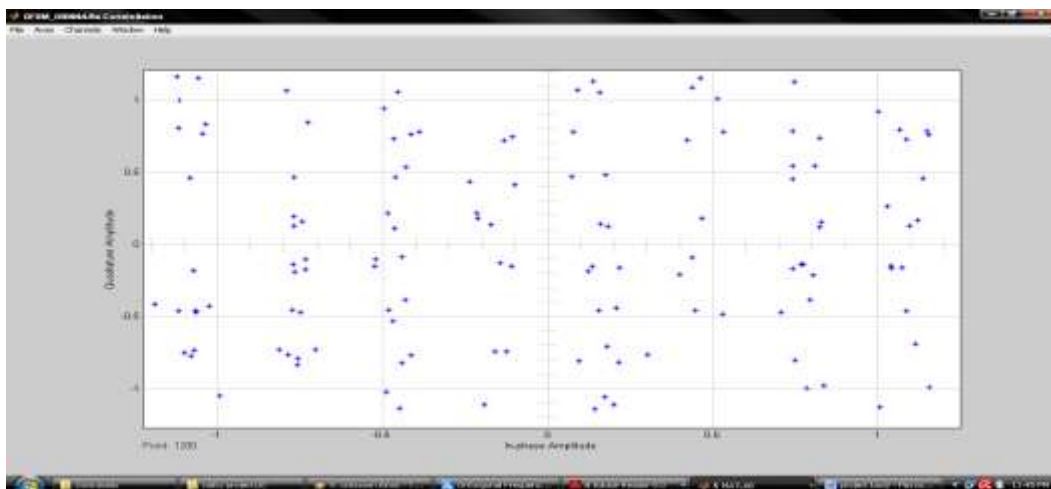


Fig 4.3 Graph of Receiver constellation

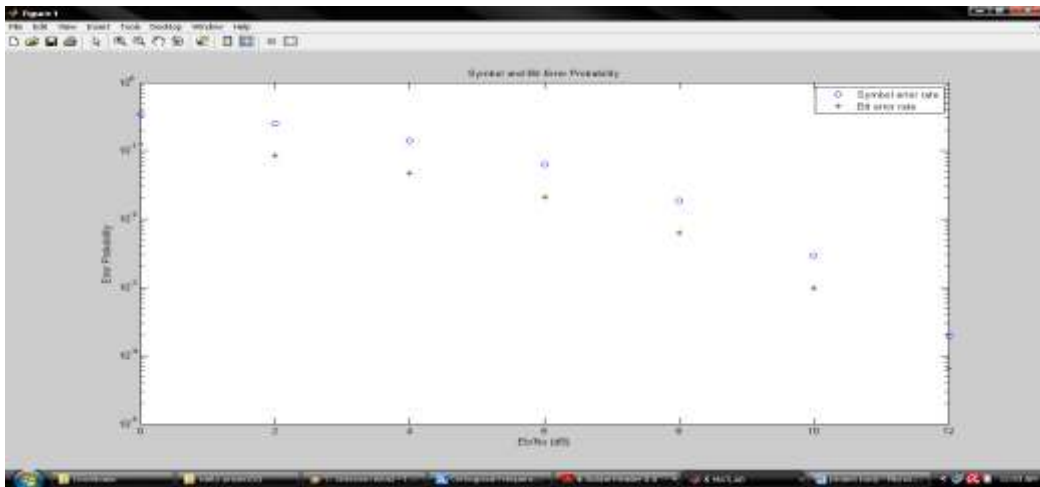


Fig 4.4 Receiver constellation

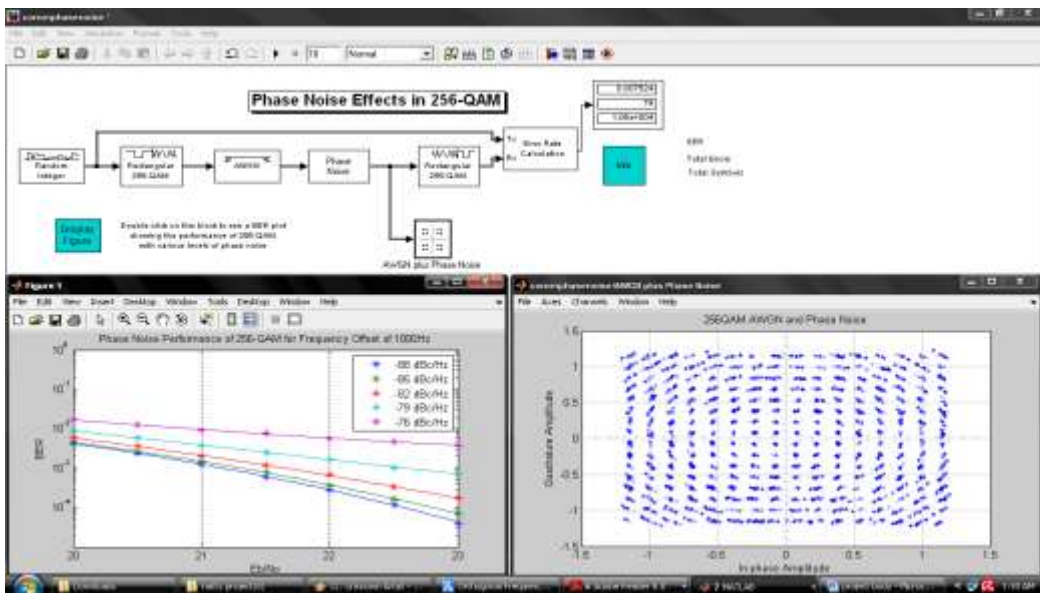


Fig 4.5 BER probability graph an OFDM modulated signal

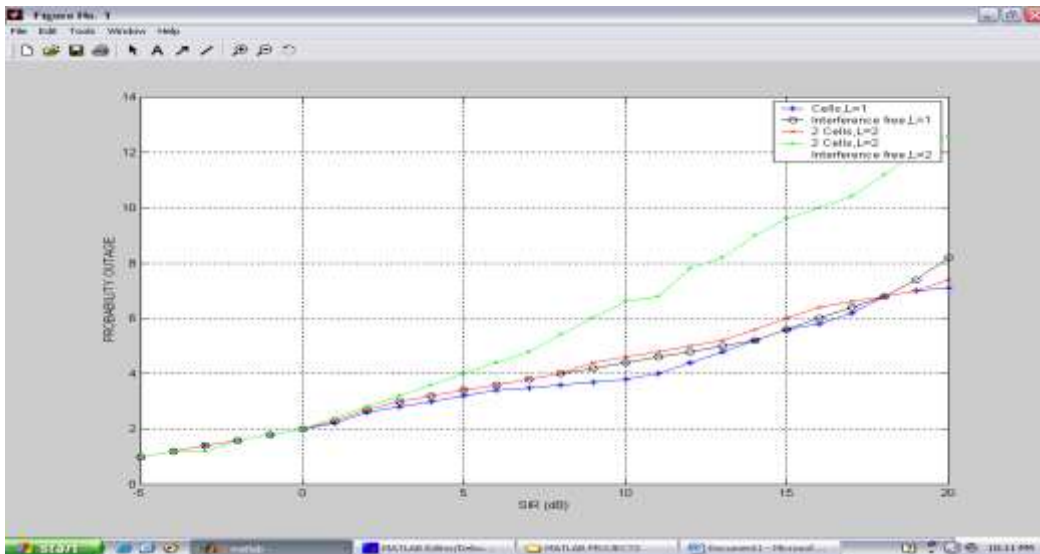


Fig 4.6 BER Probability graph of an OFDM Modulated Signal

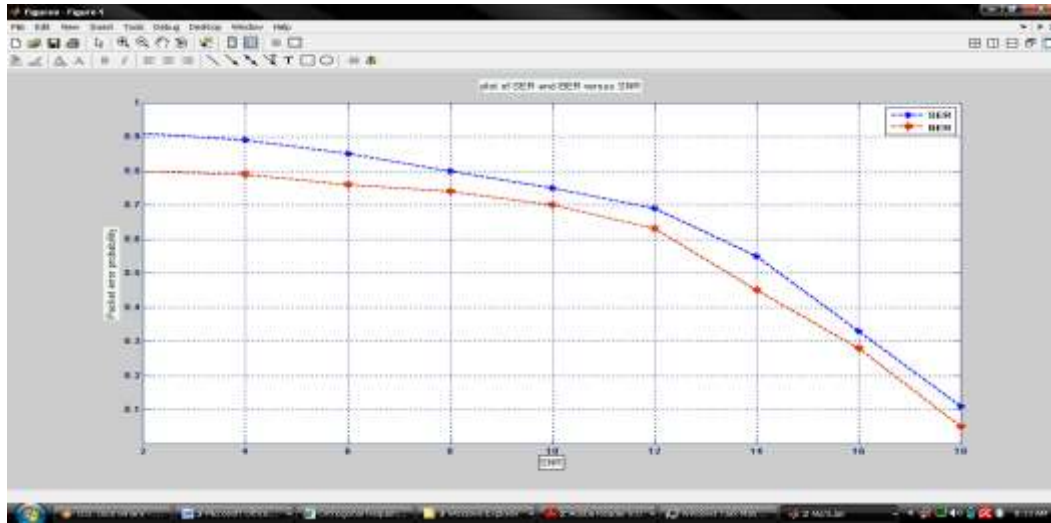


Fig 4.7 Comparison of the outage probability with the signal to interference ratio of CCI

A. Deployment

Modulation is a very important aspect of data transmission since it makes a signal more conducive for transmission over the transmission medium (in this case, the wireless channel). Hence OFDM should be widely applied to Broadband wireless access networks most especially in situations where the effects of multipath fading and noise have to be eliminated.

Networks and noisy environments. The importance of modulation can be seen in the above simulations, since the unmodulated signal always performs poorer than the modulated signal. Hence, modulation makes a signal more conducive for transmission over the transmission medium (in this case, the wireless channel). This work strongly recommends OFDM as a strong candidate for Broadband Wireless Access Network.

V. CONCLUSION

This work was able to show that modulation using OFDM technique is very important in Broadband wireless Access

APPENDIX 1

Orthogonal Frequency Division

baseband signal of OFDM is expressed as

$$S(t) = \sum_{n=0}^{N-1} (\alpha_n \cos 2\pi n f_0 t - \beta_n \sin 2\pi n f_0 t)$$

above equation can be represented as follows using an inverse discrete Fourier transform

$$S(t) = \text{Re}\{u(t)\}$$

$$u(t) = \sum_{n=0}^{N-1} (\alpha_n + j\beta_n) \exp(j2\pi n f_0 t)$$

data symbol $\alpha_n + j\beta_n$ is obtained from QAM

$$\alpha_n + j\beta_n = (\alpha_n^2 + \beta_n^2)^{1/2} \exp(j\psi)$$

$$\psi = \tan^{-1}(\alpha_n/\beta_n)$$

orthogonal frequency division multiplexing

bit stream	4bits parallel	$\alpha + j\beta$	n	γ	δ
0010010001101111111	0100	-1-j1	0	-0.5	1.5
pause	carrier	-3+j3	1	2.5	-1.5
end	0110	-3+j1	2	-0.5	1.5
	0100	-3+j3	3	-0.5	1.5

16QAM constellation

modulation 16QAM OFDM

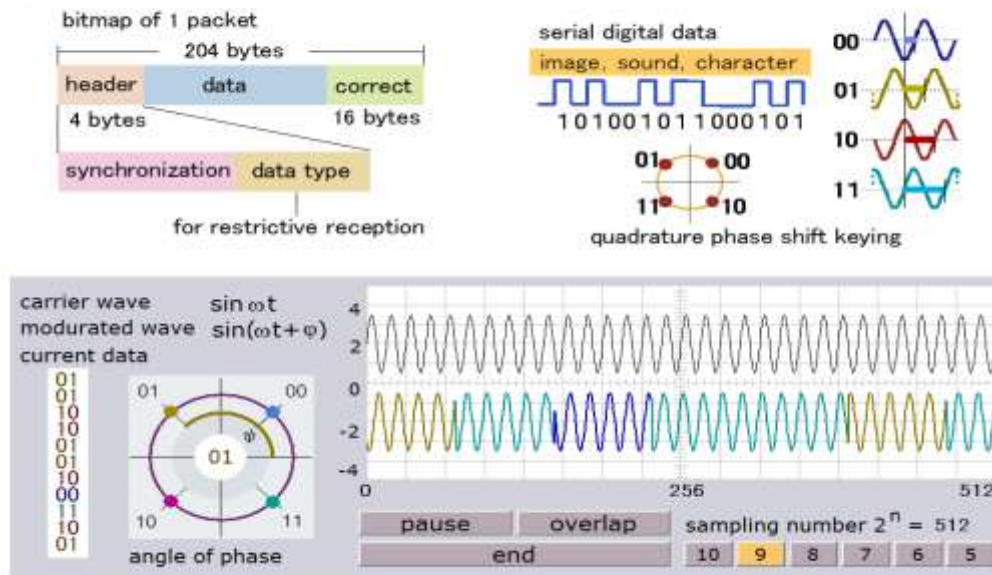
$$S(t) = \alpha \cos(2\pi f_c t) - \beta \sin(2\pi f_c t)$$

frequency spectrum

512 sampling FFT overlap

APPENDIX 2

Quadrature Phase Shift



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Sectorization of Full Kekre's Wavelet Transform for Feature extraction of Color Images

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Abstract—An innovative idea of sectorization of Full Kekre's Wavelet transformed (KWT)[1] images for extracting the features has been proposed. The paper discusses two planes i.e. Forward plane (Even plane) and backward plane (Odd plane). These two planes are sectorized into 4, 8, 12 and 16 sectors. An innovative concept of sum of absolute difference (AD) has been proposed as the similarity measuring parameters and compared with the well known Euclidean distance (ED). The performances of sectorization of two planes into different sector sizes in combination with two similarity measures are checked. Class wise retrieval performance of all sectors with respect to the similarity measures i.e. ED and AD is analyzed by means of its class (randomly chosen 5 images) average precision- recall cross over points, overall average (average of class average) precision-recall cross over points and two new parameters i.e. LIRS and LSRR.

Keywords- CBIR, Kekre's Wavelet Transform (KWT), Euclidian Distance, Sum of Absolute Difference, LIRS, LSRR, Precision and Recall.

I. INTRODUCTION

Content based image retrieval i.e. CBIR [2-6] is well known technology being used and being researched upon for the retrieval of images from the large image databases. CBIR has been proved to be very much needed technology to be researched on due to its applicability in various applications like face recognition, finger print recognition, pattern matching[7][8][9], verification /validation of images etc. The concept of CBIR can be easily understood by the figure 1 as shown below. Every CBIR systems needs functionality for feature extraction of an image viz. shape, color, texture which can represent the uniqueness of the image for the purpose of best match in the database to be searched. The features of the query image are compared with the features of all images in the feature database using various mathematical construct known as similarity measures. These mathematical similarity measuring techniques checks the similarity of features extracted to classify the images in the relevant and irrelevant classes. The research in CBIR needs to be done to explore two aspects first is the better method of feature extraction having maximum components of uniqueness and faster, accurate mathematical models of similarity measures. As the figure 1 shows the example of query image of an horse being provided to CBIR system as query and the images of relevant classes are

retrieved. Relevance feedback of the retrieval is used for the machine learning purpose to check the accuracy of the retrieval which in turn helps one to focus on the modification in the current approach to have improved performance.

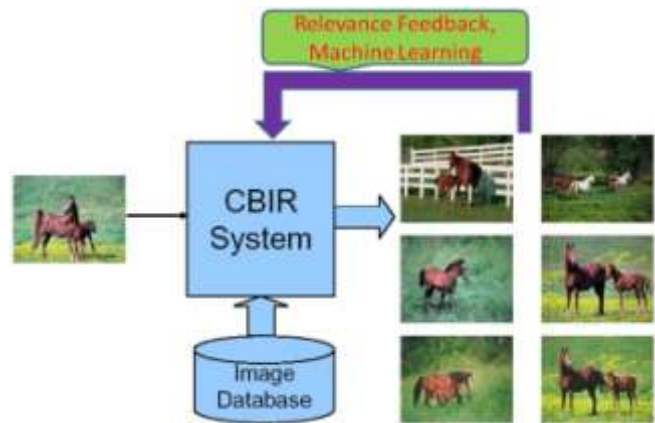


Figure 1. The CBIR System [2]

Many researches are currently working on the very open and demanding field of CBIR. These researches focus on to generate the better methodologies of feature extractions in both spatial domain and frequency domain. Some methodologies like block truncation coding [10-11], various transforms: FFT [12-14], Walsh transform [15-21], DCT [22], DST [23] and other approaches like Hashing [24], Vector quantization [25], Contour let transform [5], has already been developed

In this paper we have introduced a novel concept of Sectorization of Full Kekre's Wavelet transformed color images for feature extraction. Two different similarity measures parameters i.e. sum of absolute difference and Euclidean distance are used. Average precision, Recall, LIRS and LSRR are used for performances study of these approaches.

II. KEKRE'S WAVELET [1]

Kekre's Wavelet transform is derived from Kekre's transform. From $N \times N$ Kekre's transform matrix, we can generate Kekre's Wavelet transform matrices of size $(2N) \times (2N)$, $(3N) \times (3N)$, ..., $(N^2) \times (N^2)$. For example, from 5×5 Kekre's transform matrix, we can generate Kekre's Wavelet transform matrices of size 10×10 , 15×15 , 20×20 and

25x25. In general MxM Kekre's Wavelet transform matrix can be generated from NxN Kekre's transform matrix, such that $M = N * P$ where P is any integer between 2 and N that is, $2 \leq P \leq N$. Kekre's Wavelet Transform matrix satisfies $[K][K]^T = [D]$ Where D is the diagonal matrix this property and hence it is orthogonal. The diagonal matrix value of Kekre's transform matrix of size NxN can be computed as

$$D(x,y) = \begin{cases} 2 & , \text{if } x=y=N \\ N & , \text{if } x=y=1 \\ 0 & , \text{if } x \neq y \\ D(x+1,y+1) + 2(N-x+1) & , \text{if } x=y=p \text{ and } p \neq 1 \text{ or } N \end{cases} \quad (1)$$

III. PLANE FORMATION AND ITS SECTORIZATION [12-19],[22-23]

The components of Full KWT transformed image shown in the red bordered area (see Figure 2) are used to generate feature vectors. The average of zeroth row, column and last row and column components are augmented to feature vector generated. Color codes are used to differentiate between the co-efficients plotted on Forward (Even) plane as light red and light blue for co-efficients belonging to backward (Odd) plane. The coefficient with light red background i.e. at position (1,1),(2,2);(1,3),(2,4) etc. are taken as X1 and Y1 respectively and plotted on Even plane. The co-efficient with light blue background i.e. at position (2,1),(1,2);(2,3),(1,4) etc. are taken as X2 and Y2 respectively and plotted on Odd plane.

	0	1	2	3	4	5
0	0,0	0,1	0,2	0,3	0,4	0,5
1	1,0	1,1	1,2	1,3	1,4	1,5
2	2,0	2,1	2,2	2,3	2,4	2,5
3	3,0	3,1	3,2	3,3	3,4	3,5
4	4,0	4,1	4,2	4,3	4,4	4,5
5	5,0	5,1	5,2	5,3	5,4	5,5

Figure 2: KWT component arrangement in an Transformed Image.

Even plane of Full KWT is generated with taking KWT components into consideration as all $X(i,j)$, $Y(i+1, j+1)$ components for even plane and all $X(i+1, j)$, $Y(i, j+1)$ components for odd plane as shown in the Figure 3. Henceforth for our convenience we will refer $X(i,j) = X1$, $Y(i+1,j+1) = Y1$ and $X(i+1,j) = X2$ and $Y(i,j+1) = Y2$.

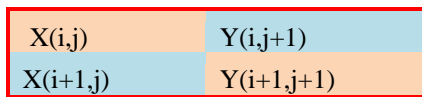


Figure 3: Snapshot of Components considered for Even/Odd Planes.

As shown in the Figure 3 the Even plane of Full KWT considers X1 i.e. all light red background cells (1,1), (2,2),(1,3),(2,4) etc. on X axis and Y1 i.e. (1,2), (2,1),(1,4),(2,3) etc. on Y axis. The Odd plane of Full KWT considers X1 i.e. all light blue background cells (1,2), (2,1),(1,4),(2,3) etc. on X axis and Y1 i.e. (1,2), (2,1),(1,4),(2,3) etc. on Y axis.

IV. RESULTS AND DISCUSSION.

Augmented Wang image database [4] has been used for the experiment. The database consists of 1055 images of 12 different classes such as Flower, Sunset, Barbie, Tribal, Cartoon, Elephant, Dinosaur, Bus, Scenery, Monuments, Horses, Beach. Class wise distribution of all images in the database has been shown in the Figure 7.

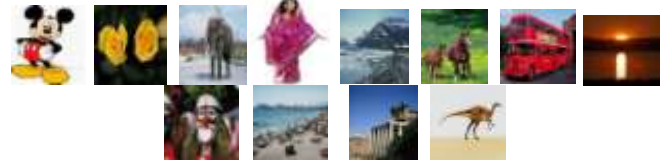


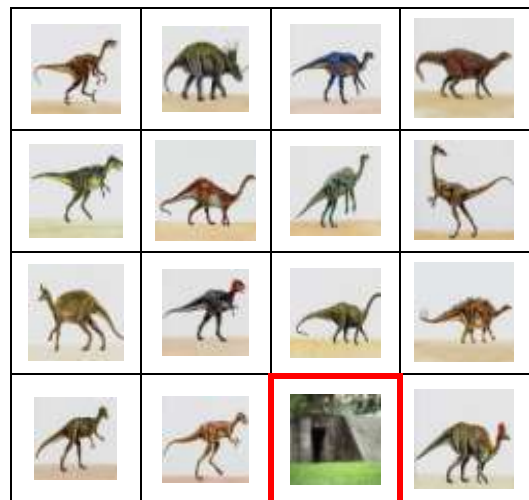
Figure 7: Class wise distribution of images in the Image database consists of
Sunset:51, Cartoon:46,
Flower:100, Elephants:100, Barbie:59, Mountains:100, Horse:100, Bus:100, Triba
l:100, Beaches:99, Monuments:100, Dinosaur :100



Figure8. Query Image

The query image of the class dinosaur has been shown in Figure 8. For this query image the result of retrieval of both approaches of Full KWT wavelet transformed image sectorization of even and odd planes. The Figure 9 shows First 20 Retrieved Images sectorization of Full KWT wavelet Forward (Even) plane (16 Sectors) with sum of absolute difference as similarity measure. There are two retrieval from irrelevant class.

The first irrelevant image occurred 15th position and second on 20th position (shown with red boundary) in the even plane sectorization. The result of odd plane sectorization shown in Figure 10; the retrieval of first 20 images containing 2 irrelevant retrievals but the first irrelevant class has occurred at 17th position.



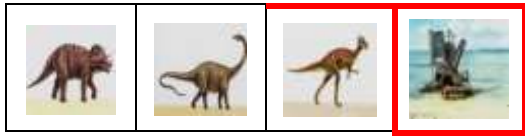


Figure 9: First 20 Retrievals of Full KWT Forward (Even) plane sectorization into 16 Sectors with sum of absolute difference as similarity measure.

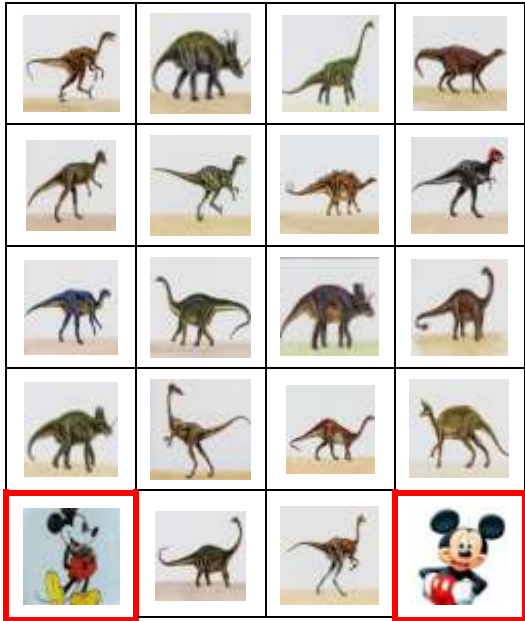


Figure 10: First 20 Retrievals of Full KWT Backward (Odd) plane sectorization into 16 Sectors with sum of absolute difference as similarity measure..

Feature database includes feature vectors of all images in the database. Five random query images of each class were used to search the database. The image with exact match gives minimum sum of absolute difference and Euclidian distance. To check the effectiveness of the work and its performance with respect to retrieval of the images we have calculated the overall average precision and recall and its cross over values and plotted class wise. The Equations (2) and (3) are used for precision and recall calculation whilst two new parameters i.e. LIRS (Length of initial relevant string of images) and LSRR (Length of string to recover all relevant images) are used as shown in Equations (4) and (5).

$$\text{Precision} = \frac{\text{Number of Relevant images Retrieved}}{\text{Total Number of Images Retrieved}} \quad (2)$$

$$\text{Recall} = \frac{\text{Number of Relevant Images Retrieved}}{\text{Total Number of Relevant Images in the Database}} \quad (3)$$

$$\text{LIRS} = \frac{\text{Length of Initial Relevant string of Images}}{\text{Total Relevant Images Retrieved}} \quad (4)$$

$$\text{LSRR} = \frac{\text{Length of String to Recover all Relevant Images}}{\text{Total Images in the Database}} \quad (5)$$

All these parameters lie between 0-1 hence they can be expressed in terms of percentages. The newly introduced parameters give the better performance for higher value of LIRS and Lower value of LSRR [8-13].

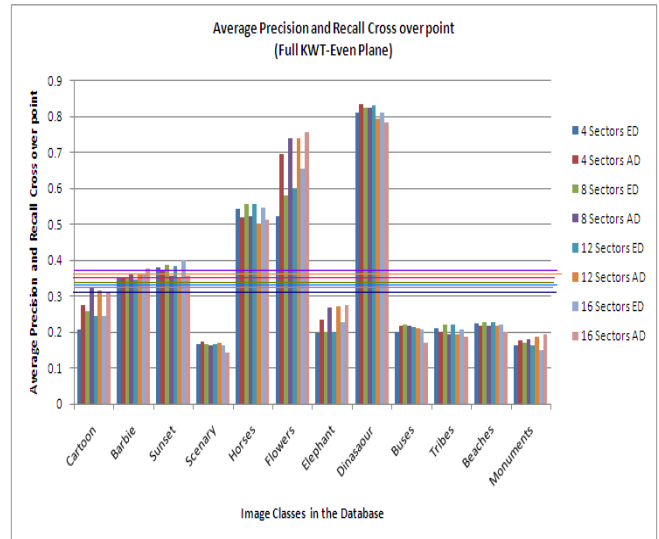


Figure 11: Class wise Average Precision and Recall cross over points of Forward Plane (Even) sectorization of Full KWT Wavelet with sum of Absolute Difference (AD) and Euclidean Distance (ED) as similarity measure.

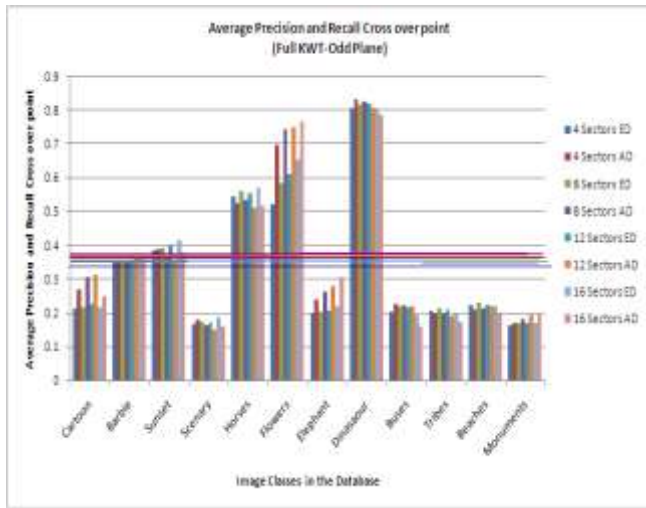


Figure 12: Class wise Average Precision and Recall cross over points of Backward Plane (Odd) sectorization of Full KWT Wavelet with Absolute Difference (AD) and Euclidean Distance (ED) as similarity measure.

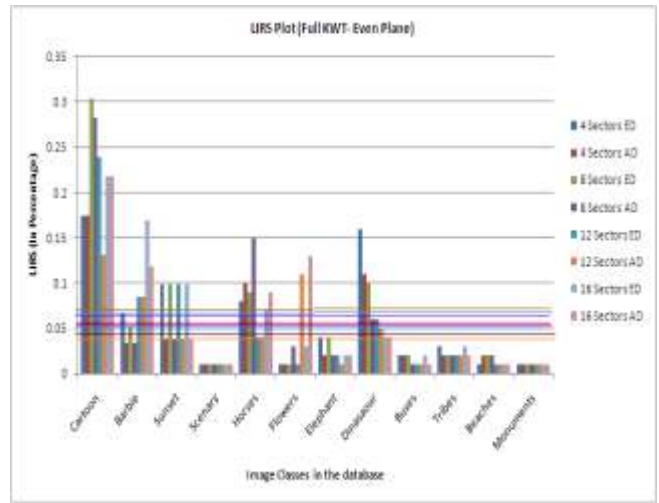


Figure 14: The LIRS Plot of sectorization of forward plane of Full KWT transformed images . Overall Average LIRS performances (Shown with Horizontal lines :0.082 (4 Sectors ED), 0.052 (4 Sectors AD), 0.071(8 Sectors ED), 0.051(8 Sectors AD), 0.075(12 Sectors ED), 0.069(12 Sectors AD), 0.053(16 Sectors ED), 0.053(16 Sectors AD)).

