Multicast Multi-path Power Efficient Routing in Mobile ADHOC networks

S.Gunasekaran † and Dr.K.Duraiswamy ††
† Faculty of Post Graduate Studies, KSR College of Technology, Namakkal, India-637215
†† Faculty of Computer Science and Engineering, KSR College of Technology, Namakkal, India-637215

Summary
The proposal of this paper presents a measurement-based routing algorithm to load balance intra domain traffic along multiple paths for multiple multicast sources. Multiple paths are established using application-layer overlaying. The proposed algorithm is able to converge under different network models, where each model reflects a different set of assumptions about the multicasting capabilities of the network. The algorithm is derived from simultaneous perturbation stochastic approximation and relies only on noisy estimates from measurements. Simulation results are presented to demonstrate the additional benefits obtained by incrementally increasing the multicasting capabilities. The main application of mobile ad hoc network is in emergency rescue operations and battlefields. This paper addresses the problem of power awareness routing to increase lifetime of overall network. Since nodes in mobile ad hoc network can move randomly, the topology may change arbitrarily and frequently at unpredictable times. Transmission and reception parameters may also impact the topology. Therefore it is very difficult to find and maintain an optimal power aware route. In this work a scheme has been proposed to maximize the network lifetime and minimizes the power consumption during the source to destination route establishment. The proposed work is aimed to provide efficient power aware routing considering real and non real time data transfer.

Key words:
Consumption, Lifetime, Perturbation, Stochastic

1. Introduction

Multicast traffic over the Internet is growing steadily with increasing number of demanding applications including Internet broadcasting, video conferences, data stream applications and web-content distributions [1]. Many of these applications require certain rate guarantees, and demand that the network be utilized more efficiently than with current approaches to satisfy the rate requirements. Traffic mapping (load balancing) is one particular method to carry out traffic engineering, which deals with the problem of assigning the traffic load onto pre-established paths to meet certain requirements. Our focus is to scrutinize the effects of load balancing the multicast traffic in an intra domain network. The existing work on multicast routing with power constraints are refer in the literatures.[2],[3],[4],[5],[7].

Propose a solution to optimally distribute the traffic along multiple multicast trees. However, the solution covers the case when there is only one active source in the network. In addition, it is assumed that the gradient of an analytical cost function is available, which is continuously differentiable and strictly convex. These assumptions may not be reasonable due to the dynamic nature of networks. [8], [9], [11].

Even though they approach the problem under a more general architecture, practicality of these solutions is limited due to the unrealistic assumption that the network is lossless as long as the average link rates do not exceed the link capacities. Moreover, a packet loss is actually much more costly when network coding is employed since it potentially affects the decoding of a large number of other packets. In addition, any factor that changes the min-cut max-flow value between a source and a receiver requires the code to be updated at every node simultaneously, which brings high level of complexity and coordination.

The proposal in this paper presented a distributed optimal routing algorithm to balance the load along multiple paths for multiple multicast sessions. Our measurement-based algorithm does not assume the existence of the gradient of an analytical cost function and is inspired by the unicast routing algorithm based on Simultaneous Perturbation Stochastic Approximation (SPSA). In addition, we address the optimal multipath multicast routing problem in a more general framework than having multiple trees. We consider different network models with different functionalities.

With this generalized framework, our goal is to examine the benefits observed by the addition of new capabilities to the network beyond basic operations such as storing and forwarding. In particular, we will first analyze the traditional network model without any IP multicasting functionality where multiple paths are established using (application-layer) overlay nodes. Next, we consider a network model in which multiple trees can be established.[6],[9] Finally, look at the generalized model by allowing receivers to receive multicast packets at arbitrarily different rates along a multicast tree. Such an assumption potentially creates a complex bookkeeping problem since source nodes have to make sure each receiver gets a distinct set of packets from different trees

Manuscript received April 5, 2010
Manuscript revised April 20, 2010

while satisfying the rates associated with each receiver along each tree.
The measurement-based routing algorithm [13] to load balance intra domain traffic along multiple paths for multiple multicast sources. Multiple paths are established using application-layer overlaying. The proposed algorithm is able to converge under different network models, where each model reflects a different set of assumptions about the multicasting capabilities of the network. The algorithm is derived from simultaneous perturbation stochastic approximation and relies only on noisy estimates from measurements. Simulation results are presented to demonstrate the additional benefits obtained by incrementally increasing the multicasting capabilities.

