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Improved CLC Routing Protocol with Node Classification Algorithm for MANET

K. Logesh[1,*] *and S. Srinivasa Rao Madane*[2]

[1] Department of CSE, Anna University, Chennai, India
[2] Department of ECE, Sri Krishna College of Engineering, Vellore, India

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Abstract: Mobile ad hoc networks (MANETs) are the group of mobile nodes that communicate without using fixed infrastructures. Most of the routing protocols in MANETs are designed without analyzing the behaviour of the intermediate node. In such a case, it cannot identify the best intermediate node when over one route is available. It degrades the performance of routing protocol. Analysing the attributes of the intermediate node and identify the best node for transmitting packets is the challenging task in MANET. In this paper we have designed node classification algorithm which helps to analyze various attributes of the intermediate node and select the best node as a router. The node classification algorithm has been adopted into the existing CLC (Cross Layer with Clump) routing protocol. The simulation results show that in terms of packet delivery ratio, throughput and energy consumption are the node classification-based CLC routing protocol which have better performance than traditional AODV, existing CLC, quality of service, oriented distributed (QOD) routing protocols.

Keywords: MANETs, node classification, cross layer design, quality of service.

1 Introduction

Mobile ad hoc networks (MANETs) are collection of mobile nodes which do not require any fixed infrastructure for communication between mobile nodes. Mobility, shared channel, available bandwidth, resource constraints are the fundamental characteristics of MANETs. Nowadays MANETs are popular in real-time networks and in future it becomes unpredictable development worldwide. Ad Hoc networks are not controlled by centralized devices. Routing in ad hoc network is a challenging task for researchers. Traditional routing protocols are not suitable for ad hoc networks due to mobility of nodes and dynamic nature [1]. Hence specialized routing protocols are required to make a path between nodes. MANETs are popularly used in military applications, collaborative and distributed computing system, emergency operations such as crowd control, search and rescue etc.,

MANETs are facing many challenges while implementing the above applications. Some of them are routing, multicasting, providing QoS and energy management [2]. Numerous routing protocols have been developed for MANETs. These protocols deal with the typical limitations of MANETs, which include low bandwidth problem, route discovery, route maintenance, high error rates and energy management. Mobility of a node degrades the performance of MANET. Many researchers consider mobility as an important factor while designing routing protocol. But sometimes, an intermediate node is placed within the transmission range of source node. Even though, path break may happen due to low energy level of an intermediate node. Bandwidth may vary between nodes in an ad hoc network. An intermediate node may transmit packets without more delay, but immediate next node takes more delay. Hence end-to-end delay increases and overall performance of a network decreases. Some researchers consider bandwidth as one of the factors.

Routing is the basic operation in MANET. Prediction of node behaviour has been required function in self-organized network [3]. Prediction about the node behaviour has been used to decide for successful transmission. Routing is difficult when mobility increases because chances of link breakage due to increasing the mobility of the nodes. It leads to increase control

* Corresponding author e-mail: lokesh.k@aol.com

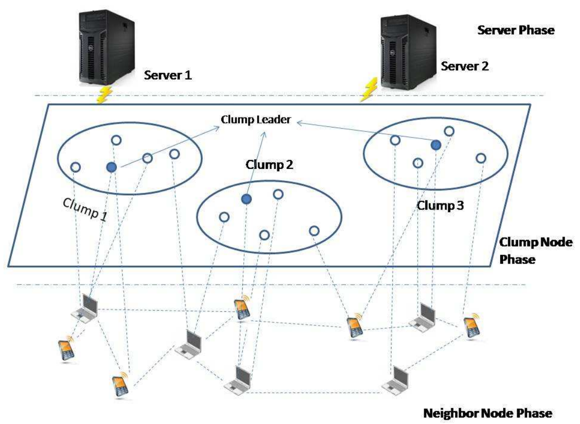

Fig. 1: Architecture for CLC routing protocol.

overhead (through RREQ packets) and reduce efficiency of network. Re-construct the route in MANET is costly. Due to these issues packet delivery ratio decreases and end-to-end delay increases. In ad hoc networks, node's battery energy and stability of the communication links often affect the transitional activities. These two factors are one of the major responsible factors for packet loss and congestion issue that networks are facing today. Hence it is important to predict the lifetime of a node helps to estimate the lifetime of the entire network. It is an acceptable solution that lifetime of each node in a network increases [11] which therefore increases entire network lifetime.