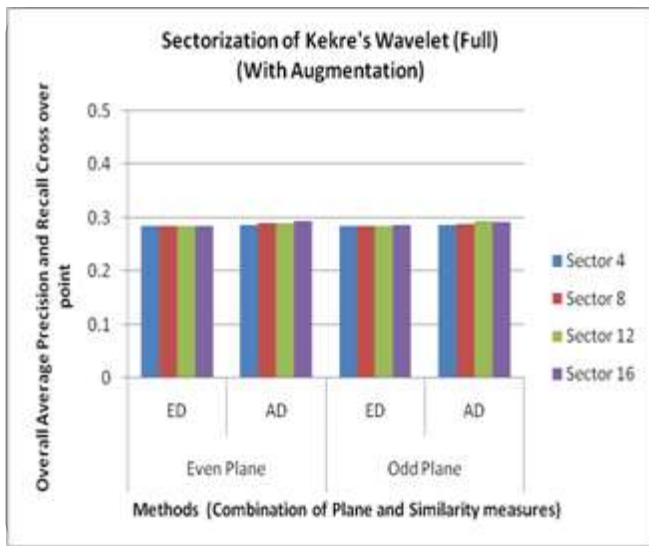


Figure 13: Comparison of Overall Precision and Recall cross over points of sectorization of Full KWT Wavelet with sum of Absolute Difference (AD) and Euclidean Distance (ED) as similarity measure.

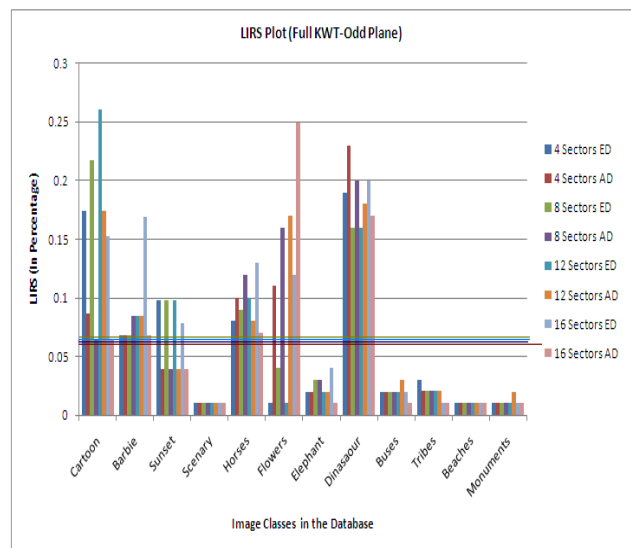


Figure 15: The LIRS Plot of sectorization of Backward plane of Full KWT transformed images . Overall Average LIRS performances (Shown with Horizontal lines :0.081 (4 Sectors ED), 0.054 (4 Sectors AD), 0.073(8 Sectors ED), 0.050(8 Sectors AD), 0.064(12 Sectors ED), 0.049(12 Sectors AD), 0.056(16 Sectors ED), 0.042(16 Sectors AD)).

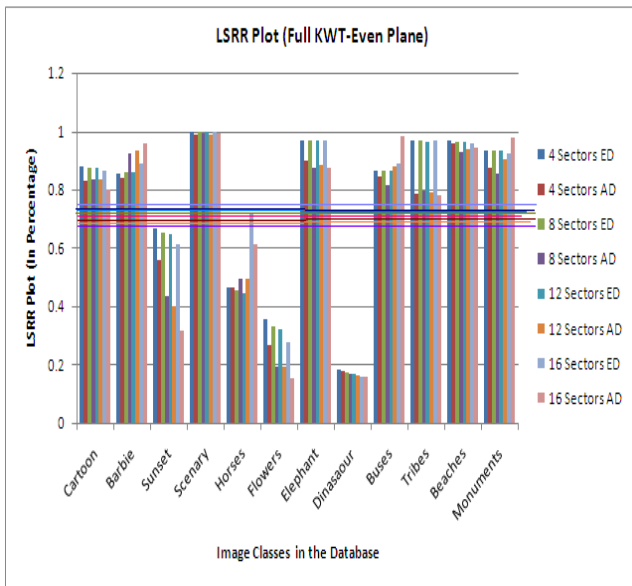


Figure 16: The LSRR Plot of sectorization of forward plane of Full KWT transformed images . Overall Average LSRR performances (Shown with Horizontal lines :0.77 (4 Sectors ED), 0.71 (4 Sectors AD), 0.76(8 Sectors ED), 0.71(8 Sectors AD), 0.76(12 Sectors ED), 0.73(12 Sectors AD), 0.74(16 Sectors ED), 0.71(16 Sectors AD)).

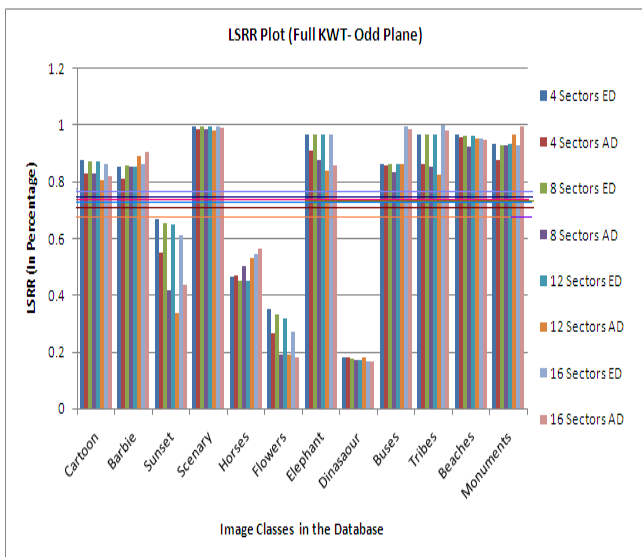


Figure 17: The LSRR Plot of sectorization of backward plane of Full KWT transformed images . Overall Average LSRR performances (Shown with Horizontal lines :0.77(4 Sectors ED), 0.729 (4 Sectors AD), 0.76(8 Sectors ED), 0.725(8 Sectors AD), 0.756(12 Sectors ED), 0.726(12 Sectors AD), 0.759(16 Sectors ED), 0.727(16 Sectors AD)).

V. CONCLUSION

The work experimented on 1055 image database of 12 different classes discusses the performance of sectorization of Full KWT wavelet transformed color images for image retrieval. The work has been performed with both approaches of sectorization of forward (even) plane and backward (odd) planes. The performance of the methods proposed checked

with respect to various sector sizes and similarity measuring approaches viz. Euclidian distance and sum of absolute difference. We calculated the average precision and recall cross over point of 5 randomly chosen images of each class and the overall average is the average of these averages. The observation is that sectorization of both planes of full KWT wavelet transformed images give less than 30% of the overall average retrieval of relevant images as shown in the Figure 13. The class wise plot of these average precision and recall cross over points as shown in Figure 11 and Figure 12 for both approaches depicts that the retrieval performance varies from class to class and from method to method wherein horses, flower and dinosaur classes have retrieval more than 50%. They have the performance above the average of all methods as shown by horizontal lines. New parameter LIRS and LSRR gives good platform for performance evaluation to judge how early all relevant images is being retrieved (LSRR) and it also provides judgement of how many relevant images are being retrieved as part of first set of relevant retrieval (LIRS).The value of LIRS must be minimum and LSRR must be minimum for the particular class if the overall precision and recall cross over point of that class is maximum. This can be clearly seen in Figures 14 to Figure 17. This observation is very clearly visible for dinosaur class however the difference of LIRS and LSRR of other classes varies. The sum of absolute difference as similarity measure is recommended due to its lesser complexity and better retrieval rate performance compared to Euclidian distance.

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Dominating Sets and Spanning Tree based Clustering Algorithms for Mobile Ad hoc Networks

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Abstract— The infrastructure less and dynamic nature of mobile ad hoc networks (MANET) needs efficient clustering algorithms to improve network management and to design hierarchical routing protocols. Clustering algorithms in mobile ad hoc networks builds a virtual backbone for network nodes. Dominating sets and Spanning tree are widely used in clustering networks. Dominating sets and Spanning Tree based MANET clustering algorithms were suitable in a medium size network with respect to time and message complexities. This paper presents different clustering algorithms for mobile ad hoc networks based on dominating sets and spanning tree.

Keywords : mobile ad hoc networks, clustering, dominating set and spanning trees

I. INTRODUCTION

MANETs do not have any fixed infrastructure and consist of wireless mobile nodes that perform various data communication tasks. MANETs have potential applications in rescue operations, mobile conferences, battlefield communications etc. Conserving energy is an important issue for MANETs as the nodes are powered by batteries only.

Clustering has become an important approach to manage MANETs. In large, dynamic ad hoc networks, it is very hard to construct an efficient network topology. By clustering the entire network, one can decrease the size of the problem into small sized clusters. Clustering has many advantages in mobile networks. Clustering makes the routing process easier, also, by clustering the network, one can build a virtual backbone which makes multicasting faster. However, the overhead of cluster formation and maintenance is not trivial. In a typical clustering scheme, the MANET is firstly partitioned into a number of clusters by a suitable distributed algorithm. A Cluster Head (CH) is then allocated for each cluster which will perform various tasks on behalf of the members of the cluster. The Performance metrics of a clustering algorithm are the number of clusters and the count of the neighbour nodes which are the adjacent nodes between clusters that are formed.

In this paper we discussed various clustering algorithms based on dominating sets [1] [4] [11] [14] [16] and Spanning Trees [6] [8] [15]. The performance metrics of a clustering algorithm are the number of clusters and the

count of the neighbor nodes which are the adjacent nodes between clusters that are formed.

II. DOMINATING SETS BASED CLUSTERING ALGORITHMS

A dominating set [9] is a subset S of a graph G such that every vertex in G is either in S or adjacent to a vertex in S . Dominating sets are widely used in clustering networks. Dominating sets can be classified into three main classes i) Independent Dominating Set ii) Weakly Connected Dominating Set and iii) Connected Dominating Set.

A. Independent Dominating Set (IDS)

IDS [6] [11] is a dominating set S of a graph G in which there are no adjacent vertices. Fig.1. shows a sample independent dominating set

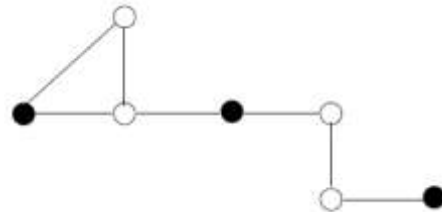


Figure 1. Independent Dominating Set.

B. Weakly Connected Dominating Sets (WCDS)

WCDS [10] [12] is S_w is a subset S of a graph G that contains the vertices of S , their neighbors and all edges of the original graph G with at least one endpoint in S . A subset S is a weakly-connected dominating set, if S is dominating and S_w is connected. Fig.2. shows a Weakly Connected Dominating Sets.

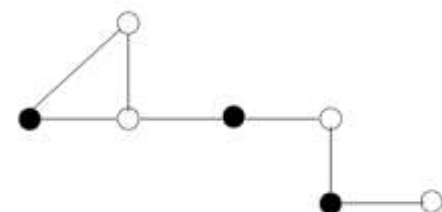


Figure 2. Weakly Connected Dominating Set.

C. Connected Dominating Set (CDS)

CDS [11] [13] is a subset S of a graph G such that S forms a dominating set and S is connected. Fig.3. shows a Weakly Connected Dominating Sets.

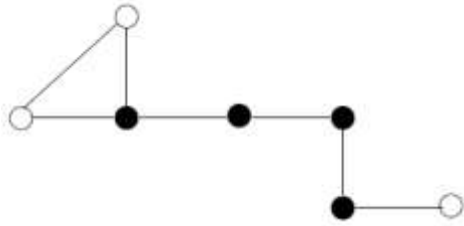


Figure 3. Connected Dominating Set.

D. Determining Dominating Sets

Algorithms that construct a CDS in ad hoc networks can be divided into two categories: centralized algorithms that depend on network-wide information or coordination and decentralized that depend on local information only. Centralized algorithms usually yield a smaller CDS than decentralized algorithms, but their application is limited due to the high maintenance cost.

Decentralized algorithms can be further divided into cluster-based algorithms and pure localized algorithms. Cluster-based algorithms have a constant approximation ratio in unit disk graphs and relatively slow convergence ($O(n)$ in the worst case). Pure localized algorithms take constant steps to converge, produce a small CDS on average, but have no constant approximation ratio. A cluster-based algorithm usually contains two phases. In the first phase, the network is partitioned into clusters and a clusterhead is elected for each cluster. In the second phase, clusterheads are interconnected to form a CDS. Several clustering algorithms [2] [4] [7] have been proposed to elect clusterheads that have the minimal id, maximal degree, or maximal weight. A host v is a clusterhead if it has the minimal id (or maximal degree or weight) in its 1-hop neighbourhood. A clusterhead and its neighbours form a cluster and these hosts are covered. The election process continues on uncovered hosts and, finally, all hosts are covered.

Wu and Li [9] proposed a simple and efficient localized algorithm that can quickly determine a CDS in ad hoc networks. This approach uses a marking process where hosts interact with others in the neighbourhood. Specifically, each host is marked true if it has two unconnected neighbours. These hosts achieve a desired global objective set of marked hosts forms a small CDS.

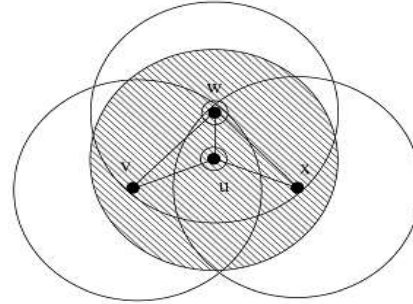


Figure 4. Example of ad hoc networks.

In Wu and Li's approach, the resultant dominating set derived from the marking process is further reduced by applying two dominant pruning rules. According to dominant pruning Rule 1, a marked host can unmark itself if its neighbour set is covered by another marked host; that is, if all neighbours of a gateway are connected with each other via another gateway, it can relinquish its responsibility as a gateway. In Fig. 4. either u or w can be unmarked (but not both). According to Rule 2, a marked host can unmark itself if its neighbourhood is covered by two other directly connected marked hosts. The combination of Rules 1 and 2 is fairly efficient in reducing the number of gateways while still maintaining a CDS.

III. LOCALIZED DOMINATING SET FORMATION ALGORITHM

A. Localized Dominating Set Formation

Fei Dai, Jie Wu [9] proposed a generalized dominant pruning rule, called Rule k , which can unmark gateways covered by k other gateways, where k can be any number. Rule k can be implemented in a restricted way with local neighbourhood information that has the same complexity as Rule 1 and, surprisingly, less complexity than Rule 2.

Given a simple directed graph $G=(V,E)$ where V is a set of vertices (hosts) and E is a set of directed edges (unidirectional links), a directed edge from u to v is denoted by an ordered pair (u,v) . If (u,v) is an edge in G , we say that u dominates v and v is an absorbent of u . The dominating neighbour set $N_d(u)$ of vertex u is defined as $\{w : (w,u) \in E\}$. The absorbent neighbour set $N_a(u)$ as $\{v : (u,v) \in E\}$. $N(u) = N_d(u) \cup N_a(u)$ Fig. 5. vertex x dominates vertex u , y is an absorbent of u , and v is a dominating and absorbent neighbour of u . The dominating neighbour set of vertex u is $N_d(u) = \{v,x\}$, the absorbent neighbour set of u is $N_a(u)=\{v,y\}$, and the neighbour set of u is $N(u)=\{v,x,y\}$. The general disk graph and unit disk graph are special cases of directed graphs.

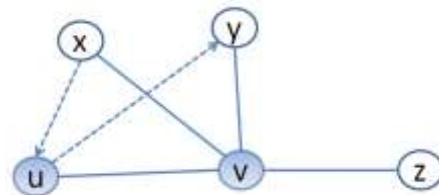


Figure 5. Example of dominating set reduction.

A set $V' \subset V$ is a dominating set of G if every vertex $v \in V - V'$ is dominated by at least one vertex $u \in V'$. Also, a set $V' \subset V$ is called an absorbent set if for every vertex $u \in V - V'$, there exists a vertex $v \in V'$ which is an absorbent of u . For example, vertex set $\{u,v\}$ in Fig. 5. is both dominating and absorbent sets of the corresponding directed graphs. The following marking process can quickly find a strongly connected dominating and absorbent set in a given directed graph.

Algorithm Marking process

- 1: Initially assign marker F to each u in V .
- 2: Each u exchanges its neighbour set $N_d(u)$ and $N_a(u)$ with all its neighbours.
- 3: u changes its marker $m(u)$ to T if there exist vertices v and w such that $(w,u) \in E$ and $(u,v) \in E$, but $(w,v) \notin E$.

The marking process is a localized algorithm, where hosts only interact with others in the neighbourhood. Unlike clustering algorithms, there is no “sequential propagation” of information. The marking process marks every vertex in G . $m(v)$ is a marker for vertex $v \in V$, which is either T (marked) or F (unmarked). Suppose the marking process is applied to the network represented by Fig. 5. host u will be marked because $(x,u) \in E$ and $(u,y) \in E$, but $(x,y) \notin E$ host v will also be marked because $(u,v) \in E$ and $(v,z) \in E$, but $(u,z) \notin E$. All other hosts will remain unmarked because no such pair of neighbour hosts can be found. V' is the set of vertices that are marked T in V ; that is, $V' = \{v : v \in V \wedge m(v) = T\}$. The induced graph G' is the subgraph of G induced by V' ; that is $G' = G[V']$. Wu [9] showed that marked vertices form a strongly connected dominating and absorbent set and, furthermore, can connect any two vertices with minimum hops.

B. Dominating Set Reduction

In the marking process, a vertex is marked T because it may be the only connection between its two neighbours. However, if there are multiple connections available, it is not necessary to keep all of them. We say a vertex is covered if its neighbours can reach each other via other connected marked vertices. Two dominant pruning rules are as follows: If a vertex is covered by no more than two connected vertices, removing this vertex from V' will not compromise its functionality as a CDS. To avoid simultaneous removal of two vertices covering each other, a vertex is removed only when it is covered by vertices with higher id's. Node id $id(v)$ of each vertex $v \in V$ serves as a priority. Nodes with high priorities have high probability of becoming gateways. Id uniqueness is not necessary, but equal id's will produce more gateways.

Rule 1. Consider two vertices u and v in G' . If $N_d(u) - \{v\} \subseteq N_d(v)$ and $N_a(u) - \{v\} \subseteq N_a(v)$ in G and $id(u) < id(v)$, change the marker of u to F; that is, G' is changed to $G' - \{u\}$.

Rule 2. Assume that v and w are bi-directionally connected in G' . If $N_d(u) - \{v,w\} \subseteq N_d(v) \cup N_d(w)$ and $N_a(u) - \{v,w\} \subseteq N_a(v) \cup N_a(w)$ in G and $id(u) < \min\{id(v), id(w)\}$, then change the marker of u to F.

C. Generalized Pruning Rule

Assume $G' = (V', E')$ is the induced subgraph of a given directed graph (V, E) from marked vertex set V' . In the following dominant pruning rule, $N_d(V_k')$ to represent the dominating (absorbent) neighbour set of a vertex set V_k' that is, $N_d(V_k') = \cup_{u_i \in V_k'} N_d(u_i)$.

Rule k. $V' \in \{v_1, v_2, \dots, v_k\}$ is the vertex set of a strongly connected subgraph in G' . If $N_d(u) - V_k' \subseteq N_d(V_k')$ and $N_a(u) - V_k' \subseteq N_a(V_k')$ in G and $id(u) < \min\{id(v_1), id(v_2), \dots, id(v_k)\}$, then change the marker of u to F.

Rules 1 and 2 are special cases of Rule k, where $|V'|$ is restricted to 1 and 2, respectively. Note that V_k' may contain two subsets: V_{k1}' that really covers u 's neighbour set, and V_{k2}' that acts as the glue to make them a connected set. Obviously, if a vertex can be removed from V' by applying Rule 1 or Rule 2, it can also be removed by applying Rule k. On the other hand, a vertex removed by Rule k is not necessarily removable via Rule 1 or Rule 2. For example, in Fig. 6(a), both vertices u and v can be removed using Rule k (for $k \geq 3$) because they are covered by vertices w, x, y , and z ; in Fig. 6(b), vertex u can be removed because it is covered by vertices w, x , and y . Note that, although x and y are not bi directionally connected, they can reach each other via vertex w . However, none of these vertices can be removed via Rule 1 or Rule 2.

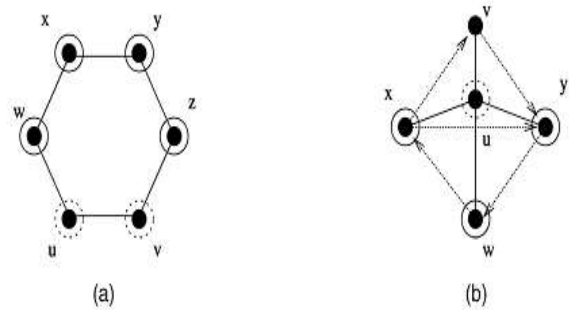


Figure 6. Limitation of Rule 1 and 2.

D. Performance Analysis

The restricted Rule k is a more efficient dominant pruning rule than the combination of the restricted Rules 1 and 2, especially in dense networks with a relatively high percentage of unidirectional links. For these networks, the resultant dominating set can be greatly reduced by Rule k without any performance or resource penalty. One advantage of the marking process and the dominant pruning rules is their capability to support unidirectional links. For networks without unidirectional links, the marking process and the restricted Rule k is as efficient as several cluster-based schemes and another pure localized algorithm, in terms of the size of the dominating set; this is achieved with lower cost and higher converging speed.

IV. A ZONAL CLUSTERING ALGORITHM

Zonal distributed algorithm [3] is to find a small weakly connected dominating set of the input graph $G = (V,E)$. The graph is first partitioned into non-overlapping regions. Then a greedy approximation algorithm [1] is executed to find a small weakly-connected dominating set of each region. Taking the union of these weakly-connected dominating sets we obtain a dominating set of G . Some additional vertices from region borders are added to the dominating set to ensure that the zonal dominating set of G is weakly-connected.

A. Graph partitioning using minimum spanning forests

The first phase of zonal distributed clustering algorithm partitions a given graph $G = (V,E)$ into non overlapping regions. This is done by growing a spanning forest of the graph. At the end of this phase, the subgraph induced by each tree defines a region. This phase is based on an algorithm of Gallager, Humblet, and Spira GHS [8] that is based on Kruskal's classic centralized algorithm for Minimum Spanning Tree (MST), by considering all edge weights are distinct, breaking ties using the vertex IDs of the endpoints.

The MST is unique for a given graph with distinct edge weights. The algorithm maintains a spanning forest. Initially, the spanning forest is a collection of trees of single vertices. At each step the algorithm merges two trees by including an edge in the spanning forest. During the process of the algorithm, an edge can be in any of the three states: tree edge, rejected edge, or candidate edge. All edges are candidate edges at the beginning of the algorithm. When an edge is included in the spanning forest, it becomes a tree edge. If the addition of a particular edge would create a cycle in the spanning forest, the edge is called a rejected edge and will not be considered further. In each iteration, the algorithm looks for the candidate edge with minimum weight, and changes it to a tree edge merging two trees into one. During the algorithm, the tree edges and all the vertices form a spanning forest. The algorithm terminates when the forest becomes a single spanning tree.

The partitioning process consists of a partial execution of the GHS algorithm [8], which terminates before the MST is fully formed. The size of components is controlled by picking a value x . Once a component has exceeded size x , it no longer participates.

B. Computing Weakly-Connected Dominating Sets of the Regions

Once the graph G is partitioned into regions and a spanning tree has been determined for each region, runs the following algorithm within each region. This color-based algorithm is a distributed implementation of the centralized greedy algorithm for finding small weakly-connected dominating sets [10] [12] in graphs.

For given a graph $G = (V;E)$ assign color (white, gray, or black) with each vertex. All vertices are initially white and change color as the algorithm progresses. The algorithm is

essentially an iteration of the process of choosing a white or gray vertex to dye black. When any vertex is dyed black, any neighbouring white vertices are changed to gray. At the end of the algorithm, the black vertices constitute a weakly-connected dominating set.

The term piece is used to refer to a particular substructure of the graph. A white piece is simply a white vertex. A black piece contains a maximal set of black vertices whose weakly induced subgraph is connected plus any gray vertices that are adjacent to at least one of the black vertices of the piece. The improvement of a (non-black) vertex u is the number of distinct pieces within the closed neighborhood of u . That is, the improvement of u is the number of pieces that would be merged into a single black piece if u were to be dyed black.

In each iteration, the algorithm chooses a single white or gray vertex to dye black. The vertex is chosen greedily so as to reduce the number of pieces as much as possible until there is only one piece left. In particular, a vertex with maximum improvement value is chosen (with ties broken arbitrarily). The black vertices are the required weakly-connected dominating set S .

C. Fixing the Borders

After calculating a small weakly-connected dominating set S_i for each region R_i of G , combining these solutions does not necessarily give us a weakly connected dominating set of G . It is likely need to include some additional vertices from the borders of the regions in order to obtain a weakly-connected dominating set of G . The edges of G are either dominated (that is, they have either endpoint in some dominating set S_i) or free (in which case neither endpoint is in a dominating set). Two regions R_i and R_j joined by a dominated edge can comprise a single region with dominating set $S_i \cup S_j$, and do not need to have their shared border fixed.

The root of region R can learn, by polling all the vertices in its region, which regions are adjacent and can determine which neighbouring regions are not joined by a dominated edge. For each such pair of adjacent regions, one of the regions must "fix the border". To break ties, the region with lower region ID takes control of this process, where the region ID is the vertex ID of the region root. In other words, if neighboring regions R_i and R_j are not joined by a shared dominated edge, the region with the lower subscript adds a new vertex from the R_i/R_j border into the dominating set.

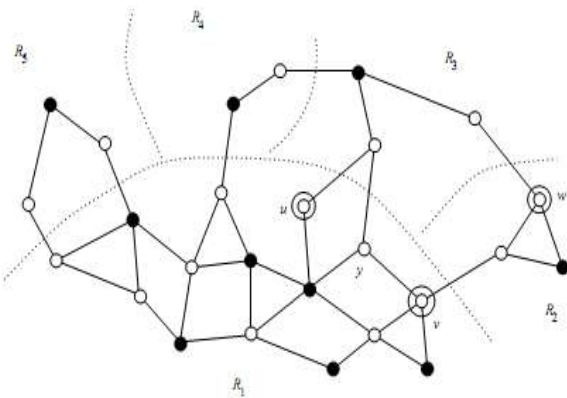


Figure 7. Fixing Borders.

For example, in Fig. 7, have regions have weakly-connected dominating sets indicated by the solid black vertices. Region R1 is adjacent to regions R2, R3, R4, and R5. Among these, regions R2 and R3 do not share dominated edges with R1. As R1 has a lower region ID than either R2 or R3, R1 is responsible for fixing these borders. The root of R1 adds u and v into the dominating set. R2 is adjacent to two regions, R1 and R3, but it is only responsible for fixing the R2/R3 border, due to the region IDs. The root of R2 adds w to the dominating set. A detailed description of this process for a given region R follows. The goal is for the root r to find a small number of dominated vertices within R to add to the dominating set. Here every vertex knows the vertex ID, color, and region ID of all of its neighbors. (This can be done with a single round of information exchange.) Root r collects the above neighborhood information from all of the border vertices of R.

This define a problem region with regard to R to be any region R0 that is adjacent to R, does not share dominated edges with R, and has a higher region ID than R. Region R is responsible for fixing its border with each problem region.

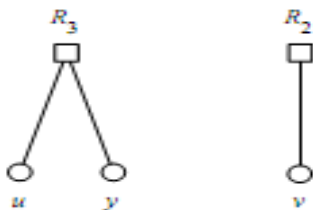


Figure 8. Bipartite Graph

A bipartite graph $B(X,Y,E)$ can be constructed from the collected information for root r. Vertex set X contains a vertex for each problem region with regard to R, and vertex set Y contains a vertex for every border vertex in R. There is an edge between vertices y_i and x_j iff y_i is adjacent to a vertex in problem region x_j in the ordinal graph. Fig. 8. shows the bipartite graph constructed by region R1 in the example of Fig. 7. In this bipartite graph, $X = \{R_2, R_3\}$ and $Y = \{u, y, v\}$. In this case, $\{u, v\}$ is a possible solution for R1

to add to the weakly-connected dominating set in order to x its borders with R2 and R3. To find the smallest possible set of vertices to add to the dominating set, r must find a minimum size subset of Y to dominate X.

D. Performance Analysis:

The execution time of this algorithm is $O(x(\log x + |S_{\max}|))$ and it generates $O(m + n(\log x + |S_{\max}|))$ messages, where S_{\max} is the largest weakly connected dominating set generated by all regions and can be trivially bounded by $O(x)$ from above. This zonal algorithm is regulated by a single parameter x, which controls the size of regions. When x is small, the algorithm finishes quickly with a large weakly-connected dominating set. When it is large, it behaves more like the non-localized algorithm and generates smaller weakly-connected dominating

V. CLUSTERING USING A MINIMUM SPANNING TREE

An undirected graph is defined as $G = (V,E)$, where V is a finite nonempty set and $E \subseteq V \times V$. V is a set of nodes v and the E is a set of edges e. A graph G is connected if there is a path between any distinct v. A graph $GS = (VS,ES)$ is a spanning subgraph of $G = (V,E)$ if $VS = V$. A spanning tree [6] [8] [15] of a graph is an undirected connected acyclic spanning subgraph. Intuitively, a minimum spanning tree(MST) for a graph is a subgraph that has the minimum number of edges for maintaining connectivity.

Gallagher, Humblet and Spira [8] proposed a distributed algorithm which determines a minimum weight spanning tree for an undirected graph that has distinct finite weights for every edge. Aim of the algorithm is to combine small fragments into larger fragments with outgoing edges. A fragment of an MST is a subtree of the MST. An outgoing edge is an edge of a fragment if there is a node connected to the edge in the fragment and one node connected that is not in the fragment. Combination rules of fragments are related with levels. A fragment with a single node has the level L = 0. Suppose two fragments F at level L and F' at level L'.

- If $L < L'$, then fragment F is immediately absorbed as part of fragment F'. The expanded fragment is at level L'.
- Else if $L = L'$ and fragments F and F' have the same minimum-weight outgoing edge, then the fragments combine immediately into a new fragment at level L+1
- Else fragment F waits until fragment F' reaches a high enough level for combination.

Under the above rules the combining edge is then called the core of the new fragment. The two essential properties of MSTs for the algorithm are:

- *Property 1:* Given a fragment of anMST, let e be a minimum weight outgoing edge of the fragment. Then joining e and its adjacent non-fragment node to the fragment yields another fragment of an MST.

