International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-1, November 2019

Proactive Fault Tolerant Routing Protocol for Mobile WSN

Shyamala C, Geetha Priya M, Sumithra Devi K A

Abstract*: In Wireless Sensor Network when the sensory nodes are mobile, it is called Mobile WSN. Since the sensors are on the move, the topology of a MWSN is perpetually dynamical. So, finding an optimal routing path from the start node (where the event takes place) to the base station in Mobile WSN is highly complicated. Recent research works have resulted in the design of many innovative protocols for MWSN, however there are many unresolved issues like fault tolerance, connectivity, reducing the energy consumption, enhancing coverage, improving security etc. This work aims at proposing a proactive FT routing scheme for Mobile WSN using a dynamic routing table PFTP and then simulating in MATLAB for evaluating the various performance metrics.*

Keywords: Mobile wireless sensor network; fault tolerance; proactive routing table; clustering.

I. INTRODUCTION

Mobile Wireless sensor network (MWSN) is a wireless sensor network in which the nodes are mobile. MWSN consists of many unattended and scattered sensor nodes that have the ability to move. A sensing node is a small device that includes three basic parts as shown in figure 1.

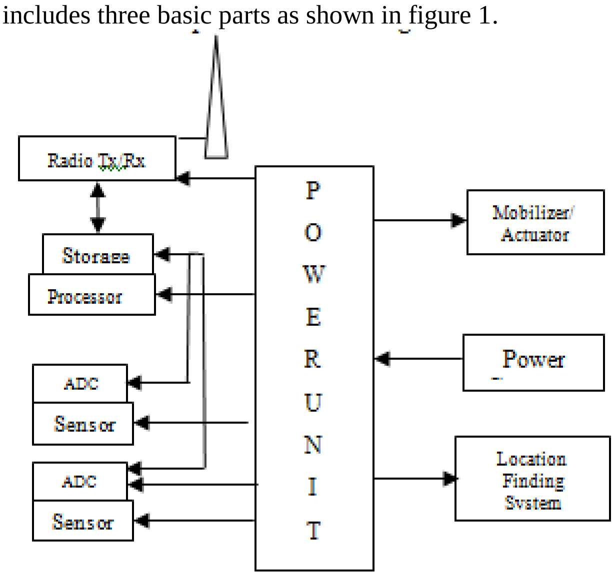

Fig 1: A Sensor Node

Revised Manuscript Received on November 30, 2019.
* Correspondence Author
Shyamala C*, Assistant Professor, Department of Electronics & Communication Engineering, GSSSIETW, Mysuru.
Dr Geetha Priya M, Professor, CIIRC and Dept. of ECE, Jyothi Institute of Technology, Bangalore.
Dr Sumithra Devi K A, Dean Academics & Head, Dept of ISE, DayanandSagar Academy for Technology and Management, Bangalore.

- A Sensory module for acquiring data from physical world around it.
- A storing and processing module for preparing the data &
- A Radio system for transmission of sensed data.

The method or rule followed in sending a data packet from source node placed in the sensed area to the final sink/base station is called Routing Protocol. There are many such algorithms already existing.

Routing protocol may be proactive or reactive. Proactive routing protocol is also known as table driven routing protocol. In this protocol, a routing table including all the details of the nodes in defined network is maintained. The proactive routing table is regularly updated, as and when topology changes. Using this table, the route from source to sink can be decided before the start of transmission.

Reactive routing algorithm is On-Demand scheme. In this protocol, the path from source to sink is computed only when a demand for that rises. When a node is ready to transmit data, a request for path is sent. On receiving the request, the route from source to BS is computed and conveyed. This incorporates a delay but useful for large networks.

Nodes are usually deployed in dangerous and vulnerable conditions. These Nodes could fail because of hardware problems, software bug, physical damage or by exhausting their energy supply. This would lead to fault, error or failure. All flaws or shortcoming that ends up in an error is called a Fault. An undefined state in the system is known as error. Failure is the result of an error. The observable demonstration of an error is failure.

