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Energy Consumption using Traffic Models for MANET Routing Protocols

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Abstract— A mobile ad hoc network (MANET) is a collection of wireless mobile nodes dynamically forming a network Topology without the use of any existing network infrastructure or centralized administration. One of the main issues in MANET routing protocols is development of energy efficient protocols due to limited bandwidth and battery life. There are various such protocols developed and analyzed under Constant Bit Rate (CBR) traffic by many authors. In the present communication the energy consumption in traffic models (CBR, Pareto and Exponential) is measured using routing protocols namely AODV, OLSR and AOMDV. Simulation and computation of energy consumed, received and transmitted energy were done with ns-2 simulator (2.34 version) with parameter variation: number of nodes, pause time, average speed and send rate.

Keywords- MANET, CBR Traffic, Pareto Traffic, Exponential traffic, NS-2.34.

1. Introduction

A Mobile Ad hoc Networks (MANET) represents a system of wireless mobile nodes that can freely and dynamically self-organize in to arbitrary and temporary network topologies, allowing people and devices to seamlessly communicate without any pre-existing communication architecture. Such infrastructure less networks are usually needed in battlefields, disaster areas, and meetings, because of their capability of handling node failures and fast topology changes. One important aspect of ad-hoc networks is energy efficiency since only a simple battery provides nodes autonomy. Thus, minimizing energy consumption is a major challenge in these networks.

Jaun Carlos Cano et. al. [1] have developed number of such protocols and analyzed them under Constant Bit Rate (CBR) traffic. J Hoong et. al. [2] have compared two reactive protocols under ON/OFF source traffic. They have selected packet delivery ratio, normalized routing overhead and average delay as the performance parameters. A. A. Maashri et. al. [3] have compared the energy consumption of various protocols under CBR traffic. D. Nitawale et. al. [4] have presented a paper on comparison of various protocols under Pareto traffic. In the present paper, we have compared the energy consumption of three routing protocols (AODV, OLSR and AOMDV) under CBR, Pareto and Exponential traffic. Total energy consumed by each node during transmission and reception process has been

evaluated as the function of number of nodes, pause time, average speed and send rate.

This paper is organized in five sections. Section 2 gives brief description of studied routing protocols. Section 3 describes simulation environment, traffic models and energy evaluation model. Simulation results are discussed in section 4. Section 5 describes our conclusion and future scope.

2. Description of MANET Routing Protocols

Description of routing protocols AODV, OLSR and AOMDV in brief are as follows:

2.1. AODV (Ad-hoc On demand Distance Vector)

This is a reactive protocol, which performs Route Discovery using control messages route request (RREQ) and route reply (RREP) whenever a node wishes to send packets to destination. To control network wide broadcasts of RREQs, the source node uses an expanding ring search technique. The forward path sets up an intermediate node in its route table with a lifetime association RREP. When either destination or intermediate node using moves, a route error (RERR) is sent to the affected source node. When source node receives the (RERR), it can reinitiate route if the route is still needed. Neighborhood information is obtained from broadcast Hello packet. As AODV protocol is a flat routing protocol it does not need any central administrative system to handle the routing process. AODV tends to reduce the control traffic messages overhead at the cost of increased latency in finding new routes. The AODV has great advantage in having less overhead over simple protocols which need to keep the entire route from the source host to the destination host in their messages. The RREQ and RREP messages, which are responsible for the route discovery, do not increase significantly the overhead from these control messages. AODV reacts relatively quickly to the topological changes in the network and updating only the hosts that may be affected by the change, using the RRER message. The Hello messages, which are responsible for the route maintenance, are also limited so that they do not create unnecessary overhead in the network. The AODV protocol is

a loop free and avoids the counting to infinity problem, which were typical to the classical distance vector routing protocols, by the usage of the sequence numbers. [5].

2.2. OLSR (Optimized Link State Routing Protocol)

This is a proactive routing protocol, so the routes are always immediately available when needed. It is an optimization version of a pure link state protocol. So the topological changes cause the flooding of the topological information to all available hosts in the network. To reduce the possible overhead in the network protocol uses Multipoint Relays (MPR). The idea of MPR is to reduce flooding of broadcasts by reducing the same broadcast in some regions in the network. Another reduce is to provide the shortest path. The reducing the time interval for the control messages transmission can bring more reactivity to the topological changes. OLSR [7] uses two kinds of the control messages: Hello and Topology Control (TC). Hello messages are used for finding the information about the link status and the host's neighbors. TC messages are used for broadcasting information about own advertised neighbors which includes at least the MPR Selector list. OLSR protocol requires each host periodically to send the updated topology information throughout the entire network. This increases the protocols bandwidth usage.

