Traffic Controller Network for Collision Detection and Warning at Intersection

S. S. Dorle[††]
GHRCE, Nagpur, India

A. G. Keskar[††]
VNIT, Nagpur, India

Megha Chakole[†††]
YCCE, Nagpur, India

Summary
In this research, a novel system is used for monitoring the vehicles at intersection points. In this system, it will be necessary that the vehicles should be able to exchange (in real time) their dynamic information such as speed, acceleration, direction, relative position etc. with the other vehicles through Intersection traffic controller. An intersection has a wireless unit called the Intersection Traffic Controller (ITC). This ITC keeps broadcasting a message all the time. Each vehicle communicates with the ITC in real time to let the ITC know about its current location. The ITC then includes this information in its message and warn the driver about the condition of the vehicle and the signal to avoid the collision. Developing Intersection traffic controller network for collision detection and warning system will be very effective for reducing fatalities, injuries and associated cost. This research work presents a collision detection and warning protocol in intersection traffic controller (ITC) to improve the intelligent transportation systems (ITS) using a wireless communication technology. Also the intersection traffic controller will calculate the shortest path of communication between the vehicles so as to provide faster and efficient communication between different networks and provide smooth traffic flow at intersections.
Keywords:
ITS, IVC, ITC

1. Introduction

Analysing or monitoring traffic behaviour at an intersection, such as collecting the traffic speed data, motion trajectory and counts for different kinds of traffic objects is very important. Many researchers in the field of ITS and computer vision have devoted to the development of vision based systems to collect such data. However, vision-based systems suffer from two problems: occlusions and sudden changes in illumination. In most of the existing systems video cameras are required to be set in a restricted position (e.g., in a high position) so that the objects on the road can be monitored with less occlusion. However, such conditions can not be easily achieved at many intersections. If additional construction is required, the setting cost might be too high for a non regular system. Thus, a new method with easy setting conditions is needed for collecting detailed traffic data at intersection.
With the advent of wireless technologies, ad-hoc networks have become common place. An ad-hoc network is formed by a group of wireless nodes that communicate amongst themselves, and set up an “ad-hoc” network. Examples of ad-hoc networks include various sensor networks, military applications for a battalion of tanks, or civilian search-and rescue operations. Modeling of ad-hoc networks differs significantly from traditional wired networks. One fundamental difference is interference. In Vehicular ad-hoc network, when a node is transmitting to one of its neighbors, other neighbors need to be silent due to the interference in the medium. This is a well studied feature and many researchers have dealt with several of its aspects [1].Road accidents account for a severe threat to human lives from both an injury as well as a financial perspective. Given that vehicles are designed to facilitate a smooth means of transportation, manufacturers have long been in the process of designing vehicles based on principles of reliability and safety. However, due to reasons such as human-error, circumstantial error and negligence, accidents occur. Today, special attention is focused on the technologies that can reduce traffic accidents. Services provided by the Intelligent Transportation System (ITS) include collision warning; collision avoidance; and automatic control are eventually expected to result in a reduction of critical traffic accidents. What is desired is a simple in-service upgradeable method for avoiding collisions amongst moving vehicles [2]. Vehicle-to-Vehicle communication (V2V) resulting from ad hoc and peer-to-peer networking has recently gathered significant attention as a low-cost method for collision avoidance. V2V technologies are also expected to augment the ITS. V2V technologies are simple to implement primarily because of their reliance on wireless communication. A wireless location aware ad hoc network of mobile nodes (vehicles) facilitates a framework for collision avoidance. Creating a wireless ad hoc location aware communicating infrastructure however is a nontrivial task. Several components are involved – location awareness, real-time communication, mapping of mobile entities and taking appropriate action. IntelliCarTS is a solution developed that

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satisfies the aforementioned components leading to effective collision avoidance [23]. Sometimes the situation arises that you are not able to understand the correct path. Similarly if any accident happened on the road and that road get blocked by the vehicles then if you go on that road then we will also face the problem of traffic. So at that time to save our time, power we can take the help of another system which is aware from this problem. So we are making such a system in which the master vehicle will send all data to any vehicle within the network. The area of network can be same or different. Initially we are considering three networks in our simulation and assuming that all the three networks are having same information in their database. The aim is to design and evaluate a set of applications so as to reduce the rate of accidents, proper knowledge of road, to send any kind of data to the vehicles through intersection point.

