Vol. 8, No. 1-4 January - December, 2013

ISSN : 0976 - 7312

SOCH - MASTNATH JOURNAL OF SCIENCE & TECHNOLOGY

(RNI No. HARENG / 2006 / 22052)

PEER-REVIEWED

Journal Issue on : 10th December, 2010

Estd. 1997

Shri Baba Mastnath Engineering College

(Recognised by : A.I.C.T.E. Govt. of India, Affiliated to M.D. University, Rohtak)

ASTHAL BOHAR, ROHTAK-124021

SOCH - MASTNATH JOURNAL OF SCIENCE & TECHNOLOGY

A Quarterly Journal of Shri Baba Mastnath Engineering College
Asthal Bohar, Rohtak - 124001

Published by : **SHRI BABA MASTNATH AYURVEDIC & SANSKRIT SIKSHAN SANSTHAN,** Asthal Bohar, Rohtak
Published from : **SHRI BABA MASTNATH ENGINEERING COLLEGE,** Asthal Bohar, Rohtak

CONTENTS

RECENT PALLADIUM BASED NANO CATALYSTS FOR USE IN SUZUKI REACTION

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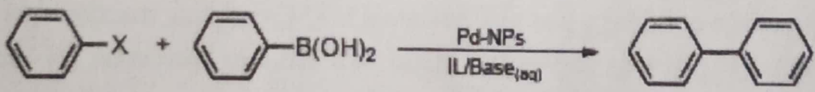
ABSTRACT

In our modern chemical sciences chemical synthesis makes heavy use of different types of catalytic system & one of them is nano- sized catalyst that give rise to several prospectus and opportunities for new technologies. In this paper we have reviewed the latest researches in the field of Palladium based nanoparticles which have proved efficient in the industrially important Suzuki Reaction for the synthesis of biaryls.

Keywords: palladium; nanoparticles; ionic liquids; cross-coupling; Suzuki;

The Suzuki reaction is an important coupling process for C-C bond formation. Palladium-based cross coupling reactions have been among the most investigated transition metal catalysed C-C coupling reactions.This reaction is an efficient method for preparing unsymmetrical biaryls from an aryl halide and boronic acid with tolerance towards a wide range of substituents.Recently it was reported that Pd-NPs in tetraalkylammonium-based ILs, prepared from the reduction of Pd(OAc)2 in the presence of TBAA at 90 °C, were used as precatalyst for the Suzuki reaction of aryl halides (Table 1) .[1]

Table 1. Suzuki cross-coupling reactions catalysed by Pd-NPs in ILs [1].a



Sr.No	X	IL	Base(aq)	T (°C)	t (h)	Conv(%)	Yield
1	Br	TBAB	Na_2CO_3	110	0.5	>99	95
2	Br	TBAB	Na_2CO_3	60	16	<1	—
3	Cl	TBAB	Na_2CO_3	140	16	15	—
4	Cl	TBAB	KOH	90	16	36	20
5	Cl	TBAB	NBu_4OH	90	3	93	86
6	Cl	THeptAB	NBu_4OH	90	3	98	92
7	Cl	TBAB	NBu_4OH	70	4.5	57	45
8	Cl	THeptAB	NBu_4OH	70	4.5	89	83
9	Cl	THeptAB	NBu_4OH	60	16	<1	—
10	Br	THeptAB	NBu_4OH	60	1.5	>99	93

a Reaction conditions: IL = 6 mmol, phenylboronic acid = 1.1 mmol, aryl halide = 1 mmol, base = 2 mmol in 1.5 mL of H2O, Pd-NPs = 2.5 mol % Pd(OAc)2 + 12.5 mol % TBAA, THeptAB = Tetraheptylammonium bromide.

It was reported that using tetrabutylammonium hydroxide as base increased the catalytic efficiency significantly, and the reaction could be performed under mild conditions. This could be explained by the higher concentration of tetraalkylammonium cations into water, contributing through partitioning equilibrium, to keeping constant the concentration of the cations in the IL phase. The result is that the metal NPs are effectively stabilized against aggregation.

It was also observed that when a hydrophobic IL (THeptAB) containing longer side chains than TBAB is employed, better results were observed during Suzuki coupling reactions, probably due to the stronger stabilization of the Pd-NPs provided by the IL. Further Pd-NPs were identified as the reservoir for the true catalysts in Suzuki reactions using Pd(OAc)2 as catalyst precursor in BMI·PF6 in the presence of functionalized ligands derived from norborn-5-ene-2,3-dicarboxylic anhydride [2]. In organic solvents the homogeneous catalyst is stabilised enough by the donor ligands, but in ILs the system is active only due to the in Situ NPs formation. So, the occurrence of metal Pd-NPs is considerably required in order to obtain an active system in ILs as reaction medium. Another paper reported that Pd-NPs are prepared by the reduction of Pd(COD)Cl2 (COD = 1,5-cyclooctadiene) with molecular hydrogen in BMI·PF6 at room temperature serve as an interesting catalystphase for Suzuki cross-coupling reactions [3]. In fact, these metal NPs exhibited star-like shaped inter-particle organisation.[1]

The researchers reported that the preformed Pd-NPs in BMI·PF6 are able to successfully catalyse the coupling of bromobenzene and phenylboronic acid at 100 °C with total conversion within 1 h reaction-time. It was found that the palladium precursor Pd(COD)Cl2 and the isolated palladium powder as heterogeneous catalyst were not active in the reaction. These result suggest that, only metal NPs stabilized in the IL serve as precatalyst for the Suzuki process. Hence, it is clear that the presence of IL is essential to the occurrence of reaction due to the stabilisation and organisation of the metal NPs. Also, this organisation is fundamental to the catalytic activity.[1]

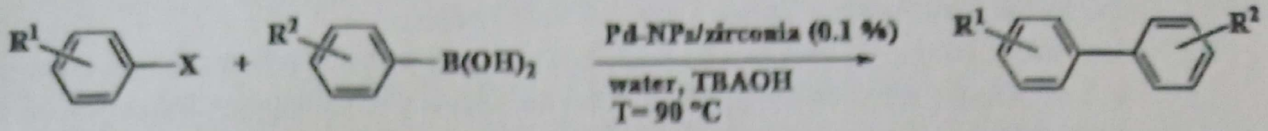
Further research showed that supported Pd-NPs were also successfully employed in Suzuki cross-coupling reactions. These were related to the efficient immobilization of these nanocatalysts in classical supports such as: polymers, [4-7] dendrimers, [8, 9] carbon nanotubes, [10] and inorganic materials [11].

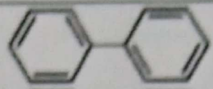
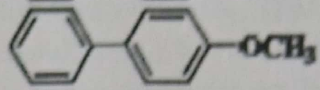
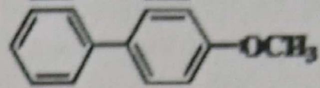
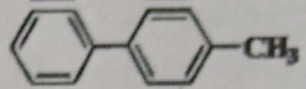
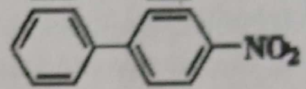
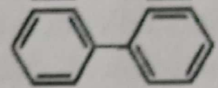
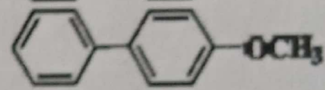
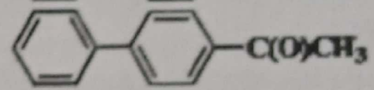
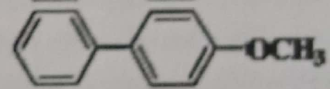
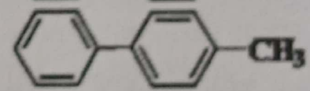
The presence of Pd-NPs was also observed in C-C coupling reactions performed only in classical organic solvents [12]. It was shown that these NPs serve as reservoirs for the real active Pd species leached from the NPs surface [13,14].

Recently, the Suzuki cross-coupling reactions with Pd-NPs/ Zirconia(0.1%) supported catalyst have been carried out in water using aryl bromides and iodides as substrates and phenyl boronic acids as nucleophiles.[15]. The aqueous medium was formed to have a positive effect on the reaction rate probably due to its ability to dissolve boron side products coating the catalyst surface.

Similarly the diblock copolymer of polystyrene- poly (ethylene oxide)(PS-PEO) has been successfully used in this reaction.[16]. In fact the amphiphilic diblock copolymer of polystyrene-poly(ethylene oxide) (PS-PEO) was dissolved in water with addition of surfactant - a cetylpyridinium chloride (CPC), its hydrocarbon chains penetrated the hydrophobic core of a micelle formed by the is polymer, with the charged groups left on the interface, giving to it a positive charge. K2PdCl4 is added which leads to adsorption of anions of PdCl42- on the interface of the core of a micelle. The palladium (II) gets reduced by KBH4, forming nanoparticles adsorbed on the interface of the core of a micelle.

Table 2. Suzuki reaction catalyzed by Pd-NPs/ZrO2 in water. [a]



Cycle	X	R^1	R^2	Product	Yield (%)
1	I	H	H		90
2	I	H	OCH_3		88
3	I	OCH_3	H		75
4	I	CH_3	H		84
5	I	NO_2	H		78
6	Br	H	H		75
7	Br	H	OCH_3		88
8	Br	$C(O)CH_3$	H		90
9	Br	OCH_3	H		40
10	Br	H	CH_3		79

[a] Reaction conditions: aryl halide (0.5 mmol), boronic acid (0.65 mmol), TBAOH (1 mmol) and Pd-NPs/ZrO2 (Pd 0.1 mol %) in 1 mL of water were stirred under air at 90 °C for 14 hours .

The authors reported that in the cross-coupling reactions the palladium supported material could be recycled up to ten times without any appreciable loss of activity. In general an average yield of 83% was found for a number of aryl bromides.

Lately, monodisperse noble metal nanoparticle stabilized in SBA-15 has been used in Suzuki reaction.[17]

CONCLUSION: We have reviewed the latest researches related to Suzuki reaction using Palladium based nanocatalysts which have proved to be of efficient compared to homogeneous and heterogeneous catalysis. Further, research is required to evolve more palladium based nanocatalysts to improve the product yields even further.

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"ORGANIZATIONAL IMPACTS OF ERP SYSTEMS IN MANUFACTURING SYSTEM"

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ABSTRACT

Successful organizations in India are continuously modifying their methods in serving their clients which also increases their profit margin. To achieve this positive result, organizations have to intelligently integrate ERP system in their business management process. The modern ERP systems are fully integrated with e-commerce supply chain solutions like e-procurement, manufacturing, distribution, shipping, supplier and buyer-oriented marketplaces and exchanges etc. ERP helps organizations improve their entire logistics operation and add value to the business. ERP provides logistics operations management functions that ensure operations run smoothly, fulfill all quality demands. These functions help to reduce downtime, increase customer loyalty while improving product quality, enable better decision making, cost, and time to market. Many of the organization consider ERP system as their most important and strategic platform because it provides a solid foundation and information backbone for eBusiness. A fully integrated web-based ERP will capture and create accurate, consistent and timely relevant data, and assist in intelligent business decision-making. It also results in improved customer responsiveness, reduced IT costs and the availability for value-added activities. As the ERP system consists of a revolution that involves every internal process, it must be preceded by a hard reevaluation of every department together with their functions, and the way they make decisions. ERP is an important and decisive tool, but in order to obtain the desired results it is also important who will be commanding it as well as the way in which the data will be saved and how information will flow. This paper conducts an extensive literature review to identify the latest trends in manufacturing systems. It also attempts to study some of the issues associated with manufacturing process along with their solutions and practices.

Keywords: ERP, Reengineering, Information technology, Internet, E-Commerce, SCM and Manufacturing system.

INTRODUCTION

Globalization, rapid technological change, and rising customer expectations, combined with growing pressure from stakeholders, are changing the paradigm of world commerce. A few years ago, the top manufacturing priorities of companies were eliminating direct labor through automation and the integration of manufacturing systems in order to have a competitive advantage. Today, on the contrary, technology is affordable and skilled workers are in short supply. More accessible information through the Internet now allows small niche players and companies in emerging markets to bypass expensive information infra-structures and to function globally. In this environment of global competition, early partnering with customers and suppliers in the products development process is very important. To make this approach work, manufacturers depend heavily on information systems such as enterprise resource planning system.

Enterprise Resource Planning (ERP) systems have been adopted by many businesses in the past decade. These systems have revolutionized the organizational ways of doing business by integrating the business processes, sharing common data and practices across the entire enterprise, producing and accessing information in a real-time environment. Enterprise resource planning (ERP) system is a business management system that comprises integrated sets of comprehensive software, which can be used, when successfully implemented, to manage and integrate all the business functions within an organization. These sets usually include a set of mature business applications and tools for financial and cost accounting, sales and distribution, materials management, human resource, production planning and computer integrated manufacturing, supply chain, and customer information (Boykin, 2001 and Chen, 2001). These packages have the ability to facilitate the flow of information between all the internal as well external supply chain processes in an organization (Al-Mashari and Zairi, 2000). Furthermore, an ERP system can be used as a tool to help improve the performance level of a supply chain network by helping to reduce cycle times (Gardiner et al., 2002). However, it has traditionally been applied in capital-intensive industries such as manufacturing, construction, aerospace and defense. Recently, ERP systems have been expanded beyond manufacturing and introduced to the finance, health care, hotel chains, education, insurance, retail and telecommunications sectors.

ERP systems offer the necessary resources for the implementation of a common database for everyone's use in a real-time environment. This database can be updated as changes occur, thus providing up-to-date status information to everyone in their part of business. Therefore, users can use data from today's events to make accurate decisions about tomorrow's activities. Globally, ERP can work in worldwide markets with multiple languages and currencies. It can tell users about how many parts are at a warehouse in one particular country and the parts' value in the respective currency. Accounting practices, government tax requirements, human resource management practices, and even manufacturing practices that are local to different regions around the globe are incorporated into the ERP system. This gathering and usage of information for complicated demand, inventory and other types of planning gives staff the ability to quickly act, and the organization the ability to greatly optimize performance.

The main idea of ERP system and how companies have seen its benefits have misled their implementation, seeing at ERP system as a magic way to become competitive, and not as a tool that depends on the way the company uses it. The tool can help companies to become competitive, or it can also take them out of business. A loss of control can occur for many reasons when an ERP system is implemented, inadequate project definition, planning and implementation is one of the most significant causes for this loss of control. Consequently, understanding of the concept of enterprise resource planning system is a vital issue to analyze the effects of ERP system implementation and benefit realization in business organizations. This study offers an overview of the concept and evolutionary phases of Enterprise resource planning (ERP) system, organizational use of ERP applications, quality management practices, client satisfaction, critical success/change factors, benefits, as well as major challenges towards the successful implementation of ERP.

Enterprise resource planning is a term derived from material resource planning and is an information system that integrates and automates all departments within a company; finance (cost management, accounts receivable/ payable, general ledger), human resource (payroll, personnel management), manufacturing (sales order entry, invoicing, and capacity planning), logistics, etc., to help enable enterprise-wide management of resources. Enterprise resource planning systems are cross-functional and span the entire enterprise wide. All functional departments that are involved in operations or production have their functions integrated in one system. In addition to manufacturing, warehousing, and shipping, this integration also includes accounting, human resources, marketing, and strategic management. ERP includes the management of every operation in a value chain to minimize cost and time. This is usually referred to, in the industry, as supply chain management (SCM), or more recently, global SCM.

ERP is a standard software package that provides integrated transaction processing and access to information that spans multiple organizational units and multiple business functions. These functions include financial and accounting, human resources, supply chain, and customer services (Van Everdingen et al., 2000). At the heart of the ERP system is a single central database. This database collects data from, and feeds data into, modular applications supporting virtually all of a company's business activities - across functions, across business units and across the world. When new information is entered in one place, related information is then automatically updated (Davenport, 1998).

Most companies expect ERP to reduce their operating costs, increase process efficiency, improve customer responsiveness and provide integrated decision information. They also want to standardize processes and learn the best practices embedded in ERP systems to ensure quality and predictability in their global business interests by reducing cycle times from order to delivery (Ross, 1999). Hence, ERP implementation and business process reengineering (BPR) activities usually are closely connected.

MRP TO ERP - THE EVOLUTION

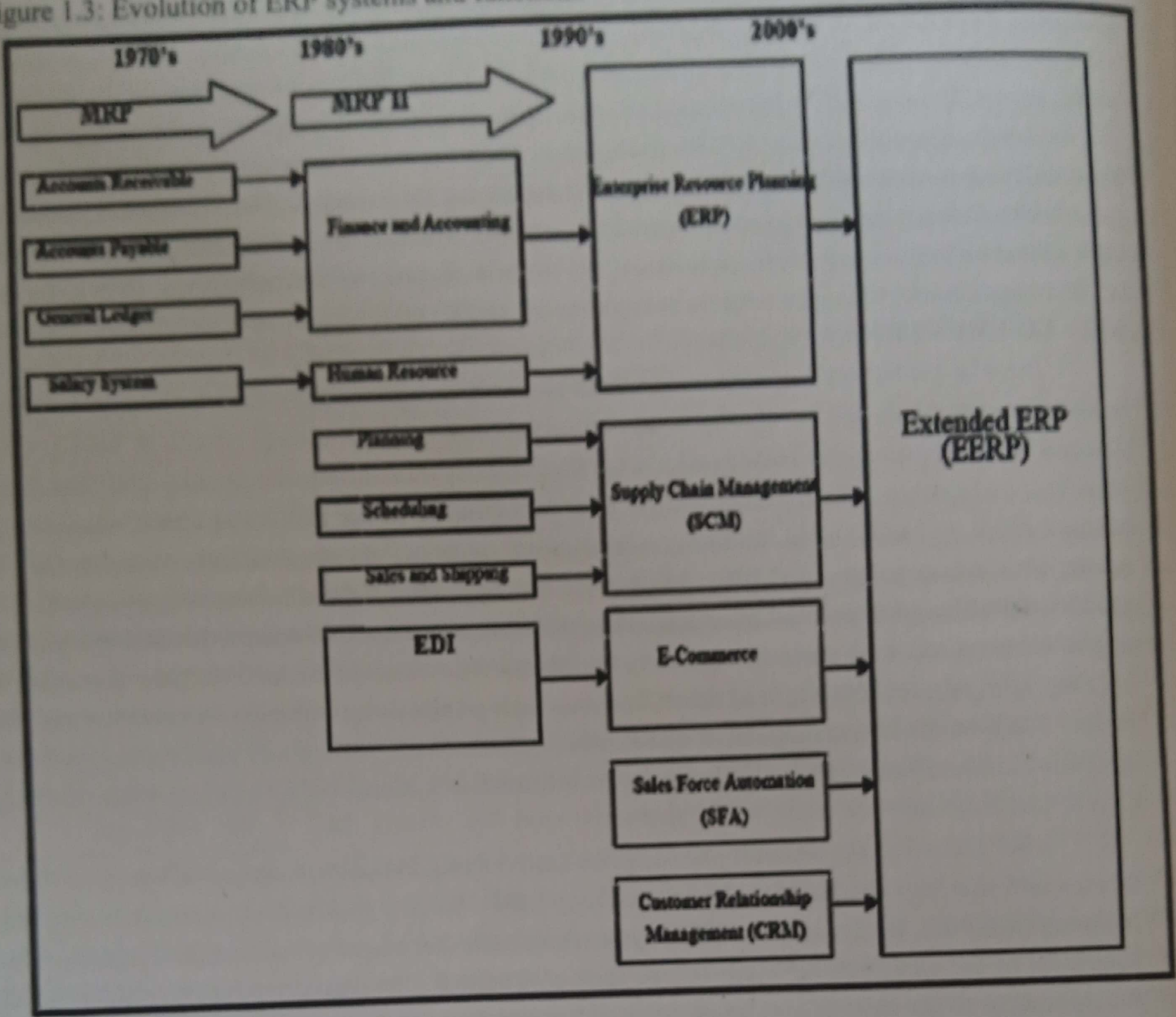
Prior to 1960, no company could afford to own a computer. Therefore, both manufacturing and inventories were handled on the basis that companies must hold enough stocks to satisfy customer demand, and that customers would order what they had ordered in the past, quantity-and time-wise. The main focus of systems was mainly towards inventory control. In the 1970s and 1980s, when computers became small and affordable, attention was focused on materials requirements planning (MRP) and master production schedule (MPS). MRP were the first off-the-shelf business application (Orlicky, 1975). MRP software supported the creation and maintenance of material master data and bill-of-materials across all products and parts in one or more plants. The concept of MRP helped managers in the manufacturing firms reduce to lead times, boost up their productivity and improve customer satisfaction. Before that systems like management information systems (MIS); integrated information systems (IIS); executive information systems (EIS); corporate information systems (CIS); and enterprise wide systems (EWS) had evolved.

MRP started as a system for planning raw material requirements in a manufacturing environment; an idea that was later extended to the "closed loop MRP." Soon it evolved into manufacturing resource planning (MRP-II), which used the MRP system as a basis and added scheduling and capacity planning activities. In the early 1990s, MRP-II was further extended into enterprise resource planning (ERP), incorporating all the MRPII functionality, in addition to Finance, Supply Chain, Human Resources and Project Management functionality.

Before the evolution of ERP, manufacturing sector was running on manufacturing resource planning system. The manufacturing resource planning included all the sources in relation to the manufacturing such as material, human resource, equipment and finances. When the competitive strategy changed from low price and great variety to speed, ERP found the right place to give profit to this new strategy. Contrary to the other applications, the ERP system connects to all the offices of a group of business throughout the entire world. ERP system allows the organizations to design products with the entrance of engineers all over the globe, installing factories in various areas to produce pieces and components for many countries, and the information of all the parties involved.

ERP system is an outcome of 40 years of trial and error. It has evolved as a strategic tool because of the continuous improvement in the available techniques to manage business and the fast growth of information technology. The term ERP made the press probably for the first time in 1992 (Lopes, 1992; Lindholm, 1992). Lopes (1992) describe how ERP had been conceived of at the time the term was coined. Moreover, Lopes praises ERP systems as "better, faster and more economical business solution". ERP is a software business management system, which integrates all business functions, including planning, manufacturing, sales and marketing. More than three years later, Thomas Davenport introduced the IS community to ERP systems at AMCIS '96 (Davenport, 1996). Figure 1.3 illustrates the gradual evolution of the ERP with respect to time.

Figure 1.3: Evolution of ERP systems and functions



Manufacturing enterprises involved in manufacturing, sales and distribution activities have been using computers for 30 years to improve productivity, manufacturing resource planning (MRP). In the 1970s, the production-oriented information systems were known by the name MRP. MRP at its core is a time phased order release system that schedules and releases manufacturing work orders and purchase orders, so that sub-assemblies and components arrive at the assembly station just as they are required. Some of the benefits of MRP are reduction of inventories, improved customer service, enhanced efficiency and effectiveness (Siriginidi, 2000). In the early 1980s, MRP expanded from a material planning and control system to a company-wide system capable of planning virtually all the firm's resources. This expanded approach was MRPII. A major purpose of MRPII is to integrate primary functions (i.e. production, marketing and finance) and other functions such as personnel, engineering and purchasing into the planning process to improve the efficiency of the manufacturing enterprise (Chen, 2001; Chung and Snyder, 2000; Mabert et al., 2003). MRPII has certain extensions like rough cut capacity planning and capacity requirements planning for production scheduling on the shop floor as well as feedback from manufacturing shops on the progress of fabrication. Since the 1980s, the number of MRPII installations has continued to increase, as MRPII applications became available on mini and micro computers (Siriginidi, 2000).

ERP is the latest enhancement of MRP II with the added functionality of finance, distribution and human resources development, integrated to handle global business needs of an integrated and networked enterprise. The Gartner Group of Stamford, CT, USA, coined the term ERP in the early 1970s to describe the business software system that is the latest enhancement of an MRPII system (encompasses all MRPII modules). A key difference between MRPII and ERP is that while MRPII has traditionally focused on the planning and scheduling of internal resources, ERP strives to plan and schedule supplier resources as well, based on the dynamic customer demands and schedules (Chen, 2001).

The maturity stage of ERP occurred in the mid-1990s. The scope offered by ERP expanded to include other "back-office" functions such as order management, financial management, warehousing, distribution production, quality control, asset management and human resources management. The evolution of extended-ERP systems has further expanded in recent years to include more "front-office" functions, such as sales force and marketing automation, electronic commerce and supply chain management systems. The scope of ERP implementation encompasses what is often referred to as the entire value chain of the enterprise, from prospect and customer management through order fulfillment and delivery. An enterprise, to stay competitive, has to not only identify information needs but also ensure that the information infrastructure provides the right support to serve the enterprise, its customers and suppliers. If it does not do so, then it runs the risk of being disconnected and excluded from future opportunities (Siriginidi, 2000).

The technological evolution of ERP from MRP has been presented in detail by Chen (2001) and Chung and Snyder (2000). Information system technology evolved from mainframe-based computing through the client/server era to the Internet era. Earlier the ERP systems were developed only to work with huge mainframe computers. Most of the current ERP systems are based on the client/server solution model (Rao, 2000; Siriginidi, 2000). In a client/server environment, the server stores the data, maintaining their integrity and consistency and processes the requests of the user from the client desktops. The load of data processing and application logic is divided between the server and the client (Gupta, 2000). Now, ERP vendors are - as many other software vendors - forced to move from a traditional client/server to browser/Web server architecture in order to deliver e-business capabilities (Scheer and Habermann, 2000). These systems are built with a clear separation of functional components. The user interface implemented using graphical user interface (GUI) techniques is deployed on client machines. Powerful server machines host the databases and business logic written as server procedures. The databases are built using relational database technology. Relational database systems have enabled the vendors to put in the necessary flexibility in terms of business logic and data structures to support parallel business practice implementations. These technologies in general have allowed the users to architect the system in such a way that installation, customisation and extensions are possible in shorter timeframes (Rao, 2000).

With more and more companies being equipped with ERP systems, companies are looking for new applications of ERP systems, requiring ERP to keep evolving to meet the new business needs. There are several current issues around ERP development that need to be addressed. First, ERP is moving its focus from the largest companies to the mid-market, which is going to involve more than a new marketing campaign. Most ERP systems are enhancing their products to become "Internet-enabled", so that customer's world-wide can have direct access to the supplier's ERP system (Waurzyniak, 2000).

ERP FOR MANUFACTURING INDUSTRY

Enterprise Resource Planning (ERP) systems and their MRP (Material Requirements Planning) predecessors have been around for almost three decades now. Accordingly, many aging implementations, based on outdated technology, are limiting the business process evolution necessary to any company who wants to thrive and grow amidst the pressures of globalization and increasingly demanding customers. On the other hand manufacturers' demand more value from ERP implementations, not only as their systems age, but as enterprise applications grow, raising questions concerning upgrade, replacement, consolidation and rationalization. This research paper will address the current consolidation, replacement and implementation landscape of ERP, and how the best in class are achieving quantifiable business value through their ERP systems.

ERP is a watchword in the manufacturing sector and more and more companies are switching to ERP solutions. With the innumerable benefits that the manufacturing units reap from the software, usage of ERP has reportedly increased in the last few years. ERP with its features like; secured, easy and timely data availability and informed decision making have helped the manufacturing units. It also provides a seamless connectivity amongst product planning, development, sourcing of material and inventory and store management. The basic mantra behind the success of the overall manufacturing process through ERP is a balanced blend of people, technology and process.

