Analysis of on Demand and Table Driven Routing Protocol for Fire Fighter Application

Annapurna D, K B Raja, Venugopal K R, L M Patnaik

***Abstract*—In an Ad hoc communication, the nodes are randomly distributed in a region are moving arbitrarily. We propose Analysis of On demand and Table driven routing protocols for Fire Fighter Applications (AOTFF) in this paper. The performance analysis on reactive protocols viz., AODV and AOMDV as well as proactive protocol DSDV are compared with Packet Delivery Fraction (PDF) and Simulation time. The model of fire fighter is developed using routing protocol to cover maximum area by knowing the path that is already been used . It is observed that the performance of reactive protocols are better than compared to proactive protocols..**

***Keywords-* AODV, AOMDV, DSDV, Firefighter, Lifeline, Routing Protocol.**

I. INTRODUCTION

An Ad hoc network has mobile computing nodes distributed randomly in a specified area and are characterized by energy, node ID and node expiry time. The communication between nodes is based on wireless trans-reception without fixed infrastructure. The computing nodes are tiny devices capable to measure and process the quantities of environmental information and communicate to the information gathering centre to take approximate action. The sensing activity by the computing node are of two types viz.,(i) Periodic Sensing in which a node senses the environmental physical parameters such as temperature, humidity, nuclear radiations and electromagnetic radiations and (ii) Sporadic Sensing in which, the nodes are used to sense and measure physical parameters such as temperature of a furnace in an industry, stress on a structure and density of vehicles in a city to keep the measured values within the specified threshold level to avoid destructions and maintain the safety norms. The routing in Ad hoc network is dynamic and links changes randomly. An intelligent routing protocol is required to find the path as the Ad hoc network is infrastructure less and network topology information of every node in the network is necessary for routing. The routing protocols [1] for Ad hoc wireless network is classified on the basis of (i) Routing Information update mechanism [ii] Use of temporal Information for routing (iii) Routing Topology (iv) Utilization of specific resources.

The routing information update mechanism is classified as

(i) *Table driven or proactive routing protocol:* Routing table holds and maintains the topological information of the nodes. Routing Information is obtained by exchanging routing tables within the network and, path finding algorithm is used, to find the path.

(ii) On demand or reactive routing protocols: The protocols do not maintain the network topology information. In order to find path, the connection is established. Hence periodical exchange of routing information among the nodes is not seen.

(iii) Hybrid Routing Protocols: The protocols form the routing with a specified zone using proactive routing scheme and reactive routing scheme is used for nodes which are beyond the zone.

Some of the routing protocols are:

(i) Ad hoc On-Demand Distance Vector (AODV) routing protocol used to find routes by on demand scheme. Route is found only when the source is in need to transmit data packets. Routes Requests (RREQs), Route Replies (RREPs) and Route Errors (RERRs) are the message types defined by AODV. If the route is not available for the desired destination then the source node floods the Route Request packet in the network and then it obtains many different routes to different destinations from a single Route Request. An AODV Route Request packet holds the source identifier, the destination identifier, the source sequence number, the destination sequence number, the broadcast identifier, and time to live field. In order to determine an up-to-date path and freshness of the route to the destination, AODV uses a destination sequence number. As the Route Request packet is received by the intermediate node, it forwards the packet or Route Reply is prepared if it has a valid route to destination, for which validity of route is indicated by the destination sequence number. Route Reply packets are sent to the source by all of the intermediate nodes which are having the valid routes to destination or the destination node itself are allowed to send Route Reply packets to source. As the node receives the Route Reply packet, it forwards the data packet with the help of the previous node Information from which the Route Reply packet was received. AODV will not repair a broken path locally. As the source node identifies the path break by the periodic beacons it reestablishes the route to destination. (ii) Ad Hoc On-demand Multipath Distance-Vector Protocol (AOMDV): is a multipath routing protocol. It is a multipath and loop-free extension of AODV.