This article is written as follows: literature survey of a various protocol for mobile ad hoc networks and overview of CLC routing protocol in next section, followed by proposed node classification technique in Section 3. In Section 4, detailed information about mathematical formulation for node classification. In Section 5, Simulations, performance evaluations and comparisons and followed by conclusion in Section 6.

2 Related Work

Node behaviour-based classification [5] analysed by the author according to their motion character. The author took four parameters. Those are node distance between neighbours, velocity of a node, moving direction of a node, range of communication. These parameters are applied in fuzzy-based evaluation for classifying nodes' behaviour. Hence the author suggested the design complexity of networking protocols can be simplified and best fit of the networking protocol can be identified correspondingly.

Characterizing the greedy behaviour of nodes in MANET [6] is an investigation work which results in greedy node to gain more bandwidth share compared with its neighbours and also performance of the greedy node's ongoing flows maintains extra bandwidth share. It helps to improve delivery ratio and decrease end-to-end delay.

The three major functions are implemented in M-OLSR [7] for improving node performance in Wireless Mesh Networks [WMNs]. But this protocol not only fits for WMNs but also adapts to MANETs. Hello exchange, topology dissemination and routing table calculation are the three functions which improves the scalability of traffic load in networks. QoS architecture proposed in [8] to support real-time data transmission in mobile ad hoc networks. Different way of bandwidth estimation is also presented in [8], for example estimation of bandwidth using cross layer design of routing and MAC layers, bandwidth estimated by MAC layer and sent to the routing layer for admission control.

Ambient QoS algorithm [15] is implemented for support of real time service. This mechanism only contented the requirements of applications like WiFi, 3G, WiMAX but also proved guaranteed QoS. In ambient QoS algorithm, the mobile node checks the availability of networks in the environment. For each available network this algorithm checks the application type and then maps to the appropriate traffic requirements. The traffics are conversation, audit/video stream, interactive traffic, best effort traffic. This algorithm evaluates the QoS parameters and bandwidth of the candidate network and the status is satisfied with the required traffic then performs the handover process. If mobile node has two or more candidate network, than ambient QoS algorithm selects the best network based on the user QoS requirements.

2.1 Existing CLC routing protocol

The functional architecture of CLC routing protocol is divided into three phases: Neighbour Node Phase, Clump Node Phase and Server Node Phase as shown in Fig. 1. This protocol helps to transmit multimedia packets from server to end user with the help of clump group. The functions and responsibilities of each phase is given below.

2.1.1 Server Phase

Server is the resource centric node which contains multimedia resources. The server is well known to all neighbour nodes in network and which share the resource to other mobile nodes whenever it is required.

2.1.2 Clump Node Phase

Clump is an unshaped bunch of thud process towards the nearest neighbour node. Some nodes organized as clump node which is used to transfer packet from neighbour to server or vice verse. These clump nodes helps to minimize long route transmission and long delay.

Usually, MANETs are grouped into different geographically scattered group. In this network setup also clump nodes are divided into different geographical distributed groups. Each group in the network is assigned an identification called clump ID. A clump node in a group with high energy, minimum queue size can hold huge volume of data and high bandwidth which increase consistent delivery until the transmission completes. Hence such nodes in a group are considered as clump leader. Clump leader can be able to transmit multimedia packets to neighbour node directly. But clump member can transmit only data packets that even is forwarded to its leader if neighbour node is not in strong receiving signal strength. Each clump node can join or leave in a clump group in terms of bandwidth and receiving signal strength. If bandwidth and signal strength are not met with its requirements then a node can decline to join in a group.

2.1.3 Neighbour Node

In neighbour node phase, the source node selects the list of neighbour node which has good communication quality, minimum queue delay, scheduling feasibility and good signal strength in terms of support for multimedia data delivery. Each node maintains neighbour list which is updated periodically to keep fresh neighbour list. While updating neighbour node it updates location of the node, neighbour count, layer level, distance and bandwidth for all the nodes in network. The node classification algorithm analyzes the above attributes and helps to select the best node for transmitting packets.

3 Proposed Node Classification Technique

The classification algorithm is implemented for improvement of QoS in MANET. In MANET, identifying various attributes of each node is an important work for successful communication. The attributes of each node in an ad hoc networks are available bandwidth, energy level, transmission range, distance based on received signal strength, deadline of each packet, priority of packet forwarding and so on.