Today's ERP implementing companies' offers powerful manufacturing software for lean, discrete, and process manufacturing businesses on a local or global scale. This ERP software is designed to give you a single view into all of your systems, including accounting, inventory management, and more. The robust functionality of ERP software delivers the control and insight you need to streamline processes, reduce costs, and increase your margins. ERP systems can also help you:

- Respond quickly to changes in customer needs, supply, and manufacturing capacities.
- Make it easy to find, use, and share information with vendors and suppliers.
- Better manage regulatory and governmental compliance.
- Enable sustainable operations that reduce energy consumption and your carbon footprint.

ERP Software for manufacturing helps organizations to manage various production processes and improve productivity. Using ERP Software, you can generate daily/weekly/monthly production plans based on your Order position, Stocking Requirements, Machine and Raw Material Availability. ERP Software for manufacturing also helps the Production Managers manage ad-hoc and Urgent production requirements which are a very common feature in many production scenarios.

NEED FOR A MANUFACTURING ERP SOFTWARE

ERP software needs to be able to evaluate how well it manages the manufacturing business functions. As manufacturers have to deal with huge piles of data in the manufacturing business the ERP software has great significance in a manufacturing concern. The software is used for a multitude of applications like dispatching the goods on time, improvement in manufacturing processes and placing an order with the suppliers of raw material on time. With the manufacturing ERP software, manufacturers can plan and schedule the entire manufacturing process in an efficient way that decreases profits and increases productivity. With needs like dispatching goods on time, improvement of manufacturing process and placing an order with the supplier of raw material on time, ERP plays a crucial role. ERP has the ability to provide finite and infinite planning capabilities which aids in developing original schedule and also enabling the supply chain to achieve production plan with sales plan.

With an ERP software and its manufacturing capabilities, businesses receive an additional capacity to create the best possible product in the most efficient and cost-effective manner. An ERP solution also helps coordinate the manufacturing process in a better manner by mobilizing resources efficiently. Packaged ERP software additionally includes tools to support improved inventory management, order management, purchasing and procurement, logistics, supply chain planning, return management, and incentive management. All of this helps businesses to effectively coordinate and control their complex supply chain workflows and activities. With ERP software, companies can better manage all supply chain operations including the sourcing, acquisition, and storage of all raw materials, the scheduling and management of all work in process, and the warehousing and distribution of all finished goods. Businesses can improve accuracy and accessibility of vital financial data.

ERP allows them to do this while streamlining and automating routine, repetitive accounting processes such as budget creation, allocation, and management; cash flow analysis; accounts payable and receivable; management of capital equipment and other assets; performance management; and financial reporting. The financial applications within most popular ERP software packages include functionality for general ledger, cash management, accounts payable and receivable, budget management, and fixed asset management.

A higher demand for customized products and services in the industrial manufacturing sector is leading to creation of more rationalized designs, greater standardization and modularity across products. Global competition and the need to protect profits are forcing manufacturers in this sector to adopt best practices along with other measures to increase quality of products and services. The purpose of ERP products for industrial manufacturers to achieve their business objectives such as containing costs, improving operating efficiencies across the value chain including manufacturing, procurement and logistics, plant maintenance, sales, distribution and aftermarket areas, and improving the time-to-market of new products.

The manufacturing sector constantly faces trouble allocating raw materials and streamlining output. An ERP solution could assist by pointing out drawbacks faced by the manufacturing process, such as the problems created by time lags and manufacturing flaws.

ERP software packages of Industrial Manufacturing services include the following:

- Streamlining business processes across the enterprise
- Streamline product design, engineering, and configuration
- Enhance the entire end-to-end process of designing and building a product
- Automate the scheduling of production activities
- Improve tracking and management of product parts
- Agile and responsive supply chain management
- Enable equipment and spares sales through efficient channel management
- Spare parts inventory optimization
- Warranty process life cycle & field service management
- Seamless production management
- Benchmark supply chain performance to industry standards
- Enterprise wide analytics for actionable information
- Accelerate manufacturing
- Improve quality assurance procedures

MANUFACTURING MODULE OF ERP

In the face of fierce competition with shorter product and service cycle times and narrower operating margins, enterprises face significant challenges to differentiate themselves from their competitors. Businesses are challenged to building and maintaining strong customer relationships is crucial for success; however, customer requirements are constantly growing, with a significant trend toward more personalized, customized products, services they desire, and improve operations throughout the supply chain, while at the same time reducing costs.

In today's era, ERP is web-based ERP software capable to connect organization's departments, branches, customers, and suppliers under a central system. ERP comprises of host of integrated functionality including, Purchase Management, Inventory & Material Management, Manufacturing, Sales and Distribution Management, Finance Resource Management, Supplier, Human Resource Management, Plant Maintenance and Excise management.

An ERP software consists of many modules with each module is integrated with the major functional area of an organization. In normal procedure, each module is designed to interact with each other with easy accessing of information concerning a particular branch, section or department. ERP modules are tightly protected with efficient security system and the staff is trained to handle the system effectively during the training session by the consultants. ERP software is designed to include modules so that it is easy to access a particular option; it is easy to train staff, easy to provide security features. Such a module based design is more intuitive to use and staff find it easy to understand.

ERP is a comprehensive enterprise resource Planning system that offers best-practice support for multi-mode manufacturers in a broad range of Industries. This is the module that maintains the data related to the manufacturing department of the organization. It provides an overview of the complete "purchase-to pay" cycle, including requisitioning and the complete "order-to-cash" cycle, including manufacturing, and aftermarket services. Also describes how to support the complete product life cycle and assets, from the definition or design phase and production ramp-up to aftermarket maintenance activities.

Data is recorded in this module when Bill of Materials, Work Orders receipts is to be created for work orders. It indicates what is being made, how and where, when it will be done, and why it won't be on time. It facilitates better resource planning in the face of rapidly changing constraints such as materials availability, market readiness, market demand, plant capacities, personnel certification and business costs per location.

ERP is designed for manufacturing excellence. With ERP, small to midsize manufacturing companies benefit from a fully integrated, on-demand ERP solution designed to reduce costs, improve customer service, improve business performance, increase margins and generate new revenue streams. Further, with Web-based ERP solution, SMB manufacturers can improve business performance with a visibility throughout the operation and embedded support for a wide variety of manufacturing processes - including make-to-stock, make-to-order, configure-to-order, just-in-time (JIT) manufacturing and materials control.

For manufacturing companies, software functionality is at the core of any ERP software selection project. While there are stand-alone manufacturing software packages available on the market, the best manufacturing solutions are tightly integrated into a centralized ERP system. The functionality of manufacturing software varies based on the industry focus and the production process utilized. Most ERP and manufacturing solutions are placed into the categories of process manufacturing software, discrete manufacturing software, or mixed-mode manufacturing software. These different manufacturing categories directly relate to the production environment and whether this environment can be classified as continuous process, contract manufacturing, job shop, batch processing, repair and maintenance, repetitive, or work order based. Manufacturing companies have long used ERP systems to streamline operations, address customization requirements and manage complicated supply chains in order to build profitable, sustainable businesses. ERP software provides integration of every aspect of procurement, production and delivery for manufacturers regardless of whether they are a make-to-stock, make-to-order or engineer-to-order manufacturer. Companies must be particularly careful about choosing an ERP system flexible enough to meet their specific operational processes and functional requirements.

Within the manufacturing industry, contract manufacturing companies need software flexible enough to manufacture a variety of product types and efficient enough to produce low cost, high quality goods in a lean and highly automated environment. Contract manufacturers need to manage multiple customer requirements simultaneously while meeting delivery deadlines, quality specifications and product design requirements. Strong contract manufacturing software will offer detailed costing information, robust demand planning and production control, integrated financial management, and a strong inventory control for raw materials and finished goods inventories. While there are ERP software packages available for this diverse set of requirements, not all ERP solutions can meet the needs of a contract manufacturer.

Manufacturing module of ERP provides real-time monitoring and control for your production and process manufacturing operations. Providing accurate 24/7 real-time manufacturing information of all your plant operations, help reduce scrap, waste and machine downtime, improve cycle times, Overall Equipment Effectiveness, plant productivity and automatic part qualification. Alerting you immediately when process and machine conditions deviate from standard, ERP help you solve production issues immediately. The drag and drop real-time scheduler provides management with a view of what's happening on the shop floor in one plant, or all plants across the entire organization.

ERP helps to manage and organize shop floor in the plant. Having manufacturing workbenches designed to give you the visibility and control of all your orders makes ERP software ideal for organizing the shop floor. Integrated Time & Attendance allows for shop personnel to provide up to the minute status of jobs while providing cost accounting and efficiency reporting data. Complex scheduling algorithms may be developed to support the way you want to do business. Complete Serial number, VIN and Lot control allow valuable information to be stored and tracked for an individual piece of material. ERP provides complete multiple plant and multiple company capability through inventory, production, planning, sales and costing making it the most desired small business ERP solution for midsized manufacturers.

The key functionality of manufacturing module is as follows:

ERP streamlines and optimizes the end-to-end logistics functionalities by providing the following operations support functionality:

Operations support - ERP supports all manufacturing strategies and processes for companies in the process, discrete, and consumer products industries. ERP helps organizations improve their entire logistics operation and add value to the business. ERP also provides logistics operations management functions that ensure operations run smoothly, fulfill all quality demands. These functions help to reduce downtime, increase customer loyalty while improving product quality, enable better decision making, cost, and time to market.

Decreased costs - ERP system can help reduce manufacturing costs in a number of ways. Accurate manufacturing information results in increased productivity and reduced errors, reduce supervision costs and improve the efficiency of shop floor task distribution.

Increased flexibility - By supporting different production strategies, such as configure-to-order, and make-to-order, ERP helps businesses rapidly respond to customer demands.

Improved visibility and insight -ERP establishes a continuous flow of information across engineering, planning, execution, and in the production process. It also ensures up-to-date information is available throughout manufacturing.

Reduced raw material and procurement expenses - ERP helps businesses better monitor material availability status, resulting in minimized procurement costs.

Inventory and warehouse management - ERP supports all major areas of inventory management and warehousing, such as inbound and outbound processing.

Instant stock verification - ERP can help businesses verify that product stock is available, up to- date stock information is available throughout the enterprise. ERP makes it easy to verify the contents of an order before it leaves the warehouse, and significantly improving order accuracy.

Transportation support - ERP provides key functions for transport execution, and business processes for foreign trade.

Integration with external systems (CAD/CAM) - ERP facilitates support functions such as change and configuration management, as well as integration with external systems such as computer-aided design (CAD), computer-aided manufacturing (CAM), and geographical information systems (GIS). CAM integration supports enterprise-wide collaboration with concurrent engineering make it easy for multiple users to simultaneously process an assembly. In addition, CAD integration provides a single access point to all CAD documents, making it easier for all users to access the resources when they needed (such as drawings and CAD models). Enhanced viewing options include different views, and the ability to view two- and three-dimensional files in a single view.

Maximized plant and equipment performance - ERP supports the complete life cycle of an asset - from specification to design phases, the development phase to the operation phase. ERP supports comprehensive asset management for optimally maintaining plants and equipment, deploying them to support appropriate projects, and complying with safety and regulatory standards. Incorporating quality engineering practices into all stages of the product life cycle reduces time to market; improves product analysis, and planning.

Reduced data maintenance and administrative burden - ERP makes it easy for organizations to replace inefficient, paper-based processes with automated business workflow solutions. ERP enable businesses to create customized electronic forms that have the same look and feel as traditional paper forms, but can be completed and submitted online. Easy-to-use electronic forms that employ a similar look and feel to paper versions help relieve employees of time-consuming data entry. In this system, information is automatically delivered to the next step in the workflow; employees are freed from concerns regarding routing. Because data from the field is entered directly in ERP, it is not necessary to reenter field information in back-office or other systems.

Improved service processes - ERP addresses basic requirements for customer support, such as order management support, including quotation and order management, management of installations and their configurations, service contracts, and warranty management. ERP increases the visibility of customer service processes, track all product manufacturing, and service information to support improvements in maintenance, product recalls, and new product design, quicker and more accurate billing and reporting.

Quality assurance and control - ERP supports quality engineering, quality assurance / control, and quality improvement. ERP support quality assurance and control for procurement, during product evaluation, design, development, production, validation, final inspection, and storage. ERP also supports quality improvement capabilities throughout sales, distribution, service, and disposal.

Reduced inspection costs - ERP offers flexible methods of organizing, recording, and reviewing inspection data, and improve the inspection process with support for multiple kinds of inspections, including goods receipt inspections, in-process checks, final product inspections, recurring batch inspections, and others.

Improved safety, regulatory and standards compliance - By supporting full compliance with regulations and standards, ERP helps businesses produce safer products, protect customers and communities, and provide safe workplaces that reduce risks to employees.

Regulatory and standards compliance - Quality management features in ERP support manufacturers with the complete documentation of quality control processes required by Six Sigma, ISO 9000 and other industry standards, manufacturing practice guidelines and other regulations governing the food and drug industry.

Increased customer satisfaction - Quality assurance, control, and improvement capabilities ensure the overall quality of products, services, and processes, resulting in products that meet or exceed customer expectations.

BENEFITS OF ERP IN MANUFACTURING INDUSTRY

In today's aggressive business environment it is essential to be prepared to face a vast and competitive world. In this time of diminishing global economic situation, the most worried sectors are the small and midsize businesses (SMBs). They are challenged by the requirement of the customer and compliance mandates, effective management of supplier, costs control and finding new customers to grow the business. Initially ERP solution was developed for the big organizations. It has also involved huge investment which was out of reach of small and medium sized industries (SMEs). Today, all industry segments are taking advantage of ERP solution and it is becoming a necessity to have ERP implemented in an organization for its successful business operation.

Manufacturing was one of the sectors that have benefited most from ERP solution. It was due to timely implantation of ERP. This attitude has lined the way for many locally made ERP solution providers entering the market with very effective applications. As the local ERP vendors were targeting the SMEs, they also kept the price tag in mind, which ultimately resulted in existence of some effective and affordable ERP products in the market. ERP offers solution that enables manufacturers to compete in the prevailing market atmosphere. ERP solution can also transform the supply chain to achieve production plan with sales plan, manufacturing, finance and customers. ERP is changing the competitive landscape for SMB manufacturers. Small to midsize manufacturing companies can benefit from a fully integrated solution designed to reduce costs, improve customer service, increase margins and generate new revenue streams. Further, SMB manufacturers can improve business performance with a deeply functional, yet easily affordable, ERP solution.

As the technology changed ERP solution also found its way to the web. Today web-enabled ERP solutions are the most effective solution available in the market. When a business application like an ERP system is enhanced with the e-Business capability, i.e. making it a web-based e-business enabled ERP, they supercharge each other. E-Business is the best vehicle to share business information with partners for creating major B2B synergies. A fully integrated web-based ERP will capture and create accurate, consistent and timely relevant data, and assist in intelligent business decision-making. The impact of ERP/e-Business integration is substantial, ranging from reduced inventory and personnel level to improved order and cash management. It also results in improved customer responsiveness, reduced IT costs and the availability for value-added activities.

What is to be cautious about the selection of an ERP system is, before you commit to any ERP system, you should first evaluate the system such as what your organization needs and wants to accomplish with its ERP strategy. The outcome of this evaluation will help you determine which applications and what kind of functionality your organization requires as well as go a long way toward easing the implementation.

Benefits

- Track on production updates by keeping record of current and previous products manufactured
- Improves customer relations by timely delivery of customer order and handling of client queries
- Saves time and money as it integrates and automates all the manufacturing processes
- Centralized and secure management of data
- Reduces paperwork and errors to greater extent
- Track on production updates by keeping record of current and previous products manufactured
- Prevents omissions and frauds with secure and systematic management of the financial information
- Scalable and Reliable
- Generation of periodic reports help the management to make right decision

The above mentioned points are some of the benefits of ERP that one can avail by implementing it into a manufacturing company.

ERP IN INDIAN MANUFACTURING ORGANIZATIONS

Indian market is very competitive and growing. Every company wants to grow rapidly for this they are working 24x7x365. Competitors also react faster than in earlier days. At present, India has emerged as a lucrative market place for ERP companies. In India, lots of small, medium and large size companies are growing very fast and they need a software package and technology to manage their growth. Therefore, now these days, ERP companies are targeting all types and size companies. These days, every top organization, consultancies and companies are constantly working towards promoting themselves. As Gartner estimates, India ERP market has been one of the fastest growths in Asia-Pacific. As per the best scenario forecast, India software revenues in 2008 are estimated to reach $ 211.9 million representing a double digit year-on-year growth for 2008 (Gartner, 2009). In context of ERP in India, Industry analyst ARC Advisory forecasts that the ERP market be over $250 million in 2009-10. According to a study from International Data Corporation (IDC), in the next four years the ERP market is expected to touch Rs. 1,550 crore ($341 million). It states, SMB potential in India is expected to be Rs 728 crore ($160 million), which stands at 47% of the total market. ARC Advisory estimates that Indian ERP will be growing at a Compound Annual Growth Rate (CAGR) of 25.2% for over the next 5 years (IDC, 2009). Today, ERP forms the backbone of a handsome number of manufacturing organizations in India. According to industry estimates, 70-75% of manufacturers use some form or the other of ERP. (Published in Express computer on 01 August 2012). According to Frost & Sullivan, the ERP market in India is estimated to grow at a CAGR of 19.2% to reach $184.7 million by 2013.

The majority of the Indian corporations have large in-house Information System and they consider ERP as a threat to their very existence. Additionally, ERP places more value on the domain knowledge of functions rather than IT skills. The hardware, networking and communication infrastructure needed to implement ERP are lacking in some of the indigenous companies. A number of well-known business houses are in India like HLL, ONGC, Telco, Maruti Udyog Ltd., Century Rayon, ESSAR, Godrej Soaps, Cadburys, ACC, Rallis India, Sony India Pvt. Ltd., Ceat Ltd., Jindal, Ford Motors, Kirloskar, Blue Star, L&T, TISCO, Hero Honda, Sony India Pvt Ltd., Hyundai, Apollo Tyres Ltd, Asian Paints, Videocon, LPS Ltd., Usha International Ltd., and Mahindra & Mahindra etc..

These organizations have utilized ERP systems to reduce inventories, shorten cycle times, reduce idle time, optimize setup and tear-down costs, and to improve their overall supply chain management practices. Due to ERP, these companies have more competitive prices and faster response time to market demand as well as speed manufacturing, improve customer service and reduce the impact of predictable errors caused by manual processes.

CONCLUSION

Business enterprises in India are in the process of a major transformation due to globalization and the deregulation of Indian economy, coupled with fundamental changes in the business models due to the emergence of Information Technology based business practices. Most of the enterprises in developing countries, such as India, are in the process of implementing Enterprise Resource Planning (ERP) system in alignment with organizational transformation and process of re-engineering initiatives. ERP system promise benefits that range from increased efficiency to transformation of quality, productivity and profitability. However, its implementation poses some unexpected organizational challenges and changes that can be structural as well as cultural in nature. ERP not only helps establish world-class best business practices and brings transparency to the organization but also demands for empowerment and flexibility in decision making process. The most promising argument is that, to thrive in the e-commerce world companies need to transform their internal business process with the deployment of ERP system. Hence, ERP is considered to be the backbone of e-business.

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CONSTRUCTION OF THE DUCTED DOMESTIC WIND TURBINE

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ABSTRACT
An energy crisis is the major problem in all over world. Most of energy requirement is fulfilled by thermal power plants based on coal & diesel, which leads to environment pollution. To avoid these polluting power sources we have to adopt alternate energy resources like solar power, wind power etc. But out of all these wind energy is preferred as domestic safe-economical energy resource. Wind turbine can be utilized on underutilized land or on lands currently in commodity crop production and which can be "harvest" on the surface and "harvest" above the surface. Then it will primarily be used for electricity generation for immediate end-use or as a "driver" for hydrogen production. The traditional wind turbines are replaced by adopting the venturimeter shaped ducted turbine we can increase the wind velocity about three times (09-15m/s) which is suitable for running the generator to its rated speed (200-600RPM) without using the gear-box, so that the maximum power is generated from low velocity wind without losing power in transmission system. The radial-flux PM machine with surface mounted magnets seems to be a good choice for the design of a large-scale directly driven wind-turbine generator. Small sized compact units of this kind of turbine may be constructed of throat diameter ranging between 0.5m-01m which can produce power from 100W to 500W with approximate cost ranging between Rs 25000 to Rs 50000, Which can be afford by a rural people easily.

Keywords: WTD-Wind Turbine Design, WMS-Wind monitoring stations, MAWS-Mean annual wind speeds, WPD-Wind power density in watt/m2, MW-mega watts, FGET- Fastest Growing Energy Technology. DAWT- Diffuser Assisted Wind Turbines. TSR-Tip speed ratio.

INTRODUCTION

The development of wind power in India began in the 1990s, and has significantly increased in the last few years. India has the fifth largest installed wind power capacity in the world. As of 31 October 2009 the installed capacity of wind power in India was 10,925 MW, mainly spread across Tamil Nadu (4889.765 MW), Maharashtra (1942.25 MW), Gujarat (1565.61 MW), Karnataka (1340.23 MW), Rajasthan (738.5 MW), Madhya Pradesh (212.8 MW), Andhra Pradesh (122.45 MW), Kerala (26.5 MW), Odisha (2MW), West Bengal (1.1 MW) and other states (3.20 MW) .It is estimated that 6,000 MW of additional wind power capacity will be installed in India by 2012. Wind power accounts for 6% of India's total installed power capacity, and it generates 1.6% of the country's power, it must be improved by adopting domestic wind mills (Low power wind turbines) at rural areas.

2. Constructional components and their working

Wind is harnessed and converted into electricity using turbines called wind turbines. The amount of electricity that a turbine produces depends on its size and the speed of the wind. All wind turbines have the same basic parts: blades, a tower, and a gearbox. These parts work together to convert the wind's kinetic energy into mechanical energy that generates electricity.

1. The moving air spins the turbine blades.
2. The blades are connected to a low-speed shaft. When the blades spin, the shaft turns.
3. The low-speed shaft is connected to a gearbox. Inside, a large slow-moving gear turns a small gear quickly.
4. The small gear turns another shaft at high speed.
5. The high-speed shaft is connected to a generator. As the shaft turns the generator, it produces electricity.
6. The electric current is sent through cables down the turbine tower to a transformer that changes the voltage of the current before it is sent out on transmission lines.

Wind turbines are most efficient when they are built where winds blow consistently, at least 13 miles per hour (21Kmph). Faster winds generate more electricity. High above ground winds are stronger and steadier, so wind turbines should be placed on top of towers that are at least 30 meters (100 feet) tall. There are many different types of wind turbines with different blade shapes. Different types of turbines operate most efficiently at different wind speeds. While one turbine might operate efficiently in winds as low as five miles per hour (8Kmph or2.25m/sec), another may need winds up to 45 miles per hour (72Kmph or 20m/sec). Wind turbines also come in different sizes, based on the amount of electrical power they can generate. Small turbines may produce only enough electricity to power one home. Large turbines are often called utility-scale because they generate enough power for utilities, or electric companies, to sell. Large turbines are grouped together into wind farms, which provide bulk power to the electrical grid.

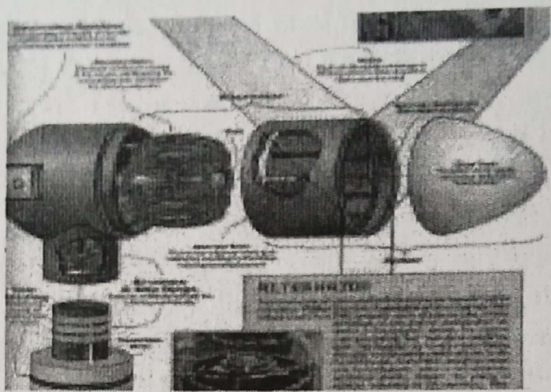


Fig.1.0 shows internal components of wind turbine [46]

The real cost of energy from wind turbines is falling dramatically. Nowadays more than 10000 MW wind power capacity has been installed world-wide. The installed capacity will be 37 MW including 63 wind turbines in Finland at the end of 1999. The machines now entering the market generate 300-1500kW per turbine rather than the 100kW average of the late eighties. This up-scaling is foreseen to continue at least one step more to a 4-6 MW offshore turbines. A present day typical and a new directly driven wind power plant are illustrated in Fig. The electromechanical system of a wind power plant usually consists of three main parts: turbine, gearbox and generator. The rotor of a typical wind turbine rotates at a speed of 20-200rpm. In conventional wind power plants, the generator rotational speed is usually 1000 or 1500 rpm. This means that a gear is needed between the turbine and the generator.

A standard asynchronous generator can be used in conventional wind power plants. The constant speed operation is commonly used in this type of the wind turbine. The generator can be connected directly to the grid, which results in a simple electrical system. However, the gearbox adds to the weight, generates noise, demands regular maintenance and increases losses. The maintenance of the Gearbox-generator system may be difficult, because the nacelle is located at the top of the tower. Furthermore, there may also be problems with materials, lubrication and bearing seals in cold climates.

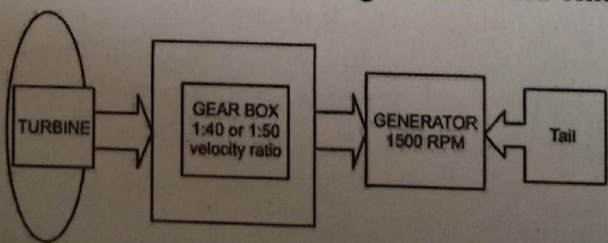


Fig.2.0 shows the block diagram of wind turbine.

Fig.3.0 shows a domestic wind turbine.

The wind power plant can be simplified by eliminating the gear and by using a low-speed Generator the rotor of which rotates at the same speed as the rotor of the turbine. Many disadvantages can also be avoided in gearless wind turbines. The noise caused mainly by a high rotational speed can be reduced. The advantages are also high overall efficiency and reliability, reduced weight and diminished need for maintenance. However, the diameter of a low-speed generator may be rather large because a great number of poles is needed in a low-speed machine. Due to the multi-pole structure, the total length of the magnetic path is short. The winding overhangs can also be shorter and stator resistive losses lower than those in a long pole pitch machine. The output frequency is usually lower than 50Hz, and a frequency converter is usually needed in low-speed applications. The converter makes it possible to use the machines in variable speed operation. The speed can be variable over a relatively wide range depending on the wind conditions, and the wind turbines can extract maximum power at different wind speeds. The advantages of the variable speed operation are, for instance, the reduction of the drive train, Mechanical stresses, the improved output power quality and the increased energy capture. In the gearless turbine has variable-speed operation and the geared turbines have constant Speed operation. The annual energy production is higher and the total weight of the rotor and nacelle lower in the gearless turbine than the average values in the geared turbines.

The generator is a four pole induction machine. The gear is a combined planetary and parallel stage design: planetary in the first stage and parallel in the second and third stages. The gear contains the main shaft bearing and the gear ratio is 50.

