Energy and Channel Aware MAC Protocol to Achieve Fairness in Multi-Hop Mobile Adhoc Networks

P.Priakanth† and Dr.P.Thangaraj††,

Kongu Engineering College, Anna University, Perundurai

Summary

The determination of possible channel capacity at different contention regions is a serious problem in Ad Hoc networks. Burstiness and time correlation errors are so frequent and hence modeling the wireless channel behavior is very challenging. We propose an energy efficient and channel aware (EECA) MAC protocol to advance the fairness among wireless nodes that may practice location-dependent channel errors. By scrutinizing the traffic, a collective score is designed and the *feasible* bandwidth and channel state of each wireless link is estimated. A routing protocol is used to send the score. The nodes with high scores are transmitted . Nodes attempting to access the wireless medium with a low score will be allowed to transmit again when their score becomes high. Thus our proposed protocol attains fairness with minimum energy in multi-hop adhoc networks.

Key words:

Mac Protocol, Multi-hop, Fairness, Channel, Energy, Bandwidth

1. Introduction

The collection of independent mobile users who communicate over bandwidth imposed wireless links are called MANET's. Due to the mobility of nodes, the topology of the network varies quickly and impulsively over time. The functions are distributed to every node in the network. The nodes should discover the topology and implement the messages. A less multi-hop wireless network where the nodes move randomly is called a MANET. The restricted wireless transmission insortment of every node through multi-hop forwarding is possible when there is no pre-arranged infrastructure. The set of applications for MANETs is diverse, ranging from small, static networks that are constrained by power sources, to large-scale, mobile, highly dynamic networks. The application for MANET's varies from static networks controlled by power sources to dynamic networks.

The design of network protocols for these networks is a complex issue. The estimation of routing, network organization and link scheduling for MANET's requires well organized distributed algorithms despite their application. Inconsistent wireless link quality, topological changes, propagation path loss, multi-user interference, power expended and fading are related areas of discussion. The routing paths in the network needs to be altered in order to lessen these effects. In adhoc networks, each node forwards packets for its peer nodes, and each flow pass through multiple hops of wireless links from a source to a destination. The flow scheduling is executed only at the router in wired networks. But in multi-hop wireless networks, flows also compete for shared channel if they are within the interference ranges of each other.

1.1 Fairness in Ad-hoc Networks

Consider set of nodes V for a wireless network. Each node $i \in V$ has a transmission range dtx and an interference range dint, which can be larger than dtx. Packet transmission in such a network is subject to location-dependent contention. The protocol model and the physical model are the two models which are used for the packet transmission. In a single wireless channel, these two models are presented as follows.

1) The Protocol Model: In the protocol model, the transmission from node i to j, $(i, j \in V)$ is successful if (1) the distance between these two nodes dij satisfies dij < dtx; (2) any node $k \in V$, which is within the interference range of the receiving node j, dkj ≤ dint is not transmitting. The protocol model can be precisely close to the state of IEEE 802.11-type MAC protocols, where the sending node i need to be provided without interference to receive the link layer acknowledgment from the receiving node j. Specifically, any node $k \in V$, which is within the interference range of the nodes i or j (i.e., dkj ≤ dint or dki ≤ dint), is not transmitting.

2) The Physical Model: This model is directly related to the physical layer characteristics. The transmission from node i to j is successful if the signal-to-noise ratio at the node j, SNRij, is not smaller than a minimum threshold: SNRij ≥ SNRthresh.

Fairness in wireless adhoc networks has been studied under various network scenarios.. Many algorithms has been proposed to achieve fairness among single-hop flows , but they do not consider multi-hops flows, which reflect the reality in wireless ad hoc networks. In previous work, fair packet scheduling mechanisms have been proposed [1],

[2], [3] and shown to execute effectively in furnishing fair shares among single-hop flows in wireless ad hoc networks, and in harmonizing between fairness and resource utilization. These set up is adequate for maintaining basic fairness attributes among localized flows, they do not organize intra-flow resource allocations between upstream and downstream hops of an end-to-end flow, and thus will not be able to achieve global optimum with respect to resource utilization and fairness.