The following are the issues while transmitting packets in ad hoc networks, if the above attributes in routing protocol are not considered. (1). Communication link may be broken between two intermediate nodes due to out-of-transmission range or reducing energy or very less receiving signal strength. (2). Intermediate node may consume more energy due to long distance in between two nodes. Even though, node may have good bandwidth capacity but due to neighbour's bandwidth usage and interference caused by other source are reduce currently available bandwidth of a node for transmitting packets. (3). Without knowing deadline for transmitting packets in intermediate node, the transmitted packets may be

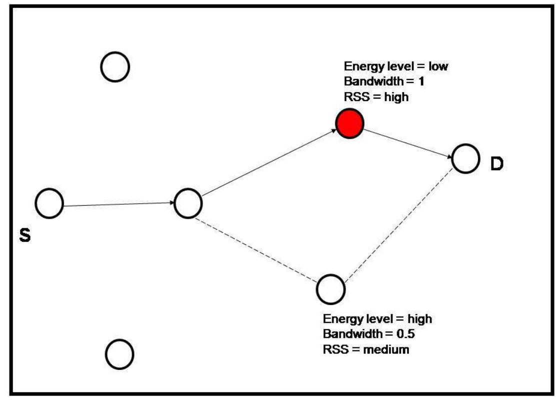

Fig. 2: MANET with various attributes.

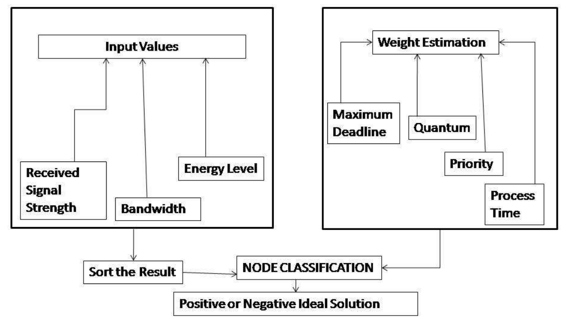

Fig. 3: Node classification architecture.

dropped due to more length of the queue in intermediate node which results in increase of packet loss ratio. Fig. 2 shows that as soon as the energy level reduced for a node immediately reads the attributes of next nearest node and checks its QoS if it is satisfied with the required QoS then path has been changed. To avoid these issues in ad hoc networks, it is needed to analyze the behaviour of each intermediate node in a network. Node behaviour analysis is used to select best neighbour node for transmitting multimedia packets as well. And it helps to improve the performance of real-time applications like online video, video conference without any interference. Node behaviour analysis is a process which is based on the available bandwidth, energy level, deadline of transmitting packet in each intermediate node and received signal strength. The following subsection deals with existing CLC [13, 14] routing protocol.

Architecture of node classification is shown in Fig. 3.

3.1 Received Signal Strength

Received Signal Strength (RSS) depends on the parameters of transmitters and receiver. Quality of packet transmission is based on RSS. Hence RSS is an important parameter for identifying node quality. RSS is calculated for each node in network and the value of RSS is considered for estimating the node strength.

3.2 Energy Computation

In MANET, each node serves as a router for forwarding packets. These nodes are powered by batteries. The depletion of battery power of intermediate nodes' in a routing decreases the network lifetime. In site charging or replacing of batteries is a difficult task [12]. It is necessary to use available energy efficiently to extend the life time of a node. Energy of each node computes and updates periodically to its neighbours. Effective paths minimize the energy consumptions and maximize the packet delivery ratio of the network [9].

3.3 Bandwidth Calculation

Bandwidth estimation is another issue in MANET. Because each node in network having inaccurate knowledge of network status. In ad hoc networks, a node's available bandwidth cannot be decided only by channel bandwidth, but also by its neighbour's bandwidth usage and interference caused by other sources, each of which reduces a host's available bandwidth for transmitting data. Hence it is difficult to optimize their coding rate without knowledge of the status of entire network [13]. Estimating accurate available bandwidth allows a node to make optimal decision before transmitting a packet in a network. Each node listens to the channel and estimate the available bandwidth periodically based on the ratio of free and busy times. The IEEE 802.11 MAC used to find out the free and busy times. If received and sent statuses are idle then it is considered that channel is free. If both change their statuses, then the channel is busy.