3. Overview of Directly Driven Wind Generators

There are different alternatives for the design of a directly driven generator (Lampola) [49]. It can be, for example, an asynchronous machine, a permanent-magnet synchronous machine or a synchronous machine excited by a traditional field winding. Furthermore, the machine can be a radial-, an axial or a transverse-flux machine. The stator core can be slotted or slot less, and there can, for example, be a toroidal stator winding in an axial-flux machine. Many different generators have been proposed in the literature as directly driven wind-turbine generators.

1. Generators with Field Winding.
2. Axial-Flux Permanent-Magnet Generators.
3. Radial-Flux Permanent-Magnet Generators.
4. Special Generators:

Some special directly driven generators have also been proposed, for example, a linear induction machine, transverse-flux machines, reluctance machines and a split-pole machine. Gripnau and Kursten (1991) and Deleroi (1992) have presented a linear induction generator for direct grid connection. This machine is a double-sided axial-flux generator. The two stator sides form a segment of the circumference and the stator is fixed to the turbine tower. The rotor is a disc which is directly coupled in or parallel to the turbine rotor. The construction of the machine is relatively simple and light compared with the conventional design. Due to the fact that the rotor diameter may be large, the air gap in the discrete stator sector will be large. The generator has a great slip, 11 to 15% and the efficiency will not exceed 81-85%. A 150kW prototype machine has been made and its efficiency is over 64%. The diameter of a 500kW machine designed is about 9m. The machine is still in a developing stage.

4. Summary of Directly Driven Generators

Many different generator designs for gearless wind turbines have been presented, i.e.Electrically-excited synchronous machines, surface-magnet and buried-magnet radial-flux PM machines, axial-flux PM machines, transverse-flux PM machines, switched reluctance machines and a linear induction machine. Some directly driven generators are used in low power commercial gearless wind turbines. The first commercial directly driven generator in the power range of some hundreds kilowatts is a synchronous machine excited by a traditional field winding. Many low-speeds experimental machines have been built and tested. The conventional asynchronous machine and the switched reluctance machine are large and heavy and they will not be very suitable designs for a large directly driven generator compared to the other designs. The transverse-flux machine is small, efficient and light compared to the other designs, but the mechanical design is very complicated. The electrically-excited synchronous machine is larger, heavier and less efficient than the PM synchronous machine. The radial-flux PM. Synchronous machine has smaller outer diameter and it is cheaper than the axial-flux machine. Cheap ferrite magnet material can be used in the buried-magnet machine, but the rotor is heavier and the mechanical design more complicated than those in the surface-magnet machine with high energy magnets. The radial-flux PM machine with surface mounted magnets seems to be a good choice for the design of a large-scale directly driven wind-turbine generator.

Fig.5.0 shows a permanent magnet generator. [49]

5. Design of ducted section of turbine

As the capability of domestic users is limited from 5feet dia. to 15feet dia. Because of the restrictions due to space availability and infrastructure availability. So the main aim of the research is to utilize the available low atmospheric wind by increasing it about three times by using the convergent and divergent sections of the venturimeter. The convergent section increase the pressure of the available wind and the divergent section create vacuum at the throat of the venturimeter , which creates the maximum throat velocity . The convergent operates as a funnel to push air through the rotor blades and the divergent serves to create vacuum and pull air through the rotor blades. This push-pull augmentation increases both the pressure differential and the air stream velocity many times that possible with the simple diffuser augmentation associated with older generation Diffuser Assisted Wind Turbines (DAWT). Now the domestic small sized turbine is placed at the throat which generates sufficient power at normal wind velocity. Today's conventional wind turbines are difficult to incorporate into Smart Grids because they only operate in moderate to high wind speeds giving them a capacity factor of less than 45 percent. You can't locate wind turbines in some places at all due to low average wind speeds.

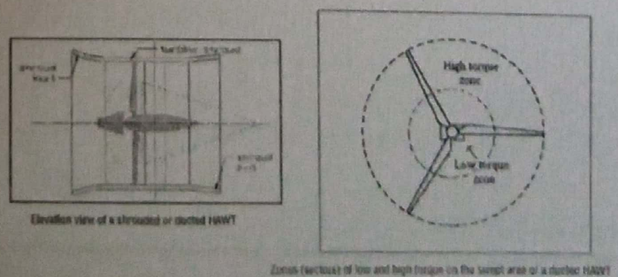


Fig.6.0 shows the wind flow through a ducted horizontal axis wind turbine (HAWTD)

We start with the simple wind turbine and the application of accepted principles of fluid mechanics. Now by adding a duct to catch air that normally escapes around the turbine blades. We then examined a proven method of increasing a wind turbine's efficiency by 30 percent adding a diffuser behind the duct. But we needed to increase the speed and energy density of the airflow many times. To achieve this, we replaced the diffuser by a larger divergent, creating more vacuum which pulls the air through the unit. Next, we added an optimized convergent to compress, align and accelerate the wind in the ducted channel, creating a ventury. The push-pull effect created by the convergent and divergent greatly increases the air stream flow velocity through the turbine blades - a critical process parameter. The wind energy then available for conversion is proportional to airstream flow velocity cubed. Triple the wind speed, and the energy produced increases by cube of 3, or 27.

Velocity at entry of the convergent section = 1m/s

Velocity at throat (around turbine blades) =3m/s

Velocity at exit of the divergent section =0.5m/s

This result is based on theoretical calculation on actual practical application due to mechanical reasons and compressibility of air the throat velocity can be achieved about 2.8m/s. now we can use two or three turbines at throat in place of single increase the efficiency of the unit.

Table shows the effect of convergent length on the throat velocity:-

Length of Convergent (M)	Throat Velocity in m/sec.	Divergent Length (M)
07 Meter	5.50	07
06 Meter	5.75	07
05 Meter	6.00	07
04 Meter	6.50	07
03 Meter	**6.79**	**07**
02 Meter	6.00	07
01 Meter	5.00	07

As discussed in theory the increase in length of divergent may leads the increase in the pull effect caused by divergent, because of the increasing area in the direction of wind flow the minute friction loss may be neglected. So we kept the divergent length 07 Meter constant during the test. Then we test the unit by changing the length of convergent section with difference of 01 meter. It has been observed that the throat velocity increases with decrease in convergent length up to 03 meter length. This occurs due to frictional losses by decreased section, because the friction loss is directly depends upon the length of convergent section. But below 03 meter, at 02meter and 01 meter again downfall in throat velocity observed. The reason behind this is the insufficient pressure rise which pushes poorly the wind threw the throat. So the optimized length of convergent is kept 03 meter (smallest as possible) and the length of divergent is kept 07 meter due to costing and space availability reasons.

6. Calculation for Design of the turbine's duct structure:

The duct is so constructed that the maximum air can enter in the convergent section of area(4*4=16m2) and converges up to throat dia.3m (area 7.065m2).the throat is 2m long. From the exit of circular throat the divergent part starts and diverges up to the exit section of the divergent part of area (6*4=24m2).

Component/segment wise dimensions of the duct are given as:-

Convergent section length along the X-axis =3m

Left end (entry point of air) along Y-axis =4m

Left end (entry point of air) along Z-axis =4m

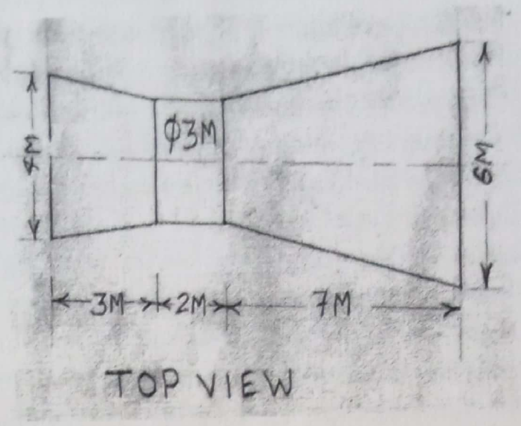
Junction point at the end of convergent part at throat entry (dia.3m) =9.42m (perimeter)

Length of throat along X-axis =2m

Junction point at the start of divergent part at throat exit (dia.3m) =9.42m (perimeter)

Length of divergent section along X-axis =7m

Right end (exit point of air) of divergent along Y-axis =6m
Right end (exit point of air) of divergent along Z-axis =4m
The detail drawing of the turbine shown below:



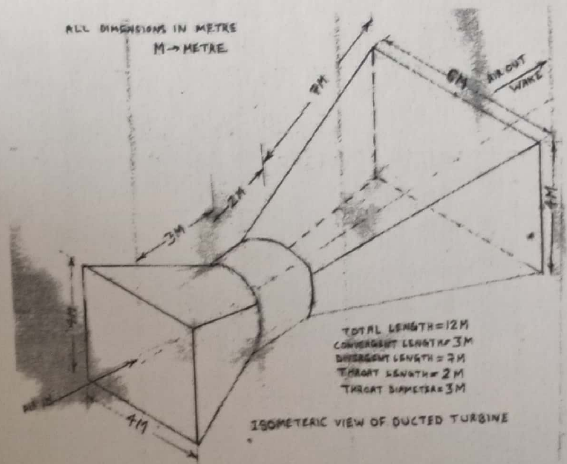


Fig.7.0 shows the complete assembly of the turbine (duct).

7. RPM and Tip Speed Ratio

Tip Speed Ratio (TSR) - The blade tip velocity divided by the wind speed. The tip speed ratio is how much faster, than the wind speed, the blade tips travel. The speed of the tips of the windmill blades should be about 5 times the speed of the wind. For a 10 m/s wind, the tips move at 50 m/s. If the windmill has a large diameter, then 20 RPM is adequate, but if the diameter is small, a high RPM is required. Now according to this criterion at normal available velocity the throat velocity ranges from 07 m/s to 21 m/s and corresponding RPM of the turbine (03m dia.) may be calculated and given as in tabular form. Now the RPM range achieved from the below table is 200-600. The alternators are available in the range of rated as 500RPM or 1000RPM or 1500RPM.now either the special gearing arrangement is to be required to match the rated speed or the DC motors (Permanent magnet) can be used as generator as discussed earlier in this chapter. There is some ideal size for a windmill such that the windmill RPM and the generator RPM are pretty well matched; unfortunately, that size is in the range of one-meter diameter. That device can produce a little power (400 w). The voltage and current variations may be controlled by using power electronics circuits.

Air velocity (Turbine)	07 m/s	14m/s	21m/s
Rotor (RPM)	222	445	668

8. Conclusions of the research

In this research we find that the output power is mainly depends upon the wind speed and the swept area of the turbine blades. The power output increased eight times if the wind speed is doubled. In the area of Haryana and Rajasthan the wind speed is low (three to five meter per second) generally. By adopting the venturimeter shaped ducted turbine we can increase the wind velocity about three times (09-15m/s) which is suitable for running the generator to its rated speed (500-1500RPM) by using the gear train of suitable velocity ratio. As discussed in previous chapters the relation with size of the blade should have to give an appropriate speed of rotation versus wind speed (called TSR, the tip-to-speed ratio). As a rough guide (tables exist for this, too) a 6-foot prop should turn at about 500 RPM and a 9-foot prop should turn about 300 RPM. This will give you some idea what you're up against when coupling various alternators to your blade rotor.

In the installations of large size wind power plants must requires the large size tower construction, which consumes a huge part of capital this problem is overcome by adopting this modified low velocity roof top wind turbine. The turbine of throat diameter ranging (01m-03m) may be used as per requirement. The 01m size can be used by a small domestic consumer (below 01KW). The consumer of high requirement must need to install 02m or 03 m diameter throat turbine. This turbine requires the roof area of about 40ft.X20ft.(800Sq ft.).

Use of the type of generators is mainly depends upon the capacity of the turbine and type i.e. directly derived or by using some gear train as discussed in the fourth's chapter different generator designs for gearless wind turbines have been presented, i.e. Electrically-excited synchronous machines, surface-magnet and buried-magnet radial-flux PM machines, axial-flux PM machines, transverse-flux PM machines, switched reluctance machines and a linear induction machine. Some directly driven generators are used in low power commercial gearless wind turbines. The first commercial directly driven generator in the power range of some hundreds kilowatts is a synchronous machine excited by a traditional field winding. Many low-speeds experimental machines have been built and tested. The conventional asynchronous machine and the switched reluctance machine are large and heavy and they will not be very suitable designs for a large directly driven generator compared to the other designs. The transverse-flux machine is small, efficient and light compared to the other designs, but the mechanical design is very complicated. The electrically-excited synchronous machine is larger, heavier and less efficient than the PM synchronous machine. The radial-flux PM synchronous machine has smaller outer diameter and it is cheaper than the axial-flux machine. Cheap ferrite magnet material can be used in the buried-magnet machine, but the rotor is heavier and the mechanical design more complicated than those in the surface-magnet machine with high energy magnets. The radial-flux PM machine with surface mounted magnets seems to be a good choice for the design of a large-scale directly driven wind-turbine generator.

If you want to charge 12V batteries and run things off of them you might go with a homemade or other permanent magnet alternator (with an efficiency of around 70%) or a car alternator (although these need to be turned at about 1800 RPM) with an efficiency of about 50% (plus the loss from the belts or whatever needed to turn it at 1800 RPM, plus the loss needed to run the field coils, about 40 watts).Another item is surplus computer tape drive motors, available for about Rs.2000. These have brushes, so there is a little bit more than just bearings to wear out, but they'll make good power for a long time for a reasonable price. Some small engine starters have permanent magnets and would probably make suitable direct-drive generators. These have the advantage of being common and repairable. Look for ones with bearings instead of bushings, which might be a bit rare. But the starters with bushings won't do well under continuous duty.

Adopting this modified roof-top wind turbine the 50% of the rural families becomes self dependent on power production they need not another kind of power connection (i.e. from Thermal power plants). Because the wind power is available throughout the year during day and night also. This adds the great wealth to the nations by saving energy and environment.

The nature of wind energy is important to take into account when you're planning to capture and utilize it. Too small a unit won't capture enough to do a lot of good, and too large a unit is too expensive to make sense: you would be better off investing the money and paying your electric bill with the interest. Because wind power is not particularly reliable over the short term, the storage/use of the power has a lot to do with how much good you'll get out of it. Your situation will determine what best to do with your wind power. The power must be stored by using battery system of suitable ratings (i.e.12volt rating).

9. Costs of the modified turbine

The approximate cost (Rupees) of this domestic roof top wind turbine is given as:-

Cost of ducting and foundation	=	50000
Cost of blades and propeller system	=	10000
Cost of alternator/DC generator	=	20000
Cost of battery for storage power	=	20000
Total cost of the turbine system	=	100000 Rupees

The above stated cost is approximate cost which may varies as per the requirement and the ratings of the generator and storage battery required which is depends upon the need of the households and the market rate fluctuations. Only 10% peoples in rural area can afford this turbine system on the basis of their financial conditions. Remaining 40% are unable to install it on their own capability due to poor financial conditions, these peoples needs to be supported by government in the forms of subsidized loans (by renewal energy department of India) through rural development banks. These turbines can be used as supplementary generator for small scale industries by constructing them on the tower of sufficient height and also may be connected with urban supplies by means of grid system. Because in summer the hot winds blown at their extreme velocity which must produce maximum power so it may supplement the need of urban area also.

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EFFECT OF LIFT ON WIND TURBINE BLADE DESIGN PARAMETER

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ABSTRACT

Blade is one of the most important parts for a wind turbine system. Power obtained from the wind can only be extracted when a better design of the blade. Power and the coefficient of lift is calculated easily which is important factor for wind blade design.

INTRODUCTION

Wind turbine blades are shaped to generate the maximum power from the wind at the minimum cost. Primarily the design is driven by the aerodynamic requirements, but economics mean that the blade shape is a compromise to keep the cost of construction reasonable. In particular, the blade tends to be thicker than the aerodynamic optimum close to the root, where the stresses due to bending are greatest. As well as varying day-to-day, the wind varies every second due to turbulence caused by land features, thermals and weather. It also blows more strongly higher above the ground than closer to it, due to surface friction. All these effects lead to varying loads on the blades of a turbine as they rotate, and mean that the aerodynamic and structural design needs to cope with conditions that are rarely optimal. The blades of a wind turbine are usually made from composite materials. Composite materials are often preferred because of the possibility of achieving high strength and stiffness-to weight ratio (Manwell et al. 2002). They are also corrosion resistant and good electrical insulators. These properties are advantageous in an offshore environment where corrosion is a critical factor to be considered.

There are two major forces acting on wind turbine blades as they rotate: Lift and Drag as shown in fig.1. Lift and drag are in constant competition, acting to cancel each other out. When optimizing wind turbine blades, the goal is to maximize the lift force while minimizing the drag force.

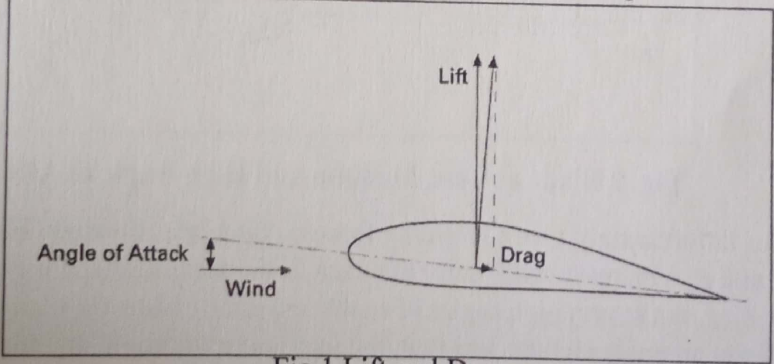

Fig.1 Lift and Drag

2. Development of Lift on an Airfoil

The airfoil is characterised by its chord length C, angle of attack and span length L of the airfoil. The lift on the airfoil is due to negative pressure created on the upper part of the airfoil. The drag force on the airfoil is always small due to design of shape of the body, which is streamed lined. From the theoretical analysis the circulation developed on the airfoil so that the stream line at the trailing edge of the airfoil is tangential to the airfoil is given as

$$\Gamma = \pi \, CU \sin\alpha \quad (1)$$

Where C = chord length
U= Free stream velocity of the airfoil
α= Angle of attack

Lift force F_L is given by the equation as

$$F_L = \rho\, UL\,\Gamma = \rho\, UL \times \pi\, CU \sin\alpha$$
$$= \rho\, \pi\, CU^2 L \sin\alpha$$

(2)
The Lift Force is given by equation as,

$$F_L = C_L \times A \times \frac{\rho U^2}{2}$$
$$F_L = C_L \times A \times \frac{\rho U^2}{2}$$

Where C_L = Co-efficient of Lift
A = Projected Area = C × L for airfoil

$$F_L = C_L \times C \times L \times \frac{\rho U^2}{2}$$

(3) Equating the two values of lift force given by the equations (3.17) and (3.18), as

$$\rho\, \pi\, CU^2 L \sin\alpha = C_L \times C \times L \times \frac{\rho U^2}{2}$$
$$C_L = \frac{2\pi\rho\, C\, U^2 L \sin\alpha}{C \times L \times \rho U^2} = 2\,\pi \sin\alpha$$

(4) Thus it is clear from the above equation (4) that co-efficient of Lift depends upon the angle of attack.

3. **Result**

From the equation (4) the lift can be calculated easily. In designing wind turbine blade lift force is important. The lift force increases as the blade is turned to present itself at a greater angle to the wind. This is called the angle of attack. At very large angles of attack the blade "stalls" and the lift decreases again. So there is an optimum angle of attack to generate the maximum lift. Fig.4 shows the positions of different angle of attack.

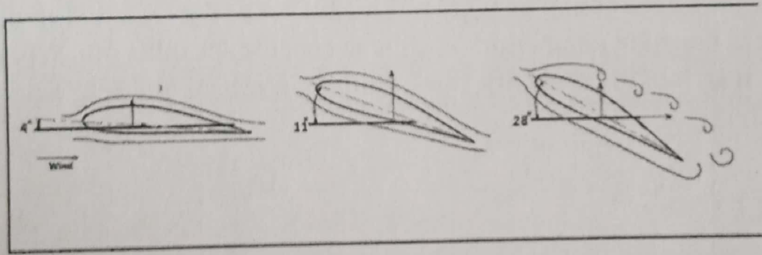

Fig. 2 Blade at Low, Medium and High Angle of Attack

There is, unfortunately, also a retarding force on the blade: the drag. This is the force parallel to the wind flow, and also increases with angle of attack. If the aerofoil shape is good, the lift force is much bigger than the drag, but at very high angles of attack, especially when the blade stalls, the drag increases dramatically. So at an angle slightly less than the maximum lift angle, the blade reaches its maximum lift/drag ratio. The best operating point will be between these two angles.

4. **Conclusion**

The blades have an aerodynamic profile in cross section to create lift and rotate the turbine. So angle of attack is 4 degree that will create enough force to rotate the turbine easily. This is optimum parameter.

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WSN PROTOCOL TO INCREASE THE NETWORK THROUGHPUT AND LIFE

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ABSTRACT

The most common problem in Sensor Network is Network Life. Either the network is clustered of not, each node release some amount of energy with each transmission. In a clustered network, the cluster selection is one of the major WSN protocol. In this existing work different approaches of cluster head selection based on distance, energy and other parameters. The cluster head selection is done on the basis of energy and distance parameters. In this present work we have improved the SPIN protocol for a clustered network. Here we have considered a congestion vector while selecting the cluster head for communication. Respective to this congestion vector the delayed communication is analyzed. We have selected a cluster for communication that is responding accurately and efficiently. We have implemented the work in Mat lab 7.8. The results shows that the presented work has improve the network life.

Keywords: LEACH, Hierarchical Routing Algorithms, clustering, wireless sensor networks.

INTRODUCTION

A Wireless Sensor Network (WSN) consists of spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants and to cooperatively pass their data through the network to a main location. The more modern networks are bi-directional, enabling also to control the activity of the sensors. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer application, such as industrial process monitoring and control, machine health monitoring, environment and habitat monitoring, healthcare applications, home automation, and traffic control.

The WSN is built of "nodes" - from a few to several hundreds or even thousands, where each node is connected to one (or sometimes several) sensors. Each such sensor network node has typically several parts: a radio transceiver with an internal antenna or connection to an external antenna, a microcontroller, an electronic circuit for interfacing with the sensors and an energy source, usually a battery or an embedded form of energy harvesting. A sensor node might vary in size from that of a shoebox down to the size of a grain of dust, although functioning "motes" of genuine microscopic dimensions have yet to be created. The cost of sensor nodes is similarly variable, ranging from hundreds of dollars to a few pennies, depending on the complexity of the individual sensor nodes. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and communications bandwidth... The topology of the WSNs can vary from a simple star network to an advanced multi-hop wireless mesh network. The propagation technique between the hops of the network can be routing or flooding.

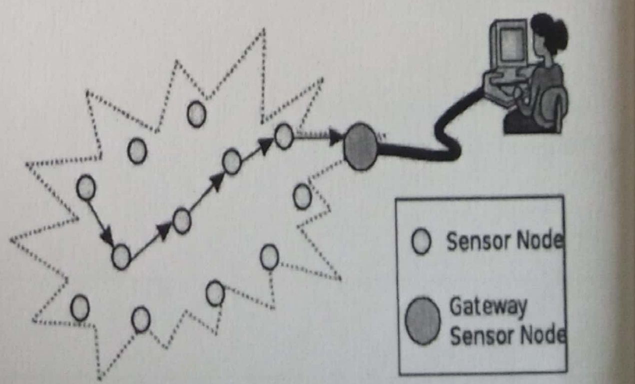

Figure 1 Typical Wireless Sensor Network Architecture

Sensors integrated into structures, machinery, and the environment, coupled with the efficient delivery of sensed information, could provide tremendous benefits to society. Potential benefits include: fewer catastrophic failures, conservation of natural resources, improved manufacturing productivity, improved emergency response, and enhanced homeland security However, barriers to the widespread use of sensors in structures and machines remain. Bundles of lead wires and fiber optic "tails" are subject to breakage and connector failures. Long wire bundles represent a significant installation and long term maintenance cost, limiting the number of sensors that may be deployed, and therefore reducing the overall quality of the data reported. Wireless sensing networks can eliminate these costs, easing installation and eliminating connectors.

Wireless Sensor Networks (WSNs) are networks of light-weight sensors that are battery powered used majorly for monitoring purposes. Recently, WSNs have been heavily researched by several organizations and by the military where we can find some of the applications in battle field surveillance and other security etiquettes. With the recent issues on climate change, WSNs can be utilized to track changes that affect the climate using a network of sensors to gather environmental variables such as temperature, humidity and pressure. One of the numerous advantages of these sensors is their ability to operate unattended which is ideal for inaccessible areas. Several clustering schemes and algorithm such as LEACH, DEEC, have been proposed with varying objectives such as load balancing, fault- tolerance, increased connectivity with reduced delay and network longevity. A balance of the above objectives can yield a more robust protocol. LEACH protocol and the likes assume a near to perfect system; an energy homogeneous system where a node is not likely to fail due to uneven terrain, failure in connectivity and packet dropping. But more recent protocols like SEP considered the reverse that is energy heterogeneity where the factors mentioned above is a possibility, which is more applicable to real life scenario for WSN.

Conventional protocol designs do not address these situations. This research explores existing work done in this area. The goal is to present a modified protocol design that is more robust and can ensure longer network life-time while taking other performance measures into consideration. Mathematical modeling and computer simulations are used for proof of concept and testing.

1.1 CHARACTERISTICS OF WIRELESS SENSOR NETWORK

The main characteristics of a WSN include:

1. Power consumption constrains for nodes using batteries or energy harvesting.
2. Ability to cope with node failures.
3. Mobility of nodes.
4. Dynamic network topology.
5. Communication failures.
6. Heterogeneity of nodes.
7. Scalability to large scale of deployment.
8. Ability to withstand harsh environmental conditions.
9. Ease of use.

1.2 WSN GOALS AND CHALLENGES

1.2.1 Goals

- Coverage and Connectivity.
- Lifetime.

1.2.2 Challenges

- Balance load evenly across network.
- Minimize unnecessary energy dissipation.
- Minimize cost and energy.
- Avoid long-range transmissions (multi-hop is less expensive).

1.3 WSN TECHNOLOGY

WSN represent a paradigm shift in wireless networks. They are being regarded as the enabling technologies for future surveillance-oriented application.

A standard wireless sensor network consists of a large number of tiny sensor nodes.
A sensor node basically consists of the following modules

- The sensing module that collects information from the environment.
- The communication module that sustains wireless data communication between nodes.
- The processing module that processes the information provided by the sensor module or received from neighbor nodes.

