Performance Optimization of Routing Protocols in Mobile Ad hoc Networks: Issues and Challenges

Dr. A. Ramesh Babu [1] Prof. S. Meenakshi Sundaram [2]

[1] Professor & Head, Dept. of Comp. Applications, Saranathan College of Engineering, Tiruchirappalli, India

[2] Professor& Head , Dept of C.S.E., M.A.M. School of Engineering, Tiruchirappalli, India

Abstract:

Ad hoc networks consist of autonomous self-organized nodes. Nodes use a wireless medium for communication. Thus two nodes can communicate directly if and only if they are within each other's transmission radius. In a routing task, a message is sent from a source to a destination node in a given network. Two nodes normally communicate via other nodes in a multi-hop fashion. Swarm intelligence follows the behavior of cooperative ants in order to solve hard static and dynamic optimization problems. Ants leave pheromone trails at nodes or edges which increases the likelihood of other ants to follow these trails. Routing paths are then found dynamically on the fly, using this so called notion of stigmergy. Creating the optimized routing protocol in MANET was first represented by the protocol that selects the shortest path. Later, context-aware metrics were considered to develop and optimize the routing protocols. Prediction, modeling, and AI techniques were also included to support the optimization. Researchers have invented optimum routing protocols with the main goal of their design formulated for particular objectives in the invented protocol. As such, there are already many routing protocols that equate the most suitable path with the shortest, most reliable, or most self-organized path. Also, there are the self-management protocols that are composed of self-protecting, self-healing, self-configuring, and self-optimizing components. Although they have different objectives, each of these protocols reflects their objective. For this reason, the search for the most effective routing protocol that provides the optimum path and satisfies the entirety of objectives still continues, as to our knowledge no routing protocol can handle and solve all these objectives at once, although there are many protocols which can solve one, two, or maybe even three of these objectives. Thus, from the survey undertaken in this paper, it can be expressed that there is a need for an approach that could deploy the existing algorithms based on the network's needs.

Keywords: *Ad hoc Networks, Swarm intelligence, optimization, AI Techniques*

I. INTRODUCTION

The evolution in mobile applications demands extra attention from the researchers working to optimize MANET for better service. The optimization in MANET, however, is more difficult than that of wired networks due to MANET characteristics such as lack of centralization, network mobility, and multi-hop communications. Routing optimization is therefore one of the most important fields in today's MANET development. A survey of various Optimization Techniques for routing in Mobile Ad hoc Networks is carried out. Various classifications for the optimized routing protocols have been presented according to the routing metrics, the prediction techniques, and the use of Artificial Intelligence (AI). An overview of the invented MANET optimized routing protocols based on routing metrics, predictions techniques, and AI techniques are presented below.

II MANET Routing Protocol Optimization

In MANETs, optimization has been used in different wireless layers and in a variety of techniques. The attention of researchers over the last decade, however, has been focused specifically on enhancing the MANET routing protocols. The principle behind optimizing MANET route is to control the flows in the network such that the flows are given better or best-effort treatment. Therefore, the best metrics to represent the success of the optimization process and also measure MANET performance could be increased throughput, reduced packet loss, reduced latency, and reduced load. As such, this paper tends to focus on throughput and delay as the two most important performance metrics for optimization solutions.

A. Optimum Routing Protocols Based on Routing Metrics

Most of the optimization protocols, as in [1], are designed based on traditional or widely implemented protocols. These optimized protocols have been enhanced from the original routing protocols by including some features that perform the optimization. This process converts the traditional routing protocols to an optimization protocol. MANET optimization has been based on routing metrics, such as the traditional hop count metric, and the context-aware metrics, as discussed below.

i) Hop Count Metric

Selecting the optimum path (that with the least cost) according to the hop count metric is one way of optimizing the route. The optimum route relaying on the minimum hop count could be accomplished in different ways, such as: by selecting the shortest path (node by node), as in Al-Khwildi and Al-Raweshidy [2]; by selecting one of many paths discovered through the route discovery process, as in Dai and Wu [3]; or by a unicast query in the route discovery process, as in Seet et al. [4].

ii) Context Aware Metrics

In Ad hoc networks, routing not only has to be fast and efficient, but also adaptive to the changes in the network topology; otherwise, the performance may be severely degraded. As mentioned earlier, route optimization can be accomplished by considering those context-aware metrics which measure MANET performance. Context-aware metrics could include mobility awareness, energy awareness, power awareness, availability, contention awareness, and congestion awareness. Research to find more context-aware metrics that affect the routing process is ongoing. Including such metrics in the invented protocols should help to improve MANET performance. Examples of those context-aware metric(s) that researchers depend upon to create their optimized protocol are listed below:

