RESEARCH ARTICLE OPEN ACCESS

Mobile Ad Hoc Network Based Efficient Broad Casting Using Random Cast Mechanism

A.Poonkodi [1], MCA,,MPhil.,
C. Mohana Priya [2], MSc (CT).,Mphil.,
Research Scholar [1], Asst.Professor [2]
Department of Computer Applications
Tiruppur Kumaran college for Women,Tirupur
Tamil Nadu – India

ABSTRACT

In mobile unexpected networks (MANETs), every node overhears each knowledge transmission occurring in its neighborhoods and thus, consumes energy unnecessarily. In IEEE 802.11 Power Saving Mechanism (PSM), a packet should be publicized before it is really transmitted. When a node receives an advertised packet that is not destined to it, it switches to a low power sleep state throughout the information transmission amount, and thus, avoids overhearing and on serves energy. However, since some MANET routing protocols like Dynamic supply Routing (DSR) collect route info via overhearing, they would suffer if they are used in combination with 802.11 PSM. Allowing no overhearing may critically deteriorate the performance of the underlying routing protocol, while unconditional overhearing may offset the advantage of using PSM. This paper proposes a new communication mechanism, known as Random Cast, via which a sender will specify the required level of overhearing, making a prudent balance between energy and routing performance. In addition, it reduces redundant rebroadcasts for a broadcast packet and therefore saves a lot of energy. In depth simulation mistreatment ns-2 shows that Random Cast is extremely energy-efficient compared to conventional 802.11 further as 802.11 PSM-based schemes, in terms of total energy consumption, energy good put and energy balance.

Mobile ad hoc networks are rapid deployable self organizing networks. Their key characteristics are dynamic topology, high node mobility, low channel bandwidth and limited battery power. Hence, it is necessary to minimize bandwidth and energy consumption. To transmit packets, available bandwidth is known along the route from sender to receiver. Thus, bandwidth estimation is the main metric to support Quality of Service (QoS). This work focuses on improving the accuracy of available bandwidth and incorporating a QoS-aware scheme into the route discovery procedure. It is also important to limit the energy consumed by nodes. Probability based overhearing method is proposed to reduce energy spent on overhearing nodes.

Keywords:- MANETs, DSR, PSM

I. INTERDUCTION

The main goal of this paper is to make the IEEE 802.11 PSM applicable in multihop MANETs when the popular (Adhoc On-demand Distance Vector) AODV is used as the network layer protocol. A major concern in integrating the AODV protocol with the IEEE 802.11 PSM is overhearing. Overhearing improves the routing efficiency in AODV by eaves dropping other communications and gathering route information. It incurs no extra cost if all mobile nodes operate in the AM mode because they are always awake and idle listening anyway. However, if mobile nodes operate in the PS mode, it brings on a high energy cost because they should not sleep but receive all the routing and data packets transmitted in their vicinity. A naive solution is to disable overhearing and let a node receive packets only if they are destined to it. However, it is observed that this solution reduces network performance significantly because each node gathers less route information due to the lack of overhearing, which in turn incurs a larger number of broadcasts flooding of route request (RREQ) messages resulting in more energy consumption. In short, overhearing plays an essential role in disseminating route information in AODV but it should be carefully re-designed if energy is a primary concern. This paper proposes a message overhearing mechanism, called Random Cast or Rcast, via which a sender can specify the desired level of overhearing when it advertises a packet. Upon receiving a packet advertisement during an ATIM window, a node makes its decision whether or not to overhear it based on the specified overhearing level. If no overhearing is specified, every node decides not to overhear except the intended receiver and if unconditional overhearing is specified, every node should decide to overhear.

Randomized overhearing achieves a balance somewhere in between, where each node makes its decision probabilistically based on network parameters such as node density and network traffic. Rcast helps nodes conserve energy while maintaining a comparable set of route information in each node. Since route information is maintained by sequence number in AODV, Rcast effectively avoids unnecessary effort to gather redundant route information and thus saves energy. The key idea behind the Rcast scheme is to explore the temporal and spatial locality of route information, as is done in the CPU cache. Overheard route information will probably be overheard again in the near future and thus it is possible to maintain the same quality of route information, while overhearing only a small fraction of packets. Even though a node misses particular route information, it is highly probable that one of its neighbors overhears it and can offer the information when the node asks for it. Note that we have chosen AODV in this paper because other MANET routing algorithms usually employ periodic broadcasts of routing related control messages, and thus tend to consume more energy with IEEE 802.11 PSM.

