Energy Efficient Routing Scheme for Performance Enhancement of MANET Through Dominating Set

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M. Sangeetha[1](✉), G. Erna[2], S. Rajes Kannan[3], Anas A. Salameh[4], Kakarla Hari Kishore[5]
[1] Department of Data Science and Business Systems, SRMIST, Kattankulathur, Chennai, India
[2] Electronics and Communication Engineering, Pace Institute of Technology and Sciences (Autonomous), Ongole, India
[3] Computer Science and Engineering, Chennai Institute of Technology, Chennai, India
[4] Department of Management Information Systems, College of Business Administration, Prince Sattam Bin Abdulaziz University, Al-Kharj, Saudi Arabia
[5] Department of Electronics and Communication Engineering, Koneru Lakshmaiah Education Foundation, Andhra Pradesh, India
sangeetk@srmist.edu.in

Abstract—Mobile Ad-Hoc network is a distributed wireless network that is self-organized and self-maintained and it doesn't require a fixed framework or central administration. Wireless nodes in a mobile ad hoc network are transient and have a short lifespan. They combine to form a self-configured, infrastructure-free network where routing is a significant difficulty. The wireless nodes in the network must synchronize in order to decide connectivity and routing. Ad hoc network synchronization includes activities including node organization, neighborhood detection, and routing. The predetermined framework resulted in an increase in network control overhead. If a node can link to every other node in the network, it is referred to as a dominating node, and a set of dominating nodes make up the dominating set. The main purpose of this article is to lessen routing overhead in the wireless network with the dominating set based routing (DSBR). In order to discover routes, shorten reroute establishment times, and increase packet delivery rates, this research presents an energy-efficient routing algorithm (EERA) that considerably increases the network performance. The effectiveness of this technique is demonstrated by the simulation analysis of the outcome.

Keywords—MANET, routing, dominating set, nodes, routing overhead, EERA

1 Introduction

Mobile Ad hoc networks (MANET) are self-organized systems made up of mobile hosts linked via wireless channels. Ad hoc doesn't have a physical backend infrastructure or central management, in contrast to wired or cellular systems. Each node in the MANET is self-sufficient and can function as a router and terminal work as a source. As a result, any node operation failure can significantly slow down network performance and disrupt the network's crucial connectivity. Energy consumption by nodes has been one major hindrance to MANET connectivity. There should be efficient utilization of node power because nodes in MANET have relatively little battery power for personal use [1].

Network packets may need gateway nodes to transmit them until they arrive at their destination, depending on the placement of nodes. Once a route is found, intermediary nodes forward the packet to the next hop to the destination, where it eventually arrives. The network's topology is dynamic, and topology changes occur often. Many routing techniques for MANET have been proposed recently. Numerous control signals are required to determine the path, which in turn results in significant control overhead. The key issue with all current on-demand algorithms is routing overhead. The three main routing protocols offered by MANET are as follows [2,3]:

1.1 Proactive routing

In proactive routing, every node has tables that maintain a list of destinations and routes latest status to send data packets to other nodes in the system. When a packet comes, the node verifies its routing database and moves the packet consequently. The proactive routing techniques are not applicable to massive systems because each node's entry in the routing table must be maintained. This increases the overhead in the routing table, resulting in increased bandwidth consumption.

Examples of this routing protocol are Destination sequenced distance vector (DSDV) and optimized link state protocol (OLSR) [4].

1.2 Reactive routing

Reactive routing protocols are also called as on-demand routing protocol and the nodes keep their routing information on a communication base. This suggests that this protocol establishes a link between the source and destination before transmitting the packet when a node wants to send data packets to another node. The connection setup process is called route discovery. If a previous connection was damaged, it is necessary to detect an alternative connection and this process is called route maintenance.

Examples of this routing protocol are "Ad-hoc On-demand Distance Vector (AODV)", "Location Aided Routing (LAR)" and "Dynamic Source Routing (DSR)".

1.3 Hybrid routing

Hybrid routing protocols are a new method that combines the merits of the proactive and reactive protocols. In order to increase the scalability and minimize route discovery overhead, this protocol is designed. An example of this routing protocol is Zone Routing Protocol (ZRP) [5].

This paper proposes a dominating set based energy efficient routing algorithm to reduce control overhead in wireless networks. Also improves the performance of

MANET by discovering routes, shortening reroute establishment times, and increasing packet delivery rates.