In order to reduce the number of traffic accidents and improve the safety and efficiency of traffic, the research on Intelligent Transportation System (ITS) has been developed for many years in many countries.. ITS gives benefits which are improvement of safety and reduction of driver stress by giving drivers useful information and control. Many researchers have taken interest in this area and proposed a number of crash avoidance systems [21]-[23].With recent advance in sensing, computing, and communication technologies, new driving assistance systems such as night vision and collision warning systems (CWS) have been designed, tested, and deployed. While night vision systems simply provide visual assistance to drivers in dark environment, collision warning and avoidance systems generally exhibit some intelligence. Despite the fact that intersection collision accounts for almost 30% of all crashes, intersection collision avoidance systems received less attention than the forward collision avoidance systems. The reason, besides the fact that the intersection collision problem is more complicated than rear-end crash, is the limitation of the radar technology, the most widely used object sensing method in vehicle collision avoidance systems.

The present technologies that are being investigated to avoid intersection collisions are differential global positioning systems (DGPS), electronic compasses, roadside sensors, etc. There are several disadvantages of these technologies. For example, the GPS signals have some errors and in some areas, especially in downtown areas with very tall buildings, the signals may not be detected. The roadside sensors may not detect some vehicles if there are multiple lanes on the road.

It becomes imperative that the vehicles exchange dynamic information such as speed, acceleration, position and direction in real time. Wireless communications do not require line-of-sight. Thus, using wireless communication technologies, the vehicles can inform each other about how far they are from the intersection and receive the dynamic information of the signal lights and the status of the intersection. The goal of the intersection collision detection and warning protocol is to warn the driver about the condition of the vehicle and the signal to avoid the collision.

2. Related work

The main purpose of the Next generation ITS is the safe driving, which is represented by the developments of Advanced Vehicle Control and Safety System (AVCSS)[24].

The goal of the AVCSS is to improve the safety and convenience of driving, optimize energy consumption by having smooth traffic flow and increase the efficiency of transport industry. Other applications of ITS such as Advanced Traffic Management Systems (ATMS) [25] and Advanced Traveler Information Systems (ATIS)[26] are going to have new developments in the future. In order to design more efficient and safe transportation systems it is very important the design of efficient and safe inter-vehicle communication protocols.

Most IVC protocols use flooding as the simplest way to broadcast. Flooding performs relatively well for a limited small number of nodes, but the performance drops quickly as the number of nodes increases. As each node receives and broadcasts the message almost at the same time, this causes contentions and collisions, broadcast storms and high bandwidth consumption [29].

Recently, a number of research groups have proposed more efficient broadcasting techniques. Centralized broadcasting schemes are presented in [26]. Algorithms in [27] utilize neighborhood information to reduce redundant messages in a Mobile Ad Hoc Network. Schemes in [28] deal with disseminating data in sensor networks.

In this paper we present the very simple and efficient system, which needs minimal neighbor-hood information. This system provides the information from the intersection point to warn the driver about the condition of the vehicle and the signal to avoid the collision.

The node's relative speed is an important metric in comparing between different mobility models. In the work of Yenliang et al. [9], it was shown that nodes in bidirectional mobility models have less correlation among each other, except for neighbouring nodes travelling in the same direction. Performance comparison of AODV and DSR protocols with different node movements and network loads was introduced in the work of Perkins et al. [10]. A random node movement in a rectangular topology was used in this work, and it was reported that AODV outperforms DSR in most studied cases. Kosch et al. [11] support the use of AODV in inter-vehicle ad hoc networks and list the reasons for this, along with presenting an adjustment to AODV to allow for positioning information. Vehicle positioning obtained from Global Positioning System

