Comparative Study of Energy Aware QoS for Proactive and Reactive Routing Protocols for Mobile Ad-hoc Networks

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ABSTRACT
In Mobile Ad-hoc Networks (MANETs), there is a tradeoff between QoS and energy consumption because in order to achieve maximum quality of services, maximum energy has to be consumed. In this paper we compare the impact of network size to provide a QoS in energy consumption for proactive and reactive routing protocols.

Keywords
MANETs – QOS in energy consumption – proactive and reactive routing protocols.

1. INTRODUCTION
Energy Efficient MANET: In ad hoc networks, each mobile node acts as both a router and an end node that takes part in route discovery and maintenance. So, the failure of a node can greatly affect the performance of the network. As wireless networking has become an integral component of modern communication infrastructure in recent years for its applications in mobile and personal communications, energy efficiency will be an important design consideration due to the limited battery life of mobile terminals. The essence of using wireless devices is that they can be used anywhere at any time. One of the greatest limitations to that goal is finite power supply. Since batteries provide limited power, a general constraint of wireless communication is the short lifetime of mobile terminals. Therefore, power management is one of the most challenging problems in wireless communication.

2. MANET Routing Protocols
Here we have described the reactive protocols DSR, AODV and Proactive protocol OLSR in brief.

2.1Dynamic Source Routing Protocol
DSR protocol, as its name implies, is a source routing protocol: a complete sequence of intermediate nodes from a source to a destination will be determined at the source node and all packets transmitted by the source node to a destination follow the same path. Every packet header contains the complete sequence of nodes to reach a destination.[2] DSR protocol is a reactive protocol and its primary objectives are: (1) to avoid periodic announcements of link states required in proactive protocols, by separating route discovery from route maintenance; (2) to avoid long convergence time of routing information; and (3) to eliminate a large routing table for forwarding packets at intermediate nodes. The routing table, is a is a data structure designed to hold routing information to reach every possible destination in a network, is not used in the DSR protocol. In DSR, routes are discovered on demand and a route cache is used to hold routes that are currently in use. As with most of the reactive protocols, DSR consists of two procedures: route discovery and route maintenance.

2.2 OLSR-Optimized Link State Routing Protocol
The Optimized Link State Routing Protocol (OLSR) is an IP routing protocol optimized for mobile ad-hoc networks, which can also be used on other wireless ad-hoc networks. OLSR is a proactive link-state routing protocol, which uses Hello and Topology Control (TC) messages to discover and then disseminate link state information throughout the mobile ad-hoc network. Individual nodes use this topology information to compute next hop destinations for all nodes in the network using shortest hop forwarding paths. [4] Being a proactive protocol, routes to all destinations within the network are known and maintained before use. Having the routes available within the standard routing table can be useful for some systems and network applications as there is no route discovery delay associated with finding a new route.

The routing overhead generated, is generally greater than that of a reactive protocol, does not increase with the number of routes being used. Default and network routes can be injected into the system by HNA messages allowing for connection to the internet or other networks within the OLSR MANET cloud. Network routes are somewhat reactive protocols do not currently execute well.

Timeout values and validity information is contained within the messages conveying information allowing for differing timer values to be used at differing nodes.

2.3 Ad hoc On-Demand Distance Vector (AODV) Routing
The AODV protocol is a reactive routing protocol that provides a good compromise between reactive source routing protocols and proactive protocols. The trade-off problem AODV addresses is the one between high messaging overhead due to periodic announcements of link states in proactive protocols and the large packet header needed to contain the entire route information to

reach a destination in source routing protocols. Unlike pure DV protocols, routes are discovered and maintained on demand in AODV. Unlike DSR, AODV uses a distributed approach, meaning that source nodes do not maintain a complete sequence of intermediate nodes to reach a destination. Unlike DV and WRP, each path is established as a pair of two streams of pointers chained between a source and a destination node (details of this are described in a later section), which eliminates the need for broadcasting error packets on a link failure. Like DSR, AODV uses route discovery and route reply mechanism to create and maintain a route on demand.

