Power Aware Routing for Mobile Ad-hoc Network

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ABSTRACT: In this paper we present a detail account of Mobile Ad-hoc On-Demand Data Delivery Protocol (MAODDP) power efficiency mechanism. MAODDP belongs to on-demand data delivery routing protocol family of Mobile ad-hoc network. It establishes route and deliver data simultaneously one after the other. The key feature of MAODDP is the integrated approach that enables the protocol to address various issues besides routing.

Power conservation in mobile ad-hoc network is an important aspect to be considered. Unlike some of the traditional routing protocol MAODDP has its own power saving mechanism. MAODDP was implemented in Java and evaluated under Scalable Wireless Network Simulator (SWANS). A series of tests were run to monitor the efficiency of power aware operation of MAODDP.

Evaluation results indicate that MAODDP is applicable in all types of simulation environments. Statistics showed that MAODDP saved 22 % more memory with an increased data delivery of 5 % under power saving mode.

KEYWORDS: ...

1. INTRODUCTION

Mobile nodes in mobile ad-hoc networks operate on low battery power. That's makes power conservation an important challenge in mobile ad-hoc networks. Most of the protocols that have been reported proposed routing without considering their affects on some other routing related issues. The current protocols for mobile ad-hoc network can generally be categorized into two groups: pro-active and re-active protocols types.

Pro-active protocols [KMK04, PGC20] establish routes via continuously evaluating the known and attempting to discover new routes try to maintain the most up-to-date view of the network. In Pro-active protocols nodes needs to be in either reception or sending mode throughout the network life. Therefore this approach adds considerable burden on available power. Reactive protocols [PR99, RP**, BMA02, RP99] determine the proper route only when required, that is, when a packet needs to be forwarded. In this instance, the node floods the network with a route-request and builds the route on demand from the responses it receives. Reactive protocols though does not require nodes to be in awake mode all the time but too many query packets could yield the same affects as in pro-active protocols.

Mobile ad-hoc network routing protocols [THH03] are specifically design to conserve battery power. However, MAODDP offers a broad routing solution and offer power conservation as a part of its integral approach. MAODDP [GH05] unlike some other protocols [JMB01, KMK03] has its own power saving mechanism. MAODDP has been implemented in Java and evaluated under SWANS. This paper presents evaluation results highlighting MAODDP power aware mechanism efficiency. Evaluation results show that MAODDP is a power efficient protocol. Rest of the paper has been organized as follows. In section 2 an introduction to MAODDP power aware mechanism will be presented. In section 3 simulation environment is defined. In the section 4 evaluation results and various observations are covered. Conclusions are given in section 5 and references are listed in section 6.

2. MOBILE AD-HOC ON-DEMAND DATA DELIVERY PROTOCOL (MAODDP)

Mobile ad-hoc on demand data delivery protocol adopts an intermediate approach in between pro-active and existing re-active routing protocols. MAODDP builds routes using a route query and data delivery process. When a source node desires a route to a destination for which it does not already have a route, it broadcasts a route query and data delivery (RQDD) packet. Nodes receiving RQDD update their routing tables for the source node and set up backwards pointers to the source node in the routing tables.

A node receiving RQDD, if it is the destination node, issues an acknowledge (ACK) back to the source node or if it is an intermediate node which has a route to the destination it forwards RQDD to the destination. Any RQDD with the same sequence number and broadcast ID is dropped by the intermediate nodes without any action.

Once the source node received the acknowledge packet, it can begin to forward data packets to the destination using the same route. If the source node later received any updated route with a smaller hop count it updates it routing table for that destination.

On the other hand if the source node does not hear any thing back from the destination within a set time limit, it considers previous attempt unsuccessful. Source node in this case can rebroadcast RQDD with a new sequence number and broadcast ID.

MAODDP allows mobile nodes to switch in between one of two modes i.e. sleep state or active state. Nodes are required to be awake only during the active transmission and they are allowed to go into sleep mode if they are not the receivers or the senders of MAODDP packets. Moreover with the addition of a specific listening time (LT) each node can switch back into listening mode after a time period of (LT). Under active mode if the node does not find itself in an active transmission they can switch back into sleep mode.

MAODDP defines number of different other functions. Joining message allows mobile nodes to establish an ad-hoc network or a mobile node wishing to join an existing ad-hoc network. Broadcast Route Query Data Delivery process calls each time node want to broadcast a RQDD. Broadcast ACK message is to broadcast ACK for the source of RQDD and Broadcast Route Error is to broadcast route error messages. MAODDP supports multicasting and has its own secure mechanism for securing data transmission.