2.1. AOMDV (Ad-hoc On demand Multipath Distance Vector)

AOMDV [7] uses the basic AODV route construction process. The main idea in AOMDV is to compute multiple paths during route discovery. It consists of two components: A route update rule to establish and maintain node and A distributed protocol to find link-disjoint paths. In AOMDV each RREQ, respectively RREP arriving at a node potentially defines an alternate path to the source or destination. Just accepting all such copies will lead to the formation of routing loops. In order to eliminate any possibility of loops, the "advertised hopcount" is introduced. The *advertised hopcount* of a node i for a destination d represents the maximum hopcount of the multiple paths for d available at i . The protocol only accepts alternate routes with hopcount lower than the advertised hopcount, alternate routes with higher or the same hopcount are discarded. The advertised hopcount mechanism establishes multiple loop-free paths at every node. These paths still need to be disjoint. When a node S floods a RREQ packet in the network, each RREQ arriving at node I via a different neighbor of S , or S itself, defines a node-disjoint path from I to S . In AOMDV this is used at the intermediate nodes. Duplicate copies of a RREQ are not immediately discarded. Each packet is examined to see if it provides a node-disjoint path to the source. For node-disjoint paths all RREQs need to arrive via different neighbors of the source. This is verified with the *firsthop* field in the RREQ packet and the *firsthop_list* for the RREQ packets at the node. At the destination a slightly different

approach is used, the paths determined there are link-disjoint, not node-disjoint. In order to do this, the destination replies up to k copies of the RREQ, regardless of the firsthops. The RREQs only need to arrive via unique neighbors.

3. Simulation Environment

The simulation is done with the help of NS-2 simulator version 2.34 [8]. The network contains 10, 30 and 50 nodes randomly distributed in a 500m X 500m area, pause time of 10s, 50s and 100s and average speed of 17.10m/s, 4.72m/s and 2.48m/s as basic scenario.

Parameter	Value
No. of nodes	10, 30, 50
Simulation Time	120s
Pause Time	10s, 50s, 100s
Average Speed	17.10m/s, 4.72m/s, 2.48m/s
Traffic Type	CBR, Pareto, Exponential
Packet Size	512byte
Send Rate	64kb, 96kb, 128kb

Table 1: Basic Simulation Scenario

The selected parameters are varied using setdest command .

3.1. Traffic Model

Traffic model used are CBR, Exponential and Pareto, which are generated using cbrgen.tcl [9].

3.1.1. CBR Traffic Model

CBR generates traffic at a deterministic rate. It is not an ON/OFF traffic.

3.1.2. Exponential Traffic Model

It is not an ON/OFF traffic with exponential distribution. It generates traffic during ON period (burst time). Average ON and OFF (idle time) time are 1.5s and 0.5s respectively.

Parameter	Value
Burst Time	1.5s
Idle Time	0.5s

Table 2: Parameter for Exponential Traffic

3.1.3. Pareto Traffic Model

It is not an ON/OFF traffic with pareto distribution. It generates traffic during ON period (burst time). Average ON and OFF (idle time) time are 1.5s and 0.5s respectively with a shape of 2.5.

Parameter	Value
Burst Time	1.5s
Idle Time	0.5s
Shape	2.5

Table 3: Parameter for Pareto Traffic

3.2. Energy Evaluation Model

We have used energy model as given in the following table:

Parameter	Value
Network Interface	WirelessPhy
MAC Type	802.11
Channel	WirelessChannel
Propagation	TwoRayGround
Antenna	OmniAntenna
Radio Frequency	281.8mW (≈ 250 m)
Initial Energy	100 Joule
Idle Power	1.0w
Receiving Power	1.1w
Transmission Power	1.65w
Transition Power	0.6w
Sleep Power	0.001w
Transition Time	0.005s

Table 4: Parameter for Energy Model

Energy is converted in joules by multiplying power with time. The following equations are used to convert energy in joules:

Transmitted Energy:

$$Tx \text{ Energy} = (Tx \text{ Power} * Packet \text{ Size}) / 2 \times 10^6 \dots \dots \dots (1)$$

Receiving Energy:

$$Rx \text{ Energy} = (Rx \text{ Power} * Packet \text{ Size}) / 2 \times 10^6 \dots \dots \dots (2)$$

Total energy consumed by each node is calculated as sum of transmitted and received energy for all control packets.

4. Results

We have made following evaluation with pause time 10s:

1. Energy consumption percentage due to packet type (routing/ MAC/ CBR or Expo or Pareto) during transmission and reception with 10 nodes (Figure 1) and with 50 nodes (Figure 2).

Figure 1: Energy consumption percentage due to packet type during transmission and reception with 10 nodes

Figure 2: Energy consumption percentage due to packet type during transmission and reception with 50 nodes

2. Energy consumption percentage of Total transmission and receiving energy due to control packets with 10 nodes (Figure 3) and with 50 nodes (Figure 4).