Fault tolerance is the capability of a sensor network to function normally in spite of the presence of sensor node failures. Fault tolerance is achieved in two steps,

Fault detection- To detect for any kind of fault or errors in the network.

Fault Recovery- To stop/recover or overcome the faults detected in the system.

Organization of the paper is - Section II discusses recent literature related to the work carried in the paper, Section III discusses about the proposed Fault tolerant protocol. Section IV presents the results and observation of the algorithm and Section V proposes the Conclusion.

II. RELATED WORK

Majority of routing protocols proposed for Mobile WSN are only variation or extension of protocols existing for wireless sensor network [1] in which nodes are static. Arslan Munir et al presented a paper [2]. In this paper a detailed modeling technique is adopted to analyze the faults present in Wireless Sensor Networks.

The paper concentrates on computing (MTTF) Mean Time to Failure, thereby characterizing the reliability in the network. The authors facilitate application-specific design for WSN by developing Markov model.

K. Rajeswari and S. Neduncheliyan in their research paper [3] proposed Genetic algorithm clustering for WSN, so as to overcome problems like message loss, energy loss, and link failure, ensuring fault tolerance in clustering process. Clusters are formed based on Energy based distance. Then cluster head are chosen with back up nodes having energy efficiency.

Begum and Nandury published a paper [4]. Interference is a major problem existing in Wireless Sensor Networks. In the paper a clustering technique avoiding interference using the Interference Fault Free Transmission technique (IFFT) is implemented between the nodes in a cluster. This ensures fault tolerance within a cluster.

Kaur and Garg proposed a technique in [5]. The authors devised an algorithm enhancing the lifetime of nodes in a WSN. Distributed clustering rule is adopted to improve the reliability in the network.

Gholamreza Kakamanshadi et al published a paper on Survey on fault tolerance techniques [6]. This paper explores the various schemes available for fault tolerance in wireless sensor networks. The authors categorize them as deployment driven, clustering driven and redundancy-driven fault tolerance mechanisms. The limitations and strengths of each of these techniques is briefed.

Lakhotia and Kumar in 2014 proposed a FT scheme [7]. This work enhances reliability in cluster head during routing and manages the movement of sensor nodes which are mobile. This reduces packet loss and improves fault tolerant transmission in Mobile WSN.

The authors Xiong Qi Zheng et al published a paper "Energy efficient And Fault Tolerant Routing Protocol for Mobile Wireless Sensor Networks"[8]. In this paper, an innovative protocol called EFTCP is presented. EFTCP advocates an alternate node for every Cluster Head. So, if a CH fails, the alternate node takes over the functioning. The CH efficiently allocates time slots to all the member nodes in the cluster depending on the amount of data to be transmitted. This checks for efficient delivery of text messages.

Rama Ranjan Panda et al in their research in [9] proposes a scheme to identify faulty nodes inside the network and ensures a strong centralized fault tolerant network.

In the paper [10], Trab et al proposed a Bayesian approach for a specific application of storing and handling Chemicals and Hazardous Products. Since this application is more prone to accidents and leads to disasters, the proposed approach will ensure a safe and non faulty environment. Using the nodes deployed in the constrained area, Bayesian technique creates a database of the chemical products and ensures a continuous monitoring of the products. This guarantees efficient fault detection in the network.

Pileggi et al in their paper [11] proposed a versatile ABC algorithm for WSN. ABC (Always Best Connected) scheme has a pre study deployment of nodes. Using this data, best connectivity of network is maintained. But in unpredictable and hostile conditions, collecting data beforehand is highly difficult. This affects the inter node communication thereby resulting in a greater number of non connected nodes in the network.

In their survey paper, Hind Alwan and Anjali Agarwal [12] analyze different routing protocols which are fault tolerant in the field of WSN. All the existing techniques are classified into two main categories namely Replication dependent and Retransmission dependent.