3. SIMULATIONS ENVIRONMENT

Each set of experiments comprises nine different tests. In total seven set of experiment were conducted over SWANS under SuSE Linux 10.1 operating environment. Six of these set were conducted under power saving mode and the last one without power saving mode.

It is not possible in SWANS to carry out simulation which can highlight direct power consumption of mobile nodes. However some of the understood concept could be utilized to make such conclusions. It can be understood that if the nodes are not in sleep states, it will increase the message activities. In other words it is expected to see more broadcast RQDD in the same network simulation frame work. Moreover, bandwidth consumption is likely to be increased. If no power saving mechanism is available the chances are that the nodes will be engaged continuously in replying to different messages which otherwise could be re-route to some other node. These two factors will be measured against those obtained under power saving mode. In this regard different readings from each of the first six sets of experiments have been taken. In table 3.1 all those reading are collected while in table 3.2 all reading for the same simulation parameters under no power saving mechanism are recorded. To obtain such readings a manual procedure was followed. Code that deal with MAODDP power aware operation were disabled and whole simulator was recompiled before running simulation for the selected readings.

Simulation environments were generated via selection of one of many input parameters. Details of each of these parameters and how they were used are as follows

Nodes were placed mainly in a grid type area of 5x5 to 30x30 within a two dimension fixed field size of 500X500 meters. However, in one set of experiments nodes were placed randomly within the same fixed field as described above. Nodes were selected from the range of 25 to 450 mobile nodes. All simulation starts at 10 seconds with a fixed resolution time of 60 seconds. MAODDP was evaluated both for short and long simulations run therefore simulation stop time was chosen from the range of 600 to 800 seconds. A fixed pause time of 10 seconds was used for all the simulation. In some sets mobility was defined as static and for the others different mobility models were used. Packet loss for most of the experiment defined as default. Please note adding packet loss to the simulation does not really test anything new, since the simulation already have packet loss even without specifying it.

Table 3.1 Results Charts with power saving mode

Number of Nodes	RQDD Sent	ACK received	Data delivery	Routes Formed	Bandwidth Saved %
25	517	350	67.698	52	46.44
50	1256	1256	100	126	52.56
100	2496	2402	96.23	251	53.58
250	10887	8219	75.49	1090	56.96
350	14015	11024	78.65	1402	56.63
450	17789	11265	63.32	1767	97.23
	7826.66	5752.66	**Avg(80.23)**	781.33	61.07 %

Table 3.2 Results Charts without power saving mode

Number of Nodes	RQDD Sent	ACK received	Data Delivery %cnt	Routes Formed	Bandwidth Saved
25	460	357	77.60	46	96.94
50	1249	1249	100	144	97.07
100	2435	2374	97.49	349	99.74
250	10553	8796	83.35	1056	97.69
350	13541	11153	82.36	1356	97.64
450	18409	12777	69.40	1842	97.13
	7774.5	6117.667	**Avg(85.03)**	798.83	97.13%

Definition and explanation of conclusions drawn from the simulation results are as follows.

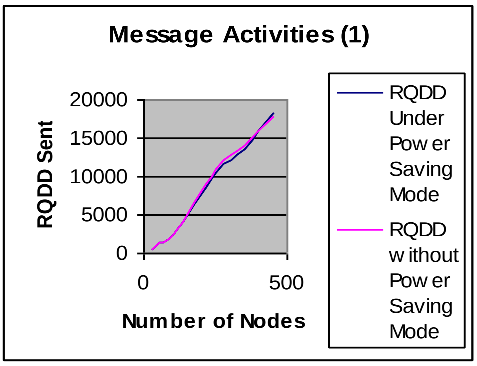
Data delivery: defines the ratio between the number of ACK sent and broadcasted RQDD.

Route formed: Defines number of new route added.

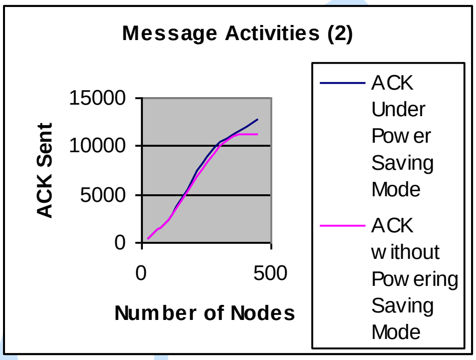
Elapsed time: It defines the time period in between simulation start time and simulation stop time.
Memory saved: It is the difference of total memory and memory used in a simulation cycle.