Route discovery—When a source node wants to send information to a destination node, it first looks up its own routing table to see if a valid route exists. If a valid route does not exist, a source node broadcasts a route request message that contains the source address, source sequence number, destination address, destination sequence number, broadcast ID and hop count. The combination of the source address and the broadcast ID is used to uniquely identify each route request message while a route request message is globally broadcast. Any node that has a valid route to the destination or the destination node is supposed to respond to route request messages by sending a route reply message. During a route discovery, two pointers are set up at every intermediate node between the source and the destination nodes. The two pointers are the back pointer and the forward pointer. A chain of the forward pointers is set up between a source and destination node while a route request message propagates from the source node to a destination. Similarly, a chain of back pointers is set up while a route reply message propagates back from the destination (or from a node that already has a valid route to the destination) to the source. As a result, all the intermediate nodes on a route maintain a pair of the forward pointer and the back pointer for every connection that goes through them. Every route request contains a list of intermediate nodes that have been encountered. If the same intermediate node appears more than once in the list, the route request message will be dropped (the chain of forward pointers must be deleted for a route request message to be deleted). This guarantees loop-free routing.

Route maintenance—The route maintenance is performed using three different types of messages: route-error message, ‘hello’ message and route time-out message. The purpose of the timeout message is obvious: if there is no activity on a route for a certain amount of time, the route pointers at the intermediate nodes will time out and the link will be deleted at the intermediate nodes. The periodic ‘hello’ messages between immediate neighbors are required to prevent the forward and backward pointers from expiration. If one of the links in a route fails, a route-error message is generated by the node upstream (i.e., from an intermediate node to source nodes on the link and the message is propagated to every source node in its upstream that uses the failed link. Thus, the error packets will not be globally broadcast in AODV. Then, the source nodes in the upstream will initiate the route discovery process. The primary advantages of the AODV protocol are as follows. Route caches are small in AODV, because of its on-demand routing. Routes are guaranteed to be loop-free and valid. Convergence time is short for propagating changes in link states because link failure information will be propagated only to the nodes that are using a failed link (i.e., no broadcast for error packets). Information of a link failure will be propagated following the back pointers to reach such nodes. This implies that messaging overhead to announce link failures will be less than for DSR, where link failure information is broadcast. As another advantage, each data packet does not contain the complete list of all the nodes on a route in AODV, which reduces the size of message packet. Like DSR, a source node is aware of multiple alternative paths. One of the disadvantages of the AODV protocol is that nodes cannot perform routing (forwarding) packets as aggregate (at least in the latest existing implementation of AODV). This is because a set of pointers is used to maintain a route and each ‘flow’ requires its own pair of back and forward pointers. For nodes where a large number of connections exist, overhead for maintaining pairs of two pointers will be significant and may not be trafficload scalable. Another disadvantage is longer route acquisition delay compared to that for proactive protocols since route discovery must still take place on demand. Unlike DSR, AODV requires periodic ‘hello’ messages to maintain pointers set up at every node on a path. Use of broadcast during route discovery, which contributes to high messaging overhead, is still the major overhead.

3. SIMULATION ENVIRONMENT

QualNet Developer is ultra high-fidelity network evaluation software that predicts wireless, wired and mixed-platform network and networking device performance. Designed to take full advantage of the multi-threading capabilities of multi-core 64-bit processors, QualNet supports simulation of thousands of network nodes.

QualNet offers unmatched platform portability and interface flexibility. QualNet runs on sequential and parallel Unix, Windows, Mac OS X and Linux operating systems, and is also designed to link seamlessly with modeling/simulation applications and live networks.

3.1 Traffic model

Traffic model used in the simulation are CBR constant bit rate.

3.2 Energy Evaluation Model

We have taken the energy model as given by Marzoni and cano [20]. The traffic model parameters for CBR. Energy is converted in joules by multiplying power with time. The following equations are used to convert energy in joule:

Table 1: Traffic Model’s Parameters

Parameters	Value
MAC Type	IEEE 802.11
Antenna	Omni directional
Simulation Time	300 Seconds
Transmission Range	600m
Node Speed	10m/s
Traffic Type	CBR
Data Payload	512bytes/packet
Packet rate	8 packets/s
Node Pause Time	0
Mobility Model	Random Waypoint
Interface Queue Type	Drop Tail/Priori Queue
Interface Queue Length	50
No. of Nodes	5 to 15

4.

