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Editorial

It is a matter of both honor and pleasure for us to put forth the seventh issue of BIJIT; the BVICAM's International Journal of Information Technology. It presents a compilation of ten papers that span a broad variety of research topics in various emerging areas of Information Technology and Computer Science. Some application oriented papers, having novelty in application, have also been included in this issue, hoping that usage of these would further enrich the knowledge base and facilitate the overall economic growth. This issue shows our commitment in realizing our vision "to achieve a standard comparable to the best in the field and finally become a symbol of quality".

As a matter of policy of the Journal, all the manuscripts received and considered for the Journal by the editorial board are double blind peer reviewed independently by at-least two referees. Our panel of expert referees posses a sound academic background and have a rich publication record in various prestigious journals representing Universities, Research Laboratories and other institutions of repute, which, we intend to further augment from time to time. Finalizing the constitution of the panel of referees, for double blind peer review(s) of the considered manuscripts, was a painstaking process, but it helped us to ensure that the best of the considered manuscripts are showcased and that too after undergoing multiple cycles of review, as required.

The ten papers that were finally published were chosen out of eighty seven papers that we received from all over the world for this issue. We understand that the confirmation of final acceptance, to the authors / contributors, is delayed, but we also hope that you concur with us in the fact that quality review is a time taking process and is further delayed if the reviewers are senior researchers in their respective fields and hence, are hard pressed for time.

We wish to express our sincere gratitude to our panel of experts in steering the considered manuscripts through multiple cycles of review and bringing out the

best from the contributing authors. We thank our esteemed authors for having shown confidence in BIJT and considering it a platform to showcase and share their original research work. We would also wish to thank the authors whose papers were not published in this issue of the Journal, probably because of the minor shortcomings. However, we would like to encourage them to actively contribute for the forthcoming issues.

The undertaken Quality Assurance Process involved a series of well defined activities that, we hope, went a long way in ensuring the quality of the publication. Still, there is always a scope for improvement, and so, we request the contributors and readers to kindly mail us their criticism, suggestions and feedback at bjit@bvicam.ac.in and help us in further enhancing the quality of forthcoming issues.

Editors

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Performance Comparison of XY, OE and DY Ad Routing Algorithm by Load Variation Analysis of 2-Dimensional Mesh Topology Based Network-on-Chip

Parag Parandkar¹, Jayesh kumar Dalal² and Sumant Katiyal³

Submitted in August 2011; Accepted in January 2012

Abstract - Network on chip is a scalable and flexible communication architecture for the design of core based System-on-Chip. Communication performance of a NOC heavily depends on routing algorithm. XY routing algorithm is distributed deterministic routing algorithm. Odd-Even (OE) routing algorithm is distributed adaptive routing algorithm with deadlock-free ability. DyAD combines the advantages of both deterministic and adaptive routing schemes. Key metrics which determines best performance for routing algorithms for Network-on-Chip architectures are Minimum Latency, Minimum Power and Maximum Throughput. We demonstrated the impact of traffic load (bandwidth) variations on average latency and total network power for three routing algorithms XY, OE and DyAD on a 3x3 2-dimensional mesh topology. The simulation is performed on nirgam NoC simulator version 2.1 for constant bit rate traffic condition. The simulation results reveals the dominance of DyAD over XY and OE algorithms depicting the minimum values of overall average latency per channel (in clock cycles per flit) as 1.58871, overall average latency per channel (in clock cycles per packet) as 9.53226, overall average latency (in clock cycles per flit) as 26.105, and total network power as 0.1771 milliwatts, achieved for DyAD routing algorithm.

Index Terms - Network-on-chip; XY routing algorithm; OE routing algorithm; DyAD routing algorithm.

1. INTRODUCTION

Network on Chip (NoC) is a new paradigm for System on Chip (SoC) design [1-5]. With the growing complexity and increasing integration, the commonly used interconnection techniques for SoC architecture, bus structure, poses practical physical problems. In NoC paradigm, cores are connected to each other through a network of routers and they communicate among themselves through packet-switched communication. The protocols used in NoC are generally simplified versions of general communication protocols used in data networks. This makes it possible to use accepted and mature concepts of communication networks such as routing algorithms, switching techniques, flow and congestion control etc. in Network-on-

chip architecture. It allows significant reuse of resources and provides highly scalable and flexible communication infrastructure for SoC design.

Data communications between segments of chip are packetized and transferred through the network. The network consists of wires and routers. Processors, memories and other IP-blocks (Intellectual property) are connected to routers. A routing algorithm plays a significant role on network's operational performance.

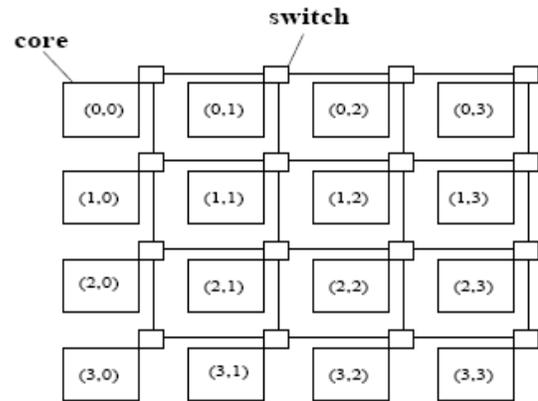


Figure 1: 4 X 4 2-Dimensional Mesh NoC

Different routing algorithms are targeted for different applications. Several routing algorithms need to be investigated and designed with various features and purposes.

The topic of Network on chip architecture is being introduced in this section. Section-2 explains about the three basic routing algorithms namely XY, Odd-even and DyAD routing algorithm in greater details. Section -3 describe architecture of a 3x3 2-dimensional mesh topology based NoC. Section -4 discusses simulation results and analysis of the proposed work. Section-5 ends with conclusion.

2. XY, OE AND DYAD ROUTING ALGORITHM

The routing algorithm, which defines the path taken by a packet between the source and the destination, is a main task in network layer design of NoC. According to where routing decisions are taken, it is possible to classify the routing as source and distributed routing [6].

Routing algorithm can be classified on the basis of adaptivity such as deterministic or adaptive. In deterministic routing, the path from source to destination is completely determined in advance by the source and destination address. Examples are XY routing. In adaptive routing, multiple paths from source to destinations are possible [7]. There also exists partially adaptive

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routing algorithms which restrict certain paths for communication with deadlock restrictions. Examples are Odd even routing. They are simple and easy to implement compared to adaptive routing algorithm. The routing algorithm that uses shortest path for communication is called minimal routing. The routing algorithm which uses longer paths for communication though shorter paths exist is known as non-minimal routing. Non-minimal routing has some advantages over minimal routing including possibility of balancing network load and fault tolerance. In static routing, the path cannot be changed after a packet leaves the source. In dynamic routing, a path can be altered anytime depending upon the network conditions. Routing algorithms can also be defined based on their implementation: lookup table and Finite State Machine (FSM). In the following text, three different routing algorithms are described in details:

2.1 XY Routing

The XY routing algorithm is one kind of distributed deterministic routing algorithm. XY routing never runs into deadlock or livelock [8]. For a 2-Dimension mesh topology NoC, each router can be identified by its coordinate (x, y) (Fig. 2). The XY routing algorithm compares the current router address (Cx,Cy) to the destination router address (Dx,Dy) of the packet, stored in the header flit [9]. Flits must be routed to the core port of the router when the (Cx,Cy) address of the current router is equal to the (Dx,Dy) address.

If this is not the case, the Dx address is firstly compared to the Cx (horizontal) address. Flits will be routed to the East port when $Cx < Dx$, to West when $Cx > Dx$ and if $Cx = Dx$ the header flit is already horizontally aligned. If this last condition is true, the Dy (vertical) address is compared to the Cy address. Flits will be routed to South when $Cy < Dy$, to North when $Cy > Dy$. If the chosen port is busy, the header flit as well as all subsequent flits of this packet will be blocked. The routing request for this packet will remain active until a connection is established in some future execution of the procedure in this router.

The following text is the XY routing algorithm:

```

/* XY routing Algorithm */
/*Source router: (Sx,Sy);destination router: (Dx,Dy); current
router: (Cx,Cy).*/
begin
if (Dx>Cx) //eastbound messages
return E;
else
if (Dx<Cx) //westbound messages
return W;
else
if (Dx=Cx) { //currently in the same column as
//destination
if (Dy<Cy) //southbound messages
return S;
else
if (Dy>Cy) //northbound messages
return N;

```

```

else
if (Dy=Cy) //current router is the destination router
return C;
}
end

```

The implementation of XY routing algorithm is simple. However, it is deterministic routing algorithm, which means this routing algorithm only provides a routing path for a pair of source and destination. Moreover, XY routing algorithm cannot avoid from deadlock appearance.

2.2 ODD-EVEN Routing (OE)

OE routing algorithm is a distributed adaptive routing algorithm which is based on odd-even turn model [10]. It exerts some restrictions, for avoiding and preventing from deadlock appearance. Odd-even turn model facilitates deadlock-free routing in two-dimensional (2D) meshes with no virtual channels.

In a two-dimension mesh with dimensions $X*Y$ each node is identified by its coordinate (x, y) [9]. In this model, a column is called even if its x dimension element is even numerical column. Also, a column is called odd if its x dimension element is an odd number. A turn involves a 90-degree change of traveling direction. There are eight types of turns, according to the traveling directions of the associated channels. A turn is called an ES turn if it involves a change of direction from East to South. Similarly, we can define the other seven types of turns, namely EN, WS, WN, SE, SW, NE, and NW turns, where E, W, S, and N indicate East, West, South, and North, respectively. As a whole, there are two main theorems in odd-even algorithm:

Theorem1: No packet is permitted to do EN turn in each node which is located on an even column. Also, No packet is permitted to do NW turn in each node that is located on an odd column.

Theorem 2: No packet is permitted to do ES turn in each node that is in an even column. Also, no packet is permitted to do SW turn in each node which is in an odd column.

The following test is a minimal OE routing algorithm in which avail_dimension_set contains dimensions that are available for forwarding the packet:

```

/* OE routing algorithm */
/*Source router: (Sx,Sy);destination router: (Dx,Dy); current
router: (Cx,Cy).*/
begin
avail_dimension_set<-empty;
Ex<-Dx-Cx;
Ey<-Dy-Cy;
if (Ex=0 && Ey=0) //current router is destination
return C;
if (Ex=0){ //current router in same column as destination
if (Ey<0)
add S to avail_dimension_set;
else
add N to avail_dimension_set;

```

```

}
else{
if (Ex>0){ //eastbound messages
if (Ey=0){ //current in same row as destination
add E to avail_demision_set;
}
}
else{
if(Cx % 2 != 0 or Cx=Sx) //N/S turn allowed only in odd
column.
if(Ey < 0)
add S to avail_dimension_set;
else
add N to avail_dimension_set;
if(Dx% 2 != 0 or Ex != 1) {
//allow to go E only if destination is odd column
add E to avail_dimension_set;
//because N/S turn not allowed in even column
}
}
}
else { // westbound messages
add W to avail_dimension_set;
if(Cx%2=0) //allow to go N/S only in even column, because N-
>W and S->W
//not allowed in odd column
if(Ey<0)
add S to avail_dimension_set;
else
add N to avail_dimension_set;
}
}
//Select a dimension from avail_dimension_set to forward the
//packet.
End

```

OE routing algorithm is more complex than XY routing algorithm. However, it is one kind of adaptive routing algorithm. For a pair of source and destination, it can provide a group of routing paths and it can prevent from dead lock appearance.

2.3 DYAD Routing

DyAD combines the advantages of both deterministic and adaptive routing schemes [11]. DyAD is a routing technique which judiciously switches between deterministic and adaptive routing based on network congestion's conditions. Compared to purely adaptive routers, the overhead of implementing DyAD is negligible, while the performance is consistently better.

With DyAD routing each router in the network continuously monitors its local network load and makes decisions based on this information. When the network is not congested, a DyAD router works in a deterministic mode, thus enjoying the low routing latency enabled by deterministic routing. On the contrary, when the network becomes congested, the DyAD router switches back to the adaptive routing mode and thus

avoids the congested links by exploiting other routing paths; this leads to higher network throughput which is highly desirable for applications.

The freedom from deadlock and livelock [8] can be guaranteed when mixing deterministic and adaptive routing modes into the same NoC.

3. ARCHITECTURE OF 2 DIMENSION 3X3 MESH TOPOLOGY NOC

The routing Algorithm is simulated based on a 2-Dimension 3X3 mesh topology NoC (Fig. 2). In the Fig. 2, each circle represents a tile in the network. Each tile consists of an IP core connected to a router by a bidirectional core channel (C). A tile is connected to neighbor tiles by four bidirectional channels (N, E, S and W). Each tile is identified by a unique integer ID. Also, each tile can be identified by a pair x-coordinate and y-coordinate. Our 2-Dimesion 3X3 mesh topology NoC is designed using wormhole switching mechanism, in which packets are divided into flits. A packet consists of 3 types of flits, which are head flit, data flit and tail flit. All the three routing algorithms, XY routing algorithm, OE routing algorithm and DyAD routing algorithms are based on these characteristics.

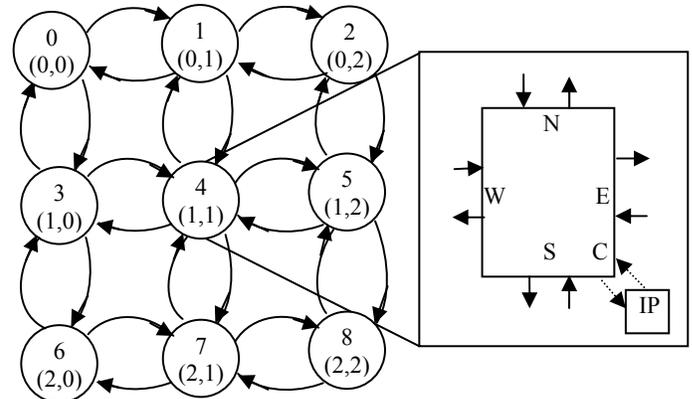


Figure 2: Architecture of a 2-dimensional 3x3 mesh topology based NoC

4. SIMULATION RESULTS AND ANALYSIS

The simulation is performed on NIRGAM simulator, a simulator for NoC Interconnect Routing and Application Modeling version 2.1. NIRGAM is an extensible and modular systemC based simulator [12] as has been depicted in Fig. 3. Simulations to all the three routing algorithms are performed under same traffic conditions and simulation control. Tiles are attached to constant bit rate (CBR) traffic generator. The packet size is of 20 bytes with random destination mode. The percentage load, maximum bandwidth to be utilized, is varied beginning with 10 % to 100 % in the steps of 10 %. The interval between two successive flits is 2 clock cycles. Simulation runs for 50000 clock cycles and the clock frequency is 1 GHz. Synthetic traffic generators generate traffic

in the first 3000 clock cycles with warm-up period of 800 clock cycles.

Fig. 3 shows the utilization of simulator for the proposed work elaborating the inputs given to the simulator and outputs taken from the simulator. There are two key measures of Performance of routing algorithms namely, overall average latency & total network power. The overall average latency in clock cycles per flit is also measured on a per channel basis on clock cycles per flit and clock cycles per packet. Total network power is measured in the units of milliWatts.

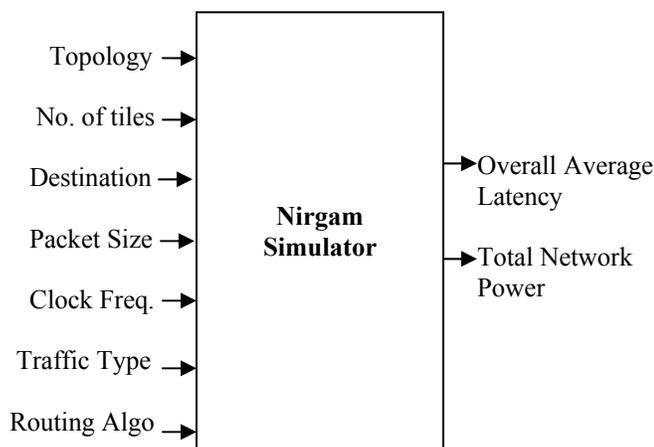


Figure3: Inputs and Outputs to Nirgam NoC Simulator

Table 1 depicts Simulation results for a 3x3 mesh topology NoC by comparing the impact of Load variation (bandwidth variation) on overall average latency per channel (in clock cycles per flit) for XY, OE and DyAd routing algorithms.

Fig.4. shows the graphical representation for simulation data of Table 1 shows Percentage Load variation vs Overall average latency per channel (in clock cycles per flit) for OE, XY and DyAD routing algorithm.

Table 2 depicts Simulation results for a 3x3 mesh topology NoC by comparing the impact of Percentage Load variation (bandwidth variation) on overall average latency per channel (in clock cycles per packet) for XY, OE and DyAd routing algorithms.

Fig.5. shows the graphical representation for simulation data of Table 2 shows Percentage Load variation vs Overall average latency per channel (in clock cycles per packet) for OE, XY and DyAD routing algorithm.

Table 3 depicts Simulation results for a 3x3 mesh topology NoC by comparing the impact of Percentage Load variation (bandwidth variation) on Overall average latency (in clock cycles per flit) for XY, OE and DyAd routing algorithms.

Fig.6 shows the graphical representation for simulation data of Table 2 shows Load vs Overall average latency (in clock cycles per flit) for OE, XY and DyAD routing algorithm.

Table 4 depicts Simulation results for a 3x3 mesh topology NoC by comparing the impact of Percentage Load variation

(bandwidth variation) on Total Network Power for XY, OE and DyAd routing algorithms.

Fig.7. shows the graphical representation for data of Table 4 shows Percentage Load variation vs Total Network Power for OE, XY and DyAD routing algorithm.

5. CONCLUSION

The routing algorithm is one of network layer researches of a NoC design, whose design approach can be adapted from a protocol stack including physical layer, data link layer, network layer and transport layer. Based on a 2-Dimension 3x3 mesh topology NoC, three different routing algorithms, XY routing algorithm, OE routing algorithm and DyAD routing algorithm are simulated on NIRGAM simulator platform and impact of Percentage Load variation is compared with four different parameters namely overall average latency per channel per packet, overall average latency per channel per flit, overall average latency per flit and overall network power respectively. The performance evaluation and the impact of Percentage Load variation (bandwidth variation) among the routing algorithms for two important parameters, overall average latency and overall network power are considered important design criteria to judge simulator as well as routing algorithm in the NoC research.

The minimum value of overall average latency per channel (in clock cycles per flit) is obtained as 1.58871, overall average latency per channel (in clock cycles per packet) is obtained as 9.53226, overall average latency (in clock cycles per flit) is obtained as 26.105, and total network power is obtained as 0.1771 milliwatts, achieved for DyAD routing algorithm. Thus proposed work shows the dominance of DyAD routing algorithm over OE and XY routing algorithms.

Thus it is concluded that compared to both deterministic and adaptive routing, significant performance improvements in terms of total network power as well as overall average latency can be achieved by using the DyAD approach for constant bit rate traffic conditions.

FUTURE SCOPE

Our conclusions are just fit for a 2-Dimension 3x3 mesh topology NoC. For other topologies, as well as taking into consideration other parameters, additional work needs to be done in the future.

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Load Variati on in %	Overall average latency per channel (in clock cycles per flit)		
	OE	XY	DyAD
10	1.89210	1.90542	1.58871
20	1.77547	2.01144	1.59463
30	1.90437	1.97100	1.59589
40	1.89210	2.02207	1.58785
50	2.07681	2.19148	1.58624
60	2.07850	2.17938	1.60494

Load Variati on in %	Overall average latency per channel (in clock cycles per flit)		
	OE	XY	DyAD
70	2.09805	2.09641	1.60256
80	2.13320	2.21263	1.61754
90	2.07522	2.23316	1.58733
100	2.61783	2.69170	1.94854

Table1: Simulation results for load variation verses overall average latency per channel (in clock cycles per flit) for XY, OE and DyAd routing algorithms

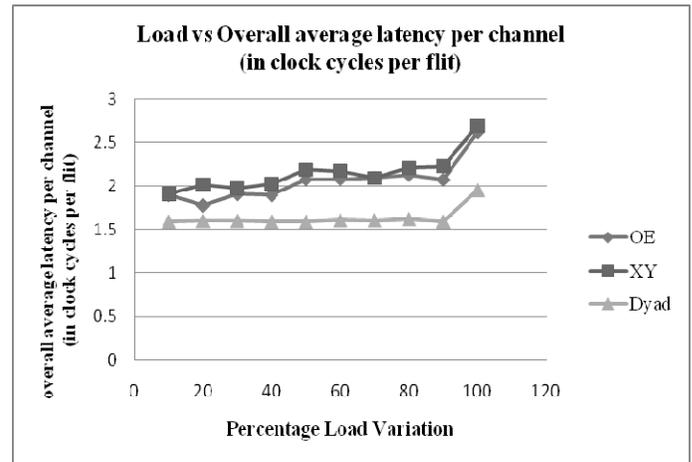


Figure4: Graph of Percentage Load variation vs Overall average latency per channel (in clock cycles per flit) for OE, XY and DyAD routing algorithm

Load Variati on in %	Overall average latency per channel (in clock cycles per packet)		
	OE	XY	DyAD
10	11.35260	11.43250	9.53226
20	10.65280	12.06860	9.56780
30	11.42620	11.82600	9.57534
40	11.35260	12.13240	9.52709
50	12.46080	13.14890	9.51746
60	12.47100	13.07630	9.62963
70	12.58830	12.57840	9.61539
80	12.79920	13.27580	9.70526
90	12.45130	13.39900	9.52396
100	15.70700	16.15020	11.69130

Table2: Simulation Data results for load variation verses overall average latency per channel (in clock cycles per packet) for XY, OE and DyAd routing algorithms.

Performance Comparison of XY, OE and DY Ad Routing Algorithm by Load Variation Analysis of 2-Dimensional Mesh Topology Based Network-on-Chip

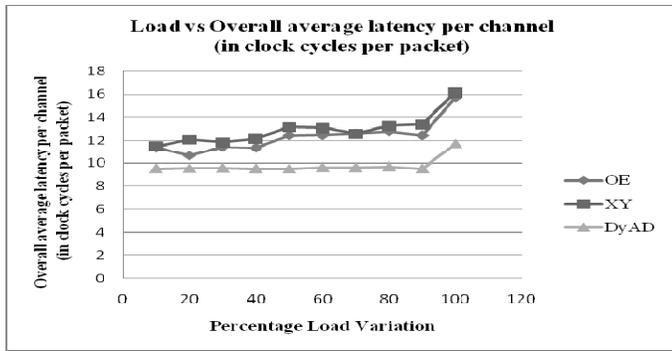


Figure5: Graph of Percentage Load variation vs Overall average latency per channel (in clock cycles per packet) for OE, XY and DyAD routing algorithm.

Load Variation in %	Overall average latency (in clock cycles per flit)		
	OE	XY	DyAD
10	30.49320	27.67840	26.10530
20	29.43840	29.04600	25.51350
30	30.77460	29.38890	25.39130
40	31.22220	29.73060	26.19350
50	34.74990	32.62700	27.58700
60	34.25790	32.04840	26.08700
70	34.40660	30.04250	26.25000
80	34.86770	31.81370	25.06520
90	34.46610	32.70150	27.40220
100	49.16410	44.60930	35.58830

Table3: Simulation results for Percentage Load variation versus Overall average latency (in clock cycles per flit) for XY, OE and DyAD routing algorithms

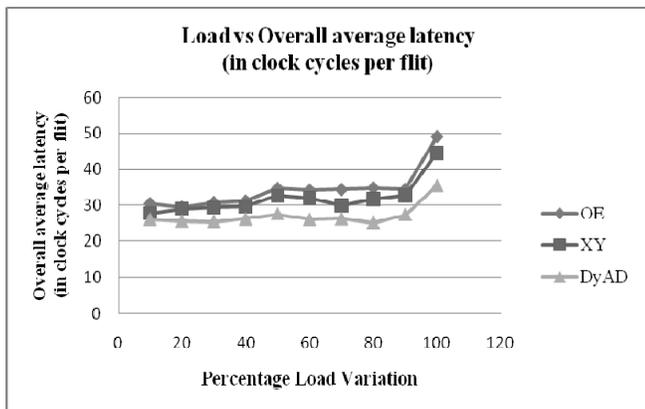


Figure6: Graph of Percentage Load variation vs Overall average latency (in clock cycles per flit) for OE, XY and DyAD routing algorithm.

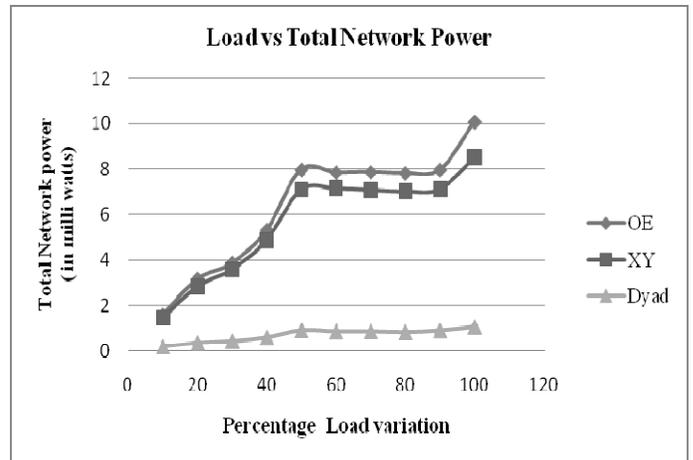


Figure7: Graph of Percentage Load variation vs Total Network power (in milliwatts) for OE, XY and DyAD routing algorithm

Load Variation in %	Total Network Power (milliwatts)		
	OE	XY	DyAD
10	1.58082	1.44145	0.17711
20	3.16042	2.83479	0.33712
30	3.85637	3.58444	0.41713
40	5.29437	4.86061	0.57989
50	7.96849	7.08161	0.89983
60	7.84587	7.13445	0.84869
70	7.86563	7.06261	0.85435
80	7.81336	7.00110	0.81458
90	7.96460	7.10278	0.89415
100	10.08040	8.54200	1.04783

Table4: Simulation results for Percentage Load variation versus Total Network power for XY, OE and DyAD routing algorithms

Determination of Efficiency of Hybrid Photovoltaic Thermal Air Collectors using Artificial Neural Network Approach for Different PV Technology

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Abstract - In this paper an attempt has been made to determine efficiency of semi transparent hybrid photovoltaic thermal double pass air collector for different PV technology and compare it with single pass air collector using artificial neural network (ANN) technique for New Delhi weather station of India. The MATLAB 7.1 neural networks toolbox has been used for defining and training of ANN for determination of thermal, electrical, overall thermal and overall exergy efficiency of the system. The ANN model uses ambient air temperature, number of sunshine hours, number of clear days, temperature coefficient, cell efficiency, global and diffuse radiation as input parameters. The transfer function, neural network configuration and learning parameters have been selected based on highest convergence during training and testing of network. About 2000 sets of data from four weather stations (Bangalore, Mumbai, Srinagar and Jodhpur) have been given as input for training and data of the fifth weather station (New Delhi) has been used for testing purpose. It has been observed that the best transfer function for a given configuration is logsig. The feed forward back-propagation algorithm has been used in this analysis. Further the results of ANN model have been compared with analytical values on the basis of root mean square error.

Index Terms - Artificial neural network (ANN), Efficiency, Photovoltaic thermal (PVT), Levenberg-Marquardt (LM), Multi-layer perceptron (MLP), Mean Bias Error (MBE), Single pass (SP), Double pass (DP).