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Prof. Annapurna D, Information Science andEngineering, Viswesvarya Technological Universit,/ PESIT South Campus,/ Peoples Education Society (PES), Bangalore,India.

Dr. K B Raja, Electronics and Communication Engineering, Bangalore University, University Visvesvaraya college of Engineering, Bangalore,India.

Dr. K R Venugopal, Principal and Dean, Faculty of Engineering, University Visvesvaraya College of Engineering, Bangalore University, Bangalore.

Dr. L M Patnaik, Honorary Professor, Indian Institute of Science, Bangalore, former Vice Chancellor, Defence Institute of Advanced Technology (Deemed University), Pune, India.

Multipath routing can provide better fault tolerance nodes as they have redundant information. If any of the links are congested then an alternate path can be used to reduce the load in any given link, this way it helps in load balancing. The effective bandwidth can be increased, as there are multiple routes from source to destination as the data to be sent can be divided over the links. This causes an increase in available bandwidth. If a link is broken, it takes long time for route discovery in case of AODV. However, the delay is less in case of AOMDV as it has multiple routes from the source. AOMDV is loop free as it ensures that alternate paths at every node is disjoint. The routing table contains the list of next hop neighbors, destination ID and hop counts.

(iii) Destination-Sequenced Distance-Vector Routing (DSDV) is a proactive and table driven routing protocol. It maintains the topological information in the form of tables at every node. At regular intervals these tables are exchanged between the neighbors at regular intervals, this helps to maintain up to date view of the network topology. Table is maintained at the every node, contains the shortest distance and the first node on the shortest path to every other node in the network. The table is updated with increasing sequence number tags which prevent loops, to counter count-to-infinity problem and for faster convergence. Destination initiates table updates with a new sequence number which is greater than the previous one. As and when the table updates are received, updating of tables at the nodes is based on the received information or holds it for some time to select the best metric received from multiple versions of the same update table from different neighboring nodes. Depending on the sequence number of the table update, it may forward or reject the table. The time involved in route setup process is less due to the availability of routes to all destinations at all times.

Contribution: In this paper AOTFF model is proposed. The performance analysis of AODV, AOMDV and DSDV protocols are compared. The fire fighter model is developed using protocols and analyzed PDF for the variation of simulation and number of nodes.

Motivation: Firefighting has been one of the toughest and most difficult profession. The main motivation behind the paper is to provide a better solution to make the firefighters operation effective, easier and safer.

Organization: This paper is organized into following sections. Section II is an overview of related work. The firefighter model is described in section III. Section IV discusses the algorithm used for this model. Section V shows the graph and performance analysis is discussed. The conclusion is discussed in section VI.

II. LITERATURE SURVEY

Kulakowski et al., [2] illustrated spreading of fire model based on appropriate percolation theory. The network consists of sensors to gather temperature data and sending it to the control station to create a map of fire and to take necessary actions. Oliveira et al., [3] concentrates on thermal parameters like internal temperature, external temperature and heat flux to detect the fireman in a dangerous thermal situation. This work has developed new equipment based on micro and nanotechnologies with smart integrated sensor on garment to monitor temperature parameters. Lungi Vallozzi et al., [4] illustrates performance of textile antenna system with wireless link which is determined by measuring topology, design considerations and radiation characteristics to prove that fire fighters are suitable antenna system for fire rescuers. Sudip Dogra et al., [5] proposed Radio Frequency Identification (RFID) technology for planning their work and save the fire men more effectively in case of nature of fire spread temperature of different areas and plan accordingly to safeguard them. Giovanni Magnenes et al., [6] developed a prototype system that remotely transmits health state data which is sensed using sensors embedded in wearable garments. This system proves reliable in presence of different and harsh environment conditions. Hady Abdel salam et al., [7] proposed an algorithm where firefighters are given support by increasing the life of the Wireless Sensor Network (WSN). This algorithm helps men at the fire area with sufficient and continuous information besides maintaining the energy of WSN. Christopher Moore and Newman [8] In MANETs, the nodes are mobile and battery operated. As the nodes have limited battery resources and multi hop routes are used over a changing network environment due to node mobility, it requires energy efficient routing protocols to limit the power consumption, prolong the battery life and to improve the robustness of the system. This paper evaluates the performance of adhoc routing protocols such as DSDV, AODV, DSR and AOMDV in terms of energy efficiency. AOMDV is analyzed as the best protocol compared to AODV, DSR and DSDV when energy efficiency is taken into consideration.

