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Quality Excellence in Technical Education: Issues and Challenges

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Abstract:
The task of nation building depends upon the quality and number of people coming out from our various school and colleges. And it is need less to say that quality education is only the tool through which these vast resources could be honed. So that the third millen-nium will proceed with accelerated pace in the direction of extensive research. And in this process we can’t deny or underestimate the role of students, schools, colleges, teachers and other governing bodies, but the molar analysis raises certain Questions. The interest in total quality management (TQM) has increased rapidly in recent years. Some people see TQM as something necessary to reach competitiveness but others claim TQM to be merely a management fad. Total Quality Management (TQM) is an approach towards maintaining quality of processes and systems in an organization. TQM calls for checking quality at every stage of product development rather than checking for the same at the very last stage. From the executive summary: ‘The term ‘Total Quality Management’ (TQM) is defined as a philosophy that integrates quality into all facets of an organization and focuses on systematic improvement. The process of TQM emphasizes on small continuous improvements rather than large-scale innovations. Tools adopted for use in Total Quality Management (TQM) range from simple charting techniques to esoteric statistical processes The tools can be used collectively to support an integrated TQM approach, or individually to solve a variety of everyday problems And a roadmap towards continues improvement of the deliverables The basic TQM tools include conducting brainstorming sessions, adopting cause and effect methods

Key words: Quality, TQM, Vision, Challenges.

Introduction
Quality technical education plays a vital role in the society. The economy of country is influenced to a great extent by the technical manpower and vocational training. The demand for technical education is large in our country. The demand is more in the knowledge based industries and IT sector. First rate technical personnel can take the country forward to dizzy heights. Technical institutions e.g. private engineering colleges, poly-technics and industrial training institutes are producing flexible and adaptable engineers and technical personnel, to serve industry, defense, government, sectors as responsible citizens. Quality is defined as “specifying worthwhile long term and short term goals and enabling students and teachers to achieve them”, so that the user industry and the society at large, is benefited. Technical Excellence can be achieved through unstinted devotion,
dedication and strong motivation towards achievement of goals. Towards this end one must channelize all his energy so that overall development is achieved. Striving hard for symbiosis of technology is essential for improving technical quality education. The quality of technical education will be better with highly qualified and motivated staff and equally motivated wards. The quality of technical education system depends on the institution, infrastructure, faculty’s research, and development activities and industry institutions interaction etc. Quality is the single most important issue in education business and government today. We all recognize that there are problems with today’s education system. Students are graduating from college unprepared, to meet the demands of society. This problem has a ripple effect throughout society. Students who are not prepared to become responsible, productive citizens become a burden on society. These students, products of an education system that does not focus on quality, increase social welfare costs. They impact the criminal justice system, they are not prepared to meet the needs of the next generations, and perhaps they are citizens who feel alienated from society. If the quality of education is to improve, the improvement must be led by today’s educational professionals. Quality management is vehicle that educational professionals can use to cope with the ‘forces of change’, that are buffering our nation’s education system. Today, there are more than Six Hundred Engineering Colleges in the country, which are providing technical education to the students. Some colleges are fully government aided, some are partially and others are self-funding. Due to economical liabilities the standard of Technical education is different in different colleges. This difference arises the need for some common quality improvement techniques, which will raise the standard and make an institute at par with other colleges.

**Major Issues and Challenges**

Statistically, India’s Technical Institutions are producing the third largest Technical Manpower in the world, but there is no denying the fact that we have miserably failed in imparting quality technical education. The main grouse of the Industrial establishments is that our training system does not keep pace with the technological advancement in the related fields. At present, our technical education system faces two major challenges:

1. Quality Assurance
2. Keeping pace with the technological advancement; and in order to meet these challenges, the following resources need to be strengthened:
   1. Human Resources
   2. Material Resources

Thus, one of the most important tasks before the Government is appropriate Human Resource Planning, Development and Utilization. The Technical education system is one of the major sources of human resources. The Society is experiencing a phenomenal advancement in Technology. New practices are replacing the existing ones. If we have a look at the Industrial scene of India, there has been lot of changes during the last few years. In the liberalized scenario, traditionally protected Indian Industry has to compete with the multinationals from all over the world. Never in the history of the country, multinationals have contributed to the Indian economy as they are doing now. “Compete or
“perish” is the echo in the industrial world of today. This kind of technological explosion has posed a big challenge to Technical Education. Other issues are as follows:

(i) Lack of necessary aptitude for the course among the concerned students;
(ii) Inadequacy of instructional facilities;
(iii) Ineffective teaching, possibly because of the teachers not being trained; and
(iv) A heavy curriculum and non-selective admission of students to the institutions;
(v) Changing mix of urban and non-urban background of students without corresponding modifications/orientation of educational methods contributing to the detriment of the non-urban element;
(vi) Inadequate utilization of even the existing instruction facilities;
(vii) In spite of adequate capital investment and hardware provided in the institutions quite often, the lack of appropriate matching provision for adequate departmental operating and training costs;
(viii) Insufficient development of the correct attitudes to the professional education by both the teachers and the students; and
(ix) External factors, such as lack of motivation because of inadequate or assured employment opportunities at the end of the course.
(x) Ever increasing influence of science and technology on human society, e.g. New materials, new energy sources, pollution, environment, radio, TV, high speed transportation etc becoming important in every day life.
(xi) Frequent development in new products, processes and technologies; e.g. carbon and ceramic matrix composites as structural materials; high temperature super conductivity in electrical systems, convergence of computer and communications leading to IT, emergence of consumer electronics, penetration of lasers in industry and the resulting rapid obsolescence in many disciplines;
(xii) Transformation of industry/service sectors into more and more electronics, computers and automation based, e.g. flexible manufacturing, CAD/CAM. Micro controllers and IT enabled services, thereby generating new employment opportunities.
(xiii) Rapidly increasing numbers of students aspiring for admission to engineering degree and programmes year by year; But, at the same time, unfilled seats increasing at an alarming rate in many states, greatly straining the engineering education system;
(xiv) Teaching faculty strength in many cases much below the critical minimum required for the programmes; Also, knowledge updating of faculty members far from satisfactory;
(xv) Inadequate access to published literature like books, journals, conference proceedings, technical reports and application manuals; In addition, laboratory facilities and teaching infrastructure in most colleges/institute much below the contemporary level;
(xvi) Limited interaction between the engineering colleges/institutes and the world of employment; and, the employment potential in the country not fully exploited.
Steps to Improve Technical Education
The Technical Education System has to undergo introspection on its weakness and take active steps to improve the quality of the educational processes. Some of the steps are:

(i) Effective Autonomy to Engineering Institutions to upgrade curricula at regular intervals to keep abreast of developments in technology as well as pedagogy.
(ii) Effective Functional and Administrative Autonomy coupled with Accountability
(iii) Shift emphasis from teaching to learning and encourage students-centric learning strategies and development of self learning tools
(iv) Develop continuous teacher competence up gradation mechanism
(v) Put emphasis on obsolesce removal of infrastructure as well as teaching/learning evaluation process.
(vi) Strong interface with Industry i.e building Industry Institute partnership
(vii) Create opportunities for student exchange with other countries, transfer of credits, appreciating cultural diversity, methods of working, engineering standards, work ethics, discipline, etc to enable them in later professional life to adjust to external environment easily.

Vision and Mission
The institution should create innovative and knowledge based society through concurrent teaching methods in technical courses. To create techno-excellent citizens who will be responsible for overall development of society. To build the institution as a center of excellence of engineering education, the institution should produce graduates who meet international standards. The institution should produce an engineer who can adopt an integrated approach in engineering and judiciously use technology to benefit the society in particular and humanity at large.

Industry-Institution Symbiosis
Industries produce engineering products and institutes produce engineers the “human resource products”. While the engineering products are used by the people from different walks of life, including engineers, scientists, students and laymen. Institutions nurture and churn out the engineers for the industry. The institution is a supplier and industry is the costumer for employing the engineers. Therefore the industry should come forward for giving practical training for technical students like medical students training in hospitals.

Quality Improvement Techniques
Quality can be described as conformance to the specifications. In education scenario, it is related to quality of education imparted and its methodologies. Engineering education at present faces a number of challenges, particularly due to the following developments:

• Rapid advancement in technologies
• Multifaceted role of engineers. Emergence of new disciplines like information
technology and management, and cross merger of existing and old disciplines like mechatronics.

**TQM in Technical Education**

Total Quality Management (TQM) is a corporate business management philosophy, which recognizes customer needs and business goals are inseparable. Globalization and liberalization of Indian economy have increased the competition in various sectors such as industry, agriculture and services and quality becomes the only weapon to service in the present scenario. That is why it is important to apply TQM in Technical Education to get quality system. TQM is a technique based on output. Total quality management has been coined combining three words. ‘Total’ stands for involving all resources such as human, technological, physical and financial. ‘Quality’ means fitness for use and ‘Management’ means to manage all the things so that process of continuous improvement can move in the institutes.

1. Quality of infrastructure / teachers / building / equipment and machinery / laboratory assistants.
2. Time to time up-gradation of syllabi and technical facilities available in the institutes
3. Quality in the attitude of management, staff and students

While considering approaches towards TQM it has clearly been notified that there is no single route to TQM because it has no single starting point. Research studies have shown that the three key factors are:

1. Organization
2. Approach
3. Motivation

**MANAGEMENT SUPPORT**

Quality
Management
System

Fig 1 (Operational Model)

There are TQM models to satisfy the factors but operational model of TQM was the best to be used by institutions to make improvements in quality. This model uses their elements viz. total participation, problem solving tools and management support and commitment. PDCA (Plan-Do-Check-Act) is another essential tool for implementing a TQM plan in organization and Institutions.

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Fig 2 (PDCA cycle)

PDCA is a Principle for continuous improvement
Quality Excellence in Technical Education: Issues and Challenges

PLAN Understanding the current circumstances. Establishes activity plan and targets. Analysis of cases. Researching the improvement plan.

DO Implementation

CHECK Regular progress review

ACT Standardization and Institutionalizing

Many institutions had adopted some factors of TQM as quality circle, continuous improvement (Kaizen), total employee involvement, participative work culture etc. but no institute had adopted the full concept of TQM, which is advisable at this stage.

Quality Function Deployment in Technical Education

It is an important quality management technique for collecting the voice of customers, (QFD) process enables to translate the voice of customers into systems design requirement and provides valuable information that helps policy makers to assess the existing system and adopt new policies to have competitive edge in the market place. Normally, customers express their requirements in vague linguistic terms, which are difficult to understand. However, application of QFD eases out the process of translating customer attributes into engineering or quality characteristics. The following are the important elements of QFD:

1. Cross – sectional team in charge of implementing it.
2. The process itself.
3. The graphical display that guides the process.

The QFD is a sequence of activities for processing customer attributes so that these attributes can directly shape and make the service / product.

The fundamental steps of this process are:

• To identify the customer
• To identify what the customer wants; and
• To identify how to fulfill what the customer wants.

Staff Selection, Employee Empowerment and Student Orientation

Role of teacher in an Institute is very effective while movement towards quality education as he is the one who can move the future of students in right directions. This is the reason that All India Council for Technical Education (AICTE) sets the qualifications for the post of lecturers, Assistant Professors, Professors, Principal and keeps on upgrading them from time to time. Various quality improvement programs being organized by AICTE from time to time. Various managements should understand the requirement of these things and must allow their staff members to join such programs for the betterment of students and Institute. The staff members of any institute should be taken as associates rather than employees. This would create a job security feeling and a healthy education atmosphere can be created for better results. The staff members must be involved in various decisions taken by the Institutes. The present education system mainly focuses on the knowledge development part and there is little emphasis on skill improvement. Knowledge without skill could be of little use so Institute must manage courses for students
as well as staff members for their upgrade. For this industrial visits and training programs can also help.

**Conclusion**

Quality in any aspects cannot be achieved and maintained accidentally. A lot of pain, work and continuous improvement effort are required. It is time consuming process in the beginning as a change in the attitude of people is required. Various quality gurus have explained these techniques thoroughly. So help can be taken from there experiences. Looking at the present position of gap between Industry and Institution and Government Institution and private Institutions it is here by recommended that these quality improvement techniques must be used as soon as possible in present system only ‘Best can survive.’ In summary, the following suggestions are made:

1. The teachers of engineering institutions should equip themselves with distinct working knowledge of the subjects, which are taught by them, by undergoing compulsory training at the relevant industry/R & D institutes.
2. Upgrading of the subject knowledge for the teacher is essential as the same is required to be imparted to the students for being effective and meaningful.
3. Accreditation status has to be encouraged and insisted on for all institutions as a means of quality assurance.
4. Industry Institution partnership activities should be encouraged in all institutions for better technical quality.

**References**

An Overview of Anesthesia Ventilator

Dr. Sunil Kumar Singla
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Abstract
Respiration is one of the foremost important functions; a human body has to perform. A healthy body automatically undergoes the natural respiration process. On the other hand, at the time of acute illness or indisposed state the same body is unable to follow the natural respiration process and thus compelled to undergo some artificial way of respiration. Artificial respirator, as suggested by its name, is a device used for the purpose of artificial respiration. This device is also known as ventilator. Ventilators are often used during anesthesia for medical treatments.

Introduction
Ventilator is equipment that provides air/oxygen with a force that inflates the lungs and also determines the respiratory cycle. While delivering a breath the ventilator controls the different parameters of the breath such as tidal volume, flow rate, respiration rate etc. Every ventilator has to perform four functions. The ventilator must inflate the patient’s lungs. It must deflate the lungs or allow passive respiration. In addition, the ventilator must have some means by which it decides when to stop the process of inflation and start the process of expiration, and some other means by which it decides when to stop the process of expiration and start the process of inflation. In some ventilators it is possible to distinguish four separate mechanisms each of which serve one of these functions. In other types, one mechanism serves two or more functions. But the four functions must always be performed. Therefore the functional specification must be split into four parts as mentioned below:

(i) The inspiratory phase
(ii) The change over from the inspiratory phase to the expiratory phase
(iii) The expiratory phase
(iv) The change over from the expiratory phase to the inspiratory phase

The anesthesiologist uses the ventilator for the following reason:

(i) For better control of arterial carbon dioxide levels
(ii) To accomplish the vital role of ventilation
(iii) For reasonable compensation of changes in lung compliance with a volume-limited ventilator.

Anesthesia Ventilators
Ventilators that are used for anesthesia are of control type, using mainly two modes of operation [3]. The two modes are:
(i) Volume Ventilation
(ii) Pressure Ventilation

Volume controlled ventilation is appropriate for most patients, but pressure controlled ventilation offers advantages to some patients [1].

**Volume Ventilation**

Volume ventilation refers to delivering a specified tidal volume to the patient during the inspiratory phase. Figure 1 shows the flow and pressure waveforms for controlled mandatory volume ventilation (CMV). In this illustration, the inspiratory flow waveform is chosen to be a half-sine-wave. Where, t1 and tc are the inspiration and exhalation period respectively, while Q1 is the amplitude. The tidal volume equal to the area under the flow waveform will be delivered by the ventilator at regular intervals.

![Flow and Pressure Waveforms for CMV](image)

In volume ventilation, the ventilator delivers the same volume of air irrespective of the patient’s respiratory mechanics. Where as, resulting pressure waveform will be different among different patients. In all volume ventilators the difference between the maximum and the minimum alveolar pressures is equal to the tidal volume divided by the compliance. The positive end expiratory pressure (PEEP) is sometimes used to save the alveoli from collapsing during expiration. Volume controlled ventilation is appropriate for most of the patients [1].

**Pressure Ventilation**

Pressure ventilation refers to raising and maintaining the airway pressure during the in-
An Overview of Anesthesia Ventilator

spiratory phase of each breath to a level set by the therapist. Figure 2 shows a plot of pressure and flow during mandatory pressure ventilation. In this case, the respirator raises and maintains the airway pressure at the desired level independent of patient airway compliance and resistance. The level of pressure during inspiration, $P_i$ is set by the therapist. Although, the ventilator maintains the same pressure trajectory for patients with different respiratory resistance and compliance, the resulting flow trajectory will depend on the respiratory mechanics of each patient.

![Figure 2](image)

Figure 2 (a) Pressure pattern for a controlled mandatory pressure ventilation breath. (b) Airway flow pattern resulting from the breath delivery.

Initially pressure-limited ventilators were used in anesthesia because of their small size and mobility; but they require frequent adjustments of the tidal volume to compensate for changes in lung compliance. The development in electronic circuitry has reduced the size of volume-limited ventilator, so, volume-limited ventilator became an integral part of the anesthesia machine. Volume ventilators designed as an integral part of the anesthesia machine are separated into a control box and a bellow assembly. The transmission of power in the anesthesia ventilator is usually indirect. The gas from the driving mechanism, which is filtered and regulated, compresses a bag or a bellow that delivers the gas to the patient. Oxygen is used as the power supply to drive the ventilator. When anesthesia ventilator is turned ON, the driving compressed Oxygen gas regulated to about 50 psig starts flowing. This gas is then filtered and passed through a very accurate internal gas regulator to reduce its driving pressure to about 38 psig and this gas is then passed through a set of five solenoid valves in parallel. The solenoid valve controls the amount of gas per minute flowing through the corresponding orifice. By precisely opening and closing the selected...
solenoid valves, the volume of the Oxygen corresponding to the calculated tidal volume and at the correct overall flow rate is delivered. From the five orifices the Oxygen flows to the collection chamber and then to the bellow chamber. The collection chamber is fitted with a pressure relief valve, venting to the atmosphere at approximately 65cm H2O. The driving compressed Oxygen gas enters the bellow chamber to deliver the gas contained to the patient circuit. The volume of the driving gas reaching the chamber is in one to one ratio with the tidal volume set and is of 100% Oxygen. As the tidal volume delivered is determined by the driving gas volume entering the bellow chamber, the bellow does not fully descend except when delivering the maximal tidal volume contained in the bellow. At the start of the inspiration the control module closes the exhalation valve and delivers driving gas to area around the bellows. When the expiratory cycle begins the solenoid valves are deactivated by the electronic control circuit which closes the pneumatic circuit and stops all Oxygen going to the bellow assembly. At the same time the exhalation valve opens and the gas flow in the breathing circuit reverses. Driving gas is released in to the atmosphere and the gas from the patient circuit after passing through the expiration limb, which contains the CO2 absorber, refills the bellow as shown in figure 2.4(b). The CO2 absorber is usually soda lime. The fresh Oxygen gas is added in the bellow to compensate for Oxygen consumption. If the fresh gas supply is just equal to the patient’s Oxygen consumption the system is called truly closed. If during the expiratory cycle (when bellow has extended completely) the pressure inside the bellow exceeds about 2.5cm H2O, the pop-off valve opens, releasing the excess gas through the bellow assemblies exhaust port to the atmosphere.

**Important Variables of the Controlled Ventilation**

While using the ventilator the anesthetist is mainly concerned with the amount of ventilation, size of each breath, the rate of inspiratory gas flow and time available for the distribution of gas in the lung. All the above four quantities are represented by minute volume, tidal volume, inspiratory flow rate and Inspiratory plateau time (Tplat) respectively. The important variables for controlled ventilation are as given below:

i) Minute volume  
ii) Tidal volume  
iii) Inspiratory flow rate  
iv) Respiration rate

**Minute Volume (MV)**

The amount of gas inspired during one minute at rest is known as minute volume [3]. The respiratory minute volume (MVe) is the product of tidal volume (Vt) and the number of respiratory cycles per minute (f). Mathematically the relation is given by :

\[ MV = Vt \times f \]  

Minute volume for the healthy human beings ranges from 1L/min for the newly born to 12 L /min for adults. The minute volume for adults normally ranges between 5 to 10 L/ min.
Tidal Volume (Vt)

It is the volume of gas inspired or expired during each normal, respiration cycle at rest [3]. Tidal volume is related to the maximum pressure in the alveoli by the compliance. In fact, the tidal volume is equal to the difference between the maximum and the minimum pressure in the alveoli multiplied by the compliance.

\[
\text{Tidal volume} = (\text{maximum pressure} - \text{minimum pressure}) \times \text{compliance}
\]

In resting healthy human beings the tidal volume ranges about 20 ml at birth to a little over 1L in large athletes. Normally we inhale about 500 cm3 of air with each breath. Majority of ventilators allow the direct setting of tidal volume. When the tidal volume is being preset the airway pressure should be monitored to reflect changes in the patient.

Inspiratory Flow Rate

The rate at which the air enters the lungs during inspiration, is known as inspiratory flow rate. Faster the flow rate into the lungs, the shorter is the inspiratory phase. Limits, however, are set to this by mechanical design problems and by the danger of the alveolar rupture in the circumstances of uneven ventilation. However, in general, tendency should be to use higher flow rates than lower during inspiration. Inspiratory flow rate at rest, ranges from about 2.5 L/min to about 50 L/min. In adults this range is about 10L/min to 50 L/min.

In the circumstances where the anesthetist is mainly concerned to reduce the mean alveolar pressure, a more extreme I:E ratio may be desired. In order to achieve the above condition, higher inflating flow will be needed.

3.3.4 Respiration Rate

The number of respirations taken by a person in a particular interval of time is known as respiration rate. Normally a man breathes 12 times per minute. A woman breathes 20 times per minute and an infant breathes about 60 times per minute. Respiration rate is very important parameter as it helps to determine the total amount of volume of air taken by a person during one minute. The relationship between the minute volume, tidal volume and respiration frequency is given by relation (1).

Alarms

The alarm is an indication to the operator or to the anesthetist that something abnormal has occurred in the machine. Each ventilator has different number of alarms depending upon its construction and the variables to be controlled. Generally the various alarms present in all ventilators are:

(i) Power fail alarm
(ii) Ventilator fail alarm
(iii) Set volume not delivered alarm
(iv) Low Oxygen supply pressure alarm  
(v) Low airway pressure alarm  
(vi) Actual I:E less than the dial setting alarm

These alarms are described in brief as follows:

4.4.1 Power fail alarm When the unit detects that the electric power given to it fails, this alarm sounds.

4.4.2 Ventilator failure alarm When the unit detects a critical internal failure, this alarm sounds.

4.4.3 Set volume not delivered alarm When the user has selected a minute ventilation and respiratory rate combination that requires a tidal volume greater than can be delivered by the ventilator, this alarm sounds.

4.4.4 Low Oxygen supply pressure alarm When the pressure in the driving gas line falls, below 40 psig, continued operation with a low gas supply, results in a minute volume less than set on the control panel, this alarm sounds.

4.4.5 Low airway pressure alarm If the airway pressure does not reach 6cm H2O after two or three ventilator cycles, this alarm sounds. It functions as circuit low-pressure alarm.

4.4.6 Actual I: E less than dial setting alarm When the settings are adjusted in such a way that the required inspiratory time to expiratory time ratio can not be obtained, this alarm sounds.

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Data Mining Techniques in Pharmaceutical Industry

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Abstract
Today IT technology is being used to help the pharmaceutical firms manage their inventories and to develop new product and services. The implications are such that by a simple process of merging the drug usage and cost of medicines (after completing the legal requirements) with the patient care records of doctors and hospitals helping firms to conduct nation wide trials for its new drugs. Other possible uses of information technology in the field of pharmaceuticals include pricing (two-tier pricing strategy) and exchange of information between vertically integrated drug companies for mutual benefit.

The paper presents how Data Mining discovers and extracts useful patterns from this large data to find observable patterns. The paper demonstrates the ability of Data Mining in improving the quality of decision making process in pharma industry.

Keywords: Data Mining, drug discovery, pharma industry.

Introduction
Data Mining is the process of extracting information from large data sets through the use of algorithms and techniques drawn from the field of Statistics, Machine Learning and Data Base Management Systems (Feelders, Daniels and Holsheimer, 2000). Data Mining, popularly called as knowledge discovery in large data, enables firms and organizations to make calculated decisions by assembling, accumulating, analyzing and accessing corporate data. It uses variety of tools like query and reporting tools, analytical processing tools, and Decision Support System (DSS) tools. Recently, numerous experts have predicted that revenue growth for the pharmaceutical industry will slow from the healthy 12% rate to a much slower 5-6% rate. (Cosper Nate, 2003) describes this trend, which is becoming increasingly accepted, has numerous implications for the drug discovery technologies companies. Most significantly, slower revenue growth will necessitate decreased expenditures throughout the organization.

The importance of decision support in the delivery of managed healthcare can hardly be overemphasized (Hampshire and Rosborough, 1993). A variety of decision support capabilities will be necessary to increase the productivity of medical personnel, analyze care outcomes, and continually refine care delivery processes to remain profitable while holding the line on costs and maintaining quality of care (Dutta and Heda, 2000). Healthcare decision support is faced with the challenges of complex and diverse data and knowledge forms and tasks (Prins and Stegwee, 2000, Sheng, 2000), the lack of standardized termi-
Data Mining Techniques in Pharmaceutical Industry

Data Mining Techniques
Pharma industries rely on decision oriented, systemic selection models that enable the decision maker to evaluate the payoff that is expected to result from the implementation of a proposed selection program. Such models go beyond an examination of the size of the validity coefficient and take a host of issues such as capital budgeting and strategic outcomes at the group and organizational levels. Many organizations generate mountains of data about their new drugs discovered and its performance reports, etc. This data is a strategic resource. Now, making use of most of these strategic resources will lead to improving the quality of pharma industries. Feelders, Daniels and Holsheimer, 2000 give six important steps in the Data Mining process as

1. Problem Definition.
2. Knowledge acquisition.
3. Data selection.
5. Analysis and Interpretation.
6. Reporting and Use.

(Berthold Michael and Hand David, 1999) identify the Data Mining process as

1. Definition of the objectives of the analysis.
2. Selection & Pretreatment of the data.
3. Explanatory analysis.
4. Specification of the statistical methods.
5. Analysis of the data.
7. Interpretation of the chosen model.

The techniques and methods in Data Mining need brief mention to have better understanding.

(A) Associations, Mining Frequent Patterns
These methods identify rules of affinities among the collections. (Hand, Mannila and Smyth, 2001) mention that patterns occur frequently during Data Mining process. The applications of association rules include market basket analysis, attached mailing in direct marketing, fraud detection, department store floor/shelf planning etc.

(B) Classification and Prediction
The classification and prediction models are two data analysis techniques that are used to describe data classes and predict future data classes. A credit card company whose cus-
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tomer credit history is known can classify its customer record as Good, Medium, or Poor. Similarly, the income levels of the customer can be classified as High, Low, and Medium. (Adriaans Peiter and Zantinge Dolf, 2005) explain that if we have records containing customer behavior and we want to classify the data or make prediction, we will find that the tasks of classification and prediction are very closely linked. The models of decision trees, neural networks based classifications schemes are very much useful in pharma industry. Classification works on discrete and unordered data, while prediction works on continuous data. Regression is often used as it is a statistical method used for numeric prediction. Primary emphasis should be made on the selection measurement accuracy and predicative efficiency of any new drug discovery. Simple or multiple regressions is the basic prediction model that enables a decision maker to forecast each criterion status based on predictor information.

Clustering
It is a method by which similar records are grouped together. Clustering is usually used to mean segmentation. An organization can take the hierarchy of classes that group similar events.
Using clustering, employees can be grouped based on income, age, occupation, housing etc. In business, clustering helps identify groups of similarities; characterize customer groups based on purchasing patterns, etc.