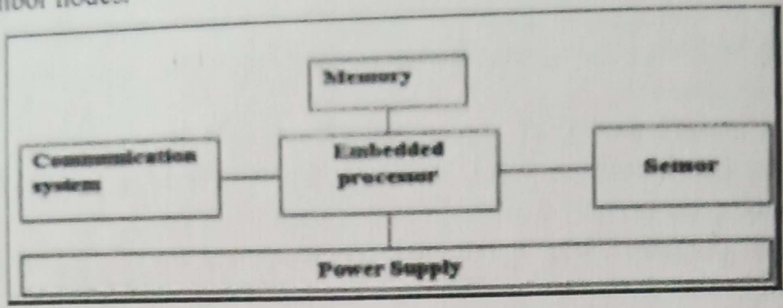

Figure 2: Architecture of a Sensor Node

These tiny sensor nodes work collaboratively to form a network (WSN). The network senses a given environment, perform in-network computation and communicate with a base station when a targeted event happens. The major handicap of these devices is resource constraint; low memory, limited power supply and limited processing capabilities. This directly affects the WSN at large. Due to the limitations, detection capacity in sensors diminishes with the increasing distance between the node and the phenomena. A WSN is characterized by the following features:

1. The network relay on a collection of tiny sensors to observe and influence the real world.
2. The sensors have a modest and sometimes non-renewable power budget and do not necessarily need to be active at all times. So sensors can be dynamically added to or removed from the network.
3. There is no infrastructure (wireless).
4. It is a self organized network.
5. Multi-hop communication is used and the network topology changes dynamically.

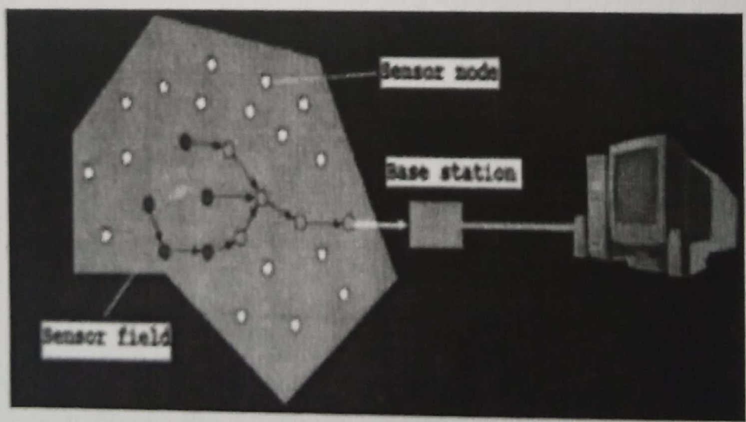

Figure 3: Architecture of a Wireless Sensor Network

Among contemporary networks, WSN are closely related to Mobile Ad hoc Networks (MANETs). They have a number of characteristics in common; network topology is not fixed, power is an expensive resource and nodes are connected to each other by wireless communication links.

1. WSNs are mainly used to collect information whilst MANETs are designed for distributed computing rather than information gathering.
2. Usually a WSN is deployed by the owner whilst MANET could be run by several unrelated units.
3. The number of nodes in WSNs can be several orders of magnitude higher than that in
4. MANETs.

5. WSN nodes are quite cheaper than those in MANETs, and are usually deployed in thousands.
6. Power resource of WSN nodes could be very limited; however nodes in MANETs can be recharged.
7. WSNs are more limited in their computational and communication capabilities compared to MANET.

Due to some of these differences, protocols used in MANETs cannot be applied directly in WSNs.

1.4 APPLICATION OF WIRELESS SENSOR NETWORK

Some of the applications of wireless sensor network in different fields are given below:

- Area monitoring
- Environmental sensing
- Air pollution monitoring
- Forest fires detection
- Greenhouse monitoring
- Landslide detection
- Agriculture
- Structural monitoring

1.5 WIRELESS SENSOR NETWORK ARCHITECTURE

Sensor nodes are normally scattered in a sensing field, every sensor has the capability of sensing, processing in form of aggregating and communicating the data to the sink or base station using various schemes. The underlying protocol scheme in the OSI model for WSNs includes the application layer, transport layer, network layer, data link layer and the physical layer. The protocol stack shown in Figure1.5, combines power and routing awareness, integrates data with networking protocols to communicates power efficiently through wireless medium, and promotes cooperative efforts of sensor nodes.

The application layer supports different application software depending on the task. The transport layer maintains the data flow, while the network layer does the routing of data from the transport layer. Depending on the deployment of the sensors, they can be either mobile or static, if the former then the data link layer, specifically the MAC protocol design must have power control mechanism, forwarding mechanism and should be able to perform communication confidentiality through encryption-decryption techniques. Finally, the task of the physical layer involves modulation and demodulation of radio carrier stream, forward error-correction (FEC) and performing efficient synchronization between the sender and receiver. The power, mobility, and task management planes were proposed to monitor the power, movement, and task distribution among the sensor nodes. Most often sensor network protocols are designed with two basic kinds of architectures; the layered and the clustering architectures; these architectures are discussed in the next sections.

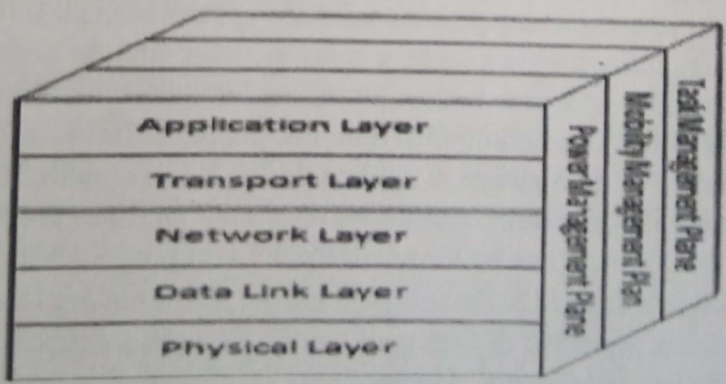

Figure 4: Protocol Stack Diagram

1.6 LAYERED ARCHITECTURE

The design of a layered architecture would normally consist of a base station and sensors scattered in the field. The layers of sensor nodes around the base station constitutes nodes that are in a single hop count to the base station, while nodes that are farther away can be multiple hop count to the BS depending on the size of the network, this is shown in Figure 1.6. One of the earliest protocols to complete the implementation of the layered architecture is the UNPF (Unified Network Protocol Framework), designed for a multi-hop infrastructure network architecture. The UNPF protocol is unified in the sense that it combines three different protocol structures: the network organization, medium access control (MAC) and the routing protocol to achieve the objectives of a robust protocol. These schemes are briefly described next.

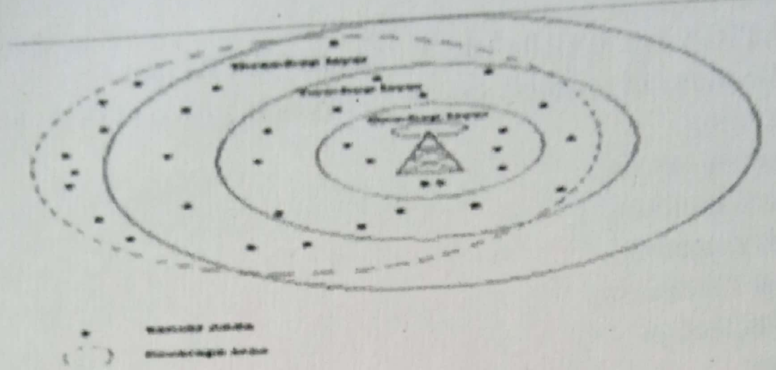

Figure 5: Layered Architecture

2. REVIEW ON WSN PROBLEM & STATEMENT

A wireless sensor network is composed by hundreds or thousands of small compact devices, called sensor nodes, equipped with sensors (e.g. acoustic, seismic or image), that are densely deployed in a large geographical area. These sensors measure ambient conditions in the environment surrounding them and then transform these data into electric signals which can be processed to reveal some characteristics about phenomena located in the area around these sensors. Therefore, we can get the information about the area which is far away. The applications may be environment control such as office building, robot control and guidance in automatic manufacturing environments, interactive toys, high security smart homes, and identification and personalization.

Wireless sensor networks (WSNs) are the products which integrate sensor techniques, embedded techniques, and distributed information processing and communication techniques. The appearance of the wireless sensor network is a revolution in information sensing and detection. Although there have been significant improvements in processor design and computing, advances in battery technology still lag behind, making energy resource considerations the fundamental challenge in wireless sensor networks. Consequently, there have been active research efforts on performance limits of wireless sensor networks. These performance limits include, among others, network capacity and network lifetime. Network capacity typically refers to the maximum amount of bit volume that can be successfully delivered to the base station ("sink node") by all the nodes in the network, while network lifetime refers to the maximum time limit that nodes in the network remain alive until one or more nodes drain up their energy. In this dissertation consider an overarching problem that encompasses both performance metrics. In particular study the network capacity problem under a given network lifetime requirement. Specifically, for a wireless sensor network where each node is provisioned with an initial energy, if all nodes are required to live up to a certain lifetime criterion, what is the maximum amount of bit volume that can be generated by the entire network? At first glance, it appears desirable to maximize the sum of rates from all the nodes in the network, subject to the condition that each node can meet the network lifetime requirement. Mathematically, this problem can be formulated as a linear programming (LP) problem within which the objective function is defined as the sum of rates over all the nodes in the network and the constraints are: 1) flow balance is preserved at each node, and 2) the energy constraint at each node is met for the given network lifetime requirement. However; the solution to this problem shows that although the network capacity (i.e., the sum of bit rates over all nodes) is maximized, there exists a severe bias in rate allocation among the nodes. In particular, those nodes that consume the least amount of power on their data path toward the base station are allocated with much more bit rates than other nodes in the network. Consequently, the data collection behavior for the entire network only favors certain nodes that have this property, while other nodes will be unfavorably penalized with much smaller bit rates.

2.1 CONCLUSION OF LITERATURE REVIEW

After reading out number of research papers I have concluded that WSN always suffer from the problem of energy loss and the life time of the network. Such kind of network always requires power for efficient utilization of energy of a battery operated devices, and routing optimization for energy efficiency is a good area for research work. We intend to optimize energy usage of battery operated devices and increase the lifetime of network in wireless sensor network. From this survey we have concluded some points as

1. The most common problems in Sensor Network is Network Life. Either the network is clustered of not, each node release some amount of energy with each transmission.
2. The energy reduction results the short network life. Lot of work is done in this direction respective to different protocols.
3. In a clustered network, the cluster selection is one of the major WSN protocol. In this literature we studied different approaches of cluster head selection based on distance, energy and other parameters.
4. Another problem we studied is the localization of nodes. The node placement in different order or based on different topology also affect the network life.
5. These papers show that a network always needs the improvement in QOS in WSN. Lot of work is done in this direction respective to protocol modification etc.

2.2 PROBLEM IDENTIFICATION

- The main problem with SPIN protocol lies in the random selection of cluster heads. There exists a probability that the cluster heads formed are unbalanced and may remain in one part of the network making some part of the network unreachable.
- The proposed work is the improvement over the SPIN. In this proposed work we are trying to improve the network life. In this work, initially when the cluster heads are selected based on the energy and the distance parameters
- Now when the cluster head dies, it is replaced by It will not selected again for the communication.
- The proposed system will improve the network life and total communication over the network.

2.3 PROBLEM STATEMENT

In Wireless Sensor network, Network life time is one of the major concerned areas. In this work, Modification in existing V Leach protocol is done to improve the network life. The cluster head selection is done on the basis of energy and distance parameters. At the same time the Vice Cluster Head is also selected along with Cluster Head Selection. As the cluster head dies it is replaced by Vice Cluster Head and a new Vice Cluster Head is selected. The proposed approaches try to keep the Cluster Heads alive for the maximum time; Because of this the life of network keeps alive for the maximum time and the communication over the network will be increase.

3. PROPOSED WORK

3.1 CLUSTERED ARCHITECTURE

The basic objective on any routing protocol is to make the network useful and efficient. A cluster based routing protocol group's sensor nodes where each group of nodes has a CH or a gateway. Sensed data is sent to the CH rather than send it to the BS; CH performs some aggregation function on data it receives then sends it to the BS where these data is needed.

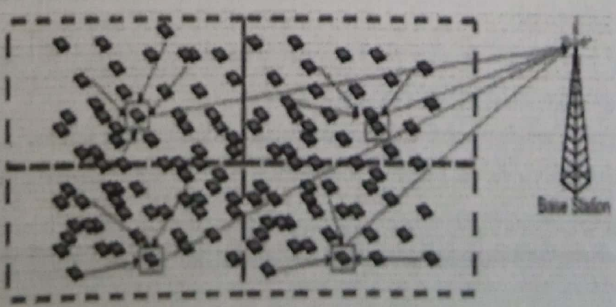

Figure 6: Clustered Architecture

A number of routing protocols have been proposed for WSN. However, few of them are cluster based. One of the most well known hierarchical protocols is LEACH. This show significant reduction in the overall network energy over other non-clustering protocol. Hierarchical routing protocols designed to reduce energy consumption by localizing communication within the cluster and aggregate data to reduce transmissions to the BS.

3.2 CLUSTERING OBJECTIVE

This section present three main objectives that are relevant to the focus of this thesis.

3.2.1 Maximizing network Life-time: Unlike in cellular networks, where mobile gadgets (e.g. phones) can easily be recharged constantly after battery drainage, thus power management in these networks remains a secondary issue. However, WSN is heavily constrained in this regard, apart from being infrastructure-less system; their battery power is very limited. Most of the sensor nodes are equipped with minimal power source; for example the Berkeley's MICA motes are powered by two AA alkaline batteries. Thus, power efficiency will continue to be of growing concern and will remain one of the main design objectives of WSN. In order to cope with energy management in WSN, clustering scheme has been pursued, to extend network life-time and help ease the burden of each node transmitting directly to BS as in conventional protocols like Direct Transmission.

3.2.2 Fault-tolerance: The failure of a sensor node should have a minimal effect on the overall network system. The fact that sensor nodes will be deployed in harsh environmental conditions, there is tendency that some nodes may fail or be physically damaged. Some clustering techniques have been proposed to address the problem of node failure by using proxy cluster-heads, in the event of failure of the original elected cluster-head or have minimal power for transmission. Adaptive clustering scheme is also employed to deal with node failures such as rotating the cluster-head. Tolerating node failure is one of the other design goals of clustering protocols.

3.2.3 Load balancing: Load balancing technique could be another design goal of clustering schemes. It is always necessary not to over burden the cluster-heads as this may deplete their energies faster. So, it is important to have even distribution of nodes in each cluster. Especially in cases where cluster-heads are performing data aggregation or other signal processing task, an uneven characterization can extend the latency or communication delay to the BS.

- Each node communicates only with close neighbor and takes turn to send to base station.
- Each node has the ability to transmit to any other node and to Base Station.
- Assume node have location information about each node.
- The base station is fixed and far from nodes network.
- The sensor nodes are homogeneous and energy constrained with uniform energy.
- In each round all data from all node and transmit to base station.
- Data fusion help to reduce amount of data transmitted between sensor node and BS.

  Transmitting

  ETx (k, d) = ETx- elec (k) + ETx-amp (k,d)

  ETx (k, d) = Eelec*k + ?amp * k* d2

  Receiving

  ERx(k) = ERx-elec(k)
- ERx(k) = Eelec*
- Packet length 2000 bit
- The main idea for each node to receive from and transmit to close neighbors and take turns being the leader for transmission to the BS.
- The nodes will be organized to form chain which can either be accomplished by sensor nodes themselves using greedy algorithm starting from some node, the BS can compute this chain and broadcast it to all sensor nodes.
- When a node dies, the chain reconstructed in the same manner to bypass the dead node.
- Nodes take turns transmitting to the BS and we will use node number I mod N (N represents the number of nodes) to transmit to the BS in round i.

- The leader in each round of communication will be at a random position on the chain.
- We can use simple control token passing approach initiated by leader to start the data transmission from the ends of the chain.
- Each node will use its neighbor's data with its own to generate a single packet of the same length and then transmit that to its other neighbor.
- Each node will receive and transmit one packet in each round and be the leader once every 100 rounds.

Algorithm

1. Define the Weightage to the distance respective to energy consumed.
2. While Selection of Next Node find
   a. Distance*Ei depending on Range
   b. Check Energy-Distance*Ei >Threshold
   c. Check For Loop Back.
3. If LookBack(True)
   a. Then
1. Discard that node.
4. If Energy-distance*Ei <Threshold
   a. Then
1. Discard that Node.
5. Find the Node having
   i. Minimum Energy Consumption respective to Distance.
   ii. Will Have Max Energy After Transmission.
   iii. Not performing the loop.
6. Move to Next Node Respective to Above Parameters.

4. SIMULATION & RESULTS

In simulation we evaluated the performance of improved protocol in terms of network lifetime, number of dead nodes, and number of alive nodes in comparison with existing protocol. The results of modification we done in Spin Protocol and perform the comparison with existing spin protocol.

4.1 SIMULATION

Life time of network related to number of alive nodes, number of dead nodes, and rate of packet transmission and how long time cluster of nodes is formed in network. System which is proposed here gives good output in all four parameters.

Following are the assumptions we used for simulation:

n	=	100
P	=	0.1;
Eo	=	0.5;
ETX	=	50*0.000000001;
ERX	=	50*0.000000001;
Efs	=	10*0.000000000001;
Emp	=	0.0013*0.000000000001;
EDA	=	5*0.000000001;
EDA	=	5*0.000000001;
a	=	1;
rmax	=	5000;
do	=	sqrt(Efs/Emp);

We have take all these values and find that there are less dead nodes and more alive nodes in proposed system. Also rate of packet transmission is enhanced and due to more alive nodes cluster formation process is ensue for a long time which tends to increase life time of wireless sensor network. Modified system output shows improvement in four areas.

- There is less number of dead nodes.
- Number of alive nodes is enhanced.
- Packet transmission to base station occurs frequently.
- Even in last round clustering process is going take place.

4.2 RESULTS

The result refers to the measurement of network life time. Figure shows the output of existing protocol, modified LEACH protocol and comparison between existing work and modified result.

4.2.1 Results of Scenario 2 (100 Nodes)

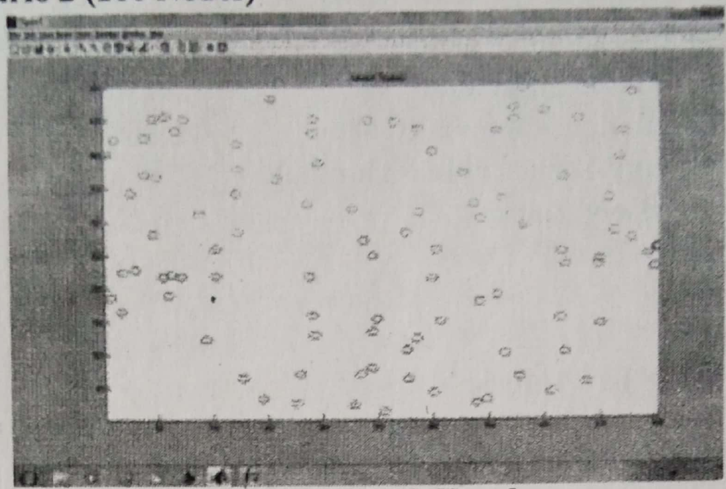

Figure 7: Network Topology

Figure 7 shows a network with 100 nodes and coverage area of 500x500. Here red circles define the nodes and blue nodes represent the receiver nodes.

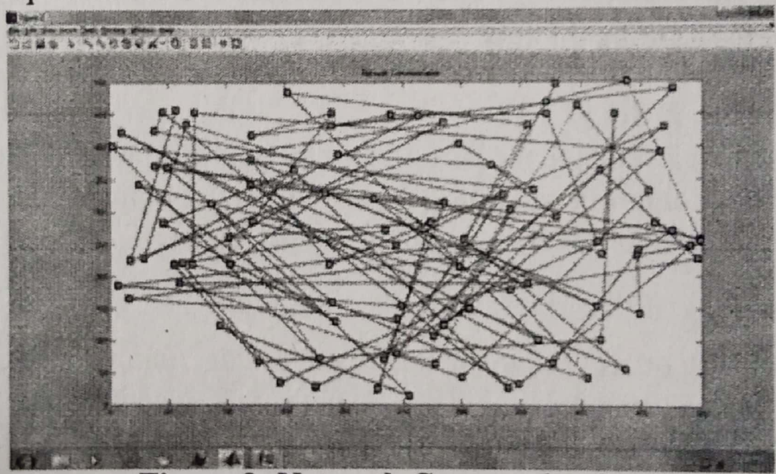

Figure 8: Network Communication

Figure 8 shows the communication over the network. The lines here represent the interconnection between nodes.

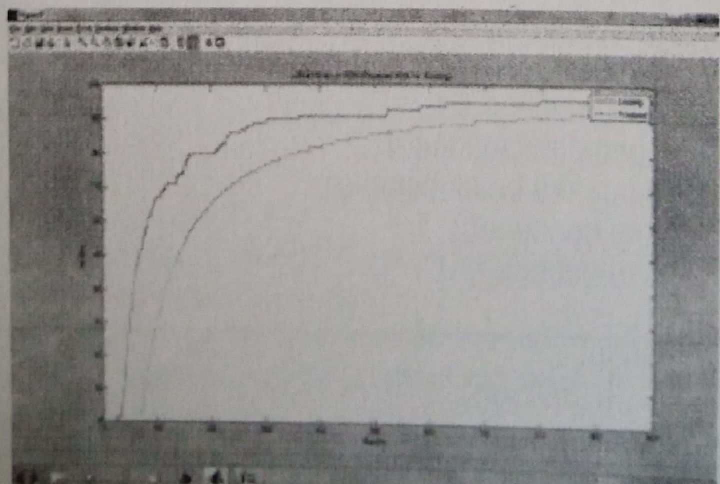

Figure 9: Dead Nodes in WSN (Proposed Work vs. Existing)

Figure 9 shows that the complete network is alive till 20 rounds and after that nodes start losing their life and about 95 nodes are dead after the completion of 1000 rounds in existing spin protocol and that the complete network is alive till 70 rounds and after that nodes start losing their life and about 92 nodes are dead after the completion of 1000 rounds in proposed spin protocol.

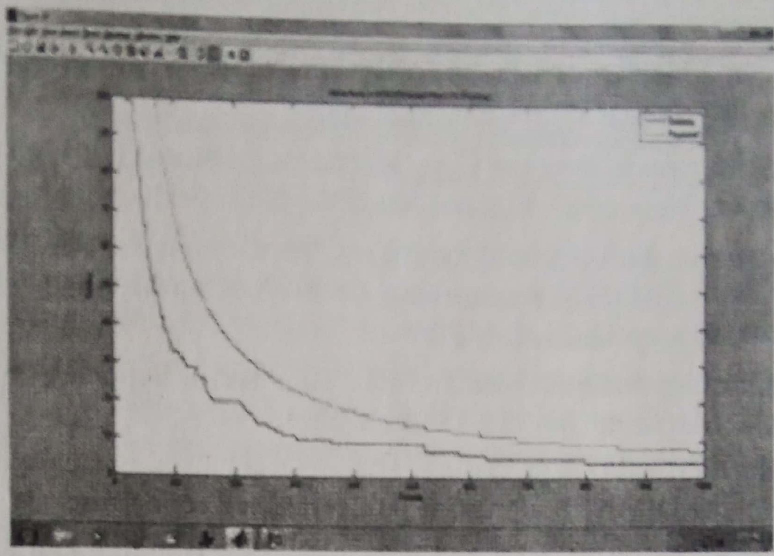

Figure 10: Alive Nodes in WSN (Proposed Work vs. Existing)

Figure 10 shows that the complete network is alive till 20 rounds and after that nodes start losing their life and about 5 nodes are still alive after the completion of 1000 rounds in existing spin protocol and that the complete network is alive till 70 rounds and after that nodes start losing their life and about 8 nodes are still alive after the completion of 1000 rounds in proposed spin protocol.

5. CONCLUSION AND FUTURE SCOPE

5.1 CONCLUSION

The proposed work is implemented on Wireless Sensor network to improve the network life in case of clustered Network. The main problem with cluster network is to find the cluster head for each cluster. Here the improvement is done for Spin protocol. In this work we have include one parameter to select the cluster head and the vice cluster head. This parameter is represented by Ideal Time Analysis. The work has considered the concept of congestion parameter along with effective throughput for that instance. The node will be selected that is working with low congestion and better throughput over the network.

5.2 FUTURE SCOPE

In this work the improvement over the Spin is proposed that will increase the network lifetime and improve the communication over the network. This work is performed on homogenous network. The work can be extended to work on heterogamous network. The heterogeneity will be in terms of type of sensor nodes, environment and the node parameters.

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SRGMS INCORPORATING ERRORS OF DIFFERENT SEVERITY USING CHANGE POINT AND STOCHASTIC DIFFERENTIAL EQUATIONS

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ABSTRACT

Different faults may require different amount of testing efforts and testing strategy for their removal. Some of the existing research incorporates this phenomenon considering that the fault removal rate is different for different types of faults and remains constant during the overall period of testing. However this assumption may not apply in general testing environment in practice. It is a common observation that as the testing progresses the fault detection and/or removal rate changes. The changing testing environment, testing strategy, skill, motivation and constitution of the testing and debugging personnel etc. are some of the major reasons behind this change. Moreover as the size of a software system is large, the number of faults detected during the testing phase becomes large ; the change of the number of faults, which are detected and removed through each debugging, becomes sufficiently small compared with the initial fault content at the beginning of the testing phase. In such a situation, we can model the software fault detection process as a stochastic process with continuous state space. In this paper we propose a general software reliability growth model considering three types of faults in the software system incorporating the effect of changing fault-debugging rate using the change point concept based on type Stochastic Differential Equation.

Keywords: Software reliability growth model, software reliability engineering, non homogeneous poisson process, severity, change point, stochastic differential equation, stochastic process, mean time between failures.

INTRODUCTION

In recent years more and more computers are used in safety-critical applications such as medicine, transportation, and nuclear energy. For a lot of software embedded system, software reliability has been the dominant driver of today's system reliability. It leads to a great demand for high quality software products. However, the poor performance due to unreliable software is exhibited by many systems. To improve the software quality, software reliability engineering balances customer needs for the major quality characteristics of reliability, availability, delivery time, and life cycle cost more effectively. Therefore the software developer attempts to have a tight control over the testing of the software

The SRGM (Software Reliability Growth Model) is a tool of SRE (Software Reliability Engineering), which can be used to evaluate the software quantitatively, develop test status, schedule status and monitor the changes in reliability performance [5]. In the last two decades several Software Reliability models have been developed in the literature to estimate the fault content, failure rate and fault removal rate per fault in software and to predict the reliability of the software at the release time. Most of these are characterized by the mean value function of a NHPP (Non Homogeneous Poisson Process) and utilize historical failure data collected during the testing phase to evaluate the quality of software. It has also been observed that the relationship between the testing time and the corresponding number of faults removed is either Exponential or S-Shaped or a mix of the two [14].

For the estimation of the parameters of the proposed model, Statistical Package for Social Sciences is used. The goodness-of-fit of the proposed models is compared with NHPP based Severity Model using change point [8]. The new proposed models provide significant improved goodness-of-fit results. Section 2 presents the model formulation for the proposed model. Sections 3 give the method used for parameter estimation. Section 4 and Section 5 gives the criteria used for validation and evaluation of the proposed model. We conclude the paper in Section 6.