Each node's value of energy level, bandwidth and received signal strength are compared with neighbour node value and selected as best neighbour for transmitting packets where the node has highest value.

The values of energy, bandwidth and signal strength from each node are received and added to all the values and arranged in the order. The following function sorting the node according to the value of its energy, bandwidth and received signal strength.

3.4 Deadline Computation

Each packet has deadline while it transmits from source to destination, if a forwarded node is unable to do transition process due to queue length or delayed processor. So the packet may meet deadline and packet destroyed. And retransmission of the packet may occur in the network. This process increases the energy consumption, network traffic and reduce the throughput. The alternate solution is to calculate deadline of each packet that is compared with estimated queue length and available bandwidth. Packet having nearest deadline is assigned highest priority and is forwarded to the node having limited queue; on the other hand, the packet which is far from the deadline will be forwarded to the node having queue delay.

3.5 Packet Priority

Source node needs to calculate queue delay of each intermediate node that can send the packet within deadline. Priority of each packet is to be predicted before sending the packet by source node. Priority of packet in each intermediate node is to be calculated and can identify total priority from source node to destination node.

4 Mathematical Formulation

Packet priority defined as sum of the priority for packets in each node can be expressed as follows:

$$\sum_{i=0}^{count} p[i] \tag{1}$$

where p is referred as priority and i is number of nodes in network. Maximum deadline is estimated with the following equation

$$\sum_{i=0}^{count} \left(\frac{1}{p[i]} \times \text{MAX\_DEADLINE} \right) \tag{2}$$

where i is number of nodes in network, $p[i]$ is priority of packet in each node. MAX_DEADLINE is fixed value for all nodes. Now a discrete quantity of energy proportional is to be calculated in each node which is called as quantum of each node. It can be expressed as follows:

$$\text{quantum}[i] = \text{current\_time} - \text{deadline}[i] \tag{3}$$

Deadline, priority and quantum of a packet transmission from source to destination are to be estimated and can be expressed as follows:

$$\text{sum}_{dl} = \sum_{i=0}^{count} \left(\text{sum}_{dl} + (\text{deadline}[i])^2\right) \tag{4}$$

$$\text{sum}_{qn} = \sum_{i=0}^{count} \left(\text{sum}_{qn} + (\text{quantum}[i])^2\right) \tag{5}$$

$$\text{sum}_{pri} = \sum_{i=0}^{count} \text{sum}_{pri} + (\text{priority}[i])^2 \tag{6}$$

where sum_{dl} denotes total deadline of a packet from source to destination in a network, $deadline[i]$ denotes deadline of packet in each node.

$$\text{sum}_{dl} = \sqrt{\text{sum}_{dl}} \tag{7}$$

Table 1: Simulation parameter.

Network size	500 × 500
No. of nodes	50
Simulation time	100,125,150,175,200
MAC	802.11
Antenna	OmniAntenna
Propogation type	TwoRay ground
Traffic	CBR
Channel type	Wireless channel
Topology	Flat grid

$$\mathrm{sum}_{qn} = \sqrt{\mathrm{sum}_{qn}} \tag{8}$$

$$\mathrm{sum}_{pri} = \sqrt{\mathrm{sum}_{pri}} \tag{9}$$

$$dl[i] = \sum_{i=0}^{node\_count} wt_{\mathrm{deadline}} \times \left(\frac{\mathrm{deadline}[i]}{\mathrm{sum}_{dl}}\right) \tag{10}$$

$$qn[i] = \sum_{i=0}^{node\_count} wt_{\mathrm{quantum}} \times \left(\frac{\mathrm{quantum}[i]}{\mathrm{sum}_{qn}}\right) \tag{11}$$

$$priority[i] = \sum_{i=0}^{node\_count} wt_{\mathrm{priority}} \times \left(\frac{\mathrm{priority}[i]}{\mathrm{sum}_{pri}}\right) \tag{12}$$

Based on the above calculations positive ideal solution or negative ideal solution to be found. Source node may select intermediate node if positive ideal solution is of higher value compared to all other nodes. If added values of deadline, quantum and priority are nearer to negative ideal solution then the intermediate node has weak attributes.

5 Simulation Results

NS2 is a leading simulation tool used in academic research circle for simulation of network and its relevant technologies. It is used for designing and analyzing routing protocols for communication networks [4]. It can evaluate the performance of a simulated network design with high quality of accuracy.