(GPS) and vehicle speeds are added to the route request (RREQ) and route reply (RREP) messages of AODV. By using the position information of the vehicle, the distance between nodes that have participated in the route is calculated and added to both RREQ and RREP messages. A prototype implementation of vehicles equipped with a computer, digital maps and special Omni directional antenna was presented in this work. The performance of inter-connected MANETs was studied in the work of Seah et al. [19].AODV and optimized link state routing (OLSR) protocols were used as representatives of reactive and proactive routing protocols, respectively. It was demonstrated that it is possible to roam between different MANETs running different routing protocols. In the work of Lee and Gerla [12], a modified AODV was introduced by adding a scheme that utilises a mesh structure and multiple alternate paths. The modified AODV was tested on 50 nodes with a maximum speed of 20 m/s (72 km/h), and the results showed an improvement in packet delivery ratio at the maximum speed. An extension to AODV by incorporating the concept of load-balancing was presented in the work of Joo-Han et al. [13], and simulation results showed that the proposed algorithm was highly efficient in throughput, packet end-to-end delay and routing overhead, especially in high-traffic loads. Another modified AODV was presented in the work of Fan et al. [14], where the hop count metric that was used in the original AODV is replaced by a new cost metric based on MAC delay, and the RREQ and RREP packets and routing table of each node are modified by adding a ‘path loss’. Simulation results showed an improvement in throughput at low node speed and higher packet size. Improving the neighbor detection algorithm in AODV, based on the differentiation between good and bad neighbors, using signal-to-noise ratio (SNR) value was proposed and experimentally verified in the work of Krco and Dupcinov [15]. Other approaches that employ location based and cluster-based location routing algorithms for inter-vehicle and vehicle-to-vehicle communications were reported in the work of Santos et al. [16, 17], respectively, and their performances were compared to AODV and DSR protocols. It was reported that enabling Hello messages decreased AODV performance, compared to the other two protocols. AODV with path accumulation added to the routing table was introduced in the work of Gwalani et al. [18], where during RREQ and RREP, each node generates or forwards messages by adding its own address to the message as well. Each node receiving any of these messages updates its routing table with path accumulation information as well as other AODV route information. In the work of Tickoo et al. [20], the RREQ message is enhanced with three additional fields. Each node receives a RREQ from all other nodes, and measures the level of signal power of the message, then, by comparing power measurements from each node it can judge if a node is approaching or departing and retains this information for 100 s before purging it. A rectangular topology and random waypoint models are used in this work. In a motorway scenario, it is not guaranteed that two messages from the same vehicle will be received when they are traveling in opposite directions, since occasionally two vehicles are in point-to-point communication range for <8 s.

3. System design approach

Here authors are showing three networks at a time with the help of programming in DSR algorithm. Our goal is to make the model, which shows the number of nodes. Here the nodes represent the vehicles. For the simulation, we use a Matlab programming to make the network. For each networks the vehicles are different. We are assuming that the first vehicle in each network is acting like a master vehicle. So our aim is to transmit the data from that master vehicle to another vehicle within that particular network. The direction of data transmission can be represented by the dotted line as shown in figure 1. There are so many routes to send the data from Intersection traffic controller to the any vehicle, but we have to send the data through the shortest path.

Existing routing protocols, where each node is required to select the next one or to continue route discovery, result in high delays in reaching the destination. Several routing protocols developed for Ad-hoc wireless networks have been modified and adapted for use in transportation systems [9].

In order to improve the communication between intersection and the vehicles, and to improve the safety and efficiency of the traffic, this proposed system is developed.

A. Intersection Collision Warning System

This collision warning system is used for safety improvement, the transmission performance of this system has stringent requirements. The collision detection and warning system is installed at ITC. This system works in NLOS situations and system assumed to give a warning message to the driver, to avoid collision.

B. Broadcasting

Broadcasting wireless unit is installed at the ITC and each vehicle should have the wireless unit which can communicate with the ITC. Vehicles do not know when the signal turns to be red or green; they exchange the information with ITC to know position, speed, lane no., road no., and time left to change the status of the signal, to avoid collision at intersection. Transmission interval is assumed to be small enough to ensure safety.

4. Simulation Setup

For simulation purpose we have used the Matlab platform. The networks are made in the form of axes as shown in the figure 2. The nodes are considered as vehicles. The value of total number of nodes can be change through program. In network 1 there are total 20 nodes. Nodes are situated as per the real time scenario. If we want to send the data from node 1 to node 13, then it sees like as shown in the network 1 of figure 2. In network 2 there are total 14 nodes. If we want to send the data from node1 to node 10 then it will see like network 2 in figure 2. In network 3 there are total 10 nodes. If we want to send the data from node 1 to node 6 then it will see like network 3 in figure 2. The data will be sending from one vehicle to another vehicle through shortest path.

Before algorithms, it is important to outline some of the assumptions. We assume a simplified geographic model whereby all nodes are located. Nodes are said to be connected to each other if their Euclidean distance is less than the transmission radius of their radios. We do not consider an uneven topology with hills or other obstructions, though the models we present here may be extended to address some of these features. Here we consider the nodes as vehicles. So it means that the total number of nodes indicate the total number of vehicles in that particular network [8].

i) NETWORK DESIGN

At the first stage of our project we decide to make single network. We design that as shown below by using Matlab. The network area which is we have taken is in axes form in meters.