Data Mining and Statistics
The ability to build a successful predictive model depends on past data. Data Mining is designed to learn from past success and failures and will be able to predict what will happen next (future prediction). The Data Mining tool checks the statistical significance of the predicted patterns and reports. Data Mining, in contrast is discovery driven. That is, the hypothesis is automatically extracted from the given data. The other reason is Data Mining techniques tend to be more robust for real-world messy data and also used less by expert users (Berson et al., 1999). Data Mining can answer analytical questions such as: what are discovery of new molecules and issues over it? What factors or combinations are directly impacting the drugs? What are the best and outstanding drugs? Which drugs are likely to be retained? How to optimally allocate resources to ensure effectiveness and efficiency? etc. Since the major chunk of literary information is in the form of unstructured text, an intelligent text mining system could provide a platform for extracting and managing specific information at the entity level.

Applications of Data Mining in:
The Pharmaceutical Industry
Most healthcare institutions lack the appropriate information systems to produce reliable reports with respect to other information than purely financial and volume related statements (Prins & Stegwee, 2000). The delivery of healthcare has always been information intensive, and there are signs that the industry is recognizing the increasing importance
of information processing in the new managed care environment (Morrisey, 1995). Most automated systems are used as a tool for daily work: they are focused on ‘production’ (daily registration). All the data, which are used to keep the organization running, These systems are also called legacy systems. A lot of information is hidden in the legacy systems. This information can easily be extracted. Most of the times this can not be done directly from the legacy systems, because these are not build to answer questions that are unpredictable.

Sampling techniques and tests of significance may be satisfactory to identify some of the more common relationships; however, uncommon relationships may require substantial search time. A user-interface may be designed to accept all kinds of information from the user (e.g., weight, sex, age, foods consumed, reactions reported, dosage, length of usage). Then, based upon the information in the databases and the relevant data entered by the user, a list of warnings or known reactions (accompanied by probabilities) should be reported. The amount of existing pharmaceutical information (pharmacological properties, dosages, contraindications, warnings, etc.) is enormous; however, this fact reflects the number of medicines on the market, rather than an abundance of detailed information about each product.

**Development of New Drugs**

The Data mining techniques that are used in developing of new drugs are clustering, classification and neural networks. The basic objective is to determine compounds with similar activity. The reason is for similar activity compounds behave similarly. This is possible only when we have known compound and looking for something better. When we don’t have known compounds but have desired activity and want to find compound that exhibits this activity, then data mining rescues this.

**Development Tests and Predicts Drug Behavior**

There are many issues which affect the success of a drug which has been marketed which can impact the future development of the drug. Firstly adverse reactions to the drugs are reported spontaneously and not in any organized manner. Secondly we can only compare the adverse reactions with the drugs of our own company and not with other drugs from competing firms. And thirdly we only have information on the patient taking the drug not the adverse reaction that the patient is suffering from. All this can be solved with creation of a data warehouse for drug reactions and running business intelligence tools on them a basic classification tool can solve much of the problems faced here. We could find out the adverse reactions associated with a specific drug and still go a step further to show if any specific condition aggravates the adverse reaction for eg age, sex, and obesity (Novartis Business Intelligence report, 2004). This could help the medical practitioner to describe the side effects to the patients being prescribed these drugs. The information like gender, body weight, disease state, etc will play crucial role. This crucial data should be fed into neural network and predict whether patient will benefit from drug. Only one of two clas-
sifications yes/no will be available on training data. Network is trained for the yes classifications and a snapshot is taken of the neural network. Then network is trained for the no classifications and another snapshot is taken. The output is yes or no, depending on whether the inputs are more similar to the yes or the no training data.

**Clinical Trials Test the Drug in:**
**Humans**
Company tests drugs in actual patients on larger scale. The company has to keep track of data about patient progress. The Government wants to protect health of citizens, many rules govern clinical trials. In developed countries food and drug administration oversees trials. The Data mining techniques used here can be neural networks. Here data is collected by pharmaceutical company but undergoes statistical analysis to determine success of trial. Data is generally reported to food and drug administration department and inspected closely. Too many negative reactions might indicate drug is too dangerous. An adverse event might be medicine causing drowsiness. As a matter of fact, Data mining is performed by food and drug administration, not as much by pharmaceutical companies. The goal is to detect when too many adverse events occur or detect link between drug and adverse event.

**Conclusion**
Until now, most of the statistics are used in the R&D department. It is also observed that Data mining techniques are seldom used in a pharmaceutical environment. This paper described that these techniques can be easily and successfully used. The paper presented on how Data mining discovers and extracts useful patterns from this large data to find observable patterns. The paper demonstrates the ability of Data Mining in improving the quality of decision making process in pharma industry.

**References**


Effect of wavelength and temperature Changes on optical performance of fiber connection with air gap

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Abstract
In this paper, characteristics of optical fiber connectors with air gap over wide wavelength and temperature ranges is investigated. When there is a small air gap between fiber ends, the insertion loss increases between 0.0 and 0.67dB over a wide wavelength range of 0.7–1.7 µm and a wide temperature range of -400C to +800C. The return loss varies greatly and the worst value is about 9 dB. The return loss depends on temperature with fiber end joints that uses index matching material.

Key Words: Connector, optical fiber connecting, optical losses, index material.

Introduction
Various types of optical fiber connectors and mechanical splices have been used in optical subscriber networks such as fiber-to-the-home (FTTH) systems [1]. Physical contact (PC)-type connectors without index matching material is used for intra office use and the place where frequent reconnections are required. While connectors and mechanical splices with index matching material are used in outside plants where low-cost joints are needed. However, some points remained doubtful. Unexpected failure when installing these fiber joints might have a detrimental effect on performance. For instance, when an air gap occurs at the contact point with PC-type connectors or connectors using index matching material, the optical performance becomes n worst. It is important to understand the worst possible optical performance of these fiber joints since this will enable us to guarantee the overall performance of a system. This paper details about some significant properties and summarizes the characteristics of fiber connections with a small air gap. Author has measured the dependence of the insertion and return losses of the fiber connections on wavelength and temperature. Paper include the characteristics that are based on the results obtained for mechanically transferable (MT) connectors [5], which are generally used in outside plants for connecting multi fiber array ribbons.
Connection Layout

Fig.1 shows the basic optical fiber connection Layout. In this Layout; two optical fibers are connected with a small air gap remaining between them.

![Fig.1 Layout of fiber connector with small air gap](image)

Here, the small air gap means a length of wavelength order. The misalignments of the offset and tilt between the fibers are not taken into account. In this figure, Fresnel reflections occur at the fiber ends because of refractive discontinuity, and some of the incident light is reflected in the small air gap. As the phase of the multiple reflected light changes whenever it is reflected, this interferes with the transmitted and reflected lights at the optical fiber connection. These multiple reflections between fiber ends are behaved like a Fabry–Pérot interferometer. Two fiber ends make up the Fabry–Pérot resonator. Based on the layout, the Fresnel reflection at the fiber end, the transmitted efficiency, and the returned efficiency are defined by the following equations:

\[
R_0 = \left( \frac{n_1 - n}{n_1 + n} \right)^2
\]  

\[
T = \frac{P_t}{P_i} = \frac{(1 - R_0)^2}{(1 - R_0)^2 + 4R_0 \sin^2 \left( \frac{2\pi n S}{\lambda} \right)}
\]  

\[
R = \frac{P_r}{P_i} = \frac{4R_0 \sin^2 \left( \frac{2\pi n S}{\lambda} \right)}{(1 - R_0)^2 + 4R_0 \sin^2 \left( \frac{2\pi n S}{\lambda} \right)}
\]

Where \( P_i \), \( P_t \), \( P_r \), \( n_1 \), \( n \), \( S \), and \( \lambda \) denote the incident power, transmitting power, returned power, core refractive index, and refractive index of the medium between fiber ends, gap size, and wavelength, respectively. According to (2) and (3), the transmitted efficiency and returned efficiency depend on wavelength, gap size, and the refractive index of the medium between the fiber ends.

Wavelength Dependence

This section describes the wavelength dependence of fiber joints with a small air gap. We obtained experimental results for MT-type connectors, which were assembled with 1.3- \( \mu \)m zero dispersion fibers. MT connectors are generally used in outside plants for connecting multi fiber array ribbons and have a small gap between two fiber ends that are filled with index matching material to reduce Fresnel reflection. The experimental procedure is described below. First, the two ends of 20 m of 1.3\( \mu \)m zero-dispersion fiber patch cord were connected to a white light source and an optical spectrum analyzer, re-
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respectively. The power from the fiber patch cord was measured as $P_i$. Next, the fiber patch cord was cut in the middle and installed in an MT connector, which was inserted between the fiber patch cords. This operation was achieved with a high degree of precision using a fusion splice. The power from the fiber patch cord installed with the MT connector was measured as $P_t$. The measurements were performed over a wide wavelength range. The insertion loss is determined by using relation $-10\log (P_t / P_i)$ caused by the installation of the MT connector. Finally, the return loss $-10\log (P_r / P_i)$ of the patch cord installed with the MT connector was measured using a laser diode and a coupler reflectometer[5]. These experiments were performed at room temperature (23oC). Fig. 2 shows typical insertion loss results for connectors with a small air-filled gap and with refractive index matching material between the fiber ends.

![Graph showing typical insertion loss results.](https://example.com/graph.png)

**Fig. 2**  Wavelength (µm)

The circles and squares represent measured results obtained with air and index matching material, respectively. The solid and dashed lines represent calculated results based on (2) for core, air, and index matching material with respective refractive indexes of 1.454, 1.0, and 1.460, and for a gap of 1.13 µm.

The experimental data for the air gap vary between 0.0 and 0.67 dB over a wide wavelength range. In contrast, the experimental data for the index matching material gap are not above 0.06 dB which is negligible. The measured results for the index matching material vary more than the calculated results; however, the two sets of results are in good agreement. These results confirmed that the above model was more precise for fiber joints with a small air gap. Fig. 3 shows typical return loss results for the same connectors with a small gap. The circles, squares, solid line, and dashed line represent measured results obtained with air and index matching material, and calculated results based on (3) for the above air and index matching material gaps, respectively. The return losses for the air gap varied greatly and resulted in a worst value of about 9.0 dB. In contrast, the return losses with the index matching material gap were kept above 47 dB to avoid influencing the transmission characteristics of the system [1]. Consequently, if there is a small air gap at the fiber joint contact point, the transmitted and returned efficiencies vary greatly depending on wavelength. The fiber joint with the index matching material gap provides
high transmitted and low returned efficiencies.

**Temperature Dependence**

This section describes the temperature dependence of fiber joints with small gaps that are filled with air or index matching material. The refractive index of the index matching material is more dependent on temperature than that of optical fiber, because its molar refractivity is more dependent on temperature. This can affect the reflection of the fiber joints where index matching material is employed. The refractive index changes linearly with temperature from 40°C to 80°C. We obtained a refractive index of 1.460 at 20°C and a thermal coefficient of \( \Delta n / \Delta T \) of \(-3.4 \times 10^{-4} / ^\circ C\) at a wavelength of 1.3\( \mu \)m using a return loss method [6]. This slight refractive index change dependence on temperature for index matching material has a great influence on the reflection from the fiber joint. On the other hand, based on the return loss method, the refractive index of air was constant with temperature.

Fig. 4 shows the temperature dependence of the insertion loss of the connectors at a wavelength of 1.3\( \mu \)m with air and index matching material, respectively.

![Graph showing return loss vs. wavelength for fiber connector with air gap and index matching material](image1)

**Fig. 3** Wavelength dependence return losses of fiber connector with an air gap & index matching material

![Graph showing temperature dependence of insertion loss for fiber connectors](image2)

**Fig. 4** Temperature (0°C)
Effect of wavelength and temperature changes on optical performance of fiber connection with air gap

Fig. 5 shows the temperature dependence of the return losses of other connectors at a wavelength of 1.3 µm with air and index matching material, respectively.

Fig. 5 Temperature (0°C)

The circles, squares, solid line, and dashed line, respectively, represent measured results for air and index matching material gaps, and calculated results based on (2) and (3) for air and index matching material gaps. Based on (2) and (3), when the wavelength and refractive index of air are 1.3 µm and 1.0 (for an air gap between fiber ends), the insertion loss vibrates between 0.0 and 0.6 dB depending on the small air gap size. The return loss also vibrates between about 9 and more than 70 dB. This value also depends on the air gap size. These features are similar to the wavelength dependence seen in Figs. 2 and 3. The worst insertion loss of 0.67 dB and the worst return loss of 9 dB are derived for gaps of S=λ/4n=0.325 µm, S=3λ/4n=0.975 µm, S=5λ/4n=1.625 µm and so on by using (2) and (3). Therefore, we used the calculated results as the worst values when derived for a gap in (2) and (3) and the calculated lines exhibit the worst values in Figs. 4 and 5. The calculated and experimental insertion losses for an index matching material gap are constant and almost all are negligible over a wide temperature range. On the other hand, the experimental data for the air gap are between 0.0 and 0.67 dB over a wide temperature range. According to (2), the insertion loss is dependent on the gap size and the refractive index of the air between the fiber ends. The refractive index of air was constant at 1.0 over a wide temperature range based on experimental results obtained with the return loss method. Therefore, the insertion loss for the air gap varies between 0.0 and 0.67 dB depending on the gap size. Based on this consideration, the experimental insertion loss variation is caused by the change in the air gap size with temperature.

We could not directly measure the gap sizes between the fiber ends of the MT connectors during the experiments. However, the results indicate that when there is a small air gap between the fiber ends, the insertion loss becomes noticeably worse. The insertion loss increases to a certain value between 0.0 and 0.67 dB depending on the air gap size. The worst value is 0.6 dB. The experimental return losses for an air gap are low and vary slightly over a wide temperature range, and the worst value is about 9 dB. This variation is also caused by the changes in gap size with temperature. In contrast, with an index
matching material gap, the measured and calculated return losses vary greatly and the peak values are over 50 dB. This change is effected by the dependence of the refractive index on the temperature of index matching material. The measured results between 300°C and 500°C are slightly lower than the calculated values.

**Conclusion**

Based on the above results, we summarized the characteristics of fiber joints with a small air gap. With a small air gap, the insertion losses vary between 0.0 and 0.67 dB over a wide wavelength range of 0.7–1.7µm. The insertion loss changes to a certain value between 0.0 and 0.67 dB over a wide temperature range of 400°C to 800°C. The return losses also vary greatly and the worst value is about 9 dB. This might occur when a fiber joint employing PC experiences an unexpected failure. In general, the optical performance of a connector that maintains perfect PC will remain stable over a 400°C to 800°C temperature range and not affected by wavelength variation [3]. However, when there is an air gap between fiber ends with PC type joints, the optical performance worsens noticeably. When the gap is small, which corresponds to a length of wavelength order, for example less than 10µm for a wavelength of 1.3 µm, the insertion loss increases between 0.0 and 0.67dB based on the above analysis? Moreover, if the gap is sufficiently longer than the wavelength, the insertion loss worsens and becomes much larger than 0.67dB based on the Marcuse analysis. For instance, the insertion loss increases about 2.65 dB when the gap is 100 µm. With fiber joints employing index matching material, the optical performance has high transmitted and low returned efficiencies over a wide wavelength range of 0.7–1.7µm. The insertion losses of the fiber joints are stable and negligibly low over a wide temperature range. In contrast, the return losses vary greatly over a wide temperature range [2]. The data vary from a peak value of more than 50 dB to a worst value of 35 dB at low temperature.

In conclusion, we have investigated the characteristics of optical fiber joints with a small air gap over wide wavelength and temperature ranges. When an air gap occurs at the contact point of a fiber joint, the insertion loss and the return loss vary with wavelength. The return losses of fiber-end joints employing index matching material depend on temperature.

**References**


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Evaluation of Just in Time Elements in Banking Sector Using ANOVA Technique

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Abstract
In today’s drastically changing business environment, no business can grow and prosper if it does not adapt to the rapidly changing work practices. Just In Time (JIT), the formalized process of reducing all kinds of wastes has been popular in the manufacturing sector for a long time. The service industry has recognized that the JIT system can be adapted successfully in their processes and add value to the basic inputs used to create the end product. The most important aspect of JIT is that it lays emphasis on the process and not on the end product. It therefore can be applied to any process within the service sector. This paper presents the relative importance and difficulties in implementation of JIT elements in the banks and verification of data with the help of Analysis Of Variance (ANOVA) Technique and also identifies the JIT elements which are most important and easy to implement in the banks.

Introduction to JIT
Just In Time (JIT) means producing goods and services exactly when they are needed. For example, a new company opens that is producing steering shaft for automobiles. The company, under the JIT system, will set up the machines to produce the jobs in a row from those who collect the metals at one end, all of the way to those who ship the product at the other end of the factory. The people at each station, as they receive the product, take the job order, perform their duties on the product, and then transfer the product out to the next station after their work is completed. Along the way, the product is screened for infirmities, and if they exist, the line is stopped until the defect is repaired. In the end, the shipping agent will receive the product and ship it to the customer. All along the way, the production never began until the order came in and then the goods were produced from that point on out, and not sitting in inventory waiting on the already finished good. JIT is a system designed to make an organization operate efficiently and with a minimum number of human and mechanical resources. JIT also improves quality, reduces inventory levels and provides maximum motivation to solve problems as soon as they occur. JIT is a revolutionary concept that challenges by its very simplicity. It introduces no advanced technology or complicated principles but instead strives to eliminate the unnecessary burdens of complexity. The first basic principle involved in JIT production approach is the elimination of waste. In a JIT system, waste is defined as anything associated with the
production process that does not add value to the product. Thus, waste includes quality defects, inventories of all kinds, time spent to move material and time spent in setting up the machines. The second principle of JIT involves the management of people. JIT philosophy assumes that people are capable and willing to take on more responsibility. If defective parts are being produced, an individual can stop the production line. Once stopped, everyone working on the line has the responsibility to solve the problem.

Methodology
Every essential element of JIT may not be easily implemented and some elements are difficult to implement. These problems may be related to inappropriate understanding of JIT methodology or may be related to technical, operational and human problems.

There are some questions related to JIT system:

i) Which are the essential elements of JIT?
ii) Which elements are important and difficult to implement?
iii) Which elements can be easily implemented?
iv) Which elements are highly beneficial in banks?

Firstly, various elements are identified from the available literature for the purpose of comparison. The procedure for the study is:

- Research design,
- Instrument,
- Survey Participants and
- Data collection.

Research Design
This study employed non-experimental quantitative research. Specifically, the design involves mail survey method, which is the most frequently used descriptive research design. This research design requires responses from banking personnel and further requires quantitative data analysis.

Instrument
A survey was designed to find out the most important elements of JIT which are easy to implement in banks. The survey consists of comparison based on following common parameters. The parameters are Organization Policies, Communication and Information sharing, People Strategy, Team Work, Employee Training, Quality Circles, Group Incentive Scheme, Top management support, Employee Empowerment and Customer Satisfaction etc.

Survey Participants
A questionnaire regarding the importance and difficulties of JIT elements was designed and distributed in various banks. This study uses a mail survey to distribute and gather the data. A mail survey provides the most appropriate method to obtain relevant, up-to-date
information from a large sample of banks.

**Data Collection**

Data were collected following the self-administered mail survey method. Self-administered mail survey has the advantages of relatively low cost and easy access to widely dispersed samples. These people were also assumed aware of the general characteristics of the Banks.

In mailing, the survey sends with:

i) The cover letter that informed an overview of the aim of the survey, identification of the researchers,

ii) Details of the JIT elements chosen for the survey.

After sending the questionnaire, a follow-up postcard was sent to the participants one week later thanking for their cooperation.

**Literature Review**

Identification of JIT Elements

Preparation of Questionnaire

Circulation of Questionnaire

Data Collection

Data Analysis and Survey

ANOVA Technique

Observations

Conclusions

Scope for Future Work
Evaluation of Just in Time Elements in Banking Sector Using ANOVA Technique

Research Methodology

Results

We identified a detailed list of 26 elements of JIT system derived by JIT implementation which are suitable for banks. But all elements of JIT may not be easy to implement. Therefore, there is a necessity to find out those elements of JIT system which are easy and which are difficult to implement in Indian context. Hence a survey of banks is carried out to give useful insights on the basis of listed elements and benefits to achieve the above mentioned objectives. Indian banks can become competitive by successful implementation of JIT as JIT benefits are visible in all areas such as quality, delivery time, service cost etc. The questionnaire was distributed in 50 banks taking 2 employees from each bank. The questionnaire was collected from all the banks successfully with a very good response. Then all the responses were analyzed. The mean score for each element was calculated. There are two tables giving the mean score of JIT elements for importance and difficulties in context of Indian banks.

The first table provides the mean score of Degree of Importance of JIT elements in various banks.

### TABLE 1: DEGREE OF IMPORTANCE OF JIT ELEMENTS IN BANKS

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>JIT ELEMENTS</th>
<th>RESPONSE</th>
<th>Mean Score (0-400)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>4 3 2 1 0</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Organization Policies</td>
<td>29 18 6 12 35</td>
<td>194</td>
</tr>
<tr>
<td>2</td>
<td>Communication and Information Sharing</td>
<td>45 17 13 16 9</td>
<td>273</td>
</tr>
<tr>
<td>3</td>
<td>People Strategy</td>
<td>21 25 16 5 33</td>
<td>196</td>
</tr>
<tr>
<td>4</td>
<td>Team Work</td>
<td>44 12 16 16 12</td>
<td>260</td>
</tr>
<tr>
<td>5</td>
<td>Employee Training</td>
<td>38 28 20 10 4</td>
<td>286</td>
</tr>
<tr>
<td>6</td>
<td>Expert Lectures</td>
<td>13 31 17 16 23</td>
<td>195</td>
</tr>
<tr>
<td>7</td>
<td>House Keeping (Orderliness, cleanliness, discipline, safety)</td>
<td>35 22 18 14 11</td>
<td>256</td>
</tr>
<tr>
<td>8</td>
<td>Infrastructure (Aesthetic Value)</td>
<td>18 26 14 13 29</td>
<td>191</td>
</tr>
<tr>
<td>9</td>
<td>Job satisfaction</td>
<td>46 28 11 6 9</td>
<td>296</td>
</tr>
<tr>
<td>10</td>
<td>Employee Feedback and Suggestions</td>
<td>19 21 13 11 36</td>
<td>176</td>
</tr>
<tr>
<td>11</td>
<td>Judoka (use of modern/automatic age)</td>
<td>29 26 20 12 13</td>
<td>246</td>
</tr>
<tr>
<td>12</td>
<td>Quality Circles</td>
<td>15 23 22 6</td>
<td>34 179</td>
</tr>
<tr>
<td>13</td>
<td>Schedule Stability</td>
<td>14 20 20 12</td>
<td>34 168</td>
</tr>
<tr>
<td>14</td>
<td>Sole Sourcing</td>
<td>12 22 14 16</td>
<td>36 136</td>
</tr>
<tr>
<td>15</td>
<td>Group Incentive Scheme</td>
<td>24 24 13 21 18</td>
<td>215</td>
</tr>
<tr>
<td>16</td>
<td>Frequent and Reliable Service</td>
<td>50 30 13 6</td>
<td>1 322</td>
</tr>
<tr>
<td>17</td>
<td>Error Prevention (Poka Yoke)</td>
<td>17 22 19 14</td>
<td>28 186</td>
</tr>
<tr>
<td>18</td>
<td>Top Management Support</td>
<td>35 24 16 12</td>
<td>13 256</td>
</tr>
<tr>
<td>19</td>
<td>Value Addition Services (CSP)</td>
<td>18 25 14 6</td>
<td>37 181</td>
</tr>
<tr>
<td>20</td>
<td>Standardization</td>
<td>30 27 23 4</td>
<td>16 251</td>
</tr>
<tr>
<td>21</td>
<td>Degree of Complexity</td>
<td>7 22 22 12</td>
<td>37 150</td>
</tr>
<tr>
<td>22</td>
<td>Employee Empowerment</td>
<td>22 23 9 11</td>
<td>35 186</td>
</tr>
<tr>
<td>23</td>
<td>Customer Awareness</td>
<td>45 24 22 4</td>
<td>5 300</td>
</tr>
<tr>
<td>24</td>
<td>Ergonomics Design (Working Conditions)</td>
<td>32 27 24 8</td>
<td>9 265</td>
</tr>
<tr>
<td>25</td>
<td>Customer Satisfaction</td>
<td>43 25 11 9</td>
<td>12 278</td>
</tr>
<tr>
<td>26</td>
<td>Commitment</td>
<td>25 26 20 10</td>
<td>19 228</td>
</tr>
</tbody>
</table>
Table 1 indicates that Frequent and Reliable Service has got the maximum value (i.e. 322), hence is the most important element of JIT for Banks and Customer Awareness got 300, as mean score, which is second most important element of JIT whereas, Sole Sourcing got 136 as mean, which is the least one, hence it can be termed as least important in banks in Indian context.

From Table 1, other most important elements are Communication and Information Sharing, Team Work and Job Satisfaction etc. and the least important elements are Degree of Complexity, Employee Empowerment, Value Addition Services (SDP), Schedule Stability and Quality Circles etc. The second table reveals the mean score of Degree of Difficulties of JIT elements in various banks. From this table the most difficult elements are Top Management Support, Standardization, Group Incentive Scheme, Sole Sourcing etc. The least difficult elements are Customer Awareness, Commitment, Degree of Complexity, Value Addition Services, Frequent and Reliable Service, Schedule Stability etc.

