International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies

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Power Management in Mobile Adhoc Network

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ARTICLE INFO

Article history:
Received 29 January 2011
Received in revised form
14 March 2011
Accepted 16 March 2011
Available online
17 March 2011

Keywords:
Adhoc,
AODV,
Energy,
Mobile,
Network,
Power,
Routing

ABSTRACT

A mobile adhoc network is a collection of wireless mobile nodes that communicate with one another without any fixed networking infrastructure. Since the nodes in this network are mobile, the power management and energy conservation become very critical in mobile adhoc network. The nodes in this network have limited battery power and limited computational power with a small amount of memory. Such nodes must conserve energy during routing to prolong their usefulness and increase network lifetime. This research paper proposes a scheme that takes into consideration the power awareness during route selection. This scheme observes power status of each and every node in the topology and further ensures the fast selection of routes with minimal efforts and faster recovery. The scheme is incorporated with the AODV protocol and the performance has been studied through simulation over NS-2.

1. Introduction

A mobile adhoc network is an autonomous system of mobile hosts which are free to move around randomly and organize themselves arbitrarily. This is viewed as suitable systems which can support some specific applications as virtual classrooms, military

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communications, emergency search and rescue operations, data acquisition in hostile environments, communications set up in exhibitions, conferences and meetings, in battle field among soldiers to coordinate defense or attack, at airport terminals for workers to share files etc. In adhoc networks, nodes can change position quite frequently. The nodes in an adhoc network can be laptops, PDA or palm tops etc. These are often limited in resources such as CPU capacity, storage capacity, battery power and bandwidth. Each node participating in the network acts both as a router and as a host and must therefore be willing to transfer packets to other nodes. For this purpose, a routing protocol should try to minimize control traffic. There is limitation of battery life and in an adhoc environment, battery is most commonly used. The concept of power as one of the deciding factor in route selection can be crucial in root discovery and root repair phase. Rest of the paper is organized as follows. Section 2 illustrates the power related issues of routing protocols in mobile adhoc network. New protocol description and system methodology is presented in section 3. Performance evaluation of new protocol using network simulator NS-2 is presented in section 4 and conclusion with future scope is given in section 5.

2. Issues and Related Work

The lack of a centralized authority complicates the problem of Medium Access Control (MAC) in mobile adhoc networks. The medium access regulation procedures have to be enforced in a distributed and hence collaborative fashion by mobile nodes. In the shared broadcast medium transmission of packets from distinct mobile nodes are prone to collision. This contention based medium access results in retransmissions and appreciable delays. The performance of the MAC scheme affects the routing protocol adversely and consequently the energy consumption for packet transmission and reception increases.

On-demand routing is composed of route discovery and route maintenance (Royer E. M. and Toh C. K., 1999). In route discovery, a source uses flooding to find a route to its destination. The large number of packets generated by flooding consumes energy of nodes unnecessarily. The transit nodes, upon receiving a query, learn the path to the source and enter the route in their forwarding tables. The destination node responds using the path traversed by the query. Route maintenance is responsible for reacting to topological changes in the network, and its implementation differs from one algorithm to the other. On-demand protocols include schemes like Adhoc On-demand Distance Vector routing (AODV) (Perkins and Royer, 1999) and Dynamic Source Routing (DSR) (Johnson and Maltz, 1996). In these protocols, route discovery and maintenance may become inefficient under heavy network load since intermediate nodes will have a higher probability of moving due to the delay in packet transmissions attributed to MAC contention. Routes have a higher probability of breaking as a result of mobility. The rediscovery or repair of routes wastes battery power. The flooding of route request and route reply packets in on-demand routing protocols may result in considerable energy drain. Every station that hears the route request broadcasts will consume an amount of energy proportional to the size of the broadcast packet. In addition, stations that hear a corrupted version of a broadcast packet will still consume some amount of energy. In a multi-hop adhoc network, nodes must always be ready and willing to receive traffic from their neighbors. All the nodes unnecessarily consume power due to reception of the transmissions of their neighbors. This wastes an extensive amount of the total consumed energy throughout the lifetime of a node.

Many researchers (Taneja *et al.*, 2010; Kuo-Qin Yan *et al.*, 2009; Chen Jie *et al.*, 2007; Joshi and Rege, 2007; Nie Nie and Comaniciu, 2006; Jin-Man Kim and Jong-Wook Jang, 2006; Woo *et al.*, 1998; Chang J. H. and Tassiulas L., 2000) have carried out lot of research work related to energy saving by optimizing the use of battery power during routing over mobile adhoc network through different kinds of tools and techniques. Their research work has been taken into consideration. The design objectives require selecting energy-efficient routes and minimizing the control messaging in acquiring the route information. Efficient battery management (Chiasserini *et al.*, 2002; Adamou and Sarkar, 2002), transmission power management (Kawadia and Kumar , 2003; Toh, 2001) and system power management (Zheng and Kravets , 2003; Singh and Raghavendra, 1998) are the major means of increasing the life of a node. These management schemes deal in the management of energy resources by controlling the early depletion of the battery, adjust the transmission power to decide the proper power level of a node and incorporate low power consumption strategies into the protocols. Typical metrics used to evaluate adhoc routing protocols are packet delivery ratio, average end to end delay, throughput, normalized routing load, and shortest hop etc.