1. INTRODUCTION

Due to depleting rate of conventional energy sources there have been sincere efforts all over the world to harness renewable energy resources. Solar energy is one of the significant renewable energy source that can be harnessed using photovoltaic thermal systems. The major applications of solar energy can be classified as: thermal system, which converts solar energy into thermal energy and photovoltaic (PV) system, which converts solar energy into electrical energy. The integrated arrangement for utilizing thermal energy as well as electrical energy, with a photovoltaic module is referred to as

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the hybrid PVT system. PVT collector produces thermal and electrical energy simultaneously and hence it is referred as hybrid PVT system. The development of sustainable technologies requires an overall evaluation of the product's environmental impacts and benefits. The solar cells currently in the market have undergone the environmental evaluations to be classified as sustainable sources of energy. Over last decade there is rapid increase in PV energy generation devices. The classification for photovoltaic technology available in the market has been given in Table 1. Since late 1990s, new PV technologies have begun to emerge commercially along with more traditional Si-based systems. The emerging non crystalline silicon technologies have started making momentous into solar cell markets. These thin film PV modules still constitute a tiny fraction of the total PV market, but things may change quickly as new manufacturers hit the market each year. (Raugei and Frankl, 2008) have compared energy cost of thin film PV-cells to that of crystalline systems. It has been observed that energy cost has dropped to 1\$/W (Fthenakis, 2009). The performance of a PV can be described in terms of its energy conservation efficiency and the percentage of incident solar ray that converts cell into electricity under standard test conditions.

Most parts of India receive abundant quantity of solar energy due to their geographical positions but it is difficult to have measurements from all locations of interest as measuring devices are expensive to purchase, install and maintain. The design of any cost effective system depend on the reliable data for which accurate techniques are required. The ANN methodology is a promising alternative to the traditional approach for estimating solar radiation. (Jiang, 2008) has developed a model for estimation of the monthly mean daily diffuse solar radiation for eight typical cities in China. It has been observed that ANN-based estimation technique is more suitable than the empirical regression models for estimation of solar radiation. (Leal et al., 2011) have measured, analyzed and compared three different statistical models and two ANN models for estimating the daily UV solar radiation from the daily global radiation. It has been observed that the statistical and ANN models have good statistical performance with RMSE lower than 5% and MBE between 0.4 - 2 %. (Koca et al., 2011) have developed an ANN model for estimation of future data on solar radiation for seven cities from Mediterranean region of Anatolia in Turkey. The obtained results indicated that the method could be used by researchers or scientists to design high efficiency solar devices.

ANN's have also been used for prediction of energy consumption (Economou, 2010; Tso & Yau, 2007; Kalogirou & Bojic, 2000). (Yoro et al., 2009) have applied the ANN method for exergy analysis of thermodynamic systems and presented the performance of the ANN method to emphasize the definition of ANN inputs. (Hui Xie et al., 2009) developed an ANN to determine the performance of solar collectors for Beijing with 10 neurons in the hidden layer considering back propagation learning algorithm and logistic sigmoid transfer function with minimum RMSE. The performance parameters ambient temperature of collector, solar intensity, declination angle, azimuth angle and tilt angle have been used as training data in the input layer for computing efficiency and heating capacity outputs. It has been observed that there is fair agreement between experimental and ANN model for performance prediction of solar collectors. (Caner et al., 2011) have designed an ANN model considering LM based MLP in Matlab nntool module to estimate thermal performances of two types of solar air collectors. The calculated and predicted values of thermal performances have been compared and statistical error analysis has been carried out to evaluate results. Further reliability of ANN has been tested by applying stepwise regression method to the data used in designing. (Almonacid et al., 2011) have compared the results of three classical and ANN methods for estimating the annual energy produced by a PV generator for Solar and Automatic Energy at the University of Jaen. It has been observed that ANN method provides better results than the alternative classical methods in study, as it takes some second order effects such as low irradiance, angular and spectral effects into consideration. (Ashhab, 2007) has used ANN technique for forecasting photovoltaic solar integrated system efficiencies. (Sozen et al., 2008) have developed an ANN model to determine the efficiency of flat plate solar collectors. The collector surface temperature, date, time, solar radiation, declination angle, azimuth angle and tilt angle have been used as the input and efficiency of flat plate solar collector has been used as the output with Logistic sigmoid transfer function in the network. The results have shown that the maximum and minimum deviations were found to be 2.558484 and 0.001969 respectively. Efficiency of solar cells has significantly improved over the last few decades. However realized values are much lower than the theoretical limits.

In this paper efficiency of a semi transparent single and double pass air collector for different PV technology have been evaluated considering four types of weather conditions defined as (Singh, 2005). Table 2 shows the number of clear days in different weather condition for New Delhi weather station. The data of solar radiations for different climates for four weather stations (Bangalore, Mumbai, Srinagar and Jodhpur) obtained from Indian Metrological Department, Pune have been used for training and data of the fifth weather station (New Delhi) has been used for testing purpose. The results of ANN models for semi transparent hybrid PVT single and double pass air

collector for different PV technology have been compared with analytical values on the basis of RMSE.

2. ARTIFICIAL NEURAL NETWORK

2.1. Theory

ANN models are computer programs designed to follow human information processing capability like knowledge processing, prediction and classifications. The ability of ANN to learn from examples provides quick responses to new information. ANN's although implemented on computers but they are not programmed to perform specific tasks rather trained with respect to data sets until they learn patterns which have been used as inputs. Once they are trained, new patterns may be presented to networks for prediction or classification. ANN model has three types of layers: input, hidden and output layer. The neurons in layers are connected together in a network topology. The input neurons receive data from the external environment, the hidden neurons receive signals from neurons in the preceding layer, and the output neurons send information back to the external environment. The information is passed through neurons along with interconnections. An incoming connection has input value and weight associated with it and the output of the unit is function of the summed value. After summation, the net input of the neurons is combined with the previous state of the neurons to produce a new activation value. The activation is then passed through an output or a transfer function that generates the actual neuron output. The transfer function modifies the value of the output signal. This function can be either a simple threshold function that only produces output if the combined input is greater than the threshold value, or it can be a continuous function that changes the output based on the weight of the combined input. When the signal reaches to the last node, an appropriate output is generated. This output when compared to the desired output gives the error. Error during learning is called MSE. This error is back propagated to nodes to readjust the weights through adaptation learning function. The complete cycle is called an iteration and the set of inputs are called epoch. Many epochs are applied to get the desired output and train the network. In training data accuracy is vital for the development of an efficient model that can provide accurate prediction. Once the network is trained the same can be used for estimation and analytical purpose. The trained model is assumed to be successful if the model gives good results for that test set. To insure that ANN models provide correct prediction or classifications, the prediction results produced by ANN models can be validated against expert predictions for the same cases or it can be validated against the results of other computer programs.

2.2. Description And Design Of Ann

ANN modeling has been done to estimate electrical, thermal, overall thermal and exergy efficiency from the arrangement shown in Figure 1(a) and (b) for single and double pass respectively. The ANN model uses ambient air temperature, number of sunshine hour, number of clear days, temperature

coefficient, module efficiency, global and diffuse radiation as input parameters and thermal, electrical, overall thermal and exergy efficiency as output parameters for the experimental setup is shown in Figure 3 (a) and (b).

Figure 2 (a) and (b) represents the typical layout of the ANN, which shows the network nodes along with biases and weights for single and double pass respectively. The network type is selected as feed forward back propagation. The ANN model has four-layer feed forward back propagation neural network architecture, input layer of seven neurons, two hidden layer of twenty and twenty five neurons for single and double pass air collector respectively and an output layer of four neurons. The hidden layers has 'tan-sigmoid' activation function, Φ defined by the logistic function as

$$\phi = 1 / (1 + e^{-n}), \text{ where } n \text{ is the corresponding input.}$$

For the output layer, a logsig activation function is used. The inputs have been normalized in the (0, 1) range. A set of 2000 epochs has been taken for training purpose. The MATLAB Neural Network Toolbox is used for the implementation of the feedforward network. The supervised training technique back propagation algorithm has been used. TRAINLM has been selected as training function and

MSE has been taken as the performance function. This training function updates the weights and bias values in accordance with LM optimization. In order to train the network the data of solar radiations for different climates has been obtained from Indian Metrological Department, Pune.

The following parameters are set while training the feed forward neural network: training pattern 2000, learning rate 0.001, MSE training goal has been set as 0.005, number of training iterations 1250, momentum 0.94. The training patterns are presented repeatedly to the ANN model and the adjustment is performed after each iteration whenever the network's computed output is different from the desired output. After several adjustments to the network parameters, the network converged to a threshold of 0.00001 using hidden nodes. The accuracy of the trained ANN model was validated using other sets of data, which are different from those used for the training process and the mean square error is 0.005. The RMSE varies from 0.0568 to 4.7633% for different output parameters. The results demonstrate that the ANN based model developed in this work can predict the efficiency at any point in time with high accuracy.

3. THEORETICAL ANALYSIS OF AIR COLLECTOR

3.1 Single Pass Air Collector

The cross sectional view of semi transparent single pass air collector has been shown in Figure 3(a). There is a provision of duct below the PV module. The air is passed through one end of the duct and gets warm by picking the thermal energy from the back side of the PV module and exit from the other end of the duct. The duct has been insulated to minimize the heat loss.

3.2 Double Pass Air Collector

The cross sectional view of semi transparent hybrid PV module double pass collector, has been shown in Figure 3(b). There is provision for two ducts. The two ducts are connected in series at the end. The air flows in the upper duct get exposed to the solar radiation. Due to exposure, the temperature of the air in the outer duct increases. The heated air is circulated through the inner duct and gets further heated due to increase in the temperature of semi transparent PV module. Thus this useful thermal energy obtained, from hybrid PVT pass air collector can be used in building for space heating in cold climatic condition.

3.3. Thermal Energy And Exergy Analysis

The hourly rate of useful thermal energy of semi transparent hybrid PVT air collector is calculated as

$$(\dot{q}_u) = \dot{m}_a C_a (T_{fo} - T_{fi}) \tag{1}$$

The daily thermal energy output in kWh of the semi transparent hybrid PVT air collector can be expressed as

$$Q_{thdaily} = \sum_{i=1}^N \frac{\dot{q}_{ui}}{1000} \tag{1a}$$

The monthly thermal energy output in kWh of the semi transparent hybrid PVT air collector can be expressed as

$$Q_{thmonthly} = \sum_{j=1}^{n_o} Q_{thdaily_j} \tag{1b}$$

The annual thermal energy output can be evaluated by using hourly equation

$$Q_{thannual} = \sum_{k=1}^{12} \frac{\dot{q}_u}{1000} \times N \times n_0 \tag{1c}$$

The annual exergy of semi transparent hybrid PVT air collector is calculated as

$$Ex_{thannual} = Q_{thannual} \left[1 - \frac{\bar{T}_a + 273}{T_{fo} + 273} \right] \tag{2}$$

The expression for outlet air temperature (T_{fo}) in Eq. (2) is given by Kamthania et al. [17, 18].

The thermal efficiency of semi transparent hybrid PVT air collector can be expressed as

$$\eta_{th} = \frac{\sum \dot{q}_u}{\sum I(t) \times b \times L} \tag{3}$$

3.4 Electrical and Equivalent Thermal Analysis

The hourly electrical energy can be written as

$$E_{el} = \eta_{el} \times A \times I(t) \tag{4}$$

The annual electrical energy can be obtained as

$$(E_{el})_{annual} = \eta_{el} \times A \times I(t)_{avg} \times N \times n_0 \tag{5}$$

The temperature dependent electrical efficiency of PV system can be written as

$$\eta_{el} = \eta_o [1 - \beta(T_c - T_a)] \tag{6}$$

where, T_a is 25°C (under Standard test condition) and value of cell efficiency (η_0) and temperature coefficient (β) for different PV technology is given in Table 3.

The equivalent thermal energy can be calculated as

$$E_{thannual} = \frac{(E_{el})_{annual}}{0.38} \quad (7)$$

The 0.38 is the conversion factor from thermal to electrical energy for thermal power plants by Huang et al. [19].

3.5. Overall Thermal Energy and Energy Analysis

The overall thermal energy can be obtained from Eqs. (1c) and (7) and is expressed as

$$(Q_{ov})_{th} = Q_{thannual} + E_{thannual} \quad (8)$$

The overall thermal efficiency of semi transparent hybrid PVT air collector can be expressed as

$$\eta_{ovth} = \eta_{th} + \frac{\eta_{el}}{0.38} \quad (9)$$

where, is calculated from Eq.(3) and from Eq.(6)

3.6. Overall Exergy

The annual exergy can be obtained from Eqs. (2) and (5)

$$Ex_{annual} = Ex_{thannual} + (E_{el})_{annual} \quad (10)$$

The exergy efficiency of semi transparent hybrid PVT air collector can be expressed as

$$\eta_{ex} = \eta_{th} \left[1 - \frac{T_a + 273}{T_{fo} + 273} \right] \quad (11)$$

The overall exergy efficiency of semi transparent hybrid PVT air collector can be expressed as

$$\eta_{ovex} = \eta_{ex} + \eta_{el} \quad (12)$$

For more details, please refer the paper written by Kamthania et al. [17, 18].

4. SYSTEM AND DATA COLLECTION

The analytical model has been derived for the experiential setup installed at the Solar energy park of IIT, New Delhi as shown in Figure3 (a) and (b). The equations are derived for the analytical model of various performance parameters (thermal, electrical, overall thermal and exergy efficiency) considering a, b, c and d type climatic conditions for different weather stations. The ambient air temperature, number of sunshine hours, number of clear days, temperature coefficient, cell efficiency, global and diffuse radiation have been used as input for training of ANN. Climatic data and results of four weather stations (Bangalore, Mumbai, Srinagar and Jodhpur) have been used for training purpose and the data of the fifth weather station (New Delhi) has been used for testing purpose of the ANN model.

5. METHODOLOGY

The ANN has been defined in MATLAB 7.1 neural network toolbox as per the above mentioned parameters. The initial values of the weights have been defined and an incremental input is given to the network for estimating the outputs. When

the outputs are closure to result matrix and the calculated MSE is within specified limits the iterations are terminated and the values of weights are recorded. If the output matrix is close to desired results then the network is trained otherwise the same procedure is repeated with new weight matrix. Thus value obtained through ANN model are compared with analytical result for New Delhi weather station. The RMSE deviation has been calculated using the following equation.

$$RMSE = \left(\sqrt{\frac{\sum (X_i - Y_i)^2}{n}} \right) \times 100 \quad (13)$$

6. RESULTS AND DISCUSSION

ANN helps in analysis and estimation studies before putting the Solar project at place. The purpose of this study is to develop an ANN model for performance analysis of a semi transparent hybrid PVT single and double pass air collector for different PV technologies. The training cities have been chosen as Bangalore, Mumbai, Srinagar and Jodhpur and test city is New Delhi. The performance parameters calculated from ANN, are compared with the results obtained from analytical study.

Figure 4 shows MSE curve for a typical iteration, the performance of the network has been shown against the goal set for the network. MSE has been taken as the performance function with MSE training goal set as 0.005. It has been observed that LM with 20 and 25 neurons in the hidden layer for single and double pass air collector respectively and 4 neurons in input and output layer is the most suitable algorithm with set MSE value for single and double pass air collector respectively.

The RMSE measures the average magnitude of error. It is better to have lower RMSE values. The RMSE has been calculated using Eq.13. The RSME values of the performance parameters calculated from both ANN model and analytical study considering a, b c and d type weather conditions have been shown in Table 4. According to the results the deviation are in the range of 0.056-4.763% for different output parameters. It has been observed that RMSE for electrical efficiency, overall thermal efficiency and overall exergy efficiency varies from 0.056 to 0.211 %, 4.068 to 4.763% and 0.298 to 0.580% respectively.

Fig 5(a) shows monthly variation of electrical efficiency of single pass air collector for different PV technologies. The minimum electrical efficiency for different PV technology is in the month of May due to maximum solar radiation and minimum in the month of January due to low solar radiation. With the increase of solar radiation the cell temperature increases and there is decrease in the electrical efficiency of solar cell. The monthly electrical efficiency is maximum for HIT and minimum for a-Si. Fig 5(b) shows monthly variation of electrical efficiency of double pass air collector for different PV technologies. The monthly electrical efficiency is maximum for HIT and minimum for a-Si due to same reason as discussed in Figure 5(a).

Figure 6, 7 and 8 shows deviations of various performance parameters for single and double pass air collector of different PV technology. It is observed that double pass air collector have higher values as compared to single pass air collector. Further it is also observed that that maximum value of electrical, overall thermal and overall exergy efficiency are obtained for 'HIT' PV technology whereas minimum value of electrical, overall thermal and overall exergy efficiency have been obtained for 'a-Si' type for New Delhi weather station. The values obtained from ANN model are very close to the analytical values.

CONCLUSION

In this paper ANN models have been developed using MATLAB 7.1 neural networks toolbox for performance analysis of a semi transparent hybrid PVT double pass air collector for different PV technology. The ANN model is based on feed forward back propagation algorithm with two hidden layer. The LM with 25 and 20 neurons for single and double pass air collector respectively in the hidden layer and 4 neurons in input and output layer is the most suitable algorithm with MSE value of 0.005. It has been observed that analytical and ANN model have fair agreement with RMSE value lower than 5%. Further it is also observed that it is advantageous to use ANN as compared to traditional method due to speed, simplicity and ability to learn from examples.

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NOMENCLATURE

n	number of samples
N	number of sunshine hour in a day
n _o	number of clear days in a month
Q _{thannual}	annual rate of useful thermal energy (kWh)
(E _{el}) _{annual}	annual rate of useful electrical energy (kWh)
(Q _{ov}) _{th}	overall thermal energy (kWh)
Ex _{thannual}	overall exergy (kWh)

Determination of Efficiency of Hybrid Photovoltaic Thermal Air Collectors Using Artificial Neural Network Approach for Different PV Technology

T_a	ambient temperature ($^{\circ}\text{C}$)
T_c	solar cell temperature ($^{\circ}\text{C}$)
T_{fo}	outlet air temperature of inner duct ($^{\circ}\text{C}$)
η_{el}	electrical efficiency (%)
η_{ovth}	overall thermal efficiency (%)
η_{ovex}	electrical efficiency (%)
η_0	cell efficiency (%)
β	Temperature coefficient ($(^{\circ}\text{C}^{-1})$)
X_i	predicted values
Y_i	calculated values

ABBREVIATIONS

a	ambient air
c	solar cell
el	electrical
ov	overall
th	thermal

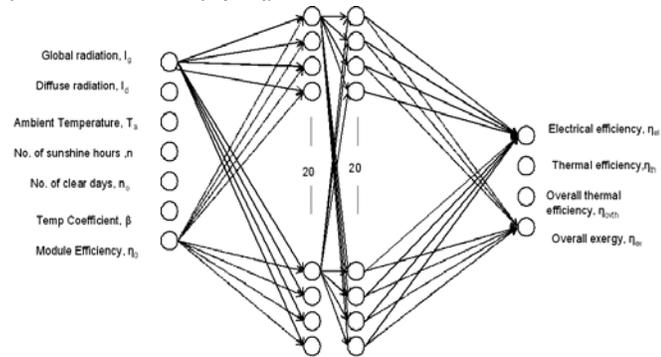


Figure 1(a): Input, output and hidden layers of ANN for single pass air collector

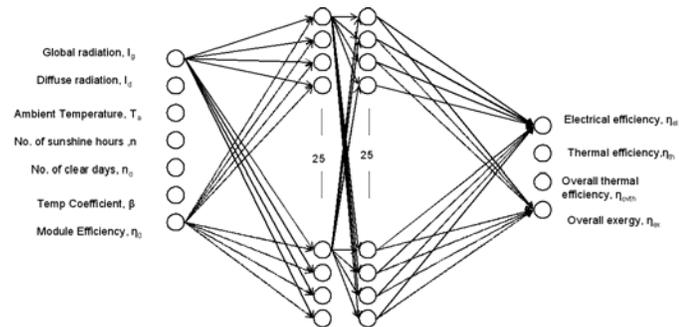


Figure 1(b): Input, output and hidden layers of ANN for double pass air collector.

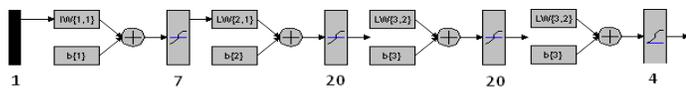


Figure 2 (a): Typical arrangement of ANN for single pass air collector.

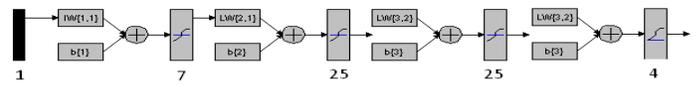


Figure 2 (b). Typical arrangement of ANN for double pass air collector.

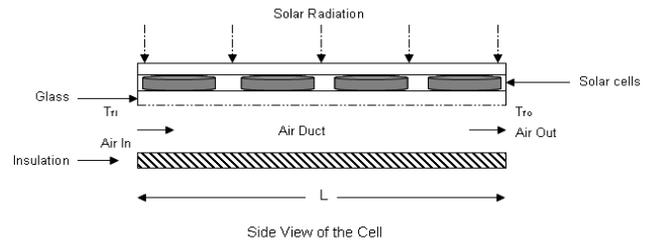


Figure 3(a): Schematic diagram of hybrid photovoltaic thermal single pass air collector.

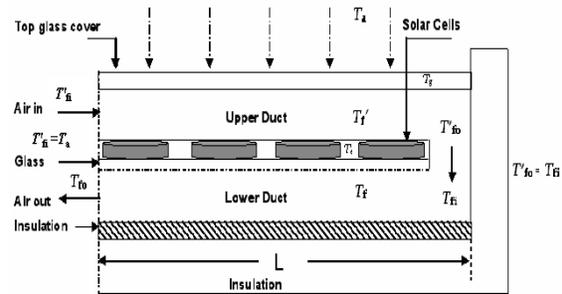


Figure 3(b): Schematic diagram of a hybrid photovoltaic thermal double pass air collector

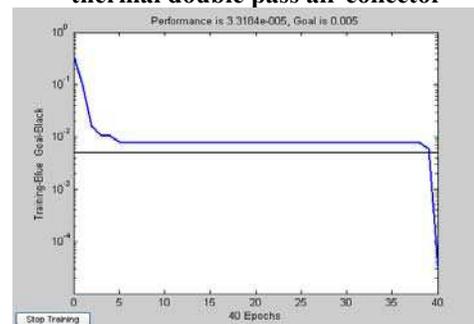


Figure 4: MSE obtained in the training of the network.

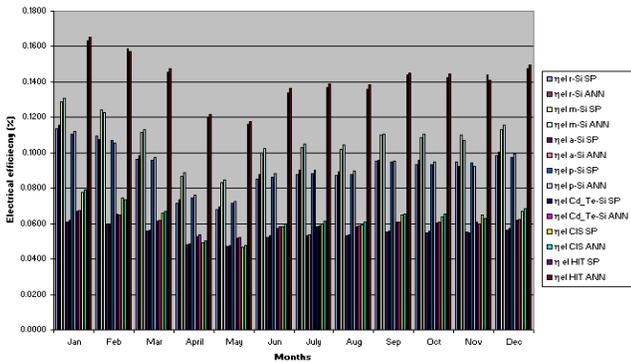


Figure 5 (a): Monthly variation of electrical efficiency of single pass air collector for different PV technology

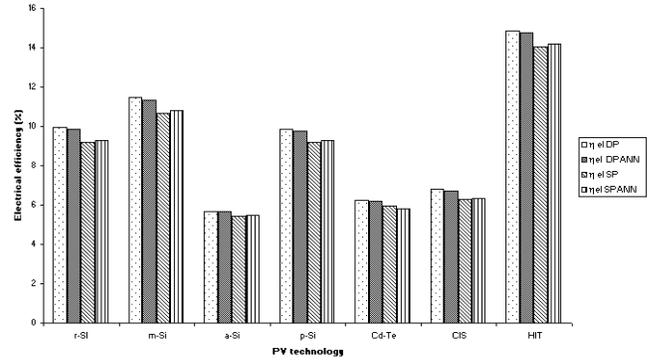


Figure 6: Annual variation of electrical efficiency of single and double pass air collector of different PV technology

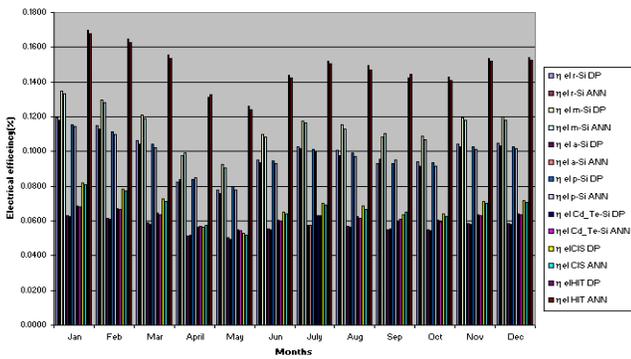


Figure 5(b): Monthly variation of electrical efficiency of double pass air collector for different PV technology

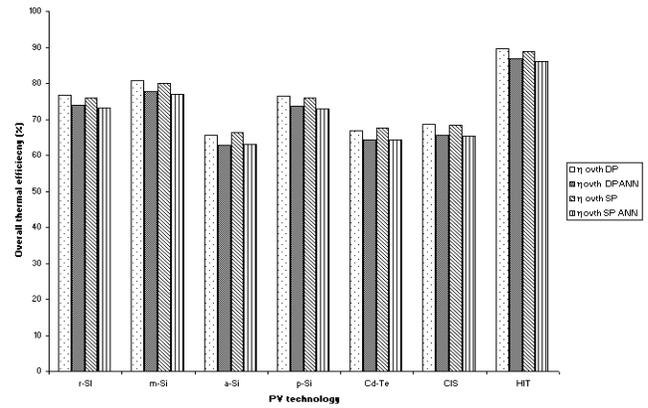


Figure 7: Annual variation of overall thermal efficiency of single and double pass air collector of different PV technology

Type of weather conditions	January	February	March	April	May	June	July	August	September	October	November	December
a	3	3	5	4	4	3	2	2	7	5	6	3
b	8	4	6	7	9	4	3	3	3	10	10	7
c	11	12	12	14	12	14	10	7	10	13	12	13
d	9	9	8	5	6	9	17	19	10	3	2	8

Table 2: Number of clear days fall in different weather condition for New Delhi weather station

PV Technology	Module efficiency η_0 (%)	Temperature Coefficient β ($^{\circ}\text{C}^{-1}$)
Ribbon cast Si (r-Si)	12.00	0.0045
Mono-crystalline silicon (m-Si)	13.50	0.0040
Amorphous silicon (a-Si)	6.30	0.0026
Polycrystalline silicom (p-Si)	11.60	0.0040
Cadmium telluride (Cd-Te)	6.90	0.0026
Copper indium diselenide (CIS)	8.20	0.0045
Heterojunction with Intrinsic Thin-layer (HIT)	17	0.0033

Table 3: Specification for various silicon and non silicon based PV modules.