1. The *energy-aware* metric was represented by two objectives; node's life time and the overall transmission power were the basis for creating the battery-life aware routing schemes for wireless Ad hoc networks in [5]. In that development, the aim was to minimize the overall transmission power requested for each connection and to maximize the lifetime of Ad hoc wireless networks, meaning that the power consumption rate of each mobile host must be evenly distributed. The routing schemes invented by Kim et al. [6] also relied on an energy aware context metric to select the path of least cost and sufficient resources. Furthermore, in the Mukherjee et al. [7] the energy aware metric was the major element in developing an analytical optimized method to minimize routing energy overhead. In the multicast routing field, Moh et al. [8] invented a robust two-tree multicast protocol also based on the energy aware context. This protocol uses two trees, a primary and an alternative backup tree, to improve the energy efficiency and to offer a better energy balance and packet delivery ratio.
2. The *bandwidth-aware* metric was utilized to create the Mukhija and Bose [9] Reactive Routing Protocol.
3. The *congestion-aware* metric was utilized in the Lu et al. paper [10] to establish distance vector routing protocol.

In addition, more than one context-aware metric was combined with the routing metric to achieve a better outcome. Reference [11] introduced the *availability aware* metric that is represented by the quantity relationship of *link status* and *mobility aware*, as the quantity is required to predict the link status for a future time period in consideration of mobility. Next, *path congestion* and *energy usage* metrics were combined with the *hop count* metric in the Cao and Dahlberg protocol [12] to represent the cost criteria that defines path cost during *Route discovery*.

Moreover, the routing schemes developed by Chen and Nahrstedt [13] select the network path with the least cost and sufficient resources to satisfy a certain delay and bandwidth requirement in a dynamic mobile environment. This protocol combines hop *count* with *energy, latency, and bandwidth-aware* metrics. Additionally, *energy-aware* and *congestion-aware* metrics were both included in the mobile routing approach of Ivascu et al. [14].

Usually, the ZRP is configured for a particular network through an adjustment of a single parameter: the routing zone radius. Paper [15] combines *mobility-*, *contention-*, and *congestion-aware* metrics to address the issue of configuring the ZRP and providing the best performance for a particular network, at any time. Finally, other combinations were also possible, such as *power-aware* and *mobility-aware* metrics for mobile Personal Area Network in Park et al. [16]. This optimization technique includes context-aware metrics with routing metrics that would be effective when activated or employed in an online or real scenario.

B. Optimum Routing Protocols Based on Prediction

While the previous optimization technique based on routing metrics can be considered as one type of optimizing, another optimization type is the predication technique. Optimizing routing metrics based on prediction is utilized in networking to achieve a better outcome. Prediction yields an initial idea about the behaviour of network elements. In the study by Jiang et al. [17], an equation was formulated to predict the link status for a time period in the future for a *mobility aware* quantity, whereas Ghosh et al. [18] predicted the user movement based on GPS receivers to control a hub-based orbital pattern in the Sociological Orbit aware Location Approximation and Routing (SOLAR) protocol.

C. Optimum Routing Protocols Based on Modeling /Prediction Techniques

Modeling is another optimization technique which is also included in this paper. The modeling process in MANET is utilized to support the prediction technique, as it includes the estimation of various performance metrics for the multi-hop wireless networks; for example, the empirical model in [19] developed to characterize the relationship between the proposed response indexes, according to influential factors. The four response indexes were packet delivery ratio, end-to-end delay, routing overhead, and jitter. The influential factors were node mobility, offered load, network size, and routing protocol.

A mathematical framework to model *contention* was presented by Jindal and Psounis [20]. This framework was used to analyze *any* routing scheme, with *any* mobility and channel model. This framework can also compute the expected delays for different representative mobility-assisted routing schemes under random direction, random waypoint, and community-based mobility models. This framework could be considered *mobility model aware* as it investigated three different mobility models [21] to conclude the delay. The delay expressions were then used to optimize the design of routing schemes. Additionally, in the bi-objective linear programming mathematical area, Guerriero et al. [22] proposed a bacterium optimization model which allows the *energy* consumption and the *link stability* of mobile nodes to be taken into account, simultaneously. Prediction based on modeling is an interesting area in optimization. This technique was employed by Nogueira et al. [23] to create a framework to model MANET. The framework integrates important functional characteristics such as traffic flow, mobility, and background traffic, with each characteristic represented by its own matrix. The mathematical network model was built from a set of (past) traffic measurements and the corresponding network performance metrics. This constructed model can then be used to predict future values of the network metrics, depending on the mathematical cost function, and based only on the network gateway's traffic measurements parameters.