**TABLE 2: DEGREE OF DIFFICULTIES OF JIT ELEMENTS IN BANKS**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>JIT ELEMENTS</th>
<th>RESPONSE</th>
<th>Mean Score (0-400)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Organization Policies</td>
<td>12 16 24 10 38</td>
<td>154</td>
</tr>
<tr>
<td>2</td>
<td>Communication and Information Sharing</td>
<td>10 15 22 21 32</td>
<td>150</td>
</tr>
<tr>
<td>3</td>
<td>People Strategy</td>
<td>20 16 27 16 21</td>
<td>198</td>
</tr>
<tr>
<td>4</td>
<td>Team Work</td>
<td>15 12 27 25 21</td>
<td>175</td>
</tr>
<tr>
<td>5</td>
<td>Employee Training</td>
<td>19 19 27 23 12</td>
<td>210</td>
</tr>
<tr>
<td>6</td>
<td>Expert Lectures</td>
<td>21 20 32 19 8</td>
<td>227</td>
</tr>
<tr>
<td>7</td>
<td>House Keeping (orderliness, cleanliness, discipline, safety)</td>
<td>25 24 16 14 21</td>
<td>218</td>
</tr>
<tr>
<td>8</td>
<td>Infrastructure (Aesthetic Value)</td>
<td>16 16 22 25 21</td>
<td>181</td>
</tr>
<tr>
<td>9</td>
<td>Job satisfaction</td>
<td>24 18 25 29 4</td>
<td>229</td>
</tr>
<tr>
<td>10</td>
<td>Employee Feedback and Suggestions</td>
<td>14 19 26 22 19</td>
<td>187</td>
</tr>
<tr>
<td>11</td>
<td>Judoka (use of modern/automatic age)</td>
<td>27 21 22 17 13</td>
<td>232</td>
</tr>
<tr>
<td>12</td>
<td>Quality Circles</td>
<td>27 18 24 21 10</td>
<td>231</td>
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<tr>
<td>13</td>
<td>Schedule Stability</td>
<td>10 21 30 11 28</td>
<td>174</td>
</tr>
<tr>
<td>14</td>
<td>Sole Sourcing</td>
<td>22 25 28 15 10</td>
<td>234</td>
</tr>
<tr>
<td>15</td>
<td>Group Incentive Scheme</td>
<td>28 22 22 17 11</td>
<td>239</td>
</tr>
<tr>
<td>16</td>
<td>Frequent and Reliable Service</td>
<td>11 12 24 23 30</td>
<td>151</td>
</tr>
<tr>
<td>17</td>
<td>Error Prevention (Poka Yoke)</td>
<td>16 18 28 21 17</td>
<td>195</td>
</tr>
<tr>
<td>18</td>
<td>Top Management Support</td>
<td>31 23 21 20 5</td>
<td>255</td>
</tr>
<tr>
<td>19</td>
<td>Value Addition Services (SDP)</td>
<td>14 20 22 17 27</td>
<td>177</td>
</tr>
<tr>
<td>20</td>
<td>Standardization</td>
<td>30 20 24 22 4</td>
<td>250</td>
</tr>
<tr>
<td>21</td>
<td>Degree of Complexity</td>
<td>10 20 28 21 21</td>
<td>177</td>
</tr>
<tr>
<td>22</td>
<td>Employee Empowerment</td>
<td>25 22 21 16 16</td>
<td>224</td>
</tr>
<tr>
<td>23</td>
<td>Customer Awareness</td>
<td>9 18 14 24 35</td>
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<tr>
<td>24</td>
<td>Ergonomics Design (Working Conditions)</td>
<td>22 22 23 14 19</td>
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</tr>
<tr>
<td>25</td>
<td>Customer Satisfaction</td>
<td>25 20 22 19 14</td>
<td>223</td>
</tr>
<tr>
<td>26</td>
<td>Commitment</td>
<td>10 13 24 20 33</td>
<td>147</td>
</tr>
</tbody>
</table>
Data Analysis
XY scatter chart is drawn between importance as abscissa and difficulty as ordinate. The axis crosses at their relative value of population mean (μ) i.e. for x axis it is 200 and for y axis its value is 200.

![XY Scatter Chart](image)

Figure 1
In Figure 1, the lower right quarter i.e. Part-1 highlights those elements of JIT which are highly important and very easy to implement. These elements are Communication and Information sharing, Team Work, Frequent and Reliable Service, Customer Awareness and Commitment. These elements are the critical elements for JIT implementation. The upper right quarter i.e. Part-2 shows those elements which are highly important but are difficult to implement. These elements are Employee Training, House Keeping (orderliness, cleanliness, discipline, and safety), Job Satisfaction, Judoka (use of modern/automatic age), Group Incentive Scheme, Top Management Support, Standardization, Ergonomics Design (Working Conditions) and Customer Satisfaction. The upper left quarter i.e. Part-3 depicts those elements which are less important and very difficult to implement in banks. These elements are Expert Lectures, Quality Circles, Sole Sourcing and Employee Empowerment. The lower left quarter i.e. Part-4 demonstrates those elements which are less important but are easy to implement. These elements are Organization Policies, People Strategy, Infrastructure (Aesthetic Value), Employee Feedback and Suggestions, Schedule Stability, Error Prevention (Poka Yoke), Value Addition Services (SDP) and Degree of Complexity. It is advisable that at the initial stage, those elements should be implemented in any organization, which are highly important and relatively less difficult to implement.

ANOVA Technique
The ANOVA technique is important in the context of all those situations where we want
to compare more than two populations such as in comparing the yield of crop from several varieties of seeds. In such circumstances one generally does not want to consider all possible combinations of two populations at a time for what would require a great number of tests before we would be able to arrive at a decision. The table 3 represents the addition of degree of importance and degree of difficulty for the five critical elements in the various banks. Now we will apply ANOVA to this data. Under the one way ANOVA, we consider only one factor and then observe that the reason for said factor to be important is that several possible types of samples can occur within that factor. We then determine if there are differences within that factor.

**TABLE 3: ADDITION OF DEGREE OF IMPORTANCE AND DEGREE OF DIFFICULTY FOR THE FIVE CRITICAL ELEMENTS**

<table>
<thead>
<tr>
<th>Bank No.</th>
<th>Communication and Information Sharing</th>
<th>Team Work</th>
<th>Frequent and Reliable Service</th>
<th>Customer Awareness</th>
<th>Commitment</th>
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<tbody>
<tr>
<td>1.</td>
<td>9</td>
<td>12</td>
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<td>10</td>
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</tbody>
</table>

The technique involves the following steps:-

(i) Obtain the mean of each sample i.e. obtain

\[ \bar{X}_1, \bar{X}_2, \bar{X}_3, \bar{X}_4, \ldots, \bar{X}_k \]
Evaluation of Just in Time Elements in Banking Sector Using ANOVA Technique

Where there are k samples.

(ii) Work out the mean of the sample means as follows:

\[
\bar{\bar{x}} = \frac{\sum x_1 + \sum x_2 + \cdots + \sum x_k}{n} = \frac{\sum x_1 + \sum x_2 + \cdots + \sum x_k}{k}
\]

(iii) Take the deviations of the sample mean from the sample means and calculate the square of such deviations which may be multiplied by the number of items in the corresponding sample, and then obtain their total. This is known as the Sum of Squares for variance between the sample (or SS between). Symbolically, this can be written:

\[
SS \text{ between } = n_1 (\bar{x}_1 - \bar{\bar{x}})^2 + n_2 (\bar{x}_2 - \bar{\bar{x}})^2 + \cdots + n_k (\bar{x}_k - \bar{\bar{x}})^2
\]

(iv) Divide the result of (iii) step by the degree of freedom between the samples to obtain variance or Mean Square (MS) between samples.

\[
MS \text{ between } = \frac{SS \text{ between}}{k-1}
\]

where (k-1) represents degree of freedom (d.f.) between samples.

(v) Obtain the deviations of the values of the sample items for all the samples from corresponding means of the samples and calculate the squares of such deviation and then obtain their total. This total is known as the sum of squares for variance within samples (or SS within).

\[
SS \text{ within } = \sum (x_{1i} - \bar{x}_1)^2 + \sum (x_{2i} - \bar{x}_2)^2 + \sum (x_{ki} - \bar{x}_k)^2
\]

(vi) Divide the result of (v) step by the degree of freedom within samples to obtain the variance or Mean Square (MS) within samples. Symbolically this can be written as:

\[
MS \text{ within } = \frac{SS \text{ within}}{n-k}
\]

where (n-k) represents degree of freedom within samples.

n= total number of items in all the samples i.e. n1+n2+…… +nk.

k=number of samples.

(vii) For a check, the sum of squares of deviations for total variance can also be worked out by adding the squares of deviations when the deviations for the individual items in all the samples have been taken from the mean of the sample means.

\[
SS \text{ for total variance } = \sum (x_{ij} - \bar{x})^2
\]

i = 1, 2, 3…

j = 1, 2, 3…
This total should be equal to the total of the result of the (iii) and (v) steps explained above i.e.
SS for total variance = SS between + SS within

The degree of freedom for total variance will be equal to the number of items in all samples minus one i.e., (n-1). The degree of freedom for between and within must add up to degree of freedom for total variance i.e.

\[(n - 1)(n - 1) = (k - 1)(k - 1) + (n - k)(n - k)\]

This fact explains the additive property of the ANOVA technique.

(viii) Finally, F-ratio may be worked out as under:

\[
F\text{-ratio} = \frac{MS\text{ between}}{MS\text{ within}}
\]

This ratio is used to judge whether the difference among several means is significant or is just a matter of sampling fluctuation. For this purpose we look into the table, giving the value of F for given degree of freedom at different levels of significance. If the worked out value of F, as stated above, is less than the table value of F, the difference is taken as insignificant i.e. due to chance and the null hypothesis of no difference between sample means stands. In case the calculated value of F happens to be either equal or more than its table value, the difference is considered as significant (which means the samples could not have come from the same universe) and accordingly the conclusion may be drawn. The table value of F is taken at 10% confidence level. The higher the calculated value of F than the table value, one can be more definite and sure about the conclusions.

### TABLE 4: AVERAGES OF ELEMENTS FOR ANOVA

<table>
<thead>
<tr>
<th>Groups</th>
<th>Count</th>
<th>Sum</th>
<th>Averages</th>
<th>Average of Averages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication and Information</td>
<td>50</td>
<td>423</td>
<td>8.46</td>
<td></td>
</tr>
<tr>
<td>Sharing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Team Work</td>
<td>50</td>
<td>435</td>
<td>8.7</td>
<td></td>
</tr>
<tr>
<td>Frequent and Reliable Service</td>
<td>50</td>
<td>473</td>
<td>9.46</td>
<td></td>
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<tr>
<td>Customer Awareness</td>
<td>50</td>
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<td>8.84</td>
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<tr>
<td>Commitment</td>
<td>50</td>
<td>373</td>
<td>7.5</td>
<td>8.6</td>
</tr>
</tbody>
</table>

### TABLE 5: CALCULATION OF F-RATIO

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>df.</th>
<th>MS</th>
<th>F-ratio</th>
<th>10% F limit</th>
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</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>101.84</td>
<td>4</td>
<td>25.46</td>
<td>2.65</td>
<td>1.97</td>
</tr>
<tr>
<td>Within Groups</td>
<td>2360.56</td>
<td>245</td>
<td>9.64</td>
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<tr>
<td>Total</td>
<td>2462.4</td>
<td>249</td>
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</tbody>
</table>
From the above table, it is clear that F-critical is less than the calculated F value. So we may conclude that the values of elements are significant.

**Conclusion**
In this paper, survey of 50 Banks is carried out. On the basis of the mean calculated for different elements of JIT on 0-400 scale, all the elements have been analyzed and plotted on a scatter chart, from where most important and less difficult elements are found out. The data has been verified with the help of ANOVA technique. The most beneficial elements for the surveyed Banks have also been identified. It is further suggested that JIT elements should be implemented in a phased manner and after confirming its success, it should be implemented to the whole process. First of all one should implement the most important and less difficult elements to the critical processes only as a pilot project. The most important and highly difficult elements should be implemented after the successful implementation of the pilot project.

**Future Scope of Research Work**
Some elements of JIT such as Employee Training, House Keeping, Job satisfaction, Judoka (use of modern/automatic age), Group Incentive Scheme etc. are difficult to implement in Indian Banks as identified by the survey results. The main reasons for these difficulties should be traced out to solve the problems of implementation. For future research, JIT may also be implemented in other service sectors like Healthcare, Education and Transportation etc.

**References**


Heterogeneous LEACH Communication Protocol for WSN

Ashish Bansal, Vijay Kumar, Nitin Mittal
ECE Deptt., Guru Nanak Institutions, Mullana, Kurukshetra
ECE Deptt., MMEC, Mullana
ECE Deptt., Modern Institute of Engg. & Tech., Mohri, Kurukshetra

Abstract
Wireless sensor networks consisting of nodes that are deployed to collect useful information from the sensor field. It is critical to operate the sensor network for a long period of time in an energy efficient manner for gathering sensed information. The paper proposes an improved LEACH protocol called hetero-LEACH (Heterogeneous Low-energy Adaptive Clustering Hierarchy), which is nearly optimal for this data gathering application in sensor networks. Most of the analytical results for LEACH-type schemes are obtained assuming that the nodes of the sensor network are equipped with the same amount of energy - homogeneous sensor networks. The key idea in hetero-LEACH is to study the impact of heterogeneity in terms of node energy. We assume that a percentage of the node population is equipped with more energy than the rest of the nodes in the same network - heterogeneous sensor networks. The lifetime of a sensor system is the time during which it gathers information from all the sensors to the base station. Given the location of sensors, the base station and the available energy at each sensor, the paper proposes an efficient manner in which the data should be collected from all the sensors and transmitted to the base station, such that the system lifetime is maximized. Further, the experimental results demonstrate that the proposed algorithm significantly outperform other methods (direct transmission protocol, minimum transmission energy protocol and LEACH protocol), in terms of system lifetime.

Keywords: WSN, clustering, LEACH, MTE, lifetime, sensor field, hetero-LEACH.

Introduction
Advance research and technologies in the field of wireless and mobile communication led to the development of wireless sensor network. Wireless sensors, which are minute devices to collect information, are called nodes. CPU (for data processing), battery, memory and transceivers are the basic constituents of nodes. Therefore, the size of node is also affected by its application. Sensor networks are the key to gathering information needed by smart environments where they are implemented. Recent advances in MEMS-based sensor technology, low-power analog and digital electronics, and low-power RF design have enabled the development of relatively inexpensive and low-power wireless microsensors [1, 2, 3]. With their flexibility, fault tolerance, high sensing fidelity, low cost and rapid deployment characteristics, they find their application in various fields like in military for enemy tracking and battle field surveillance, for civil applications like habitat monitoring, environment observation, industries, transportation system and more
where they are located very close to or even in the area where any phenomenon is to be observed. To process the collected data meant for onward transmission to the sink, a lot of energy is consumed. And till date batteries were the only option to cater the energy requirements of the nodes of wireless sensor network. The applications of WSN were also restricted in many communication fields like surveillance, military etc. where it becomes highly expensive and impossible due to environment conditions, to replace the drained off batteries frequently. It is our objective to find an alternate enhanced power-aware, energy efficient system which can extend the life time of the network.

**Energy Dissipation Radio Model**

Energy dissipation models for radio propagation are focused on predicting the average received signal strength at a given distance from the transmitter. The models that predict the signal strength for a given transmitter-receiver separation distance are useful in WSN radio model. In this model, as shown in figure 1, the energy dissipation to run the transmitter or receiver circuitry is $E_{elec} = 50 \text{ nJ/bit}$ and $E_{amp} = 100 \text{ pJ/bit/m}^2$ for the transmitter amplification. The received power decays as a function of the Tx-Rx separation distance ($d$). For relatively short distances, the Friis free space model is used in which the received power decays that are inversely proportional to $d^2$. For long distances, the received power falls off with distance raised to the forth power (two-ray ground reflection model). This is much more rapid path loss than is experienced in free space. Therefore, amplifier circuitry is required to compensate this loss by setting the amplification to a certain level.

![Figure 1: Energy Dissipation Radio model.](image)

The equations used to calculate radio energy transmission and reception costs for a $k$-bit message and the transmitter-receiver separation distance $d$ are given by:

\[
E_{Tx}(k,d) = E_{Tx}(k) + E_{amp}(k,d)
\]

\[
E_{Rx}(k,d) = kE_{Tx} + kE_{amp}(d)
\]  

(1)

The term $E_{Tx}$ denotes the per-bit energy dissipation during transmission. $E_{amp}(d)$, the per-bit amplification energy, is proportional to $d^4$ (two-ray ground reflection model).
Heterogeneous LEACH Communication Protocol for WSN

when the transmission distance exceeds the threshold $d_o$ and otherwise is proportional to $d^2$ (Friis free space model). $E_{amp}(d)$ is thus given by

$$E_{amp}(d) = \begin{cases} \varepsilon_{friss\_amp}d^2, & d \leq d_o \\ \varepsilon_{two\_ray\_amp}d^4, & d > d_o \end{cases}$$

(2)

The parameters $\varepsilon_{friss\_amp}$ and $\varepsilon_{two\_ray\_amp}$ denote transmit amplifier parameters corresponding to the free-space and the multipath fading models respectively. They depend on the required sensitivity and the receiver noise figure. The transmit power needs to be adjusted so that the power at the receiver is above certain minimum threshold. The value of $d_o$ is given by:

$$d_o = \sqrt{\varepsilon_{friss\_amp}/\varepsilon_{two\_ray\_amp}}$$

(3)

The reception energy of the k-bit data message can be expressed by the equation:

$$E_{Rx}(k) = kE_{Rx}$$

(4)

where $E_{Rx}$ is the energy dissipation of the receiver per-bit.

Communication Protocols for WSN

The expected lifetime of a WSN needs to be several years for a typical application. As, a WSN is composed of minute nodes, their energy resources are very limited. The amount of energy stored depends on the battery size. This imposes tight constraints on the operation of sensor nodes. The transceiver is the element which drains most power from the node. Thus the routing protocol plays a significant effect on the lifetime of the overall network. Also, sensors consume energy both in sensing data and in transmitting the sensed data to a base station. The power consumption for transmitting data is an exponential function of the distance from the sensor to the base station, while the power consumption for sensing data is determined by the type of sensor as well as the routing protocols.

Communication or routing protocols are the set of rules, according to which each sensor node has to play some roles, such as collecting information from neighboring nodes and transmitting it to the destination or Base station. There are various energy aware communication protocols discussed in the literature [3, 5 and 6]. Consider a simple network having n nodes as shown in figure 2(a). In Direct Transmission Protocol (figure 2(b)), each sensor node sends its data directly to the base station. If the base station is far away from the nodes, direct communication requires a large amount of transmit power from each node, since $r$ is large. In MTE routing (figure 2(c)), each nodes send data to the base station through intermediate nodes. Thus the node located at a distance $nr [3]$ from the base station would require n transmits of distance $r$ and n-1 receives. In clustering protocol, nodes are organized into clusters that communicate with their cluster head and the cluster head transmit the data to the base station.
Figure 2: Routing protocols. (a) A Linear Network having n nodes. (b) Each node sends its data directly to the base station in direct transmission. (c) Nodes send data to the base station through intermediate nodes in MTE routing.

**LEACH: Low Energy Adaptive Clustering Hierarchy**

The current interest in wireless sensor networks has led to the emergence of many application oriented protocols of which LEACH is the most aspiring and widely used protocol [5]. LEACH can be described as a combination of a cluster-based architecture and multi-hop routing as shown in figure 3. The operations that are carried out in the LEACH protocol are divided into two stages:

1. **Setup phase** and
2. **Steady-state phase**.

In the Set up phase, all the sensors within a network group themselves into some cluster regions by communicating with each other through short messages. At a point of time one sensor in the network acts as a cluster-head and sends short messages within the network to all the other remaining sensors. The sensors choose to join those groups or regions that are formed by the cluster heads, depending upon the signal strength of the messages sent by the cluster heads. Sensors interested in joining a particular cluster head or region respond back to the cluster heads by sending a response signal indicating their acceptance to join. Thus the set-up phase completes [3]. As soon as a cluster head is selected for a region, all the cluster members of that region send the collected or sensed data to the cluster head. The cluster head transmits this collected data to the base station which
Heterogeneous LEACH Communication Protocol for WSN

The above discussion describes communication within a cluster, where the routing protocols are designed to ensure low energy dissipation in the nodes and no collisions of data messages within a cluster. However, radio is inherently a broadcast medium. As such, transmission in one cluster will affect communication in a nearby cluster.

**Hetero-LEACH Protocol**

Classical clustering protocols assume that all the nodes are equipped with the same amount of energy and as a result, they can not take full advantage of the presence of node heterogeneity. We propose a heterogeneous-LEACH protocol to prolong the time interval before the death of the first node (stability period), which is crucial for many applications where the feedback from the sensor network must be reliable. The proposed protocol is based on weighted election probabilities of each node to become cluster head according to the remaining energy in each node. In WSN, sensor node assigns a dual role: it acts as a source for sensing information and as a relay. The death of some nodes may cause significant topological changes and may require re-organisation of the network. Therefore, routing algorithms has to employ some energy efficient routing tactics as well as approaches specific to WSNs, to minimize energy consumption. Similar to LEACH, in heterogeneous LEACH each sensor node may elect itself to be cluster head at the beginning of a round. Probability of becoming a cluster head is set as a function of nodes energy level relative to the aggregate energy remaining in the network. The Sensor node is a cluster head if chosen random number is less than threshold $T(n)$ given by

$$
T(n) = \begin{cases} 
\frac{P}{1 - P \times (r \mod \frac{1}{P})} & \text{if } n \in G \\
0 & \text{otherwise} 
\end{cases}
$$

If $n \not\in G$

$$
T(n) = \begin{cases} 
\frac{P}{1 - P 	imes (r \mod (1/P))} & \text{if } n \in G \\
0 & \text{otherwise} 
\end{cases}
$$
where P: desired Percentage to become a Cluster head, r: Current Round, G: Set of nodes that have not been selected as Cluster head in last 1/P rounds. In this paper, we describe heterogeneous LEACH protocol, which improves the stable region of the clustering hierarchy process using the characteristic parameters of heterogeneity, namely the fraction of advanced nodes (m) and the additional energy factor between advanced and normal nodes (\(\alpha\)). In order to prolong the stable region, the protocol attempts to maintain the constraint of well balanced energy consumption. Intuitively, advanced nodes have to become cluster heads more often than the normal nodes, which is equivalent to a fairness constraint on energy consumption. Note that the new heterogeneous setting (with advanced and normal nodes) has no effect on the spatial density of the network so the a priori setting of \(P_{opt}\), from equation 5, does not change. On the other hand, the total energy of the system changes. Suppose that \(E_0\) is the initial energy of each normal sensor. The energy of each advanced node is then \(E_0 + \alpha E_0\). The total (initial) energy of the new heterogeneous setting is equal to:

\[
(1-m)E_0 + n m E_0 = n E_0 (1+\alpha \cdot m) \tag{6}
\]

So, the total energy of the system is increased by a factor of \(1+\alpha \cdot m\). The first improvement to the existing LEACH is to increase the epoch of the sensor network in proportion to the energy increment. In order to optimize the stable region of the system, the new epoch must become equal to \(\frac{1}{P_{opt}}\) because the system has \(\alpha \cdot m\) times more energy and virtually \(\alpha \cdot m\) more nodes (with the same energy as the normal nodes.) We can now increase the stable region of the sensor network by \(\alpha \cdot m\) times, if (i) each normal node becomes a cluster head once every \(\frac{1}{P_{opt}}\) rounds per epoch; (ii) each advanced node becomes a cluster head exactly \(1+\alpha\) times every \(\frac{1}{P_{opt}}\) rounds per epoch; and (iii) the average number of cluster heads per round per epoch is equal to \(n \times P_{opt}\) (since the spatial density does not change.) Constraint (ii) is very strict—If at the end of each epoch the number of times that an advanced sensor has become a cluster head is not equal to \(1+\alpha\) then the energy is not well distributed and the average number of cluster heads per round per epoch will be less than \(n \times P_{opt}\). This problem can be reduced to a problem of optimal threshold \(T(s)\) setting with the constraint that each node has to become a cluster head as many times as its initial energy divided by the energy of a normal node. If the same threshold is set for both normal and advanced nodes with the

\[
T(n) = \begin{cases} \frac{P}{1-P\cdot [r \mod (1/P)]} & \text{if } n \notin G \\ 0 & \text{otherwise} \end{cases}
\tag{5}
\]
difference that each normal node \( \in G \) becomes a cluster head once every \( \frac{1}{p_{opt}} (1 + \alpha.m) \) rounds per epoch, and each advanced node \( \in G \) becomes a cluster head \( 1 + \alpha \) times every \( \frac{1}{p_{opt}} (1 + \alpha.m) \) rounds per epoch, then there is no guarantee that the number of cluster heads per round per epoch will be \( n \times p_{opt} \). The reason is that, there is a significant number of cases where this number cannot be maintained per round per epoch with probability 1. A worst-case scenario could be the following. Suppose that every normal node becomes a cluster head once within the first \( \frac{1}{p_{opt}} (1 - m) \) rounds of the epoch. In order to maintain the well distributed energy consumption constraint, all the remaining nodes, which are advanced nodes, have to become cluster heads with probability 1 for the next \( \frac{1}{p_{opt}} (1 - m) (1 + \alpha) \) rounds of the epoch. But the threshold \( T(s) \) is increasing with the number of rounds within each epoch and becomes equal to 1 only in the last round (when all the remaining nodes become cluster heads with probability 1). So the above constraint of \( n \times p_{opt} \) cluster heads in each round is violated. As a solution, assume heterogeneous LEACH Protocol, which is based on the initial energy of the nodes. This solution is more applicable compared to any solution which assumes that each node knows the total energy of the network and then adapts its election probability to become a cluster head according to its remaining energy [8]. Our approach is to assign a weight to the optimal probability \( p_{opt} \). This weight must be equal to the initial energy of each node divided by the initial energy of the normal node. Let us define as \( p_{nrm} \) the weighted election probability for normal nodes, and \( p_{adv} \) the weighted election probability for the advanced nodes. Virtually there are \( n(1 + \alpha.m) \) nodes with energy equal to the initial energy of a normal node. In order to maintain the minimum energy consumption in each round within an epoch, the average number of cluster heads per round per epoch must be constant and equal to \( n \times p_{opt} \). In the heterogeneous scenario the average number of cluster heads per round per epoch is equal to \( n(1 + \alpha.m) p_{nrm} \) (because each virtual node has the initial energy of a normal node.) The weighed probabilities for normal and advanced nodes are, respectively:

\[
p_{nrm} = \frac{p_{opt}}{1 + \alpha.m} \tag{7}
\]

\[
p_{adv} = \frac{p_{opt}}{1 + \alpha.m} \times (1 + \alpha) \tag{8}
\]

In Equation 5, we replace \( p_{opt} \) by the weighted probabilities to obtain the threshold that is
used to elect the cluster head in each round. We define as $T(s_{\text{norm}})$ the threshold for normal nodes, and $T(s_{\text{adv}})$ the threshold for advanced nodes.

Thus, for normal nodes, we have:

$$T(s_{\text{norm}}) = \begin{cases} \frac{p_{\text{norm}}}{1 - p_{\text{norm}} \cdot (r \mod \frac{1}{p_{\text{norm}}})} & \text{if } s_{\text{norm}} \in G' \\ 0 & \text{otherwise} \end{cases}$$

(9)

where $r$ is the current round, $G'$ is the set of normal nodes that have not become cluster heads within the last $\frac{1}{p_{\text{norm}}}$ rounds of the epoch, and $T(s_{\text{norm}})$ is the threshold applied to a population of $n(1 - m)$ (normal) nodes. This guarantees that each normal node will become a cluster head exactly once every $\frac{1}{p_{\text{opt}}} (1 + \alpha.m)$ rounds per epoch, and that the average number of cluster heads that are normal nodes per round per epoch is equal to $n(1 - m) \times p_{\text{norm}}$. Similarly, for advanced nodes, we have:

$$T(s_{\text{adv}}) = \begin{cases} \frac{p_{\text{adv}}}{1 - p_{\text{adv}} \cdot (r \mod \frac{1}{p_{\text{adv}}})} & \text{if } s_{\text{adv}} \in G'' \\ 0 & \text{otherwise} \end{cases}$$

(10)

where $G''$ is the set of advanced nodes that have not become cluster heads within the last $\frac{1}{p_{\text{adv}}}$ rounds of the epoch, and $T(s_{\text{adv}})$ is the threshold applied to a population of $n.m$ (advanced) nodes. This guarantees that each advanced node will become a cluster head exactly once every $\frac{1}{p_{\text{opt}}} (1 + \alpha.m)$ rounds. Let us define this period as sub-epoch. It is clear that each epoch (let us refer to this epoch as “heterogeneous epoch” in our heterogeneous setting) has $1 + \alpha$ sub-epochs and as a result, each advanced node becomes a cluster head exactly $1 + \alpha$ times within a heterogeneous epoch. The average number of cluster heads that are advanced nodes per round per heterogeneous epoch (and sub-epoch) is equal to $n \cdot m \times p_{\text{adv}}$.