2. Multipath Multicasting

The proposed scheme is multicast video in multiple paths over wireless networks. It consists of two parts. The first part is to split the video into multiple parts and transmit each part in a different path. In the latter part, employ multicast method to transmit the video packets to all the nodes. In this scheme, we assume that the network is lightly loaded, i.e., mobility and poor channel condition rather than congestion are major reasons for packet drop. Begin by showing the feasibility of multiple path multicasts, and then move on to describe ways to forward packets through multiple paths. The proposed method has three basic steps, discovery of the shortest route, maintenance of the Route and Data Transmission.

2.1 Route Discovery

The first criterion in wireless medium is to discover the available routes and establish them before transmitting. To understand this better let us look at the example below. The below architecture consists of 11 nodes in which two being source and destination others will be used for data transmission. The selection of path for data transmission is done based on the availability of the nodes in the region using the ad-hoc on demand distance vector routing algorithm. By using the Ad hoc on Demand Distance Vector routing protocol, the routes are created on demand, i.e. only when a route is needed for which there is no “fresh” record in the routing table. In order to facilitate determination of the freshness of routing information, AODV maintains the time since when an entry has been last utilized. A routing table entry is “expired” after a certain predetermined threshold of time. Consider all the nodes to be in the position. Now the shortest path is to be determined by implementing the Ad hoc on Demand Distance Vector routing protocol in the wireless simulation environment for periodically sending the messages to the neighbors and the shortest path.
In the MANET, the nodes are prone to undergo change in their positions. Hence the source should be continuously tracking their positions. By implementing the AODV protocol in the simulation scenario it transmits the first part of the video through the below shown path. After few seconds the nodes move to new positions.

2.2 Route Maintenance

The next step is the maintenance of these routes which is equally important. The source has to continuously monitor the position of the nodes to make sure the data is being carried through the path to the destination without loss. In any case, if the position of the nodes change and the source doesn’t make a note of it then the packets will be lost and eventually have to be resent.

2.3 Data Transmission

The path selection, maintenance and data transmission are consecutive process which happen in split seconds in real-time transmission. Hence the paths allocated priory is used for data transmission. The first path allocated previously is now used for data transmission. The data is transferred through the highlighted path. The second path selected is now used for data transmission. The data is transferred through the highlighted path. The third path selected is used for data transmission. The data is transferred through the highlighted path.

3. Multipath Multicasting Using Power Algorithm

Since a MANET may consist of nodes which are not able to be re-charged in an expected time period, energy conservation is crucial to maintaining the life-time of such a node. In networks consisting of these nodes, where it is impossible to replenish the nodes’ power, techniques for energy-efficient routing as well as efficient data dissemination between nodes is crucial.
An energy-efficient mechanism for unipath routing in sensor networks called directed diffusion has been proposed. Directed diffusion is an on-demand routing approach. In directed diffusion, a (sensing) node which has data to send periodically broadcasts it. When nodes receive data, they send a reinforcement message to a pre-selected neighbor which indicates that it desires to receive more data from this selected neighbor. As these reinforcement messages are propagated back to the source, an implicit data path is set up; each intermediate node sets up state that forwards similar data towards the previous hop.

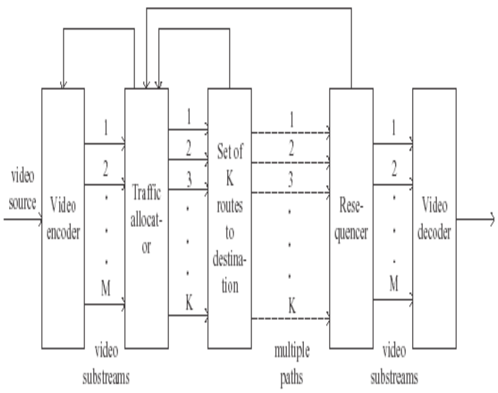


Fig: 1 Multipath multicast power Routing

The way of Directed diffusion is an on-demand routing approach; it was designed for energy efficiency so it only sets up a path if there is data between a source and a sink. However, the major disadvantage of the scheme, in terms of energy efficiency, is the periodic flooding of data. In order to avoid the flooding overhead, proposes the setup and maintenance of alternate paths in advance using a localized path setup technique based upon the notion of path reinforcement.

