Power Aware Range-based MAC Protocol for Scalable Mobile Ad hoc Networks

R. Vadivel
Assistant Professor
Department of Information Technology
School of Computer Science and Engineering
Bharathiar University
Coimbatore.

B. Narasimhan
Assistant Professor
Department of Computer Technology
Dr. N.G.P. Arts and Science College
Affiliated to Bharathiar University
Coimbatore.

ABSTRACT
In mobile ad hoc networks, collision problem which is caused by the expansion of the interference range of the receiver node due to the controlled transmission power of the sender node is uniquely a tarnished problem. This paper employs physical and virtual carrier-sensing schemes to avoid the collision problem. We analyze the relationships among the transmission range, the carrier-sensing range, and the interference range in case power control is adopted, and based on the analysis; we propose a power aware range based MAC routing mechanism to prevent the collision problem from occurring in mobile ad hoc networks. This paper further analyzes the superiority of the proposed protocol under certain situations with the conventional DSR and AODV routing protocol. Also the proposed protocol analyzes the scalability factor by simulating with nodes ranging from 50 to 200 using NS2 network simulator. Extensive simulation results proved that the proposed PAR-Mac achieves better delivery ratio with reduced overhead and total energy consumption of nodes.

1. INTRODUCTION
A mobile ad-hoc network is a network which is temporarily formed by a collection of mobile nodes that do not rely on any established or predefined infrastructure. Adaptive power management is very significant for mobile ad hoc networks because mobile nodes are usually battery-powered. Power control mechanisms can decrease mobile nodes' power consumption and further increase the network lifetime .

A lot of researchers have been paying attention for designing and developing power control schemes towards power aware routing. The basic power control mechanism can save mobile nodes' power consumption, it is disclosed that this mechanism suffers from a severe collision problem.

The receiver's interference range changes with the sender's transmission power so that when the transmission power is small, the interference range induced becomes larger.

The distances between mobile nodes in the network need to be fixed the optimal sensing threshold for transmission to avoid the collision problem. The location of each mobile node is required to derive the optimal transmission power, which is a centralized scheme.

2. RELATED WORKS
Power control mechanism is a challenging task in the field of wireless mobile ad hoc networks. A mobile ad hoc network which is a network temporarily formed by a collection of mobile nodes that do not rely on any established infrastructure. Efficient power management is very critical for wireless ad hoc networks since mobile nodes are usually battery-powered. In general, power control mechanisms can decrease mobile nodes energy consumption and further increase the network lifetime. Recently, a lot of researchers have been paying attention to designing power control schemes [1], [2], [3], [4], [5], [6], [7], [8], [9], [10], [11], [12], [13], [14], [15], [16], [17]. In [1], [2], [3], the power control mechanisms that are proposed where RTS/CTS are sent at the maximum power level (Pmax), and DATA/ACK are sent at the minimum necessary power level. In [6], [7], schemes similar to the basic power control mechanism are proposed which periodically uses Pmax, instead of Pmin, for DATA transmission to avoid the POINT problem. In [16], in order to avoid the ACK collision, FEC code is adopted. In [17], DATA transmissions accompanying the additional busy tone transmission are adopted to prevent the collision problem from occurring in mobile ad hoc networks.

3. AODV
AODV is a single-path, on-demand routing protocol. When a source node, generates a packet for a particular destination node, it broadcasts a route request (RREQ) packet. A RREQ is uniquely identified by the combination of source sequence number and broadcast ID.

An intermediate node only processes a RREQ if it has not received a previous copy of it. If an intermediate node has a route to nd with destination sequence number at least that in the RREQ, it returns a route reply (RREP) packet, updated with the information that it has. If not, it records the following information: source IP address, source sequence number, broadcast ID, destination IP address and expiration time for reverse path route entry, and forwards the RREQ to its neighbors. Like the RREQ, a RREP is only processed on first sighting and is discarded unless it has a greater destination sequence number than the previous RREP or the same destination sequence number but a smaller hop-count. The route expiration time is the time after which the route is considered to have expired and a new route discovery process must be undertaken. If it receives a later RREP which has either fresher information or a shorter hop-count, it swaps to that, discarding the original route information. When an active route link breaks, a route error (RERR) packet, with sequence number incremented from the corresponding RREP and hop-count of 1, is sent by the upstream node of the broken link to ns. Upon receipt of a RERR, ns initiates a new route discovery process if it still has packets to send to nd. Nodes also periodically send "hello" messages to neighboring nodes to maintain knowledge of local connectivity.