- *Property 2:* If all the edges of a connected graph have different weights, then the MST is unique

The algorithm defines three different states of operation for a node. The states are *Sleeping*, *Find* and *Found*. The states affect what of the following seven messages are sent and how to react to the messages: *Initiate*, *Test*, *Reject*, *Accept*, *Report (W)*, *Connect (L)* and *Change-core*. The identifier of a fragment is the core edge, that is, the edge that connects the two fragments together. A sample MANET and a minimum spanning tree constructed with Gallagher, Humblet, Spira's algorithm can be seen in Fig. 9. where any node other than the leaf nodes which are shown by black color depict a connected set of nodes. The upper bound for the number of messages exchanged during the execution of the algorithm is $5N\log 2N + 2E$, where N is the number of nodes and E is the number of edges in the graph. A worst case time for this algorithm is $O(N\log N)$.

Dagdeviren et. al. proposed the Merging Clustering Algorithm (MCA) [6] which finds clusters in a MANET by merging the clusters to form higher level clusters as mentioned in Gallagher et. al.'s algorithm [28]. However, they focused on the clustering operation by discarding the minimum spanning tree. This reduces the message complexity from $O(n\log n)$ to $O(n)$. The second contribution is to use upper and lower bound parameters for clustering operation which results in balanced number of nodes in the clusters formed. The lower bound is limited by a parameter which is defined by K and the upper bound is limited by $2K$.

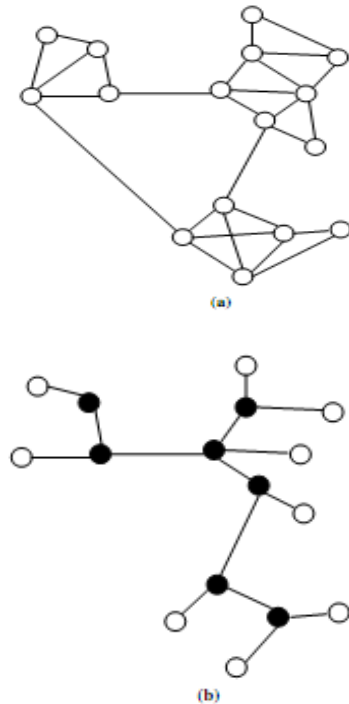


Figure 9. A MANET and its Spanning Tree.

VI. CONCLUSIONS

In this paper we discussed dominating set and spanning tree based clustering in mobile ad hoc networks and its

performance analysis. The efficiency of dominating set based routing mainly depends on the overhead introduced in the formation of the dominating set and the size of the dominating set. We discussed two algorithms which have less overhead in dominating set formation. Finally we discussed spanning tree approach in clustering MANET. Distributed spanning tree and dominating set approaches can be merged to improve clustering in MANET.

VII. FUTURE WORK

The interesting open problem in mobile ad hoc networks is to study the dynamic updating of the backbone efficiently when nodes are moving in a reasonable speed integrate the mobility of the nodes. The work can be extended to develop connected dominating set construction algorithms when hosts in a network have different transmission ranges.

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Distributed Group Key Management with Cluster based Communication for Dynamic Peer Groups

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Abstract—Secure group communication is an increasingly popular research area having received much attention in recent years. Group key management is a fundamental building block for secure group communication systems. This paper introduces a new family of protocols addressing cluster based communication, and distributed group key agreement for secure group communication in dynamic peer groups. In this scheme, group members can be divided into sub groups called clusters. We propose three cluster based communication protocols with tree-based group key management. The protocols (1) provides the communication within the cluster by generating common group key within the cluster, (2) provides communication between the clusters by generating common group key between the clusters and (3) provides the communication among all clusters by generating common group key among the all clusters. In our approach group key will be updated for each session or when a user joins or leaves the cluster. More over we use Certificate Authority which guarantees key authentication, and protects our protocol from all types of attacks.

Keywords- Secure Group Communication; Key Agreement; Key Tree; Dynamic peer groups, Cluster.

I. INTRODUCTION

As a result of the increased the popularity of group oriented applications such as pay-TV, distributed interactive games, video and teleconference and chat rooms. There is a growing demand for the security services to achieve the secure group communication. A common method is to encrypt messages with a group key, so that entities outside the group cannot decode them. A satisfactory group communication system would possess the properties of group key security, forward secrecy, backward secrecy, and key independence [1,2,3].

In this paper research efforts have been put into the design of a group key management and three different cluster based communication protocols. There are three approaches for generating such group keys: centralized, decentralized, and distributed. Centralized key distribution uses a dedicated key server, resulting in simpler protocols. However, centralized methods fail entirely once the server is compromised, so that the central key server makes a tempting target for adversaries. In addition, centralized key distribution is not suitable for dynamic peer groups, in which all nodes play the same function and role, thus it is unreasonable to make one the key server, placing all trust in it. In the decentralized approach, multiple

entities are responsible for managing the group as opposed to a single entity. In contrast to both approaches, the distributed key management requires each member to contribute a share to generate the group key, resulting in more complex protocols. And each member is equally responsible for generating and maintaining the group key.

In this paper the group key or common key is generated based on distributed key management approach. The group key is updated on every membership change, and for every session, for forward and backward secrecy [1, 2, 3], a method called group rekeying.

To reduce the number of rekeying operations, Woung et al [7] proposed a logical data structure called a key tree. And Kim et al [1], proposed a tree-based key agreement protocol, TGDH which is combination of key tree and Diffie-Hellman key to generate and maintain the group key. But it suffers from the impersonation attack because of not regularly updation of keys and generates unnecessary messages. Based on above two ideas Zhou, L., C.V. Ravishanker and Kim et al [6], proposed an AFTD (Authenticated Fault-tolerant Tree-based Diffie-Hellman key exchange Protocol) protocol, which is the combination of key trees and Diffie-Hellman key exchange for group key generation.

Assume that the total network topology considered as a group, which can be divided into subgroups called clusters. Group is divided into clusters based on the location identification number; LID's of users, and cluster is assigned with cluster identification numbers, CID, which are given by the Certificate Authority, CA at the time of user joining into cluster or group. Issuing location identification number and public key certificate to the new user are the offline actions performed by the certificate authority, CA.

Each cluster member maintains its own cluster key tree and generates the cluster group key for secure communication. We assume in every cluster, every node can receive a message broadcasted from the other nodes. Each cluster is headed by a cluster head or sponsor of cluster and he is responsible for generating cluster group key, who is shallowest rightmost to the user (in cluster key tree) joins or leaves from the cluster.

Cluster group key or cluster common key is shared by all the cluster members and communicates with it. The authentication is provided by certificate authority by issuing the

public key certificate and location identification number, LID prior to the time of joining in the cluster or group.

The rest of the paper is organized as follows. Section 2 focuses on related work in this field. We present our proposed scheme in Section 3, communication protocols and group key management techniques are discussed in Section 4. Dynamic network peer groups are presented in Section 5, security analysis in section6. Finally we make a conclusion in Section 7.

II. RELATED WORK

Key trees [6] were first proposed for centralized key distribution, while Kim et al.[1], adapted it to distributed key agreement protocol TGDH. In TGDH [1] every group member creates a key tree separately. Each leaf node is associated with a real group member, while each non-leaf node is considered as virtual member. In TGDH, every node on the key tree has a Diffie-Hellman key pair based on the prime p and generator α , used to generate the group key. Secret-public key pair for real member M_i is as follows.

$$\{KM_i, BKM_i = \alpha^{KM_i} \bmod p\} \quad (1)$$

And Secret-public key pair for virtual member V_i is as follows.

$$\{KV_i, BKV_i = \alpha^{KV_i} \bmod p\} \quad (2)$$

Public key BKM_i is also called as blinded key. Consider a node Mv whose left child is Mlv and right child node is Mrv (to simplify the description, we do not distinguish real members from virtual members here). Secret key of M_i 's can be computed in the usual Diffie-Hellman key exchange fashions as follows.

$$\{KMv \equiv (BKMLv)^{KMrv} \equiv (BKMrv)^{KMlv} \bmod p\} \quad (3)$$

With all blinded keys well-known, each group member can compute the secret keys of all nodes on its key path, comprising the nodes from the leaf node up to the root. The root node's secret key KV_0 is known to all group members, and becomes the group key. In Figure 2, cluster member U_{12} knows the key pairs of U_{12} , V_{11} and V_{10} . V_{10} 's secret key is the cluster group key.

In AFTD [6], as increasing the group size, the group rekeying operation becomes complex and it leads to the performance degradation and generates more messages to distribute the group key, this is the main limitation of the AFTD protocol.

Renuka A. and K.C.Shet [9] were proposed the cluster based communications, which is different from our approach in key management and in communication protocols. Our detailed communication protocols and key management scheme are discussed in this paper.

Lee et al. [4,5] have designed several tree-based distributed key agreement protocols, reducing the rekeying complexity by performing interval based rekeying. They also present an authenticated key agreement protocol. As the success of their scheme is partially based on a certificate authority, their protocol will encounter the same problems as centralized trust mechanisms.

Nen-Chung Wang, Shian-Zhang Fang [10], have proposed 'A hierarchical key management scheme for secure group communications in mobile ad hoc networks'. This paper involves very complex process to form the cluster and for communications.

Gouda et al. [11], who describe a new use of key trees. They are concerned about using the existing subgroup keys in the key tree to securely multicast data to different subgroups within the group. Unlike their approach, which depends on a centralized key server to maintain the unique key tree and manage all keys, our paper solves this problem in a distributed fashion.

III. PROPOSED SCHEME

A. Sytem Model

To overcome the limitations of AFTD [6] protocol the entire set of group members in the network is divided into a number of subgroups called clusters and the layout of the network is as shown in Figure 1.

The cluster is formed based on location identification number, LID's of the users and clusters are assigned with cluster identification numbers, CID, which are given offline by the Certificate Authority CA. If the CID is equal to the LID then those users are belongs to that particular cluster. CID and LID are unique for each cluster.

In this paper each cluster member maintains its own cluster key tree as shown in Figure 2 (a,b,c), the leaf nodes in cluster key tree are the cluster users (real users), and non leaf nodes are the virtual users. We propose three different types of communication protocols with distributed tree-based group key management.

The cluster communications protocols are given below.

- Intra Cluster Communication protocol (ICC),
- Inter Cluster Communication protocol (IRCC) and
- Global Communication (GC) protocol.

Communication among the users within the cluster is called Intra Cluster Communication. Communication between the clusters is called Inter Cluster Communication. When IRCC occurs between the clusters then the respective cluster key tree is generated as shown in Figure 4, for generating group key. Communication among all clusters is called Global Communication and corresponding cluster key tree is generated as shown in Figure 5, for generating group key. The illustrations of communications are as shown in Figure 3.

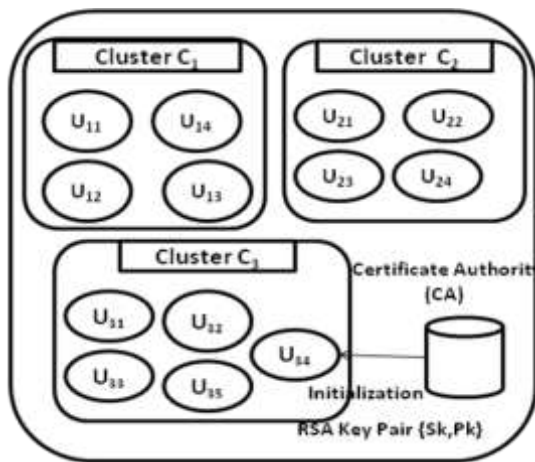


Figure 1. Network Layout and Initialization

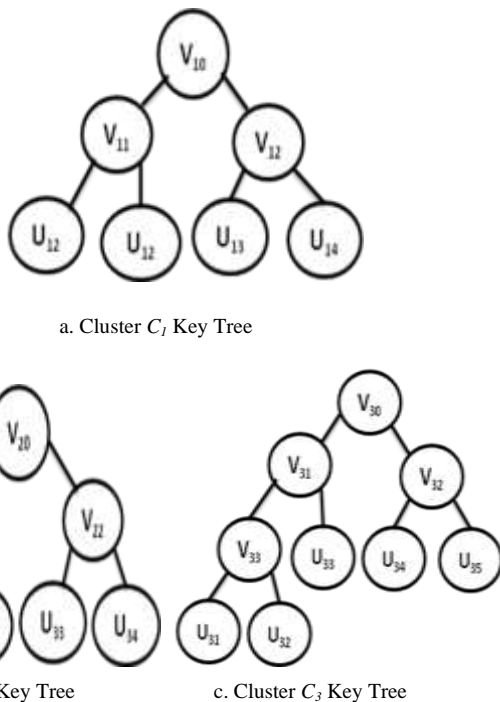


Figure 2. Key trees of clusters

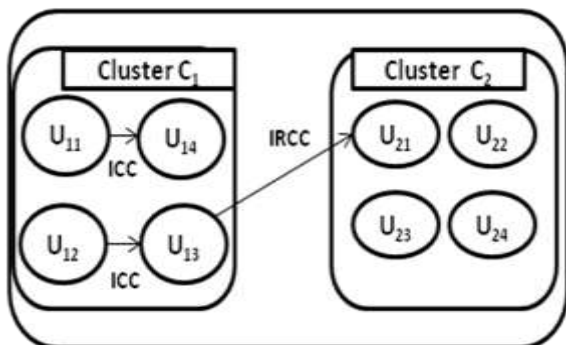


Figure 3. Illustration of communications.

B. Group Key Management Scheme

In fact an update of a blinded key need be sent only to a cluster members, instead of entire group (all clusters) based on the type of communications. We send each nodes blinded keys only to its cluster members. In this paper each cluster member constructs a key independently. Each real user U_{ij} of a cluster C_i has two key pairs first one is: Diffie-Hellman key pair, which is used to generate the group key is given below.

$$\{KU_{ij}, BKU_{ij} = \alpha^{KU_{ij}} \text{ mod } p\} \quad (4)$$

And an RSA secret-public key pair $\{Dij, Eij\}$, which is used to provide source authentication. In key tree non-leaf nodes are virtual users (virtual clusters for global communication or for inter cluster communications), and have only a Diffie-Hellman key pair as given below.

$$\{KV_{ij}, BKV_{ij} = \alpha^{KV_{ij}} \text{ mod } p\} \quad (5)$$

Group key management for user communications is occurs in two phases.

- Initialization phase
- Group key generation and distribution phase

1) Initialization Phase

Certificate authority, CA will distribute the appropriate public key certificates to clusters and it does not issue renewed public key certificates for existing group members during the process of cluster or group key update.

New member wishing to join the group may obtain joining certificate and LID (based on location where user wants to join) from the CA at any time prior to join.

The certificate authority (CA), uses an RSA secret- public key pair $\{Sk, Pk\}$ and establishes public key certificates for each cluster user U_{ij} by signing U_{ij} 's public key with its secret key Sk . User U_{ij} 's public key certificate $\langle U_{ij}, PUBU_{ij}, E_{ij} \rangle Sk$ is now distributed to its cluster user since public key Pk is well known, any user of cluster can verify this certificate and obtains U_{ij} 's public key.

2) Group Key Generation and Distribution Phase

Group key generation and distribution for cluster communication occurs in three different ways.

- Group key generation and distribution in ICC.
- Group key generation and distribution in IRCC.
- Group key generation and distribution in GC.

The above group key generation and distribution techniques for cluster communications are implemented in respective communication protocols and in dynamic peer groups (in section 5).

IV. COMMUNICATION PROTOCOLS

The communication protocols are as follows.

- Intra Cluster Communications (ICC).
- Inter Cluster Communications (IRCC).
- Global Communications (GC).

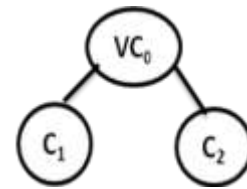


Figure 4. Reduced IRCC Key Tree.

A. Intra Cluster Communications(ICC)

Communication among the users within the cluster is called Intra Cluster Communication. Example of intra cluster communication is shown in Figure 3, and corresponding cluster key tree is shown in Figure 2.

In order to communicate users with each other within the cluster, they need to have the common cluster group key, which is generated from their cluster key trees based on Diffie-Hellman key exchange fashion.

Steps for generation and distribution of cluster group key in ICC (algorithm for cluster common key generation in ICC).

- Select the cluster in which Intra Cluster Communication is to be done.
- Each cluster (C_i) generates its own cluster key trees.
- The root node (V_{ij}) of cluster C_i 's secret key KV_{ij} is generated using the DH Key exchange fashion from its leaf nodes (the generation of Cluster group key or common key is explained in dynamic peer groups).
- The secret key of the root node V_{ij} is KV_{ij} will become the cluster group key or common key for cluster C_i and that will be shared by all members of a cluster.
- For each session the cluster group key will be changed by changing their contribution.
- New generated cluster group key KV_{ij} will be distributed among all members of cluster.

B. Inter Cluster Communications(IRCC)

Communicating one cluster with another cluster is called an Inter Cluster Communication. The example of IRCC is shown in Figure 3, and corresponding reduced cluster key tree is generated as shown in Figure 4. In this figure VC_0 is virtual cluster and it has only DH key pair as shown below.

$$\{KVC_i, BKVC_i = \alpha^{KVC_i} \text{ mod } p\} \quad (6)$$

The secret-public key pair of virtual cluster VC_i is for generating clusters common key, which is generated according DH Key fashion and distributed to the both clusters for communicating each other.

The steps for Generation and distribution of common key for clusters in IRCC (algorithm for group key generation in IRCC)

- Select the clusters for IRCC and form reduced cluster key tree as shown in Figure 4.
- Each cluster has its own cluster group key or cluster's common key, which is generated from their cluster key tree based on DH key exchange fashion.
- Cluster C_i and cluster C_j 's secret keys KC_i, KC_j are calculated respectively (as explained in intra cluster communication algorithm).
- Using KC_i and KC_j , the root node VC_i (parent node of C_i and C_j , or virtual cluster) calculates its secret key KVC_i using DH key exchange fashion.
- The root node's VC_i is, KVC_i which is common key for both cluster C_i and cluster C_j .
- KVC_i is distributed to both cluster and that will be shared by all members of each cluster for communicating each other.
- For each session the common key for clusters is recalculated by changing their shares of each clusters members and distributed to all members of both clusters.

C. Global Communication(GC)

Communicating all clusters in a group is called Global Communication. When cluster C_1, C_2 and C_3 are communicating, then reduced global communication key tree is generated as shown in Figure 5, and common global key is generated according to DH key exchange fashion. In this figure leaf nodes are real clusters and non-leaf nodes are virtual clusters.

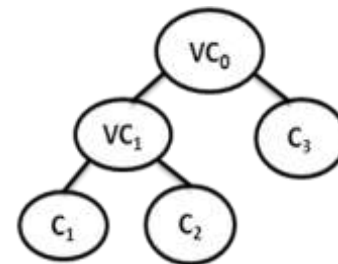


Figure 5. Reduced GC Key Tree

Steps for global key generation and distribution in GC (algorithm for global key generation & distribution in GC).

- Each cluster generates its own cluster key trees
- For each cluster key tree there will be generated the roots secret keys, which are common keys for all respective clusters.
- Cluster C_i , C_j and C_k 's secret keys KC_i , KC_j and KC_k are calculated respectively from their cluster key trees.
- With these three clusters, Reduced Global Communication Key tree will be formed as shown in Figure 5.
- The root node VC_i 's (from Reduced GC key tree) secret key KVC_i is calculated using DH key fashion, which is common key for all clusters C_i , C_j and C_k .
- VC_i 's secret key KVC_i is distributed to all clusters and that will be shared by all members of each cluster for communicating globally.
- For each session the global key recalculated by changing their shares of each cluster's members and distributed to all members of clusters.

V. DYNAMIC PEER GROUPS

The numbers of nodes or clusters in the network are not necessarily fixed. New node (user) or cluster may join the network or existing nodes or cluster may leave the network.

A. User Joins the Cluster

Assume that a new user U_{ij+1} wish to join a k-users cluster $\{U_1, U_2, \dots, U_k\}$. U_{ij+1} , is required to authenticate itself by presenting a join request signed with SK. U_{ij+1} may obtain a signature on its join request by establishing credentials with the offline certificate authority.

When the users of clusters receive the joining request, they independently determine U_{ij+1} 's insertion node in the key tree, which is defined as in [1], which is the shallowest rightmost node or the root node when the key tree is well-balanced. They also independently determine a real user called join sponsor U_s [1], to take responsible for coordinating the join, which is the rightmost leaf node in the sub tree rooted at the insertion node.

No keys change in the key tree at a join, except the blinded keys for nodes on the key path for the sponsor node. The sponsor simply re computes the cluster group key, and sends updates for blinded keys on its own key path to their corresponding clusters. The join works as shown below.

Steps for group key or cluster common key generation and distribution when user joins in cluster (algorithm for user joins in cluster).

- New User U_{ij+1} takes the LID and public key certificates from the CA.
- User U_{ij+1} selects appropriate cluster by comparing its LID with CID (for LID=CID).

- The user U_{ij+1} broadcast the signed join request to its cluster C_i .
- Cluster C_i 's members determine the insertion point, and update their key trees by creating a new intermediate node and promoting it to become the parent of the insertion node and U_{ij+1} .
- Each cluster member adjusts the cluster key tree by adding U_{ij+1} to its selected clusters adjacent to the insertion point.
- The sponsor U_s compute the new cluster group key or cluster common key.
- Then sponsor U_s sends the updated blinded keys of nodes on its key path to their corresponding clusters.
- These messages are signed by the sponsor U_s .
- U_{ij+1} takes the public keys needed for generating the cluster group key, generates group key.

The cluster group key (for cluster C_3) or cluster common key for Figure 6 is generated as follows (steps for group key or common key generation).

- Let U_{31} 's secret share is KU_{31} , and then secret-public key pair of U_{31} (according to DH Key fashion) is as shown below.

$$\{KU_{31}, BKU_{31} = \alpha^{KU_{31}} \text{ mod } p\} \quad (7)$$

- Let U_{32} 's secret share is KU_{32} then secret-public key pair of U_{32} (according to DH Key fashion) is shown below.

$$\{KU_{32}, BKU_{32} = \alpha^{KU_{32}} \text{ mod } p\} \quad (8)$$

- Let U_{33} 's secret share is KU_{33} then secret-public key pair of U_{33} (according to DH Key fashion) is shown below.

$$\{KU_{33}, BKU_{33} = \alpha^{KU_{33}} \text{ mod } p\} \quad (9)$$

- Let U_{34} 's secret share is KU_{34} then secret-public key pair of U_{34} (according to DH Key fashion) is shown below.

$$\{KU_{34}, BKU_{34} = \alpha^{KU_{34}} \text{ mod } p\} \quad (10)$$

- Let U_{35} 's secret share is KU_{35} then secret-public key pair of U_{35} (according to DH Key fashion) is shown below.

$$\{KU_{35}, BKU_{35} = \alpha^{KU_{35}} \text{ mod } p\} \quad (11)$$

- Now V_{33} 's Secret-Public keys (KV_{33} , BKV_{33}) are calculated as follows (according to the DH Key Exchange fashion from U_{31} and U_{32}).

$$\{KV_{33} \equiv (BKU_{31})^{KU_{32}} \equiv (BKU_{32})^{KU_{31}} \pmod{p}\} \quad (12)$$

$$\{BKV_{33} = \alpha^{KV_{33}} \pmod{p}\} \quad (13)$$

- Now V_{32} 's Secret-Public keys (KV_{32} , BKV_{32}) are calculated as follows (according to the DH Key Exchange fashion from U_{34} and U_{35}).

$$\{KV_{32} \equiv (BKU_{34})^{KU_{35}} \equiv (BKU_{35})^{KU_{34}} \pmod{p}\} \quad (14)$$

$$\{BKV_{32} = \alpha^{KV_{32}} \pmod{p}\} \quad (15)$$

- Now V_{31} 's Secret-Public key pair (according to the DH Key Exchange fashion from V_{33} and U_{33}) is

$$\{KV_{31} \equiv (BKV_{33})^{KU_{33}} \equiv (BKU_{33})^{KV_{33}} \pmod{p}\} \quad (16)$$

$$\{BKV_{31} \equiv \alpha^{KV_{31}} \pmod{p}\} \quad (17)$$

- Finally V_{30} 's Secret-Public key pair (according to the DH Key Exchange fashion from V_{31} and V_{32}) is

$$\{KV_{30} \equiv (BKV_{31})^{KV_{32}} \equiv (BKV_{32})^{KV_{31}} \pmod{p}\} \quad (18)$$

$$\{BKV_{30} = \alpha^{KV_{30}} \pmod{p}\} \quad (19)$$

- The root node V_{30} 's Secret key is considered as cluster C_3 's Group key or cluster common key, through which communication is need to done.
- And this common cluster key is distributed to all cluster members.

Like above steps for group key or common key generation, the common key or group key for all the different cluster communication and in dynamic peer, are generated.

In Figure 6, a new user U_{36} wants to joins in C_3 cluster. The join sponsor U_{33} creates a new intermediate node V_{34} in the key tree and promotes it to become the parent of U_{33} and U_{36} . The sponsor U_{33} computes the new cluster group key, and sends the updated BKV_{34} and BKV_{31} to remaining members $\{U_{31}, U_{32}, U_{34}, U_{35}\}$ of the cluster C_3 .

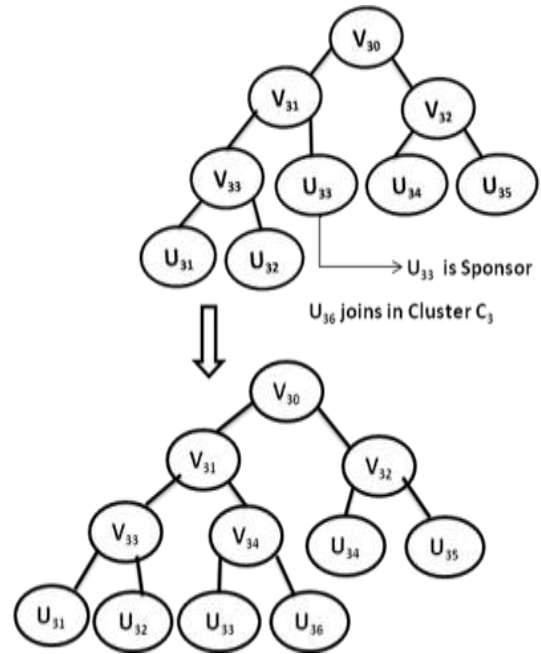


Figure 6. User joins in Cluster C3

B. User Leaves the Cluster

Assume that a member U_{ij} wishes to leave an n-member cluster. First U_{ij} initiates the leave protocol by sending a leave request. When the other users of cluster receive the request, they independently determine the sponsor node, which is the right-most leaf node of the Sub tree rooted at the leaving member's sibling node which is defined as in [1]. The leave protocol works as given below.

Steps for group key generation and distribution when user leaves the cluster (algorithm for user leave from cluster).

- User U_{ij} broadcasts its leave request to remaining users of that cluster C_i .
- The former sibling node of U_{ij} is promoted to replace U_{ij} 's parent node.
- The size of the cluster that formerly contained U_{ij} is decreased by one.
- The sponsor U_s picks a new secret key KU_s , and computes the new cluster group key, and sends the updated blinded keys of nodes on its key path to their corresponding cluster users.
- These messages are signed by the sponsor U_s
- Group prepared based on DH key exchange fashion, as explained in dynamic peer groups.

In Figure 7, U_{36} leaves a cluster C_3 . The sponsor U_{33} picks a new secret key KU_{33} and computes the new group key, sends updated BKU_{33} , BKV_{31} and BKV_{30} to their cluster users $\{U_{31}, U_{32}, U_{34}, \text{ and } U_{35}\}$.

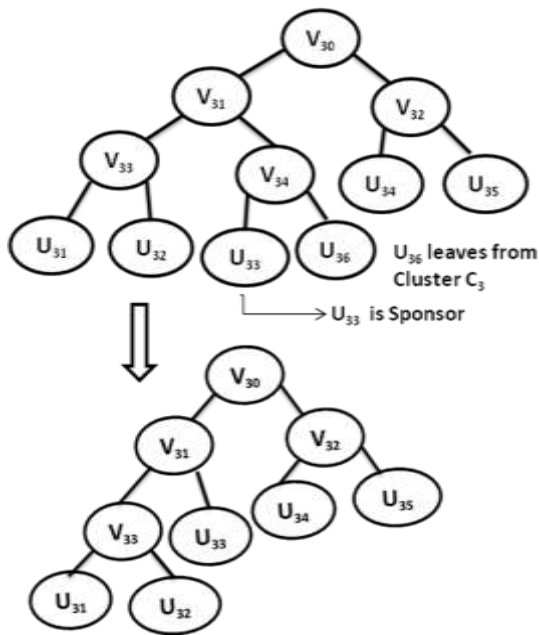


Figure 7. User U_{36} leaves the Cluster C_3 .

C. Updating Secret Shares & RSA keys

In this scheme, each group user is required to update its Diffie-Hellman keys before each group session, or during a session when it is selected as a sponsor on a user's leaving. Source authentication of the updated blinded keys is guaranteed by the sender's RSA signature. Further, to ensure the long-term secrecy of the RSA keys, group user to renew its RSA key pair periodically, and send it to its cluster users securely using its current RSA secret key.

VI. PERFORMANCE ANALYSIS

Security Analysis: Users in a network group are usually considered to be part of the security issue since there are no fixed nodes to perform the service of authentication. The Certificate Authority, which may be distributed, is on-line during initialization, but remains offline subsequently. During initialization, the CA distributes key certificates and location IDs, so that the function of key authentication can be realized and distributed across appropriate clusters.

A. Forward Secrecy

If a hacker (or old member) can compromise any node and obtain its key, it is possible that the hacker can start new key agreement protocol by impersonating the compromised node. For our scheme we can conclude that a passive hacker who knows a contiguous subset of old group keys cannot discover any subsequent group key. In this way, forward secrecy can be achieved.

B. Backward Secrecy

A passive hacker (or new joined member) who knows a contiguous subset of group keys cannot discover how a previous group key is changed upon a group join or leave.

C. Key Independence

This is the strongest property of the dynamic peer groups. It guarantees that a passive adversary who knows some previous group key cannot determine new group keys.

VII. CONCLUSION

In this paper, we have presented three communication protocols with distributed group key management for dynamic peer groups using key trees, by dividing group into subgroups called clusters. We provided the strong authentication with LID's, CID's for cluster formations. We provide the source authentication of user in communication with RSA keys. The DH secret-public key pairs are used for common key generations. Certificate Authority provided the RSA keys, LID's for all users and CID's for all clusters for all types of cluster communications.

In future we can extend this application with cluster head communications, sponsor coordination and cluster merging or cluster disjoining in dynamic network.

ACKNOWLEDGMENT

We would like to thank to K Sahadeviah for help full discussion about different key management schemes and modes of providing authentications. We thank Krishna Prasad for discussion of effective presentations of concepts. We also thank our friends for designing of network frame work.