Markus Klann et al., [9] proposed a concept for adhoc sensor network that the system helps in positioning for firefighters to act intensively at the fire area and also providing a wearable system to fulfill the mentioned task. Deepinder Singh Wadhwa et al, [10] the numbers of nodes are increasing the performance of the protocols degrades. The performance of all the protocols is almost similar but If we conclude, AODV performs better than AOMDV and DSDV. As AOMDV is a multipath protocol still it gives the nearby performance to the AODV whereas DSDV gives very less throughput than other two protocols.

Smita Singh et al., [11] evaluated the performance of AOMDV and DSDV routing protocol using ns-2.35.Comparison was based on packet delivery ratio, normalized routing load and average end to end delay. Concluded that AOMDV performs better than DSDV in both models when it comes to packet deliver ratio. In case of average end to end delay DSDV gives better result when pause time is varied but a different result is obtained on varying maximum speed of nodes, that is AOMDV performs better .When normalized routing load is evaluated DSDV performs better in both models.

Ramprasad Kumawat et al., [12] Ad-hoc On-demand Distance Vector (AODV) routing protocol, which is unipath, Ad-hoc On-demand Multipath Distance Vector (AOMDV) routing protocol and Dynamic Source routing (DSR) protocol. The paper investigates all these routing protocols corresponding to packet delivery fraction (pdf), throughput, normalized routing load and end to end delay.

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Mark A Finney et al., [13] conducted experiments to identify fire spread thresholds. It proved that fire spread is greater in deeper beds and on steep slopes. Experiments were conducted on both continuous and discontinuous fuel types. P.Periyasamy et al., [14] The AODV and AOMDV protocols are compared in terms of the variation in pause time and network load in CBR traffic under RWM. Due to randomness in mobility, the RWM and CBR are selected as scenario parameters. The AOMDV protocol is giving better performance than the AODV protocol for most of the performance parametric measures. A. Rajeswari et al., [15] introduces the concept of combining two Medium Access Control (MAC) Protocols such as Spatial Correlation based Collaborative Medium Access Control (CCMAC) and Hybrid Medium Access Control (HMAC) which will increase the energy efficiency of the Network. The four various routing protocols explored in this work are AOMDV,AODV, DSR,DSDV, comparison of energy efficient routing protocols for Wireless Sensor Networks using Spatial Correlation Based Collaborative Medium Access Control. D.D. Chaudhary et al., [16] It is observed that, Quality of Service (QoS) of the network can improve by minimizing delay in packet delivery, and life time of the network, can be extend by using suitable energy efficient routing protocol. The three protocols namely Ad-hoc on-Demand Distance Vector (AODV), Destination Sequence Distance Vector (DSDV) and Ad-hoc on-Demand Multipath Distance vector (AOMDV) are compare and analyze. They also compared with IEEE802.11 and IEEE802.15.4 MAC protocol, overall performance of WSN is analyzed by comparing the End-to-End delay, Number of packet received, Packet drop ratio and Energy consumption of the Network. V. Seethalakshmi et al., [17] have evaluated the performance of different existing routing protocols in MANET such as AOMDV, AODV, DSR, DSDV and TORA in different network environments. Results show that AOMDV consumes minimum energy compared to DSR, DSDV, TORA and AODV protocols. DSR seems to have slightly more balanced energy consumption between nodes. AOMDV is analyzed as the best protocol compared to AODV, DSR and DSDV when energy efficiency is taken into consideration. TORA exhibits poor performance among the above 5 routing protocols. It also proposed a new routing protocol MODIFIED_AOMDV in order to balance the traffic load among different nodes according to their nodal residual battery and prolong the individual node's lifetime and hence the entire system lifetime. Ramesh et al., [18] examined two routing protocols Destination Sequenced Distance Vector (DSDV) and Adhoc on Demand Distance Vector (AODV) and evaluated them on packet delivery fraction and average delay while varying the number of sources and pause time. AODV protocol is best suitable for UDP communication, while packet delivery fraction is very low for high mobility scenarios in case of DSDV. Ade and Tijare [19] compared the performances of AODV, DSR and DSDV routing protocols. It is seen that DSR/AODV performs better than DSDV when there are a large number of nodes. AODV is preferred for real time traffic and DSDV performance is high in case of less number of nodes with less mobility.