The achievable channel capacity varies at different contention regions depending on the MAC protocol. It is usually much smaller than the ideal channel capacity and can not be known in advance. Energetically determining the possible channel capacity at different contention regions is a serious problem in Ad Hoc networks. Burstiness and time correlation errors are so frequent and so modeling the wireless channel behavior is very challenging. MANETs may experience location-dependent channel errors. A node can actively communicate with other node while on the other hand one shall undergo frame drops due to errors on the channel.

In this paper we propose a topology-aware MAC protocol which attains fairness across multi-hop flows and minimizes the energy. The proposed protocol estimates the *feasible* bandwidth and channel condition of each wireless link by monitoring its traffic and calculates a combined score. The score is sent along with the data packets of the flows using any routing protocol. Then transmission is allowed only for those nodes with high scores. Nodes attempting to access the wireless medium with a low score will be allowed to transmit again when their score becomes high.

The remaining part of the paper is organized as follows: Section 2 describes the methods to estimate f feasible bandwidth, section 3 describes the methods to estimate the channel condition, section 4 incorporates the queue selection algorithm, section 5 presents the related work, simulation results are given in section 6 and finally in section 7 , we conclude the paper.

2. Estimation of Feasible Bandwidth

In the bandwidth estimation method, the sender's current bandwidth usage as well as the sender's one-hop neighbors' current bandwidth usage is credited onto the standard "Hello" message. Each host estimates its feasible bandwidth based on the information provided in the "Hello" messages and knowledge of the frequency reuse pattern. This approach avoids creating extra control messages by using the "Hello" messages to disseminate the bandwidth information. Every host estimates its occupied bandwidth by scrutinizing the packets it provides into the network. A band width utilization register records the value at the host and updates periodically.

We modify the "Hello" message to include two fields. The initial field includes host address, consumed bandwidth, timestamp, and the second field includes neighbors' addresses, consumed bandwidth, timestamp. The host receives a "Hello" message from its neighbors, and concludes whether this "Hello" is an restructured one by examining the message's timestamp.

Once a host knows the bandwidth consumption of its first neighbors and its second neighbors, the feasible bandwidth FBW is estimated as

FBW = (CHBW – UBW / WT)

Where,

CHBW - channel bandwidth, UBW - used or consumed bandwidth, WT - weight factor.

The IEEE 802.11 Mac's property and the overhead essential for the routing protocol

Constrains to divide the residual bandwidth with weight aspect.

3. Estimation of Channel Condition

Every node estimates the channel conditions for each contending flow. To represent the channel state at the LLC queue a flag is initiated. The flag can take three values: FAIR, NOT FAIR or TEST.

FAIR: A FAIR flag is set by the node when it receives, from the following flow: (i) A MAC-layer acknowledgment in response to a data frame, (ii) A CTS frame in response to an RTS frame, or (iii) an error-free data frame or RTS.

NOT FAIR : The node sets the flag to NOT FAIR after a transmission failure. If the collisions or channel errors causes transmission failure, the values of the Short Retry Limit (SRL) and the Long Retry Limit (LRL) is selected. If a transmission takes place without receiving an acknowledgement it is noted by a Long Retry Counter (LRC) and a short Retry Counter (SRC).

In all likelihood, the LRC is incremented when the transmission of a frame longer than the RTS threshold fails due to channel errors [4]. The channel errors and collisions in the shared medium is indicated by incrementation of SRC. The failure is indicated to the LLC layer if the LRC (SRC) attains the LRL (SRL) followed by the disposal of the transmission by the MAC layer. The increment of LRC consents to the recognition of channel errors, the interpretation of SRC increments is ambiguous.

TEST: The node switches the flag from NOT FAIR to TEST when a configurable timeout, that we named PTIMER, expires. PTIMER starts to run whenever the channel state switches to NOT FAIR, and its initial value is doubled when a transition from TEST to NOT FAIR occurs. The duration of PTIMER is reset to its initial value upon a transition from TEST to FAIR. A flow whose queue flag has a TEST value can transmit a frame to check the new channel state.