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Extracting Code Resource from OWL by Matching Method Signatures using UML Design Document

UML Extractor

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Abstract—Software companies develop projects in various domains, but hardly archive the programs for future use. The method signatures are stored in the OWL and the source code components are stored in HDFS. The OWL minimizes the software development cost considerably. The design phase generates many artifacts. One such artifact is the UML class diagram for the project that consists of classes, methods, attributes, relations etc., as metadata. Methods needed for the project can be extracted from this OWL using UML metadata. The UML class diagram is given as input and the metadata about the method is extracted. The method signature is searched in OWL for the similar method prototypes and the appropriate code components will be extracted from the HDFS and reused in a project. By doing this process the time, manpower system resources and cost will be reduced in Software development.

Keywords- Component: Unified Modeling language, XML, XMI Metadata Interchange, Metadata, Web Ontology Language, Jena framework.

I. INTRODUCTION

The World Wide Web has changed the way people communicate with each other. The term Semantic Web comprises techniques that dramatically improve the current web and its use. Today's Web content is huge and not well-suited for human consumption. The machine processable Web is called the Semantic Web. Semantic Web will not be a new global information highway parallel to the existing World Wide Web; instead it will gradually evolve out of the existing Web [1]. Ontologies are built in order to represent generic knowledge about a target world [2]. In the semantic web, ontologies can be used to encode meaning into a web page, which will enable the intelligent agents to understand the contents of the web page. Ontologies increase the efficiency and consistency of describing resources, by enabling more sophisticated functionalities in development of knowledge management and information retrieval applications. From the knowledge management perspective, the current technology suffers in searching, extracting, maintaining and viewing information. The aim of the Semantic Web is to allow much more advanced knowledge management system.

To develop such a knowledge management system the software company's can make use of the already developed coding. That is to develop new software projects with reusable codes. The concept of reuse is not a new one. It is however relatively new to the software profession. Every Engineering discipline from Mechanical, Industrial, Hydraulic, Electrical, etc, understands the concept of reuse. However, Software Engineers often feel the need to be creative and like to design "one time use" components. The fact is they come with unique solution for every problem. Reuse is a process, an applied concept and a paradigm shift for most people. There are many definitions for reuse. In plain and simple words, reuse is, "The process of creating new software systems from existing software assets rather than building new ones".

Systematic reuse of previously written code is a way to increase software development productivity as well as the quality of the software [3, 4, 5]. Reuse of software has been cited as the most effective means for improvement of productivity in software development projects [6, 7]. Many artifacts can be reused including; code, documentation, standards, test cases, objects, components and design models. Few organizations argue the benefits of reuse. These benefits certainly will vary organization to organization and to a degree in economic rational. Some general reusability guidelines, which are quite often similar to general software quality guidelines, include [8] ease of understanding, functional completeness, reliability, good error and exception handling, information hiding, high cohesion and low coupling, portability and modularity. Reuse could provide improved profitability, higher productivity and quality, reduced project costs, quicker time to market and a better use of resources. The challenge is to quantify these benefits.

For every new project Software teams design new components and code by employing new developers. If the company archives the completed code and components, they can be used with no further testing unlike open source code and components. This has a recursive effect on the time of development, testing, deployment and developers. So there is a base necessity to create system that will minimize these factors.

Code re-usability is the only solution for this problem. This will reduce the development of an existing work and testing. As the developed code has undergone the rigorous software development life cycle, it will be robust and error free. There is no need to re-invent the wheel. To reuse the code, a tool can be created that can extract the metadata such as function, definition, type, arguments, brief description, author, and so on from the source code and store them in OWL. This source code can be stored in the HDFS repository. For a new project, the development can search for components in the OWL and retrieve them at ease. The OWL represents the knowledgebase of the company for the reuse code.

The projects are stored in OWL and the source code is stored in the Hadoop Distributed File System (HDFS) [9]. The client and the developer decide and approve the design document. For the paper the UML class diagram is one such design document considered as the input for the system. The method metadata is extracted from the UML and passed to the SPARQL to extract the available methods from the OWL. Selecting appropriate method from the list the code component is retrieved from the HDFS. The purpose of using an UML diagram as input is before developing software this tool can be used to estimate how many methods is to be developed by extraction. The UML diagram is a powerful tool that acts between the developer and the user. So it is like a contract where both parties agree for software development using UML diagram. After extracting the methods from the UML diagram these methods are matched in the OWL. From the retrieved methods the developer can account for how many are already available in the repository and how many to be developed. If the retrieved methods are more the development time will be shorter. To have more method matches the corporate should store more projects. The uploading of projects in the OWL and HDFS the corporate knowledge grows and the developers will use more of reuse code than developing themselves. Using the reuse code the development cost will come down, development time will become shorter, resource utilization will be less and quality will go up.

The paper begins with a note on the related technology required in Section 2. The detailed features and framework for source code retriever is found in Section 3. The Keyword Extractor for UML is in section 4. The Method Retriever by Jena framework is in section 5. The Source Retriever from the HDFS is in section 6. The implementation scenario is in Section 7. Section 8 deals with the findings and future work of the paper.

II. RELATED WORK

A. Metadata

Metadata is defined as “data about data” or descriptions of stored data. Metadata definition is about defining, creating, updating, transforming, and migrating all types of metadata that are relevant and important to a user’s objectives. Some metadata can be seen easily by users, such as file dates and file sizes, while other metadata can be hidden. Metadata standards include not only those for modeling and exchanging metadata, but also the vocabulary and knowledge for ontology [10]. A lot of efforts have been made to standardize the metadata but all

these efforts belong to some specific group or class. The Dublin Core Metadata Initiative (DCMI) [11] is perhaps the largest candidate in defining the Metadata. It is simple yet effective element set for describing a wide range of networked resources and comprises 15 elements. Dublin Core is more suitable for document-like objects. IEEE LOM [12], is a metadata standard for Learning Objects. It has approximately 100 fields to define any learning object. Medical Core Metadata (MCM) [13] is a Standard Metadata Scheme for Health Resources. MPEG-7 [14] multimedia description schemes provide metadata structures for describing and annotating multimedia content. Standard knowledge ontology is also needed to organize such types of metadata as content metadata and data usage metadata.

B. Hadoop & HDFS

The Hadoop project promotes the development of open source software and it supplies a framework for the development of highly scalable distributed computing applications [15]. Hadoop is a free, Java-based programming framework that supports the processing of large data sets in a distributed computing environment and it also supports data intensive distributed application. Hadoop is designed to efficiently process large volumes of information[16]. It connects many commodity computers so that they could work in parallel. Hadoop ties smaller and low-priced machines into a compute cluster. It is a simplified programming model which allows the user to write and test distributed systems quickly. It is an efficient, automatic distribution of data and it works across machines and in turn it utilizes the underlying parallelism of the CPU cores. The monitoring system then re-replicates the data in response to system failures which can result in partial storage. Even though the file parts are replicated and distributed across several machines, they form a single namespace, so their contents are universally accessible. Map Reduce [17] is a functional abstraction which provides an easy-to-understand model for designing scalable, distributed algorithms.

C. Ontology

The key component of the Semantic Web is the collections of information called ontologies. Ontology is a term borrowed from philosophy that refers to the science of describing the kinds of entities in the world and how they are related. Gruber defined ontology as a specification of a conceptualization [18]. Ontology defines the basic terms and their relationships comprising the vocabulary of an application domain and the axioms for constraining the relationships among terms [19]. This definition explains what an ontology looks like [20]. The most typical kind of ontology for the Web has taxonomy and a set of inference rules. The taxonomy defines classes of objects and relations among them. Classes, subclasses and relations among entities are a very powerful tool for Web use.

III. SOURCE CODE RETRIEVER FRAMEWORK

The Source Code Retriever makes use of OWL is constructed for the project and the source code of the project is stored in the HDFS [21]. All the project information of a software company is stored in the OWL. The size of the project source will be of terabytes and the corporate branches are

spread over in various geographical locations so, it is stored in Hadoop repository to ensure distributed computing environment. Source Code Retriever is a frame work that takes UML class diagram or XMI (XML Metadata Interchange) file as an input from the user and suggests the reusable methods for the given Class Diagram. The Source Code Retriever consists of three components: Keyword Extractor for UML, Method Retriever and Source Retriever. The process of the Source Code Retriever Framework is presented in the “Fig. 1” The Keyword Extractor for UML extracts the metadata from the UML class diagram. The class diagram created by Umberllo tool is passed as input to the Keyword Extractor for UML.

The input for the frame work can be an existing UML class diagram or created by the tool. Both types of input are loaded in to Umberllo and the file type for storing UML class diagram is XMI format. The file is parsed for metadata extraction. The parser extracts method signatures from the XMI file and passes it to the Method Retriever component. Method Retriever component

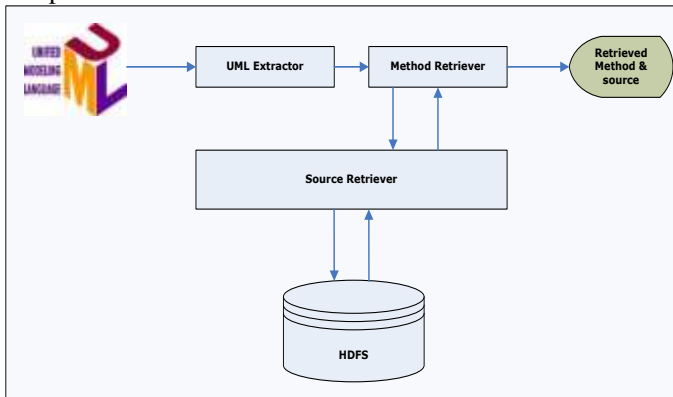


Figure 1. Process of Source Retriever

retrieves the matched methods from the repository. Method Retriever constructs SPARQL query to retrieve the matched results. The user should select the appropriate method from the list of methods and retrieve the source code by Source Retriever component which interacts with HDFS and displays the source code.

IV. KEYWORD EXTRACTOR FOR UML

Unified Modeling Language (UML) is a visual language for specifying, constructing, and documenting the artifacts of systems. It is a standardized general-purpose modeling language in the field of software engineering. To create UML class diagram Umberllo UML Modular open source tool is used. The diagram is stored in XMI format. Umbrello UML Modeller is a Unified Modeling Language diagram program for KDE. UML allows the user to create diagrams of software and other systems in a standard format. Umbrello It can support in the software development process especially during the analysis and design phases of this process. UML is the diagramming language used to describing such models. Software ideas can be represented in UML using different types of diagrams. Umbrello UML Modeller 1.2 supports Class Diagram, Sequence Diagram, Collaboration Diagram, Use

Case Diagram, State Diagram, Activity Diagram, Component Diagram and Deployment Diagram.

The XMI is an Object Management Group (OMG) standard for exchanging metadata information using XML. The initial proposal of XMI "specifies an open information interchange model that is intended to give developers working with object technology the ability to exchange programming data over the Internet in a standardized way, thus bringing consistency and compatibility to applications created in collaborative environments."The main purpose of XMI is to enable easy interchange of metadata between modeling tools and between tools and metadata repositories in distributed heterogeneous environments. XMI integrates three key industry standards: (a) XML - a W3C standard (b) UML - an OMG (c) MOF - Meta Object Facility and OMG modeling and metadata repository standard. The integration of these three standards into XMI marries the best of OMG and W3C metadata and modeling technologies allowing developers of distributed systems share object models and other Meta data over the Internet.

The process flow of Keyword Extractor for UML is given in the “Fig. 2”. The XMI or UML file is parsed with the help of the SAX (Simple API for XML) Parser. SAX is a sequential access parser API for XML. SAX provides a mechanism for reading data from an XML document. SAX loads the XMI or UML file and get the list of tags by passing name. It gets the attribute value of the tags by attributes.getValue(<Name of the attributes>) method. The methods used to retrieve the attributes are Parse, Attributes and getValue(nameOfAttribute). The Parse() method will parse the XMI file. The Attribute is to hold the attribute value. GetValue(nameOfAttribute) method returns class information, method information and parameter information of the attribute.

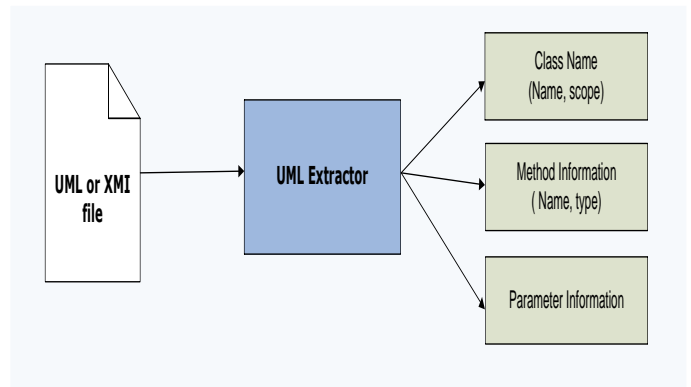


Figure 2. Process of Keyword Extractor for UML

The XMI file consists of XML tags. To extract class information, method information and parameter information are identified with the appropriate tag as given in the Table I.

TABLE I. TAGS USED TO EXTRACT METADATA FROM XMI FILE

Tag	Purpose
UML:DataType	It holds the data type information
UML:Class	It holds the class informations like name of the class, visibility of the class, etc.,

UML:Attribute	Attribute is a sub tag of class. It holds the informations of the class attributes like name of the attributes, type of the attribute, and visibility of the attribute etc.,
UML:Operation	It holds the methods information of the class like name of the method, return type of the methods, visibility of the method.
UML:BehavioralFeature.parameter	It holds the information of the methods parameters like name of the parameter, data type of the parameter.

Using the tags the metadata of the UML or the XMI is extracted. The extracted metadata are class, methods, and attributes etc., which are passed to the Method Retriever component.

V. METHOD RETRIEVER

Method Retriever component interact with the OWL and returns the available methods from the OWL for the given class diagram is represented diagrammatically in “Fig. 3”. The extracted information from the UML file by the Keyword Extractor for UML is passed to the Method Retriever component. It interacts with OWL and retrieves matched method information using SPARQL query. SPARQL is a Query language for RDF. The SPARQL Query is executed on OWL file. Jena is a Java framework for building Semantic Web applications. It provides a programmatic environment for RDF, RDFS and OWL, SPARQL and includes a rule-based inference engine. Jena is a Java framework for manipulating ontologies defined in RDFS and OWL Lite [22]. Jena is a leading Semantic Web toolkit [23] for Java programmers. Jena1 and Jena2 are released in 2000 and August 2003 respectively. The main contribution of Jena1 was the rich *Model* API. Around this API, Jena1 provided various tools, including I/O modules for: RDF/XML [24], [25], N3 [26], and N-triple [27]; and the query language RDQL [28]. In response to these issues, Jena2 has a more decoupled architecture than Jena1. Jena2 provides inference support for both the RDF semantics [29] and the OWL semantics [30].

SPARQL is an RDF query language; its name is a recursive acronym that stands for *SPARQL Protocol and RDF Query Language* used to retrieve the information from the OWL. SPARQL can be used to express queries across diverse data sources, whether the data is stored natively as RDF or viewed as RDF via middleware. SPARQL contains capabilities for querying required and optional graph patterns along with their conjunctions and disjunctions. SPARQL also supports extensible value testing and constraining queries by source RDF graph. The results of SPARQL queries can be results sets or RDF graphs.

A. Query processor

A query processor executes the SPARQL Query and retrieves the matched results. The SPARQL Query Language for RDF[31] and the SPARQL Protocol for RDF[32] are increasingly used as a standardized query API for providing

access to datasets on the public Web and within enterprise settings. The SPARQL query takes method parameters and the returns the results. The retrieved results contains project details like name of the project, version of the project and method details like name of the package, name of the class, method name , method return type, method parameter. Query processor takes the extracted method name and the method parameter as an input and retrieves the methods and project information from the OWL.

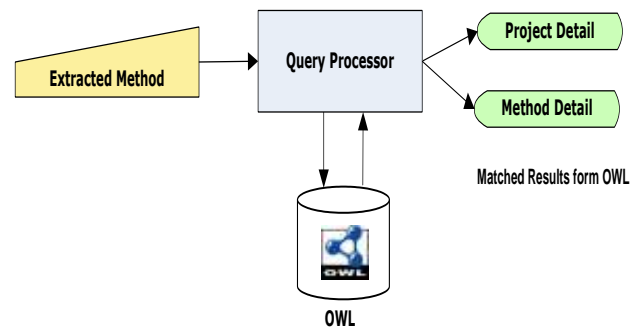


Figure 3. Method Retriever Process

B. SPARQL query

The SPARQL query is constructed to extracting project name, version of the project, package name, class name, method name, return type, and return identifier name, method parameter name and type. The sample query is as follows

```
PREFIX rdf:<http://www.w3.org/1999/02/22-rdf-syntax-ns#>
SELECT ?pname ?version ?packname ?cname ?mname
       ?rType ?identifier ?paramName ?parmDT ?parmT
WHERE {
    ?project rdf:type base:Project .
    ?project base:Name ?pname .
    ?project base:Project_Version ?version .
    ?project base:hasPackage ?pack .
    ?pack base:Name ?packname .
    ?pack base:hasClass ?class .
    ?class base:Name ?cname .
    ?class base:hasMethod ?subject .
    ?subject base:Name ?mname .
    ?subject base>Returns ?rType .
    ?subject base:Identifier ?identifier .
    ?subject base:hasParameter ?parameter .
    ?parameter base:Name ?paramName .
    ?parameter base:DataType ?parmDT .
    ?parameter base:DataType ?parmT .
    FILTER regex ( ?mname , "add" , "i" ) .
    FILTER regex ( ?parmT , "java.lang.String" , "i" ) .
}
```

VI. SOURCE RETRIEVER

Source Retriever component retrieves the appropriate source code of the user selected method from the HDFS. It is the primary storage system used by Hadoop applications.

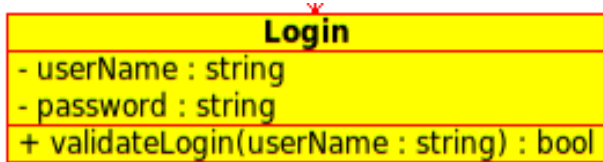
HDFS creates multiple replicas of data blocks and distributes them on compute nodes throughout a cluster to enable reliable, extremely rapid computations. The source code file location of the Hadoop repository path is obtained from the OWL and retrieved from the HDFS by the copyToLocal(FromFilepath,localFilePath) method.

QDox is a high speed, small footprint parser for extracting class/interface/method definitions from source files. When the java source file or folder that consists java source file loaded to QDox; it automatically performs the iteration. The loaded information is stored in the JavaBuilder object. From the java builder object the list of packages as an array of string are returned. This package list has to be looped to get the class information. From the class information the method information is extracted. It returns the array of JavaMethod. From this java method the information like scope of the method, name of method, return type of the method and parameter informations are extracted from the JavaMethod.

QDox finds the methods from the source code. The file that is retrieved from the HDFS is stored in the local temporary file. This file is passed to the Qdox addSource() method for parsing. Through Qdox each method is retrieved one by one. The retrieved methods are compared with methods that the user requested for source code retrieval method. If it matches the source code is retrieved by getSourceCode() method. Then the temporary file is deleted after the process. In Hadoop repository files are organized in the same hierarchy of java folder. So it gets the source location from the OWL and retrieve the java source file to a temp file. The temporary file is loaded into QDox to identify methods. Each method is compared with method to be searched. If it matches; the source code of the method is retrieved by getMethodSourceCode() method.

VII. CASE STUDY

The input for the frame work is a UML class diagram. The sample class diagram is given below



The entire process of the framework is given in the Table II. The Keyword Extractor for UML uses the class diagram and retrieves the method validateLogin(username:string). The output is given to the Method Extractor and generates the SPAQL query and extracts the matched methods which are listed in the Table III. From the list the appropriate method will be selected and the QDox retrieves the source code from the HDFS and displays the method definition of the selected methods as shown in the output of the Source Retriever in Table II.

TABLE II. PROCESS FLOW OF THE FRAMEWORK

Proces	Input	Output
--------	-------	--------

UML Extraction	Given Class Diagram	Method Information Name : validateLogin Return : Boolean visibility : public Parameters : User Name DataType : username
Method Retriever	validateLogin(String userName)	Refer Table 2
Source Retriever	validateLogin(String userName)	<pre> boolean returnStatus = false; DatabaseOperation databaseOperation = new DatabaseOperation(); String strQuery = "SELECT * FROM login WHERE uname='"+userId+"'"; ResultSet resultSet = databaseOperation.selectFrom mDatabase(strQuery); try { while(resultSet.next()){ returnStatus = true; } } catch (SQLException e) { e.printStackTrace(); } return returnStatus; </pre>

To test the performance of this framework the reusable OWL files are created by uploading the completed projects. The first OWL file is uploaded with first java project. The second OWL file is uploaded with first and the second java projects. The third OWL file is uploaded with first, second and third java projects. Similarly five OWL files are constructed. The purpose of creating OWL is to show how reusability increases when the knowledgebase grows. A sample new project is considered and it contains ten methods to be developed. The OWL files are listed with the number of packages, number of classes, number of methods and number of parameters. These methods are matches with the OWL files and the number of matches is listed in the Table IV.

TABLE III. METHOD RETRIEVER OUTPUT

Sl. No.	Information
1	Project Name : CBR_1.0 Package : com.cbr.my.engine Class Name : Login Method Name : ValidateLogin Parameters : UserName Return Type : boolean
2	Project Name : RBR_1.0 Package : com.my.rbr.utils.engine Class Name : LoginManger Method Name : LoginLog Parameters : UserName,ActivityCode

	Return Type : Boolean Method Name : LoginContol Parameters : UserName,password Return Type : Boolean
3	Project Name : BHR_1.0 Package : com.boscoits.BHR.utils.Action Class Name : ControlManager Method Name : ManageLogin Parameters : UserName,password,memberId,ActionId Return Type : Boolean Method Name : ValidateLogin Parameters : UserName,password Return Type : Boolean

These data in the row of the Table IV shows that the number of matched methods. The reusability graph shown in the “Fig. 4” shows that how the matches increases when the number of projects in the OWL grows. For the graph only five new method names are used instead of ten listed in the Table IV. The X-axis represents the OWL file numbers and the Y-axis represents the number of method matched for the new method legends. This progress shows that by uploading more projects in the knowledgebase can able to provide nearly hundred percent of the methods for reuse during software development.

TABLE IV. NEW METHOD MATCHES WITH VARIOUS KNOWLEDGEBASE

	1 OWL	2 OWL	3 OWL	4 OWL	5 OWL
Classes	86	116	129	297	321
Methods	50	1088	1130	3405	3697
Packages	12	15	22	27	31
Parameters	765	1119	1174	4552	4802
Method Name					
ValidateLogin	5	26	27	46	40
getUserType	0	0	0	0	2
addStudent	4	6	6	18	18
ManageRole	6	14	0	28	29
connect	4	5	8	11	16
InsertQuery	2	3	3	5	6
deleteQuery	2	3	3	5	6
updateQuery	2	3	3	5	6
selectQuery	2	3	3	5	6
connect	2	3	3	5	6

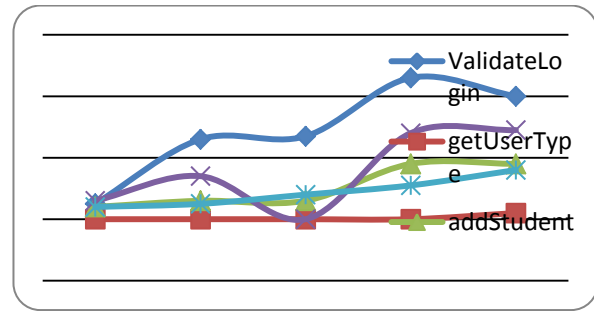


Figure 4. The number of matches for methods to the Projects

VIII. CONCLUSION

The paper presents a framework to extract the method code components from the OWL using the UML design document. OWL is semantically much more expressive than needed for the results of our searching. With these sample tests the paper argues that it is indeed possible to extract code from OWL using the UML class diagram. The purpose of the paper is to achieve the code reusability for the software development. The OWL for the source code has already been created and this paper searches and extracts the code and components and reuses to shorten the software development life cycle. Before starting the coding phase of the development the framework helps the software development team to access the possibilities of how much code can be reused and how much code need to be developed. This assessment can help project manager to allot resources to the project and reduce cost, time and resource. The software companies can make use of this framework and develop the project quickly and grab the project at the lower cost among the competitors.

After developing OWL Ontology and storing the source code in the HDFS, the code components can be reused. This paper has taken design document from the user as input, then extracted the method signature and try to search and match in the OWL. The knowledgebase gets uploaded with more and more projects the reuse rate is also higher. The future work can take the SRS as input; text mining can be performed to extract the keywords as classes and the process as methods. The SRS artifact is much earlier phase than the UML. So considerable amount of time can be reduced than using UML as input. The method prototype can be used to search and match with the OWL and the required method definition can be retrieved from the HDFS. The purpose of storing the metadata in OWL is to minimize the factors like time of development, time of testing, time of deployment and developers. By creating OWL using this framework can reduce these factors.

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Magneto-Hydrodynamic Antenna Design and Development Analysis with prototype

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Abstract—A new class of antenna based on magnetohydrodynamic technique is presented. Magneto-hydrodynamic Antenna, using electrically conducting fluid, such as NaCl solution under controlled electromagnetic fields is formulated and developed. Fluid resonator volume and electric field with magnetic field decides the resonant frequency and return loss respectively to make the antenna tuneable in the frequency range 4.5 to 9 GHz. The Maxwell's equations, Navier Stokes equations and equations of mass conservation for the conducting fluid and field have been set up. These are expressed as partial differential equations for the stream function electric and magnetic fields, these equations are first order in time. By discretizing these equations, we are able to numerically evaluate velocity field of the fluid in the near field region and electromagnetic field in the far field region. We propose to design, develop, formulate and fabricate an prototype MHD antenna [1-3]. Formulations of a rotating fluid frame, evolution of pointing vector, permeability and permittivity of MHD antenna have been worked out. Proposed work presents tuning mechanism of resonant frequency and dielectric constant for frequency agility and configurability. Measured results of prototype antenna possess return loss up to -51.1dB at 8.59 GHz resonant frequency. And simulated resonant frequency comes out to be 10.5GHz.

Keywords- Frequency agility, reconfigurability, MHD, radiation pattern, saline water.

I. INTRODUCTION

MHD antenna uses fluid as dielectric. The word magneto hydrodynamics (MHD) is derived from magneto- meaning magnetic field, and hydro- meaning liquid, and -dynamics meaning movement. MHD is the study of flow of electrically conducting liquids in electric and magnetic fields [3-5]. Here we have developed and tested magneto-hydrodynamic prototype antenna with detailed physics. Ting and King determined in 1970 that dielectric tube can resonate. To our knowledge no work has been done on MHD antenna as described here. Based on our own developed theory, we have proposed this prototype model with return loss results. Fluid antenna has advantage of shape reconfigurability and better coupling of electromagnetic signal with the probe, as no air presents in between [12]. We have developed physics as per equations (1-12) for electromagnetic wave coupling with conducting fluid in

presence of electric and magnetic field. Design and testing stages of MHD antenna is shown as per figs. 1-13. Here, we demonstrate, how the directivity, radiation resistance and total energy radiated by this magnetohydrodynamic antenna can be computed, by the elementary surface integrals. We have developed, equations for rotating frame of conducting fluid, velocity field, electric field, magnetic field, pointing vector, current density, permittivity, permeability and vector potentials to realise an MHD Antenna [6-8]. We have used saline water, ionised with DC voltage applied with the help of electrodes, in presence permanent magnetic field. Fluid acts as radiating element in the PPR (propylene random copolymer) cylindrical tube. SMA connector is used to supply RF input. Volume and shape of the fluid decides the resonant frequency. Excellent results of radiation parameters were reported on measurements of return loss and radiation pattern by the prototype, as listed in tables 1-5. We have divided this paper into five parts. First part consists introduction of MHD antenna system. Second part deals with formulations [9-11]. Section three focuses on brief explanation of the prototype development. Fourth section speaks about working of prototype system. Section five describes conclusion possible applications and scope of future work.

II. FORMULATIONS

A. Motion of fluid in rotating frame

The equation of motion of a fluid in a uniformly rotating frame with angular velocity ω is given by

$$v, t + v \cdot \nabla_v + 2 \omega \times v + \omega \times (\omega \times r) = - \frac{\nabla p}{\rho} + \nu \nabla^2 \vec{v} \quad (1)$$

Assuming the flow to be two dimensional and fluid to be incompressible, obtain an equation for the stream function.

Velocity of fluid is given below

$$v = v_x(t, x, y) \hat{x} + v_y(t, x, y) \hat{y} \quad (2)$$

Angular velocity

$$\omega = \omega_0 \hat{z}$$

The equation

$$V_{x,x} + V_{y,y} = 0$$

It gives

$$v_x = \psi_{,y} (t, x, y) \quad (3)$$

$$= - \psi_{,x} (t, x, y)$$

for some scalar function ψ called the stream function.