This simulation, models a mobile ad hoc network of randomly distributed nodes within a 500 × 500 area. The mobile nodes configured with IEEE 802.11 standard. Each of the simulation run with various time limits and varying seed value is done and the collected data is the average. Table 1 shows the parameters for the simulation used. Node traffic is generated with Constant Bit Rate (CBR). The generation rate of CBR is 100 kb/s. We randomly select the source node and send packets to destination for every 10 s. The warm up time is set as 50 s and simulation time is set from 100 ms to 200 ms.

5.1 Performance of Packet Delivery Ratio

Fig. 4 shows the resultant packet delivery ratio of CLC classification, CLC, QOD, AODV protocols. The proposed CLC Classification method extends its improvement in delivering packets in different simulation time while comparing with CLC, QOD and AODV. Table 2 summarise the packet delivery ratio in different simulation time with various routing protocol.

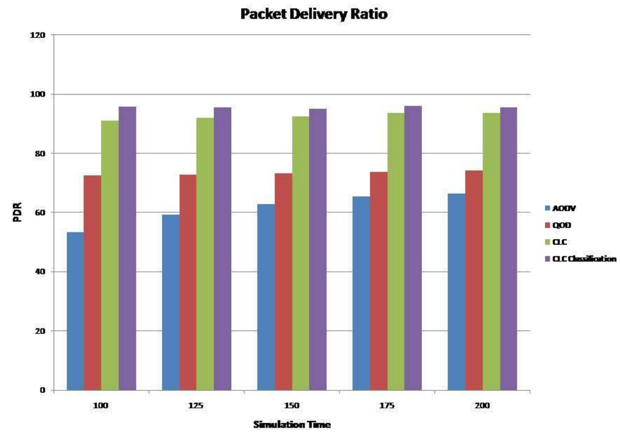

Fig. 4: Packet delivery ratio vs. simulation time.

Table 2: PDR result comparision of AODV, QOD, CLC and CLC Classification.

Simulation time	AODV	QOD	CLC	CLC Classification
100	53.3207	72.6061	91.1111	95.7447
125	59.3003	72.8505	91.9355	95.5882
150	62.9229	73.3962	92.5926	95.122
175	65.4732	73.7234	93.75	95.9596
200	66.4264	74.1322	93.578	95.5357

5.2 Performance of Average Energy Consumption

Fig. 5 shows the average energy consumption of AODV, QOD, CLC and proposed CLC Classification in various simulation times. Table 3 shows the value of average energy consumed by various routing protocol. QOD protocol always sends control packets for route request and reconstruction of route while breaking the path between two nodes. Due to this reason each node utilizes more battery energy which results in decreasing packet delivery ratio and throughput. But CLC classification method selects suitable neighbour for transmitting packets based on various attributes of a node. Hence there is no periodic path break and no chance for repeated route request which results in less energy consumption and network life time increase.

5.3 Performance of Throughput

Based on the statistics provided by our simulation, data throughput was derived and is shown in Fig. 6. An evaluation of throughput with respect to simulation time

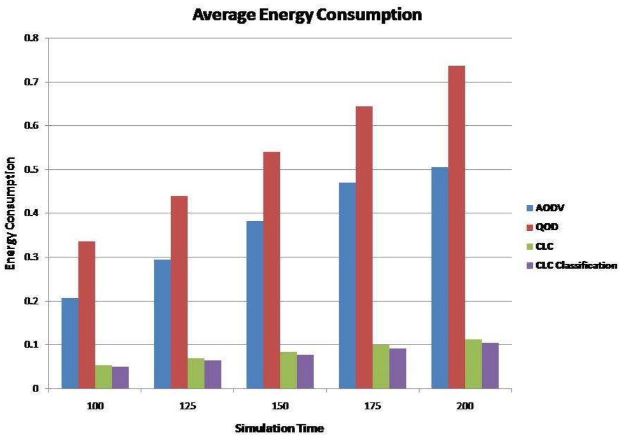

Fig. 5: Average energy consumption vs. simulation time.

Table 3: Average energy utilized for AODV, QOD, CLC and CLC Classification.