When a route is broken in any reactive algorithm, the route regeneration process reduces network performance by adding overhead. The high node mobility makes route failures more frequent. The source node is often in charge of choosing a new route when a route failure occurs [6]. Figure 1 explains the basic architecture diagram of MANET.

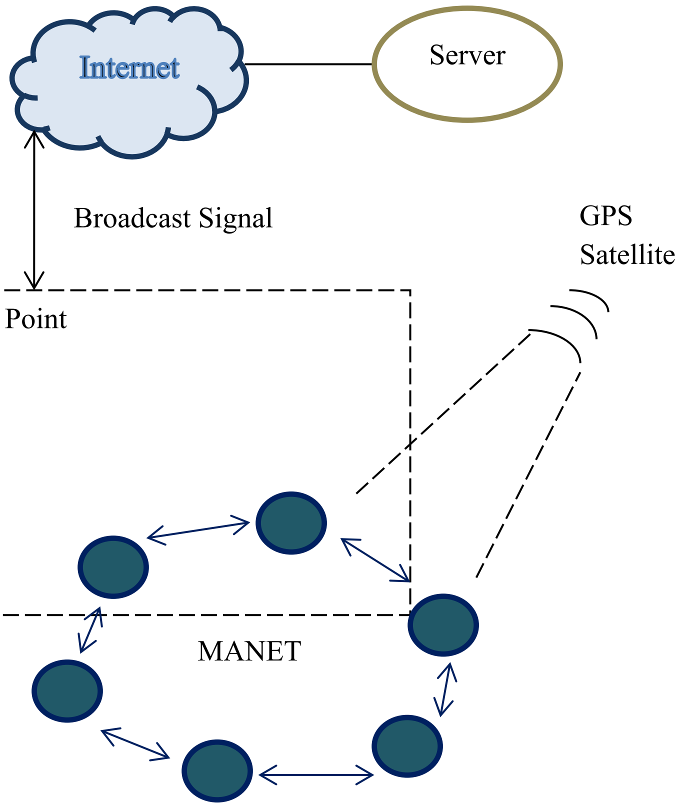

Fig. 1. MANET Architecture

1.4 Qualities of MANET

Network topologies: They often consists of multiple hops, and can alter arbitrarily and fast over time, forming links that are either bidirectional or unidirectional.

Autonomous behavior: Each node exhibits autonomy by having the ability to function as both a host and a router.

Power-constrained operation: Due to the fact that different hubs use different types of batteries or other unnecessary energy sources. Less memory, less power, and lighter weight are highlighted while describing portable hubs.

Minimal human interaction: They are dynamically independent since they only need little human interaction to configure the network.

Links with variable capacity and limited bandwidth: Compared to a wired network, wireless networks typically offer lesser dependability, efficiency, stability, and capacity [10].

2 Dominating set

Consider a connected, undirected, simple graph with the formula G = (V, E), where V is the vertex factor and E is the edge factor. If every vertex in graph G that is not in a set S is adjacent to at least one vertex in S, then S is a dominant set. The term "Dominating Collection" refers to the set of vertices that make up the least number of the graph G. If there are no adjacent vertices in a collection of vertices S, then S is independent. A subset S of graph G that both forms a dominating set and is connected is known as a connected dominating set (CDS).

The domination nodes can connect to every node in the network. There are several minimal dominating sets, but each minimum dominating set's domination set must include the same number of nodes. Figure 2 represents the domination set. All the nodes with the highest connection are put together to form a dominating set. As reachable nodes must be present in the Dominating set, detached nodes with lesser connection are also part of the Dominating set. For the network of Figure 2, D= $\{5 \cup 1\} or \{5 \cup 2\}$. The selection of node 5 excludes connections to nodes 1 and 2 due to its high connectivity. The Dominating set is therefore either (5,2) or (5,1) [7].

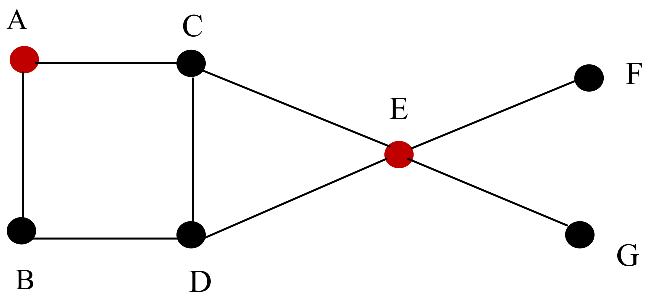

Fig. 2. Dominating Set is (A,E)

The subset of the graph is the dominating set which means that every node is either in the group. The persistence of the dominating set is disseminated between the nodes. Each node in the system can be attained via the dominating nodes. A simple dominating node in a MANET is given in Figure 3.