Key contributions of this paper are threefold: 1) it presents the Random Cast protocol that is designed to employ the IEEE 802.11 PSM in multihop MANETs. 2) In Random Cast, a transmitter can specify the desired level of overhearing to strike a balance between energy and throughput. More importantly, it helps avoid the semantic discrepancy found in most of MANET routing protocols. 3) Compared to earlier work, this paper shows that the problem of unconditional or unnecessary forwarding of broadcast packets can also be taken care of in the RandomCast framework.

Mobile ad hoc network is formed by a collection of dynamic wireless mobile nodes.
It results in a temporary network and it is established without the aid of any established Infrastructure or centralized administration. The configuration of the ad hoc network depends on the transmission power of the nodes and the location of the mobile nodes, which may change with time [1]. The primary objectives of MANET routing protocols include: maximizing network throughput, maximizing network lifetime and minimizing delay. Network efficiency is usually measured by life time, packet delivery ratio and energy consumption. Energy consumption is measured in joules. Energy consumption varies with number of packets transmitted. It measures the amount of energy consumed for the transmission of all the packets which includes both control and information exchange packets. A major challenge that a routing protocol designed for ad hoc wireless network faces is resource constraints. In wireless networks, energy consumption occurs due to three main events other than the usual operation of transmission and reception.

II. EXISTING METHOLODGY

Available Bandwidth Measurement Algorithm (ABM)

Step1: Evaluate the capacity of a node and estimate the available bandwidth.
Available bandwidth = Channel Capacity - Utilized Bandwidth (1)
Here Utilized Bandwidth = N*S*8/T
Where N- No. of packets, S- Size of packet and T- Time duration
Step 2: Estimate the link's available bandwidth. It depends on channel utilization ratio and idle period synchronization. Let it be E(b(s,r)). It is calculated based on the probability that the medium is free simultaneously at the sender and the receiver side.
Step 3: Estimate collision probability Pm=f(m).P hello (2)
Where f (m) – Lagrange interpolated polynomial function, Phello - Collision probability
Estimated based on hello packets.(Phello = (Expected - Recd no. of Hello pkts)/ Expected no. of Hello packets)
Step 4: Collision leads to retransmission of same frames. When collision occurs, log based Pipelined backoff algorithm is executed. Backoff algorithm is used to reduce collisions when more than one node tries to access the common channel. This is an additional overhead which affects the available bandwidth.

Bandwidth loss due to this additional overhead K is evaluated as,

$$K = \frac{DIFS + \overline{backoff}}{T(m)}$$

Where DIFS- DCF Inter Frame Spacing, T (m) - time between two consecutive frames and - the average number of slots decremented for a frame.

The above facts are considered and combined to estimate the final available bandwidth.

$$E_{final}\big(b(s,r)\big) = (1-K).(1-P).E(b(s,r)$$

Where E final(b(s,r)) is the available bandwidth on link by monitoring node and link A capacity, P is collision probability and K is bandwidth loss due to backoff scheme.

Step 5: Finally this estimated available bandwidth is stored in neighbor nodes with the help of Hello messages.

Step 6: Malicious nodes consume bandwidth and increases packet loss. These attackers are identified and blocked using a threshold value set for the node.

Step 7: Routing protocol called enhanced link disjoint AOMDV (Adhoc On demand Multipath Distance Vector) finds the route based on this available bandwidth.

The existing algorithm employs BEB (Binary Exponential Backoff) to reduce collision. The main problem with BEB is that the node with a long backoff value moves outside the transmission range before it accesses the channel. Also, proportion of bandwidth is wasted due to collision and channel idle time. BEB follows serial transmission. Channel idle time and contention overhead is more because of this serial transmission. Nodes go through a channel contention and packet transmission stages sequentially. Channel contention stage consumes channel bandwidth. Thus time spent on channel contention is reduced when probability of collision is less. But it is difficult to achieve because channel contention cannot be started until the current transmission finishes. Also access to a slot is not uniform. Only the winners repeatedly get the chance to access the channel. This leads to channel capture effect. In a heavily contended network, the collision probability increases which degrades the performance. To minimize these drawbacks, log based pipelining technique is applied to backoff procedure to reduce the collision overhead and improve the available bandwidth.