The overall goal of the work in this paper is to measure and compare the energy consumption behavior with increasing network size for proactive and reactive protocols. Our basic methodology consists of selecting the most represented parameter for a MANET, then defining and simulation time a basic scenario and finally the various selected parameters, they are 1. Terrain Region 2. No of Nodes 3. Pause Time 4. Simulation Time.

In this simulation, nodes moving according to a model called random way point

[8],[20], motion is characterized by two factors, a) maximum speed b) pause time during simulation each node starts moving from its initial position to a random target point, selected inside the simulation area. The motion speed value is uniformly distributed between zero and maximum speed, when a node near to the target point moves again. According to this scheme a pause time value is equal to simulation time corresponds to a static network, while a zero second pause time corresponds to a continuously changing network. All the traffic sources used in our simulation generated constant bit rate data traffic.

Number of scenarios we considered are MANET's with 5, 10 and 15 nodes randomly over a 600X600, node velocity is 36 Km/Hr and each simulation lasted 300 simulation seconds. We evaluated the performances indexes, energy consumed depending on the operations.

1. Energy Consumed in Transmit mode
2. Energy Consumed in Receive Mode
3. Energy Consumed in Idle Mode and
4. Routing Power
5. Through put
6. End-to-End Delay
7. Average Jitter

Power Consumption Mode

The mobile nodes in wireless mobile ad hoc network are connected to other mobile nodes. These nodes are free to transmit and receive the data packet to or from other nodes and require energy to such activity. The total energy [3], [12], [14], [16], [17], [20], of nodes is spent in following modes: (1) Transmission Mode (2) Reception Mode (3) Idle Mode and (4) Overhearing Mode. These modes of power consumption are described as:

4.1 Transmission Mode

A node is said to be in transmission mode when it sends data packet to other nodes in network. These nodes require energy to transmit data packet, such energy is called Transmission Energy (Tx) [8], [14], [18], of that nodes. Transmission energy is depended on size of data packet (in Bits), means when the size of a data packet is increased the required transmission energy is also increased. The transmission energy can be formulated as:

$$Tx = (330 * P\mathit{length})/2*10^6$$

And

$$P_T = Tx / T_t$$

Where Tx is transmission Energy, P_T is Transmission Power, T_t is time taken to transmit data packet and P*length* is length of data packet in Bits.

4.2 Reception Mode

When a node receives a data packet from other nodes then it said to be in Reception Mode and the energy taken to receive packet is called Reception Energy (R_x), [19], [22]. Then Reception Energy can be given as:

$$R_x = (230 * P\mathit{length})/2*10^6$$

$$\text{And } P_R = R_x / T_r$$

Where R_x is a Reception Energy, P_R is a Reception Power, T_r is a time taken to receive data packet, and P*length* is length of data packet in Bits.

4.3 Idle Mode

In this mode, [20], generally the node is neither transmitting nor receiving any data packets. But this mode consumes power because the nodes have to listen to the wireless medium continuously in order to detect a packet that it should receive, so that the node can then switch into receive mode from idle mode. Despite the fact that while in idle mode the node does not actually handle data communication operations, [12], it was found that the wireless interface consumes a considerable amount of energy nevertheless. This amount approaches the amount that is consumed in the receive operation. Idle energy is a wasted energy that should be eliminated or reduced. Then power consumed in Idle Mode is:

$$P_I = P_R$$

Where P_I is power consumed in Idle Mode and P_R is power consumed in Reception Mode.

4.4 Overhearing Mode

When a node receives data packets that are not destined for it, then it said to be in over-hearing mode [3], and it may consume the same amount of energy used in receiving mode. Unnecessary receiving these packets will consumes energy. Then power consumed in overhearing mode is:

$$P_{over} = P_R$$

Where P_{over} is power consumed in Overhearing Mode and P_R is power consumed in Reception Mode.