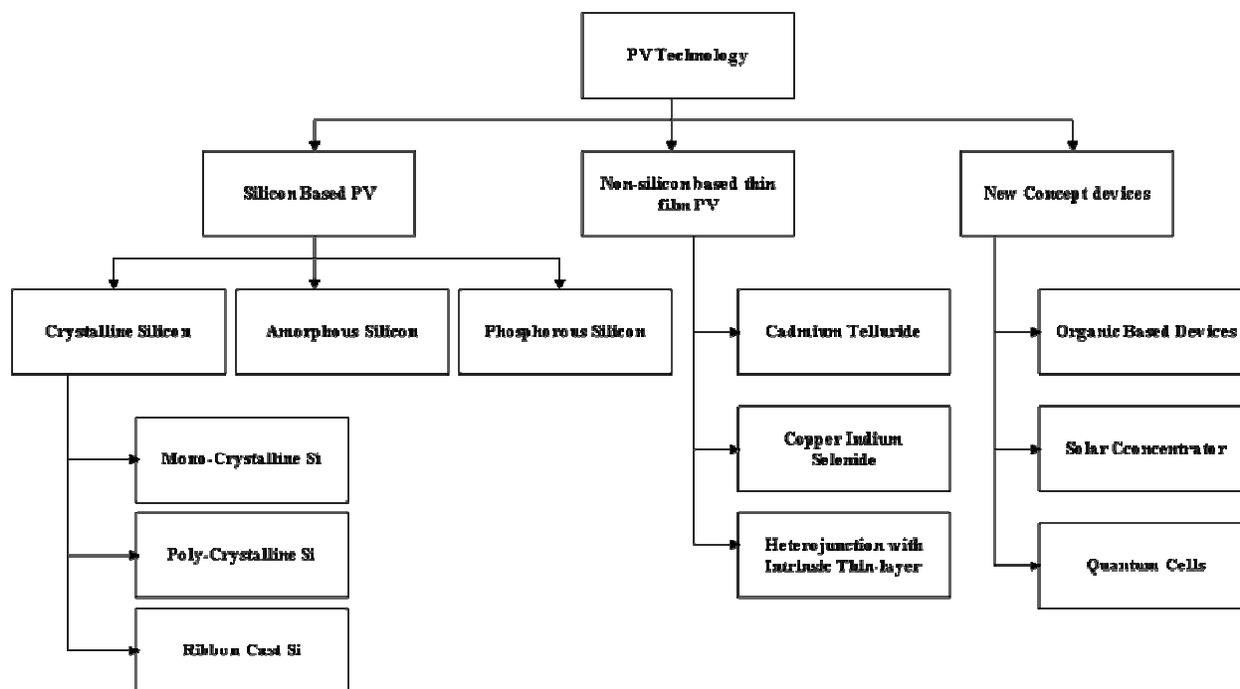


Table 1: Classification of photovoltaic on the basis of PV technology

PV Technology	Electrical Efficiency		Overall Thermal Efficiency		Overall Energy Efficiency	
	DP	SP	DP	SP	DP	SP
r-Si	0.1874	0.2031	4.1898	4.5260	0.5753	0.4125
m-Si	0.1874	0.2031	4.1898	4.5260	0.5753	0.4125
a-Si	0.0568	0.0616	4.0682	4.7633	0.4826	0.2939
p-Si	0.1610	0.1745	4.1632	4.5725	0.5553	0.3873
Cd-Te	0.0622	0.0675	4.0727	4.7532	0.4861	0.2984
CIS	0.1280	0.1388	4.1314	4.6317	0.5312	0.3565
HIT	0.1947	0.2110	4.1973	4.5133	0.5809	0.4195

Table 4: RMSE calculations of electrical, overall thermal and energy efficiency for different PV technologies for single and double pass air collector

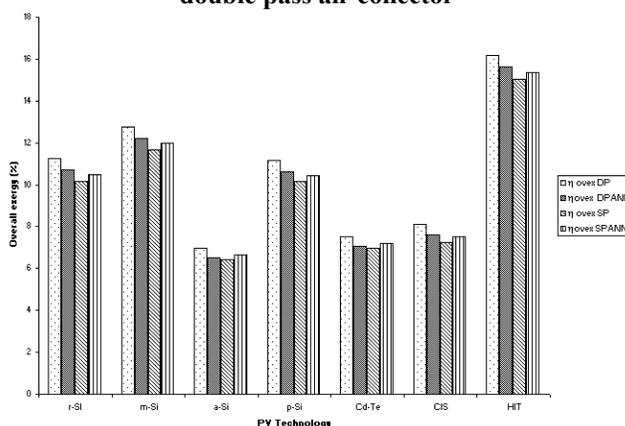


Figure 8: Annual variation of overall energy of single and double pass air collector of different PV technology

Open Source Software Reliability Growth Model by Considering Change – Point

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Submitted in April 2010; Accepted in November 2011

Abstract – *The modeling technique for Software Reliability is reaching its prosperity. Software reliability growth models have been used extensively for closed source software. The design and development of open source software (OSS) is different from closed source software. We observed some basic characteristics for open source software like (i) more instructions execution and code coverage taking place with respect to time, (ii) release early, release often (iii) frequent addition of patches (iv) heterogeneity in fault density and effort expenditure (v) Frequent release activities seem to have changed the bug dynamics significantly (vi) Bug reporting on bug tracking system drastically increases and decreases. Due to this reason bug reported on bug tracking system keeps an irregular state and fluctuations. Therefore, fault detection/removal process can not be smooth and may be changed at some time point called change-point. In this paper, an instructions executed dependent software reliability growth model has been developed by considering change-point in order to cater diverse and huge user profile, irregular state of bug tracking system and heterogeneity in fault distribution. We have analyzed actual software failure count data to show numerical examples of software reliability assessment for the OSS. We also compare our model with the conventional in terms of goodness-of-fit for actual data. We have shown that the proposed model can assist improvement of quality for OSS systems developed under the open source project.*

Index Terms - *Open source software, reliability assessment, software reliability growth model, bug tracking system, change-point*

1. INTRODUCTION

The advancement in the information technology has changed the dynamics of life and society as well as software development. It has added new dimensions like e-learning, e-conferencing, e-commerce, e-meeting e-governance..., and the list is now becoming endless. Since the mid 1990s, there has been a surge of interest among academics and practitioner in open source software. The design and development of open source software is significantly different from that of

proprietary software. Open source software is developed by community for community. The development of OSS is of interdisciplinary nature and needs knowledge and expertise from many scientific disciplines such as computer science, management and organization, social sciences, law, economics and psychology. In this paper, we measure the reliability growth of OSS quantitatively by measuring the remaining number of bugs in the software. The rest of the paper is organized as follows. Section A and B of introduction deals with literature review of OSS and change point problem in software reliability. In section 2I, we discuss modeling framework comprising notations, assumption and model development. Section 3 deals with model validation, numerical illustration and goodness of fit curves. Finally, section 4 deals with concluding remarks and future direction.

1.1 Open Source Software with Reliability

The use of open source software is increasing rapidly and its role is becoming high in different domains ranging from commercial, educational, to research. According to Gartner's report, about 80 percent of all commercial software will include elements of open source technology 2012 [24]. Open source was first evolved during 1970s. Richard Stallman, an American software developer, who believes that sharing source code and ideas is fundamental to freedom of speech, developed a free version of the widely used Unix operating system under GNU [5 and 25]. The spirit of open source software is the free right of using, reproducing, distributing and modifying the software, which creates an efficient economical, productive software development model: establishing commercial projects through the concept of open source, implementing collaborative development through the open source community based on the network, allocating resources optimizedly, increasing the transparency of projects, and reducing the risk of development [6]. Eric Raymond, the main proponent and co-founder of the open source project, is generally credited with establishing the movement of OS through his seminal paper "The cathedral and the Bazaar" [7] and attributed the open-source software development approach as:

"Given enough eyeballs, all bugs are shallow." (p. 41)

A classification of users and developers and their role as shown in figure 1 has been discussed in [17].

The author in [18] discussed many Claims and counterclaims for open source software on the basis of number of factors including cost advantage, source code availability, maturity, vendor lock-in and external support. In the available literature, many papers address the issue of reliability for open source software qualitatively. Paper [19] proposes a number of hypotheses and tries to analyze the relationship between openness and reliability. A study has also been carried out on

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bug report data of open source project and it has been concluded that traditional software reliability growth models can not apply to assess the reliability growth of open source software because the design and development of open source is different from that of closed source [1].

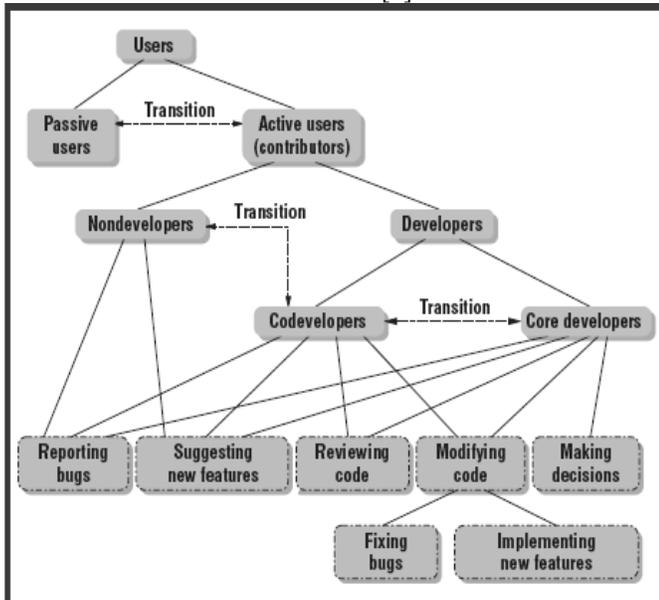


Figure 1[17]

A software reliability assessment method concerned with the software development environment of OSS has been discussed in [4]. It proposes software reliability assessment and optimization analysis method for OSS paradigm. Reliability growth models have been presented by considering user growth for open source software [23]. The paper also reveals that reliability growth curve of open source software is similar with that of closed source software by studying bug reported data from bug tracking system of software projects developed under open source environment.

1.2 Change Point Problem in Software Reliability

The fault detection rate may not be smooth and can be changed at some time moment τ due to changes in defect density, testing strategies etc. called change-point. Many researchers have incorporated change point in software reliability growth modeling. Many researchers have incorporated change point in software reliability growth modeling for closed source software. Firstly, Zaho [20] incorporated change-point in software and hardware reliability. Huang et al. [14] used change-point in software reliability growth modeling with testing effort functions. The change-point problem in OSS has been introduced by Singh et al. [15]. Kapur et al. [2, 13] introduced various testing effort functions and testing effort control incorporating change-point in software reliability growth modeling. Kapur et al. [10,11] proposed a software reliability growth model for errors of different severity using change-point. The multiple change-points in software reliability growth modeling for a fielded has been proposed by

Kapur et al. [9]. Later on SRGM based on stochastic differential equations incorporating change-point concept has been proposed by Kapur et al. [12].

2. MODEL DESCRIPTION

During middle and operational stage fault detection rate normally depends on other parameters such as execution rate of CPU instruction, code expansion or code coverage [21]. The success of OSS projects has been mostly attributed to the speed of development, reliability, portability and scalability of the resulting software. Recently, instructions executed dependent models have been proposed to measure reliability growth of open source software [23]. In this paper, we are considering number of instructions executed dependent software reliability growth model by considering change point for measuring the reliability growth for open source software..

(i) Notations

$m, m(t)$: Expected number of faults identified in the time interval $(0, t]$

$e, e(t)$: Expected number of instructions executed on the software in the time interval $(0, t]$

a : Constant, representing the number of faults lying dormant in the software.

k, β : Constants

$b(t)$: Fault removal rate as a function of testing time

(ii) Assumptions

Mathematical model, which can capture various types of growth patterns as the testing/debugging progresses, are proposed in this paper.

The proposed model is based upon the following basic assumptions.

1. Software failure phenomenon can be described by the Non-homogeneous Poisson Process (NHPP).
2. The number of failures during testing is dependent upon the number of instructions executed.
3. The number of instructions executed is a power function of testing time.
4. The fault detection rate may be change at some time moment (called change-point).

(iii) Modeling Framework

Using the above assumptions, the failure phenomenon can be described with respect to time as follows in [8]

$$\frac{dm(t)}{dt} = \frac{dm(t)}{de(t)} \frac{de(t)}{dt} \quad (1)$$

Let us consider the case when the rate at which failures occur depends not only upon the number of faults remaining in the software but also on the proportion of faults already detected. Based on this assumption the differential equation for fault identification / removal can be written as:

$$\frac{dm(t)}{de(t)} = \left[k_1 + k_2 \frac{m(t)}{a} \right] (a - m(t)) \quad (2)$$

Here k_1 is the rate at which residual faults cause failure. It is a constant as each one of these faults has an equal probability of causing failure. k_2 is the rate at which additional faults are identified without their causing any failure. Let the second component of expression (1) be defined as a power function of testing time i.e.

$$\frac{de(t)}{dt} = k_3 t^k \tag{3}$$

Substituting (2) and (3) in (1) we have:

$$\frac{dm(t)}{dt} = k_3 t^k \left(k_1 + k_2 \frac{m(t)}{a} \right) (a - m(t)) \tag{4}$$

It is a first order differential equation. Solving it with the initial condition $m(0) = 0$ we get:

$$m(t) = a \left(\frac{1 - \exp\left(-\frac{1}{k+1} b t^{k+1}\right)}{1 + \beta \exp\left(-\frac{1}{k+1} b t^{k+1}\right)} \right) \tag{5}$$

Here $b = k_3(k_1 + k_2)$ and $\beta = (k_2 / k_1)$

If we take $k = 0$ in equation (5), above model reduces to [3].

(iv) Proposed Model by Considering Change-Point

We can write differential equation for fault detection process i.e.

$$\frac{dm(t)}{dt} = b(t)(a - m(t)) \tag{6}$$

and if we take $b(t) = \frac{bt^k}{1 + \beta \exp\left(-\frac{1}{k+1} b t^{k+1}\right)}$ i.e a power

logistic function as follows in [26] and solving for equation (6), we get same solution as given in equation (5)

Now by considering change in fault detection rate at change point τ , we can write

$$b(t) = \begin{cases} \frac{b_1 t^k}{1 + \beta \exp\left(-\frac{1}{k+1} b_1 t^{k+1}\right)} & \text{for } t \leq \tau \\ \frac{b_2 t^k}{1 + \beta \exp\left(-\frac{1}{k+1} b_2 t^{k+1}\right)} & \text{for } t > \tau \end{cases} \tag{7}$$

Here, b_1 and b_2 are fault detection rates before and after change point.

The fault detection equation can be written as

$$\frac{dm(t)}{dt} = \begin{cases} \frac{b_1 t^k}{1 + \beta \exp\left(-\frac{1}{k+1} b_1 t^{k+1}\right)} (a - m(t)) & \text{for } t \leq \tau \\ \frac{b_2 t^k}{1 + \beta \exp\left(-\frac{1}{k+1} b_2 t^{k+1}\right)} (a - m(t)) & \text{for } t > \tau \end{cases} \tag{8}$$

After solving equation (8), we get

$$m(t) = \begin{cases} a \left(1 - \frac{1 + \beta}{1 + \beta \exp\left(-\frac{1}{k+1} b_1 t^{k+1}\right)} \exp\left(-\frac{1}{k+1} b_1 t^{k+1}\right) \right) & \text{for } t \leq \tau \\ a \left(1 - \frac{1 + \beta}{1 + \beta \exp\left(-\frac{1}{k+1} b_1 t^{k+1}\right)} \frac{1 + \beta \exp\left(-\frac{1}{k+1} b_2 \tau^{k+1}\right)}{1 + \beta \exp\left(-\frac{1}{k+1} b_2 t^{k+1}\right)} \right) \times \exp\left(-\frac{1}{k+1} (b_1 \tau^{k+1} + b_2 (t^{k+1} - \tau^{k+1}))\right) & \text{for } t > \tau \end{cases}$$

(9)

if we take $k = 0$, and $\beta = 0$, model reduces to [13] and [2] respectively

3. MODEL VALIDATION

To illustrate the estimation procedure and application of the SRGM (existing as well as proposed) we have carried out the data analysis of real software data set.

3.1 Description of Datasets

Data set 1(DS-1)

We collected all failure data of Keypass software developed under open source environment (www.sourceforge.net) from 19-Dec-03 to 27-Feb-07, 458 failures were observed. Keypass software is a password database utility. Users can keep their passwords securely encrypted on their computers. A single Safe Combination unlocks them all. From graphical view of data, we identify 19th month as change-point.

Data set 2(DS-II)

This data is cited from Fedora Core Linux (http://fedora.redhat.com/ and [4]), which is one of the operating system developed under an open source project. We have taken data up to release 3 for model validation. During the course of 57 days 164 failure were observed. From graphical view of data, we identify 17th month as change-point.

3.2 Comparison Criteria

The performance of SRGM are judged by their ability to fit the past software fault data (goodness of fit) and predicting the future behavior of the fault.

The Mean Square -Error (MSE)

The model under comparison is used to simulate the fault data, the difference between the expected values, $\hat{m}(t_i)$ and the observed data y_i is measured by MSE as follows.

$$MSE = \sum_{i=1}^k \frac{(\hat{m}(t_i) - y_i)^2}{k}$$

where k is the number of observations. The lower MSE indicates less fitting error, thus better goodness of fit [16].

Coefficient of Multiple Determinations (R²)

We define this coefficient as the ratio of the sum of squares resulting from the trend model to that from constant model subtracted from 1.

i.e. $R^2 = 1 - \frac{\text{residual SS}}{\text{corrected SS}}$.

R² measures the percentage of the total variation about the mean accounted for the fitted curve. It ranges in value from 0 to 1. Small values indicate that the model does not fit the data well. The larger R², the better the model explains the variation in the data [16].

Bias

The difference between the observation and prediction of number of failures at any instant of time i is known as PE_{*i*}(prediction error). The average of PEs is known as bias. Lower the value of Bias better is the goodness of fit [22].

Variation

The standard deviation of prediction error is known as variation.

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

Lower the value of Variation better is the goodness of fit [22].

Root Mean Square Prediction Error

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

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

Lower the value of Root Mean Square Prediction Error better is the goodness of fit [22].

5. NUMERICAL RESULTS AND ANALYSIS

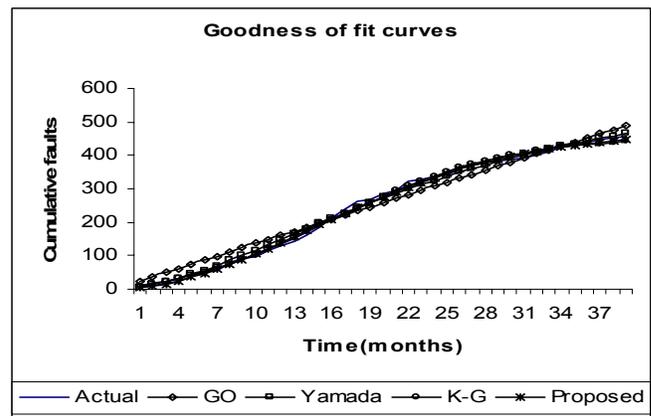
The parameter estimation and comparison criteria results for DS-I and DS-II of all the models under consideration can be viewed through Table I(a-b) and Table II(a-b) respectively. It is clear from the table that proposed model (equation 9) provides better goodness of fit for DS-I and DS-II. The proposed model gives total failure latent in software i.e. 467 against observed i.e. 458 failures, means 9 bugs are still remaining in software and 181 against observed i.e. 164 failures means 17 bugs are still remaining in software (a fairly reasonable estimate) For DS-I and DS-II. It has been also observed that GO model overestimates the value of parameter “a”.

Models	Parameter Estimates				
	A	b ₁ /b	b ₂	K	β
GO [27]	12515	.001	--	--	--
Yamada[28]	577	.075	--	--	--
KG[3]	457	.150			13
Proposed model Equation[9]	467	.0054	.0055	.8958	.0619

Models	Comparison Results				
	R ²	MS E	Bi as	Variati on	RMSPE
GO [27]	.99047	24.32	-0.95	5.25	5.333
Yamada[28]	.99353	16.51	-0.76	4.04	4.111
KG[3]	.99669	8.43	-0.35	2.92	2.938
Proposed model Equation[9]	.99685	8.04	0	2.86	2.861

Table I (a-b): Model Parameter Estimation and comparison Results DS-1)

For DS-I



Goodness of fit Curves

For DS-II

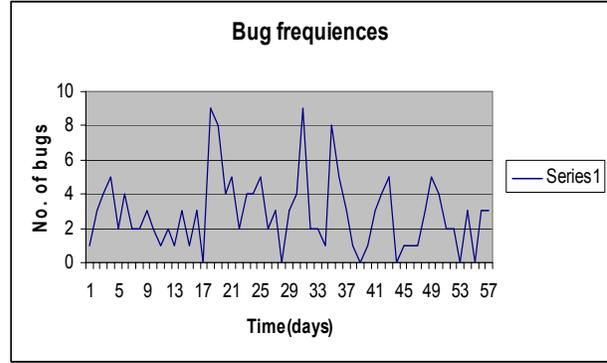
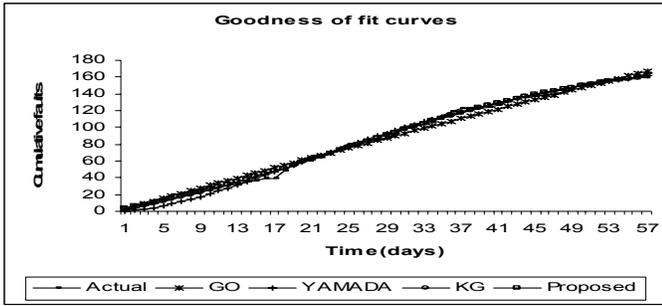


Figure3: Data set 1(DS-2) For DS-2

Models	Parameter Estimates				
	A	b ₁ /b	b ₂	k	β
GO [27]	1548	.002	-	-	-
Yamada[28]	196	.055			
KG[3]	185	.064	-	-	4.637
Proposed model Equation[9]	181	.072	.071	0	5.656

Models	Comparison Results				
	R ²	MSE	Bias	Variation	RM SPE
GO [27]	.97167	668.18	6.05	25.449	26.16
Yamada[28]	.99452	129.26	1.88	11.357	11.51
KG[3]	.99650	82.34	0.99	9.1334	9.188
Proposed model Equation[9]	.99719	66.30	-0.46	8.233	8.246

Table II (a-b): Model Parameter Estimation and comparison Results DS-2)
Bug Frequencies of OSS Projects (non cumulative bugs)

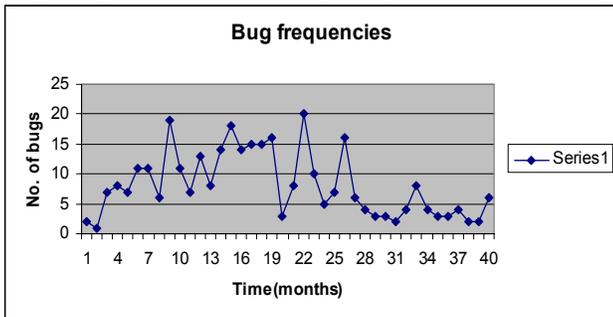


Figure2: Data set 1(DS1)

6. CONCLUSION

In this paper, we have proposed a software reliability model by considering huge user growth in case of open source software. The user growth is expressed in terms of number of instructions executed. The proposed model also incorporates change in fault detection rate due to drastic changes in reported bug on bug tracking system. Parameter estimates, comparison criteria results and goodness of fit curve has been also presented in comparison with conventional models. But, there is a need to present the model in a form that is friendly to the software developers.

In future, we will try to develop a general framework to measure reliability growth of open source software by considering detection and correction process (bug reporting and bug fixing).

ACKNOWLEDGEMENT:

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Attrition of Knowledge Workforce in Healthcare in Northern parts of India – Health Information Technology as a Plausible Retention Strategy

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Abstract - Faced with a global shortage of skilled health workers due to attrition, countries are struggling to build and maintain an optimum knowledge workforce in healthcare for delivering quality healthcare services. Forces that affect healthcare professional turnover needs to be addressed before a competent uniformly adoptable strategy could be proposed for mitigating the problem. In this study we investigate the effect of the socio-demographic characteristics on attrition of healthcare knowledge workforce in northern parts of India that have a wide gradient of rural and urban belt, taking into account both public and private healthcare organizations.

For this purpose healthcare professional attrition tracking survey (HATS) was designed. The data has been collected from a random sample of 807 respondents consisting of doctors, nurses, paramedics and administrators to explore the relationships between various factors acting as antecedents in affecting the job satisfaction, commitment and intention of a healthcare professional to stay in the job. Structured questionnaires were utilized as the data collection tools. Both public and private healthcare organizations in urban and rural areas were covered for the survey.

Descriptive statistics and factor analyses using analysis on Rotated Factor Matrix using Principal Components Analysis (PCA) in SPSS 16.0 package were carried out. Six factors of attrition namely Compensation and perks, Work Life Balance, Sense of Accomplishment, Work load leading to exhaustion, Need for automation and technology improvement, Break Monotony of Work have been identified as the main factors with a data reliability of 0.809%. Based on the survey response and analysis, a highly possible strategy of utilizing information technology implementation for increasing worker motivation, job satisfaction and commitment to reduce attrition has been proposed.

Index Terms - Healthcare professional, healthcare information technology, attrition Job satisfaction, work-life balance.

1. INTRODUCTION

Health care industry relies a lot on advanced medical technology, but it is also a labor-intensive industry. In recent times there has been increase in healthcare costs and healthcare

staff shortages leading to healthcare organizations undergoing changes [1,2]. Some of these changes have led to increased performance expectations and efficiency leading to decrease in staff morale and increase in attrition[3-5]. In this paper, the terms “health care professionals” and “human resources for health” are used interchangeably, comprise of doctors, nurses, paramedics, hospital administrators. Researchers have identified the effect of shortage of skilled workers in hospitals lead to high patient mortality, job dissatisfaction and burnout[6, 7]. The migration of health professionals has been debated to be one of the main reasons of attrition and has been the main focus of such studies [8, 9]. It has been argued that opportunities for professional training, higher salaries and perks and better living conditions act as “pull” factors, surplus production of health personnel, resultant unemployment, less attractive salary, stagnation or underemployment coupled with lack of infrastructure act as “push” factors for the youth to migrate. A number of strategies have been discussed to counteract migration [8-11]. Human resources management plays a significant role in retaining health care workers [12]. Health care industry relies a lot on advanced medical technology, but it is also a labour-intensive industry. As the Indian healthcare industry experiences phenomenal growth, hospitals are moving forward towards excellence rather than survival and gearing up to fulfil the gaps in three key areas of people, process and technology. India is the one of the most populous country with larger population in rural areas[13] with an estimated 27.5% of Indians still living below the poverty line and cannot afford the healthcare provided by private organizations due to cost and unreachable locations. Most of them utilize the public healthcare provided by the government organizations. In a recent survey of dichotomy existing in the utilization of private and public health services in India it emerged that a bias towards the use of private health services in spite of the earlier mentioned problems may be due to the view that public healthcare services are not of good quality[14].

Even with greater number of health care professionals viz, doctors, nurses, pharmacists, paramedics getting trained the Indian healthcare sector is suffering from acute shortage of healthcare professionals and facilities delivering quality healthcare services to the citizens[15]. According to survey carried out in 2008-09, India has only around 85,000 doctors practicing modern medicine and 1.5 million nurses to serve its more than one billion population. It has 0.8 beds/ 1000 population, and 0.6 doctors / 1000 population (lowest in the world). This means 6 doctors per 10,000 patients with a doctor/ nurse ratio of 0.83 compared to china having 20. This

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large disparity has indicates a high attrition of knowledge workers in healthcare.