Figure 3: Energy consumption percentage of total transmission and receiving energy due to control packets with 10 nodes

Figure 4: Energy consumption percentage of total transmission and receiving energy due to control packets with 50 nodes

Figure 1 and 2 shows the energy consumed due to traffic type CBR or Expo or Pareto control packet significantly affects the total energy consumption for all the three protocols. The protocol type REQUEST, REPLY and ERROR packets are routing control packets. Request to Send (RTS), Clear to Send (CTS) and Acknowledgment (ACK) are the MAC control packets. Energy consumed by routing control packets is increased with increasing the number of nodes while energy consumed by MAC control packets is increased with increasing the number of nodes.

Figure 3 and 4 shows the total transmission and receiving energy. The energy consumed mainly due to receiving process. When number of nodes is low, the transmitting energy is more with Expo and Pareto traffic in comparison of CBR traffic for AODV and OLSR. This is due to bursty nature of Expo and Pareto traffic. In AOMDV all traffic consumed almost same amount of energy. When number of nodes is high, all traffic type consumed similar amount of energy.

4.1. Varying Selected Parameters

Figure 5: Energy consumption Versus Average Speed

Figure 6: Energy consumption Versus Pause Time

Figure 5 shows total energy consumed in joule by all 50 nodes involved in transmitting and receiving the control packets with increasing average speed 2.48m/s, 4.72m/s and 17.10m/s. Energy consumption is more with CBR traffic and less with Expo traffic in comparisons of Pareto traffic. In CBR traffic AODV consumes more energy than AOMDV (due to less route discovery process) and OLSR (due to immediate route availability). In Pareto and Exponential traffic (bursty nature) AODV consumes less energy than AOMDV (due to route request are not immediately discarded) and OLSR (due to periodically information update).

Figure 6 shows total energy consumed in joule by all 50 nodes involved in transmitting and receiving the control packets with increasing pause time 10s, 50s and 100s. Energy consumption is more with CBR traffic and less with Expo traffic in comparisons of Pareto traffic. In CBR traffic AODV consumes less energy than AOMDV and OLSR.

The speed and pause time defines mobility of nodes, both are inversely proportional to each other. We obtain the results, which verify the same.

Figure 7: Energy consumption Versus Number of nodes

Figure 7 shows total energy consumed in joule involved in transmitting and receiving the control packets with increasing number of nodes 10, 30 and 50. All traffic models show the increment in nodes due to increase in the maintenance process. At low number of node all consume nearly same amount of energy. AODV consume more energy compare to OLSR and AOMDV with CBR traffic while AODV consume less energy compare to OLSR and AOMDV with Pareto and Exponential traffic. The energy consumption in CBR traffic is more than the Pareto traffic, while energy consumption in Exponential traffic is less than the Pareto traffic.

Figure 8: Energy consumption Versus Sending Rate

Figure 8 shows total energy consumed in joule involved in transmitting and receiving the control packets with

increasing send rate 64kb, 96kb and 128kb. In CBR traffic AOMDV performed less energy consumption with higher sending rate than OLSR and AODV. In Pareto and Exponential traffic AODV consume less energy with high send rate than AOMDV and OLSR. In Exponential traffic AOMDV consume less energy than OLSR at 64kb, while OLSR consume less energy than AOMDV at 128kb.

5. Conclusion and Future Scope

From the above simulation results, we observe that AOMDV consume less energy than OLSR and AODV with increasing number of nodes, average speed and send rate with CBR traffic, while AODV consume less energy than OLSR and AOMDV with increasing pause time. In Exponential and Pareto traffic AODV consume less energy than OLSR and AODV with increasing number of nodes, pause time, average speed and send rate. The conclusion is presented in following tables:

Table 5: Energy Consumption with CBR Traffic

Parameter with Increasing Values	Energy Consumption with CBR Traffic		
	LOW	MIDDLE	HIGH
Pause Time	AODV	AOMDV	OLSR
Average Speed	AOMDV	OLSR	AODV
Send Rate	AOMDV	OLSR	AODV
No. of Nodes	AOMDV	OLSR	AODV

Table 6: Energy Consumption with Exponential Traffic

Parameter with Increasing Values	Energy Consumption with Exponential Traffic		
	LOW	MIDDLE	HIGH
Pause Time	AODV	AOMDV	OLSR
Average Speed	AODV	AOMDV	OLSR
Send Rate	AODV	OLSR	AOMDV
No. of Nodes	AODV	AOMDV	OLSR

Table 7: Energy Consumption with Pareto Traffic

Parameter with Increasing Values	Energy Consumption with Pareto Traffic		
	LOW	MIDDLE	HIGH
Pause Time	AODV	AOMDV	OLSR
Average Speed	AODV	AOMDV	OLSR
Send Rate	AODV	OLSR	AOMDV
No. of Nodes	AODV	OLSR	AOMDV

We observed that increasing number of nodes also increases energy consumption due to routing control packets. We can reduce energy consumption by reducing the number of routing control packets to increase the lifetime of network. In future we will try to evaluate and measure performance of other routing protocols under these scenarios and develop an algorithm for reducing the number of routing packets.

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