Simulation time	AODV	QOD	CLC	CLC Classification
100	0.206257	0.336235	0.052932	0.049201
125	0.294022	0.43984	0.068039	0.064349
150	0.382533	0.540953	0.083929	0.077518
175	0.469894	0.644469	0.098581	0.091123
200	0.505665	0.736964	0.112648	0.104376

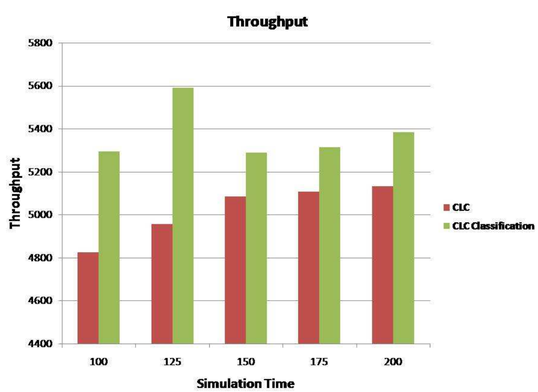

Fig. 6: Throughput vs. simulation time.

and CLC Classification are made and the result shown in Table 4. The average throughput is computed by dividing the packet size by the average end-to-end delay. The actual throughput is computed by dividing the total number of bytes received by the total end-to-end delay. Note that for CLC classification, the throughput goes as high as 5590.71 Mbps. At CLC, the throughput falls by 12%. It is observed that as simulation time increases, throughput also increase in higher level at CLC classification compared with CLC.

Table 5 shows the percentage of improvement of packet delivery ratio in CLC classification compare with AODV, QOD and CLC.

Table 4: Throughput comparison between CLC and CLC Classification.

Simulation time	CLC	CLC classification
100	4824.05	5294.05
125	4957	5590.71
150	5084.96	5287.69
175	5106.48	5314.52
200	5132.38	5383.31

Table 5: Percentage of improvement in PDR using CLC Classification algorithm.

Simulation time	% of improvement compare with		
	AODV	QOD	CLC
100	79.5	31.8	5.0
125	61.1	31.2	3.9
150	51.1	29.6	2.7
175	46.5	30.1	2.3
200	43.8	28.8	2.0

Table 6: Percentage of improvement in throughput using CLC Classification algorithm.

Simulation time	% of improvement compare with CLC
100	9.74
125	12.78
150	3.98
175	4.07
200	4.88

Table 7: Percentage of improvement in average energy utilization using CLC classification.

Simulation time	% of improvement compare with		
	AODV	QOD	CLC
100	76.1	85.3	7.0
125	78.1	85.3	5.4
150	79.7	85.6	7.6
175	80.6	85.8	7.5
200	79.3	85.8	7.3

Table 8: Overall improvements in CLC Classification algorithm.

Various performances	% of improvement
PDR increased in	3.18
Throughput increased in	7.09
Energy reduced in	6.96

Table 6 shows the percentage of improvement of throughput in CLC classification compare with AODV, QOD and CLC.

Table 7 shows the percentage of improvement of average energy utilization using CLC classification compare with AODV, QOD and CLC.

Table 8 shows that the improvement of PDR, throughput and reduced level of energy consumption while comparing with existing CLC routing protocol.

6 Conclusion

In this work, we have analyzed the behaviour of a node in mobile ad hoc networks and proven that it can improve throughput, packet delivery ratio compared to QOD and CLC protocols. As a result of this investigation, CLC routing protocol can achieve better performance with the help of node classification algorithm. This algorithm is evaluated through simulation and the obtained results highlight its importance in terms of increase in-packet delivery ratio and of reducing average energy consumption compared to other protocols.

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K. Logesh received M.C.A. degree from Madras University in 2001, and M.Tech. degree in Computer Science and Engineering from Dr. M.G.R. University, India in 2007. He is currently perusing Ph.D. from Anna University, Chennai. He is a life member of ISTE. His research interests are in routing protocol of mobile ad hoc networks, Cross layer network design and wireless sensor networks.

S. Srinivasa Rao Madane received B.E. (Electronics) from University of Kuvempu in 1991, M.Tech. (Electronics and Communications from Visvesvaraya Technological University in 2000. And Ph.D. in Computer Science & Engineering from Patna Technological University in 2009. He is currently working as Principal at Sri Krishna College of Engineering, Vellore District. His research interests are in digital electronics, embedded system, VLSI, Image Processing, Renewable Energy. He is a member of Indian Society for Technical Education (MISTE), Member of Institution of Electronics and Telecommunication Engineers (MIETE) and Member of Institute of Electrical and Electronics Engineering (MIEEE).