Implementation and utilization of information technology in healthcare (commonly identified as Health Information Technology or HIT) has proven to be of immense benefit like, improved patient care, reduced waste and inefficiency in services, reduction in adverse drug effects and medical errors etc [16-18]. Since healthcare professional job satisfaction also has important implications for quality healthcare delivery, the relationship between the use of HIT and physician career satisfaction should be probed. In an earlier small scaled study [19] it was determined that using more information technology was the strongest positive determinant of physicians' being very satisfied with their careers.

India has joined the bandwagon of information technology adaptors and is one of the main global forerunners in this area[20,21]. A number of government policies and programs have been developed pertaining to use of healthcare information technology (HIT) to improve the quality of healthcare delivery [22,23]. Major private hospitals (corporate) and public hospitals at state level have implemented hospital information systems for patient management, employee management, inventory, pharmacy, laboratory etc, [24,25]. While there are articles that indicate there is greater danger of brain drain in the area of healthcare in India, there are no detailed studies that offer effective retention strategies for reducing the attrition in Indian scenario.

The aim of this paper is to develop a probable strategy that could use implementation of information technology as a probable strategy to reduce attrition. To achieve this objective, we use the data collected from doctors, nurses, paramedics and administrators form different public and private organizations both in rural and urban area. This is in contrast to the earlier studies where the sample belongs to homogenous groups or to identical location of work.

2. MATERIALS AND METHODS

Data for this study came from the second round of the Healthcare Attrition Tracking Survey (HATS). HATS is a part of the multi-level study of the ongoing doctoral research program conducted to address these issues regarding attrition among healthcare professionals and to determine if implementation of Health Information Technology in hospitals and healthcare centres can work as an effective retention strategy in India. HATS was conducted among a non homogeneous group of skilled healthcare professionals such as doctors, paramedics, administrative and managerial staff in public as well as private hospitals covering rural and urban regions of Northern India. The survey was designed based on a non-formal discussion with nearly 40 healthcare professionals who had participated in the International Conference on Medical Informatics held by Indian Association for Medical informatics (IAMI) in Hyderabad, India (Nov. 2009).

In the first round pre-test studies were conducted in five hospitals (minimum 100 beaded) one each from the five states

of Delhi, Haryana, Uttar Pradesh, Madhya Pradesh and Jammu and Kashmir. This was followed by focus group discussions. Based on the results obtained from these an elaborate second round of data collection using a complex sampling design of 40 Hospitals randomly selected to yield a non-biased representative sample of healthcare workforce both in rural and urban areas led to the present paper. Out of the 2000 respondents approached for the survey, data was collected from 807 respondents using the questionnaire tool developed by the authors and reviewed by the experts in the field. The major challenge faced was in obtaining the permission from the HR authorities to conduct the survey due to issues of transparency of the system and HR policies.

Each participant was screened to determine survey eligibility based on the following criteria before filling the questionnaire:

Criteria 1 (origin): Health care professionals should be of Indian origin. **Criteria 2** (Completion of Training): Respondents should have completed their training and licensed in India. **Criteria 3** (Job Satisfaction): Respondents were initially questioned regarding their view on current job satisfaction. Those who responded “don't know” or “refuse to answer” were excluded from the HATS survey.

The selected respondents were provided questionnaire that contained 60 questions that could provide insight to their job satisfaction, work environment, self development, supervisor relationship, reasons for leaving job, future plan, their practical knowledge, attitude and usage of HIT. The responses were recorded on a five-point Likert scale from 1 (strongly agree) to 5 (strongly disagree), yes/ no option and as open – ended for inviting their views.

Statistical Analysis: A random 5% sample of responses was checked for coding errors. Wherever the data was left uncompleted and unclear the respondents were approached individually to recollect the data. The Reliability Test on Data was 0.809%. Data were analyzed by means of Factor Analysis on Rotated Factor Matrix using Principal Components Analysis (PCA) in SPSS 16.0 package to determine the relationships between factors influencing attrition. Descriptive statistics included percentage rates for categorical variables, means and standard deviations. The categorical variables considered were gender, marital status, age, education, work nature, location, organization type, work experience and income. Chi-square tests to find the associations between the reasons indicated for leaving a job and the number of respondents and t-tests to compare the contribution of each categorical variable on the forces of attrition were performed. Descriptive statistics were performed to analyze the knowledge, usage and the type of HIT used by the respondents.

3. RESULTS

The sample was predominantly male and the proportion ranged $57.6 \pm 0.5\%$. The respondents were mostly middle-aged (52.1%) in the range 26 to 35 years and mostly married (62.4%) living with family. Nearly 20% of the married

respondents especially male were living alone with their family in their respective home towns. Almost two-thirds of the participants were doctors, paramedics, nurses, administrators who had less than a year of practice in the current organization and also middle-aged. 54.7% of the participants were graduates while the postgraduates were 34.5%. Undergraduates were few (11.6%). Approximately nearly equal number of doctors and nurses, paramedics participated while the administrators were less. There was not much difference in the number of participants based on their income.

During the survey it was identified that many respondents had shifted job within a year and some have decided to do so within short period of time. Through open ended questions the reasons for shifting and their future plan to shift were ascertained (**Fig. 1**). The effect of socio-demographic details on the responses were calculated and plotted in graphs. Chi-test was performed to ascertain the significance of these on migration.

It was observed that gender, age, marital status, nature of the work profile, work experience and wage to have significance with respect to the reasons for shifting job. The three main reasons identified were heavy work load, no social benefits and low pay structure. The distribution of the salary drawn by the respondents had greater significance with the reasons identified than other variables. Non-cooperative boss and frequent transfers were also identified.

The factor analysis on Rotated Factor Matrix has led to 6 Factors of attrition as under:

Factor 1: Compensation and Perks

Factor 2 : Work Life Balance

Factor 3 : Sense of Accomplishment

Factor 4 : Work load leading to Exhaustion

Factor 5: Need for Automation and technology Improvement

Factor 6 : Monotony of Work.

All the above six factors were compared with the 9 descriptive parameters indicated in **Table I**. Only those that had a significance effect on the forces of attrition are described in detail in this paper. Gender, marital status, age and education did not contribute much. Time spent by a healthcare professional at an organization does contribute to the attrition. Two factors namely how the organization contributes to the work – personal life and extent of the work load seem to be the major contributors.

Stress due to over workload was the main contributor when type of the healthcare organizations ie. private versus public was considered. Nature of the work of the respondents considered seems to throw significant contributions to attrition. Nearly 4 out of the 6 factors were affected. All the four factors namely, Compensation and Perks, Work -Life balance, Sense of accomplishment and Need for Automation and Technology all were significant at 0.01 level (**Table II**).

Irrespective of the salary package five out of the six factors of attrition identified were significantly found to contribute to attrition. Compensation and Perks need for implementing

automation and technology all contributing to job satisfaction in terms of sense of accomplishment seem to be major affecting factors (**Table III**).

The proportion of respondents proposing to shift the existing job within next few years was further investigated. The doctors were more prone to shift jobs compared to others (**Fig.2**). It was determined the proportion of those who did not plan to change jobs in near future were more than those who had planned to shift within near future. The male health professionals especially those who were married and health professionals with low income packages were very much keen to change jobs. Also middle aged professionals were keener to shift with job satisfaction and salary being indicated as the prime reasons.

The respondents were also tracked regarding their usage of HIT in order to determine their awareness and willingness to adopt HIT to increase the job efficiency (**Fig 3**). It was also observed that health professionals within minimum postgraduate education and those who were middle aged had greater computer awareness.

4. DISCUSSION

Results show a significant difference in attitudes towards factors affecting attrition. The results provide evidence to demonstrate that economic motivation as a factor for changing jobs is not an independent, stand-alone factor in itself, but rather a component of broader factors that takes into consideration the yearning to improvise both developments in both professional and personal front.

The respondents were further questioned to ascertain the need of HIT in their work and their willingness to undergo further IT training. 80% of the respondents felt the need of implementing HIT to simplify their work and almost all of them were ready to undergo training with overall percentage of 60% respondents being favourable.

This finding is a departure from the previous studies that indicate the intention of healthcare professionals to frequently change jobs and migration to foreign countries are mainly dependent on remuneration [26,27].

Based on a broader framework of understanding derived from the results of this study, a number of inferences can be drawn relating to strategies to encourage retention.

Factor 1 Compensation and perks that refers to providing incentives and extra income in terms of benefits need to be structured through contested policies of public and health sector reforms that would induce the health care workers to continue in the existing organization [11].

Factor 2 Work life balance depends on the nature of the work, type of the workplace and issues in the workplace. Introducing strategies like flexible work options, specialized leave policies, paid maternal leave, paternal leave, etc. can increase the satisfaction level of the healthcare professionals. Doctors and administrators who spend greater time of the day in the hospital are affected by work life balance issues.

Factor 3(Sense of accomplishment) is about job satisfaction felt by the healthcare workers. This does not depend upon the

monetary issues and it deals with the sense of achievement and fulfilment felt by the employees. A key to build such a culture is by involving the medical staff members to make collaborative decisions in clinical and operational issues[28].

Factor 4 (Work load leading to exhaustion) and **Factor 6** (Break monotony of Work) refers to the overworked health care professionals. While this was not much of the problem in urban hospitals interviewed, it was more prominent in the rural areas. This is due to higher workloads, coverage of large geographic areas, lower access to specialists, and to a broad array of patients. This specifies the need to improve working conditions and the professional interface with other health professionals and society in the rural areas. Planned interventions could employ non-financial incentives such as recognition by management, performance review and improving inter-professional working relationships, to uphold and strengthen the professional ethos of health professionals [29].

Factor 5 (Need for Automation and Technology Improvement) implies the requirement of HIT implementation in the health care industry. The supply of good support, education and training is a key approach to attracting and retaining allied health practitioners, especially in rural locations[12,30]. HIT enables health care professionals to confidently access, interpret, and apply organisational knowledge, patient care procedures, professional workforce competencies, best practice knowledge and other skills information in a manner that improves patient satisfaction, achieves positive clinical outcomes, and maximises cost savings for the organisation [18,19]. In this present study irrespective of gender, age & education, location the importance of implementing HIT was stressed by almost all respondents. The nature of work done by respondents seems to play a significant role in assigning the need for automation and technology as a major factor of attrition. The doctors seemed to be the preferred users of computers, than the healthcare administrators and the nurses and paramedics. Also it was identified that the HIT usage was more prevalent in urban hospitals than in rural hospitals. Moreover, the difference in the salary does not seem to detract the fact that implementation of HIT was seen as a basic requirement of healthcare professionals.

Based on the discussions with the respondents it was understood that the healthcare professionals leave their jobs due to the greater job opportunities and higher pay packages in abroad. Attrition of post graduate doctors is seen to be in lure of attractive salary packages, better technologically equipped healthcare facilities besides higher studies. Medical professionals working in rural private health set ups found reasons for leaving their job in search of opportunities that not only provides good financial benefits but also better professional development through adoption of newer technologies. Given the industry standard salary, they still were ready to shift jobs to organizations that were endowed with advanced technologies of healthcare delivery.

Based on the observation the following it can be understood that for any hospital and health care system the planning of manpower (human resources) is very vital[31]. Detailed planning of human resources and a plan of action for their selection, training and deployment are very important factors to be considered right from the project planning to implementation and should be undertaken at the inception of the project.

Other than better salary packages and financial benefits, better work environment etc implementing HIT to reduce work load stress, enrich knowledge and core specialization, improve quality in service can work as an ideal strategy to increase job satisfaction of healthcare professionals thereby reducing attrition. This also reduces medical errors and increases quality in healthcare delivery [18,32]. Healthcare is rapidly becoming an interconnected ecosystem, with IT as its circulatory system. While the above strategies can be uniformly followed among all healthcare professionals irrespective of their nature of work and location the following guidelines may be followed especially in India. Since all the processes of recruitment and selection are critical and attrition rate of knowledge workers in Healthcare is significant, the healthcare industry should focus on employing right talent and develop the talent to increase retention in the organization for a longer period of time.

A potential solution to bridge acute shortage of healthcare workers and reduce attrition rate is through providing accessibility to online healthcare, which has emerged as very important tool for offering healthcare services that can be accessed by patients across boundaries. Online healthcare connects patients and doctors via internet services. Online health portals can reduce workload and streamline processes for consultations, booking appointments, maintaining patient health records, getting second opinions, among various other services offered.

Healthcare professionals must be provided financial help and resources to further their knowledge in the realm of HIT, mandatory practical exposure to using computer and internet etc. They should be offered incentives to encourage them to use the technologies implemented. They should be made aware of the benefits that would increase by using computers to reduce their work load, increase quality of service etc. They should also be trained to use the technology to learn about guidelines, surf medical and health databases to retrieve vital information, to retrieve information from journals, e-books, to keep in touch with professional groups etc. Training should be provided to them to reduce the fear of increase in work complexity through the use of technology.

Implementation of Technology and adoption of Healthcare Information Technology applications and best practices would result in simplifying processes. The benefits would be in terms of Unique Health Identification Number (UHID) for each patients, Electronic Medical Record (EMR), Telemedicine, Reduction in Physician Errors, Time Savings in processes such as information retrieval, Adoption of International Standards and best practices, Instant Availability of Administrative Data,

increased Financial Savings and Clinical Trials & Research. This in turn would bring in transparency in the system and healthier working conditions. Improved efficiency and profitability would lead to better employee compensation and working condition thereby leading to retention of knowledge workers in healthcare.

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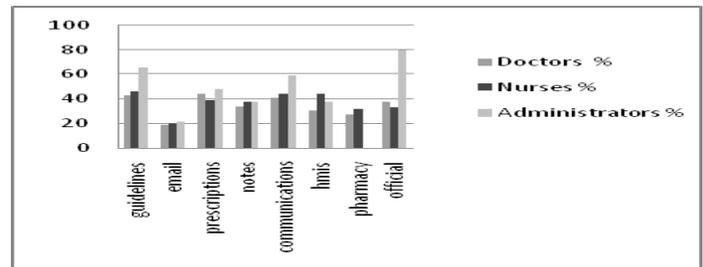
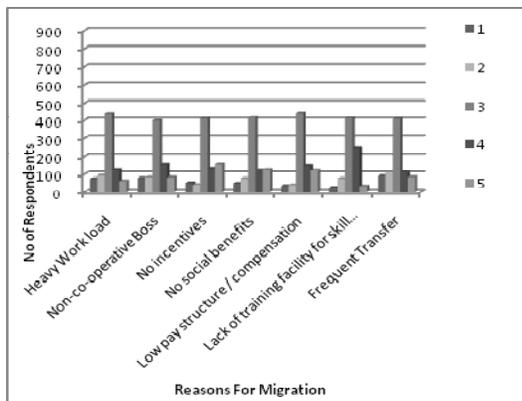


Figure 3: Proportions of Respondents using IT

TABLE I Demographic details of the respondents

		N=807	
1	Gender		
	Male	57.6%	(461)
	Female	43.2%	(346)
2	Age		
	17-25	18.7%	(150)
	26-35	52.1%	(417)
	36+	30%	(240)
3	Marital Status		
	Married	62.4%	(499)
	Unmarried	38.4%	(307)
4	Work Experience		
	< 5 years	76.1%	(609)
	> 5 years	24.7%	(198)
5	Education		
	undergraduate	11.6%	(93)
	graduate	54.7%	(438)
	postgraduate	34.5%	(276)
6	Nature of Work		
	Doctors	38.9%	(312)
	Nurses & paramedics	37.1%	(297)
	Administrators	24.7%	(198)
7	Income (Rs)		
	upto 10,000	20.5%	(164)
	10,000-20,000	18.9%	(151)
	20,000-30,000	26.6%	(213)
	30,000-40,000	16.6%	(133)
	>40,000	17.9%	(143)
8	Type of Hospital		
	Public	39.2%	(316)
	Private	60.8%	(491)
9	Location of Hospital		
	Urban	72.6%	(586)
	Rural	27.4%	(221)

Continued on page no. 420



1. Strongly disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree

Figure 1: Reasons provided for shifting jobs within last 1 year

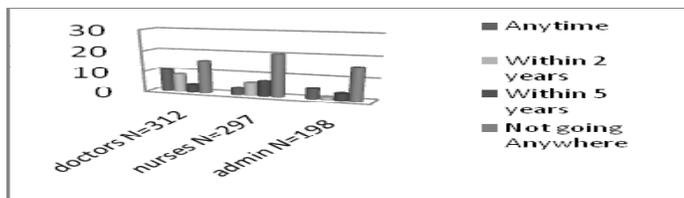


Figure 2: Proportions of Respondents planning to shift jobs

Optimization of Material Procurement Plan – A Database Oriented Decision Support System

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Abstract - Recently, the business in steel has undergone a sea change. Customer requirements for steel products have become increasingly demanding in terms of better quality and specification. Globalization has thrown open the market to intense competition. The rise in raw material cost has put pressure on steel industry to optimize the procurement strategy time to time. It has become imperative to re-look at the production strategies and production costs to work out methods to address the market situations in a dynamic manner. Minimization of the production cost in a Blast Furnace (BF) in an integrated steel plant is a complex problem as it associates the quality, quantity, cost & freight of raw materials along with the production targets and present operating regimes. Coal forms a major source of cost in the entire gamut of Iron & Steel production. Coal quality has a direct bearing on the BF productivity and the final cost of hot metal. Steel Plants procure coal based on the quality requirements, coal availability and linkages with coal sources. This paper is based on application software that deals with the procurement of coal based on optimization techniques integrated with heuristic and statistical models.

The software has been developed using C programming language, Oracle Developer tools as front end and oracle database as backend. This is an excellent tool for finalizing coal procurement plan, with a view to minimize hot metal cost and achieve desired coke quality at minimum cost. The software can be also be utilized for assessing the effect of Rupee / Dollar parity, effect of quality of any individual coal etc. on coal procurement plan and hot metal cost.

Index Terms - BF: Blast Furnace, M10: Micum 10 index, DSS: Decision Support System

1. INTRODUCTION

Hot metal production process in an integrated steel plant is shown in Fig. 1. Coke made from coal blend at coke oven, iron ore, sinter and other burden materials are used in blast furnace for production of hot metal. Coke is the most important raw material fed into the blast furnace in terms of its effect on blast furnace operation and hot metal quality. It is well known that use of superior quality coke in blast furnace results in improvements in productivity and coke rate. Coke is produced

from coal which is procured from different indigenous sources as well as sources abroad. These coals have different qualities like ash, volatile materials etc.

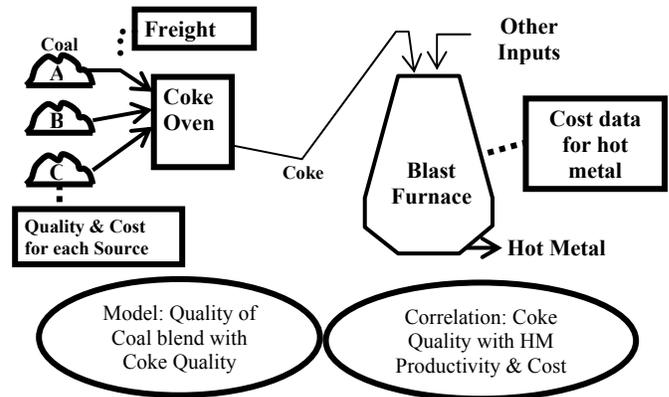


Figure 1: Schematic of hot metal production process

Customers today have different options for selecting the best. They are looking for cheaper steel with better quality. This necessitates the manufacturers to have production at optimum cost. Coal accounts for significant part of hot metal cost. Selection of coal for integrated steel plant is complex as it is governed by several logistics. One has to ensure lower ash content as well as the ranking of the coal suitable for bearing burden load in blast furnace operation. Most economic blend of Primary Coking Coal (PCC) and Medium Coking Coal (MCC) suitable for operation is the prime objective.

At first glance it seems that more use of cheaper coal such as indigenous coal shall be economical. However, it is not so. The developed application software helps in decision making for selecting the right combination of coals from different sources in order to minimize the hot metal production cost in a steel plant. The software simulates different operating scenarios at the plant, then weaves them to arrive at coal procurement plans and finally optimizes to get minimum cost hot metal solutions for a plant for a given range of target productions and operational constraints. This can also be used in techno-economic evaluation of new coals including imported coals.^[1] Steel producers have been using different technologies to produce iron at minimum cost by minimizing the coal procurement cost as well as by using proper blend of coals suitable for blast furnace production. The scope of this Decision Support System (DSS) software is limited only to minimum cost hot metal production. It covers the steel plant operation up to blast furnace and basically studies the effect of

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coal quality & cost on the hot metal cost. It simulates various operating scenarios to arrive at a minimum cost hot metal solution by integrating different models namely Blast Furnace model, Coal Blending model and Coal Distribution model.

2. OBJECTIVE

Optimization of raw materials procurement at corporate level for different plants from different sources is a complex one. There can be number of sources with varying qualities as well as costs and transport logistics. Supply from all of these sources may be possible to all the plants. There are various constraints that need to be addressed before finalization of any procurement plan e.g. limited supply from the source, the coal quality variation, logistics of supply and quantity required at each unit to meet its production target. Only human experience and judgment is used to arrive at a coal distribution plan in many cases now-a-days.

The development of this decision support system was done with an aim to:

1. Fairly accurately predict the input and output costs
2. Optimized coal procurement and hot metal solution
3. Provide alternative choices to help decision making

3. APPROACH

Lot of work has been done in establishing the relationships between coal parameters and coke parameters. The coke quality parameters considered are Micum 10 (M10), coke ash etc and the coal parameters considered are coal ash, volatile materials etc. Though many techniques have been tried in blast furnace, statistical techniques have been found to be more successful compared to other models for the process. This is due to the fact that blast furnace is a multi variable process such as blast temperature, blast pressure, blast volume, oxygen enrichment, steam, top temperature, top pressure, above burden temperature, charging sequence, burden and many others. Effect and relation of these variants and complexity of the process is still not well understood.^{[3],[4]}

Standard linear programming fails to optimize a function where the parameters involved exhibit a non-linear relationship.^[3] In this software a combination of process model and linear programming method has been used. The process models are basically statistical and heuristic models. The models helped in working out the minimum cost hot metal production through optimization of total coal cost. The system consists of the following main components^[1]:

1. Blast Furnace Production Rule Model
2. Coal Blend Model
3. Coal Distribution Model
4. Decision Support System (DSS) Simulator & Interface

Cost of hot metal production is the sum of coke cost, blast furnace operational cost, blast furnace burden cost, fixed cost, freights, interest & depreciation and the blast furnace gas. Burden cost consists of cost of iron ore, sinter and other burden materials. The coke cost is sum of landed coal cost, fixed cost, interest & depreciation, operational cost of coke oven and the

returns from the by-products. Landed coal cost in the plant is sum of two components – basic coal cost and freight charges incurred to transport the coal to plant. Coal is the major source of cost in steel plant. It is approximately 55-65% of hot metal cost.^{[1],[8]} In case of scarcity of proper coking coal within the country, coal is imported. This involves foreign exchange component too. To solve this issue, software programs have been written and a database oriented software approach has been adopted for coal procurement from indigenous as well as imported sources for optimum solution.

3.1. Blast Furnace (BF) Production Rule Model

Coke is the major input that affects the performance of a blast furnace. It is difficult to predict the effect of coke quality on blast furnace productivity and coke rate. Based on the experience, the working rules were defined and validated by the blast furnace experts from different steel plant^[2]. The working rule predicts the coke quality in terms of M10 and coke ash requirements for targeted productivity. The working rules were validated using production data. Results from working rules for blast furnace are found to be satisfactory and reliable.^[1] The working rules are written in PL/SQL and the data generated is stored in Oracle^{[7],[9]}.

3.2. CAL Blend Model^{[3],[4],[5]}

Coal blend model defines the relationship between coal quality parameters with coke quality parameters. The model considers only the measurable and regularly monitored parameters like volatile matter and ash content. It uses volatile matter (VM) and ash for coal blending while M10 and coke ash for coke property. The aim is to decide the coal blend quality parameter for specified coke quality. The program for this model has been written in C programming language. The equations are established for each steel plant separately based on the plant operating practices and the technological regimes.

3.3. COAL Distribution Model

Coal distribution model is based on the optimization program^{[6],[8]}. It generates the minimum cost coal linkage plan subject to the desired coal blend quality. The model incorporates the various constraints as follows:

1. Coal availability
2. Coal quality
3. Coal quantity requirements
4. Coal quality requirements
5. Coal transport linkage
6. Imported coal requirement limit
7. Coal type wise requirement

The model also uses various cost parameters like basic coal cost, freight cost and rupee/dollar parity for calculating the minimum cost coal linkage plan. As per the BF model different coke quality parameters combination may give similar hot metal production. Also different coal blend may yield same coke quality. Under such situation, cases are evaluated on

economic scale. This module is written in Pro*C and this is closely coupled with blast furnace and coal blend models^[9].

3.4. DSS SIMULATOR AND INTERFACE

The DSS engine simulates various operation practices for a minimum cost hot metal solution by integrating the three models viz, blast furnace model, coal blending model and coal distribution model. DSS simulator provides for^{[1],[8]}:

1. Definition of present operating scenario
2. Simulation of different operating scenarios
3. Application of blast furnace model to work out coke quality & quantity requirements
4. Application of coal blending model for blend needs
5. Integration of various cost, currency, conversion rate parameters and coal distribution model
6. Working out of a least cost solution for each scenario
7. Cost optimization for different production range

This module provides for suitable GUI (Graphics User Interface) to facilitate entry of operational base data, coal sources, constraints, cost figures for coal and other burden materials, interest depreciation, operating cost, freight charges and currency conversion rate etc^{[7],[8]}. It also provides for interfaces to see the details of different outputs in user-friendly manner. All GUIs have been developed using Oracle Developer tools.^[9]

4. SCHEME

The application software has been developed for minimization of cost of hot metal at company level through optimized procurement plan for coal. To validate the model with plant operating data, it was felt necessary to carry the optimization for one plant at a time and later on integrate for the whole company. The different inputs to this system are:

1. Present operating parameters e.g., hot metal production, productivity, coke rate, coke ash etc.
2. Blast Furnace volume, working days etc.
3. Coal source, type, quality, supply constraints, freight, cost, transportation loss, handling loss etc.
4. Blast furnace coke yield i.e., coal to coke ratio
5. Coal usage constraints by source, imported coal usage, quality constraints
6. Operational fixed costs for coke oven & blast furnace
7. Currency conversion rate

The model calculates different costs for the given range of hot metal production in small steps. It outputs the coal cost, coke cost, variable cost and total cost of production^[8]. For each production level, it gives the coal procurement plan from different sources at minimum cost. Model displays different kinds of trend graphs such as hot metal productivity vs. coal cost per ton of hot metal, hot metal productivity vs. coke cost per ton of hot metal, hot metal productivity vs. variable cost per ton of hot metal, hot metal productivity vs. hot metal cost per ton etc. Subsequently one can also generate trend graphs for imported coal %age vs. coal cost / coke cost / variable cost / hot metal cost. These graphs are useful for country like India

where the good quality coking coal is scarce and there is always a need to import the same.

5. RESULT & DISCUSSION

Coal accounts for significant part of hot metal cost. Selection of coal for integrated steel plant is complex as it is governed by several logistics. The most economical coal procurement plan differs with change in coal cost, transportation cost as well as the currency conversion rate. Considering all these factors, decision making for the best option is tough.