The goal of a localized reinforcement-based mechanism is for individual nodes to measure short term traffic characteristics and choose a primary path as well as a number of alternate paths based upon their empirical measurements. An alternate path is intended to be used when the primary fails. ”Keep-alive” data is sent through the alternate paths even when the primary path is in use. Because of this continuous “keep-alive” data stream, nodes can rapidly switch to an alternate path without going\ through a potentially energy-depleting discovery process for a new alternate path.

A multipath routing technique which uses braided multipaths is also proposed. Braided multipaths relax the requirement for node disjoint. Multiple paths in a braid are only partially disjoint from each other and are not completely node-disjoint. These paths are usually shorter than node disjoint multipaths and thus consume less energy resources; alternate paths should consume an amount of energy comparable to the primary path. A simple localized technique for constructing braids is as follows.

Base layer (BL) packets are sent along path 2, while enhancement layer (EL) packers and retransmitted BL packets are sent along Path 1. A source sends out primary path reinforcement to its (primary path) neighbor as well as alternate path reinforcements to its (alternate path) neighbors. Each node in the network performs this same neighbor and path selection process. The evaluation of the performance of the proposed energy constrained algorithms is a function of the overall goal of minimizing energy resources. It was found that energy-efficient multipath routing using the braided multipath approach expends only 33% of the energy of disjoint paths for alternate path maintenance in some cases, and have a 50% higher resilience to isolated failures.

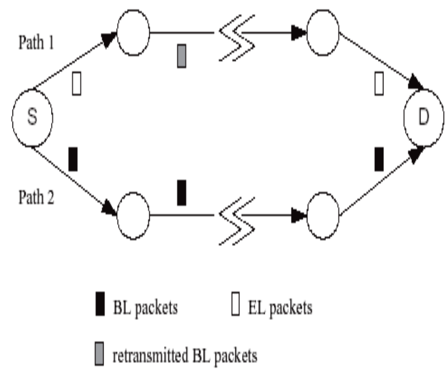


Fig:2 Multipath layered scheme.

The system for transporting video over ad hoc networks using multipath routing and source coding is proposed. The system considers two types of source coding multiple-description coding and layered coding. Both types of coding create multiple sub-streams out of a single video stream. In multiple-description coding, each sub-stream has equal importance, and therefore, each sub-stream contributes equally to the quality level. In layered coding, a base layer stream is created along with multiple enhancement layer streams. The base layer stream provides a basic level of quality, while each enhancement layer stream if correctly received add to the quality. Therefore, in layered coding, base layer packets should be sent along more reliable paths to ensure that they are received at the destination.

In the system, the source maintains multiple paths to the destination and reserves bandwidth along the paths such that the total bandwidth falls within an acceptable range. The total number of paths is not necessarily equal to the number of streams. Therefore, a path may carry packets from different streams. Similarly, packets from one stream may be allocated to different paths. The task of the source is to allocate the packets from each stream among the paths such that a minimum level of quality can be observed at the receiver. Depending on the path conditions and application requirements, the source chooses to use multiple-description coding or layered coding. The source coder also must adjust the rate allocation to each stream depending on the available bandwidth. Using intelligent path selection and traffic allocation along with adaptive source coding, the system can adapt well to fluctuating network conditions caused by path failures or changes in available bandwidth.

A scheme to provide reliable transport for video specifically using layered coding along with multipath routing is proposed. In the proposed scheme, the video data is encoded into two layers: the base layer and one enhancement layer. The source uses two disjoint paths to the destination to route data. Base layer packets are sent along one path, while enhancement layer packets are sent along the other path. Base layer packets are protected using Automatic Repeat Request (ARQ). When a base layer packet is lost, the destination sends an ARQ request to the source. When an ARQ request is received, the source retransmits the base layer packet along the enhancement layer path to ensure timely arrival of the base layer packet, and the enhancement layer packet being transmitted at that time instance is discarded. The necessary bandwidth for the base layer and enhancement layer paths are reserved using a signaling protocol.

As packet drops increase due to congestion or degraded network conditions, enhancement layer packets are dropped at the source in favor of retransmitted base layer packets. This attempts to ensure that a basic level of quality is always achieved at the destination. Using layered coding along with ARQ would work well when using lossy paths and if the extra delay for retransmissions is acceptable.