4. POWER AWARE RANGE-BASED MAC PROTOCOL [PAR- MAC]

The proposed power aware range based MAC protocol inherits the route request and route maintenance process from the AODV discussed in Section 3. The condition to be followed for the working PAR-Mac is as follows:

The key idea of PAR-Mac is to let CSR of Clear-To-Send (CTS) cover the Ifrg of the receiver node.

$$Ifrg(\min\_pow) \leq CSR(PAR-Mac) \quad (1)$$

Where Ifrg denotes interference range, min_pow denotes minimum power, CSR stands for carrier sensing range. Ifrg is highly associated to the sending node's transmission power. When the transmission power is Min_pow, it leads to maximum Ifrg which is not dependent of the distance between the source node and the destination node. Hence min_pow is the minimum required transmission power level for the sending node to transmit

$$\min\_pow = th\_pow * distSR^4 \quad (2)$$

Where th_pow denotes the threshold power and distSR gives the distance between the sending node and receiving node.

$$Ifrg(\min\_pow) = K\left(\frac{\max\_pow}{th\_pow}\right)^{\frac{1}{4}} \quad (3)$$

Where max_pow denotes maximum power and K is the constant value of 1.78.

It implies that

$$Ifrg(\min\_pow) = K * trrg(\max\_pow) \quad (4)$$

Where trrg denotes transmission range.

So in-order to derive PAR-Mac

$$K*\left(\frac{\max\_pow}{\min\_pow}\right)^{\frac{1}{4}} * distSR \leq 2*\left(\frac{pow\_Pmac}{th\_pow}\right) \quad (5)$$

Hence PAR-Mac can be obtained as,

$$PAR-Mac \geq \left(\frac{0.627*\max\_pow*distSR*th\_pow}{\min\_pow}\right) \quad (6)$$

$$PAR-Mac \geq \left(\frac{0.627*\max\_pow}{\min\_pow}, 1\right) * distSR*th\_pow \quad (7)$$

With the equation (7), the PAR-Mac is taken into account for making the routing decisions from source node to the destination node.

5. SIMULATION SETTINGS

NS2 is used to simulate PAR-Mac protocol; the channel capacity of mobile nodes is set to the same value as 2 Mbps. We use the distributed coordination function (DCF) of IEEE 802.11 for wireless LANs. It has the functionality to notify the network layer about link breakage. In our simulation, 50 to 200 mobile nodes move in a 1500 meter x 1500 meter rectangular region for 100 seconds simulation time. We assume each node moves independently with the same average speed. All nodes have the same transmission range of 250 meters. In our simulation, the speed is set as 5m/s. The simulated traffic is Constant Bit Rate (CBR) with initial energy 2.5 joules.
The simulation settings and parameters are described in table 1.

Table1. Simulation settings and parameters

No. of Nodes	50, 75, 100, 125, 150 and 200
Area Size	1500 X 1500 meters
MAC	802.11b
Radio Range	250 meters
Simulation Time	100 seconds
Traffic Source	CBR
Packet Size	512 KB
Mobility Model	Random Waypoint Model
Speed	5 m/s
Initial Energy	2.0 Joules

5.1 Performance metrics

Delivery ratio, MAC Overhead and total energy consumption of nodes.

6. SIMULATION RESULTS

From Figure.1 it can be seen that the proposed routing protocol PAR-Mac achieves better packet delivery ratio than that of the conventional protocols such as DSR and AODV. Also it can be analyzed that the packet delivery ratio of the proposed routing protocol PAR-Mac maintains the delivery ratio in a stable manner even at scalable conditions. In Figure.2 the comparison of proposed protocol PAR-Mac Vs AODV & DSR for MAC Overhead is shown. Simulation results shows that PAR-Mac is comparatively consuming less MAC overhead packets than that of AODV & DSR. In Figure.3 the comparison is carried out for total energy consumption of nodes in a scalable ad hoc network environment. Extensive simulation results shows that the proposed protocol PAR-Mac consumes less energy when compared with the existing routing protocols such as AODV and DSR.