Queue selection depends on the the MAC layer which will denotes the success or failure of the frame transmission. When the transmission succeeds, the resultant LLC frame is removed and the flag FAIR is set to indicate the channel state. (This switching occurs only if the previous state was TEST). Otherwise, if the transmission fails, the channel flag is set to NOT FAIR In this case the LLC frame is not discarded and it will be used to probe the channel afterwards.

4. Queue Selection Algorithm

Each node $\{N_i$, i=1,2…} maintains a queue $\{Q_i$,i=1,2…}. Each queue has associated with it a score $\{S(Q_i)$, i=1,2….} such that

$S(Q_i) = FBW_i$ if flag = FAIR = $- FBW_i$ if flag = NOT FAIR , i = 1,2,…..

Where FBW_i is the feasible bandwidth of the queue estimated by the corresponding node N_i , in sec.2

When a MAC layer requests a new frame to send, the queue selection algorithm is executed. At the LLC layer, queues are served in a round-robin fashion. Initially, the algorithm checks the score associated with each queue and grants the transmission opportunity for those queues in their descending order of scores. (ie) The queue with largest score is served first; the queue with second largest score is served next, and so on.

When the score is negative, the PTIMER is inspected: if still running, the next queue is polled; otherwise, the flag is set to TEST, and the queue is served. We also remark that each frame has an internal timestamp associated to it: frames that have been waiting in the queue for a time greater than a STALE TIMEOUT value are discarded. A timeout is set which prevents excessive latency through out long channel error periods. STALE TIMEOUT is set to 1 s which allows average end-to-end delay below normal values.

5. Related Work

Achieving MAC layer fairness in wireless ad-hoc networks is a very challenging issue[1] Achieving MAC fairness in wireless ad-hoc networks using adaptive transmission control Li, Z.; Nandi, S.; Gupta, A.K. refers that IEEE 802.11 exhibits substantial short-term unfairness due to the randomness in the binary exponential back-off (BEB), the freezing mechanism of the back-off timer, and the concealed information problem . To achieve short-term fairness, a fairness scheme, called adaptive transmission control (ATC). The basic idea of ATC is to make the senders to contend for the shared medium in a cooperative and adaptive manner by exploiting the overheard information. The ATC includes three mechanisms: CW-tuning, early-reset, and receiver-coordination, which are able to tackle the underlying problems that cause short-term unfairness in IEEE 802.11. Specifically, the CW-tuning mechanism reflects the past usage of the medium among the nodes, and thus greatly reduces the randomness in BEB, while the early-reset mechanism largely prevents the short-term unfairness caused by the freezing mechanism. At last, the receiver-coordination mechanism copes effectively with the concealed information problem by using information available at the receiver side. It is also shown that the proposed ATC substantially improves the short-term fairness without unduly degrading the throughput.

In the scheduling policies for maxmin fair allocation of bandwidth in wireless ad hoc networks [2]. a formalization of the maxmin fair objective under wireless scheduling constraints which gives a fair scheduling which assigns dynamic weights to the flows such that the weights depend on the congestion in the neighborhood and schedule the flows which constitute a maximum weighted matching. It is proved analytically that this policy attains both short term and long term fairness. More generalized fairness notions, and suggest mechanisms are given to attain these objectives.

The goal of packet scheduling disciplines is to achieve fair and maximum allocation of channel bandwidth [3]. However, these two criteria can potentially be in conflict in a generic-topology multihop wireless network where a single logical channel is shared among multiple contending flows and spatial reuse of the channel bandwidth is possible. In A New Model For Packet Scheduling in Multihop Wireless Networks propose a new model for packet scheduling is proposed that addresses this conflict. The main results are (a) a two-tier service model that provides a minimum “fair” allocation of the channel bandwidth for each packet flow and additionally maximizes spatial reuse of bandwidth, (b) an ideal centralized packet scheduling algorithm that realizes the above service model, and (c) a practical distributed backoff-based channel contention mechanism that approximates the ideal service within the framework of the CSMA/CA protocol.