Pipelining concept is applied to channel contention procedure of MAC (Medium Access Control) protocol. When two nodes are sharing the channel, the remaining nodes start the channel contention procedure in parallel for the next packet transmission. Pipelined backoff hides channel idle time and reduces collision probability. It is also used to control number of contending nodes.

Log based backoff algorithm uses logarithm of current backoff counter to calculate next backoff. In the existing approach, CW size is doubled on collision and backoff counter depends on this new CW. This increases the chance of losing channel access by a node. When a log value is applied to current backoff counter, the difference between two backoff counters is small. So the Waiting time of colliding nodes get reduced which improves the throughput performance.

Winning node reduces its contention window size by half. Due to this, channel capture effect is reduced. Stage1 reduces both channel idle time and collision overhead. Stage2 transmits packets and consumes channel bandwidth. Whenever collision occurs or a node looses channel in stage2, there is no need to double the contention window. This approach reduces the number of nodes in stage2. Bandwidth loss due to this backoff is estimated and final available bandwidth is calculated. Final bandwidth is stored in nodes with the help of Hello messages.

Energy efficient method

Energy saving mechanism is important for the efficient operation of the battery powered networks. All the neighboring nodes overhear when a node is transmitting a packet. Hence it is necessary to limit the number of overhearing nodes based on probability. Probability value depends on the number of neighbors. The proposed algorithm controls the number of overhearing nodes. It saves energy consumption without affecting quality of route information. When a node is ready to transmit a frame, check its overhearing level (OL) for broadcast and unicast transmission. Three possibilities such as probability overhearing, no overhearing, and unconditional overhearing are considered while finding the routes. Probability overhearing is defined as that few nodes that satisfies a probability based condition can overhear. No overhearing is one in which only a very minimum number of nodes (sender, receiver and intermediate nodes) can overhear and the others would go to low-power sleep state.

Unconditional overhearing is one in which almost all one hop neighbor nodes in a network can overhear. Sender is able to specify the level of overhearing. Sender may choose either no or unconditional or probability overhearing which is specified in ATIM frame control.

Unconditional overhearing or probability overhearing is set based on the types of messages that Are exchanged. a) Probability overhearing is applied for RREP (Route Reply) and DATA packet.

b) RERR (Route Error) messages will be assigned unconditional overhearing. The reason is that the link failure should be informed to all the nodes, so that the nodes will not use it for the next time until the path gets ready. c) RREQ (Route REQuest) is a broadcast message and based the probability (Po) values, probability overhearing is set. Each node receives ATIM and ATIM-ACK during an ATIM window and depending on its subtype; node is either in awake or sleep state.

Step 1: Check if Destination Address = Broadcast / Unicast

Step 2: If it is broadcast, check for whether it is the destination. If so, receive packet.

Step 3 : If it is Unicast, check for the subtype values and decide the level of overhearing.

Step 4 : If the subtype is for conditional overhearing then compare the probability values with the threshold and decide the level of overhearing.

Step 5: Rebroadcasting probability and overhearing probability can be identified

Step 6: Repeat the process 2 to 5.

Probability based overhearing method controls the level of overhearing and forwarding of Rebroadcast messages. Node is awakened if unconditional overhearing or probability overhearing is set or if it is a destination node. Each node maintains overhearing probability Po and rebroadcast probability Pr.

$$P_o = 1/n$$

$$P_r = cn/N^2$$

Where c is a constant, n- No. of neighbors and N- Average no of. Neighbor's neighbors.

Then the energy consumed (Ec) by the nodes is calculated as,

$$E_c = \sum(I_e - R_e) / \text{no. of pkts transmitted}$$

Where Ie is Initial energy and Re is residual energy. If a node's subtype is 1101, it generates a random number between 0 and 1 and compares it with Po. If it is greater than Po, node decides to overhear. If it is greater than Pr, node decides to rebroadcast. Po and Pr are decided based on number of neighbors. When the number of neighbors is more, redundancy is more.

The main contribution of this part of the work is to limit the number of overhearing nodes based on probability. It reduces energy consumption without affecting quality of route information. This probability based overhearing is incorporated into log based pipelined ABM and integrated with routing protocol.