Recent developments related to energy on AODV protocol have been taken into consideration. AODV is an improvement on DSDV which aims at reducing system wide broadcasts. In this protocol routes are discovered on-demand basis and maintain these routes

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only when these are in use. There exist two energy efficient algorithms based on AODV as: AODVE and AODVM. In AODVE, to increase the lifetime routing is based on the minimum remaining energy metric and that route is selected in which there is a maximum of minimum remaining energy (MIN_RE) and this field is added in RREQ as well as in the RREP. Other parameters are same as in AODV. Similar to AODVE, the latter AODVM considers the residual energy but it also considers the hop count value. It increases the lifetime of a network by arranging almost all nodes to involve in data transfer. It also shows improvement in delay and energy consumption of node. In new AODV protocol, the energy state of each node as well as of the entire network has been considered. New field is added to the RREQ message which carries the collected remaining energy of nodes participating between source and the destination. In this, destination node does not give an immediate reply to the request but waits for some time and in the mean time, calculate the mean energy of the network and this is stored in each node. In case of a new route, this mean energy is then compared with the energy remaining in the node and if it is less, then RREQ message is delayed by some time and by this the entire lifetime is extended. In energy aware AODV protocol, routing is done in the similar way as in ADOV but link breakage is detected by Signal-to-Interference Ratio (SIR). Cross layer interaction is also used by which physical layer can give information about link state to the network layer. Directional antennas are also used in energy aware AODV protocol to improve the communication Range and hence reducing interference. In our proposed algorithm, the nodes are selected on the basis of their energy status, which help in discovering alternate paths. In proposed algorithm, neighboring nodes (backbone nodes) of active route having energy above than some threshold value are selected for route establishment between source and destination. Some modifications have been done to improve the performance of AODV. It controls the transmission power consumption of nodes by listening to only their messages. This is done by adding two fields to RREQ and RREP packets. It also increases the lifetime of a network by judging the duplicity of broadcast.

3. Proposed Plan

The objective is to provide an energy efficient, more stable and long lasting path from source to destination. This has been done by modifying AODV protocol. A new routing scheme has been designed for mobile adhoc network with large number of nodes. It can handle a variety of data traffic levels. This scheme is designed for network topology in which the nodes can trust each other and there are no malicious intruder nodes. The new routing scheme has been proposed to make AODV energy efficient and for all practical purposes it has been assumed that battery status is divided into 3 categories:

1) If (battery status < 20%) It is called danger state.

2) If (20% > battery status < 50%) it is critical state

3) If (sattery status > 50%) It is active state

where %age is the decay factor of battery.

There are three major operations in this scheme: RREQ (Route Request) phase, RERR (Route Errors) phase and local repair phase. As a major change to all existing protocols, power related function starts only when RREP (Route Reply) phase occurs as in the start, when network is new, all nodes are fresh with adequate energy levels and can very well select shortest path for data transmission. This in turn reduces overhead and end to end delay. So we have used this parameter in LRR (Local Repair) and RERR phase and not in RREQ phase.

3.1 Proposed Algorithm

The proposed algorithm is as under:

Step1: The nodes which are not participating in route go to sleep mode from the start.

Step 2: Source node S broadcasts an active request to the destination D. [This request is same as RREQ as used in AODV]

Step 3: Check reply phase and set active path [only nodes with status greater than critical level are selected.]

Step 4: In case of link failure, check backbone nodes (one hop) for the link failure path. This is carried out using local repair scheme. In the route table, energy factor is added.

4. Performance Evaluation using Network Simulator

The simulations have been carried out over network simulator (Fall and Varadhan, 2009) NS-2 version 2.34. The area considered is 1KM×1KM (square flat topology). The number of wireless mobile nodes was fixed to 50 nodes. The random waypoint model (Bettstetter and Hartenstein, 2002) is used to model mobility. The random scenarios have been generated with speed varying from 1 meter/second to 10 meter/second and pause time varying from 0 seconds to 650 seconds. Traffic sources are chosen as TCP-IP with a packet-size of 512 bytes. All traffic sessions are established at random times near the beginning of the simulation run and they remain active until the end of the simulation period. Simulations are run for 500

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seconds. NS-2 inbuilt 714 MHz lucent wave LAN Direct Sequence Spread Spectrum (DSSS) model with various simulation parameters has been used for generating energy patterns.