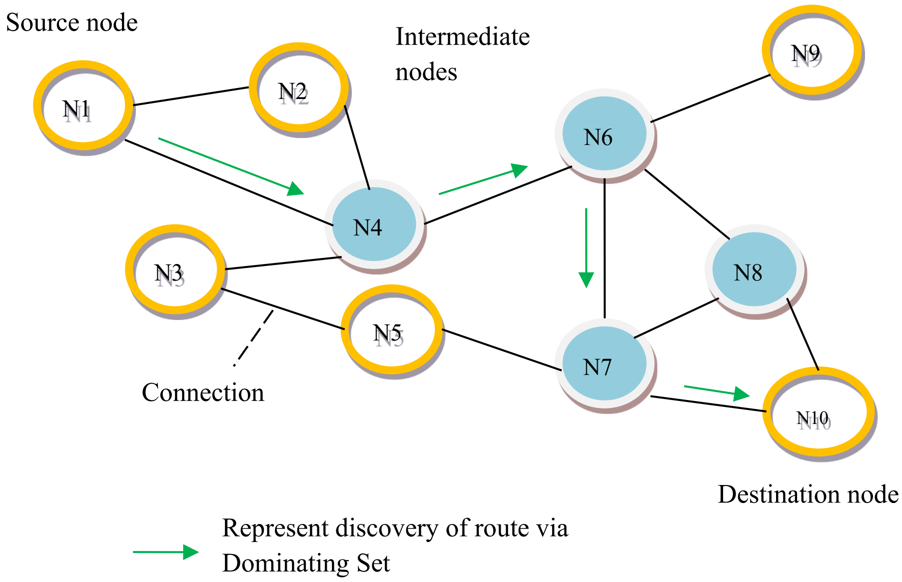

Fig. 3. Dominating node in a MANET

2.1 Dominating set based algorithm

```
 Node(m);
 If (n is a neighbor)
 {
         Include to the neighbor list
         Transmit this list to its neighbors
 }
 If (m is a neighbor of n)
 {
      Set adj[m][n]=1
 Else
      Set adj[m][n]=0
 }
 for_all row in adjacency matrix adj
 {
      Find out the row sum in the adjacency matrix
      Determine the node with the maximum degree
      Add this to the domination set
      If any node is linked to the dominating set nodes,
then include this too in the dominating set.
 }
```

3 Energy Efficient Routing Algorithm (EERA)

Energy efficient routing algorithm called EERA is discussed in this paper. Typically, the source node advertises a route request, many routes are found to the destination, and packets are transmitted across these routes without substantial link quality. But in energy efficient routing, the route selection is totally disparate when a route request is obtained and broadcasted; the source node has a couple of data to obtain an enhanced and shortest path with less energy consumption. The source node has energy used for route distance and route maintenance and information about each node's energy [8].

The shortest path and peak energy rate are achieved with the consumption of minimum energy. The sender evaluates the amount of energy consumed when using the route with the maximum level of energy to transmit the packets. When an entire route to a destination is unsuccessful, energy efficient routing algorithm starts the route discovery process. If a route is unsuccessful, the sender chooses a different way from the routing database that uses the least amount of energy and is the shortest path [9]. It is possible to calculate the ideal route that uses the least amount of energy and travel time as follows:

$$IR_a = \frac{\sum \delta(n) \in I_R \ \ X \ \ Energy\ \delta(n)}{\sum \delta \in v \ \ X \ \ Energy\ (\delta)} \quad (1)$$

Where,
δ – Vertices nodes
I_R- Ideal Route
v – Entire vertices nodes in the network

By comparing the energy levels of each path, it chooses the one with the highest energy. Based on the route distance, an alternative route is predicted. From the routing table with the shortest route distance, energy efficient routing algorithm (EERA) finds the route with the peak energy level. It compares the network's ideal links. The below formula can be used to determine the shortest path,

$$IR_b = \frac{\sum \varepsilon(n) \in I_R \ \ X \ \ Distance\ \varepsilon(n)}{\sum \varepsilon \in \ L} \quad (2)$$

Where,
ε- Edges
L- Entire links within the network

EERA first transmits route request for knowing the existing routes data to the destination, the network is computed using the energy function to locate nodes with greater energies. After comparison, the energy function determines the routes with the maximum energy while taking into account the distance of the route. The best path has higher energy content and covers the least amount of ground. The path with more energy is given precedence.