This modified algorithm is also integrated into a routing protocol called enhanced link disjoint multipath AODV (AOMDV) to find the routes from given source to destination based on available bandwidth. When a link failure occurs, the node upstream of the link detects the failure, invalidates its routing table entry for that destination and unicasts an RERR message towards the source. Once the source node receives the RERR, it switches its primary path to the next best alternate link-disjoint path. It is designed mainly for highly dynamic ad hoc networks when route

Breaks and link failures occur frequently. This method reduces routing overhead and improves the performance of the network.

Stale Route Avoidance in DSR by Cache Timeout Policy

Nodes movements result stale route cache entries. Cache staleness is a big problem in link cache scheme where individual links are combined to find out best path between source and estimation. A cache timeout policy is required to expire a route cache entry, when it is likely to become stale. DSR makes aggressive use of route cache to avoid route discovery. The performance of DSR heavily depends on efficient implementation of route cache. In this, a new cross-layer approach for predicting the route cache lifetime is presented. This approach assigns timeouts of Individual links in route cache by utilizing Received Signal Strength Indicator (RSSI) values received from wireless network interface card.

Demand based energy efficient algorithm (DBEE), the topology is changed dynamically according to the network traffic requirements. DBEE is integrated with the cross layer approach [3] to predict the route cache life time and find the stale route information. Initially a small set of nodes is computed which form a connected set, while the other nodes are put off to conserve energy. This connected set is used for routing the packets under low network load. If bulk data is transferred between a pair of nodes, the topology dynamically changes along the path between these nodes to minimize the power consumption. Steps involved in the modified DBEE - Cross layer approach as follows:

Step 1:

The first phase chooses a small set of nodes that constitutes independent set of the network. Here, we have considered 3 factors like energy factor, mobility factor, and utility factor. In energy factor, Let *E0*denote the initial node's energy and *Et* be the amount of energy of a node at time *t*. So the energy factor *Ei* of the node *i* is calculated as

$$\frac{E_o - E_t}{E_o}.$$

Mobility factor (Mi) can be derived as the ratio of Received signal strength and Probability of overhearing rate to the energy consumption at the source to be transmitted. Utility factor is derived as nodes that have a large number of neighbor nodes which have less conditional overhearing. It is denoted as Ui By forming these three factors within the limitation of region R, the node moves independently with the reducible amount of overhearing.

Step 2:

The second phase is electing more nodes to ensure that the selected nodes form a connected set.

Remaining other nodes go to sleep to conserve energy. In the third phase, the redundant nodes are removed in each region R.

Step 4:

In fourth phase, the topology is dynamically changed with the use of power control technique to minimize the total power consumption. In this technique, all nodes consume more power when it receives full transmission power. This can be reduced by choosing low energy cost path. The minimum receiving power is calculated as,

$$P_r = P_t G_t Gr\ h_t^2 h_r^2 / d^4$$

ht, hr, Gt, Gr - Antenna height and gain of the transmitter and receiver's is the distance between transmitter and receiver. The actual power is given as,

$$\zeta p, q = K \frac{P_t}{P_r} + W$$

K is function of ht, hr & d.

W is the energy consumed by each receiving node.

In DBEE algorithm, the energy consumption is minimized along the routing path using the power control technique during the transmission.

Step 5:

The steps for removing stale route information is as follows

1. RREQ packet will be broadcasted to all the nodes.
2. The overhearing level will be set in the frame type field of ATIM for RREP and RERR packets.
3. Nodes in the network may overhear the RREP and able to stores the route information in route caches.
4. If there is any link break, RERR is propagated to the source node by an upstream node, so that it can be deleted these stale route from route cache.
5. The stale route information will be present in some of the neighboring nodes due to the overhearing of RREPs.
6. Route cache is updated based on RSS by cache timeout policy to remove stale routes from the Neighboring nodes.