4. Experimental Evaluation of Power aware Multi-path multicasting

In localized proposed algorithms, the nodes in the network make routing decisions based solely on the location of itself, the location of the destination and the location of its neighbors. Localized algorithms are distributed algorithms where simple local node behavior achieves a desired global objective [12]. Non-localized algorithms are those in which the nodes require the complete knowledge of all the nodes in the network along with the corresponding edges. In ad hoc mobile networks, nodes are moving at all times and there may be several nodes exiting and entering the network at any given point of time. To keep a track of all these nodes and their corresponding edges is cumbersome and requires a huge overhead. To avoid this overhead, routing decisions are made on demand using the dynamic source routing technique.

Intuitively, want to minimize the total power required in transmission; the shortest path would be the optimal solution. This is not always true. It will get depleted the fastest and thus lead to a breakdown of the network. To avoid this condition, the remaining battery power of each node needs to be taken into consideration [10]. This is known as cost- aware routing. Presented some of the existing power aware metrics and routing algorithms.

4.1 Existing Power Aware Metrics and Routing Algorithms

There are number of power and cost aware metrics present. The two basic ones are Power aware routing. In this case, the transmission power depends on the distance between the source and the destination. Cost aware routing: In this case, the routing decisions are made based on the remaining life-time of nodes between the source and the destination.

4.2 Proposed Power aware Algorithm

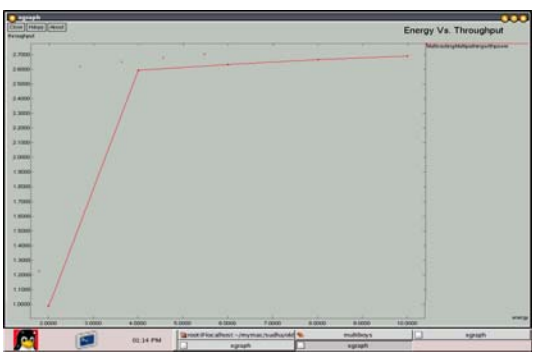
The proposed algorithm and the parameters considered for conducting this experiment extend the power-cost efficient algorithm to implement timing constraints. The results of the power-cost aware algorithm show that it performs better when the network/graph is dense. In a large network, a node will have a large number of neighbors. The computation time for calculating the minimum power-cost among the nodes' neighbors is quadratic or exponential (depending on the algorithm used, power+cost or power*cost). In order to reduce this computational time we introduce a threshold value for the remaining battery power of the nodes.

While selecting a route, nodes with battery power greater than the threshold will only be considered. It would then go on to compute the minimum power-cost route. However, if none of the nodes meet the threshold, the threshold is reduced by half. This will continue until a node meeting the threshold is found or the threshold reduces to a minimum specified value. This would imply that the network is broken and the packet cannot be delivered. An appropriate error message is then given.

The modified proposed algorithm
Threshold = 50%; success = 0; cutoff = 10%
A := S;
Repeat
If g(A) >= threshold then
B := A;
Let A be neighbor of B that minimizes
pc(B,A) = power-cost(B,A) + v(s)f'(A);
Send message to A;
success = 1;
Until A = D (* Destination reached *)
or if success <> 1 then
if threshold > cutoff then
threshold = threshold /2;
or A = B (* Delivery failed *);

5. Result Analysis Multi-path Multicast Power Model

Experiments are conducted with the intra domain network topology. It is a close approximation to analyze how our routing algorithm performs under these conditions since; recent findings suggest that many ISPs are in the process of increasing the node connectivity of their networks. Each link has a bandwidth of 20 Mbps. The topology has 3 sources that simultaneously send multicast traffic, where each source has 18 receivers and nodes 10 and 23 are selected as additional overlay nodes. Each source-destination pair has three paths including the min-hop path starting at the source node and each source generates Poisson traffic with an average rate of 10 Mbps. The routing algorithm starts from the setting that all overlay rates other than the source nodes are set to model, the algorithm starts with basic unicast routing to reach each destination. It starts with a single shortest path multicast tree rooted at each source node and gradually shifts traffic to alternative trees rooted at overlay nodes 10 and 23.
For the proposed algorithm simulated an ad-hoc network with varying densities and transmission ranges. Each node had a random location in a 1000 x 1000 area. They also had a random amount of initial power within a range of 70 joules 150 joules. The thresholds were varied from 70joules to 100 joules.