Daniele Miorandi and Eiton Altman E [20] explain the analysis of connectivity issues in one dimensional ad hoc networks. A queuing model is suggested to address network connectivity. This model helps in the study of percolation problems in adhoc networks. It shows that node distribution is based on Poisson's distribution.

III. PROPOSED MODEL

The proposed model AOTFF is a combination of Wireless Sensor Network (WSN) and Mobile Ad Hoc Network (MANET). The concept is based on the fact that the firefighters are in motion for most part of the fire rescue operation. It is very important for the fire fighters to communicate with each other effectively as the fire fighters work in an environment that is continuously changing and complex. The visibility of the firefighters is usually impaired because of the smoke and fire hence cannot see all their fellow firefighters. Commanders stay outside the building while firefighters enter the building.

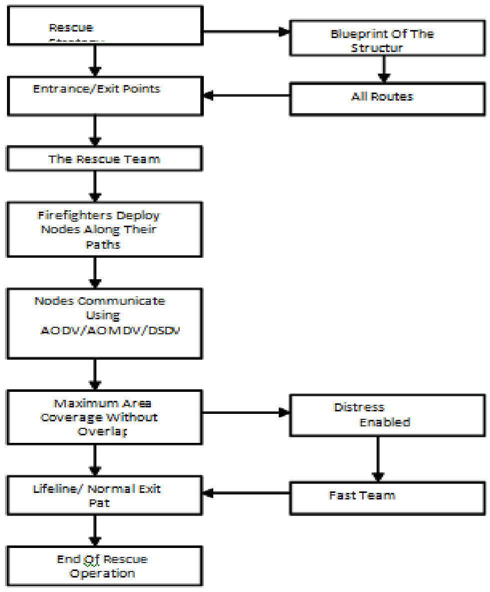

Figure 1.Block Diagram of the proposed AOTFF model

The firefighters are part of the MANET, which serves as a medium of communication among the firefighters and the commanders, because they are in motion and need not always be in the radio range of the commanders. The information still reach all the firefighters even though they are not in the radio range of the sender. Since MANETS can act as routers and due to the multiple hops the information will reach the firefighter. The firefighters are provided with a device which has the capability to drop nodes at regular intervals of time inside the building and form a WSN. The nodes contain temperature sensors and transceivers. The transceivers are used to send and receive the temperature at each node. The device that the firefighters have also a display which shows positions of all the other firefighters along with the position of nodes which are dropped by that firefighter and fellow firefighters.

A. Rescue Strategy

On reaching the destination, the Rescue Team makes a decision on the strategy to be used based on the situation. First the commander checks for the blueprint of the building then the commander finds out all the possible entry/exit points, which helps the commander to plan the rescue operation and patrol his firefighters.

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Each firefighter carries a device which has temperature sensors with transceivers. The device also has a display. This device once switched on drops nodes at regular interval. It also uses a location service system which gives the location of the firefighter all the time that helps the incident commander and fellow firefighters to know the exact location of all other firefighters.