4 Results & discussion

The dominating set based routing is analyzed using NS2 and its performance is used to examine packet delivery ratio (PDR), amount of packet delivered, throughput, and the routing overhead. The results are compared with the existing algorithms AODV and DSR. Dominating set based routing performance is better than AODV and DSR. Table 1 shows the list of selected simulation parameters used in this analysis.

Table 1. Simulation Parameter Values

Specification	Value
Routing Protocols	EERP
MAC	IEEE 802.11
Algorithm	AODV, DSBR, DSR
Amount of nodes	10,20,35,60,75
Area of Simulation	500 m x 500 m
Size of packet	256 bytes
Simulation time	500S
Packet transmitting rate	4 packets per second

The below formula is used to calculate the packet delivery ratio.

$$\text{Packet delivery ratio} = \frac{\sum \text{Number of data packets received}}{\sum \text{Number of data packets sent}} \quad (3)$$

According to observations, the proposed DSBR protocol performs better than the existing protocols AODV and DSR with respect to the aforementioned parameters.

Figure 4 shows how the DSBR performs better than the AODV and DSR. The packet delivery ratio is determined by averaging out the results of 500 simulation runs using the number of selected nodes for every event for all four various techniques.

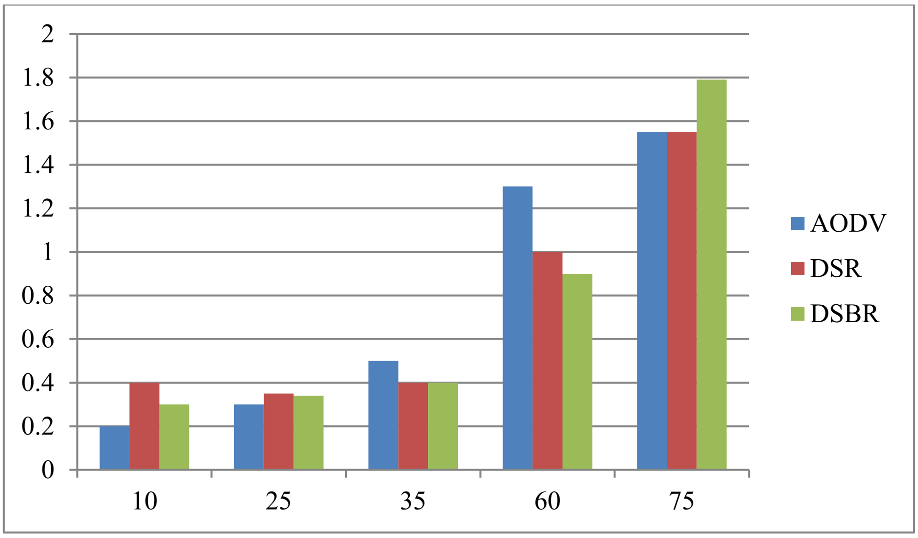

Fig. 4. PDR V/S Number of nodes

All algorithms have a nearly identical packet delivery ratio. The routing overhead in DSBR decreases as the number of nodes increases since any link failure is relatively easy to resolve in DSBR and is better than the other two. Figure 5 shows that the DSBR increases the PDR while the number of nodes improves in the network.