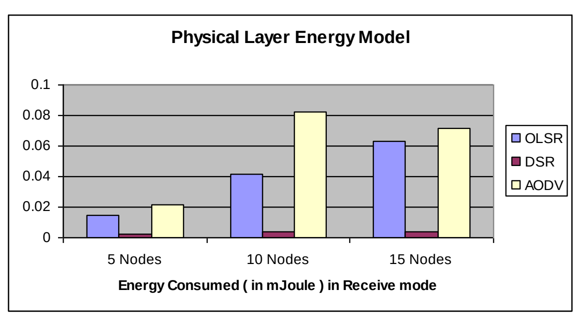


Table 2: Various Protocols Properties:

Protocol property	AVODV	DSR	OLSR
Multicast Routes	NO	YES	YES
Distributed	YES	YES	YES
Uni-directional link support	NO	YES	YES
Multicast	YES	NO	YES
Periodic Broadcast	YES	NO	YES
QoS support	NO	NO	YES
Routes maintained in reactive	Route Table YES	Route Catch YES	Route Table NO

5. RESULTS

We evaluated:

5.1 Energy consumed in transmit mode
: It is observed that energy consumed by OLSR protocol is maximum, DSR is minimum and AODV protocol consumes medium energy when compared to OSLS and DSR.

From the figure it is observed that the variance in energy consumed by OLSR protocol in Transmit mode is 0.007685, as the network size changes from 5 nodes to 15 nodes. In the case of DSR it is 0.00401 and in the case of AODV it is 0.0043009. When considering the energy consumed in Transmit mode OLSR is consumed more and DSR consumes very less in Transmit mode but in the case of AODV, it is consumes in between AODV and DSR.

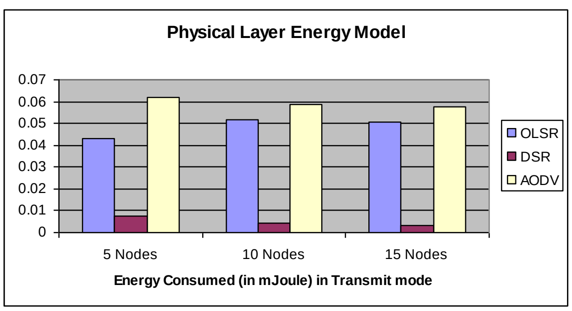


Figure 1: Comparison of OLSR, DSR and AODV protocols with respect to Energy Consumed in Transmit mode in Physical Layer

5.2 Energy consumed in receive mode
: It is observed that energy consumed by AODV protocol is maximum DSR is minimum and OLSR protocol consumes medium energy then compare to AODV and DSR.

From the figure it is observed that the variance in energy consumed by OLSR protocol in Receive mode is 0.048401, as the network size changes from 5 nodes to 15 nodes. In the case of DSR it is 0.001461 and in the case of AODV it is 0.049475. When we are considering the energy consumed in Receive mode AODV is consumed more and DSR consumes very less in receive mode but in the case of OLSR, it is consumed in between AODV and DSR.

Figure 2: Comparison of OLSR, DSR and AODV protocols with respect to Energy Consumed in Receive mode in Physical Layer

5.3 Energy consumed in idle mode
: It is observed that energy consumed by AODV protocol is maximum DSR is minimum and OLSR protocol consumes medium energy in idle mode when compared to AODV and DSR.

From the figure it is observed that the variance in energy consumed by AODV protocol in idle mode is 0.04531, as the network size changes from 5 nodes to 15 nodes. In the case of DSR it is 0.00101 and in the case of OLSR it is 0.04532. When we are considering the energy consumed in idle mode AODV consumed more and DSR consumes very less in idle mode but in the case of OLSR, it is consumes in between AODV and DSR.

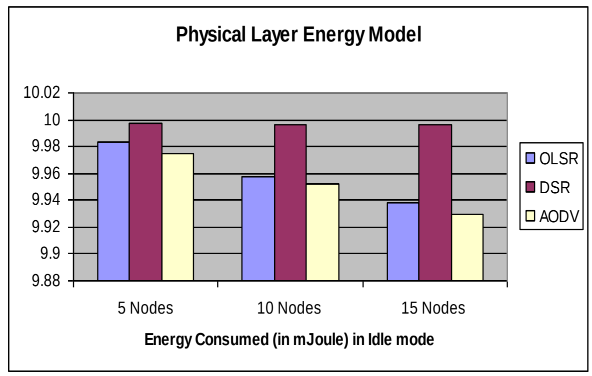


Figure 3: Comparison of OLSR, DSR and AODV protocols with respect to Energy Consumed in Idle mode in Physical Layer