The strategic decisions include deciding the number of firefighters in each Rescue Team and Firefighter Assistance and Search Team (FAST). The main task of Rescue Team is to ensure maximum area coverage so as to save as many lives as possible. FAST is assigned with the task of saving firefighters when they are in distress or when there is no lifeline. The Rescue Team initially enters through a main entrance/exit point and incident commander is stationed at this point. In case the blueprint of the building is available the incident commander will have knowledge of all the entry/exit points of the building. On finding the available and entry and exit points the rescue team proceeds.

B. Deployment of Nodes and Maximum Area Coverage

The firefighters drop nodes along their path and the display device shows the positions of all the nodes and firefighters. The nodes help the firefighter in knowing the path taken by them as well as the path taken by other firefighters. This helps in effective area coverage as the path taken by one firefighter will not be retraced by another firefighter as the display device will indicate that the path has already been taken.

C. Equations

In every device's display, the color of the nodes dropped by the holder is blue while the nodes dropped by other firefighters will be green in color. A node which is in a safe condition, that is, below a threshold temperature that can be withstood by the human body is either blue or green, while a node which shows a temperature greater than threshold turns red in color. Thus, when a node turns red, the firefighter knows that his lifeline has been interrupted. This shows that the firefighter has to take an alternate path to the exit point, thereby saving precious time in not retracing the blocked path.

D. Distress Button

The display also has a distress button. When the firefighter is in distress either due to asphyxiation or due to injuries, he initiates the distress signal. This intimates the incident commander to send the FAST to rescue the person in distress.

IV. THE PROPOSED ALGORITHM

Problem definition: The concept of WSN and MANET provide effective area coverage and a reliable lifeline to firefighters.

The objectives are:

1) To provide a reliable lifeline to the firefighter.
2) To improve the effective area coverage of the structure on fire.
3) To provide relief to firefighters in distress with the aid of the distress button.

The firefighters are mobile during the rescue operations. The proposed algorithm is used to save precious lives and property using WSN and MANETS, is given in the Table1.

TABLE 1. THE AOTFF ALGORITHM

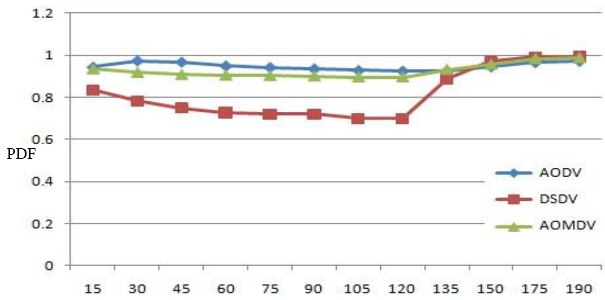
1. The firefighter team decides on the rescue strategy based on the blueprint of the building else the team chooses one point as the main entry/exit point.
2. The rescue team enters the building equipped with a wrist bound device containing numerous nodes with a temperature sensor and an attached display.
3. The firefighters deploy nodes along the path in which they traverse through the device.
4. The nodes which are dropped along the paths form a Sensor Network and the firefighters form a Mobile Ad hoc Network.
5. Maximum area coverage is achieved as each firefighter is aware of the paths taken by him as well as that of other firefighters.
6. In case a firefighter is in distress, he enables the distress button in the device, which then intimates the incident commander that the firefighter is in danger.
7. The operation ends as the firefighters reach the exit point with the help of lifelines.

V. PERFORMANCE ANALYSIS AND SIMULATION RESULTS

Packet Delivery Fraction (PDF): Is the ratio of number of packets recevied to the number of packets originated.

The graph in Figure 2 shows the variation of PDF with pause time. The movement of nodes starts at 25 seconds and ends at 125 seconds. Initially the PDF remains high for AODV and AOMDV because they are reactive protocols. Another reason is that the nodes are static at the start of simulation. Since DSDV is a table driven protocol, all the routes are not stored in the routing table, thereby justifying the low PDF.