Thus the average total number of cluster heads per round per heterogeneous epoch is equal to:

$$n \cdot (1 - m) \times p_{\text{norm}} + n \cdot m \times p_{\text{adv}} = n \times p_{\text{opt}}$$

(11)

which is the desired number of cluster heads per round per epoch.
Experimental Results
The performance of various protocols is simulated using a random 100-node network as shown in figure 4.

Figure 4: A 100-node random network

Figure 5: Cluster head nodes and cluster formation at time t.

<table>
<thead>
<tr>
<th>Number of Nodes</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network size</td>
<td>100m * 100m</td>
</tr>
<tr>
<td>Base station location</td>
<td>(50,175)</td>
</tr>
<tr>
<td>Radio propagation speed</td>
<td>3*10^8 m/s</td>
</tr>
<tr>
<td>Processing delay</td>
<td>50 μs</td>
</tr>
</tbody>
</table>
Table 1: Summary of the parameters used in the simulation experiments

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radio speed</td>
<td>1 Mbps</td>
</tr>
<tr>
<td>Data size</td>
<td>500 bytes</td>
</tr>
<tr>
<td>Initial node power</td>
<td>1 J</td>
</tr>
<tr>
<td>Simulation time</td>
<td>900 sec</td>
</tr>
</tbody>
</table>

The results of hetero-LEACH simulations are shown in figure 6 and 7 for $m = 0.1$ and $a=0.9$ with initial energy $0.5J$ and $1J$ respectively. We observe that LEACH takes some advantage of the presence of heterogeneity (advanced nodes), as the first node dies after a significantly higher number of rounds (i.e. longer stability period) compared to the homogeneous case ($m = a= 0$). The lifetime of the network is increased.

![Figure 6: Number of alive nodes using LEACH in the presence of heterogeneity with advanced nodes $m=0.1$ and normal nodes $a=0.9$ with initial energy $0.5J$.](image)

![Figure 7: Number of alive nodes using LEACH in the presence of heterogeneity with advanced nodes $m=0.1$ and normal nodes $a=0.9$ with initial energy $1J$.](image)
The simulations are performed to determine the number of rounds of communication when 1%, 20%, 50% and 100% of the nodes die using direct transmission, MTE, LEACH and heterogeneous LEACH with each node having the same initial energy level. Once a node dies it is considered dead for the rest of the simulation. The nodes begin to die at a more uniform rate after about 20% nodes die. This is because the distances between the nodes become greater, and nodes have to become leaders more often causing the energy to drain rapidly. As can be expected, the number of rounds doubles as the energy/node doubles for a given size of network. Figure 8 and 9 shows the number or rounds the complete sensor network take until 1%, 20%, 50%, and 100% nodes die with initial energy per node of 0.5J and 1J respectively for a 100m x 100m network. It is clear that as the initial energy of the sensor node decreases then the nodes drain out quickly and follows the inverse square law.

Figure 8: Performance results with initial energy 0.5J/node for a 100m x 100m network

Figure 9: Performance results with initial energy 1J/node for a 100m x 100m network
The simulation shows that heterogeneous LEACH achieves:
• Approximately 2x the number of rounds decreases compared to direct transmission, when 1%, 20%, 50%, and 100% nodes die for a 100m x 100m network.
• Approximately 2x better than MTE for a 100m x 100m network.
• As the energy level doubles the number of rounds approximately doubles for all cases.
• Near optimal performance.

Conclusions
The simulation work performed according to the new proposed heterogeneous LEACH protocol approximately doubles the lifetime of network. These type of networks are more useful in applications where network lifetime is critical. Our simulations also shows that the above said protocol performs better than direct transmission by about 100 to 500% when 1%, 20%, 50%, and 100% of nodes die for different network sizes and topologies. The protocol shows an even further improvement as the size of the network increases. When energy of a node in network is double it becomes easy for any receiver to detect it so when deploying a network for some secure data collection a trade off in between the energy level can be tuned. This protocol is more efficient when number of nodes is greater. Thus this protocol also proves its efficiency when deployed over larger areas for sensing.

References
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Polarimetric SAR Image Classification using Multifeature Combination and Extremely Randomized Clustering Forests with K-Nearest Neighbor (KERCF)

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Abstract
In this paper, extremely randomized clustering forest with k-nearest neighbor (KERCF) is introduced for polarimetric SAR (PolSAR) image classification. To start with, an optimal feature set consisting of automatic combinations of polarimetric features derived from polarimetric target decomposition is selected. Afterwards, KERCF is introduced to classify polarimetric SAR image and the results are compared with other competitive classifiers. Experiments on AIRSAR images validate the effectiveness of this novel classifier. It is fully established that KERCF achieves better performance as compared to other widely used classifiers, given the same testing and training time.

Keywords— Feature evaluation, feature selection, KERCF, multifeature combination, SAR image classification.

Introduction
The remote sensing technology has been acquiring a growing interest related to environmental monitoring and management. In practice, remote sensing is the utilization of any device for gathering information from environment. In this paper, the problem of monitoring a region on the earth surface, containing the geophysical/geographical information of interest to the end user, is addressed. In particular, the classification of different terrain types of PolSAR images is considered. PolSAR images provide more information than the conventional radar images and hence greatly improve the ability to terrain discrimination greatly. It requires dealing with the polarimetric descriptors and classifiers originated from machine learning and pattern recognition domain. In this paper, a simple and easy parallelized ensemble method viz. KERCF is proposed; as a unsupervised tool for the accurate classification of PolSAR imagery. The proposed method uses extremely randomized trees as spatial partitioning method, assigning each leaf of each tree a distinct region label, known as clustering trees. Then, KNN (k-nearest neighbor) is used as the second classifier for generating the class labels. Final map is generated by voting over the ensemble of trees. Classification is performed with each feature individually and with the multiple features selected, based on simple but efficient selection criterion. The above mentioned technique is implemented using MATLAB. The results obtained are compared to other competitive classifiers. A particular attention is devoted to the optimization of classifier parameters for better performance.
II. POLARIMETRIC FEATURE EXTRACTION & COMBINATION

2.1 Polarimetric Features

Polarimetric features of PolSAR images can be divided into two categories that is features based on original data and their transforms and the features based on polarimetric target decomposition. In this paper, features from second category are used. Table I lists the features used in this work.

<table>
<thead>
<tr>
<th>Feature Description</th>
<th>Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cloude Decomposition</td>
<td>3</td>
</tr>
<tr>
<td>Krogager Decomposition</td>
<td>3</td>
</tr>
<tr>
<td>Barnes Decomposition</td>
<td>3</td>
</tr>
<tr>
<td>H/A/α Decomposition</td>
<td>3</td>
</tr>
<tr>
<td>Huynen Decomposition</td>
<td>3</td>
</tr>
<tr>
<td>Cloude-Pottier Decomposition</td>
<td>3</td>
</tr>
<tr>
<td>Freeman-Durden Decomposition</td>
<td>3</td>
</tr>
<tr>
<td>Eigenvalue Decomposition Parameters-1</td>
<td>12</td>
</tr>
<tr>
<td>Eigenvalue Decomposition Parameters-2</td>
<td>4</td>
</tr>
</tbody>
</table>

2.1.2 Automatic Feature Combination

Automatic selection and combination of different feature types is always necessary when there are a large number of feature types. Since there may exist many relevant and redundant information between different feature types, classification accuracies of different feature types are needed to be considered along with keeping track of their correlations. In this section, a metric-based feature combination is proposed to balance the feature dependence and classification accuracy. Given a feature type pool $F_i$ ($i = 1, 2, \ldots, N$), the feature dependence of the $i$th feature type is defined in (equ.no.1)

$$\text{Dep}_i = \frac{N - 1}{\sum_{j=1, j \neq i}^{N} \text{corrcoef}(P_i, P_j)}$$  \hspace{1cm} (1)

where $P_i$ the terrain classification accuracy of the $i$th feature type in feature type pool. \text{corrcoef} ($\cdot$) is the correlation coefficient. $\text{Dep}_i$ is actually the reciprocal of average cross-correlation coefficient of the $i$th feature type which represents the average coupling of $i$th feature type with other feature types. Under the assumption that these two metrics are independent in feature combination, selection metric of $i$th feature type $R_i$ can be defined in (eq.no.2)

$$R_i = \text{Dep}_i \times A_i$$  \hspace{1cm} (2)

where $A_i$ is the average accuracy of $i$th feature type. If $R_i$ is low, the corresponding feature type will be selected with low probability and vice-versa. After classification accu-
KERC
KERC is a parallelized ensemble method used as an unsupervised tool for accurate classification of PolSAR imagery. KERC uses extremely randomized trees as spatial partitioning method, at the base for cluster formation. Then KNN is used at cluster level for assigning the class labels. Final classification map is generated by voting over the ensemble of trees. The procedure is initiated by extracting the widely used polarimetric descriptors for classification. Then, a stratified strategy is used to select the samples randomly from the dataset which are used to train the classifier. Training model is saved and class label of each testing sample is predicted with this model. The is repeated M (no. of trees in the forest) no. of times. Class labels from each run are compared, and final labeling of the testing samples is done based on majority voting afterwards. Classifier parameters are set based on experimental observations. Classification accuracy with each single polarimetric descriptor is evaluated. Automatic combination of features is recommended since it is more flexible.

Experimental Results
Experimental Dataset
The AIRSAR polarimetric SAR data of Death-Valley is used for feature analysis and comparison. The selected PolSAR image has 1024 X 1279 pixels. To avoid the computational complexities, a cropped portion of the image with 61 x 46 pixels is taken. Pseudo colormap of the cropped region is prepared using four colors which correspond to four classes. The classification accuracy of each terrain is used to evaluate the different feature types and their combination. In training stage, 50 samples of each class are selected at random as training data. One hundred samples of each class are selected at random for testing stage. Finally KNN, ERCF and KERC classifiers are used for evaluation of classification accuracy. For KNN k=1 is used. For ERCF and KERC Nmin=5, M=20, K=30 are used. The results are shown in Table II.

4.2 Experimental Observations
4.3.1 Performance of Different Classifiers
(i) KNN
• Average classification accuracy is 52.5% with complete feature set.
• Average classification accuracy is between 26% - 56% with the single feature vector.
• Average classification accuracy is between 53% - 61% with multifeature set.
feature combination (F, P)
Input: feature type pool F = {f1, f2, . . . , fN}
classification accuracy Pi with single feature type fi
Output: a certain combination S = {f1, f2, . . . , fM}
-Compute the selection metric R = {r1, r2, . . . , rN},
  ri is the metric of the ith feature type;
  S = empty set
  do
    -Find the correspond index i of the maximum of R
      if add to pool( fi, S) return true
      -select fi for combining, S = {S, fi};
      -remove fi and Ri from F and R;
    else
      return S;
  while(true)
add to pool( fi, S)
Input: a certain feature type fi, a combination S
Output: a boolean
-compute the classification accuracy Ps of S;
-compute the classification accuracy Pc of {S, fi};
  if (Pc − Ps) > T
    return true;
  else
    return false;

Figure1. Flowchart of the proposed KERCF

(ii) ERCF
• Average classification accuracy is 52.5% with complete feature set.
• Average classification accuracy is between 46% - 72% with the single feature vector.
• Average classification accuracy is between 64% - 72% with multifeature set.
(iii) KERCF
• Average classification accuracy is 78% with complete feature set
• Average classification accuracy is between 68% - 79% with the single feature vector.
• Average classification accuracy is between 77% - 79% with multifeature set.

Performance Comparison of KNN, ERCF, KERCF
• With the complete feature set classification accuracy is maximum for KERCF as compared to KNN and ERCF.
• With the single feature vector and multiple feature combination
  a. Variance in classification accuracy with different feature vector is less in KERCF to that of KNN and ERCF.
b. Classification accuracy is high for KERCF as compared to KNN and ERCF. To summarize, KERCF, introduced in the classification step, incorporated with selected multiple polarimetric descriptors have achieved satisfactory classification accuracies that are as good as or better than other state-of-the-art classification techniques having comparable computational complexities. Hence KERCF is a promising approach for POLSAR image classification and deserves the particular attention.

Fig. 3. (a) Original PolSAR image

(b) Cropped image   (c) Pseudocolor image   (d) Legend
(e) Misclassification result of individual classes using ERCF, KNN, KERCF
Above figure shows the pixels of different classes which are misclassified when the different classifiers KNN, ERCF and KERCF are employed for the classification.

1. KNN: Among the misclassified pixels red, blue and dark red pixels are dominating.
2. ERCF: Among the misclassified pixels red and dark red pixels are dominating.
3. KERCF: Less number of pixels are misclassified as compared to KNN and ERCF. Also the misclassification rate is independent of class.

(f) Misclassification result of all the classes using ERCF, KNN, KERCF
Above figure shows the pixels of all the classes on an average which are misclassified when the different classifiers KNN, ERCF and KERCF are employed for the classification.

1. KNN: Less accurate classifier as more number of pixels are misclassified.
2. ERCF: Better performance as compared to KNN as less number of pixels are misclassified.
3. KERCF: Best performance as compared to the KNN and ERCF as misclassified pixels is least with KERCF.
Conclusion

Improvement in the classification accuracy compared to other competitive classifiers is obtained. The results reveal that with the single feature dimension there is large variance in the classification accuracy among different classes with each classifier. Multifeature combination results in this variance reduction. Additionally, with multifeature combination the classification accuracy comparable to all feature set accuracy is obtained. The problem of classifying PolSAR image with multifeature combination and KERCF classifier has been addressed. The work started by testing the widely used polarimetric descriptors for classification and then considering the automatic feature combination. KERCF, introduced in the classification step, incorporated with selected multiple polarimetric descriptors have achieved the satisfactory classification accuracies that as good as or better than that using state of art classification techniques which shows that the KERCF is a promising approach for PolSAR image classification and deserves particular attention.

In future works, more features such as texture, shape etc. might be considered to perform possibly more efficient feature selection. Besides, a further validation of the performance of the method using other descriptors to represent the information of images, in order to access the effectiveness of those descriptors from a classification viewpoint and the flexibility of KERCF.

References


Six sigma for Sustainable Energy Management: A Case Study

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Abstract
The study focuses on Energy savings in foundries through six sigma’s DMAIC approach. It briefly discusses some facts and figures about foundry scenario in world and in India. It also tends to shatter the various phobias of SMEs in context of Six Sigma concepts and its implementation by validating the compatibility of it by performing a case study in an Indian foundry itself. Doing things right in first time and keeping them consistently is the only idea behind Six Sigma. An empirical investigation has been carried out in a make-to-order type (medium sized) foundry in which, a Six Sigma ‘DMAIC’ approach has been implemented successfully to decrease the scrap (or defects) of piston castings approximately from 21.2% to 10.4%, approximately and interns saved energy and fuel consumption of around 15 lakhs per annum. The picture of low productivity and high energy consumption level of Indian foundry units has been captured and further Six Sigma implementation has been suggested as more viable approach to tackle this present challenge. It is quite rare to see successful application of Six Sigma disciplines, specifically in energy intensive Indian foundry environments.

Keywords- DMAIC project, Susceptible sources of variation (SSV’s), Energy Management, Analysis of variance (ANOVA), Design of experiments (DOE).

Introduction
The phrase of energy management means, “The efficient and effective use of energy to maximize profits or minimize costs and hence enhance competitive positions” (Antony, 2007). Energy management is the key to helping organizations to increase energy efficiency, reduce green house emissions and drive down energy costs. Energy management is defined as the techniques, processes and activities which drive more efficient energy use (Carnell and Lambert, 2000). Energy management allows for a reduction in costs, carbon emission risk and ensuring the efficient use of energy consumption. Since the early days of the Industrial Revolution, when natural resources began to be intensively used in the production process, engineers have tried to increase the efficiency with which each of the factors of production is used (Chang and Wang, 2008). Energy is one of the
Six sigma for Sustainable Energy Management: A Case Study

basic input factors of production, along with labour, capital, and materials. Historically, however, energy was a minor factor, contributing only about 5%–10% of the total cost for most of the products but this is not a fact for casted products or foundries. Energy management is the process of control and optimal use of energy. It is a process comprising of smaller sub-processes which independently manages the usage of energy within a certain frame, but also, these sub-processes collectively gives rise to a more efficient form of energy management (Davison and Al-Shaghana, 2007). This paper emphasizes on project based approach for energy management, specifically in energy intensive foundry environments. It shows that how a scrap reduction project conducted in production department has achieved huge energy savings which cannot be ignored by medium or small scale foundries. It also explains the influence of energy cost in overall end product cost, during die casting process by semi automatic machines. The presented case study self explains that how scrap reduction approach by Six sigma has made the whole foundry process so capable that it can now manufacture the given quantity of parts with relatively less requirement of energy and power resources. Or in other words savings in energy and fuel is inherent property of DMAIC projects of Six sigma executed on production floors. These productivity improvement projects not only lean the whole manufacturing facilities but it also reduces our dependency on high quantity of input resources like Energy, Manpower and Material etc (Agarwal and Bajaj, 2008).

Literature Review

Based on the available literature, it appears that energy and environment related aspects of SSIs in India have not attracted the researchers and policy makers in the past to the desired extent. Though there are a few studies on MSMEs coming under “grain-mills”, “foundries”, “brick/tile units” etc., it is found that most of these studies and initiatives to improve energy efficiency or environmental performance in MSMEs have adopted a technocratic approach, predominantly. Such initiatives lacked a holistic perspective necessary for comprehensively addressing the problem (Das et al., 2006). Further, there are not many energy efficiency related studies in literature involving non-technical factors in the analysis of energy use. According to Wright and Basu (2008) energy consumption belongs to the realm of technology but energy conservation to the realm of society. Since efficiency improvement is a part of energy conservation strategy, a whole lot of social factors are relevant, in addition to manufacturing technology, in the energy efficiency analysis. The literature survey has proved that foundries are energy guzzlers and very limited efforts have been taken to tackle this menace, particularly in India (Prasada and Reddy, 2010). (refer table 1 for further details).
Six sigma for Sustainable Energy Management: A Case Study

Table-1 Monthly Energy Consumptions of some Foundry units in Haryana

<table>
<thead>
<tr>
<th></th>
<th>Casting Company</th>
<th>Production (kg)</th>
<th>Energy Consumption (MJ)</th>
<th>Units (units)</th>
<th>Fuel Consumption (litres)</th>
<th>Energy Consumption (MJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Gupta Casting Pvt. Ltd.</td>
<td>15000</td>
<td>219660</td>
<td>2336.4485</td>
<td>400</td>
<td>14400</td>
</tr>
<tr>
<td>2</td>
<td>Shree Balaji Casting</td>
<td>65000</td>
<td>95186</td>
<td>4672.8971</td>
<td>440</td>
<td>15840</td>
</tr>
<tr>
<td>3</td>
<td>Shri Ram Casting</td>
<td>9000</td>
<td>131796</td>
<td>545.1713</td>
<td>285.7142</td>
<td>10285.711</td>
</tr>
<tr>
<td>4</td>
<td>Shyam Foundry</td>
<td>4000</td>
<td>58576</td>
<td>300</td>
<td>1080</td>
<td>3600</td>
</tr>
<tr>
<td>5</td>
<td>Pooja industries</td>
<td>3000</td>
<td>43932</td>
<td>200</td>
<td>720</td>
<td>3600</td>
</tr>
<tr>
<td>6</td>
<td>Aggrawal Foundry</td>
<td>10000</td>
<td>146440</td>
<td>700</td>
<td>2520</td>
<td>14400</td>
</tr>
<tr>
<td>7</td>
<td>Arora Foundry</td>
<td>12000</td>
<td>175728</td>
<td>1800</td>
<td>6480</td>
<td>15840</td>
</tr>
</tbody>
</table>

**Problem Formulation**

There are about 3, 50,000 foundries in the world with annual production of 90 million metric tons, providing employment to about 20 million people (De Feo, 2000). The Indian foundry industry is the fourth largest in the world. There are more than 70,000 foundries in India, and most foundries (nearly 95%) in India fall under the small and medium scale category (Chakrabarty and Tan, 2007). These units produce a wide range of castings that include automobile parts, agricultural implements, machine tools, diesel engine components etc. (Aggogeri and Gentili, 2008). The productivity levels are alarmingly low since scrap rate, capacity waste, energy usage etc. are significantly high as compared to other countries (Rao and Rao, 2007) (see table 2 ahead). Foundry in India spends less than 0.6% on average, of its turnover on R&D as against the world average of 2.5% (Hoerl, 1998). Hence it appears that there is dire need of inventing new business improvement strategies and better tools/techniques for enhancing productivity levels which intern manage energy consumptions etc.

<table>
<thead>
<tr>
<th>Performance Parameters</th>
<th>Indian Foundries</th>
<th>Overseas Foundries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production of foundry / Total production per annum (in %)</td>
<td>8 to 9</td>
<td>92 to 93</td>
</tr>
<tr>
<td>Rejection (%)</td>
<td>10 to 25</td>
<td>2 to 12</td>
</tr>
<tr>
<td>Capacity Utilization (%)</td>
<td>45 to 55</td>
<td>60 to 75</td>
</tr>
</tbody>
</table>
The poor quality of coal, poor quality of power, rising cost of energy, depleting energy resources and market dynamics have created a greater need for urgent attention to energy management in these small scale industries. The national planners have also realized that the returns on investment in energy conservation efforts are much more significant as compared to the returns on investments made for energy generation.

**Methodology Adopted**

The concept of Six Sigma has been explored for energy conservation positively, through its project based DMAIC approach. It has been widely used in manufacturing sector from last 25 years as company like Motorola has been improving its processes and manages energy consumption since 1986 by using its defect reduction approach. Similarly manufacturing giants like General Electric and Honey Well have been using it as cycle time reduction and energy saving tool, since 1996. Other well known companies like Ford, Caterpillar, Our lady of Lourdes medical centre, LG and Samsung etc. are also practicing Six Sigma as a quality improvement and Energy handling technique in their respective manufacturing processes from 1999 (Banuelas et al., 2005). ‘Sigma’ is a Greek letter denoting the standard deviation of a random variable (i.e. variability) and is applied as a statistical process technology measure in organizations (Pepper and Spedding, 2010). Six Sigma can reduce defects to as low as 3.4 parts per million in an organization and hence producing Zero defect production scenario which directly saves a huge cost of poor quality (COPQ). Always remember the energy cost is one of the main content of COPQ saved and it has been found through this study that it may be up to around 50%, for foundries.

**A Case Study**

A case study has been carried out in a non-ferrous foundry at Federal Mogul India Limited Bhadurgarh, Patiala (Punjab) which casts around 9.5 million pistons annually. Foundry has a covered area of about 50144 sq. m and was established in 1954. It is a medium scale unit used to cast pistons for export to US and uses mostly semi-automatic die casting machines. Dies of different types of pistons have been installed on machines as per the monthly planning/scheduling and pouring of metal is performed manually by operators. Foundry under consideration is used to cast piston of diameter range 30mm to 300mm and capable to manufacture 13 million pistons per annum. In July 2010, a six months Six Sigma project was initiated to reduce the scrap of export-pistons (form 22% to 10% approximately) and to bring energy savings of around 15 lakhs per annum. The main five

<table>
<thead>
<tr>
<th>Productivity (T/Man/Year)</th>
<th>12 to 20</th>
<th>100 to 120 (Japan); 50 to 55 (Germany); 10 to 30 (China)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Requirement (KWH/T)</td>
<td>700 to 900</td>
<td>400 to 600</td>
</tr>
</tbody>
</table>

Table-2: Comparison of Indian and Overseas Foundries over Energy & Performance Metrics
Six sigma for Sustainable Energy Management: A Case Study

phases of project (Define, Measure, Analyse, Improve and Control) have been executed in the given foundry environment to make the Six Sigma implementation more compatible with the present dynamic environments of foundry industry.

Define Phase
The first step was to precisely define the problem, keeping in mind business objectives, customer needs and feedback. This involves identification of Critical to Quality (CTQ) issues and other items that have an impact on Quality, Energy and Customer satisfaction. Major Tools Used: Voice of Customer (QFD), Project Charter, Project Scheduler, Snaps of Problem, Historical analysis of problem, COPQ Matrix, Process by SIPOC Diagram and Project Goals.
Findings: The house of quality was generated to hear the voice of customers effectively and ‘reduction in casting scrap’ has been adopted as the most critical issue. To define the problem of large scrap quantitatively, previous six month’s data was collected regarding scrap and good pieces from production reports. It was found that all the H-family pistons had around 20% to 24% of scrap, which was causing substantial financial and non-financial losses. From the COPQ matrix, the impact of high rejection became clearly obvious as net rejection cost came out to be 30.7 million rupees per annum and it is substantial for a medium scale foundry. For intense focusing on the foundry process, the whole process was mapped. Key process input variables at each operation were found out and further classified in three categories; Noise Variables, Critic Variables and Controlled Variables.

Measure Phase
Measure phase is the second step after defining the problem which involves measurement system analysis, capability studies and finding performance gaps for the identified problem. Major Tools Used: Sigma Calculator, Cpk study, Pareto Charts, FMEA Table, Cause and Effect Matrix, Gauge R&R study, Bias Checking and Stability Test. Findings: The existing sigma level of casting process has been calculated by a sigma calculator that works on the principle of DPMO and this was calculated as 3.43 for the process. Pareto chart (see figure 1) has defined all the 20% factors that are causing 80% of the problem. In the present case shrinkage at ring zone and skirt, bottom thickness (BT) variation, blow holes in ring zone and bottom, cold lap and porosity are emerging as the prime reasons of high casting scrap in H-749 pistons.
‘Cause and Effect Matrix’ makes it clear that process parameters like gate feeding design, dimensional accuracy of die casting machine, die temperature and preheating, die coating thickness, discharge of cooling water, non-continuity in casting process, metal sticking on pins and skill level of operators are some of the susceptible source of variations (SSVs) in casting process, which are responsible for around 90% of casting scrap due to various reasons/factors like bottom thickness variation, shrinkage, blow holes, porosity, cold lap, pin hole defects etc. The next crucial step in the measurement phase is the measurement of the accuracy and precision of already ‘in-use’ measuring equipments or gauges. In the present case, it was decided to validate the calibration by conducting Gage R&R study for bottom thickness gauge (BT gauge), bias checking of immersion pyrometer and stability test of Vac-tester (metal density checker) respectively.