Trials were conducted with real life data for Bhilai Steel Plant, SAIL. The simulation model revealed that minimum hot metal cost/ton was achieved at x_1 level of productivity corresponding to x_1 % of imported coal. Coal from captive mines of SAIL was shown to be used to its maximum capacity at the minimum hot metal cost/ton. Model indicated higher use of imported coal will lead to higher level of productivity but hot metal cost/ton will shoot up. This was on account of coal from captive mines getting replaced by imported coal. The cost difference between the two was quite high.^[8]

6. CONCLUSION

The developed software is an excellent tool for finalizing coal procurement plan with a view to minimize hot metal cost and achieve desired coke quality at minimum cost. It can also be utilized for assessing the effect of Rupee/Dollar parity, quality of individual coal on coal procurement plan and hot metal cost.

FUTURE SCOPE

Coal Blending and Blast Furnace models can be further refined. Rule based part of the model may be replaced by the equations governing the process. The system can be used in any steel industry with tuning of model parameters used as per the plant practices.

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Continued from page no. 416

Factors of Attrition	W1		W2		W3		W1 V/s W2	W1 V/s W3	W2 V/s W3	F- Value
	Mean	SD	Mean	SD	Mean	SD				
Compensation and Perks	2.88	.84	3.03	.71	2.53	.80	-	*	*	11.52**
Work life balance	2.65	.78	2.80	.55	2.44	.70	-	*	*	7.77**
Sense of accomplishment	2.67	.49	2.77	.49	2.6	.55	-	-	*	3.39**
Work load leading to exhaustion	2.88	.81	2.94	.74	2.9	.84	-	-	-	.24
Need for Automation and technology improvement	2.17	.73	2.40	.72	2.17	.69	*	-	*	4.24**
Break Monotony of Work	2.94	.83	2.92	.51	2.92	.62	-	-	-	.03

NS : Not Significant * Significant at 0.05 level ** Significant at 0.01 level

Factors of Attrition	I1		I2		I3		I4		I5		compare	F - Value
	Mean	SD										
Compensation and Perks	3.00	.69	2.87	.88	2.61	.85	2.99	.77	2.9	.73	I2 Vs I3 I3Vs I5 I3 Vs I4 I1 Vs I3	3.45**
Work life balance	2.73	.47	2.66	.68	2.57	.80	2.79	.75	2.57	.67	-	1.49
Sense of accomplishment	2.81	.51	2.68	.50	2.65	.56	2.83	.49	2.50	.38	I1 Vs I5 I3 Vs I4	4.93**
Work load leading to exhaustion	3.01	.69	2.95	.77	2.74	.72	2.95	.82	2.95	.97	I1 Vs I3	1.57**
Need for Automation and technology improvement	2.47	.78	2.39	.63	2.18	.75	2.24	.69	1.98	.65	I4 Vs I5 I2 Vs I5 I1 Vs I5 I1 Vs I3	5.29**
Break Monotony of Work	3.02	.43	3.02	.63	2.97	.75	2.73	.73	2.85	.76	I3 Vs I4 I2 Vs I4 I1 Vs I4	2.33**

INS : Not Significant * Significant at 0.05 level ** Significant at 0.01 level

Rough Set Techniques for 24 Hour Knowledge Factory

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Abstract - 24 Hour Knowledge Factory [1] is the work culture that incorporates different people contributing together in collaborated manner on various modules of the same project. But as advancements occurred, it was found that the approach is as difficult to realize as it is to imagine. The smooth work flow amidst the personnel demands attention. This paper discusses a software solution to easily implement this idea by designing a workflow system between the programmers who are working in the different places in 24-Hour realm. The software presents the user interfaces to enable an employee to grasp the work done until now easily. The interface creates optimized tables generated using the rough set theory. This theory gives us a fair view of the work required by providing lower and upper approximation along with various rules that could help us to find these optimum sets. Software also facilitates the developer at the immediate next shift to be sure of the code in which he is going to work.

Index Terms - 24 Hour Knowledge Factory; Workflow Design, Rough set; Upper Approximation; Lower Approximation; 24- Hour Development; Follow the Sun

1. INTRODUCTION

24 hour knowledge factory may be considered as a process of working shifts at different places which are not only geographically distant but also temporally far from each other [1]. It involves collaboration of three or more centers in different time zones handing over work to each other in shifts. The centers are connected using internet or dedicated networks which are used to pass knowledge from one work location to other. Each center completes its work in its given time and then the work is handed over to another center which has the day time corresponding to this center's night period. This is practiced until whole 24 hour cycle is completed.

The concept of 24 hour Knowledge factory is not new. The work to improvise it is now for more than a decade old now. The past work are summarized in [1,13,14] carrying different perspective towards the problem. All have discussed the problem of bringing it to life very effectively. The commercial products based on "Follow the sun" alias 24 hour knowledge Factory were also introduced by IBM and HP in market [15]. For the effective utilization of sequential workers distributed

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across time-zones, tasks must be broken down so that they require no interaction with peers. In addition, effort required in transitioning from one employee to the next should be minimal. This paradigm requires new methodologies and tools that will allow an individual to understand in 16 minutes, the work done by others in the preceding 16 hours [7]. Also, this model requires introduction of time and state as search parameters for knowledge discovery in order to enable individuals to understand the sequence of changes being made in a project. These requirements of a 24 hour knowledge factory can be solved with the introduction of a Composite Personae (CP).

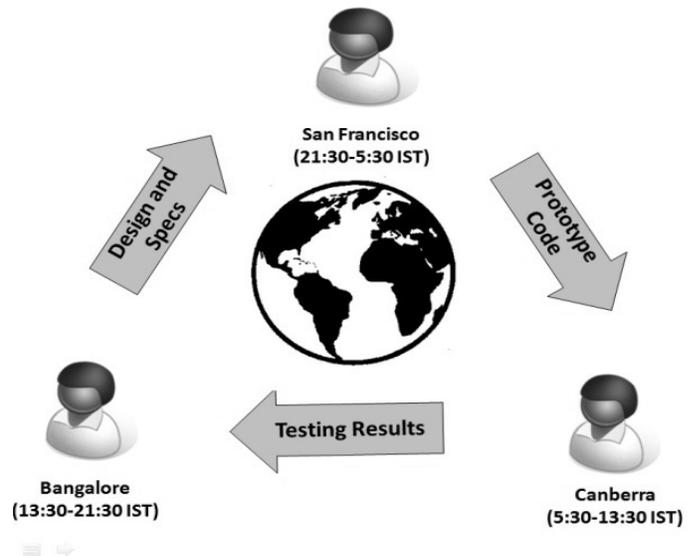


Figure 1: Cycle in 24 Hour Knowledge Factory [Adopted from Ref. 1]

A CP is a highly cohesive micro-team that possesses simultaneous properties of both an individual and a collection of individuals. It is designed to act like a singular entity even though it comprises of three or more individuals at multiple sites. In a CP, only one site is active at a single point in time. Thus, development can proceed in a manner similar to traditional one, with the difference being that a component is owned by a CP and not by an individual. It is actively involved in the process of development and conflict resolution on a round-the-clock basis [1].

The present day operating systems do not have adequate support to facilitate this concept. Application of rough set theory gives us an idea about the work that has to be done by providing the lower and the upper approximation and various rules that could help to find these optimum tables. The paper consists of five sections ahead defining motivation for this

software, revisiting rough set theory, implementation of rough set to 24 hour knowledge factory, future work and conclusion.

2. MOTIVATION FOR SOFTWARE

In analogous to the code generation in shifts, consider three people working on same wall building in temporal shift. The specification for construction of wall indicates that each brick is to be horizontally placed in the wall. Person A does his work efficiently by placing brick horizontally and finishes one third of the wall at the end of the shift. Now, another person B is handed over the work in next shift who inefficiently places the brick vertically and delivers the same work to person C at the end of his shift, person C is unaware of the inefficient work done by Person B and continuous to do his own work efficiently by placing the bricks horizontally. At this stage, if this work is handed over to person A in the next cycle, how can he be sure if the work done until now has been efficiently done?

Likewise, in the code building, each company has some norms to use e.g. ‘if then else’, ‘else if’, ‘if then’ statements in code building. Wrong practices of using these commands by the developer in their code without following the protocols make the code partially inefficient for the company’s norms. This inefficiency can be checked by 24 hour knowledge factory and the developer at the next shift can be sure of the code in which he is going to invest time in. Possibly, also find out which developer delivered the inefficient work through history log.

One may argue that Concurrent Versions System (CVS) [3] and knowledge factory, both work on the basic idea of maintaining the history of database of the same projects with the temporal differences but there lies a considerable amount of difference in the processing and maintaining the relevant information in the database.

CVS just acts as a repository of information whether it’s a code or it’s an author of the code, whereas the knowledge factory maintains the ‘knowledge’ that is the relevant and useful information only. Knowledge factory incorporates the software maintaining this useful knowledge instead of acting as a repository and saving all the information available.

Knowledge factory is capable of eliminating the redundant data provided by the user and retrieving it at the time of the need where as CVS just retrieves the data stored previously without processing it. Knowledge factory can process the code written and can differentiate its basic components like classes, modules, basic elements etc. where as CVS is not capable of this at all.

3. ROUGH SET THEORY

Rough set theory has been used in many applications varying from fault diagnosis to economic predictions [2,4,6]. It basically gives the crisp idea of selecting and deselecting the component of the entity based on its lower and upper approximation. Likewise, one can decide over the lower and upper approximation of the given entity in the case of

vagueness and uncertainty. The classical Rough Set Theory was introduced by Zdzisław I. Pawlak [5,10,11] in 1982.

3.1 Indiscernibility

Let $A' = (U; A)$ be an information system, then with any $B \subseteq A$ there is associated an equivalence relation $IND_{A'}(B)$:

$$IND_{A'}(B) = \{(x, x') \in U^2 \mid \forall a \in B \ a(x) = a(x')\}$$

where $IND_{A'}(B)$ is called the B- Indiscernibility relation. If $(x, x') \in IND_{A'}(B)$, then objects x and x' are indiscernible from each other by attributes from B. The equivalence classes of the B- Indiscernibility relation are denoted $[x]_B$

3.2 Set Approximation

If $B \subseteq A$ and $X \subseteq U$. We can approximate X from the information contained in B by constructing the B-lower and B-upper approximations of X, denoted $\underline{B}X$ and $\overline{B}X$ respectively, where

$$\begin{aligned} \underline{B}X &= \{x \mid [x]_B \subseteq X\} \\ \overline{B}X &= \{x \mid [x]_B \cap X \neq \emptyset\} \end{aligned}$$

The accuracy of the rough-set representation of the set X is defined as:-

$$\mu_B(X) = |\underline{B}X| / |\overline{B}X|$$

The accuracy of the rough set representation of X, $\mu_B(X)$, $0 \leq \mu_B(X) \leq 1$, is the ratio of the number of objects which can be placed in X to the number of objects that can possibly be placed in X.

4. REDUCTS

From an information system, some attributes can be deleted while keeping necessary attributes. The least minimal subset of attributes which ensures the same quality of classification as the set of all attributes is called a reduct in A' . Intersection of all reducts is called the core. The core is a collection of the most significant attributes for the classification in the system.

5. RULE GENERATION

Rules represent extracted knowledge, which can be used when classifying new objects. Rules are created from the condition attribute values of the object class. They are presented in the form if “IF else” statement. A decision part comprises the resulting part of the rule. Rules that have same conditions but different decisions are called inconsistent rules.

6. ROUGH SET THEORY IN 24 HOUR KNOWLEDGE FACTORY

24 hour knowledge factory require the better infrastructure and workflow design for providing the interface to the programmer joining in second shift. This knowledge-rich workflow environments [16,17] uses rough set approach [8,9] which provides the needed information in exact and intelligent way in the compact form. It is implemented using the C# win forms application. The part of class diagram can be seen in Appendix I. We have made various assumptions regarding our project and these are as stated below:

- a. All the Hardware supports of different places are assumed to be equal.
- b. There should be a predefined format for the security password and Login IDs. These can be programmer's ID.
- c. Current project Software requirement specifications are to be provided for the assessment of various data fields. The various upper and lower approximations of the SRS have to be matched against those obtained when the work is passed to the module developed, at the end of a particular shift.
- d. SRS must specify the number of objects, classes, functions and number of modules in the project.

The User needs to login for accessing the knowledge factory. This can be integrated with the corporate accounts login in later times. User may be able to work on three different sides viz, developer, and documenter and tester side.

The win forms for one side of application is the developer side. By working on the developer side we maintain a form which enable us to view three different tables [12] which are necessary from the developer's point of view that should be provided to the other developer working at the another shift of same project. Various tables that were designed are information metric table, history log table and modular table. Modular table tell us the name of module, approach maintained, function name, date of start and completion as also the language hardware and software used for designing the particular module have been used. Later the rough set approach is used to provide just useful information to the other developer which is mandatory for him to know and proceed further for his task. If we do not use rough set approach than it will result in lot of waste of time in reading a part of work done by one developer and deciding what next is to be done.

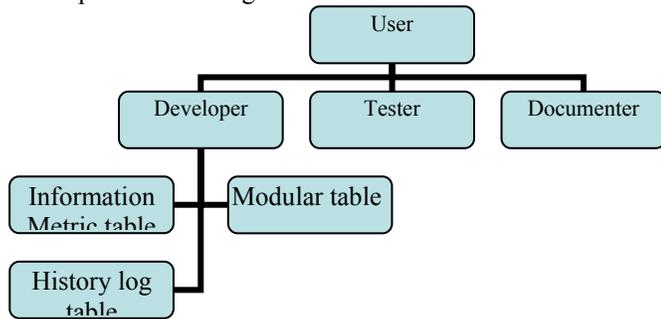


Figure 2: Design Hierarchy

Beside this, when our current approximations in rough sets are compared with the required specified approximations (provided by SRS), the developer ahead is more confident of work done by previous developer.

7. IMPLEMENTATION

We have considered various classes which will have various objects and functions which are to be considered during attribute generation. Thus, we are considering two different way of attribute generation-

- a. Object of various classes may be considered to create attribute table
- b. Function in the various classes.

Therefore, we have considered two different tables in our project. They will be filled in explicitly by the programmer for the time being. Now, various rough set rules can be used to find the optimum set attributes and then the upper approximation and the lower approximation will be found with help of rough set rules.

8. COMPARISON WITH THE SRS

It is essential to have software requirement specifications which show the desired set of classes, functions and objects. The Information given by the SRS will be used to find the desired lower approximation and upper approximation of the project.

Suppose the Lower Approximation and Upper Approximation of the SRS is given by Ls and Us and their current code is given by the Lc and Uc respectively. Then the calculation will be

- Ls should be equal to Lc.
- Us should be equal to Uc

It may not be the exactly equal until the code is complete. Lc and Uc will be some percent of Ls and Us. This will be given by –

$$\begin{aligned} \text{Current lower error} &= Lc / Ls \times 100 \\ \text{Current upper error} &= Uc / Us \times 100 \end{aligned}$$

This error should lie between minimum given range. This value can be used to keep the track of code being written in the discrete time domains and it will still assure the programmer writing the current code, that he is following the correct code which was written by previous programmer.

9. PROJECT WINDOW FORMS

Three point of views in 24 hour knowledge factory are considered as there are three main strata of people which are involved in the software project generation i.e. Developer, tester and documenter. We concentrated on code developer view point in this paper.

The developer view includes three Information Metric table, Module table and History Log to store the information about the code developed. The Information Metric Table stores general information about the module developed (figure3). The Module Table stores the specific information about the module developed (figure4). The History Log stores date and time details of the module developed (figure5).

The data is collected by each developer at the end of his shift in these three tables. This data is stored in the database which is maintained at the backend. Now, depending upon the decision attributes Lower Approximation (LA) and Upper Approximation (UA) are found by using the algorithm for approximation computation [8]. The sets which are indiscernible can be reduced to single tuple and optimize the subsets to a certain degree. The approximation is specifically

calculated to match the Lower and Upper approximation with those stated in the SRS (Software Requirement Specification).

Figure 3: Information Table

Figure 4: Module Table

Similarly, reducts can be found by applying the reduct and core computation algorithm [8]. It is a relative reduct that contain same amount of information that is held with non reduced data set. Hence, we can call it as extracted data. This is data which will be shown to the developer working at the immediate next shift to brief him about the status of the work done.

FUTURE WORK

The event of login can be connected to a database maintained specifically for verification of user name and password. Currently a predefined user name and password are being used for verification of login.

The Software Requirement Specification is an essential input in any project. In the case where SRS tends to change, due to the market requirement changes, or any other reason, the whole of the input changes which tends to disturb the output in an unexpected way. And at worst could hamper the work progress which is the main goal of this 24 hour knowledge factory. This could be changed by making some amendments and predefined norms at the time of SRS agreement. Or a system which is ready to accept the changes made in SRS and is not that depend on it.

Currently only the developer’s side of view has been considered. The other two sides i.e. the tester’s and the documenter’s also need to be implemented.

Figure 5: History Table

CONCLUSION

The goal of this paper is to generate interface for managing the 24 hour knowledge factory by implementing rough set theory. The software is capable of handling work different places which are not only geographically distant but also temporally far from each other by easily grasping the idea as quickly as possible by going through the optimised tables. Software also facilitates the developer at the immediate next shift to be sure of the code in which he is going to work.

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Appendix-I

Form3
class form
Fields
button1 button2 button3 label1 label2 label3 label4 label5 label6 label7 label8 label9 textbox1 textbox2 textbox3 textbox4 textbox5 textbox6

textbox7
Methods(Form3)
button1_click button2_click button3_click dispose form3 form3_load initializecomponent label5_click textbox1_textc textbox1_validate

Form 6
class form
Fields
button1 components label1 radiobutton1 radiobutton2 radiobutton3

Methods (Form 6)
button1_click dispose form6 initializecomponent radiobutton1_click

Form11
class form
Fields

a d_attr datagridveiw1 hashtable2 hashtable3 hashtable4 hashtable5 hahstable6 la no_array str ua
Methods (Form11)
Calculate Calculate_accuracy Calculate_la_ua Make_target Class(+1 overload)

Form2
class form

Fields
button1 button2 components label1 label2 label3 textbox1 textbox2
Methods (Form2)
button1_click button2_click dispose form2 initializecomponent label1_click

class form
Fields
button1 components label1 label2
Methods
button1_click dispose form1 initializecomponent label1_click
Program
Static class
Methods
Main

button1_click button2_click button3_click dispose form5 initializecomponent label4_click textbox_textc

Class1
class
Fields
_items button1 button2 button3 button4 combobox1 components d_attr data_grid_veiw label1 label2 label3 label4 label5 textbox1 textbox2 textbox3
Methods
button1_click button2_click button3_click combobox1_set dispose form11(+1 overload) init1 initilizecomponent listbox1_select
Form1

Form5
class form
Fields
button1 button2 button3 components label1 label2 label3 label4 label5 label6 label7 label8 label9 label10 textbox1 textbox2 textbox3 textbox4 textbox5 textbox6 textbox7 textbox8 textbox9
Methods

A Test of Transactional and Transformational Leadership Behaviour of Salesman on Customer Relationship Marketing Behaviour: A Study of the Indian Banking Sector

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Abstract - *The present study was aimed to test constituents as well as complete theories of Transactional and Transformational Leadership behaviour of salesman on customer relationship marketing behaviour in Indian Banking scenario. For Transactional Leadership it was hypothesized that contingency reward system and management by exception of salesperson positively affect customer trust, customer commitment and together they contribute to customer relationship behaviour. For transformational Leadership it was hypothesized that idealized influence behaviour, individualized consideration, Intellectual stimulation, Inspirational motivation behaviour of salespersons positively affect customers' trust, customers' commitment, customer assumptions and customers optimistic engagement. Non-Probabilistic sampling methods were used. A survey was conducted among 61 sales persons and their customers in the Indian banking sector, and the regression analysis was performed to test hypotheses. Conclusion shows that contingency reward system influence customer relationship up to a certain extent while management by exceptions is not so appropriate for maintaining the relationship with customer though it is showing correlation, while in case of transformational leadership idealized influence behaviour of salespersons positively influences customer trust, individualized consideration of salespersons, in turn influences customer commitment, Intellectual stimulation encourage creativity and changes earlier assumptions of customer and Inspirational Motivation influences optimistic engagement of customers. It was also found that the combined effect of all the constituent of Transformational Leadership theories are positively related with customers' relationship commitment. Conclusion motivate us to think complementary nature of these theories thus points out how leadership development training can be adapted to improve relationship marketing skills of sales persons.*

Index Terms - *Transactional Leadership, Contingency Reward, Management by exception, Transformational*

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leadership, Individualized consideration, Intellectual stimulation, Inspirational motivation, Idealized influence behaviour, Customer Relationship marketing, customer trust, customer commitment, assumptions of customers, optimistic engagement of customers Sales force, Business-to-Business marketing, Banking, India.

1. INTRODUCTION

Transformational leadership is relevant, desired and brings positive change in the followers, it enhances the motivation, morale and performance, through his or her idealized influence, intellectual stimulation, individual consideration and inspirational motivation. Bass added to the initial concepts of Burns (1978) to help explain how transformational leadership could be measured, as well as how it impacts follower motivation and performance [1], [2]. The followers of such a leader feel trust, commitment, admiration, inspiration, loyalty and respect for the leader. James Mac Gregor Burns (1978) first introduced the concept of transforming leadership" [2]. Burns established two concepts: "transforming leadership" and "transactional leadership." Transformational and Transactional (Bass & Avolio, 1991) are all dependent on perceptions [3].

A transactional leader align much on a series of "transactions". This person is interested in looking out for oneself, having exchange benefits with subordinates and clarify a sense of duty with rewards and punishments to reach goals-BASS BM [1]. Bass suggested that leadership can simultaneously display transformational and transactional leadership. Years of research and number of meta-analyses have shown that transformational and transactional leadership positively predicts a wide variety of performance outcomes including individual, group and organizational level variables (Bass & Bass 2008, The Bass Handbook of Leadership: Theory, Research, and Managerial Applications" 4th edition Free Press) [4]. Charismatic and transformational leadership models have attracted considerable research attention (Conger & Kanungo, 1987) [5]. The banking sector plays relevant and dynamic role in the economic development of a country by acting as centre of interest and barometer of the financial system. Liberalization of the Indian Banking sector in the early 1990s resulted the emergence of new horizons which gave the dynamism to the market and enhanced customer expectations. Indian banks need to adopt and implement innovative relationship marketing strategies to maintain the competitive edge in the marketplace. How are Banks misled by an over-reliance on technology and confusion regarding leadership

roles? Leadership roles are not constraints with manager behaviour. The salesperson perspective requires holistic understanding of customer perceptions and leadership strategy for multi-faceted relationships. There has not been any significant attempt merge transformational leadership and marketing in spite of major outcomes of transformational leadership even if so than also full transformational and transactional leadership styles were not tested at least in Indian Banking scenario. In Business-to-business marketing (BTB), the communication ally includes both the selling organization and the individual salespersons in BTB (Doney and Cannon, 1997) [6]. Meta-analyses have shown that it is significantly related to important effectiveness dimensions, e.g., higher performance ratings, enhanced innovativeness, etc, and more importantly in BTB services, Egri and Herman (2000) [7].

2. AIM OF THE STUDY

Objective of the study concentrated on the impact of transactional leadership behaviour and transformational leadership behaviour of sales person on customer relationship in Indian Banking sector, considering the transactional and transformational leadership aspects, leader-follower; salesperson-individual customer relationship and customer relationship marketing behaviour. Study examines whether the transactional leadership behaviour of individual salesperson influence customers trust in salesperson and their relationship commitment with the salesperson in the Indian Banking sector; and whether transformational leadership behaviour of individual salesperson influence customer trust, customer commitment, assumptions of customer, optimistic engagement of customer and their relationship commitment with the salesperson. After knowing the impact of both theories it can be implemented as training module and enhance customer relationship innovative marketing in Indian Banking Sector.

3. REVIEW OF RELATED LITERATURE

Literature relevant with Transformational Leadership, Transactional Leadership and customer relationship theories in the popular press and scholarly work is vast and continues to expand progressively because of its usage, diversity and implementation by academicians and researchers. Not only is the literature vast, it is often scattered. The arrangement of the literature review is as follows: Customer Trust, Customer commitment, Customer Assumptions, Customer Optimistic Engagement, Contingency Reward, Management By Exception, Individualized Consideration, Intellectual Stimulation, Inspirational Motivation and Idealized Influence.

3.1 Customer Trust

Constructing trust among salespeople and their customers has traditionally been considered a relevant element in developing and maintaining a successful sales relationship.

Trust is considered as a strategic variable in current marketing (Selnes, 1998) [8]. Trust and commitment- are the key variables of relationship marketing (Morgan and Hunt, 1994 [9]. Such assumption is nothing more than a trust credit suggested to others before experience can provide a more rational interpretation (Gefen et al .2003,p62) [10]. Some of the items of CT- "Disclose my financial secrets which may help my salesman to make my credit decisions." "Ignore the bad word of mouth (talking negatively) about my salesman."

3.2 Customer Commitment

Commitment is an vital ingredient for successful long-term relationships. Rather than routinely trying to meet or exceed every customer wildest expectations, sales departments began studying customer habits. The trick was to reward customer loyalty, Customers and their salesperson tend to believe that long-term relationships are a decisive source for competitive advantages (e.g., Ganesan 1994) [11].The outcomes for the customer of such long-term orientation (Anderson and Weitz 1992) are committed relationships that improve quality and process performance as well as increasing access to valued resources and technologies [12]. Considerable research has been done in order to illuminate the correlation of social aspects in business relationships such as commitment, satisfaction, long-term orientation, dependence and trust (Garbarino and Johnson 1999) [13]. Taking views into account, customer commitment was measured by items – "going beyond the business relationship with my CRO in order to maintain the business relationship with him/her", "appreciating my CRO's work to his/her colleagues". Some of the items of CC— "Recommending my salesman to my business colleagues for their dealings." "Ask any problem any time from salesman without any hesitation"

3.3 Customer Assumptions

Whether it's in regard to our sales efforts, during a discussion, or when trying to uncover ways to best manage customer, certain assumptions can dramatically affect the results we seek to achieve. This is especially true for research purposes. When clients ask for help in closing more sales, ask them to list the objections they hear that prevent the sale. It's when they start stumbling over their response that I ask, "Are these the objections you are hearing directly from your prospects or what you're assuming as the reason why they don't buy?" Rather than uncovering the real barrier to the sale, assuming where the objection lies becomes a detrimental process that spreads like a virus throughout every sales call. These assumptions are not based on fact but rather the salesperson's assumption of the truth. The problem arises when the salesperson fails to invest the time to go beyond the obvious and to explore the prospect's specific objectives or concerns. Thinking they "know" this prospect, the salesperson provides them with the benefits of his service that he perceives to be

important, without considering the prospect particular. Some of the suggestions to create more selling opportunities. Some of the items of CA- "Whether services offered by salesman are beneficial in nature , comparison with other products." "Whether salesman is able to change the perceived assumptions of customer."

3.4 Customer Optimistic Engagement

Disposed to take a favourable view of events or conditions and expect the most favourable outcome. The impact of transformational leadership styles on followers' effectiveness and motivation has also been documented (Bass & Avolio, 1990) [14]. A tendency to expect the best possible outcome or dwell on the most hopeful aspects of a situation: "There is a touch of optimism in every worry about one's own moral cleanliness" (Victoria Ocampo) doctrine asserted that this world is the best of all possible worlds [15].