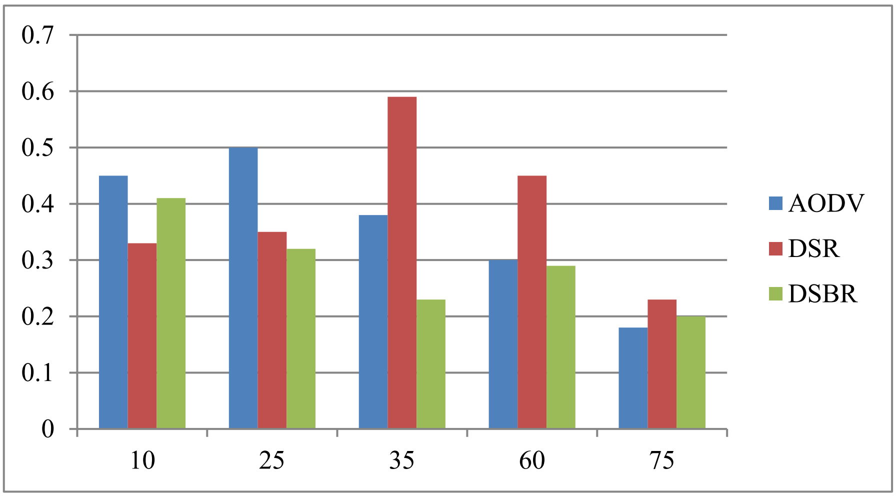

Fig. 5. Routing Overhead V/S Number of nodes

Network overhead is determined by using the below formula:

$$\text{Network Overhead} = \frac{\sum \text{Number of packets distributed}}{\sum \text{Number of data packets distributed}} \tag{4}$$

The packet drop in AODV and DSR increases quickly as the number of nodes rises. However, the packet loss in DBR is negligible. The routing overhead in DSBR decreases as the number of nodes grows because, in DSBR, every link failure is very simple to fix.

To calculate the throughput, the given formula is used.

$$\text{Throughput} = \frac{\text{Number of packets received}}{\text{Simulation time}} \, X \text{ 500 kbps} \quad (5)$$

The suggested approach ensures consistent packet delivery and minimizes the time required for re-route establishment by only routing through the network's most dependable nodes. As seen in Figure 6, the throughput of DSBR remains constant as the number of nodes increases, but AODV and DSR experience a sudden decline in throughput, lending support to the suggested algorithms.

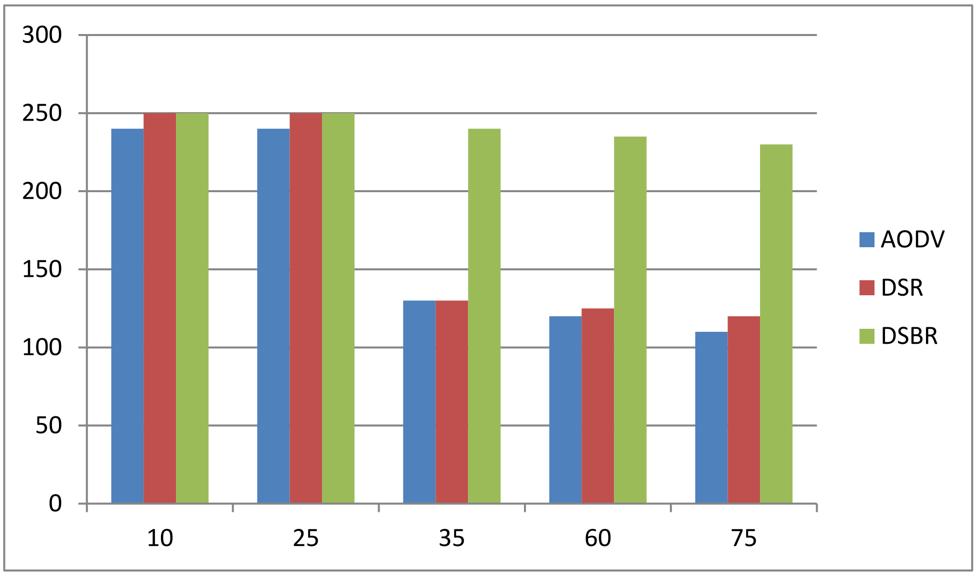

Fig. 6. Throughput V/S Number of Nodes

5 Conclusion

This paper examines the behavior of reactive, proactive and hybrid MANET routing protocols. Every protocol has its unique advantages and disadvantages. Many previous techniques are present but still lack some characteristics. In this paper, a new energy efficient routing protocol through dominating set has been proposed, analyzed and evaluated over extensive simulation parameters for MANETs. When comparing the the proposed DSBR with AODV and DSR, proposed model performs better than AODV and DSR. Hence the performance of the network is improved with proper packet delivery ratio, throughput and routing overhead.