Fairness is an important issue when accessing a shared wireless channel. With fair scheduling, it is possible to allocate bandwidth in proportion to weights of the packet flows sharing the channel [4]. A fully distributed algorithm for fair scheduling in a wireless LAN is presented where the algorithm can be implemented without using a centralized coordinator to arbitrate medium access. The proposed protocol is derived from the Distributed Coordination Function in the IEEE 802.11 standard. The proposed algorithm is able to schedule transmissions such that the bandwidth allocated to different flows is proportional to their weights. An attractive feature of the proposed approach is that it can be implemented with simple modifications to the IEEE 802.11 standard.

An admission control algorithm must coordinate between flows to provide guarantees about how the medium is shared. In wired networks, nodes can monitor the medium to see how much bandwidth is being used. However, in ad hoc networks, communication from one node may consume the bandwidth of neighboring nodes. Therefore, the bandwidth consumption of flows and the available resources to a node are not local concepts, but related to the neighboring nodes in carrier-sensing range. Current solutions do not address how to perform admission control in such an environment so that the admitted flows in the network do not exceed network capacity [6].The paper refers a scalable and efficient admission control framework - contention-aware admission control protocol (CACP) - to support QoS in ad hoc networks and several options for the design of CACP.

Admission control of flows is essential for providing quality of service in multihop wireless networks [7]. In order to make an admission decision for a new flow, the expected bandwidth consumption of the flow must be correctly determined. Due to the shared nature of the wireless medium, nodes along a multihop path contend among themselves for access to the medium. This leads to intra-flow contention; contention between packets of the same flow being forwarded at different hops along a multihop path causing the actual bandwidth consumption of the flow to become a multiple of its single hop bandwidth requirement. Determining the amount of intra-flow contention is non-trivial since interfering nodes may not be able to communicate directly if they are outside each other's transmission range. In this paper, we propose two methods to determine the extent of intra-flow contention along multihop paths. The highlight of the proposed solutions is that carrier-sensing data is used to deduce information about carrier-sensing neighbors, and no high power transmissions are necessary. Analytical and simulation results show that our methods estimate intra-flow contention with low error, while significantly reducing overhead, energy consumption and latency as compared to previous approaches.

In this paper, a medium access control (MAC) technique [8] for multi-hop wireless networks with Quality of Service (QoS) assurance is introduced. The proposed protocol deals with most of the Hidden Node problems in multi-hop environment and also provides service digerentiation for various types of traffic real-time constant bit rate (CBR) traffic, real-time variable bit rate (VBR) traffic, and non-real-time datagram traffic, by guaranteeing bounded delay for real-time traffic, at the same time avoiding lockout of datagram traffic.

The proposed IEEE 802.11 draft standard [9] defines new MAC protocols for QoS in wireless networks, mainly EDCF and HCF. EDCF is a contention-based channel access scheme and is part of HCF for infrastructure networks and may be used as a separate coordination function for wireless ad-hoc networks. The EDCF with a dynamic adaptation algorithm of the maximum contention window (CWmax) that enables each station to tune the size of the CWmax used in its back-off algorithm at run time. The purpose is to reduce delay and jitter and increases the efficiency of the transmission channel. Priorities between access categories are provisioned by updating the size of the CWmax according to application requirements and channel conditions.

The paper, proposes a novel collision resolution scheme [10] that can incorporate the time-varying mean and variance of the stochastic collision process. It can also incorporate other fairness enhancement measures to achieve both good throughput and fairness performance. The scheme is adaptive in tracking nonstationary process and is also recursive which is very simple in implementation and energy efficient. Simulation results demonstrate that such scheme can improve the throughput and fairniess significantly for IEEE 802.11 ad hoc networks.