2. Framework for Modelling

Ohba [12] refined the Goel-Okumoto model by assuming that the fault detection \ removal rate increases with time and that there are two types of faults in the software. SRGM proposed by Bittanti et al. [2] and Kapur and Garg [7] have similar forms as that of Ohba [12] but are developed under different set of assumptions. Bittanti et al. [2] proposed an SRGM exploiting the fault removal (exposure) rate during the initial and final time epochs of testing. Whereas, Kapur and Garg [7] describe a fault removal phenomenon, where they assume that during a removal process of a fault some of the additional faults might be removed without these faults causing any failure. These models can describe both exponential and S-shaped growth curves and therefore are termed as flexible models [8]. Kapur et al [9] describes the implicit categorization of faults based on the time of detection of fault. However an SRGM should explicitly define the errors of different severity as it is expected that any type of fault can be detected at any point of testing time. Therefore it is desired to study the testing and debugging process of each type of faults separately. The mean value function of the SRGM is described by the joint effect of the type of faults present in the system. Such an approach can capture the variability in the reliability growth curve due to the errors of different severity depending on the testing environment.

The models discussed above are derived under the assumption that the fault detection and\or removal rate remains constant over the entire testing period. But during the period of testing, it is observed that the FDR or FRR may not be constant and can change as the testing progresses. The changes in the FDR or FRR can be accounted due to the changes in the testing environment, testing strategy, complexity and size of the functions under testing, skill, motivation and constitution of the testing and debugging team etc. The change in FDR or FRR can be analyzed using the "change point concept". The idea behind the change point concept is that it divides the testing period into subintervals and assumes that during a particular subinterval the testing strategy and testing environment are more or less similar and are slightly different from the other subintervals. The FDR and\or FRR is either assumed to be constant or a function of testing time during each subinterval but varies (constant but different or a different relation to time) from the other subintervals. The concept of change point was started by Zhao [16] who introduced the change-point analysis in Hardware and Software reliability.

2.1 Notations for the Proposed SRGMs using SDE

The number of faults detected during the testing time t and is a random variable
Expected number of faults detected in the time interval (0, t] during testing phase
Expected number of faults identified in the time interval (0,t] during testing phase
Change Points (time from where a change in FRR is observed, i = 1,2,3
Total fault content
Initial fault content of type i faults (simple, hard and complex) i = 1,2,3
Fault removal rate for a fault type i in jth time interval (each time interval corresponding to each change point), i = 1,2,3; j =1,2,...,n
Mean value function of type i faults (simple, hard and complex) i = 1,2,3
Proportion of type i faults in the software's, i =1,2,3
Mean number of fault , i =1,2,3
Positive constant that represents the magnitude of the irregular fluctuations , i = 1,2,3
Standardized Gaussian White Noise , i = 1,2,3

2.2 Assumptions for the Proposed SRGMs using SDE

1. The Software fault-detection process is modeled as a SP (Stochastic Process) with a continuous state space.
2. Failure observation / fault removal phenomenon is modeled by NHPP.
3. Software is subject to failures during execution caused by faults remaining in the software.
4. The number of faults remaining in the software system gradually decreases as the testing procedures go on.
5. Each time a failure is observed, an immediate effort takes place to decide the cause of the failure in order to remove it.

6. The time delay between the failure observation and its subsequent removal is assumed to represent the severity of faults. The more severe the fault, more the time delay.
7. During the fault isolation / removal, no new fault is introduced into the system.
8. The fault removal process is perfect.
9. The fault removal rate per remaining fault of the each type of fault is different and the rate changes with the change point.

2.3 Software Reliability Growth Modelling for Proposed Model

All faults lying in software are not similar. Some of them may be critical from the users point of view i.e. failure due to these faults results in total system failure while others may be critical from the developers point of view in the sense that large amount of testing resources are required for their removal as they are difficult to remove due to complexity of the underlying code. In this paper we have described the severity of faults from the developers view point. Faults are categorized with respect to time they take for isolation and removal after their observation. Faults are classified as "simple" if the time between their observation and removal is negligible else If more efforts and time is required for the removal the fault is classified as "hard fault" and if on the detection of a fault the amount of effort and time required to remove it is much more as compared to hard faults, the faults are classified as complex fault [9]. Applying this type of model to the initial failure data (or past data) gives an idea about the nature of remaining faults and their respective proportions. If this information is made available to the test manager, testing effort can be streamlined to achieve better fault detection and appropriate control can be initiated for a particular category [9]. Here we model the removal phenomenon of the testing and debugging process assuming that the fault removal rate per remaining fault of the each type of fault is different and the rate changes with the change point. $m_i'(t) = b_{ij}\left[ap_i - m_i(t)\right]$ i = 1,2,3; j =1,2,...,n

(2.3.1)

Where
$$bij = \begin{cases} b_{i1}(t) & 0 \le t \le \tau_1 \\ b_{i2}(t) & \tau_1 < t \le \tau_2 \\ \dots & \\ \dots & \\ b_{in}(t) & t > \tau_n \end{cases} \quad (2.3.2)$$

The exact solution of the above model equations (2.3.1) can be obtained on substituting the functional forms of the FRR in (2.3.2) and defining the number of change points based on past data or by the experience. Now the mean value function of the expected total number of faults removed from the system is given as $m(t) = \sum_{i=1}^{3} m_i(t)$ (2.3.3)

Various diverse testing environment and testing strategies existing for different type of software can be analyzed from the above model by choosing the appropriate forms of the fault removal rates (based on the past failure data and experience of the developer). One of the most simple and general case would be the one if we consider FRR for each type of fault in each change point interval to be constant but distinct for each i and j if we observe exponential failure curve growth pattern for each type of fault. However in case of a general purpose software we may expect that the FRR for each type of fault may increase with time as the testing team gains experience with the code and learning occurs and reaches a certain constant level towards the end of the testing phase. The fault detection rate of hard and\or complex faults is slightly less than that of simple fault type. We may also observe a decreasing FRR towards the end of testing phase since most of the faults lying in the software are removed and failure intensity has become very less (see table 2.3.1).

Type of Fault	Simple	Hard	Complex
Time Interval	Fault Detection Rates		
$0 \le t \le \tau_1$	b_{11}	$(b_{21}^2 t)/(1+b_{21}t)$	$(b_{31}^3 t^2/2)/(1+b_{31}t+b_{31}^3 t^2/2)$
$\tau_1 < t \le \tau_2$	b_{12}	b_{22}	$(b_{32}^2 t)/(1+b_{32}t)$
$t > \tau_2$	b_{13}	b_{23}	b_{33}

Table 2.3.1 (Severity of faults with two Points)

Increasing and/or decreasing trend in FRR can be depicted with the time dependent forms of . From the literature study of various fault detection rates used in reliability growth modelling we summarize in the table 2.3.2 an interesting application and develop its model assuming three change points. This type of testing environment and testing strategy is usually seen while testing of safety critical systems.

Type of Fault	Simple	Hard	Complex
Time Interval	Fault Detection Rates		
$0 \le t \le \tau_1$	b_{11}	b_{21}	b_{31}
$\tau_1 < t \le \tau_2$	b_{12}	$(b_{22}^2 t)/(1+b_{22}t)$	$(b_{32}^3 t^2/2)/(1+b_{32}t+b_{32}^3 t^2/2)$
$\tau_2 < t \le \tau_3$	b_{13}	b_{23}	$(b_{33}^2 t)/(1+b_{33}t)$
$t > \tau_3$	b_{14}	b_{24}	b_{34}

Table 2.3.2 (Severity of faults with three Points)

In the beginning of the testing phase the testing team start with some constant FRR for each type of fault with b11 b21 b31 due to motivation of the testing and debugging personnel to remove the critical faults (from users point of view) from the system. After a certain period of time the fault detection rate may increase or decrease due to the various possible changes in the testing process. Here we consider the case when fault detection rate first decreases due to the reason such as addition of new testing personnel, modifications in testing strategy etc. to further improve the overall efficiency of the testing, then start increasing as the testing progresses and the learning occurs ultimately reaching a certain constant level towards the end of the testing phase. For simple faults it is reasonable to assume constant FRR in each change point interval since not much learning testing strategies are applied for their removals. Here it may be noted the above explanation reflects one particular situation, various other possibilities also exist depending upon the testing environment and testing strategies employed.

2.3.1 SDE Framework for Modelling of Proposed SRGMs

Several SRGMs are based on the assumption of NHPP, treating the fault detection process during the testing phase as a discrete counting process. Recently Yamada et. al [15] asserted that if the size of the software system is large than the number of the faults detected during the testing phase also is large and change in the number of faults, which are corrected and removed through each debugging, becomes small compared with the initial faults content at the beginning of the testing phase. So, in order to describe the stochastic behaviour of the fault detection process, we can use a Stochastic Model with continuous state space. Since the latent faults in the software system are detected and eliminated during the testing phase, the number of faults remaining in the software system gradually decreases as the testing procedure goes on. So it is reasonable to assume the following differential equation. $\frac{dN(t)}{dt} = r(t)[a - N(t)]$ (2.3.1.1) where $r(t)$ is a fault-detection rate per remaining fault at testing time t. However, the behavior of is not completely known since it is subject to random effects such as the testing effort expenditure, the skill level of the testers, the testing tools and so on and thus might have irregular fluctuation. Thus, we have $r(t) = b(t) + noise$ (2.3.1.2)

Let be a standard Gaussian white noise and σ a positive constant representing a magnitude of the irregular fluctuations. So equation can be written as $r(t) = b(t) + \sigma\gamma(t)$ (2.3.1.3) Hence, equation (2.3.1.1) becomes $\frac{dN(t)}{dt} = [b(t) + \sigma\gamma(t)][a - N(t)]$ (2.3.1.4)

Equation (2.3.1.4) can be extended to the following stochastic differential equation of a Itô Type [15]

$$dN(t) = \left[b(t) - \frac{1}{2}\sigma^2\right][a - N(t)]dt + \sigma[a - N(t)]dw(t) \qquad (2.3.1.5)$$

where $W(t)$ is a one-dimensional Wiener process, which is formally defined as an integration of the white noise $\gamma(t)$ with respect to time t. using Itô formula solution to equation 2.3.1.5; using initial condition $N(0) = 0$, as follows

$$N(t) = a\left[1 - \exp\left\{-\int_0^t b(x)dx - \sigma W(t)\right\}\right] \qquad (2.3.1.6)$$

The Wiener process is a Gaussian process and it has the following properties:

$P[w(0)=0]=1, \; E[w(t)]=0, \; E[w(t)w(t')]=\min[t,t']$

Yamada et. al [15] consider the case where fault detection rate, $b(t)$ be constant, function of time and logistic function.

In this section we derive the closed form solution of the models discussed above in table 2.3.1 and table 2.3.2.

2.3.1.1 Proposed SRGM1

Here τ_1 is the time point at which fault detection rate increases due to the expertise or efficiency gained by the present testing team, fault density, introduction of skilled testing personnel etc. Further, τ_2 is the time moment by which the testing efficiency gained by the testing team results in the removal of different type of faults with a constant FDR.

Case 1: Simple Faults

Case 1.1 $0 \le t \le \tau_1$

$$m_1'(t) = b_{11}[a_1 - m_1(t)] \qquad (2.3.1.2.1)$$

Solving the equation (2.3.1.2.1) under the boundary conditions at $t=0$, $m_1(t)=0$ we get

$$m_1(t) = a_1\left(1 - e^{-b_{11}t}\right) \qquad (2.3.1.2.2)$$

Case 1.2 $\tau_1 < t \le \tau_2$

$$m_1'(t) = b_{12}[a_1 - m_1(t)] \qquad (2.3.1.2.3)$$

Solving the equation (2.3.1.2.3) under the boundary conditions at $t=\tau_1$, $m_1(t)=m_1(\tau_1)$ we get

$$m_1(t) = a_1\left(1 - e^{-b_{11}\tau_1 - b_{12}(t-\tau_1)}\right) \qquad (2.3.1.2.4)$$

Case 1.3: $t > \tau_2$

$$m_1'(t) = b_{13}[a_1 - m_1(t)] \qquad (2.3.1.2.5)$$

Solving the equation (2.3.1.2.5) under the boundary conditions at $t=\tau_3$, $m_1(t)=m_1(\tau_2)$; considering the equation 2.3.1.6 and Taking Expectations of $N_i(t), i=1,2,3$, we get

$$E(N_1(t)) = a_1\left(1 - e^{\left(\left(-b_{11}\tau_1 - b_{12}(\tau_2-\tau_1) - b_{13}(t-\tau_2)\right) + \frac{\sigma_1^2 t}{2}\right)}\right) \qquad (2.3.1.2.6)$$

Case 2: Hard Faults

Case 2.1 $0 \le t \le \tau_1$

$$m_2'(t) = \left((b_{21}^2 t)/(1+b_{21}t)\right)[a_2 - m_2(t)] \qquad (2.3.1.2.7)$$

Solving the equation (2.3.1.2.7) under the boundary conditions at $t=0$, $m_2(t)=0$ we get

$$m_2(t) = a_2\left(1 - (1+b_{21}t)e^{-b_{21}t}\right) \qquad (2.3.1.2.8)$$

Case 2.2 $\tau_1 < t \le \tau_2$

$$m_2'(t) = b_{22}[a_2 - m_2(t)] \qquad (2.3.1.2.9)$$

Solving the equation (2.3.1.2.9) under the boundary conditions at $t=\tau_1$, $m_2(t)=m_2(\tau_1)$ we get

$$m_2(t) = a_2\left[1 - (1+b_{21}\tau_1)e^{-b_{21}\tau_1 - b_{22}(t-\tau_1)}\right] \qquad (2.3.1.2.10)$$

Case 2.3 $t > \tau_2$

$$m_2'(t) = b_{23}[a_2 - m_2(t)] \qquad (2.3.1.2.11)$$

Solving the equation (2.3.1.2.11) under the boundary conditions at $t=\tau_2$, $m_2(t)=m_2(\tau_2)$ considering the equation 2.3.1.6 and Taking Expectations of $N_i(t), i=1,2,3$, we get

$$E(N_2(t)) = a_2\left[1-(1+b_{21}\tau_1)e^{\left((-b_{21}\tau_1-b_{22}(\tau_2-\tau_1)-b_{23}(t-\tau_2))+\frac{\sigma_2^2 t}{2}\right)}\right] \quad (2.3.1.2.12)$$

Case 3: Complex Faults

Case 3.1 $0 \le t \le \tau_1$

$$m_3'(t) = \left(\left(\frac{b_{31}^3 t^2}{2}\right)\Big/\left(1+b_{31}t+\frac{b_{31}^2 t^2}{2}\right)\right)[a_3 - m_3(t)] \quad (2.3.1.2.13)$$

Solving the equation (2.3.1.2.13) under the boundary conditions at $t=0$, $m_3(t)=0$ we get

$$m_3(t) = a_3\left(1-\left(1+b_{31}t+\frac{b_{31}^2 t^2}{2}\right)e^{-b_{31}t}\right) \quad (2.3.1.2.14)$$

Case 3.2 $\tau_1 < t \le \tau_2$

$$m_3'(t) = \left((b_{32}^2 t)/(1+b_{32}t)\right)[a_3 - m_3(t)] \quad (2.3.1.2.15)$$

Solving the equation (2.2.1.15) under the boundary conditions at $t=\tau_1$, $m_3(t)=m_3(\tau_1)$ we get

$$m_3(t) = a_3\left[1-\left(\frac{1+b_{32}t}{1+b_{32}\tau_1}\right)\left(1+b_{31}\tau_1+\frac{b_{31}^2\tau_1^2}{2}\right)e^{-b_{31}\tau_1-b_{32}(t-\tau_1)}\right] \quad (2.3.1.2.16)$$

Case 3.3 $t > \tau_2$

$$m_3'(t) = b_{33}[a_3 - m_3(t)] \quad (2.3.1.2.17)$$

Solving the equation (2.3.1.2.17) under the boundary conditions at $t=\tau_2$, $m_3(t)=m_3(\tau_2)$ considering the equation 2.3.1.6 and Taking Expectations of $N_i(t), i=1,2,3$, we get

$$E(N_3(t)) = a_3\left[1-\left(\frac{1+b_{32}\tau_2}{1+b_{32}\tau_1}\right)\left(1+b_{31}\tau_2+\frac{b_{31}^2\tau_1^2}{2}\right)e^{\left((-b_{31}\tau_1-b_{32}(\tau_2-\tau_1)-b_{33}(t-\tau_2))+\frac{\sigma_3^2 t}{2}\right)}\right] \quad (2.3.1.2.18)$$

2.3.1.1 Proposed SRGM2

The example suits well to the real time safety critical systems however the testing environment migh not be exactly similar as discussed above but the model can be modified accordingly (see table 2.3.1) Here we observe at time τ_1 fault detection rate shows a decrease due to addition of new testing personne modifications in testing strategy, fault density etc carried to further improve the efficiency of the testin team. Then at time moment τ_2, fault detection rate starts increasing as the testing progresses due to th learning of the testing team and ultimately reaching a stable value after τ_3. Proceeding in the sam above manner we get equations for Proposed SRGM2. Mathematical work has been left for the reader

Case 4: Simple Faults

$$E(N_1(t)) = a_1\left(1-e^{\left(\left(-b_{11}\tau_1-b_{12}(\tau_2-\tau_1)-b_{13}(\tau_3-\tau_2)-b_{14}(t-\tau_3)\right)+\frac{\sigma_1^2 t}{2}\right)}\right) \quad (2.3.1.2.19)$$

Case 5: Hard Faults

$$E(N_2(t)) = a_2\left[1-\left((1+b_{22}\tau_2)/(1+b_{22}\tau_1)\right)e^{-b_{21}\tau_1-b_{22}(\tau_2-\tau_1)-b_{23}(t-\tau_2)}\right] \quad (2.3.1.2.20)$$

Case 6: Complex Faults

$$E(N_3(t)) = a_3\left[1-\left(\frac{1+b_{32}\tau_2+\frac{b_{32}^2\tau_2^2}{2}}{1+b_{32}\tau_1+\frac{b_{32}^2\tau_1^2}{2}}\right)\left(\frac{1+b_{33}\tau_3}{1+b_{33}\tau_2}\right)e^{\left((-b_{31}\tau_1-b_{32}(\tau_2-\tau_1)-b_{33}(\tau_3-\tau_2)-b_{34}(t-\tau_3))+\frac{\sigma_3^2 t}{2}\right)}\right] \quad (2.3.1.2.21)$$

2.4 Modelling Total Fault Removal Phenomenon

The total fault removal phenomenon of the proposed SRGMs is given by the sum of the mean valu function of the simple, hard and complex faults. Thus, the Expected mean value function of superimpose NHPP is

$$E(N(t)) = E(N_1(t)) + E(N_2(t)) + E(N_3(t)) \quad (2.4.1)$$

Which implies

$$E(N(t))=a_1\left(1-e^{\left(\left(-b_{11}\tau_1-b_{12}(\tau_2-\tau_1)-b_{13}(t-\tau_2)\right)+\frac{\sigma_1^2 t}{2}\right)}\right)$$
$$+a_2\left[1-(1+b_{21}\tau_1)e^{\left(\left(-b_{21}\tau_1-b_{22}(\tau_2-\tau_1)-b_{23}(t-\tau_2)\right)+\frac{\sigma_2^2 t}{2}\right)}\right]$$
$$+a_3\left[1-\left(\frac{1+b_{32}\tau_2}{1+b_{32}\tau_1}\right)\left(1+b_{31}\tau_2+\frac{b_{31}^2\tau_1^2}{2}\right)e^{\left(\left(-b_{31}\tau_1-b_{32}(\tau_2-\tau_1)-b_{33}(t-\tau_2)\right)+\frac{\sigma_3^2 t}{2}\right)}\right] \quad (2.4.2)$$

for the Proposed SRGM1 and

$$E(N(t))=a_1\left(1-e^{\left(\left(-b_{11}\tau_1-b_{12}(\tau_2-\tau_1)-b_{13}(\tau_3-\tau_2)-b_{14}(t-\tau_3)\right)+\frac{\sigma_1^2 t}{2}\right)}\right)$$
$$+a_2\left[1-\left(\frac{1+b_{22}\tau_2}{1+b_{22}\tau_1}\right)e^{\left(\left(-b_{21}\tau_1-b_{22}(\tau_2-\tau_1)-b_{23}(\tau_3-\tau_2)-b_{24}(t-\tau_3)\right)+\frac{\sigma_2^2 t}{2}\right)}\right]$$
$$+a_3\left[1-\left(\frac{1+b_{33}\tau_3}{1+b_{33}\tau_2}\right)\left(\frac{1+b_{32}\tau_2+\frac{b_{32}^2\tau_2^2}{2}}{1+b_{32}\tau_1+\frac{b_{32}^2\tau_1^2}{2}}\right)e^{\left(\left(-b_{31}\tau_1-b_{32}(\tau_2-\tau_1)-b_{33}(\tau_3-\tau_2)-b_{34}(t-\tau_3)\right)+\frac{\sigma_3^2 t}{2}\right)}\right] \quad (2.4.3)$$

for the Proposed SRGM2 where

$a_1 = ap_1, a_2 = ap_2, a_3 = a(1-p_1-p_2)$

3. Parameter Estimation

Software reliability engineering produces a model of a software system based on its failure data to provide a measurement for software reliability. Technically, it is more difficult to find the solution for non-linear models using Least Square method and requires numerical algorithms to solve it. Statistical software packages such as SPSS helps to overcome this problem. For the estimation of the parameters of the proposed model, Method of Least Square (Non Linear Regression method) has been used. Non Linear Regression is a method of finding a nonlinear model of the relationship between the dependent variable and a set of independent variables.

4 Comparison Criteria for SRGMs

The performance of SRGMs are judged by their ability to fit the past software fault data (goodness of fit).

4.1 Goodness of Fit Criteria

The term goodness of fit is used in two different contexts. In one context, it denotes the question if a sample of data came from a population with a specific distribution. In another context, it denotes the question of "How good does a mathematical model (for example a linear regression model) fit to the data"?

a. MSE (Mean Square Fitting Error):

The model under comparison is used to simulate the fault data, the difference between the expected values, and the observed data yi is measured by MSE [7] as follows. $MSE = \sum_{i=1}^{k} \frac{(\hat{m}(t_i) - y_i)^2}{k}$ where k is the number of observations. The lower MSE indicates less fitting error, thus better goodness of fit.

b. AIC (Akaike Information Criterion):

The criteria is defined as AIC = -2(the value of the maximum log likelihood function) + 2(the number of the parameters used in the model). This index [1] takes into account both the statistical goodness of fit and the number of parameters that are estimated in competing models. Lower values of AIC indicate the preferred model.

c. Coefficient of Multiple Determinations (R2):

We define this coefficient as the ratio of the sum of squares resulting from the trend model to that from constant model subtracted from 1[7]. i.e., $R^2 = 1 - \frac{\text{residual SS}}{\text{corrected SS}}$ .R2 measures the percentage of the total variation about the mean accounted for the fitted curve. It ranges in value from 0 to 1. The larger R2, the better the model explains the variation in the data.

d. PE (Prediction Error):

The difference between the observation and prediction of number of failures at any instant of time i is known as PEi. Lower the value of Prediction Error better is the goodness of fit [13].

e. Bias:

The average of PEs is known as bias. Lower the value of Bias better is the goodness of fit [13].

f. Variation:

The standard deviation of PE is known as variation.

$$Variation = \sqrt{\left(\frac{1}{N-1}\right)\sum (PE_i - Bias)^2}$$

Lower the value of Variation better is the goodness of fit [13].

g. RMSPE (Root Mean Square Prediction Error):

It is a measure of closeness with which a model predicts the observation.

$$RMSPE = \sqrt{\left(Bias^2 + Variation^2\right)}.$$

Lower the value of Root Mean Square Prediction Error better is the goodness of fit [13].

h. K-S Test (Kolmogorov-Smirnov Test)

The K-S test [4] is a non-parametric test. It tries to determine if two datasets differ significantly. It is based on the Empirical Distribution Function (ECDF). Lower the value of K-S test better is the goodness of fit.

5. Model Validation and Data Description

To check the validity of the proposed SRGMs and to find out their software reliability growth, it has been tested on two data sets. NHPP based Severity Model using change point Since only a few data points are available and the number of unknown parameters is sixteen therefore to yield better estimates we assume

$b_{11} = b_{12} = b_{13} = b_{14} = b_1$ (say), $b_{21} = b_{22} = b_{23} = b_{24} = b_2$ (say), $b_{31} = b_{32} = b_{33} = b_{34} = b_3$ (say) for the proposed models. The fault removal rates for each type of faults in each time interval are now as given in table 5.1-5.2

Type of Fault	Simple	Hard	Complex
Time Interval	Fault Detection Rates		
$0 \le t \le \tau_1$	b_1	$(b_2{}^2 t)/(1 + b_2 t)$	$(b_3{}^3 t^2/2)/(1+b_3 t+(b_3{}^2 t^2/2))$
$\tau_1 < t \le \tau_2$	b_1	b_2	$(b_3{}^2 t)/(1 + b_3 t)$
$t > \tau_2$	b_1	b_2	b_3

Table 5.1 (Severity of faults with two Points)

Type of Fault	Simple	Hard	Complex
Time Interval	Fault Detection Rates		
$0 \le t \le \tau_1$	b_1	b_2	b_3
$\tau_1 < t \le \tau_2$	b_1	$(b_2{}^2 t)/(1 + b_2 t)$	$(b_3{}^3 t^2/2)/(1+b_3 t+(b_3{}^2 t^2/2))$
$\tau_2 < t \le \tau_3$	b_1	b_2	$(b_3{}^2 t)/(1 + b_3 t)$
$t > \tau_3$	b_1	b_2	b_3

Table 5.2 (Severity of faults with three Points)

The above assumption implies that the fault removal rate of simple faults doesn't change over time whereas it changes for the hard and complex faults. For simple faults we may observe that not much learning is required for their removals. However it is difficult to remove hard and complex faults and require more resources for their removal therefore the developer puts more efforts to increase the learning of the testing and debugging team to remove these faults. The locations of change points are identified by plotting the cumulative number of faults versus time. The Proposed SRGMs provides better goodness of fit for both the datasets due to its applicability and flexibility. However, the increased accuracy achieved shows the capability of the model to capture different types of failure datasets. The real time data sets used for estimation are:

DS-1

This data is cited from [11]. The software was tested for 38 weeks during which 2456.4 computer hours were used and 231 faults were removed. The Parameter Estimation result and the goodness of fit results for the proposed SRGMs are given in Table 5.3. The goodness of fit curves for Proposed SRGMs are given in Figure 5.1 and Figure 5.3. In this dataset we have taken for the Proposed SRGM1and for the Proposed SRGM2. Values of p1, p2 and p3 are computed from the actual data set since data was available separately for each type of faults.

DS-2

This data is cited from [3]. The software was tested for 12 months during which 2657 faults were removed. The Parameter Estimation result and the goodness of fit results for the proposed SRGMs are given in Table 5.4. The goodness of fit curves for the Proposed SRGMs is given in Figure 5.2 and Figure 5.4. In this dataset we have taken for $\tau_1 = 4$ *and* $\tau_2 = 10$ the Proposed SRGM1and $\tau_1 = 3, \tau_2 = 5,$ *and* $\tau_3 = 11$ for the Proposed SRGM2.