**Analyze Phase**

At the end of Measure Phase, ten critical to quality (CTQ) process parameters were short listed and these seemed to be the major reasons for high scrap. As per DMAIC methodology, before targeting these susceptible sources of variations (SSVs) through ‘Improve Phase’, the authenticity and impact realization of each SSV on scrap, is required to be judged by conducting suitable investigation under Analyse Phase. This phase helps to focus improvement efforts on those SSVs which can be highly significant for positive scrap reduction. Major Tools Used: Table 3 gives a summary of various quantitative and qualitative techniques/tools used for analyzing the measured critical to quality (CTQ) process parameters.
### Analysis Technique

<table>
<thead>
<tr>
<th>Hypothesis Testing (OFAT)</th>
<th>Tool</th>
<th>SSV Analyzed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi Square Test</td>
<td>Analysis of Shift dependency</td>
<td></td>
</tr>
<tr>
<td>One Way ANOVA</td>
<td>Die Coating thickness</td>
<td></td>
</tr>
<tr>
<td>Two Sample t-Test</td>
<td>In gate design</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Discharge of cooling water</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Operator skill</td>
<td></td>
</tr>
<tr>
<td>MFAT</td>
<td>Multi Regression</td>
<td>Alloy temperature</td>
</tr>
<tr>
<td></td>
<td>Die temperature</td>
<td>Delay time</td>
</tr>
<tr>
<td>Graphical Analysis</td>
<td>Interaction Plot</td>
<td>Vaccume pressure</td>
</tr>
<tr>
<td>Quantitative Techniques</td>
<td>Fish Bone Diagram</td>
<td>Metal sticking on pins</td>
</tr>
<tr>
<td></td>
<td>Why Why Analysis</td>
<td>Machine dimensional accuracy</td>
</tr>
</tbody>
</table>

Tables-3: Identifying Analytical Tools for Each SSV

Findings: After this phase, it is amply clear that out of ten susceptible sources of variations (SSVs), only seven are actually responsible for high value of scrap and these are: in gate design, operator skill, die temperature, delay time, vacuum pressure, defective die pin and dimensional inaccuracy of machine. Unwanted SSVs have been omitted which seems to be vital for being focused on serious issues for reducing the scrap significantly.

### Improve Phase

In this phase actions are piloted and real tolerances are established to deliver desired performance. Various suggestions and new activities have been added during optimization of the out-put variable. Major Tools Used: Design of Experiments (DOE), Poka-Yoke and Kaizen

Findings:

a) DOE Results: Scrap reduction is the main problem which depends upon four selected casting process variables (factors). Each factor is defined in terms of high and low values of levels (refer table 4). To realize the effect of each factor or their interactional impact on scrap, ‘full factorial design’ has been selected for optimizing the process in-put factors. No blocking is used and experiments were replicated twice for suitable accuracy. So it requires 24 experiments and for generating effective impacts of each factor over the response, random repetition of 16 experiments
or total 32 runs were used to perform. Scrap value has been calculated for each run and figure 2 shows the analysis of the orthogonal matrix of experiments.

<table>
<thead>
<tr>
<th>Factors/Levels</th>
<th>(A) Die Temp (Degrees)</th>
<th>(B) Discharge of Water (LPM)</th>
<th>(C) Delay (Secs)</th>
<th>(D) Volume of R &amp; R (cm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>250</td>
<td>7</td>
<td>60</td>
<td>260</td>
</tr>
<tr>
<td>High</td>
<td>330</td>
<td>10</td>
<td>180</td>
<td>285</td>
</tr>
</tbody>
</table>

Table-4 Two Levels of each Critical Factor

Factorial Fit: Scrap (%) versus Die Temp, Discharge of water,

Estimated Effects and Coefficients for Scrap (%) (coded units)

<table>
<thead>
<tr>
<th>Term</th>
<th>Effect</th>
<th>Coef</th>
<th>SE Coef</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>14.281</td>
<td>0.1362</td>
<td>104.84</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>Die Temp</td>
<td>3.937</td>
<td>1.969</td>
<td>0.1362</td>
<td>14.45</td>
<td>0.000</td>
</tr>
<tr>
<td>Discharge of water</td>
<td>-1.813</td>
<td>-0.906</td>
<td>0.1362</td>
<td>-6.65</td>
<td>0.001</td>
</tr>
<tr>
<td>Delay</td>
<td>0.438</td>
<td>0.219</td>
<td>0.1362</td>
<td>1.61</td>
<td>0.128</td>
</tr>
<tr>
<td>Volume of R&amp;R</td>
<td>-4.313</td>
<td>-2.156</td>
<td>0.1362</td>
<td>-15.83</td>
<td>0.002</td>
</tr>
<tr>
<td>Die Temp*Discharge of water</td>
<td>0.062</td>
<td>0.031</td>
<td>0.1362</td>
<td>0.23</td>
<td>0.821</td>
</tr>
<tr>
<td>Die Temp*Delay</td>
<td>-0.187</td>
<td>-0.094</td>
<td>0.1362</td>
<td>-0.69</td>
<td>0.501</td>
</tr>
<tr>
<td>Die Temp*Volume of R&amp;R</td>
<td>0.563</td>
<td>0.281</td>
<td>0.1362</td>
<td>2.06</td>
<td>0.056</td>
</tr>
<tr>
<td>Discharge of water*Delay</td>
<td>-0.687</td>
<td>-0.344</td>
<td>0.1362</td>
<td>-2.52</td>
<td>0.026</td>
</tr>
<tr>
<td>Discharge of water*Volume of R&amp;R</td>
<td>0.312</td>
<td>0.156</td>
<td>0.1362</td>
<td>1.15</td>
<td>0.268</td>
</tr>
<tr>
<td>Delay*Volume of R&amp;R</td>
<td>-0.187</td>
<td>-0.094</td>
<td>0.1362</td>
<td>-0.69</td>
<td>0.501</td>
</tr>
<tr>
<td>Die Temp<em>Discharge of water</em>Delay</td>
<td>0.187</td>
<td>0.094</td>
<td>0.1362</td>
<td>0.69</td>
<td>0.501</td>
</tr>
<tr>
<td>Die Temp<em>Discharge of water</em>Volume of R&amp;R</td>
<td>-0.813</td>
<td>-0.406</td>
<td>0.1362</td>
<td>-2.98</td>
<td>0.009</td>
</tr>
<tr>
<td>Die Temp<em>Delay</em>Volume of R&amp;R</td>
<td>-0.313</td>
<td>-0.156</td>
<td>0.1362</td>
<td>-1.15</td>
<td>0.268</td>
</tr>
<tr>
<td>Discharge of water<em>Delay</em></td>
<td>-0.313</td>
<td>-0.156</td>
<td>0.1362</td>
<td>-1.15</td>
<td>0.268</td>
</tr>
<tr>
<td>Volume of R&amp;R</td>
<td>-0.437</td>
<td>-0.219</td>
<td>0.1362</td>
<td>-1.61</td>
<td>0.128</td>
</tr>
</tbody>
</table>

S = 0.770552      PRESS = 38
R-Sq = 97.09%      R-Sq(pred) = 88.36%      R-Sq(adj) = 94.36%

Figure-2: DOE Analysis of Orthogonal Array
In present case, it has been found that A, B, D, BC and ABD are more critical factors and factor interactions, which are affecting overall casting scrap substantially, as these are dotted in red and lying far away from the normal plot line of standardized effects.

<table>
<thead>
<tr>
<th>Optimal D</th>
<th>High Cur</th>
<th>Low Cur</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.99998</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Composite Desirability | Die Temp 330.0 [250.0] 250.0 | Discharg 10.0 [9.9602] 7.0 | Delay 180.0 [136.3636] 60.0 | Volume o 285.0 [281.7172] 260.0 |

Figure-3 Optimization of Process Parameters

b) Poka-Yoke Results: The improper seating of bottom on the die seat is the main reason for high scrap due to BT variation as the bottom gets tilted if it is not seated properly. Why-Why analysis has reached to a conclusion that unwanted play in the ram assembly and faulty guiding pins are major causes of improper seating of bottom and hence causing scrap due to BT variation. To make the system error free the catcher assembly and bottom assembly has been separated by installing the catcher to another side by hydraulic ram.

c) Kaizen Results: An appropriate procedure for cleaning of pins has been chalked out and this has been improved by suggesting the use of buffer motor for effective cleaning, caustic treatment for organic and inorganic removal of stains and use of graphite solution to create a lubricated layer of carbon around the pins that can provide protection against metal sticking and better surface finish of pin holes in the casted pistons. Test trails have shown that pins prepared with improved procedure have a life of 300 to 350 shots which gives pin five times more life than earlier and hence this not only reduces scrap by around 2% due to metal sticking on pins, but also decreases the breakdown in between the shift production. A proper training schedule of work force has also raised almost 1% saving in scrap.
Control Phase
In this phase, process monitoring and corrective or preventive actions are documented and executed. Basically this phase tries to check and monitor the improved process and its parametric values. Major Tools Used: Control Plan, X bar and R Chart for BT variation and p-Chart for overall scrap tracking.

Findings: In order to control the concerned parameters at their improved values, necessary modification in control plan of casting process has been done as per the output of DOE.

Results Achieved
Following are some major results achieved during execution of sequential Six Sigma phases:

• The existing high scrap (22% approx.) has been defined as most serious issue as far as overall productivity of pistons is concerned in foundry and machine shop.
• Casting scrap has been found primarily due to defects like; shrinkage, bottom thickness variation, blow holes, porosity, pin hole defect and cold lap.
• Process parameters (SSVs) like; in-gate design, dimensional inaccuracy of machine, die temperature, die coating thickness, discharge of cooling water, metal sticking on
pins, alloy temperature, shift dependency and operator skill have been measured as main reasons of above defects in piston castings.

- In Improvement Phase, four casting process parameters (i.e. Volume of R&R, Die temperature, Discharge of cooling water and Delay with in process) have been optimized to bring a significant reduction of 7% in scrap. The machine’s dimensional in-accuracy has been enhanced by altering the design of machine through Poka-yoke principles and this helped to achieve a net reduction of around 2% in scrap. The metal sticking on pins has been avoided by introducing a standard process of pin cleaning by using Kaizen rules of continues improvement and hence bring a further reduction of 2% in scrap. Then a proposed training schedule has reduced the scrap by around 1%. So overall 12% (approximately) reduction in scrap has been achieved in Improvement Phase of the case study.

- Earlier existing sigma level was 3.43 and after improvement it has been raised by 0.24. But even this has resulted in savings of around 30.7 lakhs per annum (refer annexure 1) and is remarkable for a medium scale make-to-order foundry unit.

- Total cost of energy saved has been calculated as 14.6 lakhs per annum (see annexure 2 for more details).

- So it is obvious from calculations that energy cost has an impact of approximately 48.6% on net cost of casted product and it is almost half of the total factory cost.

- Hence can be concluded that defect reduction through six sigma implementation means reducing energy requirements sustainably for meeting same production targets.

**Conclusions**

At the end following conclusions can be concluded:

a) This study has significantly reaffirmed the efficacy of Six Sigma strategy in Indian foundry industry to reduce scrap/waste from the operations, thus greatly improving the production efficiency and interns inculcating sustainable energy conservation scenario.

b) ‘Project based’ approach for Six Sigma implementation (rather then planning, training or investing in different phases of Six Sigma approach) is more motivating and helps a lot to demystify various fears on Six Sigma.

c) A cadre with sound theoretical knowledge on different statistical tools and software needs to be built up in the management, so as to bridge the gap between the theory and practice of Six Sigma and appreciate its potential while bringing in business excellence.

e) The challenge for all organizations is to integrate Six Sigma into their core business processes and operations rather than managing it as a separate initiative.

Six Sigma, a systematic framework for quality improvement and business excellence, has been widely publicized in recent years as the most effective means to combat quality problems, energy management and win customer satisfaction (Snee, 2009) but still it is in primary stage as far as Indian industries are concerned. In future it has great scope to create ‘zero defect foundries’ which indirectly reap large energy / power savings.
References


ANNEXURE-1
Cost of Poor Quality (COPQ) Matrix

<table>
<thead>
<tr>
<th>Financial Parameters</th>
<th>H273</th>
<th>H519</th>
<th>H749</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scrap/Month</td>
<td>400</td>
<td>600</td>
<td>400</td>
</tr>
<tr>
<td>Scrap Cost/Piston</td>
<td>183</td>
<td>183</td>
<td>183</td>
</tr>
<tr>
<td>Total Rejection Cost/Month</td>
<td>73200</td>
<td>109800</td>
<td>73200</td>
</tr>
<tr>
<td>Total Rejection Cost/Year</td>
<td>878400</td>
<td>1317600</td>
<td>878400</td>
</tr>
<tr>
<td>Total Rejection Cost for H family Pistons</td>
<td></td>
<td></td>
<td>30,74,400</td>
</tr>
</tbody>
</table>

Economic Analysis:
1. H-749 pistons:
   - Average scrap per month = 400 (Approximately)
   - Scrap Cost per Piston = 183 (Approximately)
   - Total rejection cost per month = 400*183 = Rs 73,200/-
   - Total rejection cost per year = 73,200*12 = Rs 8,78,400/-
2. H-519 pistons:
   - Average scrap per month = 600 (Approximately)
   - Scrap Cost per Piston = 183 (Approximately)
   - Total rejection cost per month = 600*183 = Rs 1,09,800/-
   - Total rejection cost per year = 73,200*12 = Rs 13,17,600/-
3. H-273 pistons:
   - Average scrap per month = 400 (Approximately)
   - Scrap Cost per Piston = 183 (Approximately)
   - Total rejection cost per month = 400*183 = Rs 73,200/-
   - Total rejection cost per year = 73,200*12 = Rs 8,78,400/-

Total cost saved from rejection of H-family pistons; = 8, 78,400+13, 17,600+8, 78,400
= Rs 30, 74,400/- (Approximately).

ANNEXURE-2
Energy savings from scrap reduction

<table>
<thead>
<tr>
<th>Description</th>
<th>Share</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piston cost</td>
<td>183</td>
<td>Rs</td>
</tr>
<tr>
<td>Share of Material cost</td>
<td>35%</td>
<td></td>
</tr>
<tr>
<td>Foundry Cost</td>
<td>30%</td>
<td>(Labour cost+Inventory cost+Energy Cost)</td>
</tr>
<tr>
<td>Machining Cost</td>
<td>25%</td>
<td>(Labour cost+Inventory cost+Energy Cost)</td>
</tr>
<tr>
<td>Overhead cost</td>
<td>10%</td>
<td></td>
</tr>
</tbody>
</table>
## Melting cost

<table>
<thead>
<tr>
<th>Description</th>
<th>Costing of one unit</th>
<th>Power consumption rate</th>
<th>Piston Weight</th>
<th>Piston saved from getting scrap</th>
<th>Melting cost saved per month</th>
<th>Melting cost saved per annum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power consumption rate</td>
<td>5.85 Rs</td>
<td>3.5 Kw/Kg</td>
<td>0.73 Kg</td>
<td>1400 per month</td>
<td>5.85<em>3.5</em>0.73*1400 = 20925.45 Rs</td>
<td>20925.45*12 = 251105.4 Rs</td>
</tr>
<tr>
<td>Piston Weight</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Piston saved from getting scrap</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

## Metal Holding Cost

<table>
<thead>
<tr>
<th>Description</th>
<th>Costing of one unit</th>
<th>Power consumption rate</th>
<th>Piston Weight</th>
<th>Piston saved from getting scrap</th>
<th>Melting cost saved per month</th>
<th>Melting cost saved per annum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power consumption rate</td>
<td>5.85 Rs</td>
<td>1.07 Kw/Kg</td>
<td>0.73 Kg</td>
<td>1400 per month</td>
<td>5.85<em>1.07</em>0.73*1400 = 6397.209 Rs</td>
<td>6397.21*12 = 76766.508 Rs</td>
</tr>
<tr>
<td>Piston Weight</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Piston saved from getting scrap</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
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## Die Casting Cost

<table>
<thead>
<tr>
<th>Description</th>
<th>Costing of one unit</th>
<th>Power consumption rate</th>
<th>Piston Weight</th>
<th>Piston saved from getting scrap</th>
<th>Melting cost saved per month</th>
<th>Melting cost saved per annum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power consumption rate</td>
<td>5.85 Rs</td>
<td>1.58 Kw/Kg</td>
<td>0.73 Kg</td>
<td>1400 per month</td>
<td>5.85<em>1.58</em>0.73*1400 = 9446.346 Rs</td>
<td>9446.35*12 = 113356.15 Rs</td>
</tr>
<tr>
<td>Piston Weight</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Piston saved from getting scrap</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Fettling Cost

<table>
<thead>
<tr>
<th>Description</th>
<th>Costing of one unit</th>
<th>Power consumption rate</th>
<th>Piston Weight</th>
<th>Piston saved from getting scrap</th>
<th>Melting cost saved per month</th>
<th>Melting cost saved per annum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power consumption rate</td>
<td>5.85 Rs</td>
<td>0.43 Kw/Kg</td>
<td>0.73 Kg</td>
<td>1400 per month</td>
<td>5.85<em>0.43</em>0.73*1400 = 2570.841 Rs</td>
<td>2570.84*12 = 30850.092 Rs</td>
</tr>
<tr>
<td>Piston Weight</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Piston saved from getting scrap</td>
<td></td>
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<td></td>
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</tbody>
</table>

## Heat treatment Cost

<table>
<thead>
<tr>
<th>Description</th>
<th>Costing of one unit</th>
<th>Power consumption rate</th>
<th>Piston Weight</th>
<th>Piston saved from getting scrap</th>
<th>Melting cost saved per month</th>
<th>Melting cost saved per annum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power consumption rate</td>
<td>5.85 Rs</td>
<td>2.87 Kw/Kg</td>
<td>0.73 Kg</td>
<td>1400 per month</td>
<td>5.85<em>2.87</em>0.73*1400 = 17158.869 Rs</td>
<td>17158.87*12 = 205906.43 Rs</td>
</tr>
<tr>
<td>Piston Weight</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Piston saved from getting scrap</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Machining Cost

<table>
<thead>
<tr>
<th>Description</th>
<th>Average Energy Cost of one piston</th>
<th>Piston saved from getting scrap</th>
<th>Melting cost saved per month</th>
<th>Melting cost saved per annum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power consumption rate</td>
<td>35.75 Rs/Piston</td>
<td>1400 per month</td>
<td>35.75*1400 = 50050 Rs</td>
<td>50050*12 = 600600 Rs</td>
</tr>
<tr>
<td>Piston Weight</td>
<td>0.73 Kg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Piston saved from getting scrap</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Re-Melting Cost

<table>
<thead>
<tr>
<th>Description</th>
<th>Average oil consumption rate of Furnace</th>
<th>Piston Weight</th>
<th>Cost of one litre Oil</th>
<th>Piston saved from getting scrap</th>
<th>Re-Melting cost saved per month</th>
<th>Re-Melting cost saved per annum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power consumption rate</td>
<td>0.57 L/Kg</td>
<td>0.73 Kg</td>
<td>25.5 Rs/L</td>
<td>1400 per month</td>
<td>0.57<em>0.73</em>25.5*1400 = 14854.77 Rs</td>
<td>14854.77*12 = 178257.24 Rs</td>
</tr>
</tbody>
</table>

### Total Energy Cost saved

<table>
<thead>
<tr>
<th>Description</th>
<th>14,56,841.82 Rs/Annum</th>
</tr>
</thead>
</table>

Overall savings per annum by reducing scrap (from 22% to 10.4%) 30,74,400 Rs/Annum

It Implies Share of Energy cost alone is around 14,56,841.82 / 30,74,400*100 = 47.38622 %
Application of Statistical Process Control Charts in Healthcare: A Case study

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Abstract
Quality of services rendered to the patients is of vital importance in the whole process of healthcare. On account of large population of the country, poor per capita income, inadequate ratio of number of patients to the number of doctors as well as poor medical infrastructure the quality of care is quiet poor and needs urgent attention on the part of planners and executers of healthcare system in the country. In the wake of above it was an attempt made to have a preliminary critical look at the current scenario of service quality in healthcare system. The expanse and complexity being very large it was decided to focus on a small segment using Statistical Process Control as a tool of study. A case study of the hospital was undertaken to assess the possibility of implementation of Statistical Process Control tools. The present study involves a look into the time spent by patients at various stages of healthcare process in out-patient department (OPD), to bring out the problems and suggest suitable remedial measures. The study reveals serious gaps highlighting the scope of improvement.

Key Words: Statistical Process Control (SPC), Control Charts, Healthcare, OPD.

Statistical Process Control
Statistical process control is an effective and indispensable methodology to implement Total Quality Management in all production processes. Statistical thinking (Hoeri, 1995) is becoming accepted as a necessary philosophy to reduce variation and thus improve quality and performance throughout the entire chain of marketing, development, production and sales processes, which is aimed at delivering high quality products to customers. Although SPC used to be considered applicable to production processes only mostly to production processes of high volume, but applications have shown very successful implementation in short series and low volume production as well (Does et al. 1997; Quesenberry, 1995). The philosophy of SPC has not found its similar way in the service industries yet, especially not in areas where the service provided is mainly determined by the direct contact with the customer: the “moment of truth” as this is often referred to. The application of SPC in service processes holds a promise and requires urgent con-
sideration, since the service industry and similarly sustaining processes within industrial organizations are of substantial economical value. Employment has tripled in services since 1980, whereas the employment in industry has reduced to one-third compared with the level of 1980. The anticipated benefits of applying SPC to service processes are ample in view of enhanced timeliness of service, reduction of customer complaints, reduction of time and money wasted and increased empowerment of front-line personnel. Deming 1986, aimed his quality philosophy on all processes, including services. Rosander (1991), who described a practical Deming philosophy for services, further explored this. Amsden (1991) provided an introduction in statistical techniques applied to measurements in service processes. Broadly, four application domains are identified: Engineering, industrial and environmental applications; Healthcare applications; General service sector applications; Statistical applications.

Healthcare applications present a new frontier for SPC methods. Interest in SPC is driven by a desire to improve patient outcomes in the face of capitation, cost reduction, competition, and changing healthcare industry standards. The delivery of health care requires multiple steps and patient “handoffs” with healthcare professionals operating in “separate silos”. In a paper based system, healthcare professionals act without the benefit of complete information on the patient’s history and condition and therefore end up duplicating steps, which increases costs. In an increasingly competitive and cost-conscious environment, a lack of unified electronic medical records and other electronic or digital healthcare data negatively affects quality and contributes to inefficiency and redundant efforts that, in turn, increase costs. The health system should focus on continuous improvement and a “value added” process improvement methodology in designing and maintaining all processes in order not to waste resources or patient’s time. The healthcare system should be able to use information effectively to serve the community, conserve resources; monitor costs and quality of care.

Literature Survey

SPC has not been widely adopted in healthcare in the past. Of course there is now an evidence that SPC is been increasingly applied in healthcare- for instance, a keyword literature search (using the term “statistical process control”) of the Medline database found zero hits for 1951-88, two for 1989-91, twenty-six for 1992-95, and seventy one for 996-2006. In addition, a number of healthcare specific SPC books have been published, and organizations such as the Joint Commission on Accreditation of Healthcare Organizations in the USA and the National Health Services Modernization Agency in the UK have advocated its use. Gopalakrishnan et al. (1989) have found that it is possible to validate measure and identify areas for improvements. Different quality indicators developed by them are: Waiting list for surgery, Cancellation for surgery/ admission, Waiting time for service, Infection rates, Clinical adverse occurrences, Patient feed back, Staff turnover, Exit interviews. Kohli, et al. (1995) conducted a study to reduce the turnaround time of the stat lab tests for casualty department. Different SPC tools such as Pareto diagrams, Flow chart and Control charts were used to ascertain quality standards and to monitor whether customer specification are met for producing a service in systematic
way. Lagasse et al. (1995) monitored the quality of preoperative care by statistically defining a predictable rate of adverse outcome dependent on the system in which practice occurs and respond to any special causes for variation. Outcome data also were subjected to statistical process control analysis, and industrial method that uses control charts to monitor product quality and variation. They concluded that the major determinant of patient care quality is the system through which services are delivered and not the individual anesthesia care provider. Shahian et al. (1996) employed SQC charts (x bar-s, p, u) to analyze preoperative morbidity and mortality and length of stay in 1131 non emergent, isolated, primary coronary bypass operations conducted within a 17-quarter time period. They concluded that SQC may be a valuable method to analyze the variability of these adverse post operative events over time, with the ultimate goal of reducing that variability and producing better outcomes. Hart (1997) detailed the results of a monitoring exercise introduced in local hospital of Leicester, UK to address the amount of time that patients spent waiting while attending O.P.D. in hospitals. He argued that quality measures should incorporate more qualitative dimensions, including the tapping of patient perceptions of their experiences, before a claim can be made that reducing waiting times has improved overall quality. Chadha and Singh (1998) stated that to sustain growth and competency in the long run, it is necessary for a healthcare organization to focus its attention on quality, productivity, efficiency and effectiveness in a continuous manner. Due to critical nature of healthcare operations, excess capacity should be stored in the system to provide required flexibility of response. They used queuing methodology to reduce the waiting time of patient. Levett and Carey (1999) stated that major advantage of using control chart methodology is that it allows one to determine whether the process being evaluated is in fact stable and to detect when significant or special cause variation occurs. They presented examples of using SPC charts to monitor coronary artery bypass grafting mortality, intensive care unit admission time, and length of stay. They concluded that we need to look at data over time with statistical validated methods such as control charts to better monitor our processes of healthcare and there by provide accurate statistics. Green (1999) applied SPC techniques to simulate monitoring the process of out patient service delivery at mental health centers of Sacramento County, California, using data collected 23 years earlier. He stated that one of the advantages of creating a chart to monitor the control of service delivery process is obtaining feedback about operations in real time. Whoever reads the chart and discovers variation due to a special cause can move quickly and in a timely manner to rectify the problem. This study demonstrated that by monitoring the effectiveness of behavioral health services in real time to trap unwanted causes of special or systematic variation, more timely steps can be taken to address such problems and improve service effectiveness. Bonetti et al. (2000) stated that the main driving force of today’s medicine is continuing scientific progress and increasingly rigid cost constraints. They performed a case study on patients with acute myocardial infarction receiving thrombolytic therapy. With the help of histograms, cause and effect diagram and control charts they were able to monitor and reduce the time taken for door to needle time i.e. time consumed in administering first injection after patient reaches at hospital. They concluded that formal process analyses techniques are suited to improve processes
in the intensive care unit. Hanslic et al. (2001) applied control charts to public health surveillance. They conducted a pilot study during 1998 world Football Cup throughout France. The average number of cases of communicable, environmental and societal diseases relating to mass gatherings, and total number of referrals to hospitals reported daily, were plotted on a u-chart for each condition monitored. So control charts assured that the level of the parameters chosen for general community health surveillance remain under control. Canel and Kadipasaoglu (2002) provided an analysis of the quality of service provided by a university health center. SPC charts are used to investigate the time spent by students at the various stages of the healthcare processes. Variation of waiting times at different stages of the healthcare process was determined and specific recommendations were made to improve the performance of the center. Arantes et al. (2003) concluded that SPC charts allow distinction from the natural variations observed in Nosocomial infection occurrence rates, without the need for calculations and hypothesis testing. They performed the study on 460 patients admitted to the pediatric intensive care unit of university hospital in Brazil from 1998 to 2000. Self and Enzenauer (2004) evaluated 95 patients undergoing strabismus surgery on either one or two previously un-operated eye muscles in one or both eyes. SPC charts were used to evaluate the success and validity of surgical guidelines for horizontal recession and resection procedures. Data was divided in two groups, patient with esotropia and patient with exotropia, for computerized statistical analysis. They concluded that SPC might be a valuable method to analyze the variability of the results of many ophthalmologic procedures or treatments over time with the ultimate goal of better patient outcomes by decreasing variability.