As we know vorticity

$$\Omega = \nabla \times v \quad (4)$$

$$= - \nabla^2 \psi \hat{z}$$

Using this in the equation obtained by taking the curl of the Navier Stokes equation, we have

$$\Omega, t + \nabla(\Omega \times v) + 2 \nabla \times (\omega \times v) + \nabla \times (\omega(\omega \times r)) = \nu \nabla^2 \Omega \quad (5)$$

Note that

$$\omega \times (\omega \times r) = (\omega \cdot r) \omega - \omega^2 r \quad (6)$$

so that

$$\nabla \times (\omega \times (\omega \times r)) = 0 \quad (7)$$

Since ω is assumed to be constant, thus, the Navier Stokes

equation gives

$$\Omega, t + \nabla(\Omega \times v) + 2 \nabla \times (\omega \times v) = \nu \nabla^2 \Omega \quad (8)$$

B. Far field radiation Pattern

Space here r-radius, θ – Angle of elevation, ϕ - azimuth angle, ω_1, ω_2 are first and second components of the frequency and r, ϕ, θ are spherical co-ordinates.

$$0 \leq \theta \leq 180 (\pi \text{ rad})$$

$$0 \leq \phi \leq 360 (2\pi \text{ rad})$$

$$r = \sqrt{x^2 + y^2 + z^2}$$

$$\theta = \text{Cos}^{-1} \frac{z}{r}$$

$$\phi = \text{Tan}^{-1} \frac{y}{x}$$

$$x = r \text{Sin} \theta \text{Cos} \phi$$

$$y = r \text{Sin} \theta \text{Sin} \phi$$

$$z = r \text{Cos} \theta$$

$v \times B$ shall provide pointing vector in case of fluid. $E \times H$ gives pointing vector, here H vector to embed v effect due to conducting fluid. $E_\theta, H_\phi, E_\phi, H_\theta$ are electric and magnetic fields of MHD antenna and the pointing vector shall have the effect of conducting fluid velocity generated due to E, Radiation pattern shall depend on average radiated power. Any spherical coordinate triplet (r, θ, ϕ), specify single point of three space coordinates in radiation field.

$$E_\theta = - \frac{\delta A_\theta}{\delta t} - \frac{\delta \phi}{d\theta}$$

$$E_\phi = - \frac{\delta A_\phi}{\delta t} - \frac{1}{r \text{Sin} \theta} \frac{\delta \phi}{d\theta} \quad \text{and}$$

$$E_\theta = - \frac{\delta A_\theta}{dt}$$

$$E_\phi = - \frac{\delta A_\phi}{dt}$$

$$\text{also } H_\theta = \frac{1}{\mu} \nabla \times \vec{A} = \begin{vmatrix} \hat{r} & \hat{\theta} & \hat{\phi} \\ r^2 \text{Sin} \theta & r \text{Sin} \theta & r \\ \frac{\delta}{\delta r} & \frac{\delta}{\delta \theta} & \frac{\delta}{\delta \phi} \\ A_r & r A_\theta & r \text{Sin} \theta A_\phi \end{vmatrix}$$

Solution of above matrix shall provide us

$$\frac{\hat{\theta}}{r \text{Sin} \theta} \left(\frac{\delta A_r}{\delta \phi} - \frac{\delta}{\delta r} \text{Sin} \theta A_\phi \right) + \frac{\hat{\phi}}{r} \left(\frac{\delta r A_\theta}{\delta r} - \frac{\delta A_r}{d\theta} \right)$$

Hence

$$H_\theta = - \frac{1}{r \text{Sin} \theta} \frac{\delta}{\delta r} (r \text{Sin} \theta A_\phi) = - \frac{\delta A_\phi}{\delta r}$$

And

$$H_\phi = \frac{1}{r} \frac{d}{dr} (r A_\theta) = \frac{\delta A_\theta}{dr}$$

$$(E \times H) \cdot \sigma = E_\theta H_\phi - E_\phi H_\theta, \quad (9)$$

(Resulting Pointing Vector)

On substitution

$$\text{Pointing vector} = - \frac{\delta A_\theta}{\delta t} \frac{\delta A_\theta}{\delta r} - \frac{\delta A_\phi}{dt} \frac{\delta A_\phi}{dr}$$

$$\text{Where } A_\theta = \frac{\psi(r, \phi, t)}{r} - \frac{\psi, r}{r}$$

And

$\int_0^\pi \int_0^{2\pi} (E \times H) \cdot \sigma r^2 \text{Sin} \theta d\theta d\phi$, shall provide pointing vector of radiator.

And

$J = \sigma (E + v \times B)$ shall be the resultant of MHD antenna system, we need to calculate E at a given frequency. Here, first and second component of vector potentials are.

$$A_1 = \frac{\mu}{4\pi} \sigma \int_V \frac{\vec{E}(\vec{r}', \omega) e^{-\frac{j\omega |\vec{r}-\vec{r}'|}{c}}}{|\vec{r}-\vec{r}'|} d^3 r'$$

$$\text{or } A_1 = \frac{\mu}{4\pi r} \sigma \int_V \vec{E}(\vec{r}', \omega) e^{-\frac{j\omega \hat{r} \cdot \vec{r}'}{c}} d^3 r'$$

And second component

$$A_2 =$$

$$\frac{\mu}{4\pi} \sigma \int_V \frac{\vec{v}(\vec{r}', \omega) \times \vec{B}(\vec{r}', \omega - \omega_1) e^{-\frac{j\omega |\vec{r}-\vec{r}'|}{c}}}{|\vec{r}-\vec{r}'|} d^3 r' d\omega_1$$

or

$$A_2 = \frac{\mu}{4\pi r} \sigma e^{-\frac{j\omega r}{c}} \int_V \vec{v}(\vec{r}', \omega_1)$$

$\times \vec{B}(\vec{r}', \omega - \omega_1) d\omega_1 e^{\frac{j\omega \hat{r} \cdot \vec{r}'}{c}} d^3 r'$, with the help of A_1 and A_2 , we can evaluate total magnitude of radiated energy

per unit frequency per unit volume. This spectral density can be evaluated by applying Parseval's theorem (mathematics of DFT). As electric field $E = -j\omega A_{1\theta} \hat{\theta} - j\omega A_{1\phi} \hat{\phi}$

$$E_{\theta} = -j\omega(A_{1\theta} + A_{2\theta})$$

$$H_{\phi} = -\frac{j\omega}{r}(A_{1\phi} + A_{2\phi}),$$

Here H_{ϕ} embeds the velocity component of fluid at a given frequency. Now we shall evaluate $A_{1\theta}$ and $A_{2\theta}$ to compute energy spectral density. On integration we can evaluate total radiated energy. Also, we shall work to find x, y, z component of pointing vector.

Where r' denotes source and r denotes far field distance. E_{θ} at a large distance shall contribute for $\eta = \mu/\epsilon$ for plane wave propagation.

$$A_{1\theta} \text{ and } A_{2\theta} \text{ should be function of } (\theta, \phi, \omega)$$

$$\text{also } \hat{\theta} = \hat{\phi} \times \hat{r} \text{ from spherical coordinates}$$

$E_{\theta} \times H_{\phi}$ shall provide us the pointing vector of the radiated field

Here $\frac{1}{r}$ component reside in ϕ , we need to calculate θ component to enable us far field component E_{θ} at large distance, also

$\eta = \frac{\mu}{\epsilon}$ for plane wave. We can thus evaluate total energy radiated.

We have $\hat{r} = \hat{\theta}$, and after normalization $\sin\theta$ term gets cancelled.

($E \times B$) pointing vector for x, y, z components and taking $e^{-j\omega t}$ as common, we can evaluate E_x, E_y, E_z .

$$= -j\omega A_{1\theta} \hat{\theta} - j\omega A_{1\phi} \hat{\phi}$$

Our objective is to evaluate total energy radiated per unit frequency per unit volume.

$$E_{\theta} = -j\omega (A_{1\theta} + A_{2\theta})$$

$H_{\phi} = \frac{-j\omega}{\eta} (A_{1\phi} + A_{2\phi})$, here effect fluid velocity v have been embedded in H field

$\frac{1}{2} Re[E_{\theta} H_{\phi}] = \int \frac{\omega^2}{\eta} Re(A_{\theta} A_{\phi}) d\omega r^2 \sin\theta d\theta d\phi$, assuming real part will effectively contribute.

$$\hat{r} = \hat{x} \cos\phi \sin\theta + \hat{y} \sin\phi \sin\theta + \hat{z} \cos\theta$$

$$\hat{\theta} = \frac{\delta \hat{r}}{\delta \theta} = \hat{x} \cos\phi \cos\theta + \hat{y} \sin\phi \cos\theta - \hat{z} \sin\theta$$

$$\hat{\phi} = \frac{\delta \hat{r}}{\delta \phi} = -\hat{x} \sin\phi \sin\theta + \hat{y} \cos\phi \cos\theta$$

Hence

$$A_{1\theta} = \frac{e^{-j\frac{\omega}{c}r}}{r} \left[\frac{\mu\sigma}{4\pi} \int (E_x(\vec{r}', \omega) \cos\phi \cos\theta + E_y(\vec{r}', \omega) \sin\theta \sin\phi + E_z(\vec{r}', \omega) \cos\theta \right.$$

$$\left. e^{-j\frac{\omega}{c}(x' \cos\theta \cos\phi + y' \sin\theta \sin\phi + z' \cos\theta)} dx' dy' dz' \right\}$$

$$\text{And } A_{2\theta} = \frac{e^{-j\frac{\omega}{c}r}}{r} \left\{ \frac{\mu\sigma}{4\pi} \int v_{\phi}(\vec{r}', \omega) \right.$$

$$B_r(\vec{r}', \omega - \omega_1) - v_r(\vec{r}', \omega_1)$$

$$\left. B_{\phi}(\vec{r}', \omega - \omega_1) e^{-j\frac{\omega}{c}\hat{r}\cdot\vec{r}'} d^3r' \right\}$$

Hence, pointing vector can be defined as

$$E_{\theta} = -j\omega \frac{e^{-j\frac{\omega}{c}r}}{r} (A_{1\theta}(\theta, \phi, \omega) + A_{2\theta}(\theta, \phi, \omega))$$

And

$$H_{\phi} = -j\omega \frac{e^{-j\frac{\omega}{c}r}}{r} (A_{1\phi}(\theta, \phi, \omega) + A_{2\phi}(\theta, \phi, \omega))$$

Hence energy spectral density

$$D = -j\omega \int \omega^2 Re(A_{1\theta} + A_{2\theta}) (\vec{A}_{1\phi} + \vec{A}_{2\phi}) \sin\theta d\theta d\phi$$

Energy Spectral Density be evaluated by applying Parseval's Theorem

$$\int f(t)g(t)dt = \frac{1}{2\pi} \int \hat{f}(\omega)\hat{g}(\omega) d\omega$$

or

$$\int \vec{E}(\vec{r}, t) \times \vec{H}(\vec{r}, t) \hat{x} ds dt \quad (10)$$

This shall provide us total energy radiated by the MHD antenna system.

$$D = \frac{1}{2\pi} \int \vec{E}(\vec{r}, \omega) \times \vec{H}(\vec{r}, \omega) \hat{x} ds d\omega$$

C. Permeability of MHD antenna

We evaluate permeability of MHD antenna taking, conductivity and permittivity as constant. Hence μ becomes function of polynomial

In (E, H, v) in MHD system, where E electric field, H magnetic field and v velocity of the fluid. Here p, q, r are integers.

And $a=1, 2, 3$

$$\sum_{p,q,r,0}^N \mu [p_1 p_2 p_3 q_1 q_2 q_3 r_1 r_2 r_3]$$

$$E_1^{p_1} E_2^{p_2} E_3^{p_3} H_1^{q_1} H_2^{q_2} H_3^{q_3} v_1^{r_1} v_2^{r_2} v_3^{r_3}$$

From Maxwell's equation, we have

$$\vec{\nabla} \times \vec{E} = -\frac{\delta(\mu H)}{\delta t} = -(\mu_{,t} \hat{H} + \mu \hat{H}_{,t})$$

$$\text{And, } \mu_{,t} = \sum_{a=1,2,3} (\mu_{,E_a} E_{a,t} + \mu_{,H_a} H_{a,t} + \mu_{,v_a} v_{a,t}) \quad (20)$$

Thus, we observe that, permeability $\mu_{,t}$ becomes coupled function of E, H and v.

We can minimize the difference or error (H - H_d) with variational method, here p, q, r are integers, H_d, Desired outcome and a=1,2,3. We derive the relationship of μ , permeability as function of E, H and v, where E, electric field applied, H magnetic field and v is velocity field. Also A₁, A₂ are weight or magnitude of the function and $\vec{\lambda}_1, \vec{\lambda}_2$ Lagrange multipliers. For 3D analysis we have, H_φ(t, x, y, z), E_φ(t, x, y, z), H(t, r), E(t, r)

$$A_1 \int_0^T \int_V |\vec{H} - H_d|^2 dt d^3r + A_2 \int_0^T \int_V |\vec{E} - E_d|^2 dt d^3r + \int_{[0,T] \times V} (\vec{\nabla} \times \vec{E} - \frac{\delta}{\delta t}(\mu \vec{H}))$$

Hence on taking inner product and Lagrange multiplier in variational method, we get,

$$S[\vec{H}, \vec{E}, \vec{\lambda}_1, \vec{\lambda}_2], \mu \text{ permeability is hidden in H value.}$$

As an example, Let F(x₁ ... x_n) and

$$g_i(x_1 \dots x_n) = 0$$

Where

i=1,2,..r,

$$F(x_1, \dots, x_n) + \sum_{i=1}^r \lambda_i g_i(x_1 \dots x_n) = S(x_1 \dots x_n, \lambda_1 \dots \lambda_r)$$

This gives the error value by variational method

λ_1, λ_2 Lagrangian multiplier

A₁, A₂ are magnitude or function weight

H, E satisfy Maxwell's equation.

This way, we can minimize the difference or error (H - H_d), and E, H, v are functions of μ permeability.

D. Permittivity of MHD antenna

As per Maxwell's equation

$$\nabla \times E = -\mu \frac{\delta H^{-1}}{\delta t}$$

$$\nabla(\nabla \cdot E) - \nabla^2 E = -\mu \frac{\delta}{\delta t} (\nabla \times \vec{H})$$

And

$$\nabla \times \vec{H} = J + \frac{\delta}{\delta t}(\epsilon \vec{E})$$

On substitution, we get

$$\begin{aligned} \nabla^2 E - \mu \frac{\delta}{\delta t} (J + \frac{\delta}{\delta t}(\epsilon \vec{E})) + \nabla \sum_{a,b} E_a E_{b,a} \frac{\delta f}{\delta E_b} &= 0 \\ \frac{\delta}{\delta t}(\epsilon \vec{E}) &= \frac{\delta}{\delta t}(\epsilon \vec{E}) + \epsilon \frac{\delta \vec{E}}{\delta t} = \sum_a \frac{\delta \epsilon}{\delta E_a} E_{a,t} \vec{E} + \epsilon \frac{\delta E}{\delta t} \\ J &= \sigma(\vec{E} + \vec{v} \times \vec{B}) \\ \nabla^2 E - \mu \frac{\delta^2}{\delta t^2}(\epsilon \vec{E}) - \mu \sigma \frac{\delta}{\delta t}(\vec{E} + \mu v \times H) & \\ \nabla^2 E - \mu \frac{\delta^2}{\delta t^2}(\epsilon \vec{E}) - \mu \sigma \frac{\delta}{\delta t}(\vec{E} + \mu(v \times H)) & \\ + \vec{\nabla} \sum_{a,b} E_a E_{b,a} \frac{\delta f}{\delta E_b} & \\ &= 0 \end{aligned}$$

When, ϵ is a function of (E, H, v)

$$\sum_{a,b} \frac{\delta \epsilon}{\delta E_a} E_{a,t} E_b + \epsilon \frac{\delta E_b}{\delta t} + \sigma(\vec{E} + \vec{v} \times \vec{B})_b = \sum_{a,c} e_{abc} H_{c,a} + T_{ba} E_{a,t}$$

$$\text{here } T_{ba} = E_b \frac{\delta \epsilon}{\delta E_a} \text{ or}$$

$$= -\sigma(E_b + v \times B)_b + (\nabla \times H)_b \quad (11)$$

$$e_{abc} = \text{Cyclic Tensor}$$

$\epsilon(E_1, E_2, E_3)$ are electric field dipole moments.

Call $\log \epsilon =$ function F(\vec{E}), hence $\epsilon(\vec{E}) = e^{F(\vec{E})}$

On Summed over a, b and inverse of matrix

λ_k are known values and φ_k are test functions.

Permittivity can be solved by variational method or by measurement method or test function methods.

$$\epsilon = \sum_{k=1}^n \lambda_k \varphi_k(\vec{E})$$

$$\sum_{k=1}^n \lambda_k \varphi_k(\vec{E}) I + \sum_k \lambda_k E_\alpha \frac{\delta \varphi_k(\vec{E})}{\delta E_\beta}$$

Let

$$((E_\alpha \frac{\delta \varphi_k(\vec{E})}{\delta E_\beta})) = C_{\alpha\beta}^{(K)} \text{ is matrix of element } \alpha, \beta$$

upto k

Hence

$$(\sum_k \lambda_k \varphi_k I + \sum_k \lambda_k C_{\alpha\beta}^{(K)})^{-1}$$

$$F(\{\lambda_k\}) = \int_{[0,T]_{xv}} \left(\frac{\delta \epsilon}{\delta t} - \left(\sum_{k=1}^n \lambda_k \varphi_k I + C_{\alpha\beta}^{(K)} \right)^{-1} + (\vec{E} + \mu v \times H) + \nabla_x H \right)^2 \delta t d^3r$$
 Permittivity solution can be worked out by difference method or test function method.

$$\epsilon(\vec{E}) = \sum_{k=1}^n \widehat{\lambda}_k \varphi_k(\vec{E}) \quad (12)$$

III. PROTOTYPE DEVELOPMENT

Two cylindrical tubes of PPR Pipes of diameters of 10.5cm and 6.2cm with 6.5cm lengths were mounted on copper coated plate 35 cm diameter circular sheet as ground plane. SMA connector was mounted on outer tube for RF input. Two electrodes tin electrodes of size 1.2 cm x 4.1 cm mounted on the inside wall of bigger tube having direct contact with the conducting fluid. DC voltage was given with DC source, 5-25 V with BIAS TEE arrangement. Copper coated plate 0.2mm thickness was connected 0.9cm to ground of SMA connector. Copper coated circular plate was used to create ground plane. The probe of .08 cm in diameter and 0.75cm protruded from SMA connector was inserted in such way, that it to makes direct contact with the conducting fluid. Two permanent bar magnets of 15cm x4cm x2cm were placed perpendicular to the electric field to produce Lorentz force to create fluid flow. Inside the tube saline water having 1200 - 9000 TDS (total dissolved salt) value was used in ionised state, to produce radiations. 300ml volume of saline water was used for perfect impedance matching at resonant frequency. The RF signal was given by network analyser through SMA connector with mixed DC voltage to the fluid. S11 parameters were recorded as per fig 3-5.

IV. DETAILED DESCRIPTION OF MHD ANTENNA

In this antenna, only ionised currents contribute to radiate energy in conducting fluid. Radiating resistance and resonant frequency shall depend on shape of fluid inside the tube and nano particles of the fluid. The tube was applied to external magnetic field which interacts with electric field to produce Lorentz forces, resulting in fluid flow with velocity v . Now there are three main fields i.e. electric field, magnetic field and velocity fields, which are responsible for the possible radiations. The radiated energy and its pattern are function of RF input excitation, fields applied, fluid shape and nano particle of fluid. Hence an adaptive mechanism can be built in antenna to produce versatility in radiation pattern and broad band effects, due to dynamic material perturbations.

We have formulated various equations (1-12) to focus on physics of the design analysis of an MHD antenna. Here we describe complete mechanism for beam formation, radiating patterns and resonance. Radiation pattern in the far fields depends not only on electromagnetic field but also on fluid velocity field. We have described mathematical relations of permeability as the function of E , H and v , when conductivity and permittivity are kept constant. With proper filtering techniques, MHD antenna can made to operate at one single frequency. Fluid shape with fields decides resonant frequency. The effective permeability can be controlled by applying a static magnetic field. This leads to the possibility of

magnetically tuning of polarisation of the antenna. Polarisation tuning of antenna was measured as a function of strength for magnetisation parallel to the x- and y-directions. The effects of magnetic bias on antenna have been investigated. The principle of this class of antenna is essentially that of a dielectric resonator, where salt (in solution) and electric field modifies the dielectric properties. The resonator column shape determined the operating frequency, allowing impedance match and frequency of operation to be fully tuneable. Figure 1 presents complete test set up of MHD antenna under electric and magnetic field, with RF input for S11 measurements. Figures 1-13 presents results obtained and steps of prototype development. VNA-L5230 was used to measure return loss at resonant frequency. We have varied fluid salinity, electric field, magnetic field and fluid height for all possible radiation measurement in experimentations. We have recorded return loss and radiation patterns for all possible combinations as mentioned in tables 1-2.

This antenna with conducting fluid may have multiple advantages viz reconfigurability, frequency agility, polarisation agility, broadband and beam steering capability. Here, we developed control of polarization with magnetic field biasing, frequency control with fluid height and return loss with electric field control. Non reflecting stealth property of the fluid, when no field presents, makes it most suitable for military applications.



Fig 1 Measurements of return loss/resonant frequency, MHD antenna with VNA and power supply with Bias TEE

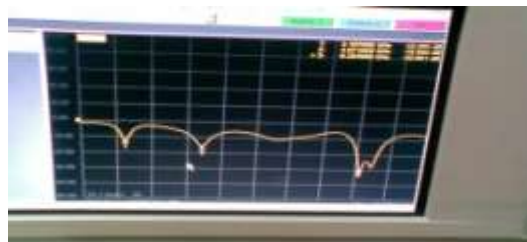


Fig 2 Return loss -33.1 dB at resonant freq 8.59 GHz, when TDS 9000, electric field Applied 15 V, DC with permanent magnetic field.

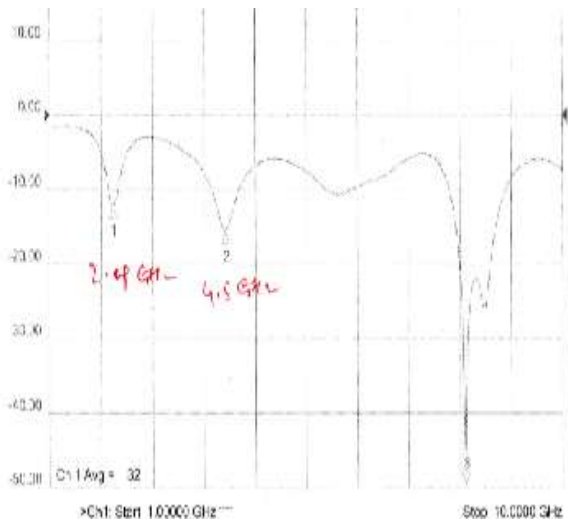


Fig 3. Return loss -51.1 dB at resonant freq 8.59 GHz, when TDS 9000, electric field applied 17 V, DC with permanent magnetic field.

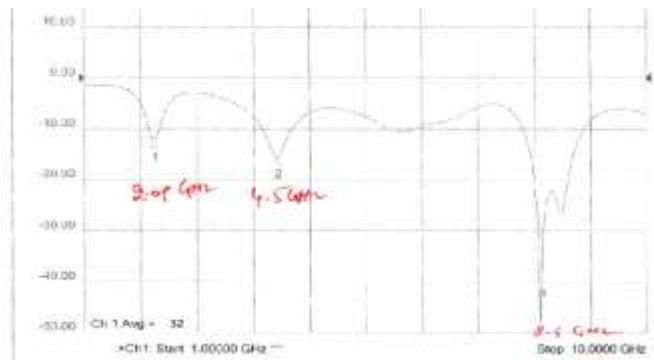


Fig 4 return loss -49.1 dB at resonant freq 8.59 GHz, when TDS 9000, electric field applied 16.9 V, DC with permanent Magnetic field.

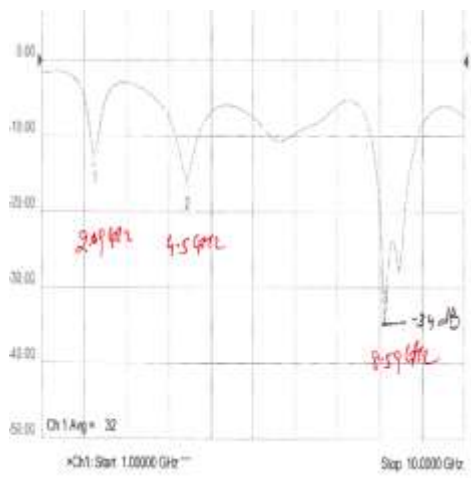


Fig 5 return loss -34.1 dB at resonant freq 8.59 GHz, when TDS 9000, electric field applied 15.0 V, DC with permanent magnetic field.



Fig 6 complete set for measurements of VSWR on MHD antenna with additional magnetic field



Fig 7 MHD antenna with Bias TEE



Fig 8 Fabricated MHD Antenna, SMA connector and filled Saline water top view



Fig 9 view of fabricated MHD antenna without ground plane



Fig 10 View of outer part of MHD antenna Tube with two tin electrodes attached



Fig 11 view of fabricated ground plane of MHD antenna with copper coating.

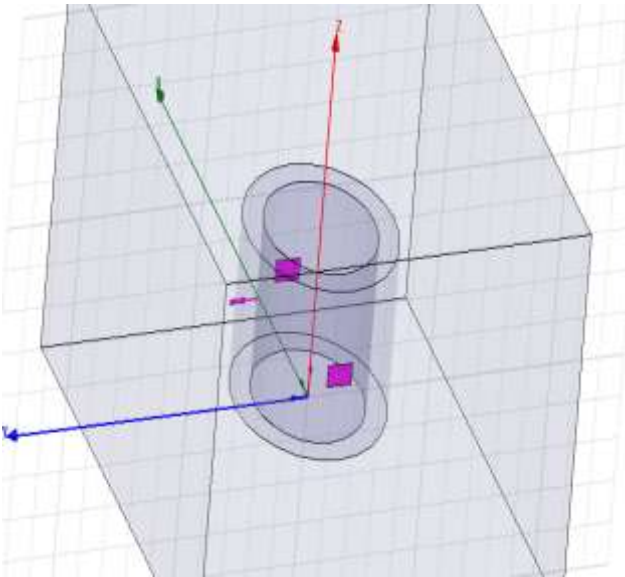


Fig 12 HFSS generated cylindrical antenna

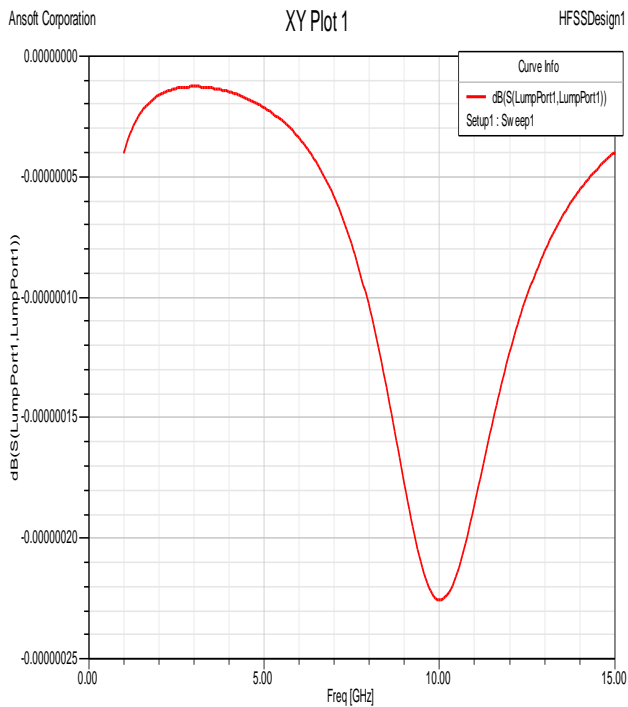


Fig 13 HFSS simulated resonant 10 GHz frequency

Freq	TDS	Electric field	Return Loss
8.59 GHz	9000	17.0V	-51.1dB
4.50 GHz	same	same	-16.7dB
2.09 GHz	same	same	-11.7dB

Freq	TDS	Electric field	Return Loss
8.59 GHz	9000	16.9V	-49.1dB
4.50 GHz	same	same	-16.1dB
2.09 GHz	same	same	-11.9dB

Freq	TDS	Electric field	Return Loss
8.59 GHz	9000	15.0V	-39.1dB
4.50 GHz	same	same	-16.2dB
2.09 GHz	same	same	-11.7dB

Freq	TDS	Electric field	Return Loss
8.59 GHz	9000	13.2V	-35.1dB
4.50 GHz	same	same	-15.2dB
2.09 GHz	same	same	-11.1dB

TDS	Fluid Height	Resonant frequency
5000	3.5 cm	4.59 GHz
7000	6.0 cm	8.58 GHz

For measuring return loss, VSWR and resonant frequency, we have used PNA-L Network analyser 10-40 GHz with DC power supply. The resonant frequency for which antenna has been fabricated destined was 8.59Ghz. However we have frequency agility and reconfigurability in this antenna . Fluid column height was varied from 2.5 cm to 6 cm and electric field was varied from 2 V DC to 17 V DC, relevent results of VSWR and Return loss were recorded.

We measured return loss by Agilent VNA(vector network analyser) , the fluid tube height was kept fixed to 6 cm and resonant frequency to 8.58Ghz , Dc voltage varied from 9V to 17 V. Return loss found varying proportionately to electric and magnetic field. Also when TDS was increased from 200 to 9000 significant improvement in return loss were observed. Mixed signal of DC and RF freq were fed to SMA connector of antenna through Bias TEE. This test set up extended safety to the network analyser.

V. CONCLUSION

It was observed from the measured results that there is significant improvement in return loss when salinity of fluid is enhanced. Also return loss improved due electric and magnetic fields intensity. We have observed that electric field have significant impact on return loss, these measured results are placed in tables1-5. Bias TEE was used to feed mixed signal from the same port .Return loss was significantly high at 17V, DC. Height of fluid tube (fluid shape), nano particles of fluid contribute to form resonant frequency of fluid antenna. When height of fluid was 3.5 cm, our antenna resonated at 4.59 GHz and when height of fluid increased to 6.0 cm , same antenna resonated at 8.59 GHz. We have also simulated taking saline water as dielectric in HFSS antenna software for resonant frequency evaluation as per fig 12-13.We could thus achieved reconfigurability and frequency agility in this antenna. It has stealth property, as reflector is voltage dependent, hence can be

most suitable for Military applications. We can also use this antenna as MIMO (multiple input outputs). More work towards micro-fluidic frequency reconfiguration, fluidic tuning of matching networks for bandwidth enhancement need to be explored.

As a Future work, we will investigate radiation patterns as a special case to this cylindrical antenna with detailed physics involved.

VI. ACKNOWLEDGEMENT & BIOGRAPHY

Prof Raj Senani, Director NSIT, who inspired me for this research work and enriched with all necessary resources required in the college. I extends special thanks to my lab technician Mr Raman, who helped me in lab for developing this prototype MHD antenna.

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An Architectural Decision Tool Based on Scenarios and Nonfunctional Requirements

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Abstract—Software architecture design is often based on architects intuition and previous experience. Little methodological support is available, but there are still no effective solutions to guide the architectural design. The most difficult activity is the transformation from non-functional requirement specification into software architecture. To achieve above things proposed “An Architectural Decision Tool Based on Scenarios and Nonfunctional Requirements”. In this proposed tool scenarios are first utilized to gather information from the user. Each scenario is created to have a positive or negative effect on a non-functional quality attribute. The non-functional quality attribute is then computed and compared to other non-quality attributes to relate to a set of design principle that are relevant to the system. Finally, the optimal architecture is selected by finding the compatibility of the design principle.