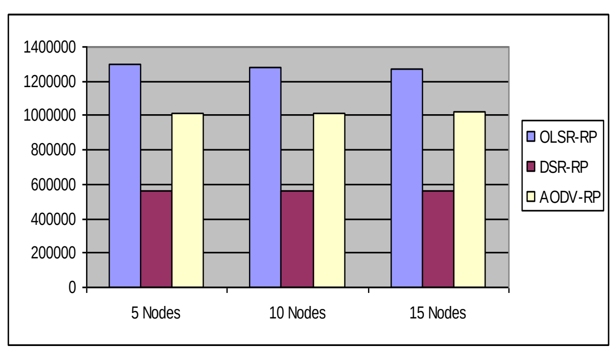
5.4 Routing Power

Routing Power is calculated by using the formula
Routing Power (RP) = (Throughput / Avg.End-to-End Delay)

As a network size varies from 5 nodes to 15 nodes it is found that there is no routing power effect on reactive routing protocols, but in proactive protocol (OLSR), routing power is reduced.

5.5 Throughput (Bits/s)

As a network size varies from 5 nodes to 15 nodes it is found that there is no effect on throughput.



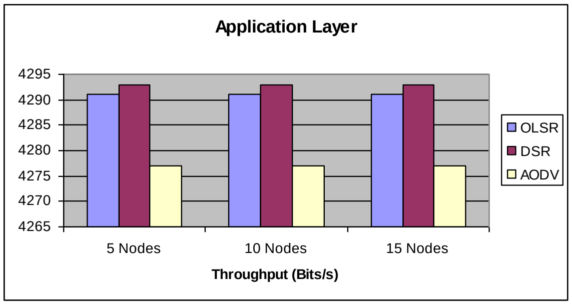


Figure 4: Comparison of OLSR, DSR and AODV Protocols with respect to Throughput in Application Layer.

5.6 Average End-to-End delay(s)

In case of AODV, the decreasing Average End-to-End delay is 0.0042271, in the case of DSR the Average End-to-End delay is 0.00344254 and in the case of OLSR the Average End-to-End delay is 0.0001477.

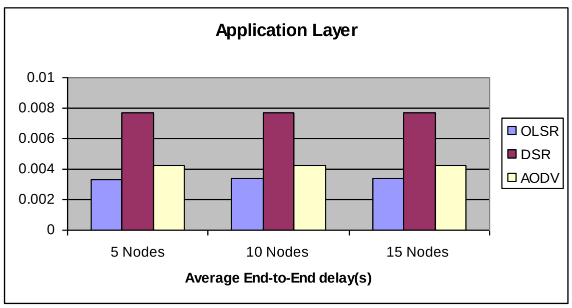


Figure 5: Comparison of OLSR, DSR and AODV Protocols with respect to Average End-to-End delay in Application Layer.

5.7 Average Jitter(s)

Average Jitter is minimum for DSR maximum for AODV and average in the case of OLSR, as a network size increases from 5 nodes to 15 nodes it is found that the increase in jitter in the case of AODV is 6.5061E-05, in case of DSR is zero and in the case of OLSR is 0.000018859. There is no impact of network size for the QoS metric of average jitter for DSR Protocol.

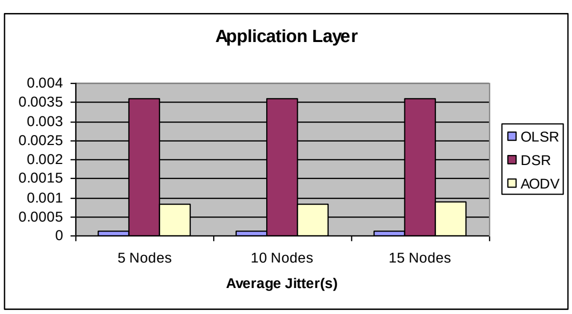


Figure 6: Comparison of OLSR, DSR and AODV Protocols with respect to Average Jitter in Application Layer.

6. CONCLUSION AND FUTURE SCOPE

We observed that increasing numbers of nodes also increase energy consumption due to routing control packets. We can reduce the energy consumption by reducing the number of routing control packets to increase the life time of network.

In future we will try to minimize the energy consumed by MANETS in different modes of operations by developing an algorithm for reducing the number of routing control packets.

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