1. to come nearer in position, time, quality, character, etc., to (someone or something)
2. to make advances to, as with a proposal, suggestion, etc.
3. a means adopted in tackling a problem, job of work, etc. ideas or actions intended to deal with a problem or situation; "his approach to every problem is to draw up a list of pros and cons"; "an attack on inflation"; "his plan of attack was misguided"
4. access: a way of entering or leaving; "he took a wrong turn on the access to the bridge."

Some of the items of CP- "Whether customer feels that future plans of banks are feasible and possible as communicated by salesman." "Whether customer engage himself with future plans of banks as told by salesman."

3.5 Contingent Reward

As many academics have pointed out, while researchers have learned a great deal about the effects of contingent reward (CR) leader behaviour, relatively little is known about its genesis. CR is traditionally viewed as an independent variable which exerts influence. The final phase in the creation of a customer service training program should be reward (Kerr & Slocum, 1987; Schein, 1985) it suggests that reward systems may work like a layer-cake[16], [17].

3.6 Management by Exception

Management by Exception is a "policy by which management devotes its time to investigating only those situations in which actual results differ significantly from planned results. The idea is that management should spend its valuable time concentrating on the more important items (such as shaping the company's future strategic course). Attention is given only to material deviations requiring investigation."

3.7 Individualized Consideration

Recent empirical evidence indicates that individualized consideration is an important leadership behavior in the workplace (Sarros, Gray, & Densten, 2003) [18]. Bass (2000) identified a developmental orientation and individualized attention to followers as important aspects of individualized consideration [19]. It pay special attention to each individual's needs for achievement and growth (Hinkin and Tracey,1999) [20]. Some of the items of ICARE "Salesman treat as individual rather than just as any other group member/customer." "Salesman spends time for individual customer queries and problems and tries to give best of his services."

3.8 Intellectual Stimulation

Intellectual stimulation is defined as having a leader who stimulate and applaud innovation and creativity, as well as critical thinking and problem-solving. Still another research initiative conducted by Hetland and Sandal in 2003 regarding 177 subordinates and superiors of mid-level Norwegian managers in five different healthcare organizations showed a positive correlation in their application of the intellectual stimulation factor, which was defined as where a leader articulates new ideas that prompt followers to rethink conventional practice and thinking [21]. Some of the items of IS- Salesman re-examine critical assumptions to question "whether they are appropriate." "Salesman seek different perspective when solving problems."

3.9 Inspirational Motivation

Leaders with inspirational motivation justify followers with high standards, communicate optimism about future goals, and provide scope for the task at hand. Followers need to have a strong sense of purpose if they are to be motivated to act. Purpose and meaning provide the energy that drives a group forward. This is an example of inspirational motivational leadership, which is part of the full-range or transformational/transactional leadership model espoused by Burns beginning in 1978 [2]. Intrinsically motivated salespeople seek peer recognition and put the organizations and the customers before their own interests (Kunz and Pfaff, 2002) [22]. Some of the items of IM- "Salesman articulate a compelling vision of the services provided and its future benefits." "Salesman talks optimistically about future and requirements for that."

3.10 Idealized Influence

Provides a role model for high ethical behaviour, in stills pride, gains respect and trust.

1. Comprehensive vision-"I believe that this is truly the right thing to do."
2. General characteristics.
 - Respects, trusts, and demonstrates confidence.

Idealized influence refers to the behaviour characterized by self-confidence, determination, persistence, high competency and willingness to take risks. Some of the items of II- “Salesman go beyond self interest for the good of the customer.” “Salesman acts in way that builds customer respect for him.”

3.11 Transactional Leadership (Hypotheses and its Background)

Some thinkers may be interested in knowing how transactional leadership as a whole influences followers relationship commitment, others provide some evidence on the impact of individual components of transactional leadership. Particularly transactional leader concentrate on the exchange process whereby leader secure the effort of followers through the use of desired incentives (Bass and Avolio, 1990) [14]. These incentives are usually offered as contingent-reinforcement or management-by-exception (Avolio and Bass al., 1991) [3]. Also, transactions may be denoted as either active or passive between leader and follower (Hater & Bass, 1988) [23]. Logically, a transactional leader is more likely to implement only those service-oriented behaviours that are in the spirit of the activities one would expect a transactional leader to undertake. Like for salesman discount and various schemes.

H1:The higher the Contingent Rewards of salesperson, the higher will be the customer trust in that salesperson.

H2:The higher the Management By Exception of a salesperson, the higher will be the customer commitment to that salesperson.

Berry (1995) stresses that attracting new customers should be viewed only as an intermediate step in the marketing process [24]. He proposed relationship marketing as attracting, creating, maintaining and in multi service organizations-enhancing customer relationships. Berry’s notion of customer relationship management resembles that of Gummesson and Evert (1981) [24], [25]. Armstrong and Seng, 2000) identify trust as an antecedent of commitment [26]. The commitment-trust theory of relationship marketing by Morgan and Hunt (1994) also proposes certain variables that contribute to achievement of trust and commitment [9].

H3:The higher the Customer Trust in a salesperson, the higher will be customer commitment with the salesperson.

We can state that both Management By Exception of a salesperson and customer trust affect customer commitment, the following hypotheses is concluded:

H4:The effect of Contingent Reward and Management By Exception(Transactional Leadership) behaviour of salesperson is relevant and positive on customer relationship commitment.

3.12. Transformational Leadership

A transformational leader would be thriving in getting a change plan implemented by intellectually stimulating the followers (Bass, 2000), that will motivate them to rethink old ways of doing business [19]. Empirical tests of the

extraordinary effects of transformational leaders on followers have become known as tests of the 'augmentation hypothesis' (Bass, 1985; Hater & Bass, 1989)[19] ,[23]. Theoretical and empirical research has identified the relevant role that employee behaviours play in the formation of customers' quality perceptions and loyalty behaviours Maxham, Netemeyer and Lichtenstein, 2008;) [27]. It shows the pathway. Successful and innovative marketers move beyond physical connections of the product, price, place, promotion to psychological connections. Some of the successful cases– The Container Store, and Harley-Davidson. Their business models cater to employee and customer emotions, making them great companies. Connected companies replace business transactions with superior human interactions (Szymanski.M.David) [28]. Salesperson are constituents of society and if they show individualized consideration for customer than certainly it will increase customer commitment which ultimately leads to enhance relationship.

H5:The higher the idealized influence behaviour of a salesperson, the higher will be the customer trust in that salesperson.

H6:The higher the individualized considerate behaviour of a salesperson the higher will be the customer commitment to that salesperson.

H7:The higher the intellectual stimulation of a salesperson the higher will be the change in the assumption of customer.

H8:The higher the inspirational motivation of salesperson, the higher will be the optimistic engagement of customer.

H9:The mutual effect of Idealized Influence, Individualized considerate behaviour, Intellectual Stimulation and Inspirational Motivation (Transformational Leadership) of salesperson is relevant and positive on the customer relationship commitment(customer trust, customer commitment, customer assumption and customer optimized engagement).

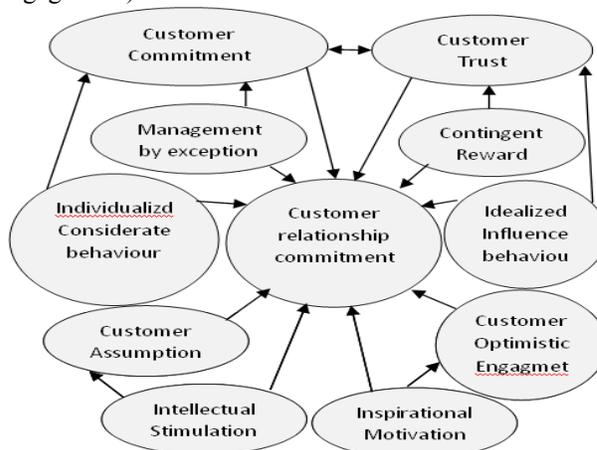


Figure 1

4. RESEARCH METHODOLOGY:

Questionnaire was used to collect the primary data to answer the research questions and objectives regarding customers' perception on Leadership behaviour of salesman in India. Study focuses on the causal relationship, thus the questionnaire method is more appropriate. Second, a valid and reliable measure of transformational leadership is readily available in questionnaire form.

5. POPULATION, SAMPLE, AND SUBJECTS

A total of 110 questionnaires were distributed to banks operating in the India. The number of questionnaires delivered to each bank was determined by the size of its customer database. From the questionnaire distributed, seventy questionnaires were collected, of which 9 were excluded due to incomplete data. Non probabilistic sampling techniques were used. Items selected to measure customer trust, customer commitment, customer assumptions and optimistic engagement of customers (four statements per each) from the existing measurements, and selected relevant items of Multifactor Leadership Questionnaire (MLQ-5x) to measure four dimensions of transactional leadership and four dimensions of transformational leadership. The questionnaire included a total of 40 items. Items were discussed with some senior bankers with experience in corporate banking with the aim of improving the content validity of the measurements. Some of the items were customize, so that customer can correlate the statements. All the variables of the present study were measured on a 4 point scale anchored by "0" indicating "not at all" and "4" indicating "frequently if not always".

6. ANALYSIS AND FINDINGS

The analysis was performed in SPSS version 17. The correlation table shows relevant correlation between variables.

6.1 Reliability Analysis

To assess the reliability and internal consistency of the data, the Cronbach alpha test was performed. Variables exceeded the value of 0.6 and concluded as reliable for the study.

Group Name	Questions	Cronbch Alpha
Contingency Reward	Q-1,2,3,4	0.6491
MBE	Q-5,6,7,8	0.7748
Individulized Consd	Q-9,10,11,12	0.6710
Intepectul Stimultn	Q-13,14,15,16	0.7022
Inspird Motivation	Q-17,18,19,20	0.6103
Idealized Influence	Q-21,22,23,24	0.7144
Customer Trust	Q-25,26,27,28	0.6552

Group Name	Questions	Cronbch Alpha
Customer Commit	Q-29,30,31,32	0.7036
Customer Asumptn	Q-33,34,35,36	0.7869
Optimizd Engagmt	Q-37,38,39,40	0.7137

Table1

6.2 Relationship Analyses

In order to understand the correlation between the transformational leadership, transactional leadership, Customer relationship commitment, the matrix of correlation coefficients were shown in Table 2. A higher coefficient indicates a stronger correlation between variables.

6.3 Contingency Reward And Customer Trust

One of the most important fact is to verify the relationship between contingency reward and trust. Table 2 displays positive and significant correlations between contingency reward and customer trust. These results provide support for a consistent positive relationship between contingency reward and customer trust, therefore suggest that Hypothesis 1 is supported. Hypothesis 1, that contingency Reward is positively correlated with customer trust, is supported.

	Intellectual Stimulation	Customer Assumption
Contingency Reward Pearson Correlation (Sig 2tail)	.479 .000	1
Customer Trust Pearson Correlt (Sig 2 tail)	1	.479 .000

Table 2

6.4 Management by Exception and Customer Commitment

Hypothesis 2 stated that the Management By Exception Behaviour of salesperson is positively correlated with Customer Commitment. Management By Exception and Customer Commitment are positively related, was supported in the findings. Table 2 indicates that there was a significant positive correlation between Management By Exception and customer commitment. However, this correlation was moderate, $r = 0.26$, $p < 0.01$. Consequently, Hypothesis 2 is supported.

	Management by Exception	Customer Commitment
Management by Exception Pearson Correlation (Sig 2tail)	.267 .038	1
Customer Commitment	1	.267 .038

Table 3

6.5 CUSTOMER TRUST AND CUSTOMER COMMITMENT

The third and central hypotheses, that customer trust and customer commitment are positively related, was supported in the findings. There was a significant positive correlation between customer trust and customer commitment shown in table 2. Correlation suggest $r = .60$. Hence Hypotheses 3 was supported.

	Customer Commitment	Customer Trust
Customer Trust Pearson Correlation (Sig 2tail)	.605 .000	1
Customer Commitment	1 .000	.605

Table 4

6.6 Transactional Leadership and Customer Relationship

Fourth and one of the most important hypotheses, that contingency reward, management by exception, customer trust and customer commitment are positively correlated. Results shows the relevance for the consistence positive relationship between the variables of transactional leadership(contingency reward, management by exception) and customer relationship commitment(customer trust, customer commitment) shown in table 2. Therefore hypotheses 4 is supported.

	Customer Trust	Customer Commit	Contgency Reward	Mgmt By Exce ption
Customer Trust Pearsn Cor 2 tail	1	.605 .000	.479 .000	.316 .013
Customer Comt Pearsn Cor 2 tail	.605 000	1	.347 .006	.267. 038
Contingency Reward Pearsn Cor 2 tail	.479 .000	.347 .006	1	.094 .473
Management By Exception Pearsn Cor 2 tail	.316 .013	.267 .038	.094 .473	1

Table 5

6.7 Idealized Influence and Customer Trust

Hypotheses 5 stated that there exist a positive and significant relationship between Idealized Influence and Customer Trust. Table 2 justified positive and significant relationship between Idealized Influence and Customer Trust.

Hypotheses 5 that there exists a positive and significant relationship between Idealized Influence and Customer Trust is supported.

	Customer Trust	Idealized Influence
Idealized Influence Pearson Correlation (Sig 2tail)	.092 .482	1
Customer Trust	1	.092 .482

Table 6

6.8 Individualized Consideration and Customer Commitment

Hypothesis 6 stated that the Individualized Consideration Behaviour of salesperson is positively correlated with Customer Commitment. Individualized Consideration and Customer Commitment are positively related, was supported in the findings. Table 2 indicates that there was a significant positive correlation between Individualized Consideration and Customer Commitment. This correlation was relevant, $r = 0.59$. Consequently, Hypothesis 6 is supported.

	Customer Commitment	Individualized Consideration
Individualized Consideration Pearson Correlation (Sig 2tail)	.596 .000	1
Customer Commitment	1	.596 .000

Table 7

6.9 Intellectual Stimulation and Customer Assumption

One of the most important relationships that need to be verified is the relationship between contingency reward and trust. Table 2 displays positive and significant correlations between Intellectual Stimulation and Customer Assumption. Correlation was relevant $r = 0.53$. These results provide support for a consistent positive relationship between Intellectual Stimulation and Customer Assumption, therefore suggest that Hypothesis 7 is supported. Hypothesis 7, that Intellectual stimulation is positively correlated with customer assumption, is supported.

	Intellectual Stimulation	Customer Assumption
Customer Assumption Pearson Correlation (Sig 2tail)	.531 .000	1
Intellectual Stimulation	1	.531 .000

Table 8

6.10 Inspired Motivation and Optimized Engagement

Hypothesis 8 stated that the Inspired Motivation Behaviour of salesperson is positively correlated with Optimized Engagement of customer. Inspired Motivation and Optimized Engagement are positively related, was supported in the findings. Table 2 indicates that there was a significant positive correlation between Inspired Motivation and Optimized Engagement. This correlation was relevant, $r = 0.58$. Consequently, Hypothesis 8 is supported.

	Optimized Engagement	Inspired Motivation
Inspired Motivation Pearson Correlation (Sig 2tail)	.589 .000	1
Optimized Engagement	1	.589 .000

Table 9

6.11 Transformational Leadership and Customer Relationship

Hypotheses 9 stated that there exist a positive and significant relationship between Transformational Leadership (Idealized Influence, Individualized Consideration, Intellectual stimulation, Inspired Motivation) and Customer Relationship (customer trust, customer commitment, customer assumption, optimized engagement). Table 2 justified positive and significant relationship between Transformational Leadership and Customer Relationship.

Hypotheses 9 that there exists a positive and significant relationship between Transformational Leadership and Customer Relationship is supported.

	Ins Mot	Opt Eng	Cst Trs	Cst Cmt	Idl Infl	Indl Cons	Intl Stm	Customer Ass
IM (2 Tal)	1	.589 .000	.207 .109	.228 .077	.047 .720	.329 .076	.224 .083	.072 .579
OE (2 Tal)	.58 .00	1	.141 .277	.324 .011	.121 .353	.211 .103	-.08 .525	-.13 .388
CT (2 Tal)	.20 .10	.141 .277	1	.605 .000	.092 .482	.380 .003	.140 .282	.216 .16
CM (2 Tal)	.22 .07	.324 .011	.605 .000	1	.086 .508	.596 .000	.019 .885	-.03 .7

	Ins Mot	Opt Eng	Cst Trs	Cst Cmt	Idl Infl	Indl Cons	Intl Stm	Customer Ass
II (2 Tal)	.04 .72	.121 .353	.092 .482	.086 .508	1	.179 .167	.316 .013	.159 .20
IC (2 Tal)	.22 .07	.211 .103	.380 .003	.596 .000	.179 .167	1	.019 .881	-.06 .45
IS (2 Tal)	.22 .08	-.083 .525	.140 .282	-.019 .885	.316 .013	.019 .881	1	.531 .31
CA (2 Tal)	.07 .57	-.113 .388	.216 .094	-.037 .776	.159 .220	-.060 .645	.531 .000	1

Table 10

IM-Inspirational Motivation, OE-Optimized Engagement, CT- Customer Trust, CM- Customer Commitment, II- Idealized Influence, IC- Individualized Consideration, IS- Intellectual Stimulation, CA-Customer Assumption.

7. MANAGERIAL IMPLICATION

Research tries to correlate leadership prospects of salesman and customer relationship behaviour. By scrutinizing each and every aspect of transactional leadership behaviour and transformational leadership behaviour of salesman on customer relationship, it can be concluded that training module programme can enhance the effectiveness of salesman customer relationship. In India, relationship marketing includes policies and procedure which are very basic in nature. In fact in some banks customer have to deal with delay and ineffective services. Customer relationship is just used as buzz word, there is no feedback and does not sufficiently recognize the salesperson as a potential means of implementing best relationship marketing. Research work showed the importance of effective and individual selling (Doney and Cannon, 1997; Beverland, 2001) the importance of personal interaction in the service industry (Armstrong and Seng, 2000) [6], [29], [26]. In fact there are well-developed transactional and transformational leadership training modules, but there are no such training modules in the area of relationship marketing especially for banking sector in India, Though Bass conceptualize transformational and transactional leadership can be employed to enhance the practice of personal selling, he failed to grouped his discussion on an appropriate theoretical base.

In this paper we have tried to address this gap, linking and finding out the impact of complete transactional and transformational approaches.

8. LIMITATION, FURTHER RESEARCH AND CONCLUSION

The sample elected for the study suffers from many constraints. The selection of banks, salesperson as well as customers depended on their willingness to participate and their convenience consequently resulted into constraints. Present study chooses two theories transactional leadership and transformational leadership however, future researchers can consider the other dimensions and leadership aspects and theories like charismatic, influential theory, behavioural theory even go for further improvement in leadership theories and enhanced for effective utilisation with relationship marketing. It is also very important to understand how much these leadership theories can be implemented on salesperson. Another constraint is that loyal customer may have some perception on customer thinking which might have influenced in knowing the actual leadership behaviour and its impact on customer. The lack of recognition for the salesperson in implementing relationship marketing may be due to the lack of research on how salespeople actually build relationships (Beverland, 2001) [29]. Future research may be focused on whole leadership concept and include all the leadership theories, even go with experimental leadership theories, they can opt for more appropriate sampling techniques even cross national surveys can be done for knowing the leadership aspects and different financial institutions can be included for research purposes. In fact, while most transformational & transactional leadership models take it granted that followers attribute leadership qualities based on face-to-face exchanges with the leader, the bulk of studies in this area result in measuring distant as opposed to close leadership relationship. Specifically, this study provides evidence of transformational and transactional effects in a real organizational setting, where followers were assessing the leader they know and deal with on a daily basis. The evolution of innovative complex business strategies has increased the challenge to banks to consider the salesman leadership behaviour-customer relationships in a dynamic way, using strategies that are new and effective. In designing this study, our initial position was that both leadership styles are necessary conditions for leadership traits. Transformational Leadership has been linked to outcomes such as leadership effectiveness, innovativeness, quality improvement, Transactional Leadership was also positively correlated with these outcomes, but, in general, the relationships were considerably weaker than those found for transformational leadership. Finally, though both transactional and transformation leadership styles ultimately self evident to enhance service performance, the impact of transformational leadership is likely to be greater and stronger than its counterpart. To maximize the satisfaction and performance levels of their followers, leaders must possess charisma, provide individualized consideration, and be intellectually stimulating and inspiring to followers.

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Applications of Public Key Watermarking for Authentication of Job-Card in MGNREGA

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Abstract- *Nowadays different state governments and central governments have taken initiative to successfully implement E-Governance in various areas of services applying Information and Communication Technology (ICT) to provide better transparency, accuracy & security of its services to the citizens. In September, 2005, Parliament of India has passed the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA), to enhance livelihood security by giving at least 100 days of guaranteed wage employment in a financial year to every house-hold in rural India. E-Governance solutions helps to simplify complex manual activities and supports transparent wage payment through agencies like Bank and Post-Offices. In e-governance, information's are exchanged between communicating parties via Internet and message may be changed, modified or destroyed by hackers during its transmission through Internet. So, information hiding is needed at the time of exchanging information via Internet. In this paper, we propose a tool, called Public-Key Watermarking algorithm, for integrity verification of Job-Card (JC) issued to individual house-hold by state governments, so that the watermark is capable enough to detect any changes made to the Job-Card by malicious users and can also identify fraudulent wage payment.*

Index Terms - *E-Governance, Watermark-Insertion, Watermark-Extraction, Cryptography, Digital Watermarking, Public-key, Private-key, JC, ICT, MGNREGA*

1. INTRODUCTION

According to New Oxford English Dictionary, Government is the sum total of the systems by which a state or community is governed. The Government of India has specified e-governance as nothing but "using IT to bring about SMART (Simple, Moral, Accountable, Responsive, Transparent) governance" [1]. The benefits of e-governance suggest that it is convenient and cost-effective for businesses and government service deliveries. By supplying most current information in easier accessing way to public, the government can save energy, time and above all money. Another advantage of e-governance is greater citizen participation in government activities in environmental friendly way as number of paper exchange is

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very less compared to conventional system. Though in the modern times every government organizations are transforming their operations into electronic way, the implementation of e-governance also produces several risks which sometimes negate the advantages. One of the major risks of successful implementation of e-governance is security of information as all the important data about government and citizens and businesses are available online and anyone can freely access that information and if want can also change them easily.

The availability of large amount of information and increased use of multimedia across the Internet has become an effective way to provide services to people around the globe. The growing usage of multimedia content on the Internet generates several serious problems like fraud, forgery, counterfeiting, violation of copyright and piracy [8]. With the availability of new generation software and hardware, anyone can easily use the copyrighted material without being caught. In modern days, the transition from analogue and paper media to digital media has provided several benefits but also creates problems for the owner as the replicas of digital media cannot be distinguished from the original. To provide copyright protection of digital content, sometimes cryptographic approach is used but it does not completely solve the problem. To restrict unauthorized user from accessing copyrighted digital information, a new technology referred as watermarking have been developed. We can divide digital watermarking into two main categories: visible and invisible [8]. In visible digital watermarking, the information is visible in the content and is equivalent to stamping a watermark on paper. In invisible digital watermarking, information is added as digital data to content, but it cannot be indentified visually.

The Government of India (GoI), in September, 2005, has launched an ambitious project, named MGNREGA, with the hope to change the socio-economic [1] structure of the rural INDIA and all its citizens. The main purpose of MGNREGA [1] is to develop long-term rural infrastructure as well as to enhance living standards of the rural people. Under this act, Gram-Panchayats play a pivotal role for planning and implementation of different schemes. The size and coverage of the scheme demands a foolproof and secure system that can ensure that benefits flow only to them for whom it is intended [1]. So, we have developed a watermarking approach via which we can support privacy, integrity, and authentication related issues of digital documents and give confidence to the user of the document that the transmission process is secure.

In section-II, we have highlighted construction of Job-Card that may be used in ICT solution for MGNREGA scheme and section-III identifies basics of Public-key Watermarking

technique. In section-IV, we have identified methods of incorporating watermark and its extraction techniques to provide authenticity of Job-Card in the light of proposed algorithm of the paper.

2. JOB CARD BASED E-GOVERNANCE

Under MGNREGA scheme, every rural family can register at Gram-Panchayats by filling a registration form that is kept under the supervision of village-head. Every registration related to wage seeker family will be sent to Computer Center (CC) at block level for higher-level processing.

For every valid application, CC will assign an ID comprising a 15 digit unique registration number. This registration number contains two parts – 11 digit code containing district, assembly, block, Panchayats, and village information and 4 digit index number for individual family.

After generating the unique registration ID for every wage seeker family, the CC will create a Job-Card and affix a scanned image of the job seeker family in the designated space within the Job-Card and will handed it over to the Gram-Panchayats for delivery of the same to the corresponding wage seeker family. The wage seekers can directly draw cash from paying agencies as per the wage list, by showing Job-Card and providing a thumb impression.

Here comes the necessity of public-key watermarking [3] technique, which not only restrict the fraudulent wage payment but also guarantees that paying agencies are not able to develop their own wage list.

The whole application can easily be fitted into Government-to-Citizen (G2C) model, where government portion of the application is responsible for the creation, distribution and processing of the Job-Card and Citizen portion is only responsible for providing necessary information.

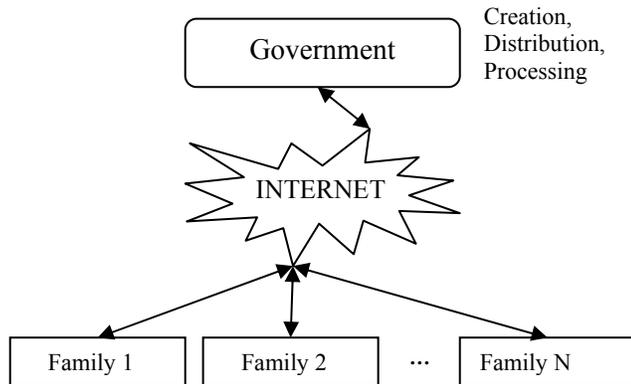


Figure 1: A G2C Model

The parameters included in the Job-Card are shown in the figure 2.

The registration process in the MGNREGA scheme is described with the help of the figure 3.

3. A G2C MODEL USING PUBLIC-KEY WATERMARKING

Digital watermarking [5] is used to insert a digital signature into the content so that the signature can be extracted for the

purposes of ownership verification and/or authentication. Digital watermarking is a way to protect ownership property from illegal usage. A watermark always resides permanently within the host information. The watermark is hidden in the host data in such a way that no one can separate it from the original work but the work is still accessible.