Keywords- Software Architecture, Automated Design, Non-functional requirements, Design Principle.

I. INTRODUCTION

Software architecture is the very first step in the software lifecycle in which the nonfunctional requirements are addressed [7, 8]. The nonfunctional requirements (e.g., security) are the ones that are blamed for a system re-engineering, and they are orthogonal to system functionality [7]. Therefore, software architecture must be confined to a particular structure that best meets the quality of interest because the structure of a system plays a critical role in the process (i.e., strategies) and the product (i.e., notations) utilized to describe and provide the final solution.

In this paper, we discuss an architectural decision tool based on a software quality discussed in [14] in order to select the software architecture of a system. In [14], we proposed a method that attempted to bridge the chasm between the problem domain, namely requirement specifications, and the first phase in the solution domain, namely software architecture. The proposed method is a systematic approach based on the fact that the functionality of any software system can be met by all kinds of structures but the structure that also supports and embodies non-functional requirements (i.e., quality) is the one that best meets user needs. To this end, we have developed a method based on nonfunctional requirements

of a system. The method applies a scenario-based approach. Scenarios are first utilized to gather information from the user. Each scenario is created to have a positive or negative affect on a non-functional quality attribute. When creating scenarios, we decided to start with some basic scenarios involving only single quality attribute, multiple scenarios were then mapped to each attribute that would have a positive or negative affect when the user found the scenario to be true. Finally, it became clear to us that we needed to allow each scenario to affect an attribute positively or negatively in varying degrees.

In this work, we have studied and classified architectural styles in terms of design principles, and a subset of nonfunctional requirements. These classifications, in turn, can be utilized to correlate between styles, design principles, and quality. Once we establish the relationship between, qualities, design principle, and styles, we should be able to establish the proper relationship between styles and qualities, and hence we should be able to select an architectural style for a given sets of requirements [8], [13].

II. NON-FUNCTIONAL REQUIREMENT

Developers of critical systems are responsible for identifying the requirements of the application, developing software that implements the requirements, and for allocating appropriate resources (processors and communication networks). It is not enough to merely satisfy functional requirements. Non-functional requirement is a requirement that specifies criteria that can be used to judge the operation of a system, rather than specific behaviours. This should be contrasted with functional requirements that define specific behaviour or functions. Functional requirements define what a system is supposed to do whereas non-functional requirements define how a system is supposed to be. Non-functional requirements are often called qualities of a system. Critical systems in general must satisfy non-functional requirement such as security, reliability, modifiability, performance, and other, similar requirements as well. Software quality is the degree to which software possesses a desired combination of attributes [15].

III. SCENARIOS

Scenarios are widely used in product line software engineering: abstract scenarios to capture behavioral requirements and quality-sensitive scenarios to specify architecturally significant quality attributes. Scenario system specific means translating it into concrete terms for the particular quality requirement. Thus, a scenario is "A request arrives for a change in functionality, and the change must be made at a particular time within the development process within a specified period." A system-specific version might be "A request arrives to add support for a new browser to a Web-based system, and the change must be made within two weeks." Furthermore, a single scenario may have many system-specific versions. The same system that has to support a new browser may also have to support a new media type. A quality attribute scenario is a quality-attribute-specific requirement

The assessment of a software quality using scenarios is done in these steps:

A. Define a Representative set of Scenarios

A set of scenarios is developed that concretizes the actual meaning of the attribute. For instance, the maintainability quality attribute may be specified by scenarios that capture typical changes in requirements, underlying hardware, etc.

B. Analyses the Architecture

Each individual scenario defines a context for the architecture. The performance of the architecture in that context for this quality attribute is assessed by analysis. Posing typical question [15] for the quality attributes can be helpful.

C. Summaries the Results

The results from each analysis of the architecture and scenario are then summarized into overall results, e.g., the number of accepted scenarios versus the number not accepted. We have proposed a set of six independent high-level non-functional characteristics, which are defined as a set of attributes of a software product by which its quality is described and evaluated. In practice, some influence could appear among the characteristics, however, they will be considered independent to simplify our presentation. The quality characteristics are used as the targets for validation (external quality) and verification (internal quality) at the various stages of development. They are refined (see Figure 1) into sub-characteristics, until the quality attribute are obtained. Sub characteristics (maturity, fault tolerance, confidentiality, changeability etc) are refined into scenarios. Each non-functional characteristic may have more than one sub characteristics is refined into set of scenarios. When we characterized a particular attribute then set of scenarios developed to describe it.

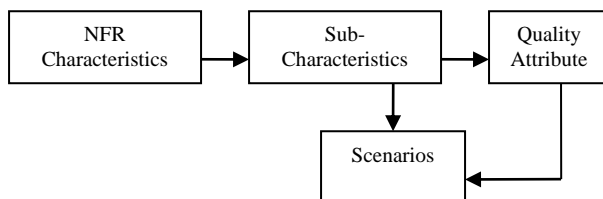


Figure 1. Analysis Scenario Diagram

IV. THE APPROACH

To establish the correct relationship between architectural styles using non functional requirements. The proposed recommendation tool consists of four activities as follows:

- Create a set of simple scenarios relevant to a single nonfunctional requirement.
- Identify those scenarios that may have positive or negative impacts on one or more nonfunctional requirements
- Establish a relationship between a set of quality attributes obtained in step 2 to a set of universally accepted design principles (tactics).
- Select a software architecture style that supports set of design principles identified by step 3.

A. Quality Attribute

Product considerations and market demands require expectations or qualities that must be fulfilled by a system's architecture. These expectations are normally have to do with how the system perform a set of tasks (i.e., quality) rather than what system do (i.e., functionality). Functionality of a system, which is the ability of a system to perform the work correctly for which it was intended, and the quality of a system, is orthogonal to one another.

In general, the quality attributes of a system is divided between two groups: 1) Operational quality attributes such as performance, and 2) non-operational, such as modifiability [8]. In this study, we have selected both operational and non-operational quality attributes as follows:

- Reliability (the extent with which we can expect a system to do what it is supposed to do at any given time)
- Security (the extend by which we can expect how secure the system is from tampering/ illegal access)
- Modifiability (how difficult or time consuming it is to perform change on the system)
- Performance (how fast the system will run, i.e., throughput, latency, number of clock cycles spend finishing a task)
- Usability (the ease by which the user can interact with system in order to accomplish a task),
- Availability (the extend by which we expect the system is up and running)
- Reusability (the extent by which apart or the entire system can be utilized)

Usability involves both architectural and nonarchitectural aspects of a system. Example of nonarchitectural features includes graphical user interface (GUI); examples of architectural features include, undo, cancel, and redo. Modifiability involves decomposition of system functionality and the programming techniques utilized within a component. In general, a system is modifiable if changes involve the minimum number of decomposed units. Performance involves the complexity of a system, which is the dependency (e.g., structure, control, and communication) among the elements of

a system, and the way system resources are scheduled and/or allocated. In general, the quality of a system can never be achieved in isolation. Therefore, the satisfaction of one quality may contribute (or contradict) to the satisfaction of another quality [12]. For example, consider security and availability; security strives for minimally while availability strives for maximally. Or, it is difficult to achieve a high secure system without compromising the availability of that system. In this case security contradicts the availability. This can be easily solved by negotiating with the user to make her/his mind. Another example has to do with security and usability: security inhabits usability because user must do additional things such as creating a password. Table I documents the correlation among quality attributes.

To summaries, five types of quality attributes relationships are identified. These relationships are defined by some numerical values which belong to 0 to 1. These relationships are: Very strong(0.9), Strong(0.7), Average(0.5), Below average(0.3), Very low(0.1), Not available(0.0).

TABLE I. QUALITY VS QUALITY

S.N.	Quality Attribute	Quality Attribute	Relationship	values
1)	Reliability	Performance	Very Strong	0.9
		Security	Very Strong	0.9
2)	Performance	Reliability	Very Strong	0.9
		Security	Below Average	0.3
3)	Security	Reliability	Average	0.5
		Performance	Very Low	0.1

B. Design Principle

According to [1, 2], a design can be evaluated in many ways using different criteria. The exact selection of criteria heavily depends on the domain of applications. In this work, we adopted what is known as commonly accepted design principles [3, 6, 7], and a set of design decisions known as tactics [3, 8, 13, 14]. Tactics are a set of proven design decisions and are orthogonal to particular software development methods. Tactics and design principle have been around for years and originally advocated by people like Parnas and Dijkstra. Our set of design principles and tactics includes: 1) Generality (or abstractions), 2) Locality and separation of concern, 3) Modularity, 4)Concurrency 5) Replicability, 6) Operability, and 7) Complexity.

Examples of design principles and tactics include a high degree of parallelism and asynchronized communication is needed in order to partially meet the performance requirement; a high degree of replicability (e.g., data, control, computation replicability) is needed in order to partially meet availability; a high degree of locality, modularity, and generality are needed in order to achieve modifiability and understandability; a high degree of controllability, such as authentication and authorization, is needed in order to achieve security and privacy.; and a high degree of locality, operatability (i.e., the efficiently by which a system can be utilized by end-users) is

needed in order to achieve usability. Table II shows the correlation among qualities and tactics.

TABLE II. TACTICS VS QUALITIES

S.N	Tactics	Quality Attribute	Relationship	values
1)	Generality	Reliability	Very Strong	0.9
		Security	Average	0.5
		Performance	Very Strong	0.9
2)	Locality	Reliability	Very Strong	0.9
		Security	Not Available	0.0
		Performance	Very Strong	0.9
3)	Modularity	Reliability	Very Strong	0.9
		Security	Very Strong	0.9
		Performance	Strong	0.7

C. Architecture Styles

In order to extract the salient features of each style we have compiled its description, advantages and disadvantages. This information was later utilized to establish a link among styles and design principles. We have chosen, for the sake of this work, main/subroutine, object-oriented, pipe/filter, blackboard, client/server, and layered systems.

A main/subroutine (MS) architectural style advocates top-down design strategy by decomposing the system into components (calling units), and connectors (caller units). The coordination among the units is highly synchronized and interactions are done by parameters passing.

An Object-oriented (OO) system is described in terms of components (objects), and connectors (methods invocations) components are objects. Objects are responsible for their internal representation integrity. The coordination among the units is highly asynchronized and interactions are done by method invocations. The style supports reusability, usability, modifiability, and generality.

A Pipe/filter (P/F) style advocates bottom-up design strategy by decomposing a system in terms of filters (data transformation units) and pipes (data transfer mechanism). The coordination among the filters are asynchronized by transferring control upon the arrival of data at the input. Upstream filters typically have no control over this behavior.

A Client/server (C/S) system is decomposed into two sets of components (clients or masters), and (servers or slaves). The interactions among components are done by remote procedure calls (RPC) type of communication protocol. The coordination and control transformation among the units are highly synchronized.

A Blackboard (BKB) system is similar to a database system; it decomposes a system into components (storage and computational units known as knowledge sources (KSs). In a Blackboard system, the interaction among units is done by shared memory. The coordination among the units, for most parts, is asynchronized when there is no race for a particular data item, otherwise it is highly synchronized. The blackboard

style enjoys some level of replications such data (e.g., the distributed database and the distributed blackboard systems) and computation.

A Layered (LYR) system typically decomposes a system into a group of components (subtasks). The communication between layers is achieved by the protocols that define how the layers will interact. The coordination and control transformation among the units (or subtasks) is highly synchronized and interactions are done by parameters passing. A Layered system incurs performance penalty stems from the rigid chain of hierarchy among the layers. Table III illustrates the relationships among design principles/tactics.

V. PROPOSED WORK

The implementation of our tool consists of six different modules to perform its functions. Average weight module calculates average weight corresponding to selected scenarios. Effective weight module calculates effective weight of each nonfunctional requirement and each nonfunctional requirement has list of scenarios. Scenarios and its corresponding weight are selected by user. Quality attribute weight module calculates quality attribute weight. It depends on average and effective module response. Quality attribute rank module calculates the rank of quality attribute. It depends on quality attribute weight module. Tactics rank module calculates tactics rank and architecture style rank module calculates the architecture rank.

TABLE III. ARCHITECTURAL STYLES VS TACTICS

S.N	Architecture Style	Tactics	Relationship	values
1)	Pipe & Filter	Generality	Very Strong	0.9
		Locality	Very Strong	0.9
		Modularity	Average	0.5
2)	Black Board	Generality	Very Strong	0.9
		Locality	Very Strong	0.9
		Modularity	Very Strong	0.9
3)	Object Oriented	Generality	Very Strong	0.9
		Locality	Very Strong	0.9
		Modularity	Very Strong	0.9

These are described in detail as follows.

- Calculate average weight of each quality attribute that is selected by user. In this step user first selects scenarios corresponding to non-functional requirement and chooses weight according to his choice. Then calculate the average weight for each non functional requirement by using following

$$AQA_i = \frac{\sum_1^n QWtn}{N}$$

formula

AQA_i = Average weight of i^{th} quality attribute

QWt_n = Weight of n^{th} selected scenario.

n = Number of scenarios

N = Total number of selected scenarios

- Calculate effective weight of each quality attribute. Each scenario may affect more than one scenarios. All effective scenarios questions for each scenario are stored in the effect table in the database. Effect table maintains the list of effected scenarios questions. Calculate effective weight for each quality attribute by using following formula.

$$EWtQA_i = \sum_1^m \sum_1^e EQ_n * QWtn$$

$EWtQA_i$ = Effective weight of i^{th} quality attribute

EQ_n = n^{th} Effective scenario.

e = Number of effective scenarios.

m = Number of scenarios

- Calculate quality attribute weight for each quality attribute. Using the output of step1 and step 2 we calculate the quality attribute weight by the following formula.

$$QAWti = AQA_i + EWtQA_i$$

$QAWt_i$ = i^{th} quality attribute weight.

- Calculate quality attribute rank. Quality to quality relationship table is stored in the database which maintains relationship values of quality to quality attribute. Calculate quality attribute rank using quality to quality relationship table by following

$$QAR_i = \sum_1^q QAWti * QtoQq$$

formula.

QAR_i = i^{th} quality attribute rank.

q = Number of quality attribute.

$QtoQ_q$ = q^{th} Quality to quality relationship

- Calculate tactics rank. Quality to tactics relationship table is stored in the database which maintains relationship values of quality to tactics. Calculate tactics rank using quality to tactics relationship table by following formula.

$$TR_i = \sum_1^t QAR_i * QtoTt$$

TR_i = i^{th} Tactics rank.

$QtoT_t$ = t^{th} Quality to tactics relationship.

t = Number of tactics.

- Calculate architecture style rank. Tactics to architecture style relationship table is stored in the database which maintains relationship values of tactics to architecture style. Calculate architecture style rank using tactics to architecture style relationship table by flowing formula.

$$ASR_i = \sum_1^a TR_i * TtoASa$$

$ASR_i = i^{th}$ Architecture style rank.
 $ToAS_a = i^{th}$ Tactics to architecture style relationship.
 $a =$ Number of architecture styles

First user will click the main page then main page opens and he will select non functional requirements. Now he has to select scenario questions and corresponding weight according to his requirement. A single user can select more than one non functional requirement

Now the user will select the submit button and Result page will open and he would be able to see the Average Weight, Effective Weight, Quality Attribute Weight, Quality Attribute rank, Tactics Rank and Architectural Style and Rank.

VI. RELATED WORK

The work in this paper is inspired by the original work in the area of architectural design guidance tool by Thomas Lane [4], and it is partially influenced by the research in [2, 5], [6], of [7], [8], [9], [11], [12], [13], and [14]. In [5], NFRs, such as accuracy, security, and performance have been utilized to study software systems.

preliminary support for the usefulness of architectural styles the work by Bass et al. [8] introduces the notion of design principle and scenarios that can be utilized to identify and implement quality characteristics of a system. In [7], the discussed the identification of the architecturally significant requirements its impact and role in assessing and recovering software architecture. In [9], the authors proposed an approach to elicit NFRs and provide a process by which software architecture to obtain the conceptual models.

In [14], the authors proposed a systematic method to extract architecturally significant requirements and the manner by which these requirements would be integrate into the conceptual representation of the system under development. The method worked with the computation, communication, and coordination aspects of a system to select the most optimal generic architecture. The selected architecture is then deemed as the starting point and hence is subjected to further assessment and/or refinement to meet all other user's expectations.

In [13], the authors developed a set of systematic approaches based on tactics that can be applied to select appropriate software architectures. More specifically, they developed a set of methods, namely, ATAM (architecture Tradeoff Analysis Method, SAAM (Software Architecture Analysis Method, and ARID (Active Reviews for Intermediate Designs. Our approach has been influenced by [13]; we did applied tactics and QAs to select an optimal architecture. However, the main differences between our approach and the methods developed by Clements *et al.* [13] are 1) our method utilizes different set of design principle and proven design, 2) establishes the correlation within QAs, tactics using tables, 3) establishes the proper correlation between QAs, tactics, and architectural styles using a set of tables and 4) the implementation of scenarios, which meant to increase the accuracy of the evaluation and architectural recommendations.

VII. CONCLUSIONS AND FUTURE WORK

In this paper, we created a tool based on a set of scenarios that allows the user to select an architecture based on non-functional requirements. Non-functional requirements are then mapped to tactics using weighting. The architecture is then selected by its compatibility with the high-scoring design principle. We believe this approach has a lot of merits. However, more research work will be required to create a complete set of scenarios having a closer coupling with quality attributes. Additional work may also be required in fine-tuning the mappings between nonfunctional and functional requirements.

Currently, our tool can be utilized to derive and/or recommend architectural styles based on NFR. To validate the practicality and the usefulness of our approach, we plan to conduct a series of experiments in the form of case studies in which the actual architectural recommendations from our tool will be compared to the design recommendations by architects. We have discussed some quality attributes, some design tactics and some architecture styles. This needs some more research work on other quality attributes, tactics and architecture styles. New research works on non functional requirements might be



Figure 2 . A simple form-based Scenario



Figure 3. The evaluation results

In [6], the authors analyzed the architectural styles using modality, performance, and reusability. Their study provided

done by project members in the future. Our tool provides facility for addition, deletion and modification of new non-functional requirements, new tactics, and new architecture styles.

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To Generate the Ontology from Java Source Code

OWL Creation

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Abstract—Software development teams design new components and code by employing new developers for every new project. If the company archives the completed code and components, they can be reused with no further testing unlike the open source code and components. Program File components can be extracted from the Application files and folders using API's. The proposed framework extracts the metadata from the source code using QDox code generators and stores it in the OWL using Jena framework automatically. The source code will be stored in the HDFS repository. Code stored in the repository can be reused for software development. By Archiving all the project files in to one ontology will enable the developers to reuse the code efficiently.

Keywords- *component: Metadata; QDox, Parser, Jena, Ontology, Web Ontology Language and Hadoop Distributed File System.*

I. INTRODUCTION

Today's Web content is huge and not well-suited for human consumption. An alternative approach is to represent Web content in a form that is more easily machine-processable by using intelligent techniques. The machine processable Web is called the Semantic Web. Semantic Web will not be a new global information highway parallel to the existing World Wide Web; instead it will gradually evolve out of the existing Web [1]. Ontologies are built in order to represent generic knowledge about a target world [2]. In the semantic web, ontologies can be used to encode meaning into a web page, which will enable the intelligent agents to understand the contents of the web page. Ontologies increase the efficiency and consistency of describing resources, by enabling more sophisticated functionalities in development of knowledge management and information retrieval applications. From the knowledge management perspective, the current technology suffers in searching, extracting, maintaining and viewing information. The aim of the Semantic Web is to allow much more advanced knowledge management system.

For every new project, Software teams design new components and code by employing new developers. If the company archives the completed code and components, it can be used with no further testing unlike open source code and components. File content metadata can be extracted from the Application files and folders using API's. During the development each developer follows one's own methods and

logic to perform a task. So there will be different types of codes for the same functionalities. For instance to calculate the factorial, the code can be with recursive, non-recursive process and with different logic. In organizational level a lot of time is spent in re-doing the same work that had been done already. This has a recursive effect on the time of development, testing, deployment and developers. So there is a base necessity to create system that will minimize these factors.

Code re-usability is the only solution for this problem. This will reduce the development of an existing work and testing. As the developed code has undergone the rigorous software development life cycle, it will be robust and error free. There is no need to re-invent the wheel. Code reusability was covered in more than two decades. But still it is of syntactic nature. The aim of this paper is to extract the methods of a project and store the metadata about the methods in the OWL. OWL stores the structure of the methods in it. Then the code will be stored in the distributed environment so that the software company located in various geographical areas can access. To reuse the code, a tool can be created that can extract the metadata such as function, definition, type, arguments, brief description, author, and so on from the source code and store them in OWL. This source code can be stored in the HDFS repository. For a new project, the development can search for components in the OWL and retrieve them at ease[3].

The paper begins with a note on the related technology required in Section 2. The detailed features and framework for source code extractor is found in Section 3. The metadata extraction from the source code is in section 4. The metadata extracted is stored in OWL using Jena framework is in section 5. The implementation scenario is in Section 6. Section 7 deals with the findings and future work of the paper.

II. RELATED WORK

A. Metadata

Metadata is defined as "data about data" or descriptions of stored data. Metadata definition is about defining, creating, updating, transforming, and migrating all types of metadata that are relevant and important to a user's objectives. Some metadata can be seen easily by users, such as file dates and file sizes, while other metadata can be hidden. Metadata standards include not only those for modeling and exchanging metadata,

but also the vocabulary and knowledge for ontology [4]. A lot of efforts have been made to standardize the metadata but all these efforts belong to some specific group or class. The Dublin Core Metadata Initiative (DCMI) [5] is perhaps the largest candidate in defining the Metadata. It is simple yet effective element set for describing a wide range of networked resources and comprises 15 elements. Dublin Core is more suitable for document-like objects. IEEE LOM [6], is a metadata standard for Learning Objects. It has approximately 100 fields to define any learning object. Medical Core Metadata (MCM) [7] is a Standard Metadata Scheme for Health Resources. MPEG-7 [8] multimedia description schemes provide metadata structures for describing and annotating multimedia content. Standard knowledge ontology is also needed to organize such types of metadata as content metadata and data usage metadata.

B. Hadoop & HDFS

The Hadoop project promotes the development of open source software and it supplies a framework for the development of highly scalable distributed computing applications [9]. Hadoop is a free, Java-based programming framework that supports the processing of large data sets in a distributed computing environment and it also supports data intensive distributed application. Hadoop is designed to efficiently process large volumes of information[10]. It connects many commodity computers so that they could work in parallel. Hadoop ties smaller and low-priced machines into a compute cluster. It is a simplified programming model which allows the user to write and test distributed systems quickly. It is an efficient, automatic distribution of data and it works across machines and in turn it utilizes the underlying parallelism of the CPU cores.

In a Hadoop cluster even while, the data is being loaded in, it is distributed to all the nodes of the cluster. The Hadoop Distributed File System (HDFS) will break large data files into smaller parts which are managed by different nodes in the cluster. In addition to this, each part is replicated across several machines, so that a single machine failure does not lead to non-availability of any data. The monitoring system then re-replicates the data in response to system failures which can result in partial storage. Even though the file parts are replicated and distributed across several machines, they form a single namespace, so their contents are universally accessible. Map Reduce [11] is a functional abstraction which provides an easy-to-understand model for designing scalable, distributed algorithms.

C. Ontology

The key component of the Semantic Web is the collections of information called ontologies. Ontology is a term borrowed from philosophy that refers to the science of describing the kinds of entities in the world and how they are related. Gruber defined ontology as a specification of a conceptualization [12]. Ontology defines the basic terms and their relationships comprising the vocabulary of an application domain and the axioms for constraining the relationships among terms [13]. This definition explains what an ontology looks like [14]. The most typical kind of ontology for the Web has taxonomy and a set of inference rules. The taxonomy defines classes of objects

and relations among them. Classes, subclasses and relations among entities are a very powerful tool for Web use.

A large number of relations among entities can be expressed by assigning properties to classes and allowing subclasses to inherit such properties. Inference rules in ontologies supply further power. Ontology may express rules on the classes and relations in such a way that a machine can deduce some conclusions. The computer does not truly "understand" any of this information, but it can now manipulate the terms much more effectively in ways that are useful and meaningful to the human user. More advanced applications will use ontologies to relate the information on a page to the associated knowledge structures and inference rules.

III. SOURCE CODE EXTRACTOR FRAMEWORK

After the completion of a project, all the project files are sent to Source code extraction framework that extracts metadata from the source code. Only java projects are used for this framework. The java source file or folder that consists of java files is passed as input along with project information like description of the project, version of the project. The framework extracts the metadata from the source code using QDox code generators and stores it in the OWL using Jena framework. The source code is stored in the Hadoop's HDFS. A sketch of the source code extractor tool is shown in "Fig. 1".

Source code extraction framework performs two processes: Extracting Meta data from the source code using QDox and storing the meta-data in to OWL using Jena. Both the operations are performed by APIs. This source code extractor will integrate these two operations in a sequenced manner. The given pseudo code describes the entire process of the framework.

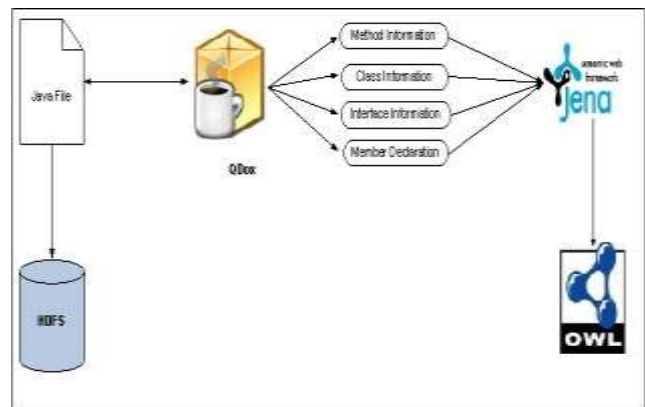


Figure 1. The process of Semantic Stimulus Tool

The framework takes project folder as input and counts the number of packages. Each package information is stored in the OWL. Each package contains various classes and each class has many methods. The class and method information is stored in the OWL. For each of method, the information such as return type, parameters and parameter type information are stored in the OWL. The framework which places all the information in the persistence model and it is stored in the OWL file.

1. Get package count by passing the file path.
2. Initialize packageCounter to zero
3. While the package count equal to packageCounter
- 3.1 Store the package[packageCounter] Information into OWL model
- 3.2 Initialize classCounter value is equal to zero.
- 3.3 Get the no of class count
- 3.4 While class count equal to classCounter
 - 3.4.1 Store the class[ClassCounter] Information into OWL model
 - 3.4.2 Initialize methodCounter to zero
 - 3.4.3 Get no of method of the class[packageCounter]
 - 3.4.4 While no of method count is equal to zero
 - 3.4.4.1 Store the method[methodCounter] information into OWL.
 - 3.4.4.2 Store the modifier informaton of the method [classCounter]
 - 3.4.4.3 Store the return type of the method[classCounter]
 - 3.4.4.4 Initialize the parmCounter to zero
 - 3.4.4.5 Get the no of parameters of method[methodCounter]
 - 3.4.4.6 While no of paramerters count is equal to zero
 - 3.4.4.6.1 Store the parameter[paramCounter] information into OWL model
 - 3.4.4.6.2 Increase paramCounter by one
 - 3.4.4.7 Increase methodCounter by one
 - 3.4.5 Increase class Counter by one
- 3.5 Increase package Counter by one
4. Write the OWL model in the OWL File.

IV. EXTRACTING METADATA

QDox is a high speed small footprint parser for extracting classes, interfaces, and method definitions from the source code. It is designed to be used by active code generators or documentation tools. This tool extracts the metadata from the given java source code. To extract the meta-data of the source, the given order has to be followed. When the java source file or folder that has the java source file is loaded to QDox, it automatically performs the iteration. The loaded information is stored in the JavaBuilder object. From the java builder object the list of packages, as an array of string, are returned. This package list has to be looped to get the class information. From the class information, the method information is extracted. It returns the array of JavaMethod. Out of these methods, the information like scope of the method, name of method, return type of the method and parameter information is extracted.

The QDox process uses its own methods to extract various metadata from the source code. The getPackage() method lists all the available packages for a given source. The getClasses() method lists all the available classes in the package. The getMethods() method lists all the available methods in a class. The getReturns() method returns the return type of the method. The getParameters() method lists all the parameters available for the method. The getType() method returns the type of the method. And when the getComment() method is used with packages, classes and methods, it returns the appropriate comments. Using the above methods the project informations such as package, class, method, return type of the method, parameters of the method, method type and comments are

extracted by the QDox. These metadata are passed to the next section for storing in the OWL.

V. STORING METADATA IN OWL

To store the metadata extracted by QDox, the Jena framework is used. Jena is a Java framework for manipulating ontologies defined in RDFS and OWL Lite [15]. Jena is a leading Semantic Web toolkit [16] for Java programmers. Jena1 and Jena2 are released in 2000 and August 2003 respectively. The main contribution of Jena1 was the rich Model API. Around this API, Jena1 provided various tools, including I/O modules for: RDF/XML [17], [18], N3 [19], and N-triple [20]; and the query language RDQL [21]. In response to these issues, Jena2 has a more decoupled architecture than Jena1. Jena2 provides inference support for both the RDF semantics [22] and the OWL semantics [23].

Jena contains many APIs out of which only few are used for this framework like addProperty(), createIndividual() and write methods. The addProperty() method is to store data and object property in the OWL Ontology. CreateIndividual() creates the individual of the particular concepts. Jena uses in-memory model to hold the persistent data. So this has to be written in to OWL Ontology using write() method.

The OWL construction is done with Protégé. Protégé is an open source tool for managing and manipulating OWL[24]. Protégé [25] is the most complete, supported and used framework for building and analysis of ontologies [26, 27, 28]. The result generated in Protégé is a static ontology definition [29] that can be analyzed by the end user. Protégé provides a growing user community with a suite of tools to construct domain models and knowledge-based applications with ontologies. At its core, Protégé implements a rich set of knowledge-modeling structures and actions that support the creation, visualization, and manipulation of ontologies in various representation formats. Protégé can be customized to provide domain-friendly support for creating knowledge models and entering data. Further, Protégé can be extended by way of a plug-in architecture and a Java-based API for building knowledge-based tools and applications.