**Introduction to hospital under study**

The study was carried out at a hospital run by an Educational Trust near Ambala, Haryana (India). It is situated in a village about 25 kilometers from Ambala. It has different departments like General Surgery, General Medicine, Pediatrics, Orthopedics, Obstetrician and Gynecology E.N.T., Ophthalmology, Skin and STD, Chest and TB, Psychiatry, Emergency and Pathology. Hospital statistics shows that about 31 surgeries are performed daily and the average length of stay of patients is 9 days and bed occupancy rate is 84%. It shows that numbers of patients who visit are increasing and expected to further rise in the next academic year. Increasing number of patients visit will result in further strain on the hospital facilities. Case study was performed at General Medicine’s out patient department (OPD) of the hospital. A long waiting of patients at waiting room of OPD motivated this study. Growing number of patients would continue to increase demand for hospital services and strain the capacity of the hospital to provide timely, cost-effective and efficient services to its users. So, it was felt to examine its current activities to determine where the services needed improvement and to highlight opportunities to provide better service.

**Objectives of study**

- To explore the possibility of using SPC tools in healthcare at this hospital and to
identify the relevant techniques.

- To recommend suitable measures for reducing the waiting time of patients at various stages of service delivery by OPD General Medicine Unit.

The methodology adopted for the study include personal visits at OPD and tracking the patient from reception till care provider’s (doctor’s) consultation. Time at each stage of patient wait was recorded. Four patients were followed daily for the study. Total of four-week study was carried out from June 2006 to August 2006. At the time the medicine department had a staff of 21: Twelve doctors out of them four alternated their duties for OPD daily; two dieticians; two nurses; One ECG operator; one computer operator; one clerk; two attendants. The health care process provided by the hospital OPD has several stages. Figure 1 shows the flow chart of patient travel in OPD to receive healthcare services.

![Flow diagram of patient stay in hospital’s OPD](image)

**Figure 1  Flow diagram of patient stay in hospital’s OPD**

**Methodology and data collection**

Upon registration of a patient for medicine OPD, the patient was tracked. Time was recorded using international time (1:00 pm = 13.00). The following information was recorded: Date; Gender; Old or new; Total number of registration in a day; Registration
time (T0); Check in time (T1); Provider time; (T2); Discharge time (T3). Subtracting the time for the following step from the measure of previous one generate length of time spent at each step of the care service. This results time for four steps, which are reported herein. These are:

- T1-T0  Time between registration and check in.
- T2-T1  Time in waiting room awaiting care provider.
- T3-T2  Time with care provider.
- T3-T0  Total time in the OPD.

Measurements are collected as follows: for each of the four steps above, measurements are taken for four patients each day. Therefore sample size is four (n=4) and the total numbers of measurements are 24 in a week. Measurements were collected during summer 2006, resulting in 24 days of data collection (six days * four weeks). Subject for the study comprised total of 96 patients visiting medicine OPD. Two patients among early hours and two among late arrivals were selected randomly each day as per OPD timings from 8.30 to 14.30.

<table>
<thead>
<tr>
<th>Day</th>
<th>Average time between check in and registration (T1-T0) minutes</th>
<th>Average time waiting in waiting room for care provider (T2-T1) minutes</th>
<th>Average time with care provider (T3-T2) minutes</th>
<th>Average of total time spent in OPD (T3-T0) minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday</td>
<td>8.12</td>
<td>49.25</td>
<td>15.68</td>
<td>72.5</td>
</tr>
<tr>
<td>Tuesday</td>
<td>6.93</td>
<td>46.37</td>
<td>16.18</td>
<td>67.8</td>
</tr>
<tr>
<td>Wednesday</td>
<td>5.75</td>
<td>48.43</td>
<td>15.93</td>
<td>69.3</td>
</tr>
<tr>
<td>Thursday</td>
<td>5</td>
<td>48.5</td>
<td>16.56</td>
<td>71.12</td>
</tr>
<tr>
<td>Friday</td>
<td>5.18</td>
<td>47</td>
<td>16.5</td>
<td>68.68</td>
</tr>
<tr>
<td>Saturday</td>
<td>4</td>
<td>40.87</td>
<td>15</td>
<td>63</td>
</tr>
</tbody>
</table>

Table 1 Average waiting times

**Results**

Of the patients passing through the hospital’s OPD in the study 53 % are female and 16 % of the visits are of old patients. The average number of patients who registered for healthcare markedly decreased throughout the week from a high on Monday of 92 to the Saturday low of 56. The Monday high could be attributed to be back log of patients who failed to seek healthcare on Saturday or who became ill or in need of health care over the weekend, when OPD does not provide care. These results indicate that the OPD’s busiest day of the week is Monday and its least busy is Saturday. The average time of the entire health-care process, from registration to discharge, ranged from 63.0 to 72.5 minutes. The two steps with the longest average times are the waiting in room for care provider (49.25 - 40.87 min) and time spent with care provider (16.56-15.0 min) So the controlling step is
that involving the healthcare provider. Further analysis is done with plotting the data for the above steps separately on X bar and R chart. For each of the four steps – waiting time for the four different stages – individually charted. For T1-T0, time between registration and check-in, an X-bar and an R chart were constructed. For T2-T1, time in waiting room awaiting care provider, a separate X-bar and R chart were constructed and similarly separate X-bar and R charts were constructed for T3-T2 and T3-T0. In addition, since the hospital congestion varies considerably on different days of the week, separate charts are constructed for each day. All Monday measurements for a step (T1-T0, for example) were then used to calculate the average and range of waiting time for that step or Monday. Similarly, all Tuesday measurements for a step were used to calculate the average and range of waiting time for that step for Tuesday, etc. figure 2 show the central line, upper limit and lower limit for the X-bar and R charts for each step and each day. For each chart: the central line is the mean, the average value, of all measurements for the specified day and the specified step. The upper limit is the mean X-bar + 3 standard deviations from the mean, and lower limit is the mean – 3 standard deviations from the mean. Control charts (X-Bar) were drawn for each day of week i.e. from Mon. to Sat. for the whole four-week study period for the four steps of waiting by patients in OPD. Fig. 2 shows control charts (X bar and R) for the time between registration and check-in (T1-T0) and time in waiting room waiting for care provider (T2-T1) for the whole four-week study period.
Application of Statistical Process Control Charts in Healthcare: A Case study

Control charts for T1-T0, time between registration and check in, varies within the limits around mean time of 5.64 minutes. There are no indications of special cause variation for this step. Whereas control chart for T2-T1, time in waiting room waiting for care provider shows that there are six continuous points above the mean line which indicate that process of waiting at this stage in varying abnormally which requires some improvement. Moreover, the waiting at this stage is quite high and efforts should be directed to bring some useful changes in the service of health delivery. It is the case with T3-T2, time with care provider, six consecutive points in x-bar chart are above average line and R chart also shows one point above UCL. Total time in OPD on x-bar chart shows seven consecutive points above average line. This shows that waiting of patients at OPD is not uniform and requires urgent attention. X-bar charts for T1-T0 for each day of week shows one point each out of UCL on Thursday and Saturday. This may be due to the fact that there was no computer operator at the counter. X-bar charts for T2-T1 shows that process of waiting for care provider is showing some specific reasons for above average waiting at six points on Monday and Tuesday. X- bar chart for T3-T2 shows some points beyond UCL and LCL on Monday, Wednesday and Thursday. This process is beyond control as it depends upon patient to patient but efforts may be made to reduce this time by providing one paramedical staff to each care provider.

Further analysis of the data collected was done with multi server queue model known as M / M / C / ∞ / FIFS assuming arrival rate in Poisson distribution (M), service time in exponential distribution (M), multi server channel (C), infinite patients (∞) and service in First In First Served order.
Application of Statistical Process Control Charts in Healthcare: A Case study

### Table 2: Queue lengths on different days of week with different number of servers

<table>
<thead>
<tr>
<th>Day</th>
<th>No. Of Patients</th>
<th>Arrival Rate Per hour</th>
<th>Time with Care provider</th>
<th>Service Rate Per hour</th>
<th>Queue length With 4 care providers</th>
<th>Queue length With 5 care providers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mon</td>
<td>92,000</td>
<td>13.143</td>
<td>15.680</td>
<td>3.827</td>
<td>4.289</td>
<td>0.784</td>
</tr>
<tr>
<td>Tue</td>
<td>67,000</td>
<td>9.571</td>
<td>16.180</td>
<td>3.708</td>
<td>0.633</td>
<td>0.155</td>
</tr>
<tr>
<td>Wed</td>
<td>65,000</td>
<td>9.286</td>
<td>15.930</td>
<td>3.766</td>
<td>0.495</td>
<td>0.121</td>
</tr>
<tr>
<td>Thu</td>
<td>67,000</td>
<td>9.571</td>
<td>16.560</td>
<td>3.623</td>
<td>0.718</td>
<td>0.176</td>
</tr>
<tr>
<td>Fri</td>
<td>58,000</td>
<td>8.286</td>
<td>16.500</td>
<td>3.636</td>
<td>0.330</td>
<td>0.079</td>
</tr>
<tr>
<td>Sat</td>
<td>56,000</td>
<td>8.000</td>
<td>15.000</td>
<td>4.000</td>
<td>0.174</td>
<td>0.040</td>
</tr>
</tbody>
</table>

So if we continue with present three care providers there is probability of 10 patients not attended and going back without availing service. This means that we have to increase the care providers at least by one. Which will reduce the queue length on Monday to 4.2 and on Tuesday from 4.6 to 0.6, on Wednesday from 3.1 to 0.4, on Thursday from 5.7 to 0.7, on Friday from 1.8 to 0.3 and on Saturday from 0.8 to 0.1? If not possible with current financial situations, we can provide one part time care provider on Monday only.

Further data was analyzed keeping in mind if old patients were called on rest of days except Monday then queue model gives results as in Table 3. In this, average number of old patients registered on Monday are subtracted and added uniformly on rest of days. Table 4.8 shows that if old patients are be asked to come a day except Monday then queue length will be reduced, with four care providers on Monday to 1 and 0.8, 0.6, 0.9, 0.4, 0.2 respectively from Tuesday to Saturday.

### Table 3: Queue lengths if old patients withdrawn from Monday.

<table>
<thead>
<tr>
<th>Day</th>
<th>No. Of Patients</th>
<th>Arrival Rate Per hour</th>
<th>Time with Care provider</th>
<th>Service Rate Per hour</th>
<th>Queue length With 4 care providers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mon</td>
<td>75,000</td>
<td>10.714</td>
<td>15.680</td>
<td>3.827</td>
<td>1.000</td>
</tr>
<tr>
<td>Tue</td>
<td>67,000</td>
<td>9.571</td>
<td>16.180</td>
<td>3.708</td>
<td>0.873</td>
</tr>
<tr>
<td>Wed</td>
<td>65,000</td>
<td>9.286</td>
<td>15.930</td>
<td>3.766</td>
<td>0.682</td>
</tr>
<tr>
<td>Thu</td>
<td>67,000</td>
<td>9.571</td>
<td>16.560</td>
<td>3.623</td>
<td>0.999</td>
</tr>
<tr>
<td>Fri</td>
<td>58,000</td>
<td>8.286</td>
<td>16.500</td>
<td>3.636</td>
<td>0.465</td>
</tr>
<tr>
<td>Sat</td>
<td>73,000</td>
<td>10.429</td>
<td>15.000</td>
<td>4.000</td>
<td>0.264</td>
</tr>
</tbody>
</table>

**Discussion of case study**

The hospital should focus on quality healthcare that is convenient, efficient and accessible for all patients. In order to improve the quality of services provided to the patients the hospital should make every effort to get feedback from the patients and employees. In reality most of the staffs were aware of the following: Patients were waiting too long to get attention; the longest wait was in waiting for care provider; the hospital needed to improve the efficiency of the medical providers.
Developing control limits are useful in establishing minimum standards of service quality based on time spent at different stages of the healthcare process. Monitoring these aspects indicate the points in the process at which inefficiently is occurring and which require attention to determine the cause of bottlenecks. Other aspects of health-care process, such as successful diagnoses and health recovery, must be considered with efficient time usage to gain a full understanding of the overall efficacy of the hospital. Use of control limits for times spent at various stages of health-care process must be considered in conjunction with such other important factors as the type of health problem, the patient load, staff training and staff numbers, to determine whether those times are efficient or not. This proactive approach to reduce the waiting-times is consistent with the hospital’s continuous effort to improve the quality of services provided to community.

**Recommendations**

Based on the findings from the study the following recommendations are suggested:

- The waiting time of patients in receiving services at OPD medicines were 40.8 – 49.2 min in waiting for care provider and 15 –16.5 min with care provider which can be reduced by introducing an examination process by nursing staff and appointing one part time staff for the period of high activity from 9 am to 12 noon. Introduce an examination process by nursing staff before the patient enters the care provider’s room. This will reduce time with care provider and total wait.

- Queue length with present 4 doctors was high up to 4.2 on Monday. By appointing one more care provider the queue length can be reduced from 4.2 to 0.78 on Monday. Queue length on Monday can also be reduced to 1.0 by asking the old patients to come on rest of days except Monday, as the day was the most loaded in terms of number of patients. It should be prefered that the old patients are not given time to come on Monday they may be asked to revisit preferably on Saturday or any other day except Monday if possible. This will reduce load of number of patients on Monday at OPD. This ultimately will result in less waiting time at OPD.

**Future scope of the study**

During the study particularly while interacting with patients, doctors and paramedical staff it was proved beyond doubt that healthcare services especially in general hospitals needed a very careful and urgent attention. Inadequacy of physical as well as medical infrastructure got projected dually and it was found to be the root cause of delays as well as inefficiencies. Problem of quality in healthcare service is quiet complex and vast. It does require a thorough investigation. The situation can be comprehended quite effectively by using statistical approach. All the processes involved in the exercise are amenable to statistical analysis and hence control. What has been attempted here is only one aspect and it is perhaps only the tip of iceberg. SPC can provide a deep insight and effective solution to several of the processes and situations involved. Further work can be carried out on customer care and satisfaction, time control, effectiveness of service, process productiv-
ity as well as cost control. A full length and in-depth study can be conducted to achieve useful holistic results.

References


Application of Statistical Process Control Charts in Healthcare: A Case Study


Quality Management in Supply chain: A case study

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Abstract
In recent years, many organizations have looked upon continuous improvement and total quality management (TQM) within manufacturing as the means by which they could maintain a competitive edge. Now, only manufacturing is not responsible for success of any company but it is matter of complete supply chain. A manufacturing supply chain is an integrated set of business functions, encompassing all activities from raw material acquisition to final customer delivery. Even though much attention has been focused on supply chain management (SCM) concepts in recent years, its interlinking with the quality management perspective is often limited and tangential in nature. While the importance of quality management is universally recognized, academic researchers need a more focused approach in evaluating quality management issues within the internal and external supply chain contexts.

Keywords—Total quality management, Supply Chain Management, Analytical hierarch process (AHP), Swot analysis.

Introduction
Understanding Total quality management (TQM)
In today’s global competition and economic liberalization, quality has become one of the important factors for achieving competitive advantage. A good quality product or service enables an organization to add and retain customers. Poor quality leads to discontented customers, so the costs of poor quality are not just those of immediate waste or rectification but also the loss of future sales. Technological innovations have diffused geographical boundaries resulting in more informed customers. The business environment has become increasingly complex and the marketplace has changed from local to global. Constant pressure is applied on the management to improve competitiveness by lowering operating cost and improving logistic. Customers are becoming increasingly aware of rising standards, having access to wide range of products and services to choose from. There is an ever-increasing demand for quality product and/or services and this global revolution had forced organizations to invest substantial resources in adopting and implementing total quality management strategies. Total Quality Management has many definitions. Gurus of the total quality management discipline like Deming, Juran, Crosby, Ishikawa and Feigenbaum defined the concept in different ways but still the essence and spirit remained the same. According to Deming, quality is a continuous quality improve-
ment process towards predictable degree of uniformity and dependability. Deming also identified 14 principles of quality management to improve productivity and performance of the organization. Juran defined quality as “fitness for use.” According to him, every person in the organization must be involved in the effort to make products or services that are fit for use. Crosby defines quality as conformance to requirements. His focus has been on zero defects and doing it right the first time. Ishikawa also emphasized importance of total quality control to improve organizational performance. According to him quality does not only mean the quality of product, but also of after sales service, quality of management, the company itself and the human life. Feigenbaum defined total quality as a continuous work processes, starting with customer requirements and ending with customer’s satisfaction. Definitions of quality have changed with the passage of time with changing customer’s needs and requirements. But the essence has more or less been to develop an approach to problem solving, conformation to standards for customer satisfaction. With management functions getting complex, approaches to managing quality in functional areas are becoming difficult. Organizations, which have successfully use TQM principles, have customer and quality embedded in their corporate strategy. Any organization is a system of interrelated units. For TQM to succeed, all of the components within the organization must be collectively involved. Initially, organizations implemented TQM in the hope that improvement in the shop-floor activities would solve all existing productivity and quality problems. Later, they have realized that TQM is much more than just shop-floor improvements. The definitions of quality incorporate factors like top management commitment, leadership, team work, training and development, rewards and recognition, involvement and empowerment of employees etc. These critical factors are the foundation for transformational orientation to create a sustainable improvement culture for competitive advantage on a continuous basis. According to Selladurai Raj, TQM interventions or activities must be guided by four change principles, namely work processes, variability, analysis, and continuous improvement. Product design and production processes must be improved; variance must be controlled to ensure high quality; data must be systematically collected and analyzed in a problem-solving cycle; and commitment made to continuous learning by the employees about their work.

**Understanding of Supply Chain Management (SCM)**

This is a growing attention on global supply chain management. Supply chain management is a holistic and a strategic approach to demand, operations, procurement, and logistics process management (Kuei et al., 2001). Traditionally, the focus of supply chains was on specific functionalities such as purchasing, manufacturing, and shipping to support logistics operations. The effective management of quality is the key to increased quality and enhanced competitive position in today’s global environment. Kuei (2001) suggests that quality management agreement should be distinguished from supply chain management. Fynes and Voss (2002) write about the impact of quality management on supply chain performance. Based on their empirical study, it is imperative to realize that stronger relationship quality is a must to achieve superior supply chain performance. Campbell and Sankaran, (2005) discuss integration issues in supply chains for small
and medium size enterprises. They provide a framework to facilitate such an integration process for use and analysis by practitioner and researchers alike and analyses the problem of changes in customer preferences requiring customization of products, and how information sharing under such circumstances can assist in improving quality in supply chain performance. It is found that even though the philosophies of quality management and SCM have been researched extensively in the literature, few studies examine these agendas jointly. Rather, the topic of quality management in the supply chain is largely fragmented and dispersed across many other disciplines such as supplier–buyer activities, strategic management, manufacturing practices, and process integration. Thus it is supporting our view that research about quality management in the supply chain is highly disjointed and lacks treatment as a significant dimension of SCM. The basic elements of QM are customer focus, strategic planning and leadership, continuous improvement and learning, and empowerment and teamwork. Mehra7 (2001) compiled an extensive review of QM research and suggested that there are at least 45 elements that affect QM implementation categorizing these topics into the five key areas of culture & people, measurement and feedback, innovation management, system and techniques and customer orientation. Similarly, various lecture reviews and analysis of SCM literature reveal that this evolving body of knowledge stems from the research disciplines of physical distribution, transportation and networked system of materials logistics and transportation, best practices, organizing and relation and partnership (Croom et al., 2000; Tan, et al, 2001)8. The supply chain is the network of autonomous and semi-autonomous business entities, which are involved through upstream and downstream linkages in the difference processes and activities that produce value in the form of physical and services in the hands of the ultimate customers. Supply chain consists of the network of organizations that connects suppliers and end-users. It provides the route through which raw material is converted into finished goods/services into the hand of customers. Supply chain management, in turn, “comes the flow of goods from suppliers through manufacturing and distribution chains to the end uses”. The concept of supply chain management is important as it provides a framework for the integration of information, material and finances of the enterprise, right from the suppliers to the customers. The coordination element of the supply chain includes: Procurement also known as source, manufacturing also known as make, logistics also known as more, warehousing also known as store, market also known as sell. A supply chain is a network of facilities and distribution options that performs the function of procurement of material, transformation of these materials into intermediate and finished products, and the distribution of these finished products to customers. Supply chains exist both in service and manufacturing organizations, although the complexity of the chain may vary greatly from industry to industry and firm to firm.

A CASE STUDY
Introduction
Analyzing the supply chain and quality management helps provide a baseline of success for the business. The automotive OEMs differ widely in growth trends, economic distinctiveness, competitors, and technological issues. The assessment of these two key
areas will affect how the position of company within the supply chain, for the customers, and development of basic competitive strategies. Quality management and supply chain analysis of an automotive OEM uses basic factors and sub factors like culture & people, measurement and feedback, customer focus and orientation, continuous improvement and learning, Innovation management, empowerment & team work, system& techniques, strategic management, transportation and logistic, marketing, relationship and partnership, best practices, Organizational behaviour, Organizing techniques, marketing, transportation and logistics and strategic management. This analysis assists the company to think strategically about industry’s overall quality management in complete supply chain and draw conclusion regarding the potential for growth & profitability and competitiveness. This analysis is carried out in XYZ Ltd (The X company name has been changed on request of management) is an automotive OEM that produce four strokes motorcycles in India with technical collaboration of Y Ltd company Japan. X Ltd is the word largest two-wheeler manufacturing business of bicycle components had originally started in the 1940’s and turned into the world’s largest bicycle manufacturer today. X Ltd is a name synonymous with two-wheelers in India today. The X Ltd rolls their own steel, make free wheel bicycle critical components and have diversified into different ventures like product design. The X Ltd Group philosophy is: “To provide excellent transportation to the common man at easily affordable prices and to provide total satisfaction in all its spheres of activity”. The X Ltd vision is to build long lasting relationships with everyone (customers, workers, dealers and vendors). The Y Ltd was incorporated in 1948. Since its inception, Y Ltd has become the largest Japanese industrial concern among those companies incorporated after World War II. Today Y Ltd is acknowledged as the undisputed leader in motorcycle technology. Recognized the world over as a pioneer, the Y Ltd name is a guarantee of the technological and manufacturing excellence which includes automobiles and power products (lawn movers, generators and outboard motors). Y Ltd Company has 83 overseas production facilities in 35 countries looked after by a 93000 strong force. In 2001, its consolidated sales amounted to over 140000 crores. X Ltd & Y Ltd Collaboration, Leaders are not born they evolve over time. In the year 1984, a four stroke revolution that was ushered when the X Ltd group is world’s largest manufacturer of bicycles, joined hands with Y Ltd Firm, Japan is also a world leader in motorcycles given a new name the company XYZ Ltd that was first company to introduce new generation 4-stroke technology in India. With motorcycles that set the benchmark for fuel efficiency and pollution control. Today, there are over 17.5 million motorcycles on Indian roads. With each of its seven models addressing different customer needs. Well entrenched in the domestic market, XYZ Ltd turned its attention overseas, and exports have been steadily on the rise. Today XYZ Ltd commands 48% of the total market. Combined with technical excellence is a large dealer network, reliable & quality after sales and the provision of genuine spare parts. XYZ Ltd Mission Statement is: “We are continuously striving for synergy between technology, systems, and human resources to provide products and services that meet the quality, performance, and price aspirations of our customers. While doing so, we maintain the highest standards of ethics and societal responsibilities, constantly innovate products and processes, and develop teams that keep the momentum
Quality Management in Supply chain: A case study

going to take the company to excellence in the new millennium”. XYZ Ltd has its three word class plants in different prime location of India.

Competitive Performance of XYZ Ltd
Performance measurement is the process of quantifying the efficiency and effectiveness of manufacturing system. Performance of an enterprise is often measured as a ratio of output to input. The outputs constitute the products of the enterprise and the inputs are the resources used by the enterprise. Performance Analysis confidence and trust are the two enduring values associated with XYZ Ltd. These values define the bond that XYZ Ltd establishes with customers cutting across geographic locations, income levels, and market segments. The reliability and durability of this relationship has resulted in positive word-of-mouth from satisfied customers, working to the brand’s advantage. Over the years, XYZ Ltd has maintained its leadership in the two-wheeler market by continuously improving its competitiveness. Competitiveness of a firm can be assessed on multiple parameters: Market Results, Financial Results, Comparisons with competitors, Product Results, Process Results, Customer Results, etc as shown in Table 1.

<table>
<thead>
<tr>
<th>ABC Ltd</th>
<th>Particulars</th>
<th>2006-07</th>
<th>2007-08</th>
<th>2008-09</th>
<th>2009-10</th>
<th>2010-11</th>
<th>P**</th>
<th>Q**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales (nos)</td>
<td>1677537</td>
<td>2070147</td>
<td>2621400</td>
<td>3000751</td>
<td>805740</td>
<td>2568000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Growth in Sales (nos) (%)</td>
<td>17.70</td>
<td>23.40</td>
<td>26.60</td>
<td>14.50</td>
<td>16%</td>
<td>20%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Growth in Total Income (%)</td>
<td>14.40</td>
<td>15.50</td>
<td>26.00</td>
<td>17.40</td>
<td>17.2</td>
<td>19.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Profit before Tax</td>
<td>885</td>
<td>1072</td>
<td>1217</td>
<td>1412</td>
<td>168.45</td>
<td>10864</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Profit after Tax</td>
<td>581</td>
<td>728</td>
<td>810</td>
<td>971</td>
<td>117.00</td>
<td>7668</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net Fixed Assets</td>
<td>517</td>
<td>589</td>
<td>715</td>
<td>994</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Assets (net)</td>
<td>995</td>
<td>1314</td>
<td>1695</td>
<td>2195</td>
<td>1378</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Market Capitalization</td>
<td>3758</td>
<td>9797</td>
<td>10943</td>
<td>17781</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Economic Value Added (EVA)*</td>
<td>481</td>
<td>569</td>
<td>564</td>
<td>641</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table-1. ABC Ltd Performance tracking and comparative analyses
* EVA is the difference between the return on a Company’s capital and the cost of that capita
** P and Q are other competitive

Research Objective
On the basis of mapping of an organization on these key areas of supply chain, strong and weak areas for the organization are identified by prioritizing the factors of quality man-
management system in different area of supply chain. Strategies should be framed to overcome on weak areas and take leverage on strong areas for improving supply chain. This framework can be also used to quantify with AHP calculation of its quality management factors. For the case company this diagnostic and strategy formulation approach has been demonstrated in following sections. Various sources of information about the company consist of annual reports, control charts, documentation of various processes and discussion with managers of various departments during regular scheduled visits. Therefore this study is aimed to

I. Illustrate the concept of quality management systems in supply chain by taking a real life example of a automobile OEM to motivate other OEMs.