In the mid-region of the graph, that is, from 30 seconds to 125 seconds, the nodes are highly mobile. Since the topology changes are rapid, on demand routing performs better as the routes are determined every time a packet has to be sent to a destination. On the other hand, DSDV being table driven takes much longer to react to these rapid topology changes resulting in large packet loss. In the last part of the graph the nodes are almost static and hence the topology is constant and the routes remain same for all the destination nodes. DSDV performs better as the route updates are less frequent in constant topology. However AODV and AOMDV take time to find routes to new destinations though there being not much change in the topology of the network.



Simulation Time (s)

Figure2. Gragh shows the PDF of AODV, AOMDV and DSDV with simulation time.

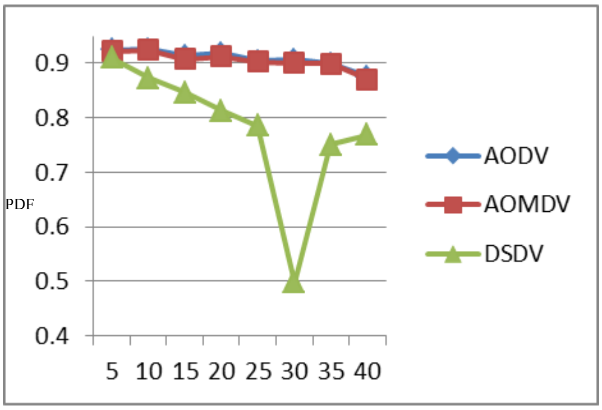


Figure 3. Gragh shows PDF of AODV, AOMDV and DSDV with number of nodes

The firefighters will be highly mobile during the operation and in the simulation the nodes are in motion during 25sec to 125sec region. The AODV out performs AOMDV and DSDV with respect to PDF

Figure 3 shows variation of number of nodes and PDF, and with pause time of 150 sec. In case of AODV and AOMDV as the number of nodes increases the PDF decreases slightly as the traffic increases. In case of DSDV, the values of PDF is decreasing rapidly as the number of nodes are increasing, with this the routing overhead is increased and hence the PDF is decreasing rapidly as the number of nodes are increasing, with this the routing overhead is increased.

TABLE II. VARIATION OF PDF WITH SIMULATION TIME FOR AODV

Simulation Time (Sec) (AODV)	Packets Sent by Agent	Packets Received by Agent	Packets Lost by Agent	PDF= R/S
15	616	581	35	0.9432
30	1868	1816	52	0.9722
45	2746	2654	92	0.9665
60	3299	3129	170	0.9485
75	3735	3518	217	0.9419
90	4185	3913	272	0.9350
105	4595	4265	330	0.9282
120	5018	4642	376	0.9251
135	5620	5206	414	0.9263
150	7669	7253	416	0.9458
175	11815	11399	416	0.9648
190	14305	13889	416	0.9709

Table II shows variation of PDF with simulation time for AODV protocol. PDF is high when mobility is low; it decreases slightly with increase in mobility. PDF increases again with the decrease in mobility.

TABLE III. VARIATIONS OF PDF WITH SIMULATION TIME FOR AOMDV.

Simulation Time (Sec) (AOMDV)	Packets Sent by Agent	Packets Received by Agent	Packets Lost by Agent	PDF= R/S
15	321	300	21	0.9346
30	329	302	27	0.9179
45	499	453	46	0.9078
60	514	465	49	0.9047
75	515	465	50	0.9029
90	516	465	51	0.9012
105	519	465	54	0.8960
120	519	465	54	0.8960
135	1099	1024	75	0.9318
150	2247	2150	97	0.9568
175	6224	6127	97	0.9844
190	8615	8518	97	0.9887

Table III shows variation of the PDF with simulation time for AOMDV protocol. PDF is high when mobility is low; it decreases slightly with increase in mobility. PDF increases again with the decrease in mobility.