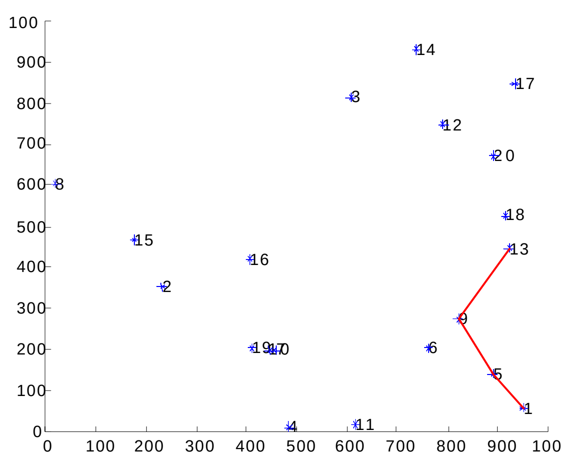

Fig 1. Single network showing data transmission from master vehicle to another vehicle within that network.

We are assuming that the first vehicle in each network is acting like a master vehicle. So our aim is to transmit the data from that master vehicle to the vehicles within that particular network. The direction of data transmission can be represented by the dotted line as shown in figure 1.

Figure 1 indicates only one network. The nodes are considered as vehicles. In this network there are total 20 nodes. The value of total number of nodes can be change through program. If we want to send the data from node 1 to node 13 then it will seen as shown in figure 1.The data will be sending from one vehicle to another vehicle through shortest path. The master vehicle means node 1 can send the data to any vehicle in the network by changing the value of node in the program. The advantages of this network are that any kind of data can be send to the vehicle from the master vehicle.

We make above window in the GUIDE function in Matlab software. The nodes are considered as vehicles. The value of total number of nodes can be change through program. In network 1 there are total 20 nodes. They are situated randomly in the network. If we want to send the data from node 1 to node 13, then it see like as shown in the network 1 of figure 2.In network 2 there are total 14 nodes. If we want to send the data from node1 to node 10 then it will see life network 2 in figure 2. In network 3 there are total 10 nodes. If we want to send the data from node 1 to node 6 then it will see like network 3 in figure 2. The data will be sending from one vehicle to another vehicle through shortest path. When we click on the RUN NETWORK button then and only then the all three networks will show its nodes connection and when we click on the EXIT button then Guide window will be closed [8].

ii) Modulation Scheme

In this protocol the Orthogonal Frequency Division Multiplexing (OFDM) is used it is a multicarrier transmission technique, which divides the available spectrum into many carriers, each one being modulated by a low rate data stream. OFDM is similar to FDMA in that the multiple user access is achieved by subdividing the available bandwidth into multiple channels, which are then allocated to users. However, OFDM uses the spectrum much more efficiently by spacing the channels much closer together. This is achieved by making all the carriers orthogonal to one another, preventing interference between the closely spaced carriers. The orthogonality of the carriers means that each carrier has an integer number of cycles over a symbol period. Due to this, the spectrum of each carrier has a null at the centre frequency of each of the other carriers in the system. This results in no interference between the carriers, allowing then to be spaced as close as theoretically possible. This overcomes the problem of overhead carrier spacing required in FDMA.

Fig (2) shows the OFDM model used for simulation in MATLAB. Serial pseudorandom data is input through the OFDM transmitter as shown in the fig. (2) then the serial data is converted into the parallel data. Fig (3) shows the input pseudorandom data. Different modulation techniques can be taken like BPSK, QPSK etc. In this protocol design BPSK modulation scheme is used. The required spectrum is then converted back to its time domain signal using an Inverse Fourier Transform (IFFT). The Fast Fourier Transform (FFT) transforms a cyclic time domain signal into its equivalent frequency spectrum. Before this one of the most important properties of OFDM transmissions is the robustness against multipath delay spread. This is achieved by having a long symbol period, which minimizes the inter-symbol interference. The level of robustness can be increased even more by the addition of a guard period between transmitted symbols.

iii) Transmission and Reception:

Vehicles broadcast packets repeatedly. The transmission timing is selected at random. Symbol timing adjustment is performed by correlating the stored training sequence with the training sequence of received signals. Channel estimation is performed by employing a training sequence. When all symbols in a packet is completely demodulated, the reception of the packet is considered as success. Fig (4) shows the received OFDM signal data.

iv) Packet Structure

A vehicle broadcasts packets which include position, speed, heading and acceleration information. Position information is composed of latitude and longitude information. These are used for calculating relative distance and relative velocity of the vehicle.