4. EVALUATIONS RESULTS

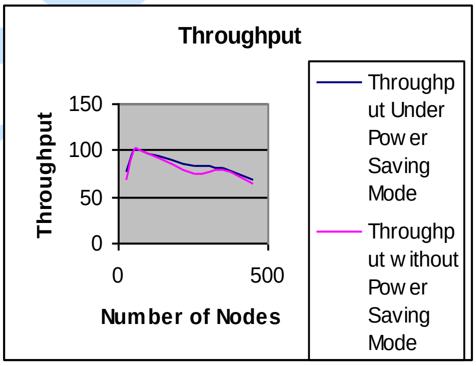
In the light of all the evaluation results it can easily be seen that MAODDP is well suited in all types of environments. Almost all the operations as defined under MAODDP specification are practically applicable and can produce good results. Variations of different types of tests have been conducted over MAODDP. These simulation environments were selected in a way which can best reflect the nature of mobile ad-hoc network communication pattern.
Evaluation experiments were run with different mobility models. Results showed that highest message activity in terms of broadcasted RQDD was recorded in the random waypoint model. It might be due to limited and specific communication pattern of mobile nodes.
In general, message activities both in terms of broadcasting RQDD and sending ACK were quite high as shown in graph (1) and graph (2) respectively. Statistics of table 3.1 and table 3.2 shows an increase of 1 % in broadcasted RQDD. In graph (1) it can be observed that more RQDD broadcasted without power saving mode then under power saving mode as it was expected. It also shows that MAODDP routing functions performed as normal as any other standard protocol of mobile ad-hoc network This further explains that without having power saving mechanism node performance could be dropped. Results showed 5 % increase in data delivery under power saving mode as it is shown in graph (3). It can be assumed that this .1 % broadcasted packets might be the one's who have broadcasted before. This further supports power aware operation of MAODDP as it could be helpful in avoiding dealing with the same packets again. This assumption can also be supported with the fact that more routes were established as shown in table 3.1 under power saving mode than when it was off as shown in table 3.2. Graph (4) presents a comparison of route formation in between two modes. It can be observed that probability of new route formation increased with the addition of mobile nodes.
Among the three mobility model used teleport proved to be most memory conserving. Statistics of table 3.1 and 3.2 shows that MAODDP saved almost 22.05 % {(Memory Saved (1)/Memory Saved (2)) * 100} available memory under power saving mode. A graphical comparison in terms of memory saved can also be observed in graph (5).



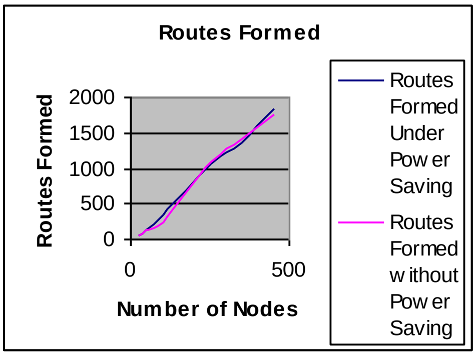
Graph 1. Message Activities (1)



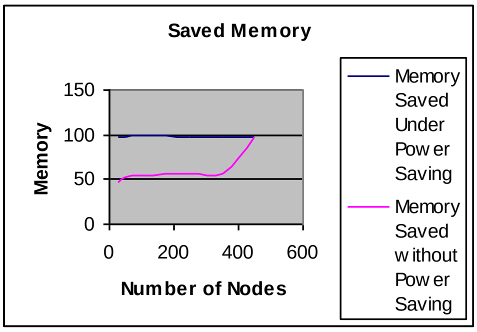
Graph 2. Message Activities (2)



Graph 3. Data Delivery



Graph 4. Routes Formed



Graph 5. Saved Memory

5. CONCLUSIONS AND FUTURE WORK

In this paper we have presented evaluation results of MAODDP power saving mechanism. MAODDP proved to be an effective routing protocol in terms of data delivery and conserving available memory. Results showed an increased of 5% in data delivery with 22 % more memory was saved under power saving mode. Moreover the probability of route formation is considerably increased in power saving mode. In future we will be conducting evaluation tests to monitor scalability factor of MAODDP. We are committed to contribute our research findings with the ongoing research in this area.

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