4.1 Simulation results on the basis of packet delivery ratio

Figure 1 depicts the packet delivery ratio using pause time as a parameter for AODV and New AODV protocol. The results are on the basis of 50 mobile nodes having UDP connections. Pause time has been varied from 0 seconds to 650 seconds. The results show that, when the pause time ranges between 0 to 100, AODV outperforms New AODV but when the pause time is further increased from 100 seconds to 650 seconds, the new AODV starts outperforming than AODV in terms of packet delivery. On an average, New AODV outperforms AODV protocol.

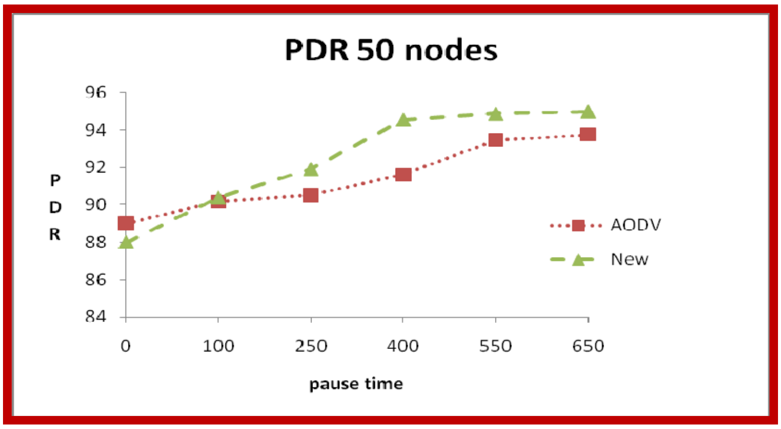

Figure 1: Pattern analysis with UDP connections and varying pause time.

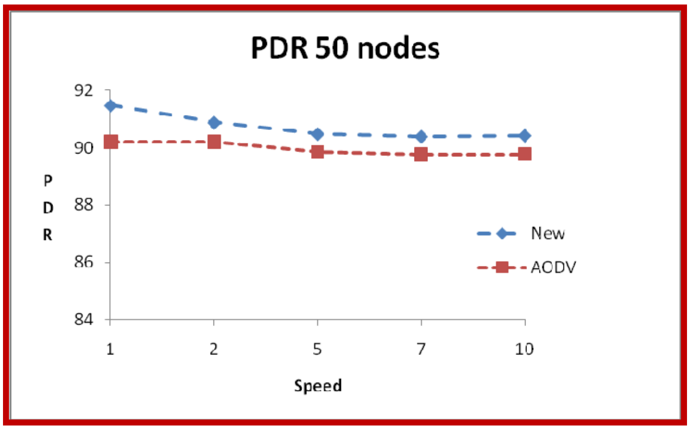

Figure 2: Pattern analysis with UDP connections and varying speed.

The packet delivery ratio using speed as a parameter for AODV and new AODV protocol has been illustrated in Figure 2. The results are on the basis of 50 mobile nodes having UDP connections. Speed has been varied from 1 meter/second to 10 meter/second. The results show that, the new AODV outperforms the AODV protocol irrespective of speed.

The packet delivery ratio using pause time as a parameter for AODV and new AODV protocol is depicted in Figure 3. The results are on the basis of 50 mobile nodes having TCP connections. Pause time has been varied from 0 seconds to 650 seconds. The results show that, the new AODV outperforms the AODV protocol irrespective of pause time.

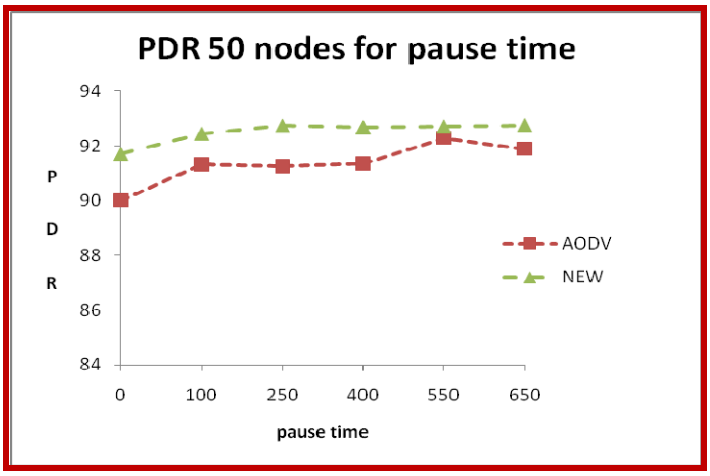

Figure 3: Pattern analysis with TCP connections and varying pause time.