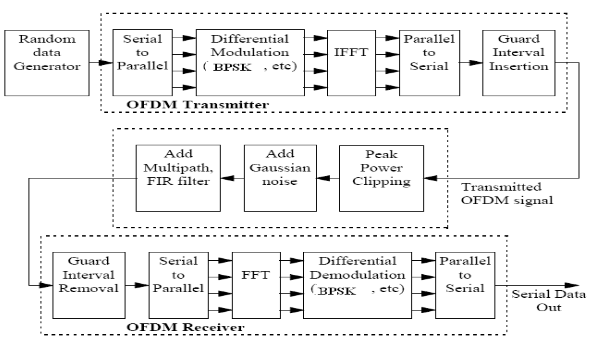

Fig 2. OFDM Model

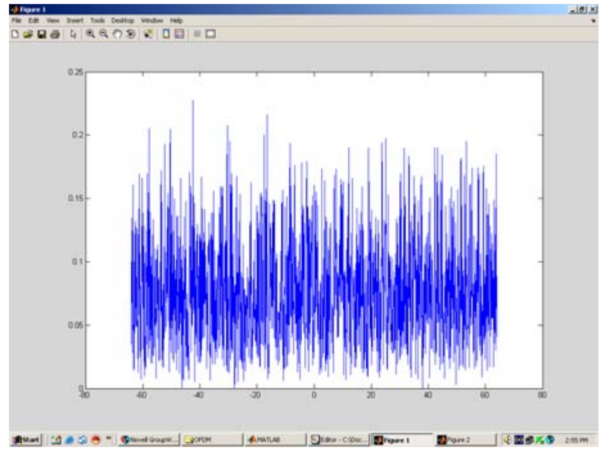

Fig. 3 A pseudorandom signal input

Fig. 3 shows an example of the pseudorandom signal which is given as a input to the OFDM Transmitter. The above signal is processed through the OFDM model and accordingly we get the received signal shown in fig. 4.

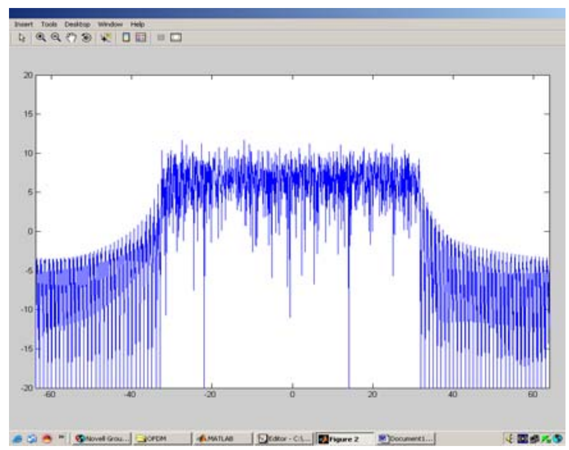

Fig.4 Received ofdm signal

5. Results

It is observed that all the three networks appear on the screen. Further from the base station anyone can monitor the position of vehicles and the number of vehicles within the network. On the screen one can also see the communication between the vehicle within one or different network. The data can be transmitting from master vehicle to another vehicle within that network by dotted lines as shown in figure 5. Traffic intersection controller can easily find out which vehicle is communicating with the within the network. Also it is tested that communication between two different networks can be seen. In this way the system is useful for monitoring traffic conditions.

Conclusion

In this work, we have shown that this system is suitable for vehicular communication and have supported our hypothesis. The Intersection traffic controller sends the data to the different vehicles within that particular network through shortest path. This data can be used by the vehicle so as to avoid the accidents. Now we are trying to make the program to see the transmitted data at the receiver end. We hope to use the results from this design is to help in investigating issues dealing with safe trajectory planning and integrated for communication systems for multiple autonomous vehicle environments. We believe that this will be the most efficient way to communicate with vehicle systems. Finally, this research can be used to aid in the development of real-time operational management systems for multiple vehicles in dynamic and partially-known environments.

In future, work will be carried out to improve the emergency conditions requirements on roads. Also some sort of unambiguous situations may be caught with the help of this intelligent data communication.