Graph 1: Energy Vs Throughput for multi-path multicast data delivery

As seen from the graph, the life of the network depends on various factors, which include the initial threshold, density of the network and range of the transmitters. These parameters need to be adjusted for each network. This is still work in progress. The project presented here studied the various power saving techniques employed by mobile devices. The initial results show that the various parameters affect the lifetime of the network. This is still work in progress. At this point, we are not taking into consideration the nodes' personal tasks. In the future, we can take into account the power consumed by these activities, to see its impact on the lifetime of the network.

In this proposed method the video can be split into five parts and transmitted in multipath based on the availability of the nodes. The source and the destination for the transmission are visible. The five paths taken are shown below.

Path 1: 0-10-15-17-13-21-24
Path 2: 0-1-4-19-24
Path 3: 0-10-20-3-21-24
Path 4: 0-1-18-6-19-24
Path 5: 0-2-16-12-7-22-24

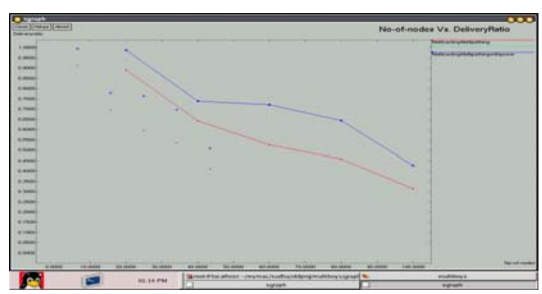
Eventually the video is multicast from destination 24 to all nodes. Throughput is the number of useful bits per unit of time forwarded by the network from a certain source address to a certain destination, excluding protocol overhead, and excluding retransmitted data packets. Throughput is the amount of digital data per time unit that is delivered over a physical or logical link, or that is passing through a certain network node.

Delivery Ratio = (Number of Packets Received) / (Number of packets Sent)

Delay is defined as the average time taken by the packet to reach the server node from the client node.

Delay = (Number of packets Received) / (Simulation Time)

Pause-time is the time for which a packet stops in when it reached a destination after a travel from the place of origination. The unit of pause-time is seconds. Mobility is the velocity with which a node moves from the source to destination. It is usually specified in m/s. Dropped packets are number of packets dropped due to the effect of link breaks. The dropped packets may be a control packets or data packets.



Graph 2: Number of nodes Vs Delivery ratio for multi-path multicast transmission

Simulation result shows that video quality of multiple path multicast video communication is significantly higher than that of single path multicast video communication, with similar routing overhead and forwarding efficiency. The video multicasting technique applied in this paper is much superior to the existing technique. By the extensive use of AODV protocol the QoS parameters, viz, Delay and Throughput have significantly improved. From the simulation results the delay has been reduced by 0.5 s and the throughput has been increased by 5%.Wireless multicast is required for a range of emerging wireless applications employing group communication among mobile users.

6. Conclusion

The proposed power aware multicast identifies the characteristics of the proposed routing algorithm. It evaluates its performance under various network conditions. Each plot presented illustrates the average of 10 independent runs that are initiated with different random seeds. For the optimization algorithm, the link cost function is selected, and defined. In all simulations, the period of link state measurements is selected as one second. As a consequence, source nodes can update their rates at best approximately every two seconds since it require two measurements for estimating the gradient vector according to the modified power algorithm. For simplicity set the rate of redundancy due to source coding, to zero.

The optimal values suggest that the complexity of having smart routers that are able to forward packets onto each branch at a different rate offers only a marginal benefit in this scenario. However, it is hard to draw any further conclusions as this result may depend on the specific topology and source-destination pair selections. Also, our algorithm does better than tradition power algorithm as a consequence of the availability of multiple trees to distribute the traffic load. However, while under network topology model the algorithm is able to minimize the cost to a certain level, it cannot eliminate the packet losses and has a much higher overall cost compared to traditional ones. The reason behind this result is the lack of multicast functionality. Since we cannot create multicast trees, the only savings due to multicasting occurs between the sources and overlay nodes.

Once multicast packets reach the overlays, overlay nodes need to create independent unicast sessions for each destination ignoring the multicast nature of the traffic, and this creates a high level of link stress as multiple copies of the same packets are generated. One important observation is that the algorithm is able to converge faster in network model NM-IIb than all other models. This is due to the fact that, it is only need to optimize the overlay rates instead of individual receiver rates. Hence, the number of parameters to be calculated is much smaller than the other two cases.