II. To develop a supply chain analysis framework for analysing quality management system.

III. To identify major quality systems in complete supply chain of an automotive OEMs in highly competitive automotive sector.

IV. To identify key success factors through AHP calculation for sustaining quality management system in supply chain of OEM organization.

Case Study Framework
In the context of international logistics, benchmarking systems such as Quality Assurance Accreditation (QAA), Total Quality Management (TQM) and internal Composite Logistics Modelling (CLM) tools can be combined to maximize logistics efficiency. This project assesses the contribution of QM systems to performance enhancement in supply chain of an automobile OEM. We have used both internal and external quality management systems in order to provide optimal solutions for the success supply chain of automotive OEM. It is shown that such techniques contribute positively to a company’s internal efficiency and to its position in the market. All the critical factors i.e. culture & people, measurement and feedback, customer focus and orientation, continuous improvement and learning, Innovation management, empowerment & team work, system& techniques of quality management and Figure 5 strategic management, transportation and logistics, marketing, relationship and partnership, best practices, Organizational behaviour, Organizing techniques, marketing, transportation and logistics and strategic management of Supply Chain have been analyzed in details for XYZ Ltd.
According to this framework, Quality management in supply chain of an organization will depend on its successful implementation of quality management system. We will analyze and prioritize that which quality system is best in supply chain. In Figure 6 all the critical factors are given.

**SWOT Analysis A Strategic Management**

Business success depends on the formulation and implementation of viable strategies. XYZ Ltd is going forward to reinforce their leadership by developing the appropriate strategy for achieving word no1 status in the two wheeler market. The company has planned to launch eight new motorcycles in the market at different customer segment. XYZ Ltd has launched India’s first fuel injection two wheeler a technology as revolution same as XYZ Ltd launched first two stroke engine two decades ago in 1984. The XYZ Ltd is facing new competition is in terms of reduced cost, improved quality, and products.
with higher performance, a wider range of products and better service, and all delivered simultaneously.

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weakness</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Strong financial condition</td>
<td>• Obsolete facilities</td>
</tr>
<tr>
<td>• Strong brand name image</td>
<td>• Higher overall costs than rivals</td>
</tr>
<tr>
<td>• Widely recognized as market leader</td>
<td>• Missing some key skills/competencies</td>
</tr>
<tr>
<td>• Strong communications</td>
<td>• Internal operating problems</td>
</tr>
<tr>
<td>• Product innovation</td>
<td>• Falling behind in R&amp;D</td>
</tr>
<tr>
<td>• Good customer service</td>
<td></td>
</tr>
<tr>
<td>• Better product quality</td>
<td></td>
</tr>
<tr>
<td>• Better Technology</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Opportunity</th>
<th>Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Expanding product line</td>
<td>• Entry of 1Lac car by Tata</td>
</tr>
<tr>
<td>• Transferring skills to new products or services</td>
<td>• Substitute products or services</td>
</tr>
<tr>
<td>• Take market share from rivals</td>
<td>• Slowing market growth</td>
</tr>
<tr>
<td>• Openings to exploit new technologies</td>
<td></td>
</tr>
<tr>
<td>• Openings to extend brand name/image</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. SWOT Analysis

**Application of AHP to prioritize the key Factors in Supply chain**

Quality management (QM) is often regarded as a philosophy that aims to achieve customer satisfaction through continuous improvement and team work. The transformation towards QM is coupled with its spread, from the manufacturing to the service sector and onto public services (Dale, 1999). Implementation of QM becomes a top management agenda in many organizations in the pursuit of positive business benefits, such better product quality, higher customer satisfaction and less quality cost and improved supply chain. Some recent studies advocated that many organizations launched QM programs have gained any positive results. There have been several approaches and models suggested for the QM introduction and implementation. This paper presents main findings of a recent study that investigated the critical factors of quality management affecting the implementation of QM in supply chain. This study attempted to identify the critical factors and sub-factors for an automotive OEM (XYZ Ltd) to implement quality management in supply chain using analytical hierarchy process (AHP) approach. A general hierarchy model was elaborated to help prioritization these factors and formulate strategy for quality management implementation in supply chain of automotive OEM.

**Steps of AHP Calculation**

Step-1 Make the hierarchy of factors & sub factors
Step-2 Calculate an Individual-level matrix.
Step-3 normalize the comparisons.
Step-4 Calculate the Priority score and consistency score.
Step-5 Determine consistency ratio

Critical Factors and Sub Factors of Quality Management
Implementing quality management needs to be a totally integrated, continuous and open system based on the commitment from to management and employees, as well as the communication with customers. An exhaustive list of critical factors consolidated from case study is depicted in Figure 7. For facilitating discussions, they are divided into seven categories of factors or elements, namely System and Techniques, Empowerment & Teamwork, Innovation Management Culture & People Customer Focus & Orientation, Measurement and feedback and continuous improvement. Each categories factor has several factors as elaborated in Figure 7.

As per the decision hierarchy of Quality Management, the consistency ratio (CR) for all critical factors and sub-factors of Quality management is shown in table 3.

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Critical factor &amp; Sub factor</th>
<th>Checking Consistency Index</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>CI = (\lambda_{max} - n)/(n - 1) and Consistency Ratio (CR) = CI/RI</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RI as per Table 4</td>
</tr>
<tr>
<td>1</td>
<td>Technology prioritization</td>
<td>CR= 0.091 is less than 0.1</td>
</tr>
<tr>
<td>2</td>
<td>Empowerment &amp; teamwork prioritization</td>
<td>CR= 0.099 is less than 0.1</td>
</tr>
<tr>
<td>3</td>
<td>Innovation management prioritization</td>
<td>CR= 0.063 is less than 0.1</td>
</tr>
<tr>
<td>4</td>
<td>Culture &amp; People Prioritization</td>
<td>CR= 0.095 is less than 0.1</td>
</tr>
</tbody>
</table>
Selection of best area of SCM by AHP

AHP is a problem-solving framework and flexible, systematic method employed to represent the elements of a complex problem. It is based on the three principles: decomposition, comparative judgment and synthesis of priorities. The general structure of AHP is shown in Figure 8. The characteristic of AHP is allowing both qualitative and quantitative attributes to be included to carry out evaluation. For each sub-criterion, ratings are necessary to provide a basis and ease for the comparison of the performance of a large number of companies to be evaluated. The priorities of criteria and sub-criteria are synthesized to establish the overall priorities for decision alternatives. AHP is a theory of measurement for dealing with tangible and intangible factors. The saty demonstrates the potential of AHP in supply chain development. The AHP-based approach is explained to Identify and prioritize logistics critical success factors (CSF) so as to evaluate the performance levels. Consequently, competitive advantage and disadvantage can then be highlighted for continuous improvement.

The AHP uses paired comparisons of objects with respect to a common goal or criteria. The end result of the AHP is a set of weights derived from the pair-wise comparisons. See the Appendix for the AHP instrument completed by the management-level employees of the participating companies. Each manager made two decisions when completing the AHP instrument:

1. Selecting the more important performance category for measuring and monitoring the company’s performance.
2. Recording the magnitude of importance the category selected has over the category not selected.
Thomas Saaty, the developer of the AHP, recommends a one-to-nine ratio scale when deciding between the two alternatives. A one-to-five ratio scale (Table 5) was used in this study. Using a different scale does not violate the theoretical foundation of the AHP as long as the scale used is a bounded ratio scale and the alternatives are homogeneous with respect to the scale both requirements are met in this study.

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
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<th>I</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td></td>
</tr>
<tr>
<td>2</td>
<td>SCM area</td>
<td>Composite/Comparison Matrix</td>
<td>Normalise Matrix</td>
<td>Priority Score</td>
<td>Consistency Score</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>3</td>
<td></td>
<td>Supp</td>
<td>Manuf</td>
<td>Cust</td>
<td>Supp</td>
<td>Manuf</td>
<td>Cust</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Supplier</td>
<td>1.000</td>
<td>1.500</td>
<td>3.000</td>
<td>0.500</td>
<td>0.474</td>
<td>0.545</td>
<td>0.506</td>
</tr>
<tr>
<td>5</td>
<td>Manufacturing</td>
<td>0.667</td>
<td>1.000</td>
<td>1.500</td>
<td>0.233</td>
<td>0.316</td>
<td>0.273</td>
<td>0.307</td>
</tr>
<tr>
<td>6</td>
<td>Customer</td>
<td>0.333</td>
<td>0.667</td>
<td>1.000</td>
<td>0.167</td>
<td>0.211</td>
<td>0.182</td>
<td>0.186</td>
</tr>
<tr>
<td>7</td>
<td>Sum</td>
<td>2.000</td>
<td>3.167</td>
<td>5.500</td>
<td>Consistency ratio = 0.008</td>
<td>Average = 3.009</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5, Best Area Prioritization in SCM by AHP
Quality Management in Supply Chain: A Case Study

Selection of Best Area in SCM of ABC Ltd

In this section, XYZ Ltd is analyzed to know the best area in supply chain, which has the best quality system. As XYZ Ltd is the leading two wheeler company and producing 35 lacks motorcycles per annum. The XYZ Ltd is technical collaborated with Japan and making wide range of motorcycles (100cc to 233cc) in 15 models with approximately 80 variants. More of XYZ Ltd has already been discussed in article 2.1.

AHP Calculation Using Microsoft Excel

There are five steps to do the AHP calculation for all factors. A Program can be made in excel sheet as per following steps

1. Enter pair-wise responses in Excel.
2. Calculate an Individual-level matrix.
3. Normalize the comparisons.
4. Calculate the performance score and consistency score.
5. Determine consistency ratio.

Step 1: Enter pair-wise responses in Excel

Entering the pair-wise responses of each manager in Excel in a matrix format is the first step. The Performance Pair-Wise Comparisons section of Figure 9 displays the matrix format for the performance AHP. The key to remember when entering the pair-wise comparisons are the assumption of reciprocity. For example, if the supplier performance category is evaluated as three times better quality management than the customer category, the reciprocity axiom states that the customer category is 1/3 times more important than the supplier category. The AHP matrix shown in Table 6 is designed to account for reciprocity by entering the reciprocal formula in the lower half of the matrix. When entering data in the upper half of the matrix, one must enter the preference denoted by the respondent (i.e., Pij, where i = column and j = row) or its reciprocal (i.e., Pji = 1/Pij). Notice that cell H4 represents the magnitude of supplier over manufacturing. Because the respondent indicates supplier is more 1.5 times better quality management than manufacturing, 1.5 is entered in cell E4, and Excel automatically places a “0.667” in cell G5, indicating manufacturing is 0.667 times bet-
Step 2: Calculate an Individual-level matrix
The objective of step two is to develop a single matrix from the individual respondents. This step is accomplished by taking the geometric mean across the respondents. The geometric mean is calculated for each cell across all of the individual matrices. The result is a single, composite matrix. Once an AHP matrix is completed as composite or comparison matrix, the normalize matrix is created. Figure 9 displays the composite matrix for all three companies.

Step 3: Normalize the Comparisons
Normalizing the pair-wise comparisons is accomplished with two procedures. Calculating the sum of each column is the first procedure (i.e., the formula for cell B7 in Table =SUM (B4:B6)). The formula for cell B7 is copied to cells C7 and D7. The next procedure involves dividing each entry in the matrix by its column sum (i.e., the formula for cell E4: =B4/B$7). The formula for cell E4 is copied to cells E5 to E6. And Complete column E4 to E6 to be copied to G4 to G6. Completing those two procedures creates the normalized comparison matrix as in Figure 9.

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
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</thead>
<tbody>
<tr>
<td>1</td>
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<td>2</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>SCM area</td>
<td>Composite/Comparison Matrix</td>
<td>Normalise Matrix</td>
<td>Priority Score</td>
<td>Consistency Score</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Supplier</td>
<td>Supp</td>
<td>Manuf</td>
<td>Cust</td>
<td>Supp</td>
<td>Manuf</td>
<td>Cust</td>
<td>Supp</td>
</tr>
<tr>
<td>5</td>
<td>Manufacturing</td>
<td>1.000</td>
<td>1.500</td>
<td>3.000</td>
<td>0.500</td>
<td>0.474</td>
<td>0.545</td>
<td>0.506</td>
</tr>
<tr>
<td>6</td>
<td>Customer</td>
<td>0.667</td>
<td>1.000</td>
<td>1.500</td>
<td>0.333</td>
<td>0.316</td>
<td>0.273</td>
<td>0.307</td>
</tr>
<tr>
<td>7</td>
<td>Sum</td>
<td>2.000</td>
<td>3.167</td>
<td>5.500</td>
<td>Consistency ratio = <strong>0.008</strong></td>
<td>Average = <strong>3.000</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure: 9, Best area prioritization in SCM for System and Techniques in Excel

Above calculation can be done by making a small program on Microsoft excel sheet as per Figure 10. Only rating is typed all the calculations will be done instantly and automatically.

Step 4: Calculate the Priority Score and Consistency Score
The average of each row in the normalized matrix is used as the Performance score for each decision alternative-supplier, manufacturing and customer (i.e., the formula for cell
Quality Management in Supply chain: A case study

H4 in above table = AVERAGE (E4:G4). That formula is copied to cells H5 to H6. The result is the performance score (relative importance weight) for each area of SCM for quality management in respect of system and techniques. The performance scores in table indicate that the respondent ranks supplier (0.506) has better system and techniques, followed in manufacturing (0.307) and customer (0.186). For Consistency score, the formula is =MMULT (B4:D4, $H$4:$H$6)/H4) or as per Figure 10 for cell I4 and this is to be copied in I5 to I6 for consistency score. Multiplying each alternative in the original matrix by the normalized scores and dividing the result by the respective normalized score calculates the consistency measure found in Figure 9. In other words, you multiply each row in the performance pair-wise comparison matrix by the performance scores, then divide the result by the respective performance score (i.e., the formula is to be used as per table for calculating consistency ratio). The formula is copied for manufacturing and customer. If the respondent is perfectly consistent, the consistency measure will equal the number of alternatives (i.e., three).

![Microsoft Excel - AHP](image)

**Formulas for Table 4.3.1**

<table>
<thead>
<tr>
<th>SCM area</th>
<th>Composite/Comparison Matrix</th>
<th>Normalize Matrix</th>
<th>Priority Score</th>
<th>Consistency Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplier</td>
<td>Supp 1.000 Rating</td>
<td>=B4/B7 =C4/C7 =D4/D7</td>
<td>=AVERAGE(B4:D4)</td>
<td>=H4<em>B4+H5</em>C4+H6*D4/H4</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>Supp =C4/C7</td>
<td>=B5/B7 =C5/C7 =D5/D7</td>
<td>=AVERAGE(B5:D5)</td>
<td>=H4<em>B5+H5</em>C5+H6*D5/H5</td>
</tr>
</tbody>
</table>

**Step 5: Determine Consistency Index and Consistency Ratio**

The final step in applying the AHP is determining the consistency of the results. The respondents should be consistent in their pair-wise comparisons. In other words, if the respondent considers supplier has system and techniques 1.5 times more than manufacturing, and supplier has three times more than customer then the respondent should consider manufacturing 1.5 times more than customer. If the results are not consistent, the scores should not be used. Figure 9 indicates the respondent was perfectly consistent. The performance scores can be treated as reasonably accurate. A consistency ratio is calculated to determine reasonable consistency. The consistency ratio is calculated as follows: Consistency ratio = CI / RI, where CI = Consistency Index = (lmax - n) / (n – 1) lmax = the average consistency measure for all alternatives n = the number of alterna-
tives. RI = the appropriate random index (0.58, when n = 3) from Figure 9. The formula for Consistency Ratio is: = (AVERAGE (I4:I6) -3)/ 2*0.58). The consistency ratio calculated shown in Figure 9 is 0.008. A consistency ratio of 0.10 or less is considered acceptable, so the performance scores calculated. And we can consider that supplier has better quality management is in respect of system and techniques.

Checking Consistency

\[
l_{\text{max}} = (3.014+3.008+3.005)/3 = 3.009
\]

Consistency index (CI) = \((l_{\text{max}} - n)/(n - 1) = (3.009-3)/2 = 0.004\)

Consistency Ratio (CR) = CI/RI = 0.004/0.58 = 0.008 is less than 0.1 means rating is acceptable

The Overall rating of all three areas are calculated and shown in Table 6. The supplier has the maximum rating i.e. 0.503. The supplier has the best quality management at supplier end in XYZ Ltd.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Criteria Priority</th>
<th>OEM Priority</th>
<th>Overall Priority of OEM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>1</td>
<td>0.115</td>
<td>0.506</td>
<td>0.307</td>
</tr>
<tr>
<td>2</td>
<td>0.101</td>
<td>0.404</td>
<td>0.329</td>
</tr>
<tr>
<td>3</td>
<td>0.109</td>
<td>0.411</td>
<td>0.328</td>
</tr>
<tr>
<td>4</td>
<td>0.291</td>
<td>0.544</td>
<td>0.243</td>
</tr>
<tr>
<td>5</td>
<td>0.115</td>
<td>0.524</td>
<td>0.261</td>
</tr>
<tr>
<td>6</td>
<td>0.147</td>
<td>0.406</td>
<td>0.369</td>
</tr>
<tr>
<td>7</td>
<td>0.122</td>
<td>0.665</td>
<td>0.231</td>
</tr>
<tr>
<td>Overall Best Area of SCM</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 7, Best area selection in SCM for Quality management,

Here
A = criteria Priority; B = Supplier; C = Manufacturing;
D = Customer; A*B = Supplier; A*C= Manufacturing;
A*D = Customer; 1 = System & Technique; 2 = Empowerment & Team; 3 = Innovation Management; 4 = Culture & People;
5 = Customer Focus; 6 = Measurement & Feed back; 7= Continues Improvement.

Conclusion

As the XYZ Ltd is facing tough competition due to others two wheeler OEMs are continuously reducing price of their product and doing proliferation in product. To be remained most competitive the two wheeler manufacturer is giving priorities in cultural and people development and measurement and feed back to reduce product cost and enhance quality. For staying in competitive market an organization must have continuous improvement throughout the organization with innovative plan to improve its supply chain. This study
has demonstrated that even an automotive OEM organization, facing tough competitions due to globalization of markets and can maintain good quality management at supplier end. For this it is essential that organizations should not target only end results but should develop its quality system in all area of supply chain. The cultural & people and measurement & feedback are the two factors prioritized i.e. 0.291 and 0.147 respectively in AHP calculation which makes a supply chain and quality management best integration. Any OEM can have best quality management in supply chain by enhancing the people culture and measurement & feedback system. A crucial element in the formulation of any business strategy to build people culture is having the right information about the industry and the environment, at the right time. In a competitive industry, this translates into having access to reliable and actionable information about competitors, as well as the competitive environment in the industry, including information about competitors. XYZ Ltd has greatly improved its quality management in supply chain and best at supplier and can be a role model for other area of supply chain in companies. However, “quality management” is a journey and continuous improvement and not a destination. XYZ Ltd has still a long way to go. As XYZ Ltd moves up in the value chain and targets foreign markets, it will have to identify new factors of quality management in supply chain, and acquire and build appropriate competencies.

References
Quality Management in Supply chain: A case study


Digital Image Acquisition and Processing In Medical X-Ray Imaging

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Department of Electronics & Communication Engineering
Geeta Institute of Management and Technology, Kanipla
Samalkha Group Of Institutions, Samalkha

Abstract
The techniques of digital image processing have found a myriad of applications in diverse fields of scientific, commercial, and technical endeavour. Image-processing operations can be grouped into three categories: Image Rectification and Restoration, Enhancement and Information Extraction. The former deals with initial processing of raw image data to correct for geometric distortion, to calibrate the data radio metrically and to eliminate noise present in the data. The enhancement procedures are applied to image data in order to effectively display the data for subsequent visual interpretation. It involves techniques for increasing the visual distinction between features in a scene. The objective of the information extraction operations is to replace visual analysis of the image data with quantitative techniques for automating the identification of features in a scene. This involves the analysis of multispectral image data and the application of statistically based decision rules for determining the land cover identity of each pixel in an image.

Introduction
An image may be defined as a two-dimensional function, where x and y are spatial coordinates, and the amplitude of at any pair of coordinates is called the intensity or gray level of the image at that point. When x, y, and the amplitude values of are all finite, discrete quantities, we call the image a digital image. The field of digital image processing refers to processing digital images by means of a digital computer. Note that a digital image is composed of a finite number of elements, each of which has a particular location and value. These elements are referred to as picture elements, image elements, peels, and pixels. Pixel is the term most widely used to denote the elements of a digital image.

Vision is the most advanced of our senses, so it is not surprising that images play the single most important role in human perception. However, unlike humans, who are limited to the visual band of the electromagnetic (EM) spectrum, imaging machines cover almost the entire EM spectrum, ranging from gamma to radio waves. They can operate also on images generated by sources that humans are not accustomed to associating with images. These include ultrasound, electron microscopy, and computer-generated images. Thus, digital image processing encompasses a wide and varied field of applications. There is no general agreement among authors regarding where image processing stops and other related areas, such as image analysis and computer vision, start. Sometimes a distinction is made by defining image processing as a discipline in which both the input
Digital Image Acquisition and Processing In Medical X-Ray Imaging

and output of a process are images. There are no clear-cut boundaries in the continuum from image processing at one end to computer vision at the other. However, one useful paradigm is to consider three types of computerized processes in this continuum: low-, mid-, and high-level processes. Low-level processes involve primitive operations such as image pre-processing to reduce noise, contrast enhancement, and image sharpening. A low-level process is characterized by the fact that both its inputs and outputs are images. Mid-level processes on images involve tasks such as segmentation (partitioning an image into regions or objects), description of those objects to reduce them to a form suitable for computer processing, and classification (recognition) of individual objects. A mid-level process is characterized by the fact that its inputs generally are images, but its outputs are attributes extracted from those images (e.g., edges, contours, and the identity of individual objects). Finally, higher-level processing involves “making sense” of an ensemble of recognized objects, as in image analysis, and, at the far end of the continuum, performing the cognitive functions normally associated with human vision.

Imaging Challenges
Radiology and fluoroscopy applications present several challenging machine vision requirements. One is the need to acquire and process in real time huge sequences of hundreds of images so that doctors can review them on the fly, a task that is not easily accomplished by many vision systems. In Digital Subtraction Angiography (DSA), for example, the difference between the acquired image and a reference image is displayed on-screen so that doctors can trace the path of the contrast media in the vessels. As the original images are being processed, they must also be stored simultaneously to the system’s hard disk. The ability to select and apply in real time the look up tables necessary to enhance all image features relevant from the radiologist’s point of view is also crucial to these applications, says Ciro Rebuffat, Software Development Manager at Italray. “In these types of radiology applications, images are typically acquired with a 12-bit CCD camera,” Rebuffat explains. “A different LUT is needed, depending not only on exam typology but also on image content, to accurately convert these 12 bits to 8 bits for accurate image display.”
Medical Imaging
Medical imaging refers to the techniques and processes used to create images of the human body (or parts thereof) for clinical purposes (medical procedures seeking to reveal, diagnose or examine disease) or medical science (including the study of normal anatomy and physiology). As a discipline and in its widest sense, it is part of biological imaging and incorporates radiology (in the wider sense), radiological sciences, endoscopy, (medical) thermograph, medical photography and microscopy (e.g. for human pathological investigations). Measurement and recording techniques which are not primarily designed to produce images, such as electroencephalography (EEG) and magneto encephalography (MEG) and others, but which produce data susceptible to be represented as maps (i.e. containing positional information), can be seen as forms of medical imaging. Medical imaging is often perceived to designate the set of techniques that noninvasively produce images of the internal aspect of the body. In this restricted sense, medical imaging can be seen as the solution of mathematical inverse problems. This means that cause (the properties of living tissue) is inferred from effect (the observed signal). In the case of ultrasonography the probe consists of ultrasonic pressure waves and echoes inside the tissue show the internal structure. In the case of projection radiography, the probe is X-ray radiation which is absorbed at different rates in different tissue types such as bone, muscle and fat.

X-Ray Imaging
Advantages of digital imaging over conventional analog methods include the possibility to archive and transmit images in digital information systems as well as to digitally process pictures before display, for example, to enhance low contrast details. After reviewing two digital x-ray radiography systems for the capture of still x-ray images, we examine the real time acquisition of dynamic x-ray images (x-ray fluoroscopy). As digital image
Digital Image Acquisition and Processing In Medical X-Ray Imaging

quality is predominantly determined by the relation of signal and noise, aspects of signal transfer, noise, and noise-related quality measures like detective quantum efficiency feature. A key feature of digital imaging is the inherent separation of image acquisition and display. Whereas analog screen/film combinations use film as a medium for both image recording and viewing, digitally acquired images can be processed in order to correct accidental over- or underexposure, or to enhance diagnostically relevant information before display. Also, digital images can be stored and transmitted via picture archiving and communication systems (PACS), and be presented on different output devices, like film printers or cathode ray tube (CRT) monitors (softcopy view). The separation of image acquisition and display in a digital system is illustrated by comparing analog and digital acquisition of single high resolution projection images (x-ray radiography). The principle of the imaging setup is that radiations are passed through the patient before exposing a detector. Widely used for image detection are analog screen/film combinations which consist of a film sheet sandwiched between thin phosphor intensifying screens. The phosphor screens convert the incoming x radiation into visible light blackening the film, which, after developing, is examined by viewing on a light box. Well-established digital alternatives include storage phosphor systems (SPS), also known as computed radiography (CR) systems, and a selenium-detector based digital chest radiography system [(DCS), “Thoravision”]. In CR systems, the image receptor is a photo stimulable phosphor plate, which absorbs and stores a significant portion of the incoming x-ray energy by trapping electrons and holes in elevated energy states. The stored energy pattern can be read out by scanning the plate with a laser beam. The emitted luminescence is detected by a photomultiplier and subsequently digitized. Common plate sizes are 35x35 cm² sampled by a 1760x1760 matrix, 24x30 cm² sampled by a 7576x1976 matrix, and for high resolutions 18x24 cm² sampled by a 1770x2370 matrix. The resulting Nyquist frequencies are between 2.5 and 5 lp/mm. The detector of a DCS consists of an amorphous selenium layer evaporated onto a cylindrical aluminium drum. Exposure of the drum to x radiation generates an electrostatic charge image, which is read out by electrometer sensors. Maximum size of the sampled image matrix is 2166 x2448 pixels, with a Nyquist frequency of 2.7lp/mm. In analog as well as in digital systems, the acquired radiographs are degraded by no ideal system properties. These include limitations of contrast and resolution, and are described for instance by the modulation transfer function (MTF). Other undesired effects are spatially varying detector sensitivity and unwanted offsets. Additional degradations can be introduced by accidental over- or underexposed-sure. Unlike screen/film systems, however, digital systems enable the compensation of such known degradations by suitable processing like gain and offset correction and MTF restoration. Furthermore, the problem of over- or underexposures is virtually eliminated by the wide latitude of the SPS and DCS image receptors (about four orders of magnitude) and the possibility to digitally adjust the displayed intensity range. Finally, methods like “unsharp masking” and “harmonization” can be employed to enhance relevant detail with respect to diagnostically less important information, and to optimize image presentation on the selected output device. An imaging-inherent oasis ourcei s the discrete nature of x radiation, generating so-called x-ray quantum noise in the acquired images. This type
of noise is particularly relevant for images recorded with very low x-radiation doses, and affects both analog and digital imaging systems. Clearly, noise introduced within the imaging system during later processing stages, e.g., quantization noise during analog-to-digital (A/D) conversion, can further deteriorate the imaging performance.