Authors, J Kumar Rout et al proposed a Fault-Tolerant technique in their paper [13]. In this work, SFTP, a Secure Fault-Tolerant Paradigm is presented for monitoring the Blackhole attack in Mobile Ad hoc Networks. SFTP algorithm uses three different phases for finding the coverage area; for modeling a fault tolerant network and to find the best route for delivery of data from source to sink. This is achieved by different algorithms like Network Connection and Route Discovery schemes. Thus the network is made fault-free with improved performance.

In the paper, [14] the authors A. J. Jara et al have devised a protocol to monitor the mobility in inter WSN. This protocol considers the deployment of sensors in hospital and implements the 6LoWPAN network thereby reducing the number of messages and overhead.

The authors Karim and Nasser, in their paper "Reliable location-aware routing protocol for mobile wireless sensor network" [15] modified FTCP-MWSN with the inclusion of anchor nodes to propose LFCP-MWSN. Only some nodes are equipped with GPS assisting for location detection called as anchor nodes. The position of mobile nodes is computed with reference to these nearby anchor nodes. This reduces the energy consumption and cost of the network. But node failure is not identified in this algorithm as only one frame is used.

The same authors again proposed a novel energy efficient and fault tolerant clustering routing algorithm FTCP-MWSN [16] for MWSN. The proposed protocol assumes that all nodes are mobile and any node may leave or enter a cluster. In FTCP additional time slot is not allocated for the computation of mobility and failure of nodes. In the regular TDMA schedule itself, the node transmits the data and mobility information.

Existing technique to realize fault tolerance is redundancy (i.e to duplicate the parts of network system which are very important for its proper operation), alternate path or aggregation. The main objective of the proposed paper is to offer reliable and resilient communication (i.e fault tolerant) by proactive routing protocol. Proactive routing protocol includes a dynamic proactive routing table technique.

III. ASSUMPTIONS

Several assumptions are made while proposing the Proactive fault tolerant protocol (PFTP). A random network topology is considered. Number of nodes are dynamically chosen. The network is a location aware network. All the nodes (except the sink node) is mobile. If a node is faulty, the adjacent node which is in close proximity is considered for transmission/ routing.

IV. METHODOLOGY

The proposed protocol, Proactive fault tolerant protocol (PFTP) includes six phases.

The six phases are:
1. Formation of clusters
2. Cluster head Election
3. Proactive Routing Table formation
4. Faulty node Isolation
5 CH Re-election
6. Data Transmission from source to sink via CH.

A. Formation of Clusters

The network under consideration is categorized into several clusters. A cluster comprises of number of nodes in close proximity and viewed as a single sub-system. All the nodes within a same cluster are designed to deliver the same task. These nodes are centrally controlled by one of the nodes in the cluster, i.e CH (cluster head). The communication within the cluster is scheduled by program in CH. Cluster formation relies on the geographical area of network. Cluster Size depends on the density of nodes existing within the region, under consideration. Physical area occupied by a cluster will be inversely proportional to denseness of nodes which means more the node density less will be the geographical area of the cluster.

B. Cluster Head Election

One of the Nodes will be chosen as the Cluster Head in each cluster. So, chosen Cluster head would be a node inside the cluster that's liable for gathering information from all the other sensor nodes within its cluster and relay the aggregated data to sink. The responsibility of Cluster Head is sequentially relayed among the nodes within cluster. CH is chosen based on below metrics

- Smaller delay
- Less power consumption (More energy retained)
- Location of the node (preferably at the centre of the cluster)
- long life time
- No data loss

CH election technique offers better QoS ensuring good transmission of data.

C. Proactive Routing Table Formation

All the nodes are polled and their parameters like energy etc are updated in a proactive routing table. The table is constantly updated. The nodes which are faulty, will contain negative or non-coherent parametric values.