JOB CARD REGISTRATION NUMBER (15 DIGIT)		
DISTRICT	(2 DIGIT)	PASTE PHOTO HERE
ASSEMBLY	(3 DIGIT)	
BLOCK	(2 DIGIT)	
PANCHAYAT	(2 DIGIT)	
VILLAGE	(2 DIGIT)	
FAMILY INDEX	(4 DIGIT)	

Figure2: Schematic representation of Job-card mentioning different parameters

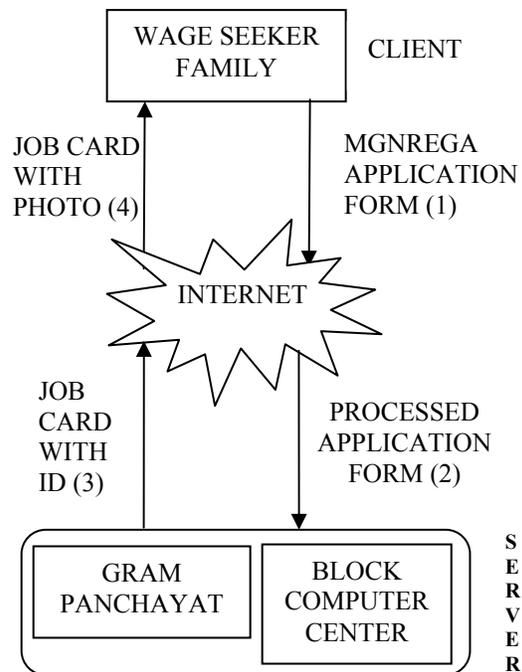


Figure 3: Registration Process in MGNREGA Scheme

It inserts the hidden information into the content, also called the cover-media [6]. This hidden information is called the watermark. After inserting the watermark via specific algorithms, the original media will be slightly modified and is referred as watermarked media. There might be no or little perceptible differences between the original media content and

the watermarked one. After embedding the watermark, the watermarked media are sent over the transmission channel to the receiver, where they are checked for authenticity of the content owner. A technique called watermark extraction [10] is performed here for verification of the ownership. The watermark information is fully depends on the application type. The generalized algorithm of watermarking is described below.

- Step 1: Initially, select a cover media.
- Step 2: Insert hidden information (watermark) into the content (cover media).
- Step 3: After watermark embedding, the watermarked media is sent to the receiver via transmission channel.
- Step 4: Watermark extraction approach is applied at the receiver end to identify the authenticity of the owner.

Watermark embedding and detection can sometimes be considered analogous to encryption and decryption in cryptography. There are two types of cryptographic approaches that we can use in watermark applications – Secret-key approach and Public-key approach.

In Secret-key watermarking, we have an embedding function that takes a message, an original work and outputs a watermarked work. Similarly, we have a detection function, which takes a watermarked work and outputs a message. The mapping between watermarked works and the messages is controlled by a watermark key. Watermarking algorithms based on a Secret-key present a major drawback; they do not allow a public recovery of the watermark. In order to overcome this limitation, Public-key watermarking algorithms have been proposed; such systems consist of two types of keys: a public and a private one. Content can be watermarked using the private key, whereas the public key is used to verify the mark.

We might develop a Public-key system, so that knowledge of either key does not allow an adversary to find out the other key. The public key can be widely distributed without risk of giving away the private key. Depending on the application, either the encryption key or the decryption key can be public.

The description of Public-key allows feasible computation of the mapping in only one direction. To implement Public-key watermarking, the watermark embedding use one watermark key and the watermark detector use a different watermark key. The assumption is that knowledge of the detection key is not sufficient to allow an adversary to remove a watermark.

4. PROPOSED ALGORITHM

In our approach, we use two types of keys, one is Public-key (E) for Watermark-Insertion within the information present in Job Card (JC) and the other is Private-key (D) for Watermark-Extraction from the watermarked message. Encryption and Decryption method both use MODULAR_EXPONENTIATION [3] technique and the modulus n, a very large number (256 bits) is created during the key generation process by using conventional RSA algorithm [3].

a) **Key Generation Algorithm:** Using this algorithm, we generate two types of keys that are used in the watermarking application. This process actually executed in the Government side (Computer Center) of the G2C model.

- 1. Using conventional RSA algorithm, we find e, n and d, where e is public exponent, d is private exponent, and we choose, the modulus n, a very large number (256 bits) for the purpose of better security.
- 2. Then we apply ITERATED HASH FUNCTION [3] on the original information present in Job-Card using the generated e and d and generate corresponding Public-key (E) and Private-key (D).

b) **Watermark Insertion Algorithm:** This algorithm is developed to insert generated watermark in the original information present in the Job-Card to provide security and authenticity. This process is also executed in the Government side (Computer Center) of the G2C model.

- 1. Let, M_k denotes the k^{th} block of data [7] within the message I.
- 2. Let, $H(.)$ be a Cryptographic Hash Function such as MD5 [3]. We compute $H(M_k, E) = (m_1, m_2, \dots, m_s)^k$, where s is the size of MD (message Digest) [In our algorithm, we have chosen the minimum length of s is 256 bits].
- 3. Finally, we encrypt the generated result of individual blocks with encryption function $E(.)$ using the public key E to produce the corresponding watermarked block M_k' .

Here, in watermark insertion process [9, 12], the input to the scheme is the watermark (unique Job-Card registration number), the cover-media (Job-Card) and a Public-key (generated using our proposed algorithm). The Public-key is used to enforce security, which is the prevention of unauthorized parties from recovering and manipulating the watermark. The output of the watermarking scheme is the watermarked Job-Card, which will be distributed to the wage seeker families via Panchayats.

Here, we achieved a better security by applying multiple keys to the information of the Job-Card. Before watermarking, we encrypt the information using some encryption keys and then apply watermark information on that encrypted information. In this way, use of two different keys allow us to provide better security as no one can interpret the actual hidden information until and unless they possess both the keys.

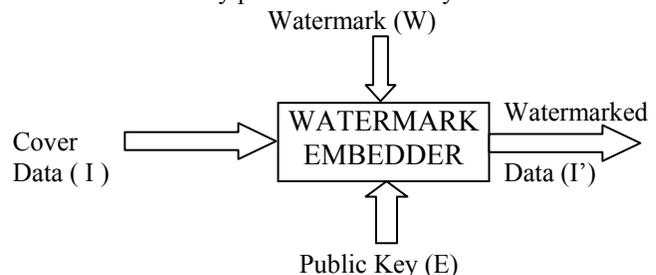


Figure 4: Digital Watermark Insertion Scheme

c) **Watermark Extraction Algorithm:** This algorithm is developed to extract generated watermark from the watermarked information in the Job-Card to identify authenticity of the message. This process is executed in the client side (Bank, Post-Offices) of the G2C model.

1. We split the watermarked message I'' into s number of blocks.
2. Apply a decryption function $D(.)$ on individual blocks M_k' using the private-key D to produce the corresponding block M_k of watermarked message I'' .
3. Finally, we apply the same Hash function, which is used to encrypt the message, on M_k to produce the final message using private-key D and generate authenticity information about the message as final outcome.
4. Depending on the generated authenticity information, the Job-Card will either be accepted or rejected.

In Watermark extraction process [2, 4, 11], inputs to the scheme are the watermarked data, Private-key (generated by the same proposed algorithm that are used to develop public key), and the original watermark. The output of the scheme gives us some kind of confidence measure indicating whether the test data is authentic or not.

Here, we achieved better security by using multiple keys at different levels of application. Initially, watermark is extracted from the information of the Job-Card using watermark key and successful extraction of which actually guarantees the authenticity of the owner. Then we apply decryption key to the authenticated information to produce the actual information from the encrypted information. In this way, two tier applications of keys provide a better hiding of valuable information from the intruders and only knowing of both the keys actual help to extract the information from the Job-Card. Thus the security measurement is very high if we use the above mentioned approach. Watermark (W)

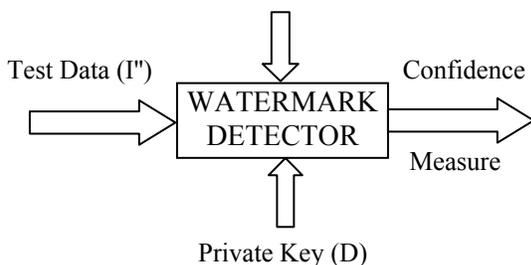


Figure 5: Digital Watermark Extraction Scheme

5. CONCLUSION

Here, we have used a public key for watermark insertion and a private key for watermark detection. So, any person can perform the authenticity check by simply using a private key and a watermark detector device. Though the approach specifies a direct relationship between Watermarking and Cryptography, there are some fundamental differences exists between them. In Public-key Watermarking, the mapping between Job-Card and information's within the Job-Card are

many-to-one, so that given information may be embedded in any given Job-Card. On the other hand, in Public-key Cryptography, the mapping between cipher-text and plain-text is always one-to-one.

Our approach combines the advantages of both Watermarking and Cryptography and produce a robust system to keep secure information hidden from the intruders. At the time of Job-Card production, we apply both cryptographic and watermarking approach and at the time of extracting information from that Job-Card, we again apply both cryptographic and watermarking approach, but the order of applying them is reverse in this case. The proposed approach is robust enough to protect against any kind of malicious attack performed by intruders. Any changes made to either the Job-Card or to its information, can easily be detected and thus the purpose of security is maintained.

FUTURE SCOPE

The Public-key algorithm stated here requires much more computation than Secret-key algorithm. It is impractical to encrypt and decrypt large messages using the above method. So, it is common to use a Secret-key algorithm for transmission of large amounts of data and to transmit its key, we need to use a Public-key algorithm. As the space in all the contents where watermarking techniques can be useful is very limited, it is impossible for us to use many kinds of watermarking techniques for some applications ambitiously. Our proposal is that, prior to application of watermark information compress the whole data using any compression algorithm. In this way we can reduce both the computation time as well as storage requirement.

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Study of Impact of Mobile Ad – Hoc Networking and its Future Applications

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Abstract - Today, many people carry numerous portable devices, such as laptops, mobile phones, PDAs and mp3 players, for use in their professional and private lives. For the most part, these devices are used separately-that is, their applications do not interact. Imagine, however, if they could interact directly: participants at a meeting could share documents or presentations; all communication could automatically be routed through the wireless corporate campus network. These examples of spontaneous, ad hoc wireless communication between devices might be loosely defined as a scheme, often referred to as ad hoc networking, which allows devices to establish communication, anytime and anywhere without the aid of a central infrastructure.

This paper describes the concept of mobile ad hoc networking (MANET) and points out some of its applications that can be envisioned for future. Also, the paper presents two of the technical challenges MANET poses, which include Geocasting and QoS.

Index Terms - Ad hoc networking, MANET, MIPMANET, Personal Area Network (PAN), Bluetooth technology, QoS, Geocasting.

1. INTRODUCTION

A Mobile Ad-hoc Network (MANET), also known as Mobile Packet Radio Networking, is a collection of wireless mobile nodes dynamically forming a temporary network without the use of any existing infrastructure or centralized administration. Since the nodes in a network of this kind can serve as routers and hosts, they can forward packets on behalf of other nodes and run user applications.

MANETs are networks in which mobile routers are connected via wireless links forming dynamic topologies. An important function of network management in a MANET is to observe network conditions: at the node level, this may mean keeping track of the traffic load; at the network level, the system must monitor active routes and changes in the network topology. [1] MANETs have their own advantages such as high robustness and ease to set up despite the resource constraints like limited bandwidth and power. Typical applications of MANETs are in tactical networking and disaster recovery operations. Recently, the rising popularity of multimedia applications among end users in various networks and the potential usage of MANETs

in civilian life have led to research interest in providing QoS support in MANETs. It is a huge challenge to provide QoS in MANETs. A network's ability to provide a specified quality of service between a set of endpoints depends upon the inherent properties such as delay, throughput, loss rate, error rates of links and nodes, etc.

Many mobile phones and other electronic devices already are or will soon be Bluetooth-enabled. Consequently, the ground for building more complex ad hoc networks is being laid. In terms of market acceptance, the realization of a critical mass is certainly positive. But perhaps even more positive- as relates to the end-user- is that consumers of Bluetooth-enabled devices obtain a lot of as-yet unraveled ad hoc functionality at virtually no cost.

The purpose of this paper is to propose technological requirements for the successful working of MANETs. The main features of the proposal are (1) to show efficient routing algorithms as a necessity to develop MANETs and (2) to provide excellent quality of service (QoS).

The remainder of the paper is structured as follows in the form of five sections. First Section reviews the background of ad hoc networking. Second Section describes the MANET technology. Third Section elaborates on Mobile IP for mobile ad hoc networks (MIPMANET). Fourth Section focuses on some of the significant applications of MANETs. Fifth Section provides the technological requirements for the development of an ad hoc network and proposes the importance of QoS and Geocasting in MANETs.

2. HISTORY OF AD-HOC NETWORKING

The roots of ad hoc networking can be traced back as far as 1968, when work on the ALOHA network was initiated (the objective of this network was to connect educational facilities in Hawaii). Although fixed stations were employed, the ALOHA protocol lent itself to distributed channel-access management and hence provided a basis for the subsequent development of distributed channel-access schemes that were suitable for ad hoc networking. The ALOHA protocol itself was a single-hop protocol, that is, it did not inherently support routing. Instead every node had to be within reach of all other participating nodes.

Mobile Ad Hoc Network is a name currently being given to a technology under development for the past 20 or so years, principally through research funding sponsored by the U.S. Government. Its initial sponsors included the Defense Advanced Research Projects Agency (DARPA), the U.S. Army and the Office of Naval Research (ONR). [8]

Inspired by the ALOHA network and the early development of fixed network packet switching, Defense Advanced Research

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Projects Agency (DARPA) began work, in 1973, on the PRnet (packet radio network)-a multihop network. In this context, multihopping means that nodes cooperated to relay traffic on behalf of one another to reach distant stations that would otherwise have been out of range. PRnet provided mechanisms for managing operation centrally as well as on a distributed basis. As an additional benefit, it was realized that multihopping techniques increased network capacity, since the spatial domain could be reused for concurrent but physically separate multihop sessions. Although many experimental packet radio networks were later developed, these wireless systems did not ever really take off

in the consumer segment. When developing IEEE 802.11-a standard for wireless local area networks (WLAN)- the Institute of Electrical and Electronic Engineering (IEEE) replaced the term packet-radio network with *ad hoc* network. Packet-radio networks had come to be associated with the multihop networks of large-scale military or rescue operations and by adopting a new name, the IEEE hoped to indicate an entirely new deployment scenario. The *ad hoc* devices can also relay traffic between devices that are out of range.

Mobile ad hoc wireless networks differ fundamentally both in functionality and capability from their static wireline network counterparts due to a variety of reasons, including random node mobility, unpredictable network dynamics, fluctuating link quality, limited processing capabilities, power constraints, etc. All of these characteristics give rise to a need for dynamic changes both in the functioning and management of the underlying network.

3. MANET-THE TECHNOLOGY

A Mobile Ad hoc NETWORK (MANET) consists of mobile platforms (each platform logically consisting of a router, possibly with multiple hosts and wireless communications devices), herein simply referred to as "nodes"--which are free to move about arbitrarily. A MANET is an autonomous system of mobile nodes. The nodes may consist of separate, networked devices, or may be integrated into a single device such as a laptop computer. The nodes may be located in or on airplanes, ships, trucks, cars, perhaps even on people, and there may be multiple hosts per router. The nodes are equipped with wireless transmitters and receivers using antennas which may be omnidirectional (broadcast) highly-directional (point-to-point) or some combination thereof. At a given point in time, depending on the nodes' positions and their transmitter and receiver coverage patterns, transmission power levels and co-channel interference levels, a wireless connectivity in the form of a random, multihop graph or "ad hoc" network exists between the nodes. This is in contrast with the topology of the existing Internet, where the router topology is essentially static (barring network reconfiguration or router failures). In a MANET, the routers are *mobile* and inter-router connectivity may change frequently during normal operation. Unlike conventional wireless networks, ad hoc networks have no fixed network infrastructure or administrative support. The topology

of the network changes dynamically as mobile nodes join or depart the network or radio links between nodes become unusable. [4] A MANET may operate either in isolation, or may be connected to the greater Internet via gateway routers.

MANETs have several salient characteristics:

1. **Dynamic topologies:** Nodes are free to move arbitrarily; thus, the network topology--which is typically multihop--may change randomly and rapidly at unpredictable times. Adjustment of transmission and reception parameters such as power may also impact the topology.
2. **Bandwidth-constrained, variable capacity links:** Wireless links will continue to have significantly lower capacity than their hardwired counterparts. One effect of the relatively low to moderate link capacities is that *congestion* is typically the norm rather than the exception, i.e. aggregate application demand will likely approach or exceed network capacity frequently.
3. **Power-constrained operation:** Some or all of the nodes in a MANET may rely on batteries for their energy. For these nodes, the most important system design criteria for optimization may be that of power conservation.
4. **Limited physical security:** Mobile wireless networks are generally more prone to physical security threats than are fixed, hardwired nets. Existing link security techniques are often applied within wireless networks to reduce security threats.

3.1 MIPMANET

Mobile IP for mobile ad hoc networks (MIPMANET) is designed to give nodes in ad hoc networks

1. Access to the Internet; and
2. The services of mobile IP.

The solution uses mobile IP foreign agents as access points to the Internet to keep track of the ad hoc network in which any given node is located and to direct packets to the edge of that ad hoc network.

The ad hoc routing protocol is used to deliver packets between the foreign agent and the visiting node. A layered approach that employs tunneling is applied to the outward data flow, to separate the mobile IP functionality from the ad hoc routing protocol. This makes it possible for MIPMANET to provide Internet access by enabling nodes to select multiple access points and to perform seamless switching between them. In short, MIPMANET works as follows:

1. Nodes in an ad hoc network that want Internet access use their home IP addresses for all communication, and register with a foreign agent.
2. To send a packet to a host on the Internet, the node in the ad hoc network tunnels the packet to the foreign agent.
3. To receive packets from hosts on the Internet, packets are routed to the foreign agent by ordinary mobile IP mechanisms. The foreign agent then delivers the packets to the node in the ad hoc network.
4. Nodes that do not require Internet access interact with the ad hoc network as though it were a stand-alone network

that is, they do not require data regarding routes to destinations outside the ad hoc network.

5. If a node cannot determine from the IP address whether or not the destination is located within the ad hoc network, it will first search for the visiting node within the ad hoc network before tunneling the packet.

In MIPMANET, only registered visiting nodes are given Internet access, thus the only traffic that will enter the ad hoc network from the Internet is traffic that is tunneled to the foreign agent from a registered nodes home agent. Likewise, traffic that leaves the *ad hoc* network is tunneled to the foreign agent from a registered node. This results in a separation between, and thereby the capacity to control, traffic that is local in the *ad hoc* network and traffic that enters the *ad hoc* network.

4. APPLICATIONS OF AD-HOC NETWORKING

Characterized by their flexibility to be deployed and functional in on-demand situations, combined with their capability to transport a wide spectrum of applications, mobile ad hoc networks (MANETs) are gaining rapid momentum both in the commercial and military arenas. To turn mobile ad hoc networks into a commodity, we should move to more pragmatic “opportunistic ad hoc networking” in which multihop ad hoc networks are not isolated self-configured networks, but rather emerge as a flexible and low-cost extension of wired infrastructure networks coexisting with them. [7]

4.1 Military Sector

The ad hoc packet-radio networks have mainly been considered for military applications, where a decentralized network configuration is an operative advantage or even a necessity. In the military sector, MANETs are becoming the basis for the future network-centric warfare (NCW) paradigm as exemplified by the Future Combat Systems (FCS) and Warfighter Information Network-Tactical (WIN-T) programs. The success of MANETs is however critically tied to their capability of transporting a wide spectrum of applications with varying quality of service (QoS) requirements or service level agreements (SLAs), and providing continued/un-interrupted service (i.e., seamless recovery) despite failures in the underlying network.

Today, MANETs enable war fighters to benefit from a sophisticated Internet protocol (IP)-based communications network that can be set up even in difficult terrain and in remote war zones. Furthermore, tactical network applications of MANETs also include realization of automated battlefields, wherein autonomous robots and autonomous ground vehicles are used to explore hostile battlegrounds and check for land mines. These significant strides have made ad hoc networking a very valuable option in modern tactical military communication networks and the industry is facing significant demand for MANET solutions from defense establishments worldwide.

4.2 Commercial Sector-Pan

Short-range ad hoc networks can simplify intercommunication between various mobile devices (such as a cellular phone and a PDA) by forming a PAN, and thereby eliminate the tedious need for cables. This could also extend the mobility provided by the fixed network (that is, mobile IP) to nodes further out in an ad hoc network domain. The Bluetooth system is perhaps the most promising technology in the context of personal area networking (PAN).

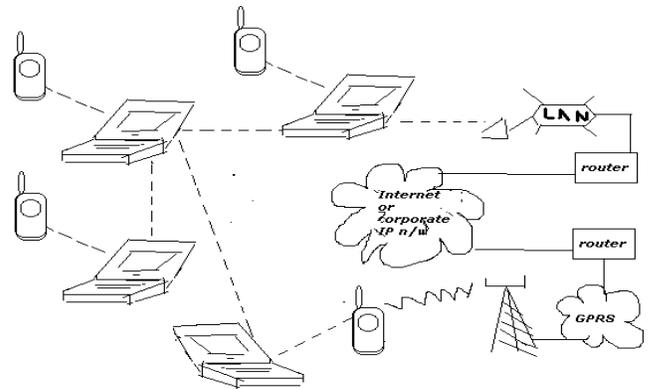


Figure1. PAN scenario with four interconnected PANs, two of which have an Internet connection via a Bluetooth LAN access point and a GPRS/UMTS phone.

A PAN can also encompass several different access technologies distributed among its member devices which exploit the ad hoc functionality in the PAN. For instance, a notebook computer could have a wireless LAN (WLAN) interface (such as IEEE 802.11) that provides network access when the computer is used indoors. Thus, the PAN would benefit from the total aggregate of all access technologies residing in the PAN devices.

Figure 1 shows a scenario in which four Bluetooth PANs are used. The PANs are interconnected via laptop computers with Bluetooth links. In addition, two of the PANs are connected to an IP backbone network, one via a LAN access point and the other via a single GPRS/UMTS phone.

In traditional 802.11 networks, clients dictate timing of communication, and APs do not coordinate with one another (client-controlled communication). Instead, the clients choose when to connect and which AP to connect with, and APs choose when to respond to each client. With an infrastructure-controlled approach, the WLAN can decide which AP or client transmits when and can guarantee packet delivery while dynamically reserving bandwidth over the air for VoIP communication.

4.3 Commercial Sector-Bluetooth Networking

Worldwide, the industry has shown a tremendous interest in techniques that provide short-range wireless connectivity. In this context, Bluetooth technology is seen as the key component.[5] However, Bluetooth technology must be able to

operate in ad hoc networks that can be stand-alone, or part of the IP-networked world, or a combination of the two.

Bluetooth devices can interact with one or more other devices in several different ways. The simplest scheme is when only two devices are involved, one of the devices acts as the master and the other as a slave. This ad-hoc network is called a piconet. A piconet can consist maximum of eight devices. The interconnection of piconets is called scatternet. The main purpose of Bluetooth is to replace cables between electronic devices, such as telephones, PDAs, laptop computers, digital cameras, printers, and fax machines, by using a low-cost radio chip. Short-range connectivity also fits nicely into the widearea context, in that it can extend IP networking into the personal-area network domain, as discussed earlier. Bluetooth must be able to carry IP efficiently in a PAN, since PANs will be connected to the Internet via UMTS or corporate LANs, and will contain IP-enabled hosts.[5] Generally speaking, a good capacity for carrying IP would give Bluetooth networks a wider and more open interface, which would most certainly boost the development of new applications for Bluetooth. In February 1998, the Bluetooth Special Interest Group (SIG) was founded to promote, develop and define the Bluetooth specification. The Bluetooth SIG aims at delivering a universal solution for connectivity among the heterogeneous devices. This is one of the first commercial realizations of ad-hoc wireless networking.

5. TECHNICAL CHALLENGES IMPOSED BY AD-HOC NETWORKING

This section outlines the technical requirements for mobile ad-hoc networks to achieve their potential because ad hoc wireless networks are self-creating, self-organizing, and self-administering. It outlines the need for QoS.

5.1 Geocasting

Geocasting is a variant of the conventional multicasting problem. For multicasting, conventional protocols define a multicast group as a collection of hosts which register to a multicast group address. However, for geocasting, the group consists of the set of all nodes within a specified geographical region. Hosts within the specified region at a given time form the geocast group at that time. [9]

When an application must send the same information to more than one destination, multicasting is often used, because it is much more advantageous than multiple unicasts in terms of the communication costs. Cost considerations are all the more important for a mobile ad hoc network (MANET) consisting of mobile hosts that communicate with each other over wireless links, in the absence of a fixed infrastructure. In MANET environments, the multicast problem is more complex because topology change of the network is extremely dynamic and relatively unpredictable. To do multicasting, some way is needed to define multicast groups. In conventional multicasting algorithms, a multicast group is considered as a collection of hosts which register to that group. It means that, if a host wants to receive a multicast message, it has to join a particular group

first. In order to send a message to the multicast group, a host just needs to multicast the message to the address of that group. All the group members then receive the message. [6]

In Geocasting, the message (geocast message) is delivered to the set of nodes within a specified geographical area. Unlike the traditional multicast schemes, here, the multicast group (or geocast group) is implicitly defined as the set of nodes within a specified area. [9]

This section briefly explained the problem of *geocasting* – broadcasting to every node in a specified geographical area – in mobile ad hoc environments.

The basic routing philosophy on the Internet is “best-effort”; there are several requirements for it that are explored in the next section.

5.2 Ensuring QoS

This section addresses some of the quality of service issues for ad hoc networks which have recently started to receive increasing attention in the literature. The focus is on QoS routing. This is a complex and difficult issue because of the dynamic nature of the network topology and generally imprecise network state information. [2]

Quality of Service (QoS) refers to the ability of a network to provide better, more predictable service to selected network traffic over various underlying technologies, including IP-routed networks. QoS features are implemented in network routers by supporting dedicated bandwidth, improving loss characteristics, avoiding and managing network congestion, shaping network traffic, and setting traffic priorities across the network.

The notion of QoS is a guarantee by the network to satisfy a set of predetermined service performance constraints for the user in terms of the end-to-end delay statistics, available bandwidth, probability of packet loss, and so on. QoS guarantees can be attained only with appropriate resource reservation techniques. The most important element among them is *QoS routing*, that is, the process of choosing the routes to be used by the flow of packets of a logical connection in attaining the associated QoS guarantee. The cost of transport and total network throughput may be included as parameters. Obviously, enough network resources must be available during the service invocation to honor the guarantee. The first essential task is to find a suitable path through the network, or *route*, between the source and destination(s) that will have the necessary resources available to meet the QoS constraints for the desired service. The task of resource (request, identification, and) reservation is the other indispensable ingredient of QoS. By QoS routing, we mean both these tasks together. QoS routing offers serious challenges even for today's Internet. Different service types (e.g., voice, live video, and document transfer) have significantly different objectives for delay, bandwidth, and packet loss. [3]

Three distinct route-finding techniques are used for determining an optimal path satisfying the QoS constraints. These are *source routing*, *destination routing*, and *hierarchical routing*. In source routing, a feasible path is locally computed

at the source node using the locally stored global state information, and then all other nodes along this feasible path are notified by the source of their adjacent preceding and successor nodes. In distributed or hop-by-hop routing, the source as well as other nodes is involved in path computation by identifying the adjacent router to which the source must forward the packet associated with the flow. Hierarchical routing, as the name suggests, uses the aggregated partial global state information to determine a feasible path using source routing where the intermediate nodes are actually logical nodes representing a cluster. *Flooding* is not an option for QoS routing, except for broadcasting control packets under appropriate circumstances (e.g., for beaconing, or at the start of a route discovery process).

This section briefly described the new but rapidly growing area of research on guaranteeing QoS in ad hoc mobile wireless networks.