It has been proposed to upgrade the performance of medium access control (MAC) schemes [11] through the use of beamforming directional antennas, to achieve better power and bandwidth utilization. The paper considers a shared wireless medium as employed in a mobile ad hoc wireless network. A random access MAC algorithm that is combined with the use of directional beamforming formed by each transmitting mobile entity. Mathematical equations are derived to characterize the throughput performance of such a directional-ALOHA (D-ALOHA) algorithm. The paper, presents a new collision-free MAC protocol–Carrier Sense Media Access [12] with ID

Countdown (CSMA/IC) for ad hoc wireless networks that can achieve 100% collision-free performance by solving the “hidden terminal” problem and the concurrent sending problem. Compared to CSMA/CA of IEEE 802.11, it also improves the network's performance in decreasing the average delay of packet sending, dropping discard ratio, and increases the network's throughput significantly.

The paper analyses the performance of the DQCA AD HOC MAC protocol for scenarios [13] where the communication nodes have different mobility conditions, corresponding to different applications such as sensor networks, inter-vehicular and pedestrian applications. It has been demonstrated that under low mobility conditions, the protocol performance is near-optimum. This performance is slightly reduced due to the cluster setup time when the relative movement speed of the nodes is increased.

This paper proposes a distributed self configurable architecture designed for wireless mobile ad hoc networks [14]. In this kind of networks, nodes move around varying constantly the topology of the network, so it is necessary to reconfigure the network as time goes by. The proposed self-configurable architecture permits the use of centralized or distributed MAC protocols in MANETs only with slight adaptations in these protocols.

The paper proposes a novel Interference Graph based MAC protocol (IG-MAC)[15] to improve the throughput of ad hoc wireless networks. The key point is to model the interference information by means of Interference Graph and send busy tone with encoded communication information to prevent the potentially interfering nodes from initiating new transmissions.

The paper discusses the role of ad hoc networking in future wireless communications. Ad hoc networks[16] are’ classified as isolated ad hoc networks with large and small sizes, integrated ad hoc networks in various scenarios and cellular ad hoc networks for the future mobile access networks. Integration of small size ad hoc networks with the global Internet can be realized by ad hoc gateways that are proposed in this paper.

The paper highlights the implications that using a recently proposed layered space-time multi-user detection technique [17] has on MAC protocol design for ad hoc networks with multiple antennas. The work relates to both physical layer and network layer studies.

6. Experimental Results

6.1Simulation Model and Parameters

We use NS2 to simulate our proposed algorithm. In our simulation, the channel capacity of mobile hosts is set to the same value: 2 Mbps.

In our simulation, 50 mobile nodes move in a 1000 meter x 1000 meter rectangular region for 100 seconds simulation time. Initial locations and movements of the nodes are obtained using the random waypoint (RWP) model of NS2. We assume each node moves independently with the same average speed. All nodes have the same transmission range of 250 meters. In this mobility model, a node randomly selects a destination from the physical terrain. It moves in the direction of the destination in a speed uniformly chosen between the minimal speed and maximal speed. After it reaches its destination, the node stays there for a *pause time* and then moves again. In our simulation, the speed is 10 m/s. and pause *time is 10* seconds. The simulated traffic is Constant Bit Rate (CBR). For each scenario, ten runs with different random seeds were conducted and the results were averaged.

6.2 Performance Metrics

We compare the standard IEEE 802.11 MAC protocol with our proposed MAC protocol.. We evaluate mainly the performance according to the following metrics:

Aggregated Througput: We measure aggregated throughput of all flows by varying the no. of nodes as 20, 40, 60…..100.

Average Energy Comsumption: The average energy consumed by the nodes in receiving and sending the packets are measured, for nodes of varying sizes 20, 40, ….100.

Fairness Index: For each CBR flow, we measure the fairness index as the ratio of throughput of each flow and total no. of flows.

The performance results are presented graphically in the next section.