Algorithm 1 : Proactive Routing Table formation

Send Ping messages to all nodes in defined area.
If (node responds)
    Node is active;
    Range, energy and position information received from the node
    Parameters updated in the routing table
else
    The node is inactive
    Negative/faulty node data updated in the table

D. Faulty node Isolation

Faulty node is the sensory node that transmits improper or digressive information. Nodes which are faulty, identified from the table are dynamically separated and solely the correct sensors are included for sending data. The adjacent node which is in close proximity to the faulty node is identified for transmission/ routing. The identification of faulty sensors is based on below characteristics

- Higher power consumption
- Smaller life time
- Larger delay
- More Data loss

E. CH Re-election

Node mobility inside the predefined area is taken into account as movement of node inside cluster. Each time, the node moves across this boundary, two potential events are expected to occur.

1. The node might enter into the neighboring cluster.
2. The node might come back to original cluster.

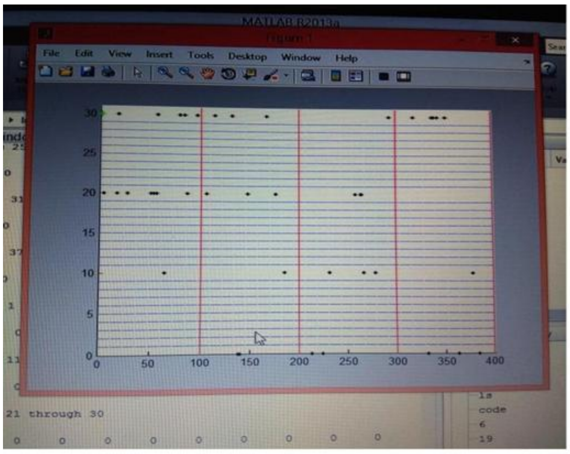

Fig 2: Movement of the Nodes

When a node drifts into another nearby cluster and if, this moved node is a CH (cluster head); then CH has to be re-elected in both the concerned clusters. Choosing a cluster head from the member nodes presently in the cluster is known as CH Re-election. If the drifted node returns back to same cluster, association is revived.

Also, if the cluster head is itself faulty, then a new Cluster Head is chosen for the cluster. The steps involved are the same as in **B**. if one of the members in the cluster are faulty, this step is ignored.

Algorithm 2: CH Re-election

All nodes (except BS) are assumed to be mobile.
If (Movement of nodes is within cluster)
    No change in the phases to be followed.
elsif(Node is CH)
    Re-election of cluster head is initiated.
elsif(Node reenters the cluster)
    Association between CH and node is re- established.
else
    Disasociation with the CH of old cluster
    Association with CH of new cluster.

Cluster formation is maintained.

F. Data Transmission from source to sink via CH

The distance of each node from base station is available on the routing table. Based on Djikstra's shortest path algorithm, the shortest route from the source to destination is decided. The motes involved in the chosen path become relay nodes. Then the packets are sent from member node to CH, then to several relay nodes (usually CH's of other clusters) and then finally to destination or base station.

Algorithm 3: Transmission of data

The range and position of each node is updated in the routing table
 Using Djikstra's shortest path algorithm, the shortest path from the source to BS is identified.
 If(any selected node is faulty)
  The adjacent node to faulty node is chosen
   Check if (adjacent node is active)
    Include in routing path.
   else
    Choose another close by node.
 else
  Include in routing path as a relay node.

Data packets are transmitted from source node through the CH and relay nodes and finally to destination or BS. A fault tolerant network is thus created.

V. FLOW CHART

The flow chart is depicted in Fig 3.