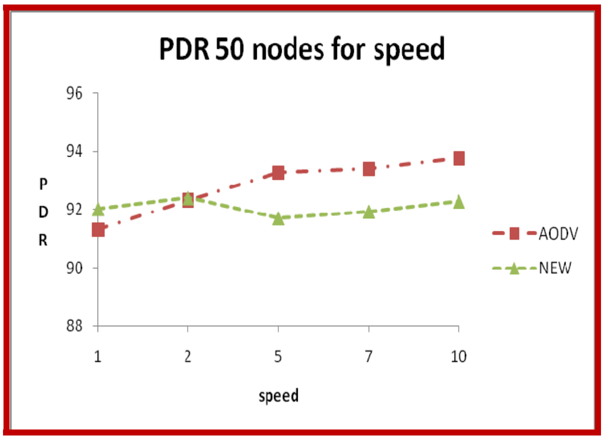

Figure 4: Pattern analysis with TCP connections and varying speed.

Figure 4 depicts the packet delivery ratio using speed as a parameter for AODV and new AODV protocol. The results are on the basis of 50 mobile nodes having TCP connections. Speed has been varied from 1 meter/second to 10 meter/second. The results show that, when the speed lies between 1 meter/second to 2 meter/seconds, New AODV outperforms AODV but when the speed is further increased from 2 meter/second to 10 meter/second, the AODV

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protocol starts outperforming than New AODV. On an average, the AODV protocol outperforms than New AODV.

4.2 Simulation results on the basis of exhausted nodes

Exhausted nodes are the number of nodes that die out at the end of each simulation run, due to the consumption of whole energy supplied to them at the start of the simulation. The figure 5 illustrates the behavior of AODV and new AODV for varying number of sources with respect to exhausted nodes. It can be observed that on an average, more number of nodes died till the end of simulation in case of new AODV while less number of deaths was reported in the case of AODV.

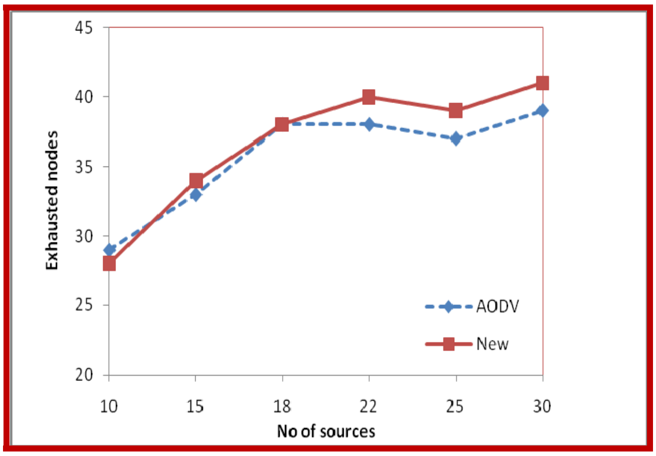

Figure 5: Pattern analysis on the basis of exhausted nodes.

5. Conclusion and Future Scope

Many researchers have worked in the field of power aware routing over mobile adhoc network using efficient battery management, transmission power management and system power management. Their research work has been considered and an effort has been made to modify the existing AODV protocol by introducing power efficiency. In proposed algorithm, the route selection depends upon the battery strength of neighboring nodes which can be in danger state, critical state or active state. The new AODV makes optimum utilization of battery strength during route selection. The results have been derived by carrying out experiments over network simulator NS-2. The performance evaluation of new AODV and existing AODV has been done on the basis of packet delivery ratio and exhausted nodes. The proposed scheme in new AODV works on a reactive approach and utilizes alternate paths by satisfying a set of energy based criteria. This scheme can be incorporated into any adhoc on-demand routing protocol to reduce frequent route discoveries. Alternate routes are utilized only when data cannot be delivered through the primary route. Simulation results indicate that the proposed scheme provides robustness to mobility and enhances protocol performance. Average increase in packet delivery occurs for different network scenarios. The scheme performs better in denser medium as more nodes are available for better route selection. In this scheme, power related function starts only when route reply phase starts. This is a major change to all existing protocols. Efforts are still going on to make this scheme to work better in sparse medium and to get better results for new AODV when TCP connections are there and nodes are moving at high speed. The work is also being carried out to get better results for new AODV when exhausted nodes are used as parameter for performance evaluation.

6. Acknowledgement

A very special thank you is due to Dr. Piya Techateerawat for insightful comments, helping clarify and improve the manuscript.

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Peer Review: This article has been internationally peer-reviewed and accepted for publication according to the guidelines given at the journal's website.

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