III. PROPOSED METHODS

NO, UNCONDITIONAL, AND RANDOMIZED OVERHEARING

The unicast packet is delivered only to an intended receiver if the IEEE 802.11 PSM is employed. Consider that a node S transmits packets to a node D via a pre-computed routing path with three intermediate nodes as shown in Fig. 1(a). Only five nodes are involved in the communication and the rest would not overhear it (*no overhearing*). However, if each neighbor is required to overhear as in AODV, each sender should be able to ―broadcast‖ a unicast message. i.e., it specifies a particular receiver but at the same time asks others to overhear it as shown in Fig. 1(b) (*unconditional overhearing*).*Randomized overhearing* adds one more possibility in between unconditional and no overhearing. As shown in Fig. 1(c), some of the neighbors overhear, but others do not and these nodes switch to the low-power state during the data transmission period. Randomized overhearing saves substantial amount of energy compared to unconditional overhearing. With respect to route information, it does not deteriorate the quality of route information by exploiting the spatial and temporal locality of route information dissemination as explained in the introduction. Consider an example in Fig. 1(c), in which nodes X and Y are two neighbors of the communicating nodes A and B. When node receives a RREP from node B, it obtains a new route (S→ D) and stores it in its route cache. Nodes X and Y do not overhear the RREP as shown in the figure but, since there will be a number of data packets transferred from node A to B, they will obtain the route information (S → D). In this figure, node X overhears the second data packet and node Y overhears the second from the last packet. Fig. 1 also shows when the route becomes stale and gets eliminated from the route cache.

RandomCast Probability

A key design issue in the Random Cast implementation is randomization. Basically, each node maintains an overhearing (rebroadcast) probability, PR (PF), determined using the factors listed below.

Sender ID: The main objective of RandomCast is to minimize redundant overhearing. Since a node would typically propagate the same route information in consecutive packets, a neighbor can easily identify the potential redundancy based on the sender ID. For instance, when a node receives an ATIM frame with subtype 11012, it determines to overhear it if the sender has not been heard for a while. This means that the traffic from the sender happens rarely or the node skips too many packets from the sender.

Number of neighbors: When a node has a large number of neighbors, there potentially exists a high redundancy. For example, when a node asks for a routing path by sending an RREQ, it is possible that a neighbor offers one.

Mobility: When node mobility is high, link errors occur frequently and route information stored in route caches becomes stale easily. Therefore, it is recommended to overhear more conservatively (a higher PR) but to rebroadcast more aggressively (a lower PF) in this case. Each node can estimate its mobility based on connectivity changes with its neighbors.

Remaining battery energy: This is one of the most obvious criteria that helps extend the network lifetime: less overhearing (a lower PR) and less rebroadcast (a lower PF) if remaining battery energy is low. However, it is necessary to take other nodes' remaining battery energy into consideration in order to achieve balanced energy consumption. Overhearing decision can be made based on the criteria mentioned above, but in this paper, we adopt a simple scheme using only the number of neighbors (PR ¼ 1= number of neighbors) to show the potential benefit of Random Cast.

PERFORMANCE EVALUATION

The performance of Random Cast is evaluated using ns-2, which simulates node mobility, a realistic physical layer, radio network interfaces, and the DCF protocol. Since ns-2does not support 802.11 PSM, we modified the simulator based on suggestions in [7]. Our evaluation is based on the simulation of 50 mobile nodes located in an area of 1500 _ 300m2. The radio transmission range is assumed to be 250 m, and the two-ray ground propagation channel is assumed with a data rate of 2 Mbps. The data traffic simulated is constant bit rate (CBR) traffic. Twenty nodes out of 50 generate CBR streams at the data rate of 0.2-2.5 256-byte data packets every second (Rpkt). Random waypoint mobility model is used in our experiments with a maximum node speed of 5 m/s and a pause time (Tpause) of 0-900 seconds. With this mobility model, a node travels (at 5 m/s) toward a randomly selected destination in the network. After the node arrives at the destination, it pauses for the predetermined period of time (Tpause) and travels toward another randomly selected destination. Simulation time is 900 seconds, and each simulation scenario is repeated 10 times to obtain steady state performance metrics. We compare four different schemes: 802.11, 802.11 PSM, ODPM, and RandomCast. 802.11 is unmodified IEEE 802.11 without PSM. ODPM is one of the most competitive energy-efficient schemes developed for multihop networks. For ODPM, a node remains in AM for 5 seconds if it receives an RREP (RREP time-out). It remains in AM for 2 seconds if it receives a data packet or it is a source or a destination node (Data time-out).