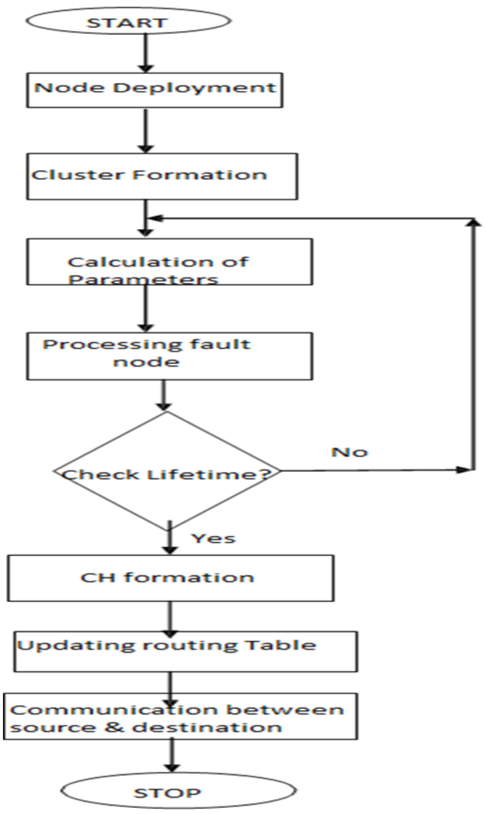

Fig 3: Flow Chart

VI. RESULTS AND DISCUSSIONS

The protocol was implemented and simulated using MATLAB R2013a. First formation of the cluster is carried out and then CH is chosen. Then proactive Routing table is updated. This is followed by choosing the source and destination node for transmission of packets as shown in Fig 4

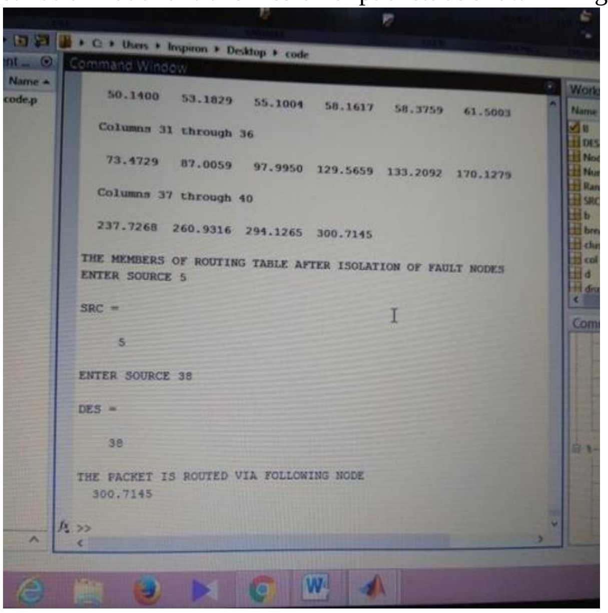

Fig 4: Choosing of source and sink nodes

The performance metrics updated in the proactive routing table is shown in the Fig 5.

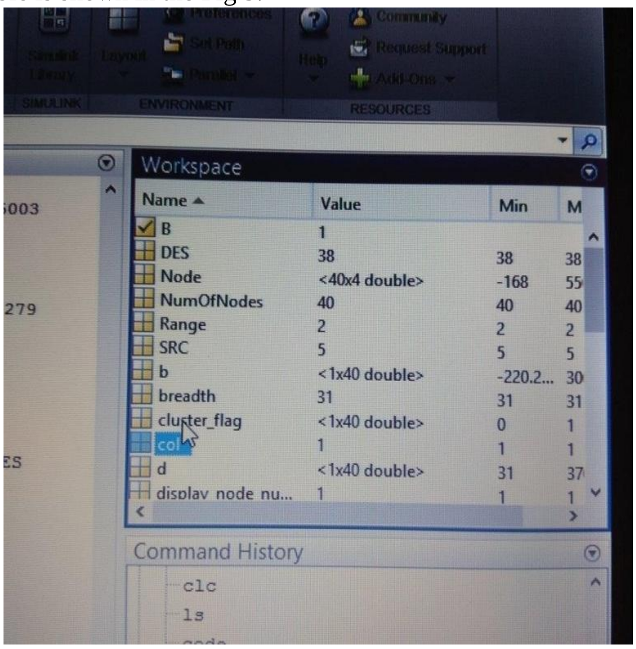

Fig 5: Parameters considered during the communication

The data received from the nodes in the routing table is shown in Fig 6. From this table the nodes displaying negative or non coherent values are isolated as faulty.