**X-Ray Image Detection**

An x-ray tube generates x radiation by accelerating electrons in an electric field towards a tungsten anode. On hitting the anode, about 1% of the electrons generate x-ray quanta, which leave the tube through an x-ray transparent window. The x-ray beam consists of a discrete number of x-ray quanta of varying energy, with the maximum energy being limited by the applied tube voltage. Typical values for the tube voltage range between 60 and 150 kV. The energy distribution of the x-ray quanta determines the beam quality. A thin aluminium plate about 3 mm thick, which absorbs low-energy x-ray quanta unable to pass through the patient, is integrated directly into the tube window. A real detector absorbs only a fraction of the incoming x-ray quanta given by the detector absorption efficiency.

**Digital X-Ray Fluoroscopy**

X-ray fluoroscopy is a real time dynamic x-ray imaging modality which allows a physician to monitor on-line clinical procedures like catheterization or injection of contrast agents. Today’s detection front ends consist of an x-ray image intensifier- (XRII) coupled by a tandem lens to a TV camera, which is followed by an A/D converter (Fig). The XRII is a vacuum tube containing an enhance screen attached directly to a photocathode, an electron optics, and a phosphor screen output window. Images are detected by a fluorescent caesium iodide (CsI) layer on the entrance screen, which converts the incoming x-ray quanta into visible photons, which in turn reach the photocathode. The CsI screen is a layer approximately 400 μm thick and evaporated onto an aluminium substrate. The absorption of these creensis about 60%-70%. The generated photoelectrons are accelerated when passing through the electron optics and focused onto the output window, where they generate luminescence photons. The resulting visible pictures are then picked up by the camera. The diameter of the circular XRII entrance screen ranges between 15 and 40 cm, depending on the application, while the diameter of the XRII output window is between 25 and 50 mm. Apart from image intensification, the electron optics allow demagnification, and zooming by projecting a small subfield of the entrance screen onto the output window. To pick up the images from the XRII output window, electronic camera tubes like plumb icons, vidicons or sati cons are still in wide use today. In Europe, camera readout is mostly with 625 lines/image, with the full frame rate of 25 images per second in interlaced or progressive format. However, special high resolution modes (1250 lines/image) are also often available. In applications where temporal resolution is less critical, the frame rate can be reduced down to only a single image per second (low frame rate pulsed fluoroscopy) in order to save x-ray dose. The analog video signal is then amplified and fed to an 8 bit-10 bit A./D converter. In case of digitization by 8 bit,
the gain of the amplifier is higher for smaller signal amplitudes than for larger ones in order to enhance dark parts of the images. This is commonly referred to as analog white compression.

**Main Sources of Noise in X-Ray Fluoroscopy**

**A. System internal noise**

System-internal noise sources include so-called fixed pattern noise, and signal shot noise. Fixed pattern noise is mainly caused by inhomogeneities of the XRII output screen, which are stable over time. Signal shot noise is generated by the discrete nature of the conversion of information carriers, e.g., from luminescence photons into electrons in the XRII photocathode and the camera. As the power spectrum of signal shot noise is approximately flat, while the spectrum of quantum noise is low pass shaped, shot noise can affect the SNR and the DQE mostly for high spatial frequencies. Still, signal shot noise is often negligible compared to x-ray quantum noise.

**B. Noise in Camera Tubes**

The visible images are projected from the XRII output window onto the photoconductive target layer of the camera tube, which for plumb icons, consists of lead oxide (PbO). The resulting electrostatic charge image is then read out by scanning the target layer line wise with an electron beam (scanned device). Line-by-line scanning means that sampling in the vertical direction is carried out directly on the photoconductive target, with the size of the electron beam spot being sufficiently large to prevent alias. Horizontal sampling is done later at the A/D converter. Unavoidable capacitances of the target layer itself as well as of the subsequent first amplifier stage act as a low pass filter, which attenuates high frequency signal components. This attenuation has to be compensated by a high pass-like transfer function of the amplifier, which, however, also amplifies high-frequency components of originally white electronic noise.

**Enhancing Image using Digital Signal Processing**

To achieve optimal detector performance, it is necessary to compensate fixed pattern effects like variations in offset and gain of the sensor elements by suitable digital processing. An additional effect which should be connected digitally is the memory effect, which denotes the remaining of an undesired residual image after image readout. This is caused by the incomplete flowing off of electrons from the photodiodes. One possibility to reduce quantum noise in the observed images is by appropriate digital noise filtering. In full frame rate fluoroscopy with 25 or more images per second, this can be done by, recursive temporal averaging, what can be interpreted as digitally introducing an intended lag. To prevent blurring of moving objects, filtering is reduced or switched off entirely in areas where object motion is detected (motion adaptive filtering). For low frame rate fluoroscopy, however, temporal filtering is often not feasible, so that the only option which remains is spatial filtering within single images. Starting with a decomposition of the input images into overlapping blocks which are subjected to a standard block transform.
Digital Image Acquisition and Processing In Medical X-Ray Imaging

[discrete Fourier transform (DFT) or discrete cosine transform (DCT)], the central idea is to compare each transform coefficient to the corresponding “noise only” expectation, i.e., to its counterpart from the NPS. Each coefficient is then attenuated depending on how likely it is that it contains only noise’. The purpose of the block decomposition is to make the filter algorithm adaptive to small image detail as well as to nonstationarities of noise.

X-Ray Phase Imaging for Medical Applications

X-ray radiographic absorption imaging is an invaluable tool in medical diagnostics and materials science. For biological tissue samples, polymers, or fiber composites, however, the use of conventional X-ray radiography is limited due to their weak absorption. This is resolved at highly brilliant X-ray synchrotron or micro-focus sources by using phase-sensitive imaging methods to improve contrast. The requirements of the illuminating radiation mean, however, that hard x-ray phase-sensitive imaging has until now been impractical with more readily available x-ray sources, such as x-ray tubes. The aim of this project is to develop a method suitable for phase contrast imaging with conventional x-ray tubes. In conventional x-ray imaging, contrast is obtained through the differences in the absorption cross section of the constituents of the object. The technique yields excellent results where highly absorbing structures, e.g., bones, are embedded in a matrix of relatively weakly absorbing material, e.g., the surrounding tissue of the human body. However, in those cases where different forms of tissue with similar absorption cross-sections are under investigation (e.g., mammography or angiography), the x-ray absorption contrast is relatively poor. Consequently, differentiating pathologic from non-pathologic tissue from an absorption radiograph obtained with a current hospital-based x-ray system still remains practically impossible for certain tissue compositions.

Figure2. X-RAY Phase Imaging
X-Ray Instruments, Medical Imaging and Irradiations

A. The X-Ray Reflect meter Description

The X-ray reflect meter is a Analytical Expert Pro instrument. The instrument is capable of measuring reflectivity at air-solid or air-liquid interfaces. The X-ray reflectometry method provides information complementary to that from neutron reflectometry which is available at OPAL. The X-ray reflectometry is used for research on thin-films and surfaces by the Australian scientific and industrial communities. The sample geometry is horizontal with (specular reflectivity) taking place in the vertical plane. It is suitable for the study of air-solid and air-liquid interfaces (i.e. horizontal surfaces). The X-ray reflect meter is equipped with a Cu tube source with parallel beam optics, motorised beam defining slits, an automatic beam attenuator, a “De Wolf” beam knife and a Xe scintillate detector (capable of >106cps). Solid samples will be mounted on a motorised XYZ, Phi sample stage while a motorised Huber stage will be employed for liquid studies.

B. Applications

X-ray reflectometry is used to probe the structure of surfaces, thin-films or buried interfaces as well as processes occurring at surfaces and interfaces such as adsorption, adhesion and interdiffusion. In particular, recent years have seen an explosion of interest in the biosciences as well as the emerging field of nanotechnology. Applications cover photosensitive films, electrochemical and catalytic interfaces, surfactant layers, polymer coatings and biological membranes. The increasing importance of hybrid materials, the properties of which are determined by their interfaces and the rapid development in the field of thin film technology provides a strong demand for x-ray reflectometry.

Figure 3. Schematic of the X-ray Reflect meter

A New Real-Time X-Ray Technology for Inspecting Critical Medical Devices

Real-time X-ray inspection has gained worldwide use as a rapid and effective tool for quality assurance in highly technical industries such as electronic circuit manufacturing. However, it has not yet been as widely used in medical device manufacturing, for two
primary reasons: the material characteristics of medical devices and the limitations of traditional real-time X-ray detectors. Many critical medical devices are fabricated from rubbers, plastics and ceramics, materials that have low X-ray absorption and consequently do not lend themselves to most real-time X-ray inspection methods. These materials must be X-ray imaged with low settings of the X-ray tube anode voltage, in order to obtain X-ray absorption that is sufficient to yield a satisfactory X-ray image. The real-time X-ray imaging detectors that have been available to date do not respond to these low voltages, in either resolution or gray scale accuracy, particularly when the devices being inspected are placed in close proximity to the detector. Film-based X-ray imaging systems do have the accuracy required, but have been precluded from use because of the time required to obtain an X-ray film image.

**Real-Time X-Ray Detectors**

Real-time or fluoroscopic X-ray inspection systems are found extensively in a number of applications, including food processing, mail security and electronic component quality Assurance. In each case, the types of detectors used fall into one of three categories: caesium iodide image intensifiers, linear array detectors or flat panel detectors. Because the intrinsic resolution of these detectors is relatively low, they require geometric magnification (positioning the device close to the x-ray source) to see fine details. Additionally, these detectors do not image well at the lower voltages necessary to inspect materials with low radiographic density, such as those frequently used in medical device fabrication. This is most likely the reason that medical device manufacturers have not readily adopted real-time X-ray inspection as part of their quality assurance programs.

**Conclusion**

The field of medical x-ray image acquisition and processing by digital techniques, some of which are already well established, while others are presently emerging. By first comparing digital radiography systems to analogue ones, it was shown that a key advantage of digital imaging lies in the inherent separation of image acquisition and display media, which enables one to digitally restore and enhance acquired images before they are displayed. It turned out that the amount of restoration and enhancement which can be applied is fundamentally limited by noise. The performance of digital imaging systems was therefore characterized by the signal-to-noise ratio and related measures. Expressing the SNR in terms of x-ray quantum flow resulted in the two principal performance measures, viz., noise equivalent quanta (NEQ and detective quantum efficiency (DQE). Essentially, the measures quantify how effectively the incoming quantum flow is exploited by an imaging system at different spatial frequencies.

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Abstract
XML is being adopted widely for a variety of applications and types of content. It is also forming the basis for distributed system protocols to integrate applications across the Internet, such as Web Services protocols. XML languages are text based and designed to be extended and combined. It should be natural to provide integrity, confidentiality and other security benefits to entire XML documents or portions of these documents in a way that does not prevent further processing by standard XML tools. XML Security therefore must be integrated with XML in such a way as to maintain the advantages and capabilities of XML while adding necessary security capabilities. This is especially important in XML-based protocols, such as XML Protocol (XMLProt, Simple Object Access Protocol, SOAP), that are explicitly designed to allow intermediary processing and modification of messages.

How XML Security is different
Transport Layer Security (TLS) is the de facto standard for secure communication over the Internet. TLS is an end-to-end security protocol that follows the famous Secure Socket Layer (SSL). SSL was originally designed by Netscape, and its version 3.0 was later adapted by the Internet Engineering Task Force (IETF) while they were designing TLS. This is a very secure and reliable protocol that provides end-to-end security sessions between two parties. XML Encryption is not intended to replace or supersede SSL/TLS. Rather, it provides a mechanism for security encrypting part of the data being exchanged that is not covered by SSL. With XML Encryption, each party can maintain secure or insecure states with any of the communicating parties. Both secure and non-secure data can be exchanged in the same document. For example, think of a secure chat application containing a number of chat rooms with several people in each room. XML-encrypted files can be exchanged between chatting partners so that data intended for one room will not be visible to other rooms.
XML Encryption can handle both XML and non-XML (e.g. binary) data. We’ll now demonstrate a simple exchange of data, making it secure through XML Encryption. We’ll then slowly increase the complexity of the security requirements and explain the XML Encryption schema and the use of its different elements.
XML Encryption example

<table>
<thead>
<tr>
<th>Before:</th>
<th>After CreditCard data is encrypted:</th>
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<tr>
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<td><code>&lt;FName&gt;</code></td>
</tr>
<tr>
<td>Sanjay</td>
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<tr>
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<td><code>&lt;LName&gt;</code></td>
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<tr>
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<td>Sharma</td>
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<tr>
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Security Requirements

Security is vital to online business. Technologies designed to meet security requirements have evolved, but the requirements have remained relatively constant. These requirements include Authentication, Authorization, Integrity, Signature, Confidentiality, Privacy and Digital Rights Management and are briefly summarized below:

Authentication - Who is it?
Determine the identity or role of a party attempting to perform some action such as accessing a resource or participating in a transaction. A role may be appropriate to many parties, for example “Human Resources Person”.

Authorization - What can they do?
Determine whether some party is allowed to perform a requested action, such as viewing a web page, changing a password, or committing an organization to a 10 million dollar transaction.

Integrity - Ensure that information is intact
Ensure that information is not changed, either due to malicious intent or by accident. This may be information transmitted over a network, such as from a web browser to a web server, information stored in a database or file system, or information passed in a web services message and processed by intermediaries, to give a few examples.

Signature - Create and verify electronic signatures analogous to handwritten signatures
XML Security

Produce or verify an electronic signature intended to be the equivalent of a handwritten signature. Such a signature may be used for different purposes such as approval, confirmation of receipt, acceptance or agreement.

Confidentiality - Make content unreadable by unauthorized parties
Ensure that content may only be viewed by legitimate parties, even if other access control mechanisms are bypassed. Confidentiality is generally associated with encryption technologies, although other approaches such as steganography (information hiding) might serve a similar purpose.

Privacy - Limit access and use of individually identifiable information.
Personally identifiable information is required by individuals and companies in order to perform services for the individual. An example is a Doctor’s office that requires medical records to track a patient’s health. Privacy relates to control over what is done with this information and whether it is redistributed to others without the individual’s knowledge or consent. Privacy may be managed by a combination of technical and legal means. Confidentiality technology may be used to protect privacy, but cannot prevent inappropriate sharing of information.

Digital Rights Management - Limit use and sharing of content according to license agreements
Ensure that content is used according to license agreements. Generally access rules are incorporated with the content, and enforcement controls are integrated with the clients needed to use the content.

Core XML Security Standards
XML Security Standards developed by W3C and OASIS is the definition of meta-data to protect XML documents and elements. The following standards have been evaluated regarding access control, rights management and communication protection preparing the development of XML Security Services. The core XML Security standards are:
1. XML Digital Signature: For integrity and signatures.
2. XML Encryption: For confidentiality.
3. XML Key Management (XKMS): For key management,

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LabVIEW and its Features

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Thapar University Patiala

Abstract
Laboratory Virtual Instrument Engineering Workbench (LabVIEW) is a graphical programming language platform from National Instruments. It is a program development application, much like C, C++ or FORTRAN, however, is different from those languages in the sense that LabVIEW uses a graphical programming language, G, to create programs in block diagram form, while other programming languages use text-based instructions to create lines of code. In this paper, LabVIEW, its features have been discussed.

Introduction
LabVIEW is a graphical programming language that uses icons instead of lines of text to create different applications. In contrast to text-based programming languages, LabVIEW uses dataflow programming, where the flow of data through the nodes on the block diagram determines the execution order of the program. It is an interactive program development and execution system designed specifically for scientists and engineers. Originally released for the Apple Macintosh in 1986 [1], LabVIEW is used for data acquisition, instrument control, and industrial automation on a variety of platforms including Microsoft Windows, UNIX, Linux, and Mac OS. LabVIEW can create programs that run on above platforms, as well as on Microsoft Pocket PC, Microsoft Windows CE, and a variety of embedded platforms, including Field Programmable Gate Arrays, Digital Signal Processors, and microprocessors [2]. The latest version of LabVIEW is version LabVIEW 2011 [1,3]. LabVIEW language has a tremendous collection of libraries and structures that have been introduced and improved over the past 25 years or so [1,3]. LabVIEW programs are known as virtual instruments. Each virtual instrument like most of the conventional instruments consists of [4,5]

(i) Front Panel
(ii) Block diagram
(iii) Icon and connector

Front panel
The front panel simulates the front panel of a physical instrument [6]. The front panel consists of Numeric & Boolean controls, LEDs (square or round), Knobs, waveform graphs and charts, Strings & arrays etc.. The controls and indicators pass the data to the block diagram and receive the data from the block diagram for the display purpose respectively. All the controls and indicators are available in a special pallet known as control pallet. Figure 1 shows the Front panel of a virtual instrument.
Corresponding to every object on the front panel there is an icon on the block diagram.

**Block Diagram**

Block diagram is the brain of the virtual instruments. It consists of the actual executable code. In other words block diagram determine what functions the virtual instrument will perform. On the block diagram one can perform the different loops, case structures, arithmetic or logical operations etc. As mentioned earlier front panel objects have corresponding terminals on the block diagram so data can pass from user to the program and back to the user. The Block Diagram of the virtual instrument is shown in Figure 2.
**Icon and Connector**
For using a VI as a SUBVI i.e. for using the VI in the block diagram of another VI, it must have an icon and a connector. Icon is the VI’s pictorial representation while connector defines the inputs and outputs of VI to pass the values of different parameters and to receive the values of output parameters from SUBVI.

**Features of LabVIEW**
The following are the key elements of the LabVIEW development platform:

**Point- and Click Approach**
The point-and-click approach used in LabVIEW reduces the time it takes to get from initial setup to a final solution [3]. LabVIEW is a graphical programming language environment. Because graphical representations are a more natural design notation than text-based code so this process of applications development reduces the learning curve. One can access the different front panel objects, available in the control pallet and different functions, available in the function pallet of LabVIEW to develop an application.

**Dataflow Programming**
LabVIEW uses the dataflow programming [3,7]. In this type of programming a particular node or point will fire (gives output) whenever data is available at all its input terminals irrespective of its place and position. In this way the data is passed from one block to the next, eventually defining the execution order and functionality of the entire application. Dataflow is comparable in nature to reading a flow chart.

**Modularity**
Modularity refers to both the tightness of coupling between components, and the degree to which the “rules” of the system architecture enable (or prohibit) the mixing and matching of components [8]. LabVIEW encourages modularity and reuse of code. Users create VIs, with a graphical front panel that displays the inputs and outputs of the functional code as graphical controls and indicators. The users can easily plug these VIs (known as subVIs) into other VIs, allowing for modular, hierarchical code that enables users to gradually build up complex systems. There is no limit to the number of SubVIs that can be used in an application [3].

**Debugging**
Debugging in LabVIEW is easy and interactive. It contains all features of traditional programming languages, such as breakpoints, step over, step into, step out of, and so on. LabVIEW also contains an unique debugging tool know as bulb in which the user can visualize data within the algorithms. However, this tool will slow down the speed of operation [3].
Interactive Execution and Flexibility
The LabVIEW language is interactive and flexible in nature. The users can easily experiment with different available functions during the development stage and one can easily change the shape, size, color etc. of the available icons as per its requirement [3].

Applications of LabVIEW
LabVIEW finds extensive applications in the many areas of life. Some of these are

<table>
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<th>(i)</th>
<th>Instrumentation &amp; control</th>
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<td>- Acquiring and processing the data</td>
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<td>- Test and validation</td>
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<td>- Analysis of signals</td>
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<td>- Monitoring and control</td>
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<td>Dimensional measurement</td>
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<td>Speech processing &amp; recognition</td>
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<td>Palmprint authentication</td>
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<td>Hand geometry authentication</td>
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<th>(iv)</th>
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<td>ECG monitoring and analysis</td>
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<td></td>
<td>EEG monitoring and analysis</td>
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<td></td>
<td>Blood flow measurement</td>
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<td>Pressure Measurements</td>
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Apart from the above mentioned applications the LabVIEW finds applications in chemical engineering, Mechanical engineering, Civil engineering etc..

Advantages of LabVIEW
The following are the main advantages of LabVIEW

(i) LabVIEW can work on many platforms such as Microsoft Windows, UNIX, Linux, and Mac OS etc.[9] while most of the other systems use windows only.

(ii) It is very much easy to work with LabVIEW. Even people with limited coding experience can write programs and deploy test solutions in a small time frame when compared to more conventional systems [10].
LabVIEW and its Features

(iii) With LabVIEW it is very easy to program different tasks that can be performed in parallel by means of multithreading [1].

(iv) LabVIEW has many built in libraries with a large number of functions for data acquisition, signal generation, mathematics, statistics, signal conditioning, analysis, etc.[10].

(v) LabVIEW consists of a text-based programming component called MathScript which can be integrated with graphical programming using “script nodes” and can use .m file script syntax [11].

Conclusion
In this paper, Laboratory Virtual Instrument Engineering Workbench (LabVIEW) which is a graphical programming language environment has been discussed. In this paper, different features of LabVIEW, some of its applications and advantage have also been included. From the above discussion it is clear that LabVIEW has many good features which make it a versatile feature for its use in many engineering applications.

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Analysis of Data Security Level by using Multiple Keys

Ajay Kakkar,
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Abstract
Secured data transmission involves encryption algorithm and multiple keys. The management of keys is a vital process; it needs to be optimized in order to achieve reliable data communication between two parties. Otherwise, faulty keys always congestion and at the same time they also consume more power, definitely the heat dissipation is also very high. In this paper, the heat dissipation has been evaluated by the using Fuzzy Interference System (FIS).

Key words: Encryption, keys, FIS, Heat Dissipation.

Introduction
The security of the cryptographic model has been analyzed on the basis of the encryption algorithm and the key management scheme. Each encryption algorithms has its own characteristics; e.g.; one algorithm provides security at the cost of hardware, other is more reliable but uses large number of keys, another takes more processing time. For an optimized model the combination of data and key length must be selected in such a way that it will not cause congestion and inaccurate results in encryption and decryption process. It has been observed that the encryption algorithm is the building block of cryptography; S-Boxes are used to generate, select and process the keys for the encryption of data at various nodes. There is also few performance measures are present for a cryptographic model such as (i) CPU time required by a machine for a given processing speed to generate the key, (ii) Number of user accommodated by the model, (iii) Time required by the model to recover the data in case of key failure, and Power Consumption and heat dissipation. The powerful processors consume more power in the key generation process and dissipate more heat, as a result node capacitance, charge sharing and leakage current exists in the model [5, 7-8]. These parameters are responsible for the loss of data and cause node failure.

Related work
Martin E. Hellman [1] discussed that the error occurred in the encryption process causes a serious delay in cryptographic scheme. It was also stated that the need of data compression would be required in near future due to the increase in users. R.L. Rivest et. al. [2] proposed a method for obtaining digital signatures and public key cryptosystems. They assumed that the deciphering function for the received message in order to obtain the original message was known to receiver. If key size was increased then hacker required more number of attacks in order to get an access of the data, hence it took more time to recover the data. The detail of time required to decrypt the data from a pool with random
keys is shown in table 1

<table>
<thead>
<tr>
<th>Digits</th>
<th>Number of operations</th>
<th>Time</th>
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<tbody>
<tr>
<td>50</td>
<td>1.4 * 1010</td>
<td>3.9 hours</td>
</tr>
<tr>
<td>75</td>
<td>9.0 * 1012</td>
<td>104 days</td>
</tr>
<tr>
<td>100</td>
<td>2.3 * 1015</td>
<td>74 years</td>
</tr>
<tr>
<td>200</td>
<td>1.2 * 1023</td>
<td>3.8* 1009 years</td>
</tr>
<tr>
<td>300</td>
<td>1.5 * 1029</td>
<td>4.9* 1015 years</td>
</tr>
<tr>
<td>500</td>
<td>1.3 * 1039</td>
<td>4.2* 1025 years</td>
</tr>
</tbody>
</table>

Table 1: key size, number of operations and time required by the hacker to break the system

M, Naor et al. [3] proposed an idea that by knowing the information about power, radiation and data/key length hacker can be able to break the cryptographic model. Their model was not so much compatible with the multiple keys having different failure rates. S .K. Lee et. al. [4] presented hierarchical approach to resolve multiple failures at the multi-node network (MN). The key combination in lower classes was weak; therefore, the higher level keys which were derived from lower classes remained unreliable. Yuh-Min Tseng [6] presented a heterogeneous network aided by public-key management scheme used to encrypt the data in mobile adhoc networks. In order to reduce the overheads only few nodes were forced to share the certificate authority before constructing the network which was the main limitation of the work.

The following observations have been drawn from the related work

- The encryption algorithms which are based upon large number of round functions are not suitable to generate multiple keys due to various overheads.
- The keys used by the higher classes are derived from lower classes; therefore, the reliability of higher level keys depends upon the lower level keys.
- Power consumption and heat losses are more in case of multiple keys and they go on increasing in key length increases.

**Simulation Results**

By keeping the utility of multiple keys in the mind, the FIS has been used to forecast the heat dissipation. It has two inputs (key and data length) and one output has been designed and shown in figure 1. Key length has five categories which are named as: Very Short (VS), Short (S), Normal (N), Long (L) and Very Long (L). Similarly, the second input has eight categories which are named as: Very Short (VS), Short (S), Below Normal (BN), Moderately Normal (MN), Normal (N), Above Normal (AN), Long (L) and Very Long (L). These inputs are processed by using Mamdani’s model to forecast the heat dissipation at various nodes of the model. Triangular membership functions have been used due to easiness and eight different categories for the forecasted heat dissipation have been made named as: Very Low, Low, Subnormal, Moderately Normal, Normal, Above Normal, High and Very High.
Figure 1: Mamdani’s model for Heat Dissipation
When 16 bit data length is encrypted with 16 bit key length then the heat dissipation (2.71*10^3 mW) has been observed. The cryptographic model is little bit secured because the data length is equal to the key length. If the data length is further increased, the model consumes more power and dissipates more heat. At the same time the security level also falls due to fact that the encryption of large data length sequence with short key length. In figure 3, the encryption of 512 data sequence has been carried out with 16 bit key and the model dissipates 3.02*10^3 mW amount of heat.
The cryptographic model does not able to provide security against the attacks generated by the hacker; therefore, it is highly essential to create a model in which long key length is used to encrypt the short data length sequence. In figure 4, the short data length sequence (8 bit) has been encrypted with 32 bit key length, this combination provides more secured model and the heat dissipation (2.65*10³mW) is also manageable.
Conclusions and Future Scope
Correct key combination with data provide more secured system and reduce the processing and hacking time; as a result the better secured model has been achieved. The heat dissipation always increases if there is increase in the data length. For better security level, the 32 bit key length has been used to encrypt the 8 bit data length. Further increase key length also provide more secured model but at the cost of overheads.

References
in GMPLS Networks” Proceedings of 31st International Conference on Parallel Processing Workshops (ICW ’02), 2002, pp. 177-182.


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