D. Optimum Routing Protocols Based on Application Requirements

Prediction based on MANET application requirements is a very important issue that could be considered as another type of optimization in MANET. The Cross-layer Route Discovery Framework (CRDF) [24] proposes Routing Strategy Automation (RoSAuto) technique that enables wherein each source node automatically decides the routing strategy based on the application requirements, and then each intermediate node further adapts the routing strategy so that the network resource usage can be optimized. In addition, CRDF was designed to provide a flexible architecture for searching desirable routes with low control overhead. CRDF relies on the Priority-based Route Discovery Strategy (PRDS) mechanism to solve the "next-hop racing" problem and the "rebroadcast redundancy" problem.

E. Optimum Routing Protocols Based on Programmable Framework

Prediction based on a programmable platform is another type of optimization in MANET. Papers [25], [26], and [27] present a context-based programmable framework and functionality for dynamic service/protocol deployment. This technique allows the nodes of a MANET to download and safely activate the required service/protocol software dynamically. According to the available contextual information, the nodes will evaluate the preconditions that will trigger the downloading and activation. This strategy leads to the arrangement of the nodes' capabilities so that common services and protocols can be deployed even if the downloading and activation are not available at every node. In addition, dynamic context-driven deployment may lead to a degree of network self-optimization.

F. Optimum Routing Protocols Based on Artificial Intelligence

Evolving Artificial Intelligence (AI) has played a key role in optimization. There are a variety of optimization techniques to solve MANET routing problems in AI standard repertoire, examples of which are given below.

a) Neural Network Approach

Guo and Malakooti [28] present a solution for optimizing the route through employing intelligent use of the nodes' past experiences of the network traffic conditions in order to make predictions for future network traffic conditions based on these experiences. Furthermore, Guo and Malakooti developed a neural network to predict the mean per-packet one-hop delays. The nodes then used the predicted one-hop delays to participate in dissemination of routing information.

b) Neuro Fuzzy Approach

Martinez-Alfaro and Hernandez-Vazquez [29] used an Adaptive Neuro-fuzzy Inference System (ANFIS) as a predictor. ANFIS is employed inside an Ad hoc hierarchical network to resolve the route error optimization problem. The principal problem to resolve was how many nodes the routing protocol can accept? Given that, the larger the network size, the more performance will suffer. In this Ad hoc hierarchical network, ANFIS predicts future node mobility to keep the network working at the same level irrespective of how many nodes join the network.

c) Swarm Intelligence Approach

Many routing protocols draw inspiration from Swarm Intelligence similar to the ant colony adaptive routing algorithm of Caro et al. [30]. In their study, the authors presented the algorithm as a robust, decentralized, and self-organised method of routing. Moreover, Huang et al. [31] investigated a multicast routing protocol which strived to meet the variation of network topology behaviour (scalability), and satisfy the requirements of specific multimedia traffic, utilising Particle Swam Optimisation (PSO) in volatile MANET environments. In the sensors network, Shih [32] evolved PSO to create an *energy aware* cluster-based routing protocol that exploits the geographical location information of nodes to assist in network clustering. Also, in the same Ad hoc sensor network area based on Swarm Intelligence, a robust *mobility aware* and *energy aware* SIMPLE routing protocol [33] was the solution suggested by Yang et al. for the data acquisition problem found in those networks with mobile sinks.

Furthermore, Rajagopalan and Shen [34] used the Swarm Intelligence mechanisms in Ad hoc networking with Swarm Intelligence (ANSI) to produce a *congestion aware* ANSI routing protocol to select next-hops for both pure and hybrid Ad Hoc networks. Finally, based on the Swarm Intelligence mechanism, Shen and Rajagopalan [35] created an adaptive Protocol-Independent Packet Delivery Improvement Service (PIDIS) mechanism to recover lost multicast packets. The advantage of this mechanism is that the operations of PIDIS do not rely on any underlying routing protocol and can be incorporated into any Ad hoc multicast routing protocol.