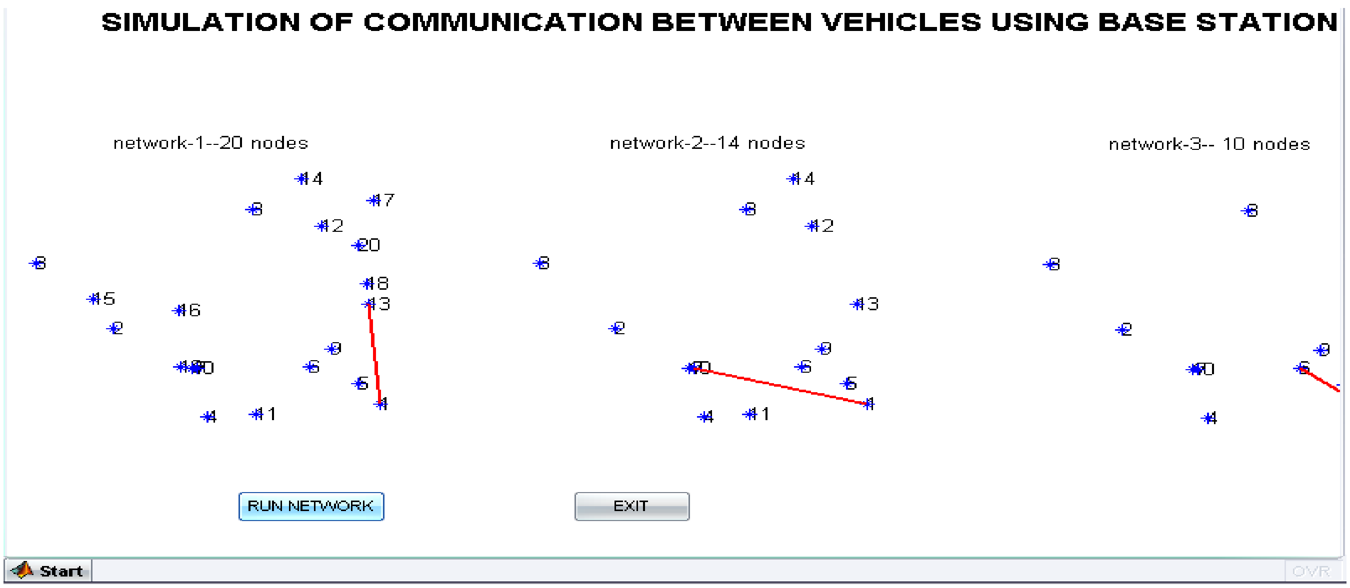

Figure 5. Three different networks showing transmission of data from master vehicle to another vehicles within that nerwork

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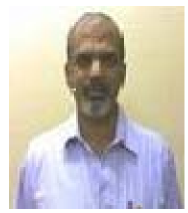
S. S. Dorle received the B.E. degree from YCCE Nagpur and M.Tech. (Electronics Design & Technology) degree from CEDTI, Gorakhpur, India in 1997 and 2002, respectively. He is pursuing Ph.D. from VNIT Nagpur. He has published around 20 research papers and attended various International conferences. He worked as Program Chair for 2nd International Conference on Emerging Trends in Engg & Technology (ICETET-09). He has worked as reviewer for many International & National conferences. He is a member of IEEE, CSI, ISTE. His research areas include VANET, Embedded Electronics Systems, etc. He is also recipient of Best Teacher Award for 2008-09.



Dr.A.G.Keskar is working as Professor at VNIT, Nagpur, India. He is recipient of Gold Medal at BE & ME. He has 20 years of Teaching & 7 years Industry experience. He has published many research papers and attended International conferences at abroad. He has completed an Industrial Project at Rotterdam, UK. He has undertaken many consultancies. He is Senior Member IEEE, FIETE, LMISTE, FIE. He has guided many Ph.D. candidates. His research areas include Embedded Systems, Fuzzy logic, Soft computing etc

Megha Chakole received the B.E. degree and M.Tech. (Electronics) degree from RTM Nagpur University, India in 2003 and 2008, respectively. She has published research papers in International. She has worked as reviewer for International & National conferences. He is a member of ISTE. Her research areas include Wireless Communications, Embedded Electronics Systems, etc. She is currently working as lecturer with YCCE in Electronics & Telecommunication Engineering Department, Nagpur