6.3 Simulation Results

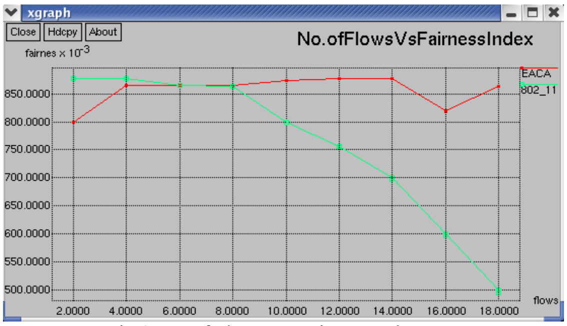

Fig 1: No of Flows Vs Fairness Index

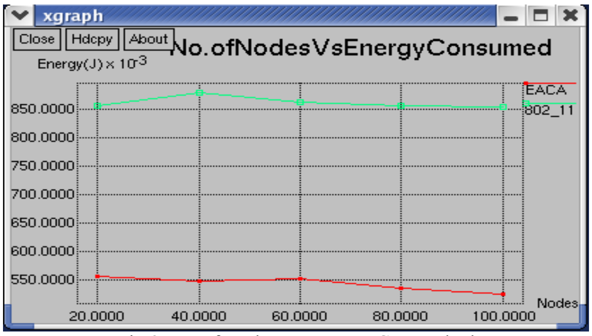

Fig 2: No of Nodes Vs Energy Consumed

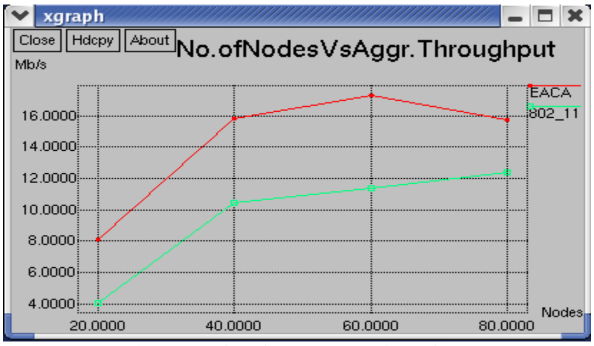

Fig 3: No of Nodes Vs Aggr. Throughput

7. Conclusion

The proposed MAC protocol improves the fairness among wireless nodes that may exhibit location-dependent channel capacity and errors. The feasible bandwidth and channel condition of each wireless link is estimated by monitoring its traffic and calculating its score. Nodes attempting to access the wireless medium with a low score will be allowed to transmit again when their score becomes high. Thus our proposed protocol achieves fairness with minimum energy in multi-hop adhoc networks.

References

[1] T. Nandagopal, T.-E. Kim, X. Gao, and V. Bharghavan, "*Achieving MAC Layer Fairness in Wireless Packet Networks*," in *Proc. Of ACM Mobicom*, 2000.

[2] L. Tassiulas and S. Sarkar, "*Maxmin fair scheduling in wireless networks,*" in *Proc. of INFOCOM*, 2002.

[3] H. Luo, S. Lu, and V. Bharghavan, "*A New Model For Packet Scheduling in Multihop Wireless Networks,*" in *Proc. of ACM Mobicom*, 2000.

[4] N.H. Vaidya, P. Bahl, and S. Gupta, "*Distributed fair scheduling in a wireless LAN*," *IEEE/ACM MobiCom'00,* Boston, MA, USA, Aug. 2000.

[5] J. Li, C. Blake, D. D. Couto, H. Lee, and R. Morris, "*Capacity of ad hoc wireless networks,*" in *Proc. 7th ACM Int. Conf. Mobile Comput. Netw. (MobiCom'01)*, 2001.

[6] Y. Yang and R. Kravets, "*Contention-aware admission control for ad hoc networks*," Univ. Illinois at Urbana–Champaign, Urbana–Champaign, IL, Tech. Rep. 2003-2337, 2003.