III. RELATED WORKS

i) Models

As seen previously, a mathematical equation was utilized in MANET to create models such as those of Jindal and Psounis [20], Guerriero et al. [22], and Nogueira et al. [23]. Also relevant is an attempt by Martinez-Alfaro and Hernandez-Vazquez [29] to utilize AI modeling techniques to solve MANET routing problems. The work in [23] creates MANET mathematical models. The work in [20] and [22] have created models for parameters in the network, whereas this paper represents the network performance against context parameters.

ii) Prediction

Both works, in [23] and this paper utilized prediction components for optimization. The work in [23] relies on mathematical equations whereas, in this paper routing protocols optimization system utilizes AI by implementing Particle Swarm Optimization.

iii) Design

The main difference between most of the mentioned works and the work in this paper is that previous researchers have proposed new protocols to be added to the numerous existing routing protocols, as each protocol is only useful in a certain network context. However, in this paper no new protocol is suggested; it is a selection approach that deploys the available routing protocols to their best advantage. Second, the work in [20] and [35] on the invented model or mechanism could be applied with any network routing protocol. Both researches are relevant to the re-tuned system in that they are flexible and can be adapted to changes. The Programmable Ad Hoc network (PAN) project [27] has the basic design idea to select routing protocol depending on contextual information. The features of the PAN project are indicated below:

1. The PAN project considers network programmability to solve MANET routing problems.
2. It creates context models utilizing lightweight Unified Modeling Language (UML).

3. The PAN project models represent the network context.
4. The hierarchal network of the PAN project consists of three layers, manger head, cluster head, and cluster node.
5. The PAN project is both *mobility aware* and *scalability aware*, these parameters were implemented in different ways. For the PAN project, the scalability problem is solved by changing the network topology to a hierarchal approach that consists of three layers so that as the number of nodes increases, more clusters are added.
6. The work presented in the PAN project was time discrete; there was no graph presenting one continuous experimental (or simulation) scenario to show the switching of the invented scheme through time or which routing protocol (AODV or OLSR) was adopted for each period. Also, the cluster nodes switching adaptation strategy was not clear.

IV CONCLUSION

Creating the optimized routing protocol in MANET was first represented by the protocol that selects the shortest path. Later, context-aware metrics were considered to develop and optimize the routing protocols. Prediction, modeling, and AI techniques were also included to support the optimization. Researchers have invented optimum routing protocols with the main goal of their design formulated for particular objectives in the invented protocol. As such, there are already many routing protocols that equate the most suitable path with the shortest, most reliable, or most self-organized path. Also, there are the self-management protocols that are composed of self-protecting, self-healing, self-configuring, and self-optimizing components. Although they have different objectives, each of these protocols reflects their objective. For this reason, the search for the most effective routing protocol that provides the optimum path and satisfies the entirety of objectives still continues, as to our knowledge no routing protocol can handle and solve all these objectives at once, although there are many protocols which can solve one, two, or maybe even three of these objectives. Thus, from the survey undertaken in this paper, it can be concluded that there is a need for an approach that could deploy the existing algorithms based on the network's needs.

REFERENCES

[1] S. Jiang, Y. Liu, Y. Jiang, and Q. Yin, "Provisioning of adaptability to variable topologies for routing schemes in MANETs," *IEEE Journal on Selected Areas in Communications,* vol. 22, issue 7, pp. 1347–1356, 2004.

[2] A. N. Al-Khwildi and H. S. Al-Raweshidy, "A proficient path selection for wireless Ad hoc routing protocol," *The 8th International Conference on Advanced Communication Technology, ICACT 2006,* vol.1, pp. 599–604, 2006.

[3] F. Dai and J. Wu, "Proactive route maintenance in wireless Ad hoc networks," *IEEE InternationalConference on Communications, ICC 2005*, vol. 2, pp. 1236–1240, 2005.

[4] B. Seet, B. Lee, and C. Lau, "Optimisation of route discovery for dynamic source routing in mobile Ad hoc networks," *IET Journals, Electronics Letters,* vol. 39, issue 22 , pp. 1606–1607, 2003.

[5] C. K. Toh, H. Cobb, and D. A. Scout, "Performance evaluation of battery-life aware routing schemes for wireless Ad hoc networks," *IEEE International Conference on Communication , ICC 2001,* vol. 9, pp. 2824–2829, 2001.