Based on the java source code study the ontology domain is created with the following attributes. To store the extracted metadata, the ontology is created with project, packages, classes, methods and parameters. The project is concept that holds the information like name, project repository location, project version and the packages. The package is a concept that holds the information like name and the class. The class is a concept that holds the class informations such as author, class comment, class path, identifier, name and the methods. The method is a concept that holds the information like method name, method Comment, method identifier, isConstructor, return type, and the parameter. The parameter is a concept that holds the information like name and the data type.

Concepts/Classes provide an abstraction mechanism for grouping resources with similar characteristics. Project, package, class, method, parameter are concepts in source code extractor ontology.

Individual is an instance of the concept/ class.

Property describes the relation between concepts and objects. It is a binary relationship on individuals. Each property has domain and range. There are two types of property namely object and data property

Object Property links individuals to individuals. In source code ontology, the object properties are hasClass, hasMethod, hasPackage and hasParameter. hasClass is an object property which has domain Package and range Class. hasMethod is an object property which has domain class and range method. hasPackage is an object property which has domain Project and range Package. hasParameter is an object property which has domain method and range range.

Datatype Property links individuals to data values. Author is a dataproperty which has domain Class and the String as range. ClassComment is a data property which has domain class and string as range. DataType is a data property which has domain parameter and the range string as range. Identifier is a data property which has domain method, class and the range boolean as range. IsConstructor is a data property which has domain method and string as range. MethodComment is a data property which has domain method and string as range. Name is a data property which has domain project, package, class, method, parameter and string as range. Project_Date is a data property which has domain project and string as range. Project_Description is a data property which has domain project and string as range. Project_Repository_Location is a data property which has domain project and string as range. Project_Description is a data property which has domain project and string as range. Project_Version is a data property which has domain project and string as range. Returns is a data property which has domain method and string as range.

VI. CASE STUDY

To evaluate the proposed framework the following simple java code is used.

```
package com.sourceExtractor.ontology;
import java.io.FileNotFoundException;
import java.io.FileOutputStream;
import java.io.IOException;
import java.io.OutputStream;
import java.util.ArrayList;
import java.util.List;
import org.apache.log4j.Logger;
import org.apache.log4j.spi.RootLogger;
import com.hp.hpl.jena.ontology.DatatypeProperty;
/** * To manage the ontology related informations
 * @author Sagayaraj */
public class OntoManager {
    private Logger LOGGER =
RootLogger.getLogger(OntoManager.class);
    @SuppressWarnings("static-access")
    public OntModel getModel(String modelLocation) {
OntModel ontModel = null;
ontModel = ModelFactory.createOntologyModel();
ontModel.read(new FileManager().get().open(modelLocation),
""");
return ontModel;
}
/**
 * To create Individual In OWL
```

```
* @param model
* @param concept
* @param individual */
public void createIndividual(OntModel model, String concept,
String individual) {
OntClass ontClass =
model.getOntClass(addNameSpace(concept, model));
model.enterCriticalSection(Lock.WRITE);
try {if (ontClass != null) {
ontClass.createIndividual(addNameSpace(individual, model));
} else {
LOGGER.error("Direct Class is null");// todo
}} finally {
model.leaveCriticalSection();
}}
```

The sample java code is given as input to QDox document generator through the Graphical User Interface (GUI) provided in the “Fig. 2”.

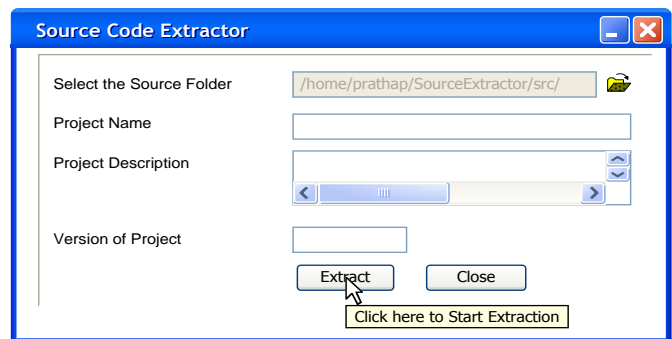


Figure 2. GUI for locating folder

Using the QDox API’s metadata is extracted as given in the Table 1. The output of the QDox stores metadata in the form of strings. To store the metadata the OWL ontology, template is created using Protégé. The strings are passed to the Jena framework and the APIs place the metadata in to the OWL Ontology. The entire project folder, stored in the HDFS, is linked to the method signature in the OWL ontology for retrieval purpose. The components will be reused for the new project appropriately. The obtained OWL Ontology successfully loads on both Protégé Editor and Altova Semantics. The sample OWL file is given below as the output of the framework.

```
<owl:Ontology rdf:about="http://www.owl-ontologies.com/SourceExtractorj.owl#" />
<owl:Class rdf:about="http://www.owl-ontologies.com/SourceExtractorj.owl#Package" />
<owl:Class rdf:about="http://www.owl-ontologies.com/SourceExtractorj.owl#Project" />
<owl:Class rdf:about="http://www.owl-ontologies.com/SourceExtractorj.owl#Class" />
<owl:Class rdf:about="http://www.owl-ontologies.com/SourceExtractorj.owl#Method" />
<owl:Class rdf:about="http://www.owl-ontologies.com/SourceExtractorj.owl#Parameter" />
<owl:ObjectProperty rdf:about="http://www.owl-ontologies.com/SourceExtractorj.owl#hasPackage" />
<rdfs:domain rdf:resource="http://www.owl-ontologies.com/SourceExtractorj.owl#Project" />
<rdfs:range rdf:resource="http://www.owl-ontologies.com/SourceExtractorj.owl#Package" />
```

```
</owl:ObjectProperty>
<owl:ObjectProperty rdf:about="http://www.owl-
ontologies.com/SourceExtractorj.owl#hasParameter">
  <rdfs:domain rdf:resource="http://www.owl-
ontologies.com/SourceExtractorj.owl#Method"/>
  <rdfs:range rdf:resource="http://www.owl-
ontologies.com/SourceExtractorj.owl#Parameter"/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:about="http://www.owl-
ontologies.com/SourceExtractorj.owl#hasClass">
  <rdfs:domain rdf:resource="http://www.owl-
ontologies.com/SourceExtractorj.owl#Package"/>
  <rdfs:range rdf:resource="http://www.owl-
ontologies.com/SourceExtractorj.owl#Class"/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:about="http://www.owl-
ontologies.com/SourceExtractorj.owl#hasMethod">
  <rdfs:range rdf:resource="http://www.owl-
ontologies.com/SourceExtractorj.owl#Method"/>
  <rdfs:domain rdf:resource="http://www.owl-
ontologies.com/SourceExtractorj.owl#Class"/>
</owl:ObjectProperty>
<owl:DatatypeProperty rdf:about="http://www.owl-
ontologies.com/SourceExtractorj.owl#Project_Date"/>
<owl:DatatypeProperty rdf:about="http://www.owl-
ontologies.com/SourceExtractorj.owl#Identifier">
  <rdfs:domain>
    <owl:Class>
      <owl:unionOf rdf:parseType="Collection">
        <owl:Class rdf:about="http://www.owl-
ontologies.com/SourceExtractorj.owl#Method"/>
        <owl:Class rdf:about="http://www.owl-
ontologies.com/SourceExtractorj.owl#Class"/>
      </owl:unionOf>
    </owl:Class>
  </rdfs:domain>
  <rdfs:range>
    <owl:Class>
      <rdf:type rdf:resource="http://www.w3.org/2002/07/owl#DataRange"/>
      <owl:oneOf rdf:parseType="Resource">
        <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
>public</rdf:first>
        <rdf:rest rdf:parseType="Resource">
          <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
>private</rdf:first>
          <rdf:rest rdf:parseType="Resource">
            <rdf:first
rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
>protected</rdf:first>
            <rdf:rest rdf:resource="http://www.w3.org/1999/02/22-rdf-syntax-
ns#nil"/>
          </rdf:rest>
        </rdf:rest>
      </owl:oneOf>
    </owl:Class>
  </rdfs:range>
</owl:DatatypeProperty>
```

VII. CONCLUSION AND FUTURE WORK

This paper presents an approach for generating ontologies using the source code extractor tool from source code. This approach helps to integrate source code into the Semantic Web. OWL is semantically much more expressive than needed for the results of our mapping. With these sample tests the paper argues that it is indeed possible to transform source code in to OWL using this Source Code Extractor framework. The framework created OWL which will increase the efficiency and consistency in development of knowledge management and information retrieval applications. The purpose of the paper is to achieve the code re-usability for the software development.

By creating OWL for the source code the future will be to search and extract the code and components and reuse to shorten the software development life cycle. Open source code can also be used to create OWL so that there will be huge number of components which can be reused for the development. By storing the projects in the OWL and the HDFS the corporate knowledge grows and the developers will use more of reuse code than developing themselves. Using the reuse code the development cost will come down, development time will become shorter, resource utilization will be less and quality will go up.

After developing OWL and storing the source code in the HDFS, the code components can be reused. The future work can take off in two ways. One can take a design document from the user as input, then extract the method signature and try to search and match in the OWL. If the user is satisfied with the method definition, it can be retrieved from the HDFS where the source code is stored. Second one can take the project specification as input and text mining can be performed to extract the keywords as classes and the process as methods. The method prototype can be used to search and match with the OWL and the required method definition can be retrieved from the HDFS. The purpose of storing the metadata in OWL is to minimize the factors like time of development, time of testing, time of deployment and developers. Creating OWL using this framework can reduce these factors.

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TABLE I. METADATA EXTRACTED FROM THE SAMPLE CODE

Project	Project Name	Ontology_Learn	
	Project Version	1.0.0	
	Project Date	10/10/10	
	Repository Location	/opt/SourceCodeExtrctor/	
	HasPackage	com.sourceExtractor.ontology	
Package	Name	com.sourceExtractor.ontology	
	HasClass	OntoManager	
Class	Name	OntoManager	
	Class Comment	It manage the ontology operation	
	Class Path	/SampleOntology/com/sourceExtrctor/ontology/OntoManager.java	
	Author	Sagayaraj	
	Identifier	Public	
	HasMethod	getModel createIndividual	
	Method	Name	getModel createIndividual
		Identifier	Public Public
		Returns	OntoModel Void
		Method Comment	-undefined- To add the data property in owl file
IsConstructor		FALSE	
		FALSE	
HasParameter		modelLocation	
		Individual model Concept	
Parameter		Name	modelLocation
		Data Type	java.lang.String
	Name	Individual	
	Data Type	java.lang.String	
	Name	Model	
	Data Type	OntModel	
	Name	Concept	
	Data Type	java.lang.String	

Query based Personalization in Semantic Web Mining

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Abstract— To provide personalized support in on-line course resources system, a semantic web-based personalized learning service is proposed to enhance the learner's learning efficiency. When a personalization system relies solely on usage-based results, however, valuable information conceptually related to what is finally recommended may be missed. Moreover, the structural properties of the web site are often disregarded. In this Paper, we present a personalize Web search system, which can helps users to get the relevant web pages based on their selection from the domain list. In the first part of our work we present Semantic Web Personalization, a personalization system that integrates usage data with content semantics, expressed in ontology terms, in order to compute semantically enhanced navigational patterns and effectively generate useful recommendations. To the best of our knowledge, our proposed technique is the only semantic web personalization system that may be used by non-semantic web sites. In the second part of our work, we present a novel approach for enhancing the quality of recommendations based on the underlying structure of a web site. We introduce UPR (Usage-based Page Rank), a Page Rank-style algorithm that relies on the recorded usage data and link analysis techniques based on user interested domains and user query.

Keywords-Semantic Web Mining; Personalized Recommendation; Recommended System

I. INTRODUCTION

Comparing with the traditional face-to-face learning style, e-learning is indeed a revolutionary way to provide education in the life-long term. However, different learners have different learning styles, goals, previous knowledge and other preferences; the traditional "one-size-fits-all" learning method is no longer enough to satisfy the needs of learners. Nowadays more and more personalized systems have been developed and are trying to find a solution to the personalization of the learning process, which affect the learning function outcome. The Semantic

Web is not a separate web but an extension of the current one, in which information is given well-defined meaning, and better enabling computers and people to work in cooperation [1]. Under the conditions of Semantic Web-based learning system the learning information is well-defined, and the machine can understand and deal with the semantics for the learning contents to provide adaptable learning services with a powerful technical support.

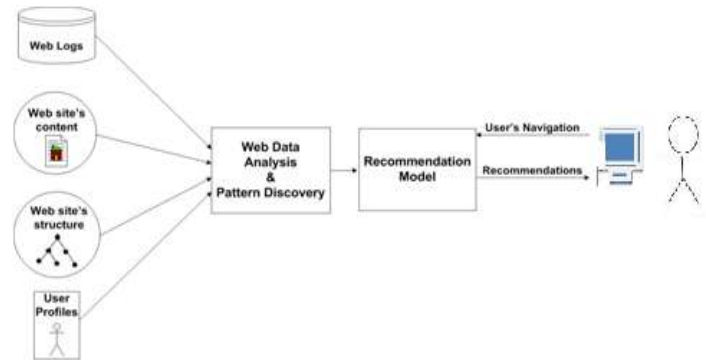


Figure: 1 the web personalization process

The problem of providing recommendations to the visitors of a web site has received a significant amount of attention in the related literature. Most of the research efforts in web personalization correspond to the evolution of extensive research in web usage mining, taking into consideration only the navigational behavior of the (anonymous or registered) visitors of the web site. Pure usage-based personalization, however, presents certain shortcomings. This may happen when, for instance, there is not enough usage data available in order to extract patterns related to certain navigational actions, or when the web site's content changes and new pages are added but are not yet included in the web logs. Moreover, taking into consideration the temporal characteristics of the web in terms of its usage, such systems are very vulnerable to the training data used to construct the predictive model. As a result, a number of research approaches integrate other sources of information, such as the web content or the web structure in order to enhance the web personalization process [1] and [2].

As already implied, the users' navigation is largely driven by semantics. In other words, in each visit, the user usually aims at finding information concerning a particular subject. Therefore, the underlying content semantics should be a dominant factor in the process of web personalization. The web site's content characterization process involves the feature extraction from the web pages. Usually these features are keywords subsequently used to retrieve similarly characterized content. Several methods for extracting keywords that characterize web content have been proposed. The similarity between documents is usually based on exact matching between these terms. This way, however, only a binary matching between documents is achieved, whereas no actual *semantic* similarity is taken into consideration. The need for a

more abstract representation that will enable a uniform and more flexible document matching process imposes the use of semantic web structures, such as ontology's. By mapping the keywords to the concepts of an ontology, or topic hierarchy, the problem of binary matching can be surpassed through the use of the hierarchical relationships and/or the *semantic similarities* among the ontology terms, and therefore, the documents. Finally, we should take into consideration that the web is not just a collection of documents browsed by its users. The web is a directed labeled graph, including a plethora of hyperlinks that interconnect its web pages. Both the structural characteristics of the web graph, as well as the web pages' and hyper links' underlying semantics are important and determinative factors in the users' navigational process. The main contribution of this paper is a set of novel techniques and algorithms aimed at improving the overall effectiveness of the web personalization process through the integration of the content and the structure of the web site with the users' navigational patterns. In the first part of our work we present the semantic web personalization system for Semantic Web Personalization that integrates usage data with content semantics in order to compute semantically enhanced navigational patterns and effectively generate useful recommendations. Similar to previously proposed approaches, the proposed personalization framework uses ontology terms to annotate the web content and the users' navigational patterns. The key departure from earlier approaches, however, is that Semantic Web Personalization is the only web personalization framework that employs automated keyword-to-ontology mapping techniques, while exploiting the underlying semantic similarities between ontology terms. Apart from the novel recommendation algorithms we propose, we also emphasize on a hybrid structure-enhanced method for annotating web content. To the best of our knowledge, Semantic Web Personalization is the only semantic web personalization system that can be used by any web site, given only its web usage logs and a domain-specific ontology [3] and [4].

II. BACKGROUND

The main data source in the web usage mining and personalization process is the information residing on the web site's logs. Web logs record every visit to a page of the web server hosting it. The entries of a web log file consist of several fields which represent the date and the time of the request, the IP number of the visitor's computer (client), the URI requested, the HTTP status code returned to the client, and so on. The web logs' file format is based on the so called "extended" log format.

Prior to processing the usage data using web mining or personalization algorithms, the information residing in the web logs should be preprocessed. The web log data preprocessing is an essential phase in the web usage mining and personalization process. An extensive description of this process can be found. In the sequel, we provide a brief overview of the most important pre-processing techniques, providing in parallel the related terminology. The first issue in the *pre-processing* phase is *data preparation*. Depending on the application, the web log data may need to be cleaned from entries involving page accesses that returned, for example, an error or graphics file accesses. Furthermore, crawler activity usually should be

filtered out, because such entries do not provide useful information about the site's usability. A very common problem to be dealt with has to do with web pages' *caching*. When a web client accesses an already cached page, this access is not recorded in the web site's log. Therefore, important information concerning web path visits is missed. Caching is heavily dependent on the client-side technologies used and therefore cannot be dealt with easily. In such cases, cached pages can usually be inferred using the referring information from the logs and certain heuristics, in order to re-construct the user paths, filling out the missing pages. After all page accesses are identified, the *page view identification* should be performed. A *page view* is defined as "the visual rendering of a web page in a specific environment at a specific point in time". In other words, a page view consists of several items, such as frames, text, graphics and scripts that construct a single web page. Therefore, the page view identification process involves the determination of the distinct log file accesses that contribute to a single page view. Again such a decision is application-oriented. In order to personalize a web site, the system should be able to distinguish between different users or groups of users. This process is called *user profiling*. In case no other information than what is recorded in the web logs is available, this process results in the creation of aggregate, anonymous user profiles since it is not feasible to distinguish among individual visitors. However, if the user's registration is required by the web site, the information residing on the web log data can be combined with the users' demographic data, as well as with their individual ratings or purchases. The final stage of log data pre-processing is the partition of the web log into distinct *user* and *server sessions*. A user session is defined as "a delimited set of user clicks across one or more web servers", whereas a *server session*, also called a *visit*, is defined as "a collection of user clicks to a single web server during a user session". If no other means of session identification, such as cookies or session ids is used, *session identification* is performed using time heuristics, such as setting a minimum timeout and assumes that consecutive accesses within it belong to the same session, or a maximum timeout, assuming that two consecutive accesses that exceed it belong to different sessions [1] and [5] and [6].

A. Web Usage Mining and Personalization:

Web usage mining is the process of identifying representative trends and browsing patterns describing the activity in the web site, by analyzing the users' behavior. Web site administrators can then use this information to redesign or customize the web site according to the interests and behavior of its visitors, or improve the performance of their systems. Moreover, the managers of e-commerce sites can acquire valuable business intelligence, creating consumer profiles and achieving market segmentation. There exist various methods for analyzing the web log data. Some research studies use well known data mining techniques such as association rules discovery, sequential pattern analysis, clustering, probabilistic models, or a combination of them. Since web usage mining analysis was initially strongly correlated to data warehousing, there also exist some research studies based on OLAP cube models. Finally some proposed web usage mining approaches that require registered user profiles, or combine the usage data

with semantic meta-tags incorporated in the web site's content. Furthermore, this knowledge can be used to automatically or semi-automatically adjust the content of the site to the needs of specific groups of users, i.e. to personalize the site. As already mentioned, web personalization may include the provision of recommendations to the users, the creation of new index pages, or the generation of targeted advertisements or product promotions. The usage-based personalization systems use association rules and sequential pattern discovery, clustering, Markov models, machine learning algorithms, or are based on collaborative filtering in order to generate recommendations. Some research studies also combine two or more of the aforementioned techniques [2] and [4].

B. Integrating Content Semantics in Web Personalization:

Several frameworks supporting the claim that the incorporation of information related to the web site's content enhances the web personalization process have been proposed prior or subsequent to our work. In this Section we overview in detail the ones that are more similar to ours, in terms of using a domain-ontology to represent the web site's content.

Dai and Mobasher proposed a web personalization framework that uses ontologies to characterize the usage profiles used by a collaborative filtering system. These profiles are transformed to "domain-level" aggregate profiles by representing each page with a set of related ontology objects. In this work, the mapping of content features to ontology terms is assumed to be performed either manually, or using supervised learning methods. The defined ontology includes classes and their instances therefore the aggregation is performed by grouping together different instances that belong to the same class. The recommendations generated by the proposed collaborative system are in turn derived by binary matching of the current user visit, expressed as ontology instances, to the derived domain-level aggregate profiles, and no semantic similarity measure is used. The idea of semantically enhancing the web logs using ontology concepts is independently described in recent. This framework is based on a semantic web site built on an underlying ontology. The authors present a general framework where data mining can then be performed on these semantic web logs to extract knowledge about groups of users, users' preferences, and rules. Since the proposed framework is built on a semantic web knowledge portal, the web content is already semantically annotated focuses solely on web mining and thus does not perform any further processing in order to support web personalization.

In recent (through the existing RDF annotations), and no further automation is provided. Moreover, the proposed framework t work also proposes a general personalization framework based on the conceptual modeling of the users' navigational behavior. The proposed methodology involves mapping each visited page to a topic or concept, imposing a concept hierarchy (taxonomy) on these topics, and then estimating the parameters of a semi-Markov process defined on this tree based on the observed user paths. In this Markov models-based work, the semantic characterization of the content is performed manually. Moreover, no semantic similarity measure is exploited for enhancing the prediction process, except for generalizations/specializations of the

ontology terms. Finally, in a subsequent work, explore the use of ontologies in the user profiling process within collaborative filtering systems. This work focuses on recommending academic research papers to academic staff of a University. The authors represent the acquired user profiles using terms of research paper ontology (is-a hierarchy). Research papers are also classified using ontological classes. In this hybrid recommender system which is based on collaborative and content-based recommendation techniques, the content is characterized with ontology terms, using document classifiers (therefore a manual labeling of the training set is needed) and the ontology is again used for making generalizations/specializations of the user profiles [7] and [8] and [9].

C. Integrating Structure in Web Personalization:

Although the connectivity features of the web graph have been extensively used for personalizing web search results, only a few approaches exist that take them into consideration in the web site personalization process. To use citation and coupling network analysis techniques in order to conceptually cluster the pages of a web site. The proposed recommendation system is based on Markov models. In previous, use the degree of connectivity between the pages of a web site as the determinant factor for switching among recommendation models based on either frequent item set mining or sequential pattern discovery. Nevertheless, none of the aforementioned approaches fully integrates link analysis techniques in the web personalization process by exploiting the notion of the *authority* or *importance* of a web page in the web graph.

In a very recent work, address the data sparsity problem of collaborative filtering systems by creating a bipartite graph and calculating linkage measures between unconnected pairs for selecting candidates and make recommendations. In this study the graph nodes represent both users and rated/purchased items.

Finally, subsequent work, proposed independently two link analysis ranking methods, *Site Rank* and *Popularity Rank* which are in essence very much like the proposed variations of our *UPR* algorithm (*PR* and *SUPR* respectively). This work focuses on the comparison of the distributions and the rankings of the two methods rather than proposing a web personalization algorithm [9] and [10].

III. PROPOSED TECHNIQUE

In this paper, we present Semantic Enhancement for Web Personalization, a web personalization framework that integrates content semantics with the users' navigational patterns, using ontologies to represent both the content and the usage of the web site. In our proposed framework we employ web content mining techniques to derive semantics from the web site's pages. These semantics, expressed in ontology terms, are used to create semantically enhanced web logs, called C-logs (concept logs). Additionally, the site is organized into thematic document clusters. The C-logs and the document clusters are in turn used as input to the web mining process, resulting in the creation of a broader, semantically enhanced set of recommendations. The whole process bridges the gap between Semantic Web and Web Personalization areas, to create a Semantic Web Personalization system.

A. Semantic Enhancement for Web Personalization System Architecture:

Semantic Enhancement for Web Personalization uses a combination of web mining techniques to personalize a web site. In short, the web site's content is processed and characterized by a set of ontology terms (categories). The Web personalization process include (a) The collection of Web data, (b) The modeling and categorization of these data (preprocessing phase), (c) The analysis of the collected data, and (d) The determination of the actions that should be performed. When a user sends a query to a search engine, the search engine returns the URLs of documents matching all or one of the terms, depending on both the query operator and the algorithm used by the search engine. *Ranking* is the process of ordering the returned documents in decreasing order of relevance, that is, so that the "best" answers are on the top. When the user enters the query, the query is first analyzed. The Query is given as input to the semantic search algorithm for separation of nouns, verbs, adjectives and negations and assigning weights respectively. The processed data is then given to the personalized URL Rank algorithm for personalizing the results according to the user domain, interest and need. The sorted results are those results in which the user is interested. The personalization can be enhanced by categorizing the results according to the types. Thus after building the knowledge base, the system can give use recommendation based on the similarity of the user interested domain and the user query. The recommendation procedure of the System has two steps:

- The system gives user a list of interested domains .Detect user's current interested domain.
- Based on user's current interested domain and combined his or her profile, the system will give him or her set of URLs with ranking scores.

In this way, the system could help the user to retrieve his or her potential interested domains. Besides, a user can change his or her current interested domain by clicking the interested domain list on the same page but with more convenience. In the beginning, if the user does not have a profile in the database, the system displays the user available domains, and then keeps a track of the user's selections. The user's selections is used to construct a table that uses URL weight calculation. The current interested domains recommendation is based on last selections. The figure 2 shows the complete process.

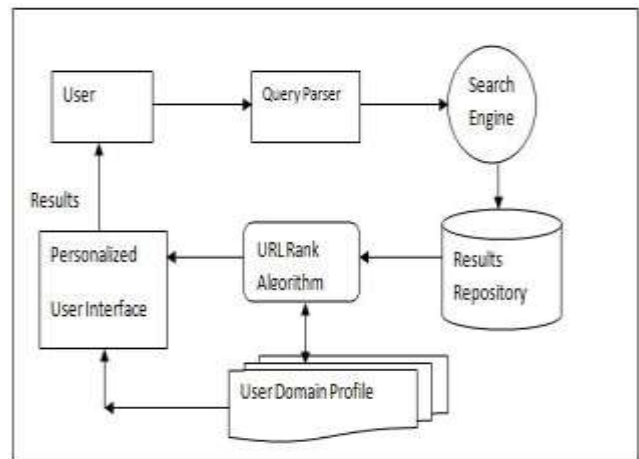


Figure 2: Web Personalization architecture

B. Recommendation process:

The learner's implicit query defined previously under both of its shapes constitutes the input of the recommendation phase. The recommendation process task is accomplished using basically: content based filtering (CBF) and collaborative filtering (CF) approaches (Figure 3). First, we apply the (CBF) approach alone using the search functionalities of the search engine. We submit the term vector to the search engine in order to compute recommendation links. Results are ranked according to the cosine similarity of their content (vector of *TF-IDF* weighted terms) with the submitted term vector. Second, we apply the collaborative approach (CF) alone by comparing, first, the sliding window pages to clusters (groups of learners obtained in the offline phase by applying two-level model based collaborative filtering approach) in order to classify the active learner in one of the learner's group. Then, we use the *ARs* of the corresponding group to give personalized recommendations. The current session window is matched against the "condition" or left side of each rule.

It is worth noting that several recommendation strategies using these approaches have been investigated in our work. After applying a CF and CBF approaches alone, we included next the possibility to combine both of the recommendation approaches (CBF and CF) in order to improve the recommendation quality and generate the most relevant learning objects to learners. Hence, two approaches are to be considered: Hybrid content via profile based collaborative filtering with cascaded/feature augmentation combination, which performs collaborative recommendation followed by content recommendation (the reverse order could also be considered); and Hybrid content and profile based collaborative filtering with weighted combination, where the collaborative filtering and content based filtering recommendations are performed simultaneously, then the results of both techniques are combined together to produce a single recommendation set. In the Hybrid content via profile based collaborative filtering with cascaded/feature augmentation combination approach, we apply first CF approach giving as output a set of recommended links, then we apply CBF approach on these links. In fact, recommended links are mapped to a set of content terms in

order to compose a term vector (top k frequent terms), a parser tool must be used for this task. Finally, these terms are submitted to the search engine which returns the final recommended links.

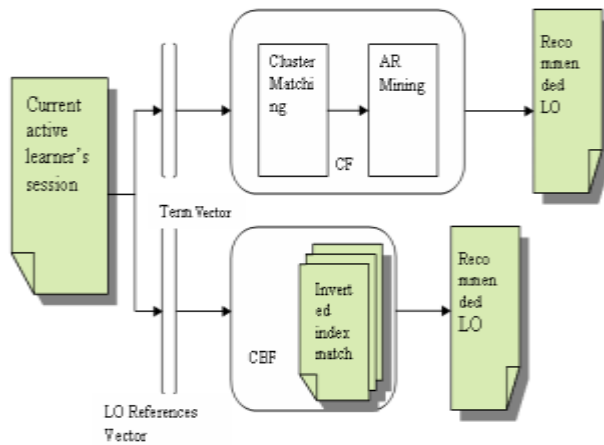


Figure 3: Recommendation process

In the Hybrid content and profile based collaborative filtering with weighted combination approach, the collaborative filtering and content based filtering are performed separately, then the results of both techniques are combined together to produce a single recommendation set.

C. This process uses the following steps:

- I. Step 1** is performed in the same way as in CF approach; the result is called Recommended Set 1;
- II. Step 2** maps each LO references in the sliding window to a set of content terms (top k frequent terms). Then these terms are submitted to the search engine which returns recommended links. This result is called Recommended Set 2;
- III. Final** collaborative and content based filtering recommendation combination: both recommended sets obtained previously are combined together to form a coherent list of related recommendation links, which are ranked based on their overlap ratio.

IV. METHODOLOGY

- **Data Set** The two key advantages of using this data set are that the web site contains web pages in several formats (such as pdf, html, ppt, doc, etc.), written both in Greek and English and a domain-specific concept hierarchy is available (the web administrator created a concept-hierarchy of 150 categories that describe the site's content). On the other hand, its context is rather narrow, as opposed to web portals, and its visitors are divided into two main groups: students and researchers. Therefore, the subsequent analysis (e.g. association rules) uncovers these trends: visits to course material, or visits to publications and researcher details. It is essential to point out that the need for processing online (up-to-date) content, made it impossible for us to use other publicly available web log

sets, since all of them were collected many years ago and the relevant sites' content is no longer available. Moreover, the web logs of popular web sites or portals, which would be ideal for our experiments, are considered to be personal data and are not disclosed by their owners. To overcome these problems, we collected web logs over a 1-year period (01/01/10 – 31/12/10). After preprocessing, the total web logs' size was approximately 105 hits including a set of over 67.700 distinct anonymous user sessions on a total of 360 web pages. The sessionizing was performed using distinct IP & time limit considerations (setting 20 minutes as the maximum time between consecutive hits from the same user).