RandomCast uses no/unconditional/randomized overhearing depending on the packet type. We additionally evaluate RCAST, which employs randomized overhearing like RandomCast but not randomized rebroadcast. This is introduced to see the additional performance enhancement due to randomized rebroadcast. ATIM window size and the beacon interval are set to 0.02 and 0.4 seconds in ODPM. On the contrary, they are 0.05 and 0.25 seconds in PSM and RandomCast. Since nodes are allowed to send packets without prior announcements in ODPM, they require a smaller ATIM window than in 802.11 PSM and RandomCast. Nonetheless, considering the relative overhead due to ATIM windows, ODPM is advantageous in terms of energy consumption. However, our simulation results show the opposite, which tells the superiority of the proposed RandomCast protocol.

In short, RandomCast performs on par with other schemes in terms of PDR but achieves a significant energy saving as well as a better energy balance in comparison to existing schemes. The benefit of RandomCast is significant when traffic is light. This is because nodes stay in low-power sleep state more intelligently in RandomCast. It consumes less energy at high traffic condition as well, but the benefit in this case comes from less Rx energy. This is credited to more judicious overhearing decisions than other schemes.

The average energy consumption per node, and energy good puts for the five different schemes mentioned above with varying packet injection rate (0.2- 2.5 packets/second). In the high packet injection rate, both 802.11 and ODPM show a higher PDR than 802.11 PSM, RCAST, and RandomCast because all (802.11) or more (ODPM) nodes are in AM and participate in the packet transmission. On the other hand, 802.11 and ODPM consume more energy than RCAST and RandomCast. It is important to note the performance difference between RCAST and RandomCast. RandomCast achieves a higher PDR, particularly when packet rate is high. In the graph it is clear that after certain extent the overhead increases exponentially with increase in number of nodes.

Data sending for each node

Data sending for each node and find nearest node

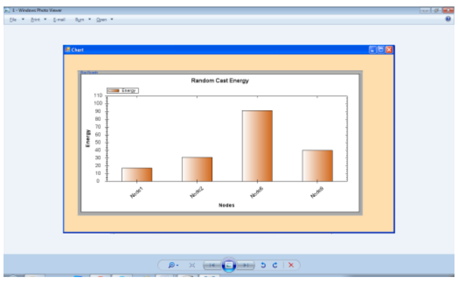

Figure show energy level for ever node based

IV. CONCLUSION

Hence, this method improves the available bandwidth and reduces energy consumed by overhearing nodes so that as much as possible bandwidth is available for actual data transmission. In power-controlled wireless ad-hoc networks, battery energy at conventional routing objectives was to minimize the total consumed energy in reaching the destination. However, the conventional approach may drain out the batteries of certain paths which may disable further information delivery even though there are many nodes with plenty of energy. In RandomCast, when a packet is transmitted, nodes in the proximity should decide whether or not to overhear it considering the trade-offs between energy efficiency and routing efficiency. RandomCast also improves energy good put by as much as 56 percent, that is, an integrated measure of energy and PDR. The performance results indicate that the proposed scheme is quite adaptive for energy-efficient communication in MANETs. In particular, applications without stringent timing constraints can benefit from the RandomCast scheme in terms of power conservation.

REFERENCES

[1] L. Chen and W. Heinzelman, “QoS-aware Routing Based on Bandwidth Estimation for Mobile Ad Hoc Networks”, IEEE Journal on Selected Areas of Communication, Vol 23, No 3, 2005.

[2] T. Bheemarjuna Reddy, I. Karthigeyan, B.S. Manoj, C. Siva Ram Murthy, “Quality of service provisioning in ad hoc wireless networks: a survey of issues and solutions”, Ad Hoc Networks, pp.83–124(Elsevier), June 2004.

[3] C.E. Perkins and E.M. Royer, “Ad-hoc on-demand distance vector routing”, in proceedings of the 2nd IEEE Workshop on Mobile computing Systems and Applications, New Orleans, LA, pp. 90–100, Feb 1999.

[4] Perumal Sambasivam, Ashwin Murthy, E. M. Belding-Royer, “Dynamically Adaptive Multipath Routing based on AODV”, Proc. 3rd Annual MAHN, 2004.