6. WHERE DO WE GO FROM HERE: POSSIBLE SOLUTION TO THE CHALLENGES

The huge way in which research activity has been going on, in both academia and industry, on wireless mobile ad hoc networks, is a representation of their tremendous potential now being well recognized. More and more results are appearing on problems related to basic network limitations, new protocols and their performance evaluations, network architecture and design, new technologies, and so on. For increased network reliability and enhanced QoS, it is required to develop and implement efficient routing algorithms and protocols. The significant thing is that such an algorithm must be evolved which dynamically calculates the route to forward and transfer data reliably, within the ad-hoc network or to a node that wishes to communicate with the wider internet. Such an algorithm will achieve multicast efficiency by tracking the availability of resources for each node within its neighborhood. Computation of free bandwidth will be based on reservations made for ongoing sessions and the requirements reported by the neighbors. The algorithm will proactively choose the next node on the route and generate table spontaneously. An ad-hoc network is highly dynamic, and transmissions are susceptible to fades, interference, and collisions from hidden/exposed stations, therefore, the algorithm will provide routes that can most probably satisfy the bandwidth requirement of a route, as long as the route is established.

Also, the algorithm will dynamically re-establish routes for ongoing connections upon link failures and topology changes in the ad hoc network. This will make it easy to perform efficient resource utilization or to execute critical applications. Moreover, the algorithm must be optimized in order to minimize its computation complexity and hence achieve better results within the hardware constraints such as power limitations. The seamless integration of mobile ad hoc networks with other wireless networks and fixed infrastructures will be an essential part of the evolution towards future fourth generation communication networks. From a technological

point of view, the realization of this vision still requires a large number of challenges to be solved related to devices, protocols, applications and services.

7. CONCLUSION

The objectives of this paper have been to examine the history of the ad hoc networking and various applications of MANETs esp. in commercial sector; to suggest the significance of the role of Geocasting in MANETs and to propose QoS as the new but rapidly growing area of research on guaranteeing QoS in ad hoc mobile wireless networks, and as a technical challenge and a necessary requirement to the growth of ad hoc networks.

MANETs have evolved a great deal over the two decades since its inception. Although the technology was confined to the military arena up until now, it is currently gaining traction in the commercial domain of late. The technology at present demands renewed attention owing to recent developments in radio communications and advancements in wireless networking. The proliferation of unmanned aerial systems (UAS) over the last decade is one of the most significant drivers for the increased deployment of MANETs in the battlefield.

FUTURE SCOPE

Guaranteeing QoS in such a network may be impossible if the nodes are too mobile. The challenges increase even more for those ad hoc networks that, like their conventional wireless counterparts, support both best effort services and those with QoS guarantees, allow different classes of service, and are required to interwork with other wireless and wireline networks, both connection-oriented and connectionless. Algorithms, policies, and protocols for coordinated admission control, resource reservation, and routing for QoS under such models are only beginning to receive attention. QoS for ad hoc networks is a new area of research.

Much work remains to be done on cost-effective implementation issues to bring the promise of ad hoc networks within the reach of the public.

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Genetic Algorithm Based Optimal Testing Effort Allocation Problem for Modular Software

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Abstract - *Software reliability growth models (SRGM) are used to assess modular software quantitatively and predict the reliability of each of the modules during module testing phase. In the last few decades various SRGM's have been proposed in literature. However, it is difficult to select the best model from a plethora of models available. To reduce this difficulty, unified modeling approaches have been proposed by many researchers. In this paper we present a generalized framework for software reliability growth modeling with respect to testing effort expenditure and incorporate the faults of different severity. We have used different standard probability distribution functions for representing failure observation and fault detection/ correction times. The faults in the software are labeled as simple, hard and complex faults. Developing reliable modular software is necessary. But, at the same time the testing effort available during the testing time is limited. Consequently, it is important for the project manager to allocate these limited resources among the modules optimally during the testing process. In this paper we have formulated an optimization problem in which the total number of faults removed from modular software is (which include simple, hard and complex faults) maximized subject to budgetary and reliability constraints. To solve the optimization problem we have used genetic algorithm. One numerical example has been discussed to illustrate the solution of the formulated optimal effort allocation problem.*

Index Terms - *Non-homogenous Poisson process, software reliability growth model, Probability Distribution Functions, Fault Severity, Genetic Algorithm*

1. INTRODUCTION

Nowadays large and complex software systems are developed by integrating a number of small and independent modules. Modules can be visualized as independent softwares performing predefined tasks, mostly developed by separate teams of programmers and sometimes at different geographical locations. During the development of modular software, faults can crop in the modules due to human imperfection. These

faults manifest themselves in terms of failures when the modules are tested independently during the module testing phase of software development life cycle. However, in today's computer invaded world these failures can lead to big losses in terms of money, time and life. Thus it is very important to evaluate software reliability of each module during modular testing phase.

To assess modular software quantitatively and predict the reliability of each of the modules during module testing, software reliability growth models (SRGM) are used. Numerous SRGM's, which relate the number of failures (fault identified) and the Execution time (CPU time/Calendar time) have been discussed in the literature [19,5,3]. All these SRGMs assume that the faults in the software are of the same type. However, this assumption is not truly representative of reality. The software includes different types of faults, and each fault requires different strategies and different amounts of testing effort for removal. Ohba [8] refined the Goel-Okumoto[1] model by assuming that the fault detection/removal rate increases with time and that there are two types of faults in the software. SRGM proposed by Bittanti et al. [22] and Kapur and Garg [13] has similar forms as that of Ohba [8] but they developed under different set of assumptions. These models can describe both exponential and S-shaped growth curves and therefore are termed as flexible models [22, 8, 13]. Kapur et al. [16] developed Flexible software reliability growth model with testing effort dependent learning process in which two types of software faults were taken. Further, they proposed an SRGM with three types of faults [19]. The first type of fault was modeled by an Exponential model of Goel and Okumoto [1]. The second type was modeled by Delayed S-shaped model of Yamada et al. [21]. The third type was modeled by a three-stage Erlang model proposed by Kapur et al. [19]. The total removal phenomenon was modeled by the superposition of the three SRGMs. Shatnawi and Kapur [11] later proposed a generalized model based on classification of the faults in the software system according to their removal complexity.

The above literature review reveals that in the last few decades several SRGM's have been proposed. This plethora of SRGM's makes the model selection a tedious task. To reduce this difficulty, unified modeling approaches have been proposed by many researchers. The work in this area started as early as in 1980s with Shantikumar [4] proposing a Generalized birth process model. Gokhale and Trivedi [23] used Testing coverage function to present a unified framework and showed how NHPP based models can be represented by probability

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distribution functions of fault –detection times. Another unification methodology is based on a systematic study of Fault detection process (FDP) and Fault correction process (FCP) where FCPs are described by detection process with time delay. The idea of modeling FCP as a separate process following the FDP was first used by Schneidewind [10]. More general treatment of this concept is due to Xie et al [9] who suggested modeling of Fault detection process as a NHPP based SRGM followed by Fault correction process as a delayed detection process with random time lag. The unification scheme due to Kapur et al [17] is based on Cumulative Distribution Function for the detection/correction times and incorporates the concept of change point in Fault detection rate. These schemes have proved to be fruitful in obtaining several existing SRGM by following single methodology and thus present a perceptive investigation for the study of general models without making many assumptions. In this paper we made use of such unified scheme for presenting a generalized framework for software reliability growth modeling with respect to testing effort expenditure and incorporate the faults of different severity. We have used different standard probability distribution functions for representing failure observation and fault correction times. Also, the total number of faults in the software are labeled as simple, hard and complex faults. It is assumed that the testing phase consists of three different processes, namely failure observation, fault isolation and fault removal. The time delay between the failure observation and subsequent removal is assumed to represent the severity of the fault.

Developing reliable modular software is necessary. But, at the same time the testing effort available during the testing time is limited. These testing efforts include resources like human power, CPU hours, and elapsed time, etc. Hence, to develop a good reliable software system, a project manager must determine in advance how to effectively allocate these resources among the various modules. Such optimization problems are called “Resource Allocation problems”. Many authors have investigated the problem of resource allocation [2, 7]. Kapur et al [20, 15] studied various resource allocation problems maximizing the number of faults removed from each module under constraint on budget and management aspirations on reliability for exponential and S-shaped SRGMs [1,19,8]. In this paper we have formulated an optimization problem in which the total number of faults removed from modular software is (which include simple, hard and complex faults) maximized subject to budgetary and reliability constraints.

To solve the effort allocation problem formulated in this research paper we use Genetic Algorithm(GA). GA stands up a powerful tool for solving search & optimization problems. The complex non linear formulation of the optimal effort allocation problem is the reason behind choosing genetic algorithm as the solving tool. GA always considers a population of solutions.

There is no particular requirement on the problem before using GA's, as it can be applied to solve any kind of problem.

The paper is organized as follows. Section 2 gives the generalized framework for developing the software reliability growth model for faults of different severity. In section 3 parameter estimation and model validation of the proposed model is done through SPSS. The testing effort allocation problem is formulated in section 4. In section 5 genetic algorithm is presented for solving the discussed problem. Section 6 illustrates the optimization problem solution through a numerical example. Finally, conclusions are drawn and are given in section 7.

2.1 Notations

$W(t)$: Cumulative testing effort in the interval $(0,t]$.

$w(t)$: Current testing-effort expenditure rate at testing time t .

$$\frac{d}{dt}W(t) = w(t)$$

$m_j(W_t)$: Expected number of faults removed of type j (j =simple, Hard, Complex Faults).

$m(W_t)$: Expected number of total faults removed.

b : Constant fault detection rate.

β : rate of consumption of testing-effort

$\lambda(W_t)$: Intensity function for Fault correction process (FCP) or Fault correction rate per unit time.

$G(W_t), F(W_t), H(W_t)$: Testing effort dependent

Probability Distribution Function for Failure observation, Fault Detection and Fault Correction Times

$g(W_t), f(W_t), h(W_t)$: Testing effort dependent Probability Density Function for Failure observation, Fault Detection and Fault Correction Times

* : Convolution.

\otimes : Steiltjes convolution.

2.2 Basic Assumptions

The proposed model is based upon the following basic assumptions:

1. Failure occurrence, fault detection, or fault removal phenomenon follows NHPP.
2. Software is subject to failures during execution caused by faults remaining in the software.
3. The faults existing in the software are of three types: simple, hard and complex. They are distinguished by the amount of testing effort needed to remove them
4. Fault removal process is perfect and failure observation/fault isolation/ fault removal rate is constant.
5. Each time a failure occurs, an immediate effort takes place to decide the cause of the failure in order to remove it. The time delay between the failure observation and its subsequent fault removal is assumed to represent the severity of the faults. The more severe the fault, more the time delay.

6. The fault isolation/removal rate with respect to testing effort intensity is proportional to the number of observed failures.

2.3 Modeling Testing Effort

The proposed SRGM in this paper takes into account the time dependent variation in testing effort. The testing effort (resources) that govern the pace of testing for almost all the software projects are Manpower and Computer time.

To describe the behavior of testing effort, Exponential, Rayleigh, or Weibull function has been used.

The testing-effort described by a Weibull-type distribution is given by:

$$W(t) = \alpha \cdot \left[1 - \exp\left(-\int_0^t g(\tau) d\tau\right) \right] \tag{1}$$

In equation (1), if $g(t) = \beta$.

Then, there is an exponential curve, and the cumulative testing-effort in (0,t] is $W(t) = \alpha \cdot [1 - \exp(-\beta \cdot t)]$. (2)

Similarly in (1) if $g(t) = \beta \cdot t$.

Then, there is a Rayleigh curve and the cumulative testing-

effort is given by: $W(t) = \alpha \cdot \left(1 - \exp\left[-\frac{\beta}{2} \cdot t^2\right] \right)$. (3)

And if $g(t) = \gamma \cdot \beta \cdot t^{\gamma-1}$ in (1), then

$$W(t) = \alpha \cdot \left(1 - \exp\left[-\beta \cdot t^\gamma\right] \right) \tag{4}$$

which is cumulative testing effort of Weibull curve.

2.4 Model Development

Let a_1 , a_2 and a_3 be the simple, hard and complex faults respectively at the beginning of testing. Also 'a' is the total fault content i.e. $a = a_1 + a_2 + a_3$.

2.4.1 Modeling Simple Faults

Simple faults are the faults which can be removed instantly as soon as they are observed. The mean value function for the simple faults of the software reliability growth model with respect to testing effort expenditure can be written as [18]:

$$m_1(W_t) = a_1 F(W_t) \tag{5}$$

where, $F(W_t)$ is testing effort dependent distribution function.

From Equation (5), the instantaneous failure intensity function $\lambda(W_t)$ is given by:

$$\lambda(W_t) = a_1 F'(W_t) \tag{6}$$

Or we can write

$$\lambda(W_t) = \frac{dm/dt}{dW_t/dt} = [a_1 - m(W_t)] \frac{F'(W_t)}{1 - F(W_t)} \tag{7}$$

2.4.2 Modeling Hard Faults

The hard faults consume more testing time for the removal. This means that the testing team will have to spend more time to analyze the cause of the failure and therefore requires greater time to remove them. Hence the removal process for hard faults is modeled as a two-stage process and is given by[18]:

$$m_2(W_t) = a_2 (F \otimes G)(W_t), \text{ and} \tag{8}$$

$$\lambda(W_t) = \frac{(f * g)(W_t)}{1 - (F \otimes G)(W_t)} [a_2 - m(W_t)] \tag{9}$$

2.4.3 Modeling Complex Faults

These faults require more testing time for removal after isolation as compared to hard fault removal. Hence they need to be modeled with greater time lag between failure observation and removal. Thus, the removal process for complex faults is modeled as a three-stage process:

$$m_3(W_t) = a_3 (F \otimes G \otimes H)(W_t) \tag{10}$$

And the instantaneous failure intensity function $\lambda(W_t)$ is:

$$\lambda(W_t) = \frac{(f * g * h)(W_t)}{1 - (F \otimes G \otimes H)(W_t)} [a_3 - m(W_t)] \tag{11}$$

2.4.4 Modeling Total Faults

The total fault removal phenomenon is the superimposition of the simple, hard and complex faults, and is therefore given as:

$$m(W_t) = m_1(W_t) + m_2(W_t) + m_3(W_t) \tag{12}$$

$$= a_1 F(W_t) + a_2 (F \otimes G)(W_t) + a_3 (F \otimes G \otimes H)(W_t)$$

A particular case of the proposed model is tabulated in Table 2.1

Faults	F(W _t)	G(W _t)	H(W _t)	m(W _t)
Simple	W _t ~ exp(b ₁)	-	-	m ₁ (W _t) = a ₁ [1 - e ^{-bW_t}]
Hard	W _t ~ exp(b ₂)	W _t ~ exp(b ₂)	-	m ₂ (W _t) = a ₂ [1 - ((1+bW _t)e ^{-bW_t})]
Complex	I(W _t)	I(W _t)	W _t ~ N(μ, σ ²)	m ₃ (W _t) = a ₃ [Φ(W _t , μ, σ ²)]

MVF of Total Fault

$$m(W_t) = a_1 [1 - e^{-bW_t}] + a_2 [1 - ((1 + bW_t)e^{-bW_t})] + a_3 [\Phi(W_t, \mu, \sigma^2)]$$

Table 2.1: A Particular Case

2.5 Reliability Evaluation

Using the SRGM we can evaluate the reliability of the software during the progress of testing and predict the reliability at the release time. Reliability of software is defined as “given that the testing has continued up to time t, the probability that a software failure does not occur in time interval (t, t + Δt) (Δt ≥ 0)”. Hence the reliability of software is represented mathematically as

$$R(t) \equiv R(t + \Delta t | t) = \exp^{-(m(t+\Delta t) - m(t))} \tag{13}$$

Another measure of software reliability at time t is defined as “the ratio of the cumulative number of detected faults at time t to the expected number of initial fault content of the software” given by[4]:

$$R(t) = \frac{m(t)}{a} \tag{14}$$

To incorporate the effect of testing effort in the reliability estimation of each module Equation (14) can be modified as:

$$R(W_t) = \frac{m(W_t)}{a} \tag{15}$$

3. PARAMETER ESTIMATION AND MODEL VALIDATION

To measure the performance of the proposed model we have carried out the parameter estimation on the data set cited in M.Ohba [8](DS-I). The software was tested for 19 weeks during which 47.65 computer hours were used and 328 faults were removed. The estimation results for Exponential, Rayleigh, and Weibull function are given in table 3.1

Testing Effort Function	Parameter Estimation for DS-I			
	α	β	γ	R^2
Exponential function	19029.3	0.0001	-	0.992
Rayleigh function	49.2961	0.0137		0.974
Weibull function	782.603	0.0023	1.114	0.996

Table 3.1: Testing Effort Function Parameter Estimates

Weibull effort function is chosen to represent the testing effort as it provided the best fit on the testing effort data (based on the highest value of R².) Based upon these estimated parameters, parameters of proposed SRGM were estimated. The goodness of fit measures used are Mean Square Error (MSE) and Coefficient of multiple determination (R²). The results are compared with SRGM proposed by Kapur et al. [19] with three types of fault. The results are tabulated in table 3.2 (Letting b₁=b₂=b₃=b)The goodness of fit curves for DS-I is given in Figure: 3.1

Parameter Estimates	Proposed Model	Kapur et al. Model [19]
a	353	378
b	0.05218	0.09722
μ	26.71107	-
σ	6.530279	-
R²	0.996	0.992
MSE	38.79684	75.31579

Table 3.2: Parameter Estimates for DS-I

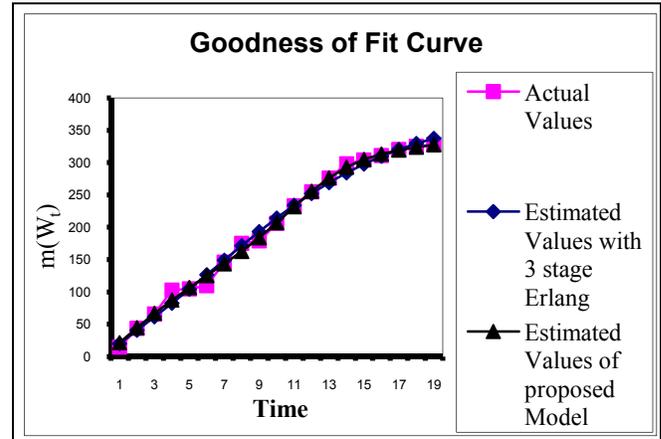


Figure 3.1: Goodness of Fit Curve for DS-I

4. TESTING RESOURCE ALLOCATION PROBLEM

4.1 Notations:

j : 1,2,3; Simple faults-1; Hard Faults-2, Complex Faults-3

i : Module, 1,2..N

N : Total number of modules

m_i(W_i) : Mean value function for ith module

b_{ji} : Constant fault detection rate for jth fault type in ith module

a_{ji} : Constant, representing the number of jth fault type

lying dormant in ith module at the beginning of testing,

c_{ji} : Cost of removing jth fault from ith module

W_i : Testing effort for ith module

R_i : Reliability of each module

B : Total cost of removing different types of faults

W : Total testing effort expenditure

4.2 Mathematical Formulation

Consider software with ‘N’ modules where each module is different in size, complexity, the functions they perform etc. In each module there are three types of faults; simple, hard and complex. The software has to be released in the market at a predefined software release time with limited availability of testing resources expenditure. Further the cost of removing the fault from each module is dependent on its severity.

Therefore, the problem of maximizing the faults of each of N independent modules such that reliability of each module is at least R_0 is formulated as:

Maximize

$$m(W_i) = \sum_{i=1}^N m_i(W_i) \\ = \sum_{i=1}^N (a_{1i} (1 - e^{-b_{1i}W_i})) + \sum_{i=1}^N (a_{2i} (1 - (1 + b_{2i}W_i)e^{-b_{2i}W_i})) \\ + \sum_{i=1}^N (a_{3i} [\Phi_i(W_i, \mu_i, \sigma_i^2)])$$

Subject to:

$$\sum_{i=1}^N (C_{1i}m_{1i}(W_i) + C_{2i}m_{2i}(W_i) + C_{3i}m_{3i}(W_i)) \leq B \quad i = 1, 2, \dots, N$$

$$\sum_{i=1}^N W_i \leq W \quad i = 1, 2, \dots, N$$

$$R_i \geq R_0 \quad i = 1, 2, \dots, N \quad (P1)$$

$$W_i \geq 0 \quad i = 1, 2, \dots, N$$

5. GENETIC ALGORITHM FOR TESTING RESOURCE ALLOCATION

The above optimization problem is solved by a powerful computerized heuristic search and optimization method, viz. genetic algorithm (GA) that is based on the mechanics of natural selection and natural genetics. In each iteration (called generation), three basic genetic operations i.e., selection /reproduction, crossover and mutation are executed.

For implementing the GA in solving the allocation problem, the following basic elements are to be considered.

5.1 Chromosome Representation

Genetic Algorithm starts with the initial population of solutions represented as chromosomes. A chromosome comprises genes where each gene represents a specific attribute of the solution. Here the solution of the testing-effort allocation problem in modular software system includes the effort resources consumed by individual modules. Therefore, a chromosome is a set of modular testing effort consumed as part of the total testing effort availability.

5.2 Initial Population

For a given total testing time W, GA generates the initial population randomly. It initialize to random values within the limits of each variable.

5.3 Fitness Of A Chromosome

The fitness is a measure of the quality of the solution it represents in terms of various optimization parameters of the solution. A fit chromosome suggests a better solution. In the effort allocation problem, the fitness function is the objective of testing effort optimization problem along with the penalties of the constraints that are not met.

5.4 Selection

Selection is the process of choosing two parents from the population for crossover. The higher the fitness function, the more chance an individual has to be selected.

The selection pressure drives the GA to improve the population fitness over the successive generations. Selection has to be balanced with variation from crossover and mutation. Too strong selection means sub optimal highly fit individuals, will take over the population, reducing the diversity needed for change and progress; too weak selection will result in too slow evolution. We use “*Tournament selection*” here.

5.5 Crossover

Crossover is the process of taking two parent solutions and producing two similar chromosomes by swapping sets of genes, hoping that at least one child will have genes that improve its fitness. In the testing resource allocation problem, crossover diversifies the population by swapping modules with distinct time consuming, particularly when the population size is small.

5.6 Mutation

Mutation prevents the algorithm to be trapped in a local minimum. Mutation plays the role of recovering the lost genetic materials as well as for randomly disturbing genetic information.

The important parameter in the mutation technique is the mutation probability. The mutation probability decides how often parts of chromosome will be mutated. If there is no mutation, offspring are generated immediately after crossover (or directly copied) without any change. In our problem of testing resource allocation, we have used a mutation probability of 10%.

With the basic modules of genetic algorithm described above, the procedure for solving the optimal effort allocation problem is as follows [6]:

Step 1: Start

Step 2: Generate random population of chromosomes

Step 3: Evaluate the fitness of each chromosome in the population

Step 4: Create a new population by repeating following steps until the new population is complete:

[Selection] Select two parent chromosomes from a population according to their fitness

[Crossover] With a crossover probability, cross over the parents to form new offspring (children). If no crossover is performed, offspring is the exact copy of parents.

[Mutation] With a mutation probability, mutate offspring at each locus (position in chromosome)

[Accepting] Place new offspring in the new population

[Replace] Use new generated population for further sum of the algorithm.

[Test] If the end condition is satisfied, stop and return the best solution in the current population

[Loop] Go to step 3 for fitness evaluation

6. NUMERICAL EXAMPLE

The Effort Allocation Problem described in section 4 is illustrated numerically in this section. Consider a software system consisting of three modules, whose parameters have already been estimated using software failure data. These parameter estimates for each module is shown in Table 6.1. The total testing resources available is assumed to be 5000 units. Total cost for removing the different types of faults is 10000 units. Also, it is desired that the reliability of each module is at least 0.9.

odule	a ₁	a ₂	a ₃	b	c ₁	c ₂	c ₃	μ	σ
1	313	107	81	0.00368	5	10	15	16.292	5.586
2	332	97	76	0.00234	5	10	15	14.987	4.123
3	298	64	32	0.0018	5	10	15	12.456	7.654

Table 6.1: Parameter Estimates for effort allocation problem

Based on the above information, the problem (P1) is solved using genetic algorithm. The parameters used in GA evaluation are given in table 6.2.

Parameter	Value
Population Size	106
Number of Generations	26
Selection Method	Tournament
Crossover Probability	0.9
Mutation Probability	0.1

Table 6.2: Parameter of the GA

The optimal testing time allocation to each type of fault in module and hence total fault removed from each module and their corresponding cost of removing is shown in table 6.3.

Module	W	m ₁	m ₂	m ₃	m	Reliability	Cost of removing faults
1	1192.22	309	100	81	490	0.978	3758.87
2	1602.294	324	86	76	486	0.962	3622.524
3	2202.934	292	58	32	382	0.969	2521.486
Total	4997.448				1358		9902.88

Table 6.3: The optimal testing effort expenditure with the corresponding cost of each module

7. CONCLUSION

In this paper we have discussed the problem for modular software at the unit testing stage. We have made use of unified scheme for presenting a generalized framework for Software reliability growth modeling with respect to testing effort expenditure and incorporated the faults of different severity. The faults in each module are of three types-simple, hard and complex. Further we have optimally allocated the testing effort to each type of fault and the modules and have found out the different types of faults removed in the modules with a fixed budget and a prerequisite level of reliability. Genetic Algorithm is developed to solve the problem of resource allocation. Numerical example is discussed to illustrate the solving of the discussed optimization problem through GA.

FUTURE SCOPE

The present study is done under the assumption of independence of the failures of different modules. In future, dependence of the failures from different modules as well as the architecture styles and connectors reliability can also be studied.

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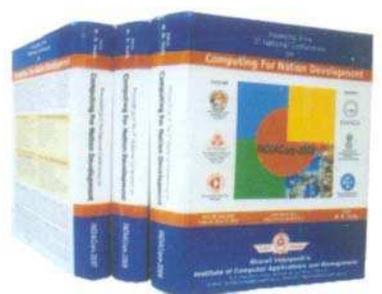


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Engineers (IETE), Delhi Centre



(Copies of the proceedings of past INDIAComs)

Correspondence

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Registration Fees

Category of Delegates/ Authors	Early Bird on or before 20 th December, 2011 (in Rs.)		After 20 th December, 2011 (in Rs.)		Spot Registration (only in Cash)	
	*CSI/IETE IEEE/ISTE Members	General	*CSI/IETE IEEE/ISTE Members	General	*CSI/IETE IEEE/ISTE Members	General
Students# (Delegates only)	600.00	800.00	800.00	1000.00	1000.00	1200.00
Teachers/Research Scholars	2200.00	2500.00	2700.00	3000.00	3000.00	3500.00
Industry	3000.00	3500.00	3500.00	4000.00	4000.00	4500.00

10% discount will be given on three or more registrations from one organization in General Category only.

* Members must mention their membership number of CSI / IETE / IEEE / ISTE.

Authors can not register under Students Category. Bonafide students as on 31st January, 2012, must submit the Bonafide certificate from their Institute / College / Department. Students will not be given the hard copy of the Conference Proceeding. Soft copy will only be given.

The registration fee includes tea, lunch, conference kit and the Soft and hard copies of Conference Proceedings along with other printed materials related to the conference. The payment can be made in Cash in the office of the Institute or by Demand Draft in favour of **Director, Bharati Vidyapeeth's Institute of Computer Applications and Management**, payable at **New Delhi**.

NSC-2012

5th National Students' Convention on Computing For Nation Development February 25, 2012

Bharati Vidyapeeth's CSI Students' Branch is also organizing 5th National Students' Convention (NSC-2012) on the same theme of "Computing For Nation Development" on 25th February, 2012. Further details are available in the attached brochure and also on the website www.bvicam.ac.in/ns