Here it can also be seen that $b_1 > b_2 > b_3$ as the testing teams have to spend more time to analyze and remove the cause of failure of hard and complex faults and therefore require greater efforts to remove them as the faults in the components comprising a complete software can be of different severity. For SRGM 1 and SRGM 2 the fluctuation level is high in newly developed components as compared to reused components because the cumulative number of detected faults is an exponential curve when a software system consists of several used software components (the growth is uniform); while on the other hand; the cumulative number of faults is described by an s-shaped growth curve when the newly developed software components are used (the growth is not uniform, it is irregular).

Table 5.3: for DS-I (Misra 231 faults)

Models under Comparisons	Parameter Estimation									
	a	b_1	b_2	b_3	p_1	p_2	p_3	σ_1	σ_2	σ_3
Proposed SRGM1	301	.060	.024	.017	.59	.23	.17	.02	.23	.27
[8]	293	.050	.018	.012	.64	.34	.017	-	-	-
Proposed SRGM2	265	.053	.040	.026	.56	.28	.019	.05	.17	.24
[8]	260	.049	.030	.010	.64	.34	.017	-	-	-

Table 5.3: for DS-II (Continued)

Models under Comparison	Comparison Criteria						
	R^2	MSE	AIC	Bias	Variation	RMSPE	K-S Test
Proposed SRGM1	.99571	85	165	-1.54	8.54	8.59	.97
[8]	.97224	103	197	-1.86	10.11	10.28	.109
Proposed SRGM2	.99856	57	146	-0.024	6.67	6.69	.072
[8]	.98051	72	194	-1.61	8.46	8.61	.096

Table 5.4: for DS-II (Brooks & Motely 2657 faults)

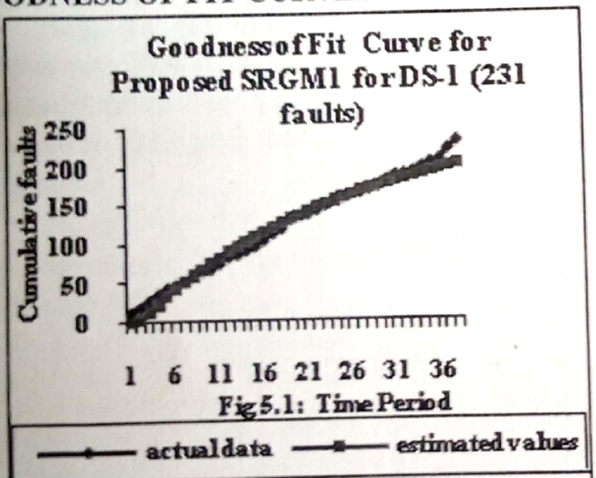
Models under Comparisons	Parameter Estimation									
	a	b_1	b_2	b_3	p_1	p_2	p_3	σ_1	σ_2	σ_3
Proposed SRGM1	3289	.176	.089	.048	.78	.17	.06	.04	.32	.43
[8]	3227	.158	.097	.012	.07	.34	.017	-	-	-
Proposed SRGM2	3331	.19	.12	.065	.93	.27	.08	.08	.27	.68
[8]	3289	.176	.089	.048	.78	.17	.06	-	-	-

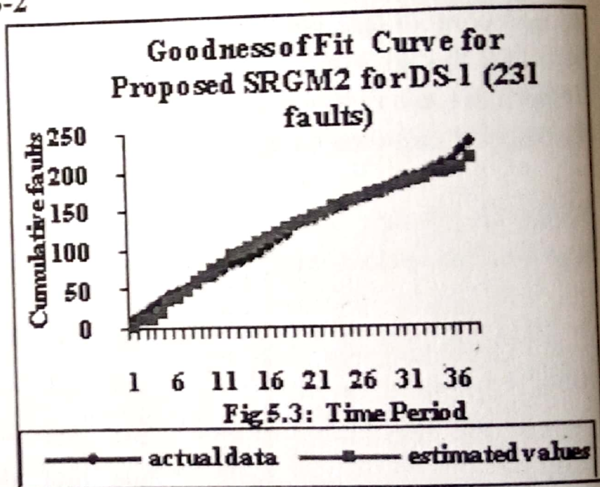
Table 5.4: for DS-II (Continued)

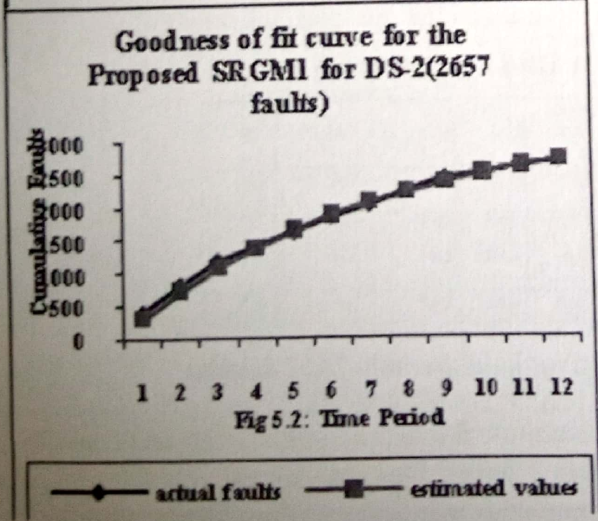
Models under Comparison	Comparison Criteria						
	R^2	MSE	AIC	Bias	Variation	RMSPE	K-S Test
Proposed SRGM1	.99695	2670	170	-2.104	32.56	32.59	.321
[8]	.99332	3278	195	-4.97	42.42	58.67	.504
Proposed SRGM2	.99878	2156	154	-1.032	27.34	27.38	.245
[8]	.99525	2330	185	-3.96	43.76	49.89	.467

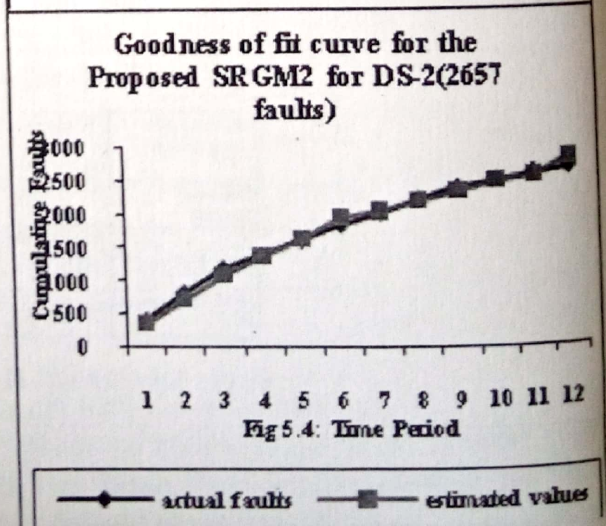
The curves given below in Figures 5.1-5.4 reflects the initial learning curve at the beginning, as test members become familiar with the software, followed by growth and then leveling off as the residual faults become more difficult to uncover.

GOODNESS OF FIT CURVES FOR DS-1 & DS-2









6. Conclusion and Future Scope

In this paper we propose a general software reliability growth model considering three types of faults in the software system incorporating the effect of changing fault-debugging rate using the change point concept based on type Stochastic Differential Equation. The results obtained show better fit and wider applicability of the model to different types of failure datasets due to the flexible nature of the proposed SRGMs higher degree of accuracy and wider applicability. It makes the models adaptable to any type of software dataset say Exponential, S-Shaped type. The higher level of accuracy and better predictability for the reliability of the software being tested makes the model quite valuable for the situations where safe and risk free operation of the system are the high priority. The usability of SDE is not only restricted to the models described in this paper but it can also be extended to improve the results of any other SRGM. The Proposed Model can also be used incorporating error generation and various Testing Effort functions.

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ABSTRACT

India is the second largest populated country in this world and has wealthy financial institutions; there are 21 public sector banks, 23private banks and 36 foreign banks besides a large number of cooperative banks and rural banks etc. Indian banking is well matured and serves common men through multiple banking channels and products. At present, coverage of banking across the population cannot be determined because of multiple accounts in different banks. Some of the customers have multiple bank accounts because of the standing instructions with old account or mandate to have an account in specific bank. But that could change quickly if Bank Account Number Portability (BANP) were to become reality. The goal of BANPis to enable customersmove their bank accounts seamlessly from one bank to another, and thereby save them the hassle of closing and opening accounts, reissuing standing instructions, and so on. However, for it to work, BANP requires all banks to adopt a standardized practice of account numbering, indicating the bank and code number of the branch owning the account. This is already the case in some countries of Europe and North America. But other countries, which follow a different system of account numbering, will need to spend massive effort and resources to change. It is doubtful if they will bewilling to do so. But if implemented successfully, bank account number portability couldwell bethenext gamechanger.

Keywords: Bank Account Number Portability (BANP), Know Your Customer (KYC), Mobile Number Portability (MNP), Reserve Bank of India (RBI), Permanent Account Number (PAN).

INTRODUCTION

The idea is to save customers the inconvenience of opening and closing bank accounts or keeping multiple accounts if they have to shift to a new location or find their bank's services unsatisfactory.

"We have started preliminary discussions with the RBI and banks, and they are on board. Bank account number portability will allow a migrant worker to shift his account from one bank to another simply by writing an application to his home branch," said a finance ministry official, adding the move might take another three years or so to materialize. The banks may not need much preparation on the technology front, as already some services (like ATMs) are integrated and most banks are fully on the core banking system.

However, the biggest challenge before the government is security. A lapse on the part of a bank in following KYC norms can pose threats to national security and client confidentiality. There could be customers switching banks too frequently to escape the Prevention of Money Laundering Act. The official said all such aspects would be considered. With the deregulation of interest rates on saving deposits, customers will have the choice of switching to a bank offering higher rates without much paper work.

Bank account number portability is being introduced in different forms in countries such as Sweden, the UK, Australia, Hungary and South Africa. After successful implementation ofMobile Number Portability (MNP) and changing service providers for Health Insurance, people may soon taste another portability called Bank account Number Portability (BNP). The concept has been made overture by Govt. of India for wide discussion in the society. BNP allows customers to switch one bank account to another without changing their account numbers. The finance ministry has started discussions with the Reserve Bank of India (RBI) and banks, including private sector lenders, to assess the feasibility of introducing the move over the next few years.

If you are troubled by a bank's service and its terms, you are free to use the same account number with another bank. You will be able to transfer your account to the bank you want. The Ministry of Finance's disclosed its intention to implement bank account number portability. Finance Ministry and Reserve Bank have agreed on it. Reserve Bank has begun to consider the draft.

Mobile number and health insurance is already in operation and has been reported very success. Recently, the Finance Ministry, banks are allowed to set interest rates on savings accounts. This will increase competitive. Prior implementation, opinions from public and private banks will be considered too. Government wants the bank account portability draft will be ready by December, so it can be applied in December or January. However, senior officer of a public sector bank that is not fair to apply it in a hurry.

In a step towards this direction, all banks will be asked to follow common KYC (know-your-customer) norms. An expert committee will be formed to explore it further and prepare a report. BNP introduced due to the inconvenience occurred one's move from one place to another location or unsatisfactory services of the banks.

Due to change of city, individuals are under some circumstances like if bank's branch is not nearby the residence and if employer is not having account in similar banks desired by employee, customers are required to open one more account. The account portability will reduce the forced opening of new account.

The account portability across the banking world in India will facilitate the customers to retain same account number after changing the banks/cities and enjoy the facility of automated banking with entire standing instructions without any extra efforts. It will also facilitate the customers to select the best service provider with suitable pricing and maximum benefits by paying minimum rent and charges.

BACKGROUND AND CONTEXT

The customers are happy to get facility of automated banking transaction and most of the banks are now providing it to pay utility bills, insurance payments etc. Similarly all market investments need to be linked with a savings bank account. In case of change of account number it has to be informed to the standing creditors/debtors as well as register the new account with investment agencies. Change of account number needs to be informed to bill/ insurance agencies. There are several studies that have discussed about the selection of branch location (See Denton and Chan, 1991; Kennington, et al., 1996; Zineldin, 1996, 1997; Gerrard and Cunnigham, 1997; Ta and Har, 2000; Almossawi, 2001; Lee and Marlowe, 2003). Citizens Charter (2012) permitted the customers to quit the branch only if the bank is same. Presently, few banks are allowing this and most of the banks are allowing it but account number has changed with the change of branch.

REASONS OF BANP PORTABILITY

In case of portability between two banks still an issue for policy makers. I have observed some key issues in this regards some of them are listed below:

Change of location

After the globalisation, economic growth of India helped to get employment as well as change of employer easily. Few customers are regularly changing the working place. Because of change of employer or transfer to another city, customer needs to start new banking relations. The change of bank becomes essential if employer has account in different bank or new location does not have the bank of existing account. Change of city gives one more challenge to the customers to produce the KYC documents and they are embarrassed sometimes especially for address proof.

Dissatisfaction

With the significant contribution of information technology, banks have started a number of facilities like internet banking, ATM services, phone banking, mobile banking etc. Whether all these banking channels are giving satisfactory services or not are an important issue while opting for banks. When a bank fails to satisfy the customer, the customer thinks to quit the bank. The literature on criterion of banking selection shows the cost-benefits, service delivery, size and reputation, staff factors, convenience etc plays important role in selection of bank.

Product features

Banks are service providers to give secure environment for deposit of surplus fund and do the payments. These services are done by banks through several channels and several products by establishing good business relationship. There are several studies that the business relationship depends on the product features, till features of the product will satisfy the customer's requirements, they continue with the bank. When bank will not be able to give the product that can satisfy customer's requirement s/he will quit the bank. One more issue also promotes the customer to quit the banks if associated rent/ charges with banking product are more in comparison to other market players.

KYC

Banking, investment and insurance activities always ask for documentary proof of KYC before starting the business relations (KYC/AML norms (2012). In existing banking system the proof of KYC is with servicing branch. When account will be ported from one bank to another bank, which bank will be liable for KYC compliance? Should the copy of KYC proof be stored in old serving bank or should it be transferred to new bank will be the first question before implementation of account portability. Should new bank believe on old serving bank's KYC proof or request for new submission, will be a crucial question. In present banking system resubmission of proof of address is a mandatory requirement. Someone may raise issues with the existing account's enclosures. In-boarding bank may ask for clarification and out-boarding banks should be bound to produce the clarification. The authority/central bank should give clear guidelines in this regards. AML and

Different digits account number

Presently, banks are following different digits account number ranging from 7 digits to 18 digits. Success of account portability depends on same numbers of digits in the account number. Before starting the account number portability it has to be mandated that bank account should be in unique format. In practice the account number should reflect the bank and branch with account number. After account portability, account number must be unique and bank code will modify. Banks and branch code differs from bank to bank. It will be a hurdle for portability. Authority/central bank should deregulate payment routes as the change of bank and branch will automatically be updated with the linked credit/debit instruction.

Dues and promotional offers

Banks are regularly charging for additional banking services like Locker facility, credit account (negative balance) with the old banks account. After portability request, bank will have right to recover the loss or not, will be a regulatory issue. Sometimes banks give promotional offers with the account number as a result of presumed long-term relationship. When a customer quits the bank after availing the promotional offer, as the bank may recover the charges by other long term banking services, how bank will recover these. How will bank be permitted to charge these? Similarly, when an existing customer requests for promotional offers but not yet reimbursed who will take care of liabilities with the promotional offers. One regulatory authority will be required to take care of the dues and doubts between banks.

SUGGESTED SOLUTION

This goal can be achieved by followings ways:

Unique account number

The unique account number of customers will be easiest way of bank account portability. By submitting the request to the old and new bank, customer will change the bank/branch. As the banking transaction will be only based on the account number and related entities like bank, branch may be developed within the centralized server so common man need not use the bank information and banking should be done.

For example, there is a customer Mr. X who wants to quit bank-1 (out-boarding bank) and join bank-2 (inboarding bank). Mr. X will submit the request to bank-2 that will pass the request to bank-1 and communicate the information to central server. After accepting the portability of Mr. X, bank-1 will transfer the all entities to bank-2 and inform it to the central server. In this system centralised server is basic requirement and routing will be done through it.

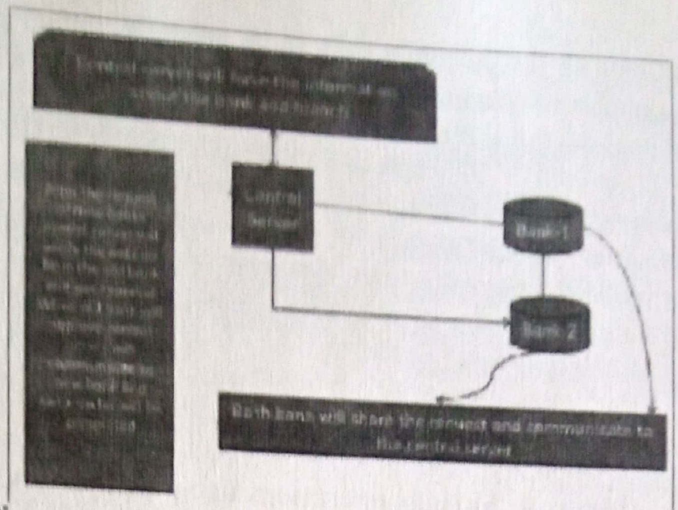

Figure 1: Central Server Sharing Data among Banks

ADHAAR of unique identity number

As in India, banks are following different pattern of account number so the account portability is not possible. In this case one possibility is there to develop a system by which the banking should be continued even the change of bank assigned new account number. Banking transaction will be routed through unique identity like.

ADHAAR number, PAN number etc or some other unique number will be assigned by some authority. The unique number will associate all savings bank account number. Here, all payment will be routed through unique number; the flow will be Payee [Bank A/C → Customer's Unique Number] →Receivers [Customer's Unique Number → Bank A/c]. In this case with the NEFT/RTGS flow unique identity number will come in picture. All account ill be associated with this unique identity number. Simply I can say that the face of the payment will be unique identity number. The multiple accounts in different bank will be permitted but the structure for standing instruction, which will be routed through the unique identity number. The facilitation of multiple accounts for standing instruction will not be permitted in this system. The structure is given below:

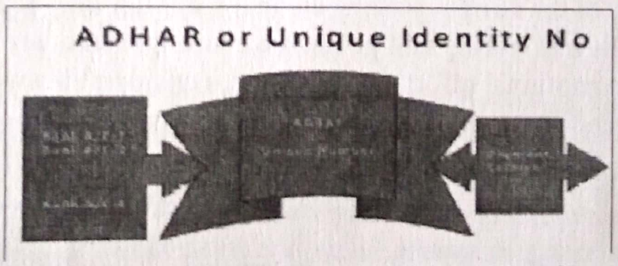

Figure 2: Adhaar as Unique Identity No

This structure will help the customer not to communicate to different agencies for the payment. S/He has to inform the repository authority and associate the new account for future services.

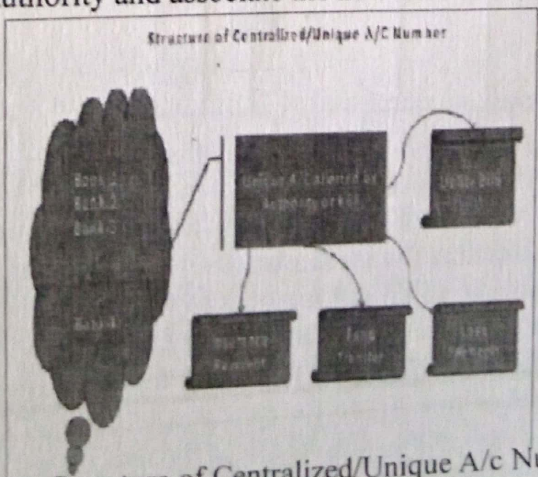

Figure 3: Structure of Centralized/Unique A/c Number

This system will facilitate to the customer with more secure payment gateway because the unique number be a valid source for the payment with already registered agencies.

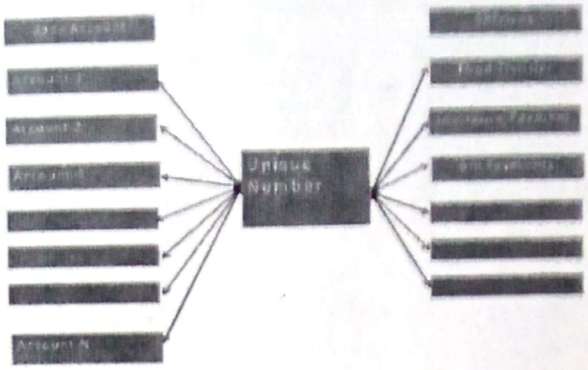

Figure 4: Various operations using Unique Number

This will provide continue KYC verification because unique number will also provide the proof of KYC at the time of transaction. After the portability, new account will be assigned with the unique number. Her/His, banking will be routed through the unique identity number which will be same always but the other banking entities will be changed.

COST-EFFECTIVE SWITCHING ARRANGEMENTS

Existing switching arrangements

Although not widely known, a formal switching scheme was established in Australia in late 2008. Its stated aim was to make it easier for customers to switch their transaction accounts among financial institutions, and provide a boost to competition in the process. The scheme covers the transaction accounts of banks, building societies and credit unions. As noted earlier, these accounts hold readily accessible funds and can be used to make payments of various kinds, as well as to make direct debits and receive direct credits. The scheme does not extend to term-deposits, and nor does it bear directly on the switching of mortgages. (To the extent customers find it convenient to keep all their banking products with one provider, easier switching of transaction accounts might indirectly assist some customers to switch mortgage accounts also.)

Other features of the current scheme are that it applies only to retail customers and not to small business customers. Its monitoring and governance arrangements are also somewhat vague and it has not received much promotional effort. As discussed, considerable switching of accounts has occurred since 2008 but the schemes' contribution has been miniscule — less than 6000 switches have been executed through the scheme since its inception.

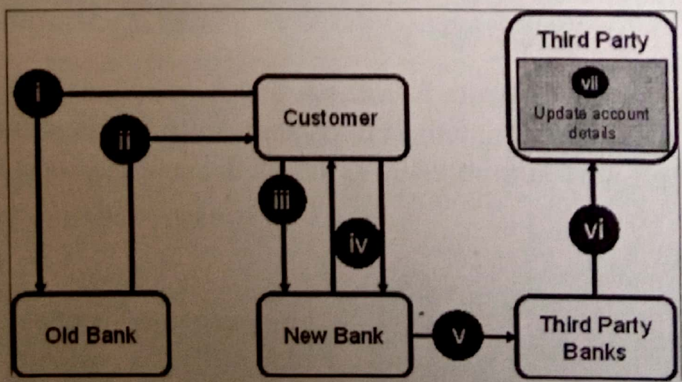

Figure 5: Relationship among various channels

The steps involved in accessing the service are shown in Diagram 1 and verbalized below:

1. A customer intending to switch institutions informs the existing institution of this intent, and requests a list of all direct debits and credits pertaining to the account in question;
2. The existing institution is obliged to provide that list to the customer within five working days;
3. The customer takes this list to the new institution and requests that institution to effect the transfer of any direct debits and credits to the new account;

4. The new institution provides the customer (in person, or by electronic means or mail) with an authorisation form or letter for each direct debit or credit that the customer wants moved across to the new account —the customer is responsible for signing each of these letters and returning them to the new institution for the switch to proceed;

5. In the course of affecting the transfers by the new institution, the various institutions of the third parties associated with the direct debits (for example, billers and merchants) and direct credits (for example, employers) are made aware of the customer's switched transaction account. (These third party financial institutions are involved in this process because of their direct relationships with the third parties. APCA retains a record of all these third parties and their relevant financial institutions, which all financial institutions can access.);

6. Those institutions then notify the third parties (their customers) of the switch in accounts; and the third parties update their customer details to ensure that they debit or credit the customer's new account.

7. The steps involved in the revamped scheme are sketched in Diagram 2. In short:

8. The customer requests the chosen new institution to switch the relevant transaction account from an existing institution, and signs a single form authorizing the new institution to facilitate the switch on their behalf (including the transfer of associated direct debits and credits);

9. The acquiring institution sends a request to switch to the customer's current provider through the proposed APCA mailbox (see below) and requests details of relevant direct debits and credits;

10. The current institution provides these details to the acquiring institution, again through the APCA mailbox, within an agreed time frame;

11. As under existing arrangements, the acquiring institution informs the institutions of the third parties (that is, the initiators of the direct debits and credits) and the customer that the switch has occurred;

12. The institutions of the third parties inform those third parties of the switch; and

13. The third parties adjust their account details accordingly.

Particularly steps (i) and (ii), should be viewed in the light of the letter dated 9 June 2011 from the CEO of APCA; a copy of this helpful letter is attached (Attachment 1). APCA manages a number of payments clearing systems and has been discussing with its members (which include banks, building societies and credit unions) possible enhancements to its systems to empower the customer's new provider to better manage switching.

The APCA proposal envisages the development of a switching 'mailbox', a convenient and secure electronic means through which a customer's new institution could request details of direct debits and credits and the customer's existing institution could similarly provide that material quickly and efficiently. In other words, the mailbox would allow financial institutions to both make and respond to requests for relevant details of direct debit and credit arrangements of customers switching their transaction accounts. APCA estimates that its work on the project would take about six months to complete and cost it about $250,000; some additional spending — unquantifiable at this time but likely to be modest — would be required by participating financial institutions on changes to their back-office and processing arrangements.

A WAY FORWARD & RECOMMENDATION

Switching arrangements of the kind outlined in this research paper, are practical and relatively straight-forward. They could be implemented within Australia's existing payments system infrastructure, which is likely to remain in place for some years yet. They would be customer-friendly and could help to nudge hesitant switchers into action. They would avoid heavy costs to industry, and deliver a better alignment of incentives between acquiring and losing institutions. Judging from the views expressed during the consultative process there would appear to be a good measure of support among stakeholders generally to move in the direction proposed, subject (not unreasonably) to the satisfactory resolution of the detail surrounding a number of issues. The list of issues requiring further consideration is quite a long one and includes the following:

1. The design of a single form which the customer would use to authorise the acquiring institution to initiate and conduct the switching process. This is a key part of the proposal and raises several matters. Customers, institutions and billers and other third-parties would all need to agree

form which would adequately protect their various legal, security and privacy interests. Other countries have got to this point in their schemes.

2. The nature of industry's commitment to the proposed arrangements. If a new scheme is to be implemented there should be a clear commitment from industry participants that they support the scheme and will cooperate to make it work effectively. One option would be to incorporate a section on the new switching arrangements in the codes of practice that are already in place for the banks and (separately) for credit unions and mutual building societies. Alternatively, a separate, stand-alone code confined to the new scheme could be formulated and endorsed by all participating institutions, with inputs from regulators, consumer bodies and biller groups.

RECOMMENDATION

Against the background of the fore-going discussion, it is recommended that:

1. Arrangements be made for the prompt release of this report; and
2. That release be accompanied by a preliminary response to the effect that:

While many details remain to be settled, there appears to be merit in account switching arrangements of the kind proposed in this research paper;

1. A Working Party — to be led by Treasury — be established and will consult widely with all stakeholders to consider and resolve the outstanding issues; and
2. The Working Party will be asked to complete its task within nine months so that new arrangements can be implemented and be operative not later than 1 July 2012.