[5] Cheikh Sarr, Claude Chaudet, Guillaume Chelius, and Isabelle Gue´ rin Lassous,” Bandwidth Estimation for IEEE 802.11-Based Ad Hoc Networks”, IEEE Transactions on Mobile Computing,Vol. 7, No. 10, Oct 2008.

[6] Cheikh Sarr, Claude Chaudet, Guillaume Chelius, Isabelle Guerin Lassous, “Available Bandwidth Estimation for IEEE 802.11-based Ad Hoc networks”, INRIA 00154208, Version 2, June 2007.

[7] R. de Renesse, M. Ghassemian, V. Friderikos, A.H Aghvami, “QoS Enabled Routing in Mobile Ad Hoc Networks”, IEEE International Conf. on 3G mobile communication Technologies, Oct 2004.

[8] C. Sarr, C. Chaudet, G. Chelius, and I. Guerin Lassous, “A node-based available bandwidth evaluation in IEEE 802.11 ad hoc networks”, International Journal of Parallel, Emergent and Distributed Systems, 21(6), 2006.

[9] Mohammed Saghir, Tat-Chee Wan, Rahmat Budiarto, “QoS Multicast Routing Based on Bandwidth Estimation in Mobile Ad Hoc Networks”, Proceedings of the Int. Conf. on Computer and Communication Engineering, ICCCE’06 Vol. I, 9-11 May 2006, Kuala Lumpur, Malaysia.

[10] Bharghavan, A. Demers, S. Shenker, and L. Zhang, “MACAW: A Media Access Control Protocol for Wireless LANs,” Proc. SIGCOMM ’94 Conf. ACM, pp. 212-225, 1994.

[11] Bianchi, “Performance analysis of the IEEE 802.11 distributed coordination function”, IEEE Journal on Selected Areas in Communications, Vol. 18. No. 3, March 2000.

[12] Chunyu Hu, H.Kim, J.C. Hou, “An Analysis of the Binary Exponential Backoff Algorithm in Distributed MAC Protocols”, Technical Report No. UIUCDCS-R-2005-2599 (Engr. No. UILUENG-2005-1794), July 2005.

[13] N. Song, B. Kwak, J. Song, and L.E. Miller, "Enhancement of IEEE 802.11 distributed coordination function with exponential increase exponential decrease backoff algorithm", Proc. IEEE VTC 2003-Spring, 2003.
[14] J. Deng, P.K. Varshney, and Z.J. Haas, "A new backoff algorithm for the IEEE 802.11 distributed coordination function", Proc. CNDS 2004, Sandiego, CA, Jan. 2004.
[15] P. Chatzimisios, A.C. Boucouvalas, V. Vitsas, A. Vafiadis, A. Oikonomidis, and P. Huang. "A simple and effective backoff scheme for the IEEE 802.11 MAC protocol", in CITSA, Orlando,Florida, USA, July 2005.
[15] J. Gomez, A.T. Campbell, M. Naghshineh,C. Bisdikian, A distributed contention control mechanism for power saving in random-access ad-hoc wireless local area networks, Proceedings of IEEE International Workshop on Mobile Multimedia Communications, 1999, pp.114-123.
[16] J.H. Ryu, D.H. Cho, A new routing scheme concerning power-saving in mobile ad-hoc networks, Proceedings of IEEE International Conference on. Communications, vol. 3, 2000, pp. 1719-1722.
[17] Jung E and Vaidya N, "A Power Control MAC Protocol for Ad Hoc Networks," Proc. ACM MobiCom, pp. 36-47, 2002.
[18] Kawadia V and Kumar P, "Power Control and Clustering in Ad Hoc Networks," Proc. IEEE INFOCOM, pp. 459-469, 2003.
[19] Kravets R, Kravets K and Krishnan P, "Power Management Techniques for Mobile Communication," Proc. ACM MobiCom, pp. 157-168,1998.
[20] Kyasanur P, Choudhury R. and Gupta I, "Smart Gossip: An Adaptive Gossip-Based Broadcasting Service for Sensor Networks," Proc.Second IEEE Int'l Conf. Mobile Ad Hoc and Sensor Systems, pp. 91-100, 2006.
[21] Li Z and Li B, (2005) "Probabilistic Power Management for Wireless Ad Hoc Networks," Mobile Networks and Applications, Vol. 10, No. 5,pp. 771-782, 2005.