[6] D. Kim, J. J. Garcia-Luna-Aceves, K. Obraczka, J. Cano, and P. Manzoni, "Routing mechanisms for mobile Ad hoc networks based on the energy drain rate," *IEEE Transactions on Mobile Computing*, vol.2, no. 2, pp.161–173, 2003.

[7] T. Mukherjee, S. K. S. Gupta, and G. Varsamopoulos "Energy optimisation for proactive unicast route maintenance in MANETs under end-to-end reliability requirements," *Performance Evaluation*, vol.66, pp. 141–157, 2009.

[8] S. Moh, C. Yu, B. Lee, and H. Y. Youn, "Energy efficient and robust multicast protocol for mobile ad hoc networks," *Proceedings of the Pacific Rim International Symposium on Dependable Computing*, pp.145–152, 2002.

[9] A. Mukhija and R. Bose, "RRP - A bandwidth-efficient routing protocol for mobile Ad hoc networks," *Proceedings of the 2nd International Information and Telecommunication Technologies Symposium (I2TS 2003),* Florianopolis, Brazil, 2003.

[10] Y. Lu, W. Wang, Y. Zhong, and B. Bhargava, "Study of distance vector routing protocols for mobile Ad hoc networks," *Proceedings of the First IEEE International Conference on Pervasive Computing and Communications, PerCom 2003,* pp.187–194, 2003.

[11] S. Jiang, Y. Liu, Y. Jiang, and Q. Yin, "Provisioning of adaptability to variable topologies for routing schemes in MANETs," *IEEE Journal on Selected Areas in Communications,* vol. 22, issue 7, pp. 1347–1356, 2004.

[12] L. Cao and T. Dahlberg, "Path cost metrics for multi-hop network routing," *Proceedings of the 25th IEEE International Conference on Performance, Computing, and Communications, IPCCC 2006,* pp.7–22, 2006.

[13] S. Chen and K. Nahrstedt, "Distributed quality-of-service routing in Ad hoc networks," *IEEE Journal on Selected Areas in Communications,* vol.17, no. 8, pp.1488–1505, 1999.

[14] G. I. Ivascu, S. Pierre, and A. Quintero, "QoS routing with traffic distribution in mobile Ad hoc networks," *Computer Communications,* vol. 32, pp. 305–316, 2009.

[15] M. R. Pearlman and Z. J. Haas, "Determining the optimal configuration for the zone routing protocol," *IEEE Journal on Selected Areas in Communications,* vol. 17, issue 8, pp. 1395–1414, 1999.

[16] M. H. Park, C. M. Park, S. H. Kim, S. B. Hong, and J. S. Choi, "A novel routing protocol for Personal Area Network MObility (PANEMO) environment," *Proceedings of the 6th International Conference on Advanced Communication Technology*, vol. 1, pp.11–14, 2004.

[17] S. Jiang, Y. Liu, Y. Jiang, and Q. Yin, "Provisioning of adaptability to variable topologies for routing schemes in MANETs," *IEEE Journal on Selected Areas in Communications*, vol. 22, no. 7, pp.1347–1356,2004.

[18] J. Ghosh, S. J. Philip, and C. Qiao, "Sociological orbit aware location approximation and routing in MANET," *Ad Hoc Networks,* vol. 5, no. 2, pp.189–209, 2007.