ADVANTAGES OF BANP

The account portability will develop competitive environment for improvement of Indian banking system. Customer will be able to retain his/ her account number after changing their working place, employment, bank etc. Benefits of account portability are listed below:

Maximum benefits

At present, customers are having multiple accounts and always lose some benefits because of minimum balance, different interest rates etc. After the successful implementation of account portability, customer can get maximum benefit with minimum savings. In savings bank account customer is always concerned about the associated benefits like interest rate, service charges etc. After the bank account portability, the customer may opt for the bank who is offering better benefits like interest rates, minimum quarterly/monthly balance, service charges etc.

Better facilitation of the customers

In case of unsatisfactory service, customer may request for the change of bank. Savings bank portability will facilitate the customers to retain the same account number for banking activities, whereas all entities and banking activities will be continued without any extra efforts. If banks are not serving fine or another bank puts forward better benefits to the customer then customer has a right to switch the bank without losing identity of bank account.

Saving of resources

As we all know, India is the second most populated country in this world. All banking account requires maintenance cost and after the core banking and IT interference, bank account is managed at the data center, data warehouse. Obviously, every account appears as separate entity and it aids the digital world and increases the data centre cost as well as consumes more natural/ electrical resource of country. After the bank account portability, the growth of unnecessary or unused account shall be minimized, which will save the national resources like men power, space, electricity, administrative monitoring etc.

Better pricing

Account portability will improve the Indian banking system as it is more oriented about the customer benefits. It will bound the banking players to have the pricing with emotions that customer will be more benefited as well as rent/charge will be minimum in respect to other market players. Sometime pricing depends on the profit of the organization so common men do not get the best pricing. After the acceptance of saving bank account portability, the customer will be in the position to decide freely the banking partner with best pricing.

DISADVANTAGES OF BANP

The banks account portability will facilitate the customer to retain their bank account identity but raise some critical issue; some of them are listed below:

Temporary restrictions

The financial activities are regular activities and after the ATM/internet banking, it became 24X7X60X60, every second you can do the banking transaction. In the case of hacking attacks, bank reviews the account security and sometimes they block the account for time being. After the portability, one person may have only one account and this temporary restriction will not happen because person needs the banking services which are blocked by bank, for customer it will be infuriating.

Cross marketing

The cross marketing will be encouraged after the account portability and sometimes it will start ill competition in the market. Marketing competitor may use account portability for defaming others and start some hidden policy to capture the other bank's customers. In this instance issues and obligations between market players will be increased.

Customer viciousness

Sometimes customers force the serving body to accept their demands otherwise they will defame the bank. Account portability will provide an instrument to force the bank for her/his acceptance even s/he is claiming extra ultimatum. Other market player may enjoy the situation and create an ill marketing strategy which will disturb the banking community as well as regulator of Indian Banking.

CONCLUSION

The major concern of the government is to optimize the use of natural resources and provide the infrastructure to the common man. These views are more important for the highly populated country. India is a country which is the second largest populated country in the world with high population density. The businesses of banks are nurturing through the number of customer and in most of the ways, objective of the banks fulfilled because of multiple banking. Sometimes multiple banking opted by the customers in forced environment or because of standing instruction. The bank account portability is giving challenges to the researchers and banking experts to evaluate present banking account system and possible solution. Present study reviewed existing banking and presented the pros and cons for bank account portability with possible solution for the discussion to the experts and researcher in banking area.

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FLEXIBLE SRGMS USING STOCHASTIC DIFFERENTIAL EQUATIONS

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ABSTRACT
Last decade of twentieth century will be noted in history for incredible growth in information technology. Consequently computers and computer-based systems have pervaded in every aspect of our daily life. While it has benefited society in many ways and increased our productivity, it has made our lives critically dependent on their failure free operation. Successful operation of any computer system depends largely on its software component; therefore it is very important for a software developer to develop highly reliable software systems. One of the most effective ways to develop highly reliable software is to apply methods of software reliability engineering to the development of software process in order to produce fault free software. Defects can creep into the software during any stage of its development process. These faults need to be identified and removed. Over the last several decades, many SRGM (Software Reliability Growth Models) have been developed to greatly facilitate engineers and managers in tracking and measuring the growth of reliability as software is being improved. Several SRGM based on a NHPP (Non-Homogeneous Poisson Process) have been proposed by many researchers. In this paper we develop a class of Generalized SRGMs based on type SDE (Stochastic Differential Equation), which fit on all types of data sets and thus providing better fit and improved predictability over the existing SRGMs. As a software system increases in size, the number of faults detected during the testing phase becomes large ; the change of the number of faults, which are detected and removed through each debugging, becomes sufficiently small compared with the initial fault content at the beginning of the testing phase. In such a situation, we can model the software fault detection process as a stochastic process with continuous state space. In this paper, two new SRGMs based on type of stochastic differential equation have been proposed. In SRGM 1 SDE based generalized Erlang model and in SRGM 2 SDE based generalized Erlang model with logistic error detection function is being considered. The models are validated on real life data sets to show its applicability and it is shown that the proposed models integrated with concept of SDE perform comparatively better than the existing NHPP based models.

Keywords: software reliability growth model, software reliability engineering, non homogeneous poisson process, stochastic differential equation, stochastic process, mean time between failures

INTRODUCTION

Due to the incredible growth in information technology and science, computers and computer-based systems have invaded every sphere of human activity e.g. in nuclear research, telecommunications, space research programmes, aviation, transportation, banking education and health-care etc. With the world of information technology changing at a staggering rate and proliferation of internet, more and more systems are being automated, thus an increase in the dependence of mankind on computers. Though this technology revolution has made our lives better, concern for safety and security has never been greater. There are already numerous instances where failures of computer-controlled systems have led to colossal loss of human lives and money. With increased complexity of products design, shortened development cycles and higher customer satisfaction of quality and highly destructive consequences of software failures a major responsibility lies in the areas of software debugging, testing and verification. Moreover, the competition in the software market is intense and because of the nature of applications involved, purchasers look for quality in terms of reliability of the software. The nature and complexity of software requirements have drastically changed in the last few decades and users all over the world have become much more demanding in terms of cost, schedule and quality.

Computer based systems typically consist of hardware and software. Quality hardware can now be produced at a reasonable cost but the same cannot be said about software. Software development consists of a sequence of activities where perfection is yet to be achieved. Therefore there is a possibility that fault can be introduced and can remain in software. These faults can lead to failures with catastrophic results. A lot of emphasis is put on avoiding introduction of faults during software development and to remove dormant faults before the product is released for use. The only way to verify and validate the software is by testing. The software testing involves running the software and checking for unexpected behavior of the software output. During the testing phase test cases that simulate the user environment are run on the software and any departure from specifications or requirements is called a failure and immediately an effort is made to remove the cause of that failure (i.e. fault). The successful test can be considered to be the one, which reveals the presence of the latent faults. Therefore, the software should be thoroughly tested to expose as many software faults as possible. Testing phase is an extremely important component of Software Development Life Cycle (SDLC) where around 50 % of the developmental resources are consumed. Testing goes on till the management is satisfied with the reliability of the software. But software cannot be tested exhaustively within a limited time period. This is the reason, why we often hear about failures of software in operation and sometimes even for safety critical systems. These failures are caused by the faults that remain even after testing.

The SRGM is a tool of SRE (Software Reliability Engineering), which can be used to evaluate the software quantitatively, develop test status, schedule status and monitor the changes in reliability performance [5]. In the last two decades several Software Reliability models have been developed in the literature to estimate the fault content, failure rate and fault removal rate per fault type in software and to predict the reliability of the software at the release time. Most of these are characterized by the mean value function of a NHPP and utilize historical failure data collected during the testing phase to evaluate the quality of software. It has also been observed that the relationship between the testing time and the corresponding number of faults removed is either Exponential or S-Shaped or a mix of the two [16]. The software includes different types of faults and each fault requires different strategies and different amounts of testing effort to remove it.

For the estimation of the parameters of the proposed model, Statistical Package for Social Sciences is used. The goodness-of-fit of the proposed models is compared with NHPP based Generalised Erlang Model [9] and NHPP based Generalised Erlang Model with logistic error detection function [10]. The new proposed models provide significant improved goodness-of-fit results. The paper has been divided into the following six sections. Section 1 was introductory. Section 2 presents the model formulation for the proposed model. Sections 3 describe software reliability measures. Section 4 and Section 5 give the method used for parameter estimation and criteria used for validation and evaluation of the proposed model. We conclude the paper in Section 6.

Framework for Modelling

Ohba [13] refined the Goel-Okumoto model by assuming that the fault detection \ removal rate increases with time and that there are two types of faults in the software; simple faults and hard faults. SRGM proposed by Bittanti et al. [2] and Kapur and Garg [8] have similar forms as that of Ohba [13] but are developed under different set of assumptions. Bittanti et al. [2] proposed an SRGM exploiting the fault removal (exposure) rate during the initial and final time epochs of testing. Whereas, Kapur and Garg [8] describe a fault removal phenomenon, where they assume that during a removal process of a fault some of the additional faults might be removed without these faults causing any failure. These models can describe both exponential and S-shaped growth curves and therefore are termed as flexible models [8].

Computing has now reached the state of distributed computing. Furthermore, these systems improve the performance of a computing system and individual users through parallel execution of programs, load balancing and sharing, and replication of programs and data. Ohba [13] proposed the Hyper-exponential SRGM, assuming that software consists of different modules. Each module has its characteristics and thus the faults detected in a particular module have their own peculiarities. Therefore, the Fault Removal Rate for each module is not the same. He suggested that the fault removal process for each module be modeled separately and that the total fault removal phenomenon is the addition of the fault removal process of all the modules. Kapur et al. [7] proposed an SRGM with three types of fault; simple, hard and complex. For each type, the Fault Removal Rate per remaining faults is assumed to be time independent. The first type is modeled by an Exponential model of Goel and Okumoto [6]. The second type is modeled by Delayed S-shaped model of Yamada et al. [16]. The third type is modeled by three stages Erlang model proposed by Kapur et al. [7]. The total removal phenomenon is again modeled by the superposition of the three SRGMs [7]. Later they extended their model to cater for more types of faults [7]. In this model [7] they ignore the role of the learning process during the testing phase by not accounting for the experience gained with the progress of software testing. Yamada et al. [17] have proposed an SRGM based upon NHPP for a distributed software system consisting of n reused and m newly developed software components. Later on Kapur et al. proposed a Flexible SRGM for Distributed Systems [10].

2.1 Notations for the Proposed SRGMs using SDE

$(N(t))$ The number of faults detected during the testing time t and is a random variable

$E(N(t))$ Expected number of faults detected in the time interval (0, t] during testing phase

a Total fault content

a_i Initial fault content for reused components with simple faults

a_j, a_k Initial fault content for newly developed components with hard and complex faults

b_i Fault detection rates for reused components with simple faults

b_j, b_k Fault detection rates for newly developed components with hard and complex faults

$E(N_i(t)), E(N_j(t)), E(N_k(t))$ Mean number of fault for reused and newly developed Components

β Constant parameter in the Fault Removal Rate function

$\sigma_i, \sigma_j, \sigma_k$ Positive constant that represents the magnitude of the irregular fluctuations for Type I (reused) components, Type II (newly developed) components and Type III (newly developed) components

$\gamma_i(t), \gamma_j(t), \gamma_k(t)$ Standardized Gaussian White Noise for Type I (reused) components, Type II (newly developed) components and Type III (newly developed) components

2.2 Assumptions for the Proposed SRGMs using SDE

1. The Software fault-detection process is modeled as a SP (Stochastic Process) with a continuous state space.
2. The number of faults remaining in the software system gradually decreases as the testing procedures go on.
3. Software is subject to failures during execution caused by faults remaining in the software.
4. Software system consists of a finite number of reused and newly developed sub-systems.
5. Software reliability growth in the reused sub-system is constant while in the newly developed sub-system is not.
6. The faults existing in the software are of three types: simple, hard and complex. They are distinguished by the amount of testing effort needed to remove them and are modeled by one-stage, two-stage and three-stage processes respectively.
7. During the fault isolation / removal, no new fault is introduced into the system.
8. The fault removal process i.e., the debugging process is perfect.

2.3 SDE Modelling for Distributed Development Environment

In the development of computer operations systems, a number of faults are detected and removed during the long testing period, and the systems is then released to the market. However, the users then find a number of faults, and the software company release or updated version of the system. Thus in this case the number of faults that remain in the system can be considering being stochastic process with continuous state space [14]. A few works has been done in this area. Yamada et al [19] proposed a simple software reliability growth model to describe the fault detection process during the testing phase by applying type SDE (Stochastic Differential Equation) and obtain several software reliability measures using the probability distribution of the stochastic process. Later on he proposed a flexible SDE Model describing a fault-detection process during the system-testing phase of the distributed development environment [19]. Lee et al. [11] used SDEs to represent a per-fault detection rate that incorporates an irregular fluctuation instead of a NHPP, and consider a per-fault detection rate that depends on the testing time t. In this paper SDEs has been used to represent fault-detection rate that incorporates an irregular fluctuations. The cases of fault detection rate for simple, hard and complex faults have been considered respectively. In practice, it is more realistic to describe the rate for three different types of faults.

2.3.1 Framework for Modelling of Proposed SRGMs

Several SRGMs are based on the assumption of NHPP, treating the fault detection process during the testing phase as a discrete counting process. Yamada et. al [18] asserted that if the size of the software system is large then the number of the faults detected during the testing phase also is large and change in the number of faults, which are corrected and removed through each debugging, becomes small compared with the initial faults content at the beginning of the testing phase. So, in order to describe the stochastic behaviour of the fault detection process, we can use a Stochastic Model with continuous state space. Since the latent faults in the software system are detected and eliminated during the testing phase, the number of faults remaining in the software system gradually decreases as the testing procedure goes on. So it is reasonable to assume the following differential equation.

$$\frac{dN(t)}{dt} = r(t)\left[a - N(t)\right] \qquad (2.3.1.1)$$

where is a fault-detection rate per remaining fault at testing time t. However, the behavior of is not completely known since it is subject to random effects such as the testing effort expenditure, the skill level of the testers, the testing tools and so on and thus might have irregular fluctuation. Thus, we have

$$r(t) = b(t) + noise \qquad (2.3.1.2)$$

Let be a standard Gaussian white noise and a positive constant representing a magnitude of the irregular fluctuations. So equation (2.3.1.2) can be written as

$$r(t) = b(t) + \sigma\gamma(t) \qquad (2.3.1.3)$$

Equation (2.3.1.1) becomes

$$\frac{dN(t)}{dt} = \left[b(t) + \sigma\gamma(t)\right]\left[a - N(t)\right] \qquad (2.3.1.4)$$

Equation (2.3.1.4) can be extended to the following stochastic differential equation of a $\dot{\text{Ito}}$ Type [18]

$$dN(t) = \left[b(t) - \frac{1}{2}\sigma^2\right]\left[a - N(t)\right]dt + \sigma\left[a - N(t)\right]dw(t) \qquad (2.3.1.5)$$

where is a one-dimensional Wiener process, which is formally defined as an integration of the white noise with respect to time t. using formula solution to equation 2.3.1.5; using initial condition as follows

$$N(t) = a\left[1 - \exp\left\{-\int_0^t b(x)dx - \sigma W(t)\right\}\right] \qquad (2.3.1.6)$$

The Wiener process is a Gaussian process and it has the following properties:

$$\Pr\left[w(0) = 0\right] = 1,\ E\left[w(t)\right] = 0,$$

$$E\left[w(t)w(t')\right] = \min\left[t, t'\right]$$

Yamada et. al [18] consider the case where fault detection rate, be constant, function of time and logistic function.

In this paper we consider the fault detection rate, which is constant and a function of time. The faults observed are simple, hard and complex in nature. In practical situation it has been observed that a large number of simple (trivial) faults are easily detected at the early stages of testing while fault removal may become extremely difficult in the later stages. In this case the fault removable rate has a high value at the beginning as compared to the value of the end of the testing phase.

We now briefly describe the Generalised Erlang and Generalised Erlang with logistic error detection function. The proposed models based on SDE as described in the next section.

Generalised Erlang SRGM [9]

The model assumes that the testing phase consists of three processes namely, failure observation, fault detection and fault removal. The software faults are categorized into three types according to the amount of testing effort needed to remove them. The time delay between the failure observation and the subsequent fault removal is assumed to represent the testing effort. The faults are classified as simple if the time delay between the failure observation, fault detection and removal is negligible. For the simple faults, the fault removal phenomenon is modeled by the exponential model of Goel and Okumoto [6].

i.e. $$m_1(t)=a_1(1-e^{-b_1 t}) \quad (2.3.1.7)$$

If there is a time delay between failure observation and subsequent fault detection and removal, the fault is classified as a hard fault. The hard faults are modeled by the Delayed S-Shaped Model of Yamada et. al [16]

$$m_2(t)=a_2\left(1-(1+b_2 t)e^{-b_2 t}\right) \quad (2.3.1.8)$$

If the removal of a fault after its detection involves even a greater time delay, it is classified as a complex fault. The fault removal process is consequently modeled by three stage Erlang Model [7]

$$m_3(t)=a_3\left(1-\left(1+b_3 t+\frac{b_3^2 t^2}{2}\right)e^{-b_3 t}\right) \quad (2.3.1.9)$$

The total removal phenomenon is modeled by the superposition of the three processes i.e.

$m(t)=m_1(t)+m_2(t)+m_3(t)$

$$m(t)=a_1(1-e^{-b_1 t})+a_2\left(1-(1+b_2 t)e^{-b_2 t}\right)+a_3\left(1-\left(1+b_3 t+\frac{b_3^2 t^2}{2}\right)e^{-b_3 t}\right) \quad (2.3.1.10)$$

where $a_1 = ap_1$, $a_2 = ap_2$ and $a_3 = a(1-p_1-p_2)$

From equations (2.3.1.7), (2.3.1.8) and (2.3.1.9), it has been observed that the removal rate per fault for simple faults is a constant (no learning is required as the faults are simple in nature); whereas for hard and complex faults, these rates are function of time t and are given respectively by

$$b_2(t)=\frac{b_2^2 t}{1+b_2 t} \quad (2.3.1.11)$$

$$b_3(t)=\frac{\frac{b_3^3 t^2}{2}}{1+b_3 t+\frac{b_3^2 t^2}{2}} \quad (2.3.1.12)$$

Note that $b_2(t)$ and $b_3(t)$ increases monotonically with time and tend to constant b_2 and b_3 respectively as $t\to\infty$.

Generalised Erlang Model with Logistic Error Detection Function [10]

For the simple faults, the fault removal phenomenon is modeled by the exponential model of Goel and Okumoto [6] as explained above.

$$m_1(t)=a_1(1-e^{-b_1 t}) \quad (2.3.1.13)$$

It is assumed that the faults of some newly developed components consume more testing effort when compared with faults of reused component. This means that the testing team will have to spend more time to analyze the cause of the failure and therefore requires greater efforts to remove them. The removal process for such faults is modeled as a two stage process. The first stage describes the failure observation process. The second stage of the two-stage process describes the delayed fault removal process. During this stage the fault removal rate is assumed to be time dependent. The reason for this assumption is to incorporate the effect of learning on the removal process. With each fault removal insight is gained into the nature of faults present and function described called logistic function can account for that. So its mean value function will be given by

$$m_2(t) = \frac{a_2\left[1-\{1+b_2 t\}e^{-b_2 t}\right]}{1+\beta\, e^{-b_2 t}} \qquad (2.3.1.14)$$

There can be components still having harder faults or complex faults. These faults can require more effort for removal after isolation. These need to be modeled with greater time lag between failure observation and removal. The first stage describes the failure observation process, the second stage describes the fault isolation process and the third stage describes the fault removal process. During this stage the fault removal rate is assumed to be time dependent. Logistic learning function is used again to represent the knowledge gained by the removal team. The mean value function will be given by

$$m_3(t) = \frac{a_3\left[1-\left(1+b_3 t+\frac{b_3^2 t^2}{2}\right)e^{-b_3 t}\right]}{1+\beta\, e^{-b_3 t}} \qquad (2.3.1.15)$$

The total removal phenomenon is modeled by the superposition of the three processes i.e.

$$m(t) = a_1(1-e^{-b_1 t}) + \frac{a_2\left[1-(1+b_2 t)e^{-b_2 t}\right]}{1+\beta\, e^{-b_2 t}} + \frac{a_3\left[1-\left(1+b_3 t+\frac{b_3^2 t^2}{2}\right)e^{-b_3 t}\right]}{1+\beta\, e^{-b_3 t}} \qquad (2.3.1.16)$$

where $a_1 = ap_1$, $a_2 = ap_2$ and $a_3 = a(1-p_1-p_2)$

From equations (2.3.1.13), (2.3.1.14) and (2.3.1.15), it has been observed that the removal rate per fault for simple faults is a constant b_1, whereas for hard and complex faults, these rates are function of time t and are given respectively by

$$b_2(t) = \frac{m_2'(t)}{a_2 - m_2(t)}$$

$$b_2(t) = \frac{b_2(1+\beta+b_2 t) - b_2\left(1+\beta e^{-b_2 t}\right)}{(1+\beta+b_2 t)\left(1+\beta e^{-b_2 t}\right)} \qquad (2.3.1.17)$$

$$b_3(t) = \frac{m_3'(t)}{a_3 - m_3(t)}$$

$$b_3(t) = \frac{b_3\left(1+\beta+b_3 t+\frac{b_3^2 t^2}{2}\right) - b_3\left(1+\beta e^{-b_3 t}\right)(1+b_3 t)}{\left(1+\beta+b_3 t+\frac{b_3^2 t^2}{2}\right)\left(1+\beta e^{-b_3 t}\right)} \qquad (2.3.1.18)$$

Proposed SRGM1

Now in the proposed model considering the form of $b(t)$ as i.e., for simple, hard and complex faults respectively.

Now considering the equation 2.3.1.6 and using the above form of $b(t)$; we have

$$N_i(t)=a_i\left[1-\left\{e^{-b_i t-\sigma_i W_i(t)}\right\}\right],\quad N_j(t)=a_j\left[1-(1+b_j t)\left\{e^{-b_j t-\sigma_j W_j(t)}\right\}\right]$$

$$\text{and } N_k(t)=a_k\left[1-\left(1+b_k t+\frac{b_k^2 t^2}{2}\right)\left\{e^{-b_k t-\sigma_k W_k(t)}\right\}\right] \qquad (2.3.1.19)$$

Taking Expectations of $N_i(t), N_j(t)$ and $N_k(t)$, we have

$$E(N_i(t))=a_i\left[1-\left\{e^{-b_i t+\frac{\sigma_i^2 t}{2}}\right\}\right], \qquad (2.3.1.20.1)$$

In the above equation if we assume $a_i=a, b_i=b, \sigma_i=\sigma$

then the Model turns out to be **GO Model with SDE**

$$E(N_j(t))=a_j\left[1-(1+\beta+b_j t)\left\{e^{-b_j t+\frac{\sigma_j^2 t}{2}}\right\}\right] \text{ and}$$

In the above equation if we assume $a_j=a, b_j=b, \sigma_j=\sigma$ (2.3.1.20.2)

then the Model turns out to be **Yamada's S-Shaped Model with SDE**

$$E(N_k(t))=a_k\left[1-\left(1+\beta+b_k t+\frac{b_k^2 t^2}{2}\right)\left\{e^{-b_k t+\frac{\sigma_k^2 t}{2}}\right\}\right] \qquad (2.3.1.20.3)$$

In the above equation if we assume $a_k=a, b_k=b, \sigma_k=\sigma$

then the Model turns out to be **Kapur's 3-Stage Model with SDE**

Proposed SRGM2

Now in the proposed model considering the removal rate per fault for simple, hard and complex faults are as follows.

Now, considering the equations (2.3.1.6) and using the above form of $b(t)$; we have

$$N_i(t) = a_i\left[1-\left\{e^{-b_i t-\sigma_i W_i(t)}\right\}\right], \quad N_j(t) = \frac{a_j\left[1-(1+\beta+b_j t)\left\{e^{-b_j t-\sigma_j W_j(t)}\right\}\right]}{1+\beta e^{-b_j t}} \text{ and}$$

$$N_k(t) = \frac{a_k\left[1-\left(1+\beta+b_k t+\frac{b_k^2 t^2}{2}\right)\left\{e^{-b_k t-\sigma_k W_k(t)}\right\}\right]}{1+\beta e^{-b_k t}} \quad (2.3.1.22)$$

Taking Expectations of $N_i(t), N_j(t)$ and $N_k(t)$, we have

$$E(N_i(t)) = a_i\left[1-\left\{e^{-b_i t+\frac{\sigma_i^2 t}{2}}\right\}\right], \quad E(N_j(t)) = \frac{a_j\left[1-(1+\beta+b_j t)\left\{e^{-b_j t+\frac{\sigma_j^2 t}{2}}\right\}\right]}{1+\beta e^{-b_j t}} \text{ and}$$

$$E(N_k(t)) = \frac{a_k\left[1-\left(1+\beta+b_k t+\frac{b_k^2 t^2}{2}\right)\left\{e^{-b_k t+\frac{\sigma_k^2 t}{2}}\right\}\right]}{1+\beta e^{-b_k t}} \quad (2.3.1.23)$$

2.4 Modelling Total Fault Removal Phenomenon

The proposed model is the sum of 'p' reused and 'q' & 's' newly developed components.

$$E(N(t)) = \sum_{i=1}^{p} E(N_i(t)) + \sum_{j=p+1}^{p+q} E(N_j(t)) + \sum_{k=p+q+1}^{p+q+s} E(N_k(t)) \quad (2.4.1)$$

This is the mean value function of superimposed three simple, hard and complex faults respectively.