Table 2. No.of Nodes Vs Delivery Ratio

	DSR	AODV	PAR-Mac
50	0.52	0.91	0.95
75	0.51	0.89	0.96
100	0.50	0.89	0.98
125	0.48	0.86	0.91
150	0.22	0.60	0.89
200	0.04	0.42	0.85

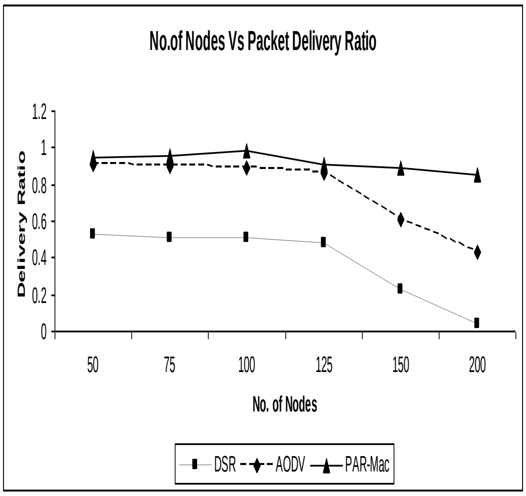

Figure 1. No.of Nodes Vs Packet Delivery Ratio

Table 3. No.of Nodes Vs Overhaed

	DSR	AODV	PAR-Mac
50	1721	1509	1074
75	1845	1633	1067
100	1957	1745	1058
125	2052	1840	1424
150	2154	1942	1377
200	2001	1789	1222

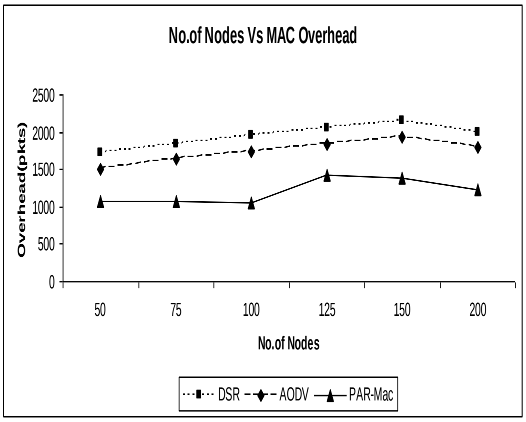

Figure 2. No. of Nodes Vs MAC Overhead

Table 4. No.of Nodes Vs TotEnergyConsumption

	DSR	AODV	PAR-Mac
50	10.23	8.75	6.38
75	11.18	9.70	7.01
100	11.48	10.00	5.98
125	12.57	11.08	8.07
150	13.18	11.70	7.67
200	14.43	12.95	7.62

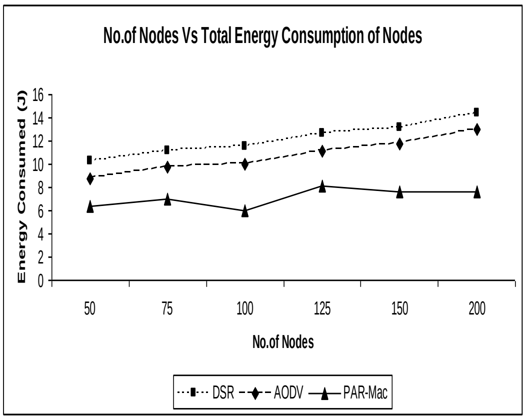

Figure 3. No.of Nodes Vs Total Energy Consumption

6. CONCLUSION

This paper proposed a power aware range based MAC protocol for scalable mobile ad hoc networks. The proposed protocol inherits several routing mechanism from AODV. Also a novel power aware range based MAC mechanism is involved. With the simulation results the proposed PAR-Mac protocol achieves better throughput along with reduced overhead and energy consumption.

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