Acknowledgment

The authors would like to express their cordial thanks to all good hearted peoples for their valuable support.

References

[1] S.-Y. R. Li and R. W. Yeung, “Linear network coding,” IEEE Transactions on Information Theory, vol. 49, pp. 371–381, 2003.
[2] T. Noguchi, T. Matsuda, and M. Yamamoto, “Performance evaluation of new multicast architecture with network coding,” IEICE Trans. Commun, vol. E86-B, pp. 1788–1795, 2003.
[3] Y. Zhu, B. Li, and J. Guo, “Multicast with network coding in application-layer overlay networks,” IEEE Journal on Selected Areas in Communications, vol. 22, pp. 107–120, 2004.
[4] Li Q, Aslam J, Rus D, “Online Power-aware Routing in Wireless Ad-hoc Networks,” Proceedings of Int’l Conf. on Mobile Computing and Networking (MobiCom’2001), 2001.
[5] Stojmenovic I, Lin X. “Power-Aware Localized Routing in Wireless Net108 works,” IEEE Trans. Parallel and Distributed Systems 2001; 12(11):1122-1133.
[6] Doshi S, Brown TX, “Minimum Energy Routing Schemes for a Wireless Ad Hoc Network,” Proceedings of the Conference on Computer Communications (IEEE Infocom 2002), 2002.
[7] Woo K, Yu C et al., “Localized Routing Algorithm for Balanced Energy Consumption in Mobile Ad Hoc Networks,” Proc. of Int'l Symp. on Modeling, Analysis and Simulation of Computer and Telecommunication Systems 2001,117-124.
[8] Toh C-K,“Maximum Battery Life Routing to Support Ubiquitous Mobile Computing in Wireless Ad hoc Networks,” IEEE Communications Magazine, vol. 39, no. 6, pp. 138-147, June 2001.
[9] M. Adamou and S.Sarkar, “A Framework for Optimal Battery Management for Wireless Nodes,” Proceedings of IEEE INFOCOMP 2002, pp. 1783-1792.
[10] C. F. Chiasserini, and R. R. Rao, “Improving Battery Performance by Using Traffic Shaping Policies,” IEEE Journal on Selected Areas of Communications, vol. 19, no. 7, pp. 1385-1394, July 2001.
[11] S. Agarwal, A. Ahuja, and J. P. Singh, “Route –Lifetime Assessment-Based Routing (RABR) for Mobile Ad Hoc Networks,” Proceedings of IEEE ICC 2000, vol. 3,pp. 1697-1701, June 2000.
[12] S. Agarwal, R. H. Katz, S. V. Krishnamurthy, and S.K. Dao, “Distributed Power Control in Ad Hoc Wireless Networks,” Proceedings of IEEE PIMRC 2001,vol. 2, 59-66,October 2001.
[13] T. G¨uven, C. Kommareddy, R. J. La, M. A. Shayman, and B. Bhattacharjee, “Measurement based optimal multi-path routing,” in Proceedings of the Conference on Computer Communications (IEEE Infocom), Hong Kong, Mar.2004.

Gunasekaran Shanmugam received the B.Sc(Maths) and MCA Degrees from Bharathiyar University, Coimbatore. He completed his M.Sc(IT) ,M.Phil (C.S) degrees at Alagappa University and Bharathidasan University respectively. He is working as a Professor in Department of Computer Applications at K.S.R College of Technology, Tiruchengode. His areas of interests are Artificial Intelligence, Expert Systems and Computer Networks. He is a Life Member of Indian Society for Technical Education.

Dr.K.Duraiswamy received the B.E, M.E and Ph.D (Communication Engineering) in 1972, 1974 and 1987 respectively. He had worked as a Lecturer in the Department of Electrical Engineering in Government College of Engineering; Salem affiliated to Anna University and as an Asst.Professor in Government College of Technology, Coimbatore and as a Professor and Principal at K.S.R College of Technology. Currently, he is working as a Dean in the Department of Computer Science and Engineering at K.S.R College of Technology. His research interest includes Mobile Computing, Soft Computing, Computer Architecture and Data Mining .He is a Sr. member of ISTE, SIEEE and CSI.