For Proposed SRGM1

$$E(N(t)) = \sum_{i=1}^{p} a_i\left[1-\left\{e^{-b_i t+\frac{\sigma_i^2 t}{2}}\right\}\right] + \sum_{j=p+1}^{p+q} a_j\left[1-(1+b_j t)\left\{e^{-b_j t+\frac{\sigma_j^2 t}{2}}\right\}\right] + \sum_{k=p+q+1}^{p+q+s} a_k\left[1-\left(1+b_k t+\frac{b_k^2 t^2}{2}\right)\left\{e^{-b_k t+\frac{\sigma_k^2 t}{2}}\right\}\right] \quad (2.4.2)$$

Further, we consider the simple case where software system consists of one reused (i.e., p=1) and two newly developed components (one of which contains errors represented by a two stage error removal phenomenon while other contain errors represented by a three stage error removal phenomenon i.e., $p=1$, $q=1$ and $s=1$ respectively). Call this case as 1-1-1. Accordingly equation (2.4.2) can be rewritten as

$$E(N(t)) = \sum_{i=1}^{1} a_i\left[1-\left\{e^{-b_i t+\frac{\sigma_i^2 t}{2}}\right\}\right] + \sum_{j=2}^{2} a_j\left[1-(1+b_j t)\left\{e^{-b_j t+\frac{\sigma_j^2 t}{2}}\right\}\right] + \sum_{k=3}^{3} a_k\left[1-\left(1+b_k t+\frac{b_k^2 t^2}{2}\right)\left\{e^{-b_k t+\frac{\sigma_k^2 t}{2}}\right\}\right] \quad (2.4.3)$$

where $a_i = ap_i$, $a_j = ap_j$ and $a_k = a(1-p_i-p_j)$

For Proposed SRGM2

$$E(N(t)) = \sum_{i=1}^{p} a_i\left[1-\left\{e^{-b_i t+\frac{\sigma_i^2 t}{2}}\right\}\right] + \sum_{j=p+1}^{p+q} \frac{a_j\left[1-(1+\beta+b_j t)\left\{e^{-b_j t+\frac{\sigma_j^2 t}{2}}\right\}\right]}{1+\beta e^{-b_j t}} + \sum_{k=p+q+1}^{p+q+s} \frac{a_k\left[1-\left(1+\beta+b_k t+\frac{b_k^2 t^2}{2}\right)\left\{e^{-b_k t+\frac{\sigma_k^2 t}{2}}\right\}\right]}{1+\beta e^{-b_k t}} \quad (2.4.4)$$

Further, we consider the simple case where software system consists of one reused (i.e., p=1) and two newly developed components (one of which contains errors represented by a two stage error removal phenomenon while other contain errors represented by a three stage error removal phenomenon i.e., p=1, q = 1 and s = 1 respectively). Call this case as 1-1-1. Accordingly equation (2.4.4) can be rewritten as

$$E(N(t)) = \sum_{i=1}^{1} a_i \left[1 - \left\{ e^{-b_i t + \frac{\sigma_i^2 t}{2}} \right\}\right] + \sum_{j=2}^{2} \frac{a_j \left[1 - (1+\beta + b_j t)\left\{ e^{-b_j t + \frac{\sigma_j^2 t}{2}} \right\}\right]}{1+\beta e^{-b_j t}} + \sum_{k=3}^{3} \frac{a_k \left[1 - \left(1+\beta + b_k t + \frac{b_k^2 t^2}{2}\right)\left\{ e^{-b_k t + \frac{\sigma_k^2 t}{2}} \right\}\right]}{1+\beta e^{-b_k t}} \qquad (2.4.5)$$

where $a_i = ap_i$, $a_j = ap_j$, and $a_k = a(1 - p_i - p_j)$

3. **Software Reliability Assessment Measures**

In this section, we present expression for various software reliability measures. Information on the current number of detected faults in the system is important to estimate the situation of the progress on the software testing procedures. Since it is a random variable in our models, so its expected value can be useful measures. We have already calculated the expected value for our models in equation 2.3.1.14.

For Proposed SRGM1

Instantaneous MTBF (Mean Time between Failure):- The instantaneous MTBF is average Time between Failure in an interval dt. The instantaneous mean time between software failures is useful to measure the property of the frequency of software failure occurrence. The instantaneous MTBF for the proposed models is given by:

$$MTBF_I = \frac{1}{\frac{E[dN(t)]}{dt}} \qquad (3.1.1)$$

The mean numbers of detected faults up to testing time t for the simple, hard and complex faults are as follows.

For Simple faults

$$E(N_i(t)) = a_i \left[1 - \left\{ e^{-b_i t + \frac{\sigma_i^2 t}{2}} \right\}\right] \qquad (3.1.2)$$

For Hard faults

$$E(N_j(t)) = a_j \left[1 - (1 + b_j t)\left\{ e^{-b_j t + \frac{\sigma_j^2 t}{2}} \right\}\right] \qquad (3.1.3)$$

For Complex faults

$$E(N_k(t)) = a_k \left[1 - \left(1 + b_k t + \frac{b_k^2 t^2}{2}\right)\left\{ e^{-b_k t + \frac{\sigma_k^2 t}{2}} \right\}\right] \qquad (3.1.4)$$

where density function of is given by

$$f(W_i(t)) = \frac{1}{\sqrt{2\pi t}} \exp\left\{-\frac{W_i(t)^2}{2t}\right\} \qquad (3.1.5)$$

From equation (2.3.1.5) and taking expectation; we have

$$E[dN(t)] = a\left[b(t) - \frac{1}{2}\sigma^2\right] e^{-\left(b - \frac{1}{2}\sigma^2\right)} dt \qquad (3.1.6)$$

The instantaneous MTBF of the simple, hard and complex faults are as follows

For Simple faults

$$MTBF_i^S(t)=\frac{1}{a_i\left[b_i-\frac{1}{2}\sigma^2\right]e^{-\left(b_i-\frac{1}{2}\sigma^2\right)t}} \quad (3.1.7)$$

$where\ i=1,2,\ldots,p$

For Hard faults

$$MTBF_j^H(t)=\frac{1}{a_j(1+b_jt)\left[\frac{b_j^2t}{1+b_jt}-\frac{1}{2}\sigma^2\right]e^{-\left(b_j-\frac{1}{2}\sigma^2\right)t}} \quad (3.1.8)$$

$where\ j=p+1,\ldots,p+q$

For Complex faults

$$MTBF_k^C(t)=\frac{1}{a_k\left(1+b_kt+\frac{b_k^2t^2}{2}\right)\left[\frac{\frac{b_k^2t^2}{2}}{1+b_kt+\frac{b_k^2t^2}{2}}-\frac{1}{2}\sigma^2\right]e^{-\left(b_k-\frac{1}{2}\sigma^2\right)}} \quad (3.1.9)$$

$where\ k=p+q+1,\ldots,p+q+s$

where $MTBF^S(t)$, $MTBF^H(t)$ and $MTBF^C(t)$ are instantaneous mean time before failure for simple, hard and complex faults respectively.

3.1 Cumulative MTBF:- The cumulative MTBF is the average time between failure from the beginning of the test (i.e., t=0) up to time t. It is given by:

$$MTBF_C=\frac{t}{E[N(t)]} \quad (3.2.1)$$

The Cumulative MTBF of the three models is respectively as follows.

For Simple faults

$$MTBF^S(t)=\frac{t}{a_i\left[1-\left\{e^{-b_it+\frac{\sigma_i^2t}{2}}\right\}\right]}$$

$where\ i=1,2,\ldots,p$ (3.2.2)

For Hard faults

$$MTBF^H(t)=\frac{t}{a_j\left[1-(1+b_jt)\left\{e^{-b_jt+\frac{\sigma_j^2t}{2}}\right\}\right]}$$

$where\ j=p+1,\ldots,p+q$ (3.2.3)

For Complex faults

$$MTBF^C(t)=\frac{t}{a_k\left[1-\left(1+b_kt+\frac{b_k^2t^2}{2}\right)\left\{e^{-b_kt+\frac{\sigma_k^2t}{2}}\right\}\right]}$$

$where\ k=p+q+1,\ldots,p+q+s$ (3.2.4)

where $MTBF^S(t)$, $MTBF^H(t)$ and $MTBF^C(t)$ are cumulative mean time before failure for simple, hard and complex faults respectively. Similarly, we can work for SRGM 2.

4. Parameter Estimation

Software reliability engineering produces a model of a software system based on its failure data to provide a measurement for software reliability. The mathematical and statistical functions used in software reliability modeling employ several computational steps. The equations for the models themselves have parameters that are estimated using techniques like least squares fit or maximum likelihood estimation. Technically, it is more difficult to find the solution for non-linear models using Least Square method and requires numerical algorithms to solve it. Statistical software packages such as SPSS helps to overcome this problem. SPSS is a Statistical Package for Social Sciences. For the estimation of the parameters of the proposed model, Method of Least Square (Non Linear Regression method) has been used. Non Linear Regression is a method of finding a nonlinear model of the relationship between the dependent variable and a set of independent variables. Unlike traditional linear regression, which is restricted to estimating linear models, nonlinear regression can estimate models with arbitrary relationships between independent and dependent variables.

4.1 Comparison Criteria for SRGMs

The performance of SRGMs are judged by their ability to fit the past software fault data (goodness of fit).

4.1.1 Goodness of Fit Criteria

The term goodness of fit is used in two different contexts. In one context, it denotes the question if a sample of data came from a population with a specific distribution. In another context, it denotes the question of "How good does a mathematical model (for example a linear regression model) fit to the data"?

a. MSE (Mean Square Fitting Error):

The model under comparison is used to simulate the fault data, the difference between the expected values, $\hat{m}(t_i)$ and the observed data y_i is measured by MSE [7] as follows. $MSE = \sum_{i=1}^{k} \frac{(\hat{m}(t_i) - y_i)^2}{k}$

where k is the number of observations. The lower MSE indicates less fitting error, thus better goodness of fit.

b. AIC (Akaike Information Criterion):

The criteria is defined as AIC = -2(the value of the maximum log likelihood function) + 2(the number of the parameters used in the model). This index [1, 7] takes into account both the statistical goodness of fit and the number of parameters that are estimated in competing models. Lower values of AIC indicate the preferred model.

c. Coefficient of Multiple Determinations (R^2):

We define this coefficient as the ratio of the sum of squares resulting from the trend model to that from constant model subtracted from 1[7]. i.e., $MSE = \sum_{i=1}^{k} \frac{(\hat{m}(t_i) - y_i)^2}{k}$ .R^2 measures the percentage of the total variation about the mean accounted for the fitted curve. It ranges in value from 0 to 1. The larger R2, the better the model explains the variation in the data.

d. PE (Prediction Error):

The difference between the observation and prediction of number of failures at any instant of time i is known as PEi. Lower the value of Prediction Error better is the goodness of fit [15].

e. Bias:

The average of PEs is known as bias. Lower the value of Bias better is the goodness of fit [15].

f. Variation:

The standard deviation of PE is known as variation.

$$Variation = \sqrt{\left(\frac{1}{N-1}\right)\sum (PE_i - Bias)^2}$$

Lower the value of Variation better is the goodness of fit [15].

g. RMSPE (Root Mean Square Prediction Error):

It is a measure of closeness with which a model predicts the observation.

$$RMSPE = \sqrt{(Bias^2 + Variation^2)}.$$

Lower the value of Root Mean Square Prediction Error better is the goodness of fit [15].

h. K-S Test (Kolmogorov-Smirnov Test)

The K-S test [4] is a non-parametric test. It tries to determine if two datasets differ significantly. It is based on the Empirical Distribution Function (ECDF). Since it is non-parametric, it treats individual observations directly and is applicable even in the case of very small sample size, which is usually the case with SRGM validation. Lower the value of K-S test better is the goodness of fit.

5. Model Validation

The Proposed models have been tested on three different data sets for its software reliability growth. The Proposed Models i.e., SRGM1 and SRGM2 have been compared with NHPP based Generalised Erlang Model [9] and Generalised Erlang Model with logistic error detection function [10]. With the prior knowledge of proportion of different types of faults, programmer can act with better strategy for removing theses faults. For the proposed SRGMs the results are better for both the data sets. Proposed SRGM2 gives better results than Proposed SRGM 1 because of the flexibility in curve in capturing the relevant actual data points as the growth is not uniform, it is irregular. However, the increased accuracy achieved shows the capability of the model to capture different types of failure datasets e.g. Exponential, s-Shaped. The real time data sets used for estimation are:

DS- I

This data is cited from Misra [12]. The software was tested for 38 weeks during which 2456.4 computer hours were used and 231 faults were removed Based upon the estimated parameters, parameters of SRGMs (2.3.1.20.1, 2.3.1.20.2, 2.3.1.20.3, 2.4.3, 2.4.5) were estimated. The Parameter Estimation result and the goodness of fit results for the proposed SRGMs are given in Table 5.1. The goodness of fit curve for DS-I is given in Figure 5.1 and Figure 5.4. The goodness of fit attributes for SRGM (2.3.1.20.1) is better than SRGM (2.3.1.20.2) and worse than (2.3.1.20.3) due to the flexible nature of curve.

DS-II

This data is cited from Brooks and Motley (1980) [3]. The fault data set is for a radar system of size 124 KLOC (Kilo Lines of Code) tested for 35 weeks in which 1301 faults were removed. Based upon the estimated parameters, parameters of SRGMs (2.3.1.20.1, 2.3.1.20.2, 2.3.1.20.3, 2.4.3, 2.4.5) were estimated. The Parameter Estimation result and the goodness of fit results for the proposed SRGMs are given in Table 5.2. The goodness of fit curve for DS-II is given in Figure 5.2 and Figure 5.5.The goodness of fit attributes for SRGM (2.3.1.20.1) is better than SRGM (2.3.1.20.2) and SRGM (2.3.1.20.2) is better than (2.3.1.20.3) due to the S-Shaped nature of curve.

DS-III

This data is cited from M. Ohba [13]. The software was tested for 19 weeks during which 47.65 computer hours were used and 328 faults were removed. Based upon the estimated parameters, parameters of SRGMs (2.3.1.20.1, 2.3.1.20.2, 2.3.1.20.3, 2.4.3, 2.4.5) were estimated. The Parameter Estimation result and the goodness of fit results for the proposed SRGMs are given in Table 5.3. The goodness of fit curve for DS-III is given in Figure 5.3 and Figure 5.6. The goodness of fit attributes for SRGM (2.3.1.20.1) is better than SRGM (2.3.1.20.2) and SRGM (2.3.1.20.2) is better than (2.3.1.20.3) due to the exponential nature of curve.

The improved results of SRGMs (2.3.1.20.1, 2.3.1.20.2, 2.3.1.20.3) encouraged us to develop SRGMs 4 & 5 for distributed systems. Values of p1, p2 and p3 are computed from the actual data set since data was available separately for each type of faults. Here it can also be seen that as the testing teams have to spend more time to analyze and remove the cause of failure of hard and complex faults and therefore require greater efforts to remove them as the faults in the components comprising a complete software can be of different severity. The values of initial fault contents can be calculated from the tables 5.1 and 5.2 for both the datasets i.e., DS-I and DS-II using . For SRGM 4 and SRGM 5 the fluctuation level is high in newly developed components as compared to reused components because the cumulative number of detected faults is an exponential curve when a software system consists of several used software components (the growth is uniform); while on the other hand; the cumulative number of faults is described by an s-shaped growth curve when the newly developed software components are used (the growth is not uniform, it is irregular).

Table 5.1: for DS-I (Misra 231 faults)

Models under Comparisons	Parameter Estimation									
	a	b_1/b	b_2	b_3	z	p_1	p_2	σ/σ_1	σ_2	σ_3
(2.3.1.20.1)	534	.05	-	-	-	-	-	.16	-	-
GO Model	475	.01	-	-	-	-	-	-	-	-
(2.3.1.20.2)	248	.14	-	-	-	-	-	.28	-	-
S-Shaped Model	353	.09	-	-	-	-	-	-	-	-
(2.3.1.20.3)	460	.23	-	-	-	-	-	.45	-	-
3- Stage Model	336	.09	-	-	-	-	-	-	-	-
Proposed SRGM1	322	.06	.01	.01	-	.64	.34	.02	.23	.27
Generalised Erlang Model [10]	270	.04	.02	.01	-	.64	.34	-	-	-
Proposed SRGM2	360	.08	.05	.014	11	.64	.34	.01	.25	.37
Generalised Erlang Model with logistic error detection function [9]	355	.09	.03	.02	24	.64	.34	-	-	-

Table 5.2: for DS-II (Brooks & Motley 1301 faults)

Models under Comparisons	Parameter Estimation									
	a	b/b	b_2	b_3	z	p_1	p_2	σ/σ_1	σ_2	σ_3
(2.3.1.20.1)	1325	.003	-	-	-		-	1.2	-	-
GO Model	10589	.004	-	-	-		-	-	-	-
(2.3.1.20.2)	1362	.04	-	-	-		-	.42	-	-
S-Shaped Model	1689	.09	-	-	-		-	-	-	-
(2.3.1.20.3)	1383	.14	-	-	-		-	.10	-	-
3- Stage Model	1441	.16	-	-	-		-	-	-	-
Proposed SRGM1	1396	.04	.03	.019	-	.58	.21	.02	.39	.48
Generalised Erlang Model [10]	1541	.05	.06	.014	-	.49	.25	-	-	-
Proposed SRGM2	1367	.05	.04	.015	16	.39	.33	.01	.51	.58
Generalised Erlang Model with logistic error detection function [9]	1366	.06	.05	.024	39	.59	.24	-	-	-

Table 5.1: for DS-I (Continued)

Models under Comparison	Comparison Criteria					
	R^2	MSE	AIC	Bias	Variation	RMS PE	K-S Test
(2.3.1.20.1)	.99498	18	201	-.06	4.12	4.18	.270
GO Model	.99458	20	204	-.08	4.54	4.57	.283
(2.3.1.20.2)	.99356	211	218	3.13	13.22	13.35	.288
S-Shaped Model	.99210	221	229	4.54	14.36	15.06	.295
(2.3.1.20.3)	.99535	899	272	-19.67	17.89	17.97	.243
3- Stage Model	.99501	1044	281	-25.78	19.73	32.47	.278
Proposed SRGM1	.99595	14.48	211.1	-0.104	3.855	3.857	.107
Generalised Erlang Model [10]	.99546	16.84	219.9	-0.489	4.130	4.159	.112
Proposed SRGM2	.99821	6.68	200.7	-0.013	2.637	2.639	.076
Generalised Erlang Model with logistic error detection function [9]	.99785	7.98	205.7	-0.020	2.864	2.865	.082

Table 5.2: for DS-II (Continued)

Models under Comparison	Comparison Criteria						
	R^2	MSE	AIC	Bias	Variation	RMSPE	K-S Test
(2.3.1.20.1)	.99726	584	512	7.75	51.34	51.45	.506
GO Model	.95810	8923	807	19.3	93.81	95.79	.789
(2.3.1.20.2)	.99576	902	580	11.5	31.23	31.26	.589
S-Shaped Model	.98726	2713	518	6.83	52.40	52.84	.732
(2.3.1.20.3)	.99502	1059	460	-4.5	27.03	27.89	.612
3- Stage Model	.99423	1250	487	-7.4	35.06	35.86	.678
Proposed SRGM1	.99686	669	550	1.25	26.22	26.25	.107
Generalised Erlang Model [10]	.99578	898	571	2.41	30.31	30.40	.112
Proposed SRGM2	.99970	68	319	.097	8.452	8.453	.076
Generalised Erlang Model with logistic error detection function [9]	.99960	85	338	0.18	9.340	9.341	.082

Table 5.3: for DS-I (Ohba 328 faults)

Models under Comparisons	Parameter Estimation									
	a	b_1/ b	b_2	b_3	z	p_1	p_2	σ/σ_1	σ_2	σ_3
(2.3.1.20.1)	575	.07	-	-	-	-	-	.18	-	-
GO Model	760	.03	-	-	-	-	-	-	-	-
(2.3.1.20.2)	431	.10	-	-	-	-	-	.27	-	-
S-Shaped Model	374	.19	-	-	-	-	-	-	-	-
(2.3.1.20.3)	481	.14	-	-	-	-	-	.36	-	-
3- Stage Model	576	.17	-	-	-	-	-	-	-	-
Proposed SRGM1	413	.41	.08	.07	-	.59	.40	.04	.32	.37
Generalised Erlang Model [10]	422	.20	.13	.24	-	.52	.36	-	-	-
Proposed SRGM2	347	.05	.13	.69	3.4	.55	.33	.03	.27	.42
Generalised Erlang Model with logistic error detection function [9]	354	.32	.33	.29	24	.58	.42	-	-	-

Table 5.3: for DS-III (Continued)

Models under Comparison	Comparison Criteria						
	R^2	MSE	AIC	Bias	Variation	RMS PE	K-S Test
(2.3.1.20.1)	.98437	157.8	252	3.34	14.67	14.87	.567
GO Model	.99214	139.8	226	1.17	12.08	12.14	.512
(2.3.1.20.2)	.98566	97.54	214	-0.26	10.14	10.15	.631
S-Shaped Model	.98366	168.6	225	-2.9	13.00	13.25	.679
(2.3.1.20.3)	.98262	1678	467	-32.56	25.67	25.78	.789
3- Stage Model	.98021	2944	482	-42.28	34.94	54.98	.800
Proposed SRGM1	.99541	42.6	211.1	-0.104	6.85	6.87	.805
Generalised Erlang Model [10]	.99107	92.17	218.6	-0.06	9.85	9.86	.844
Proposed SRGM2	.99628	35.97	209.8	-0.05	5.96	5.95	.455
Generalised Erlang Model with logistic error detection function [9]	.99460	55.70	229.5	-0.03	7.64	7.66	.646

The curves given below in Figures 5.1-5.6 reflects the initial learning curve at the beginning, as test members become familiar with the software, followed by growth and then leveling off as the residual faults become more difficult to uncover.

GOODNESS OF FIT CURVES FOR DS-1 & DS-2

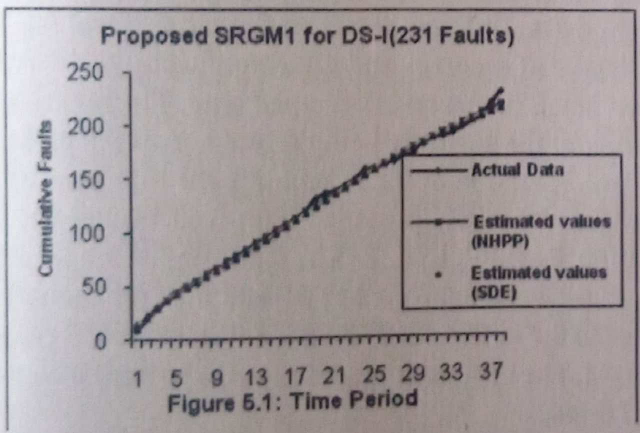

Figure 5.1: Time Period

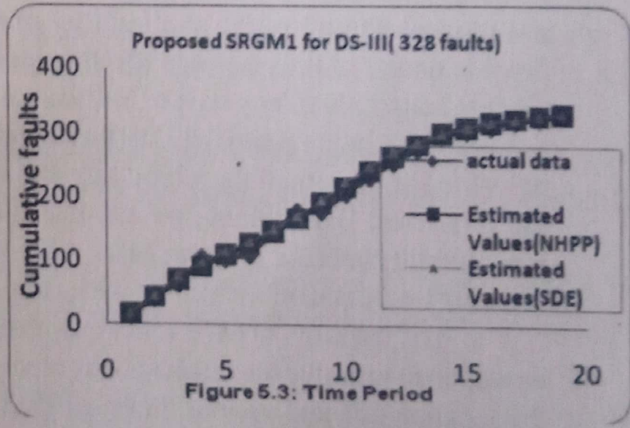

Figure 5.3: Time Period

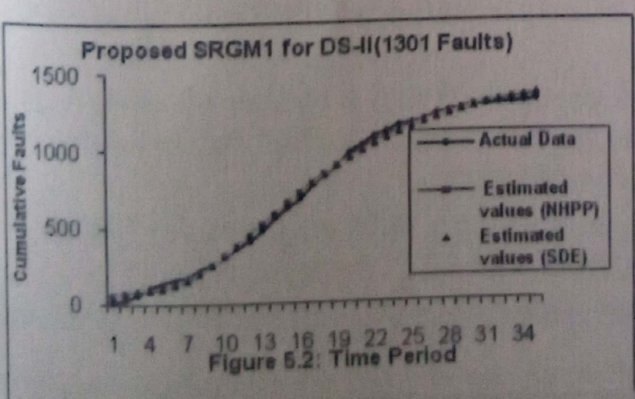

Figure 5.2: Time Period

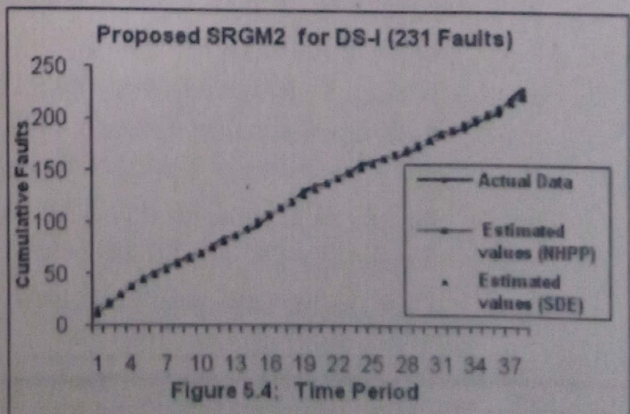

Figure 5.4: Time Period

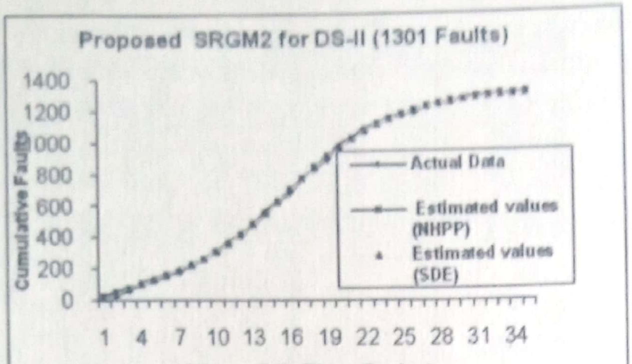

Figure 5.5: Time Period

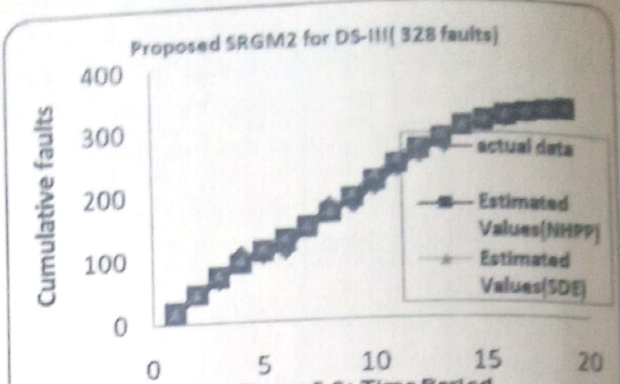

Figure 5.6: Time Period

6. Conclusion and Future Scope

Software Reliability Engineering is emerging as a very important field of study in the area of Information Technology. The mathematical models play a significant role in its growth as these models provide quantitative tools to assess the reliability of the software by developers. New dimensions have been added to the flexible modelling by introducing the concept of SDEs. This paper presents SRGMs for distributed systems based on type SDEs. In this paper, we have extended the SDE approach adopted by Yamada et al. [18] to the case where the faults are simple, hard and complex in nature. The model considers that software system consists of a finite number of reused and newly developed sub-systems. The proposed SRGMs can depict different type of failure growth curves depending on the estimated values of its parameters. The goodness of the fit analysis has been done on two real software failure datasets. The goodness-of-fit of the proposed Models is compared with NHPP based Generalised Erlang Model [9] and Generalised Erlang Model with logistic error detection function [10]. The results obtained show better fit and wider applicability of the model to different types of failure datasets due to the flexible nature of the proposed SRGMs higher degree of accuracy and wider applicability. It makes the models adaptable to any type of software dataset say Exponential, S-Shaped type. The higher level of accuracy and better predictability for the reliability of the software being tested makes the model quite valuable for the situations where safe and risk free operation of the system are the high priority. From the numerical illustrations, we see that the Proposed Models provides improved results with better predictability because of lower MSE, AIC, Variation, RMSPE, Bias, K-S Test and higher R2. As software reliability assessment measures, we have derived the instantaneous MTBF and the cumulative MTBF.

The usability of SDE is not only restricted to the models described in this paper but it can also be extended to improve the results of any other SRGM. The Proposed Model can also be used incorporating error generation and various Testing Effort functions.

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