- **Keyword Extraction: Category Mapping:** We extracted up to 7 keywords from each web page using a combination of all three methods (raw term frequency, inlinks, outlinks). We then mapped these keywords to ontology categories and kept at most 5 for each page.
- **Document Clustering:** We used the clustering scheme described in recent, i.e. the DBSCAN clustering algorithm and the similarity measure for sets of keywords. However, other web document clustering schemes (algorithm & similarity measure) may be employed as well.
- **Association Rules Mining:** We created both URI-based and category-based frequent item sets and association rules. We subsequently used the ones over a 40% confidence threshold.

V. RESULTS

In our paper work we compare the performance of the three ranking methods based on pure similarity, plain Page Rank and weighted (personalized) URL Rank.

The personalization accuracy was found to be 75%; the random search accuracy is 74.6 %. The average of personalization accuracy is 74.7%. Because the interested domains personalization is done considering the user selected domain, the accuracy is higher than the random recommendation in our experiment. Above Fig. 4 is a comparison of the interested domains personalization accuracy based on random selection and based on our personalization method. Figure 4 shows Relevance Query Results vs. Random & Personalization Selection graph.

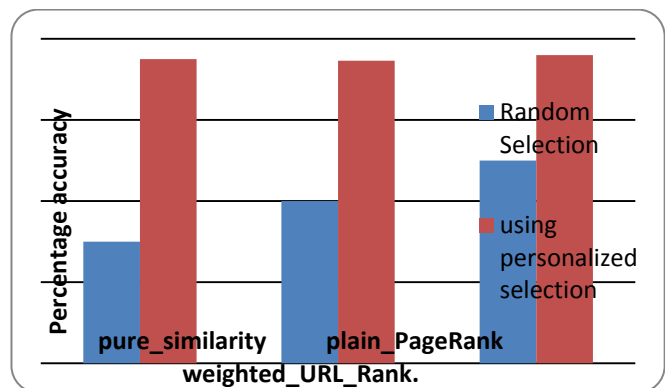


Figure 4 – Random Selection accuracy

The URL personalization accuracy based on the interested domains selection is 71.3%; and the URL personalization accuracy without the interested domains selection assistance is 31.9 % in Fig. 5. From this result, we can see that the interested domains recommendation help the system to filter lots of URLs that the user might not be interested in. Moreover, the system could focus on the domains that users are interested in to select the relevant URL. Figure 5 shows Relevance Query Results vs. Random & Personalization Selection graph.

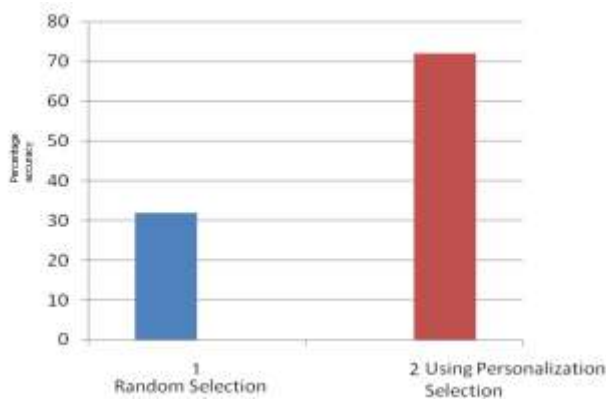


Figure 5- Personal accuracy in interested domain

VI. CONCLUSION

In this paper contribution is a core technology and reusable software engine for rapid design of a broad range of applications in the field of personalized recommendation systems and more. We present a web personalization system for web search, which not only gives user a set of personalized pages, but also gives user a list of domains the user may be interested in. Thus, user can switch to different interests when he or she is surfing on the web for information. Besides, the system focuses on the domains that the user is interested in, and won't waste lots of time on searching the information in the irrelevant domains. Moreover, the recommendation won't be affected by the irrelevant domains, and the accuracy of the recommendation is increased.

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A Short Description of Social Networking Websites And Its Uses

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Abstract—Now days the use of the Internet for social networking is a popular method among youngsters. The use of collaborative technologies and Social Networking Site leads to instant online community in which people communicate rapidly and conveniently with each other. The basic aim of this research paper is to find out the kinds of social network are commonly using by the people.

Keywords-Social Network, kinds, Definition, Social Networking web sites, Growth.

I. INTRODUCTION

A web site that provides a social community for people interested in a particular subject or interest together. Members create their own online profile with data, pictures, and any other information. They communicate with each other by voice, chat, instant message, videoconferencing, and the service typically provides a way for members to connect by making connections through individuals is known as Social networking. Now days there are many web sites dedicated to the Social Networking, some popular websites are. Facebook, Orkut, Twitter, Bebo, Myspace, Friendster, hi5, and Bharatstudent are very commonly used by the people. These websites are also known as communities network sites. Social networking websites function like an online community of internet users. Depending on the website in question, many of these online community members share common interests in hobbies, discussion. Once you access to a social networking website you can begin to socialize. This socialization may include reading the profile pages of other members and possibly even contacting them.

II. DEFINITION

Boyd and Ellison (2007) define social network services as web-based services which allow individuals to Construct a public or semipublic profile within a bounded system, Communicate with other users; and View the pages and details provided by other users within the system. The social networking websites have evolved as a combination of personalized media experience, within social context of participation. The practices that differentiate social networking sites from other types of computer-mediated communication are uses of profiles, friends and comments or testimonials profiles are publicly viewed, friends are publicly articulated, and comments are publicly visible.

Users who join Social networking websites are required to make a profile of themselves by filling up a form. After filling up the forms, users are supposed to give out information about their personality attributes and personal appearances. Some social networking websites require photos but most of them will give details about one's age, preference, likes and dislikes. Some social networking websites like Facebook allow users to customize their profiles by adding multimedia content. (Geroimenko & Chen, 2007)

III. CHARACTERISTICS OF SOCIAL NETWORKING SITES

Social networking websites provide rich information about the person and his network, which can be utilized for various business purposes. Some of the main characteristics of social networking sites are:

- They act as a resource for advertisers to promote their brands through word-of-mouth to targeted customers.
- They provide a base for a new teacher-student relationship with more interactive sessions online.
- They promote the use of embedded advertisements in online videos.
- They provide a platform for new artists to show their profile.

IV. OBJECTIVE

The basic objective of this research is to analysis about the awareness and frequency regarding the use of social networking websites.

V. HISTORY OF SOCIAL NETWORKING WEBSITES

The first social networking websites was launched in the year 1997 Sixdegrees.com. This company was the first of its kind; it allowed user to list their profiles, provide a list of friends and then contact them. However, the Company did not do very well as it eventually closed three years later. The reason for this was that many people using the internet at that time had not formed many social networks hence there was little room for maneuver. It should be noted that there were also other elements that hinted at Social network websites. For instance, dating sites required users to give their profiles but they could not share other people's websites. Additionally,

there were some websites that would link former school mates but the lists could not be shared with others. (Cassidy, 2006)

After this there was the creation of Live Journal in the year 1999. It was created in order to facilitate one way exchanges of journals between friends. Another company in Korea called CY world added some social networking features in the year 2001. This was then followed by Lunar Storm in Sweden during the same year. They include things like diary pages and friends lists. Additionally, Ryze.com also established itself in the market. It was created with the purpose of linking business men within San Francisco. The Company was under the management of Friendster, LinkedIn, Tribe.net and Ryze. The latter company was the least successful among all others. However, Tribe.net specialized in the business world but Friendster initially did well; this did not last for long. (Cohen, 2003)

VI. SOCIAL NETWORKING WEBSITES THAT ARE COMMONLY USED BY THE PEOPLE

The most significant Social networking websites commonly used by the people especially by the youngster like, Friendster, Myspace, Facebook, Downlink, Ryze, SixDegrees, Hi 5, LinkedIn, Orkut, Flickr, YouTube, Reddit, Twitter, FriendFeed, BharatStudent and Floper.

A. Friendster

Friendster began its operations in the year 2002. It was a brother company to Ryze but was designed to deal with the social aspect of their market. The company was like a dating service, however, match making was not done in the typical way where strangers met. Instead, friends would propose which individuals are most compatible with one another. At first, there was an exponential growth of the Comply. This was especially after introduction of network for gay men and increase in number of bloggers. The latter would usually tell their friends about the advantages of social networking through Friendster and this led to further expansion. However, Friendster had established a market base in one small community. After their subscribers reached overwhelming numbers, the company could no longer cope with the demand. There were numerous complaints about the way their servers were handled because subscribers would experience communication breakdowns. As if this was not enough, social networks in the real world were not doing well; some people would find themselves dating their bosses or former classmates since the virtual community created by the company was rather small. The Company also started limiting the level of connection between enthusiastic users. (Boyd, 2004)

B. MySpace

By 2003, there were numerous companies formed with the purpose of providing social networking service. However, most of them did not attract too much attention especially in the US market. For instance, LinkedIn and Xing were formed for business persons while services like MyChurch, Dogster and Couchsurfing were formed for social services. Other companies that had been engaging in other services started offering social networking services. For instance, the You Tube

and Last. FM was initially formed to facilitate video and music sharing respectively. However, the started adopted social networking services. (Backstrom et al, 2006)

C. Facebook

This social networking service was introduced with the purpose of linking friends in Harvard University in 2004. Thereafter, the company expanded to other universities then colleges. Eventually, they invited corporate communities. But this does not mean that profiles would be interchanged at will. There are lots of restrictions between friends who join the universities social network because they have to have the .edu address. Additionally, those joining corporate network must also have the .com attachment. This company prides itself in their ability to maintain privacy and niche communities and have been instrumental in learning institutions. (Charnigo & Barnett-Ellis, 2007)

D. Downlink

This website was founded in 2004 for the lesbian, gay, bisexual, and transgender community. Some features include social networking, weblogs, internal emails, a bulletin board, DowneLife and in the future, a chat.

E. Ryze

The first of the online social networking sites, Adrian Scotts founded Rzye as a business-oriented online community in 2001. Business people can expand their business networks by meeting new people and join business groups, called Networks, through industries, interests, and geographic areas.

F. SixDegrees

Six Degrees was launched in 1997 and was the first modern social network. It allowed users to create a profile and to become friends with other users. While the site is no longer functional, at one time it was actually quite popular and had around a million of members.

G. Hi5

Hi5 is established in 2003 and currently boasting more than 60 million active members according to their own claims. Users can set their profiles to be seen only by their network members. While Hi5 is not particularly popular in the U.S., it has a large user base in parts of Asia, Latin America and Central Africa.

H. LinkedIn

LinkedIn was founded in 2003 and was one of the first mainstream social networks devoted to business. Originally, LinkedIn allowed users to post a profile and to interact through private messaging.

I. Orkut

Launched in January 2004, is Goggle's social network, and while it's not particularly popular in the U.S., it's very popular in Brazil and India, with more than 65 million users. Orkut lets users share media, status updates, and communicate through IM.

J. Flickr

Flickr has become a social network in its own right in recent years. They claim to host more than 3.6 billion images as of June 2009. Flickr also has groups, photo pools, and allows users to create profiles, add friends, and organize images and video.

K. YouTube

YouTube was the first major video hosting and sharing site, launched in 2005. YouTube now allows users to upload HD videos and recently launched a service to provide TV shows and movies under license from their copyright holders.

L. Reddit

Reddit is another social news site founded in 2005. Reddit operates in a similar fashion to other.

M. Twitter

Twitter was founded in 2006 and gained a lot of popularity during the 2007. Status updates have become the new norm in social networking.

N. FriendFeed

Friend Feed launched in 2007 and was recently purchased by Facebook, allow you to integrate most of your online activities in one place. It's also a social network in its own right, with the ability to create friends lists, post and updates.

O. BharatStudent

Bharatstudent is a social utility that brings together all the young Indians living across the globe. It is for every Young Indian who is a student or a non-student, fresh graduate, a working professional or an Entrepreneur, and is focused on providing comprehensive solutions for any personal and professional issues.

P. Fropper

Fropper is ALL about meeting people, making new friends & having fun with photos, videos, games & blogs! Come, become a part of the 4 Million strong Fropper communities.

VII. GROWTH OF SOCIAL NETWORKING WEBSITES.

Now day's Social networking popularity is increasing rapidly around the world. Social networking behemoth MySpace.com attracted more than 114 million global visitors age 15 and older in June 2007, representing a 72-percent increase versus year ago. Facebook.com experienced even stronger growth during that same time frame, jumping 270 percent to 52.2 million visitors. Bebo.com (up 172 percent to 18.2 million visitors) and Tagged.com (up 774 percent to 13.2 million visitors) also increased by orders of magnitude. (ComScore)

A. Worldwide Growth of Selected social Networking Sites between June 2006 and June 2007

During the past year, social networking has really taken off globally, Literally hundreds of millions of people around the world are visiting social networking sites each month and many are doing so on a daily basis(Bob Ivins) see table I.

TABLE I. ANALYSIS OF SOCIAL NETWORKING SITES

Social Networking sites Worldwide	Growth of Social Networking Sites		
	June-2006	June-2007	Percent Change
MySpace	66,401	114,147	72
FaceBook	14,083	52,167	270
Hi5	18,098	28,174	56
Friendster	14,917	24,675	65
Orkut	13,588	24,120	78
Bebo	6,694	18,200	172
Tagged	1,506	13,167	774

B. Worldwide Growth of Selected social Networking Sites between June 2007 and June 2008

During the past year, many of the top social networking sites have demonstrated rapid growth in their global user bases. Facebook.com, which took over the global lead among social networking sites in April 2008, has made a concerted effort to become more culturally relevant in markets outside the U.S. Its introduction of natural language interfaces in several markets has helped propel the site to 153 percent growth during the past year. Meanwhile, the emphasis Hi5.com has put on its full-scale localization strategy has helped the site double its visitor base to more than 56 million. Other social networking sites, including Friendster.com (up 50 percent), Orkut (up 41 percent), and Bebo.com (up 32 percent) have demonstrated particularly strong growth on a global basis. See table II.

TABLE II. ANALYSIS OF SOCIAL NETWORKING SITES

Social Networking sites Worldwide	Growth of Social Networking Sites		
	June-2007	June-2008	Percent Change
Asia Pacific	162,738	200,555	23
Europe	122,527	165,256	35
North America	120,848	131,255	9
Latin America	40,098	53,248	33
Middle East – Africa	18,226	30,197	66

C. Worldwide Growth of Selected social Networking Sites between July 2009 and July 2010

Social Networking sites in India, that Facebook.com grabbed the number one ranking in the category for the first time in July with 20.9 million visitors, up 179 percent versus year ago. The social networking phenomenon continues to gain steam worldwide, and India represents one of the fastest growing markets at the moment, "Though Facebook has tripled its audience in the past year to pace the growth for the category, several other social networking sites have posted their own sizeable gains." (Will Hodgman)See table III.

More than 33 million Internet users age 15 and older in India visited social networking sites in July, representing 84 percent of the total Internet audience. India now ranks as the seventh largest market worldwide for social networking, after the U.S., China, Germany, Russian Federation, Brazil and the U.K. The total Indian social networking audience grew 43 percent in the past year, more than tripling the rate of growth of the total Internet audience in India.

TABLE III. ANALYSIS OF SOCIAL NETWORKING SITES

Social Networking sites Worldwide	Growth of Social Networking Sites		
	July-2009	July-2010	Percent Change
United States	131,088	174,429	33
China	N/A	97,151	N/A
Germany	25,743	37938	47
Russian Federation	20,245	35,306	74
Brazil	23,966	35,221	47
United Kingdom	30,587	35,153	15
India	23,255	33,158	43
France	25,121	32,744	30
Japan	23,691	31,957	35
South Korea	15,910	24,962	57

VIII. CONCLUSION

Social networking websites is also one of the social media tools which can be used as a tool in education industry to generate on line traffic and a pipe line for new entrants. The use of these websites is growing rapidly, while others traditional online is on the decrease. Social network user numbers are staggering, vastly increasing the exposure potential to education industry through advertising industry.

Social network offers people great convenience for social networking. It allows people to keep in touch with friends, and with old friends, meet new people, and even conduct business meeting online. You can find people with similar interests as you and get to know them better, even if they are in a different country. Every day people are joining the Social Network. And the growth and uses of social networking are increasing, all over the World.

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Multilevel Security Protocol using RFID

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Abstract—Though RFID provides automatic object identification, yet it is vulnerable to various security threats that put consumer and organization privacy at stake. In this work, we have considered some existing security protocols of RFID system and analyzed the possible security threats at each level. We have modified those parts of protocol that have security loopholes and thus finally proposed a modified four-level security model that has the potential to provide fortification against security threats.

Keywords- RFID, Eavesdropping, Slotted ID, Spoofing, Tracking.

I. INTRODUCTION

Radio Frequency Identification is a generic term for identifying living beings or objects using Radio Frequency. The benefit of RFID technology is that, it scans and identifies objects accurately and efficiently without visual or physical contact with the object [1], [3].

A typical RFID system consists of:

An RFID tag

A tag reader

A host system with a back-end database[2]

Each object contains a tag that carries a unique ID [3]. The tags are tamper resistant and can be read even in visually and environmentally challenging conditions [3] such as snow, ice, fog, inside containers and vehicles etc [2]. It can be used in animal tracking, toxic and medical waste management, postal tracking, airline baggage management, anti-counterfeiting in the drug industry, access control etc. It can directly benefit the customer by reducing waiting time and checkout lines [3] due to its very fast response time. Hence, it should be adopted pervasively.

For low cost RFID implementation, inexpensive passive tags that do not contain a battery [5] and can get activated only by drawing power from the transmission of the reader [4] through inductive coupling are used. Tags don't contain any microprocessor [6], but incorporate ROM (to store security data, unique ID, OS instructions) and a RAM (to store data during reader interrogation and response) [2], [6],

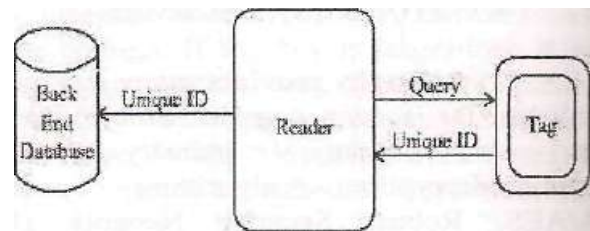


Fig. 1

In the simplest case, on reader interrogation the tag sends back its secret ID (Fig-1). The universally unique ID makes the tag vulnerable towards tracking as it moves from one place to another. It violates "location privacy". Unprotected tags could be monitored and tracked by business rivals. An ID known to an illegal reader could be used to produce fake tags that would successfully pass through security checks in future.

Hence, the security of RFID tags and the stored ID is of extreme importance and sensing : probable security loopholes we have proposed a :k monitoring protocol that would reduce the security threats due to eavesdropping and tracking.

II. SECURITY THREATS

A. Eavesdropping Scenario:

Eavesdropping normally occurs when the attacker intercepts the communication between an RFID token and authorized reader. The attacker does not need to power or communicate with the token, so it has the ability to execute the attack from a greater distance than is possible for skimming. It is, however, limited in terms of location and time window, since it has to be in the vicinity of an authorized reader when transaction that it is interested in, is conducted. The attacker needs to capture the transmitted signals using suitable RF equipment before recovering and storing data of interest [4], [8].

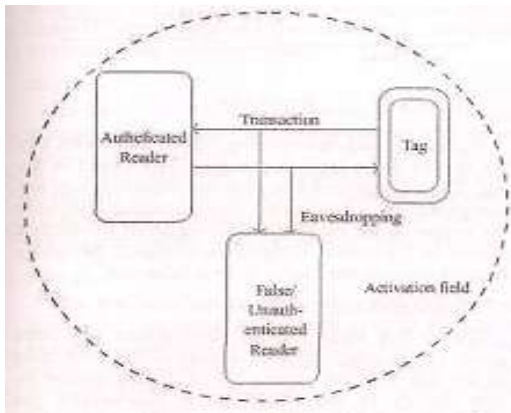


Fig. 2

B. Forward privacy:

Forward privacy ensures that messages transmitted today will be secure in the future even after compromising the tag. Privacy also includes the fact that a tag must not reveal any information about the kind of item it is attached to [9], [10].

C. Spoofing:

It is possible to fool an RFID reader into believing it is receiving data from an RFID tag or data. This is called "SPOOFING". In spoofing someone with a suitably programmed portable reader covertly reads and records a false transmission from a tag that could contain the tag's ID. When this data transmission is retransmitted, it appears to be a valid tag. Thus, the reader system cannot determine that data transmission is not authenticated [11], [12].

D. Tracking:

A primary security concern is the illicit tracking of RFID tags. Tags which are world-readable, pose a risk to both personal location privacy and corporate security. Since tag can be read from inside wallets, suitcases etc. even in places where it's not expected to items to move often it can be a smart idea to find ways to track the item. Current RFID deployments can be used to track people the tag they carry. To solve this problem, we cannot use a fixed identifier [7], [12].

III. RELATED WORK

To resolve the security concerns raised in the previous section many protocols have been proposed in various research papers.

In the work [4], the authors proposed a 'Hash lock Scheme'. In this scheme, the tag carries a key and a meta ID that is

nothing but the hashed key. Upon request from a reader, the tag sends its stored meta ID back to the reader. Reader then forwards this meta ID to the back end database where the key of the tag has been found by looking up the database using meta ID as the search key. The reader forwards the key found from the database to the tag which hashes this key value and matches the calculated hashed value with the stored meta ID. On a successful match the tag is unlocked for further information fetch.

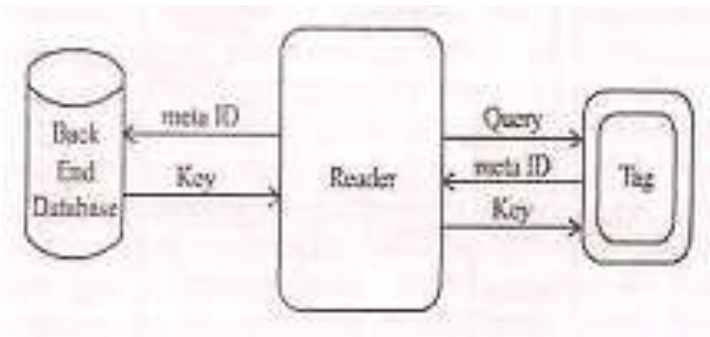


Fig. 3

The drawback of this protocol is that the meta ID is still unique. A tag can still be tracked using this meta ID despite of knowing the original ID. So, "location privacy" is still under threat. Again, while transmission of the key from back end database through reader, it can easily be captured by an eavesdropper though the connection between the reader and tag has been an authenticated one. Hence, eavesdropping is still a major problem. From this, it is inferred that no unique and 'static' value can ever be sent back to the reader.

To overcome this problem, a new protocol has been predicted [4] in which tag responses change with every query. To realize this, the tag sends a pair $\langle r, h(ID, r) \rangle$ where r is a random number upon request. The database searches exhaustively through its list of known IDs until it finds the one that matches $h(ID, r)$, for the given r . Though this technique resolves the tracking problem yet increases the overhead of the database and the search complexity increases with r . This is handled by the protocol discussed by us in the next section.

Our tag contains a unique meta ID. As we cannot send the unique meta ID, we are generating a random number in the tag. This random number is fed to a down counter. The down counter counts down to zero and sends a clock pulse to a sequence generator. The sequence generator sends a pair $\langle r, q \rangle$ where r is the random number and q is the new state generated by the sequence generator. At the reader end a reverse sequence generator is implemented through which the state equal to the original meta ID has been found.

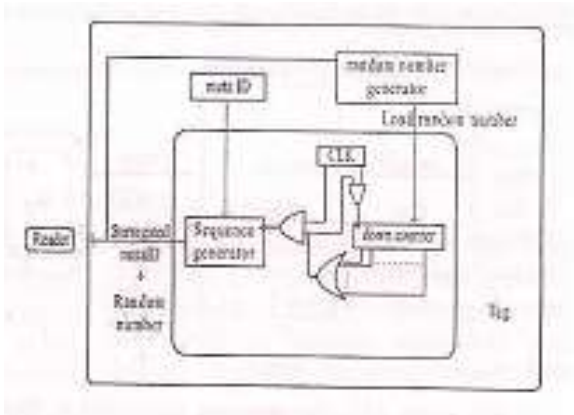


Fig.4

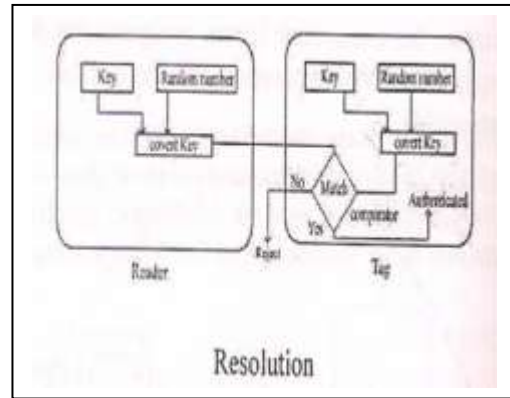


Fig. 6 Example of an Image with Acceptable

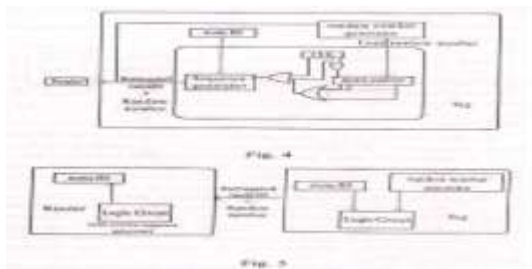


Fig. 5

A. Reader Identification:

Since the reader plays an important role in RFID system, the tag must identify its authenticated reader. An authenticated reader has the capability to modify, change, insert or delete the tag's data. As an extension to the previous section, after generating the original meta ID the system looks into the back-end database and retrieves the corresponding key. Now, before sending the key to the tag, the logic circuit effaces some of the bits from the key and sends the modified key to the tag. Which bits are to be deleted is determined by the random number r . generator with each down count, on receiving of which the sequence generator each time generates a new state starting from the state equivalent to the meta ID. When the down counter becomes zero, the state of sequence generator is recorded.

IV. SECURITY PROPOSALS

A. Mitigating Eavesdropping:

In the first part of our work, we came up with a novel idea to alleviate eavesdropping introducing meta ID concept in a new

At the tag end, the missing bits of the covert key are copied down from the original key stored in the tag. Then the stored key and the modified key are compared. On a successful match, the tag considers the reader to be valid and unlocks itself for further access of the reader. Otherwise, it rejects the query request sensing the reader to be a false one.

B. Slotted ID Read:

Up to this stage only a valid reader has been given the privilege to gain access of the next level of the tag. Still the unique ID of the tag cannot be sent openly to the reader as it can readily get skimmed and tracked by an eavesdropper. To deal with it, the ID is divided into a number of slots of varying length. Some additional bits are added at the beginning of each slot that holds the length of the ID belonging to that slot. Then the entire data packet is encrypted. As only the authenticated, reader knows the number of bits used to specify the length of that slot, it provides an extra security to this approach. The transmission of data packets in several slots is continued until the end of the ID.

Length of Data	Data + Padding Bits
----------------	---------------------

Fig. 7. Typical packet

C. Tag Identification:

At the reader end after receiving the each packet, it first decrypts the data and then eliminates the bits used to specify the length of that slot recovers a part of the original ID. This method continued for each packet and then the decry IDs are combined together to reform the entire unique ID. Thus, the unique ID is transmitted to the authenticated reader and at the same time it also stymied the false readers from reading it.

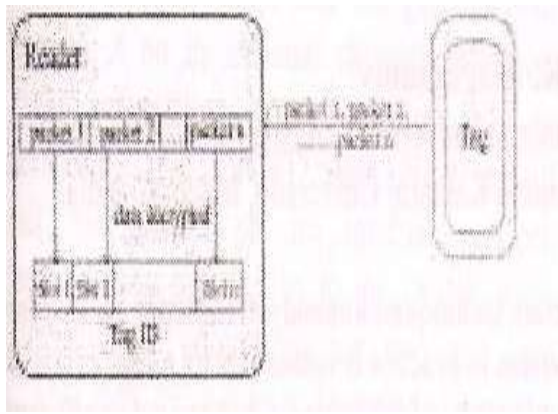


Fig. 8 Example of an Image with acceptable resolution

V. SECURITY ANALYSIS

In our protocol, we have provided a four step security to the ID that prevents the tag from getting cloned and reduces the risk of spoofing, eavesdropping by many folds.

- As the $\langle r, q \rangle$ pair sent to the reader from the tag changes every time, an eavesdropper can never track a tag through its meta ID. In work [4] though this was achieved, it increased the database overhead and complexity of brute-force search algorithm. In our method, the same goal was met but the problem of work [4] has also been resolved.
- The key retrieved from the back-end database of the reader has not directly been sent to the tag as any false reader can catch this key on its way to the tag and can prove itself to be a valid reader at any moment. Hence, the key has been modified with special method and as the same key is modified in a different manner each time, it doesn't allow a false reader or an eavesdropper to discover the key.
- The received and modified key is reconstructed and matched with the key stored in the tag to authenticate a reader. This feature bars all readers apart from the valid one to gain further access of the tag contents.
- The entire ID has been slotted and each slot is different length. The first few bits of each slot represent the number of bits of ID belonging to that slot. Then the data of the entire slot is being encrypted and sent to the reader. The ID is sent in several steps and the unique ID has never been sent in its original form. This is the entire method allows only an authenticated reader to find the original ID.

Thus, we have beefed up the security of the ID through our protocol and provided secure tag-to-reader transactions.

The proposed protocol can be mixed up with other research works to make it more beneficial for practical life implementation towards the goal of manufacturing low cost RFID. With the passage of time and generation new ideas along with new technology will sprung up, which will definitely make this RFID technology, a more preferable and

cost effective. As the radiation from RFID is not good for human exposure, RFID radiation is inadvertently causing damage to human cells, tissues on its exposure. So there is a wide space in this field also to minimize its effect on human beings. Hence there is a plethora of fields in which we can work on.

VI. CONCLUSION

As our work revolves around security only, we have provided a 3-way security level in our proposal. With our limited resources we had tried our best to give tag-reader identification a higher priority since both have their own importance in security analysis measurement. By combining the random variable concept for tag-reader identification we have provided an additional security. The most important characteristic of our protocol is that at no point of time we are leaving our IDs/keys in their original form. Even if a false reader reads any information, it's of no use for that reader. That said, our proposed security definitions are just a starting point. They certainly do not capture the full spectrum of real-world needs. We had proposed important areas for further work.

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