TABLE IV. VARIATIONS OF PDF WITH SIMULATION TIME FOR DSDV

Simulation Time (Sec)	Packets Sent By	Packets Received	Packets Lost by	PDF= R/S
15	85	71	14	0.8353
30	92	72	20	0.7826
45	96	72	24	0.75
60	99	72	27	0.7273
75	100	72	28	0.72
90	100	72	28	0.72
105	103	72	31	0.699
120	103	72	31	0.699
135	519	461	58	0.8882
150	2001	1942	59	0.9705
175	6004	5945	59	0.9902
190	146186	33621	8408	0.2299

Table IV shows variation of the PDF with simulation time for DSDV protocol, PDF is high when the mobility is very low, that is, from 135 second to 190 second period and decreases with the increase in mobility.

VI. CONCLUTIONS

The Adhoc network has moving nodes in predefined area and wireless communication between nodes. The reactive and proactive protocols are used to develop fire fighter model for efficient and quick communications in the case of emergency. The performance of AODV, AOMDV and DSDV protocols are compared and observed that AODV and AOMDV are better than compare to DSDV.

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AUTHORS PROFILE

D.Annapurna is an Associate Professor, Dept of Information Science and Engineering, PESIT South Campus, Hosur Road, Viswesvarya Technological University, Bangalore. She has obtained her MTech in Comuter Science and Engineering and a Research Scholar in Computer Science and Engineering, Bangalore University.she is a member of IEEE Organisation. Her research intrests include Computer Networks and Wireless Communications.

K B Raja is an Assistant Professor, Dept. of Electronics and Communication Engineering, University Visvesvaraya college of Engineering, Bangalore University, Bangalore. He obtained his BE and ME in Electronics and Communication Engineering from University Visvesvaraya College of Engineering, Bangalore. He was awarded Ph.D. in Computer Science and Engineering from Bangalore University. He has over 60 research publications in refereed International Journals and Conference Proceedings. His research interests include Image Processing, Biometrics, VLSI Signal Processing, computernetworks.

K R Venugopal is currently the Principal and Dean, Faculty of Engineering, University Visvesvaraya College of Engineering, Bangalore University, Bangalore. He obtained his Bachelor of Engineering from University Visvesvaraya College of Engineering. He received his Masters degree in Computer Science and Automation from Indian Institute of Science, Bangalore. He was awarded Ph.D. in Economics from Bangalore University and Ph.D. in Computer Science from Indian Institute of Technology, Madras. He has a distinguished academic career and has degrees in Electronics, Economics, Law, Business Finance, Public Relations, Communications, Industrial Relations, Computer Science and Journalism. He has authored 27 books on Computer Science and Economics, which include Petrodollar and the World Economy, C Aptitude, Mastering C, Microprocessor Programming, Mastering C++ etc. He has been serving as the Professor and Chairman, Department of Computer Science and Engineering, University Visvesvaraya College of Engineering, Bangalore University, Bangalore. During his three decades of service at UVCE he has over 250 research papers to his credit. His research interests include computer networks, parallel and distributed systems, digital signal processing and data mining.

L M Patnaik is a Honorary Professor, Indian Institute of Science, Bangalore, former Vice Chancellor, Defence Institute of Advanced Technology (Deemed University), Pune, India. During the past 35 years of his service at the Indian Institute of Science, Bangalore, He has over 550 research publications in refereed International Journals and Conference Proceedings. He is a Fellow of all the four leading Science and Engineering Academies in India; Fellow of the IEEE and the Academy of Science for the Developing World. He has received twenty national and international awards; notable among them is the IEEE Technical Achievement Award for his significant contributions to high performance computing and soft computing. His areas of research interest have been parallel and distributed computing, mobile computing, CAD for VLSI circuits, soft computing, and computational neuroscience.