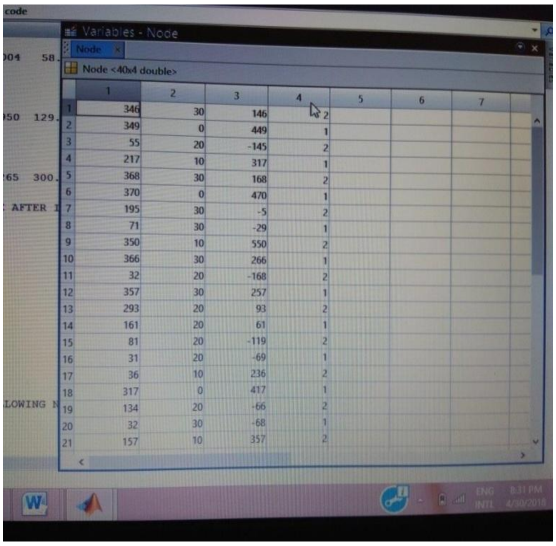

Fig 6: Detection of faulty nodes and its position.

VII. CONCLUSION

The proposed protocol offers a proactive reliable transmission in Mobile WSN. Providing a fault tolerant communication for Mobile Wireless Sensor Network is a daunting work. In this paper it is achieved by updating a proactive routing table and isolating the faulty nodes. The major benefit of the proposed scheme is that instead of finding faults during communication, in starting stage before transmission itself the various faults and errors are identified and isolated. As a result, the time consumed is considerably marginalized leading to less power consumption and increased lifetime.