[7] K. Sanzgiri, I. Chakeres, and E. Belding-Royer, *"Determining intra-flow contention along multihop paths in wireless networks,"* in *Proc. Broadnets 2004 Wireless Netw. Symp.*, Oct. 2004

[8] Zhou Ying, A. L., Ananda, and Lillykutty Jacob "*A QoS Enabled MAC Protocol for Multi-hop Ad Hoc Wireless Networks*" Conference Proceedings of the 2003 IEEE International**.**

[9] Gannoune, L.; Robert, S.; Tomar, N.; Agarwal, T."*Dynamic Tuning of the Maximum Contention Window (CWmax) for Enhanced Service Differentiation in IEEE 802.11 Wireless Ad-Hoc Networks***"**Vehicular Technology Conference, IEEE,2004.

[10] Jiankun Hu and C.D. Raymond "*A Statistics Based Design of MAC Protocols with Distributed Collision Resolution for Ad Hoc Networks***"** Wireless Networks, Communications and Mobile Computing, 2005 International Conference.

[11] Ju-Lan Hsu and Izhak Rubin " *Performance Analysis Of Directional Random Access Scheme For Multiple Access Mobile Ad-Hoc Wireless Networks* "Military Communications Conference, 2005. MILCOM 2005. IEEE

[12] Tiantong You Chi-Hsiang Yeh Hossam Hassanein *"CSMA/IC: A New Class of Collision–free MAC Protocols for Ad Hoc Wireless Networks*" Computers and Communication, Eighth IEEE International Symposium on Digital Object Identifier 2003.

[13] Jesús Alonso, Christos Verikoukis L Alonsa "*Performance Analysis of a Distributed Queuing MAC Protocol for Ad-Hoc Networks with Different Mobility Conditions* "in Proc. of the 7th IFIP International Conference on Mobile and Wireless Communication Networks (MWCN 2005)

[14] Alonso,J.Alonso,L. "*Dynamic Self-Configurable Master-Slave Architecture For Ad Hoc Wireless Networks With A Distributed Mac Scheme",* Personal, Indoor and Mobile Radio Communications, 2004. PIMRC 2004. 15th IEEE International Symposium.

[15] Weiming Lin Chongqing Zhang Minglu Li Min-You Wu *Interference Graph based MAC protocol (IG-MAC)* ,Computer and Information Technology, 2006. CIT '06. The Sixth IEEE International Conference

[16] Bangnan Xu; Hischke, S.; Walke, B.*"The Role of Ad hoc Networking in Future Wireless Communications"* Communication Technology Proceedings, 2003. ICCT 2003. International Conference.

[17] Casari, P. Levorato, M. Zorzi, M. *" On the Implications of Layered Space-Time Multiuser Detection on the Design of MAC Protocols for Ad Hoc Networks* "Personal, Indoor and Mobile Radio Communications, 2005. PIMRC 2005. IEEE 16th International Symposium**.**

P. Priakanth received the Master of Computer Applications degree in 1998 from Bharathiar University. His Masters Thesis research was on "Throughput comparison of various Medium Access Techniques of wireless networks", and has completed Master of Engineering in Computer Science at Anna University in the year 2005. His M.E thesis research was on "Scalable Time slot Medium Access techniques for Multi Hop Adhoc Networks". Currently he is an Assistant Professor and research scholar at Kongu Engineering College, Anna University. His area of research is Medium access techniques in Ad-hoc Networks.

Dr.P.Thangaraj received the Bachelor of Science degree in Mathematics from Madras University in 1981 and his Master of Science degree in Mathematics from the Madras University in 1983. He completed his M.Phil degree in the year 1993 from Bharathiar University. He completed his research work on Fuzzy Metric Spaces and awarded Ph.D degree by Bharathiar University in the year 2004. He completed the post graduation in Computer Applications at IGNOU in 2005. His thesis was on "Efficient search tool for job portals". He completed his Master of Engineering degree in Computer Science in the year 2007 from Vinayaka Missions University. His thesis was on "Congestion control mechanism for wired networks". Currently he is a Professor and Head of Computer Technology Department at Kongu Engineering College, Anna University. His current area of research interests are in Fuzzy based routing techniques in Ad-hoc Networks.