[19] I. Ajbar and D. Perkins, "Evaluating mobile Ad hoc networks: A performance index and statistical model," *IEEE Proceedings Conferences of 16th International Conference on Computer Communications and Networks, ICCCN 2007*, pp. 284–290, 2007.
[20] A. Jindal, and K. Psounis, "Contention-aware performance analysis of mobility-assisted routing," *IEEE Transactions on Mobile Computing*, vol. 8, no. 2, pp.145–161, 2009.
[21] T. Camp, J. Boleng, and V. Davies, "A survey of mobility models for Ad hoc network research," *Wireless Communication and Mobile Computing, WCMC, Special issue on Mobile Ad Hoc Networking: Research, Trends and Applications*, vol. 2, no. 5, pp. 483–502, 2002.
[22] F. Guerriero , F. De Rango, S. Marano, and E. Bruno, "A biobjective ptimization model for routing in mobile Ad hoc networks," *Applied Mathematical Modelling* , vol. 33, no. 3, pp.1493–1512, 2009.
[23] A. Nogueira, P. Salvador, and R. Valadas, "Joint modeling of MANET characteristics for QoS prediction," *The 12th IEEE Symposium on Computers and Communications, ISCC 2007*, pp. 429–435,2007.
[24] B. Zhou, A. Marshall, J. Wu, T. H. Lee, and J. Liu, "A cross-layer route discovery framework for mobile Ad hoc networks," *EURASIP Journal on Wireless Communications and Networking*, issue 5, pp. 645–660, 2005.
[25] A. Malatras, G. Pavlou, and S. Sivavakeesar, "A programmable framework for the deployment of services and protocols in mobile Ad hoc networks," *IEEE Transactions on Network and Service Management*,vol. 4 , issue 3, pp.12–24, 2007.
[26] A. Malatras, A. Hadjiantonis, and G. Pavlou, "Exploiting context-awareness for the autonomic management of mobile Ad hoc networks," *Journal of Network and Systems Management*, Springer, vol.15, no. 1, pp. 29–55, 2007.
[27] "Programmable Ad hoc Network (PAN) project," *EPSRC*, Grant Reference: GR/S02129/01, [Online], availableon:http://personal.ee.surrey.ac.uk/Personal/G.Pavlou/projects/PAN,
[28] Z. Guo and B. Malakooti, "Delay prediction for intelligent routing in wireless networks using neural networks," *Proceedings of the 2006 IEEE International Conference on Networking, Sensing and Control, ICNSC '06*, pp. 625–630, 2006.
[29] H. Martinez-Alfaro and M. A. Hernandez-Vazquez, "DSR protocol scalability optimization in mobile Ad hoc networks with ANFIS," *IEEE International Conference on Systems, Man and Cybernetics*, vol. 4, pp. 3414–3419, 2003.
[30] G. Di Caro, F. Ducatelle, and L. M. Gambardella, "Swarm Intelligence for routing in mobile ad hoc networks," *In Proceedings of the 2005 IEEE Swarm Intelligence Symposium, SIS 2005*, pp. 76–83, 2005.
[31] C. Huang, Y. Chuang, and K. Hu, "Using particle swam optimization for QoS in Ad hoc multicast," *Engineering Applications of Artificial Intelligence*, vol. 22, issue 8, pp. 1188–1193, 2009.
[32] T. Shih, "Particle swarm optimization algorithm for energy-efficient cluster-based sensor networks," *IEICE Transactions on Fundamentals of Electronics, Communications and Computer Sciences*, vol.E89–A, no.7, pp.1950–1958, 2006.
[33] H. Yang, F. Ye, and B. Sikdar, "A swarm-intelligence-based protocol for data acquisition in networks with mobile sinks," *IEEE Transactions on Mobile Computing*, vol. 7, issue 8, pp. 931–945,2008.
[34] S. Rajagopalan and C. Shen, "ANSI: A swarm intelligence-based unicast routing protocol for hybrid ad hoc networks," *Journal of Systems Architecture*, vol. 52, issue 8, pp. 485–504, 2006.
[35] C. Shen and S. Rajagopalan, "Protocol-independent multicast packet delivery improvement service for mobile Ad hoc networks," *Ad Hoc Networks*, vol. 5, issue 2, pp. 210–227, 2007.

AUTHORS PROFILE

Dr. A. Ramesh Babu is working as Professor and Head, in the Department of Computer Applications at Saranathan College of Engineering, Tiruchirappalli, India. He obtained Degrees in M. Tech (Advanced IT), M.Sc., and Ph.D. His area of interest includes Graph theory, Operation Research, Discrete mathematics, Automata theory, Design and Analysis of Algorithm, Cryptography and Network Security, Data mining & Data ware housing, Graphics and Multimedia. He presented 10 papers in National and International Conferences and two papers in National Journals and two papers in International Journals. He has 23 years of teaching experience.

Prof. S. Meenakshi Sundaram is working as Professor & Head, in the Department of Computer Science & Engineering at M.A.M. School of Engineering, Tiruchirappalli, India. He obtained Bachelor Degree in Computer Science & Engineering from Bharathidasan University in 1989. He obtained M. Tech in VLSI Systems from National Institute of Technology, Tiruchirappalli in 2006. He has published 1 paper in International Conference and 6 papers in International journals and has attended more than 20 Workshops / Seminars and organized 10 Workshops / Seminars / Faculty Development Programmes. Currently he is pursuing Ph.D. in wireless communication networks. He has 23 years of experience in teaching.