REFERENCES

1. Shyamala C, Geetha Priya M and Sumithra Devi K A, Mobile Wireless Network: A Survey, *Journal of Wireless Communication, Network and Mobile Engineering Technology*, Volume 3 Issue 2, 2018.
2. Arslan Munir et al, Modeling and Analysis of Fault Detection and Fault Tolerance in Wireless Sensor Networks, *ACM Transactions on Embedded Computing Systems (TECS)*, Vol 14, Issue 1, January 2015.
3. Rajeswari and Neduncheliyan, *Genetic algorithm-based fault tolerant clustering in wireless sensor network*, in IET Communications, vol. 11, no. 12, pp. 1927-1932, 24 8 2017.
4. Begum and Nandury, *Interference-Fault Free Data Aggregation in Tree-Based WSNs*, 2016 International Conference on Information Technology (ICIT), Bhubaneswar, 2016, pp. 180-187.
5. P. Garg and M. Kaur, Improved Distributed Fault Tolerant Clustering Algorithm for Fault Tolerance in WSN, *2016 International Conference on Micro-Electronics and Telecommunication Engineering (ICMETE)*, Ghaziabad, 2016, pp. 197-201.
6. Kakamanshadi et al, *A survey on fault tolerance techniques in Wireless Sensor Networks*, 2015 International Conference on Green Computing and Internet of Things (ICGCIoT), Noida, 2015, pp. 168-173.
7. J. Lakhotia and R. Kumar, Fault tolerant and mobility aware routing protocol for mobile wireless sensor network, *2014 International Conference on Control, Instrumentation, Communication and Computational Technologies (ICCICCT)*, Kanyakumari, 2014, pp. 584-590.
8. XiongQi Zheng et al, *Energy efficient and Fault Tolerant Routing Protocol for Mobile Wireless Sensor Networks*, 2014 International Conference on Information and Communications Technologies (ICT 2014), Nanjing, China, 2014, pp. 1-5.
9. R. R. Panda et al, *Efficient fault node detection algorithm for wireless sensor networks*, 2014 International Conference on High Performance Computing and Applications (ICHPCA), Bhubaneswar, 2014, pp. 1-5.
10. S. Trab et al, *Application of distributed fault detection in WSN to dangerous chemical products based on Bayesian approach*, 2013 International Conference on Advanced Logistics and Transport, Sousse, 2013, pp. 129-134.
11. Pileggi, Palau and Esteve, *Multimode WSN: Improving Robustness, Fault Tolerance and Performance of Randomly Deployed Wireless Sensor Network*, 2010 2nd International Conference on Computational Intelligence, *Communication Systems and Networks*, Liverpool, 2010, pp. 112-117.
12. Alwan and Agarwal, *A Survey on Fault Tolerant Routing Techniques in Wireless Sensor Networks*, *2009* Third International Conference on Sensor Technologies and Applications, Athens, Glyfada, 2009, pp. 366-371.
13. Kumar Rout et al, *SFTP: A Secure and Fault-Tolerant Paradigm against Blackhole Attack in MANET*, International Journal of Computer Applications, Vol. 64, issue 4, pp. 27-32.
14. A. J. Jara et al, *HWSN6: Hospital Wireless Sensor Networks Based on 6LoWPAN Technology: Mobility and Fault Tolerance Management*, Computational Science and Engineering, 2009. International Conference, Vancouver, BC, 2009, pp. 879-884.
15. L. Karim and N. Nasser, Reliable *location-aware routing protocol for Mobile Wireless Sensor Network*, IET Communications, vol. 6, no. 14, pp. 2149-2158, September 25 2012.
16. Karim and Nasser, *Energy Efficient and Fault Tolerant Routing Protocol for Mobile Sensor Network*, *2011*, (ICC) IEEE International Conference on Communications, Kyoto, 2011, pp. 1-5.

AUTHORS PROFILE

Shyamala C is working as an Assistant Professor in Department of Electronics & Communication Engineering, GSSSIETW, Mysuru. She is also a research scholar at Jain University, Bengaluru under the guidance of Dr Geetha Priya M, Professor, CIIRC, JIT and Dr Sumithra Devi K A, Dean Academics & Head, Dept of ISE, DayanandSagar Academy for Technology and Management, Bangalore. She has obtained her Bachelor's Degree in Electronics from Bangalore University in 1995. She has secured Master's Degree (VLSI Design and Embedded Systems) in VTU University in 2011. She has supervised several UG projects. Her research interests Wireless Sensor Networks, Embedded Systems, VLSI and HDL, Wireless Communication etc. She is a life member of IETE.

Dr Geetha Priya M is Professor, CIIRC and Dept. of ECE, Jyothi Institute of Technology, Bangalore. She has obtained her Doctorate, Master's Degree and Bachelor's Degree from Anna University, Chennai. Her Specific Area of Interest are Remote Sensing Applications, Image Processing, Reversible Logic Computing and GNSS. She is the supervisor in several funded projects. She is an accomplished journal reviewer. She has authored several patents. She is an active member of Centre for Incubation and Innovative Research Centre, JIT. She is a member of IETE and IAENG.

Dr Sumithra Devi K A is Dean Academics & Head, Dept of ISE, DayanandSagar Academy for Technology and Management, Bangalore. She has received her Doctorate from Avinashlingam Deemed University for Women, Coimbatore. She has worked in the capacity of HoD, Principal, Dean and Director. She is also the Member Evaluation, Computer Science and Engineering, National Board of Accreditation, New Delhi. She has authored several papers in reputed journals. She is the supervisor for many research scholars. She is a (SMIEEE) Senior member of IEEE and life member of IETE, CSI etc. Her areas of Interest include VLSI Partitioning CAD Tool.