6 Acknowledgment

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8 Authors

M. Sangeetha received her B.E degree in CSE from Sakthi Mariamman Engineering College, affiliated to Anna University, 2006, M.E degree in CSE from Sapthagiri College of Engineering, 2010 and pursuing her research in the area of Machine Learning and her research area includes Big Data Analytics and Deep

Learning. She has 10 years of Academic Experience, currently working as Assistant Professor in the Department of Information technology, SRM Institute of Technology. She has published several research papers in reputed SCIE indexed/Scopus indexed International Journals and International Conferences. She holds professionally qualification in Big Data Visualization Tool (TABLEAU), Machine Learning, Python Language. She has been also the organizing committee member of several national and international conferences across the nation. She is a Professional member of IAENG, CSI, IEEE, ISTE, Indian Science Congress Association and ISTE. She is the editor for the Lecture series in Networks and Systems 130, Artificial Intelligence techniques for Advanced Computing Application, Springer, 2020. She is the Imperative member of Robotics learning centre. She has planned and implemented special college events with the proper coordination along with the supportive officials along with the community representatives (email: sangeetk@srmist.edu.in).

Dr. G. Erna is an Associate Professor in ECE Department Pace Institute of Technology & Sciences (autonomous) Ongole. He has 15 years of Experience, out of 15 years 14 of teaching and one year in industrial as RTL Verilog coding and system Verilog (Verification). Ha has completed a B. Tech in Electronics and Communication Engineering from Jawaharlal Nehru Technological University, Hyderabad Telengana in 2003, M.Tech in VLSI SYSTEM DESIGN JNTU HYDERABAD Telengana in 2008 and awarded Ph.D (Performance Enhancement of Various Multipliers for DSP Applications) in the domain of VLSI SYSTEM DESIGN from Pondicherry University (Central University), Puducherry in 2021. He has received NPTEL Certificate in different subjects. . He published 10 research papers in reputed journals and in National and International conferences. He awarded best papers in conference and Journals and he attended several FDP, STTP and Webinars which was organized by IIT's, NIT'S and C-DAC which is around 50. He is a senior Fellow of IETE, IEI and ISTE. He has qualified in FET-2011 conducted by JNTUH. His research interests on those fields like Low power VLSI Signal Processing, Wireless Communication, Machine Learning, AI and IOT (email: erna_g@ pace.ac.in).

Dr. S. Rajes Kannan is currently working as an assistant professor at Chennai Institute of Technology, Chennai. He has more than 13 years of experience and published articles in Annexure II journals. 2005 to 2007 Worked as a PROGRAMMER in Veltech Engineering, College, Avadi, Chennai, Tamil Nadu, India. 2008 to 2011 worked as a PROGRAMMER in Sri Muthukumaran Institute of Technology, Mangadu, Chennai, Tamil Nadu, India. 2011 to 2015 worked as an Assistant Professor in the Department of Computer Science and Engineering, Sri Muthukumaran Institute of Technology, Mangadu, Chennai, Tamil Nadu, India. 2015 to till Date Working as an Assistant Professor in the Department of Computer Science and Engineering, Chennai Institute of Technology, Kundrathur, Chennai, Tamil Nadu, India (email: rajeskannans@citchennai.net).

Anas A. Salameh is an Associate Professor at, Department of Management Information Systems, College of Business Administration, Prince Sattam Bin Abdulaziz University since 2016, and the current deputy director of the students' activities committee as well as a member of the exams scheduling committee, PSAU.

His major research interest focusing on the area such as e-commerce (m-commerce), e-business, e-marketing, technology acceptance/adoption, e-learning, e-CRM, service quality, and he evaluated service quality in many areas related to e-services aspects. (email: a.salameh@psau.edu.sa) Orcid: https://orcid.org//0000-0002-4694-3771Dr

Kakarla Hari Kishore was born in Vijayawada, Andhra Pradesh, India. He received B.Tech (ECE) from JNTUH, M.Tech from SK University, A.P, India. He received his PhD in the field of VLSI from Koneru Lakshmaiah University (KLEF). He received his Postdoctoral Fellowship (PDF) in Malaysia. He is working as Professor in ECE. He has published 4 IEEE Transactions and more than 122 research articles published in International Journals/Conferences. He has filled 07 patents and published 3 Textbooks. He had received several awards like the International Book of Records and the Indian Book of Records for the highest number of citations and H-index in Scopus/WoS. He is Editorial Board Member/Reviewer for several International Journals/Conferences. His research interests include VLSI Design, Fault Tolerance and Digital Testing, IOT, Communications and Signal Processing. He is a life member of ISTE, IE, IACSIT and IAENG (email: kakarla.harikishore@ kluniversity.in).

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