A Comparative Analysis On Energy Consumption Of Routing Protocols For Mobile Ad-Hoc Sensor Networks

Md. Niaz Imtiaz[1]
Department of Computer Science and Engineering,
Pabna University of Science and Technology,
Pabna, Bangladesh.
E-mail: imtiaz.cse.buet@gmail.com

Subir Saha[2]
Department of Computer Science and Engineering,
Pabna University of Science and Technology,
Pabna, Bangladesh.
E-mail: ss.buet@gmail.com

***Abstract*—In Mobile Ad-hoc Sensor Network, routing is based on multi-hop routing from a source to destination. Here each node acts as a router. In MANET energy consumption is an important issue as most mobile hosts operate on limited battery resources. Due to limited battery power, nodes die out early and affect the network lifetime. This paper evaluates energy consumption for three ad-hoc routing protocols (AODV, OLSR and DYMO) in different network scales taking into consideration the mobility factor and network size. We calculate the energy consumed by a node, the average remaining energy of nodes and the total energy consumed due to a flow in the network. This paper shows the comparative analysis on energy consumed by the three protocols and also the impact of network properties on energy consumption.**

Keywords—Ad-hoc Network, Sensor Network, Power Aware Routing, Energy Consumption, AODV, OLSR, DYMO.

I. INTRODUCTION

Mobile ad hoc sensor network is an infrastructure-less multi-hop network, where each node communicates with other nodes directly or indirectly through intermediate nodes. Thus, all nodes in a Mobile ad hoc sensor network basically function as mobile routers participating in some routing protocol required for deciding and maintaining the routes. Mobile Wireless Sensor Network comprises of massive number of densely deployed resource constrained sensor nodes spatially distributed over a geographical region [5]. Since Mobile ad hoc networks (MANETs) are infrastructure-less, self-organizing, rapidly deployable wireless networks, they are highly suitable for applications involving special outdoor events, communications in regions with no wireless infrastructure, emergencies, natural disasters, and military operations. While configuring a MANET the main concern is enabling each device, to continuously maintain the information required for proper routing of the traffic. These networks may operate on their own or may be connected to larger Internet.

The main challenges of deployment of ad-hoc network are limited battery power, limited bandwidth, multi hop routing, dynamic topology and security. In particular, energy efficient routing may be the most important design criteria for MANETs, since mobile nodes will be powered by batteries with limited capacity [7][10]. Power failure of a mobile node not only affect the node itself but also its ability to forward packets on behalf of others and thus the overall network lifetime. For this reason, many research efforts have been devoted to developing energy aware routing protocols [11]. In this paper we analyze the power consumption of ad-hoc routing protocols-AODV, OLSR and DYMO in different network scenarios.

II. MANET ROUTING PROTOCOLS

Routing is the process of selecting paths in a network along which to send data or physical traffic. Routing directs the passing of logically addressed packets from their source toward their ultimate destination through intermediary nodes. A number of protocols have been developed for MANET [2]. According to routing strategy, routing protocols of ad hoc networks can generally be classified into three categories:

-**Table Driven Routing Protocols** such as DSDV, OLSR, STAR, CGSR.

-**On-demand Routing Protocols** such as AODV, DYMO, DSR.

-**Hybrid Routing Protocols** such as ZRP, ZHLS.

AODV

The AODV (Ad-Hoc On -demand Distance Vector protocol) [1] uses on-demand approach. Periodic exchange of routing information does not take place in this protocol. Here neighbor nodes store the route information of its next hop neighbors only. This protocol is based on two mechanisms i.e. route discovery and route maintenance. AODV nodes use four types of messages to communicate among each other. Route Request (RREQ) and Route Reply (RREP) messages are used for route discovery.

Route Error (RERR) messages and HELLO messages are used for route maintenance. The destination sequence number is used to make this routing protocol loop free and identify the most recent paths [2]. When route for destination is not available, the source floods the Route Request packet in the network. It consists of source identifier, destination identifier, source and destination sequence number, broadcast identifier and time to live field. When a node has to send data and wants a path to the destination, it sends Route Request message to the next neighbor nodes. The node which receives this message either forwards it to the next node or sends a Route Reply message if it has a path to the destination. AODV does not repair the broken links locally. When a link breaks between any two nodes, they send a Route Error message to inform the end nodes about the link break and this link is removed from the table of the end nodes. Once again the source starts the path finding process with a new broadcast ID and old destination number [1].

OLSR

OLSR (Optimized Link-State Routing protocol) being a proactive protocol, routes are already available in routing table, so no route discovery delay is associated. OLSR is an optimization of classical link state routing protocol. Key concept here is MPRs (Multi Point Relaying). Instead of allowing each node to broadcast topology messages only selected nodes (MPRs) are used to broadcast topology information during flooding process [6]. This significantly reduces the overhead caused by flooding in link state routing protocol. OLSR is characterized by two types of control messages: neighborhood and topology messages, called respectively HELLO messages and Topology Control (TC) messages. HELLO messages are used to identify local topology information, setting TTL to 1. Now, nodes perform distributed election to elect a set of MPRs from its neighbors based on fact which neighbor provide shortest forwarded path to all of its 2 hop neighbors [4]. To diffuse topology information, nodes periodically exchange Topology Control (TC) message with their neighbors. Upon receiving this information every node in network is aware of the fact which MPR to follow if they wish to communicate with one of the MPR's selector [6].

DYMO

Dynamic MANET On-demand (DYMO) routing protocol enables reactive, multi-hop unicast routing between participating DYMO routers [3]. DYMO is an enhanced version of AODV. DYMO operation is split into route discovery and route maintenance. Routes are discovered on-demand when the originator initiates hop-by-hop distribution of a RREQ (rout request) message throughout the network to find a route to the target, currently not in its routing table. This RREQ message is swamped in the network using broadcast and the packet reaches its destination. The target then sends a RREP (route reply) to the source. Upon receiving the RREP message by the source, routes have been established between the two nodes. For maintenance of routes which are in use, routers elongate route lifetimes upon successfully forwarding a packet [5]. In order to react to changes in the network topology, routers monitor links over which traffic is flowing. When a data packet is received for forwarding and a route for the destination route is broken, missing or unknown, then the source of the packet is notified by sending a RERR (route error) message. Upon receiving the RERR message, the source deletes that route. In future, it will need to perform route discovery again, if it receives a packet for forwarding to the same destination [3]. DYMO uses sequence numbers to ensure loop freedom and enable them to determine the order of DYMO route discovery messages, thus avoiding use of outdated routing information.

III. SIMULATION

To evaluate the energy consumption performance of AODV, DYMO and OLSR routing protocols in wireless sensor networks a simulation study is performed.

Simulator

We have used NS-2 (version- 2.34) as a simulator [13][14] to model and simulate our scenario architecture.

Simulation Environment

We have designed various scenarios with nodes ranging from 10 to 50, pause time ranging from 0s to 100s and node speed ranging from 0m/s to 40 m/s deployed in field configuration of 500x500 m^2. In the scenario TCP (Transmission Protocol) connection was used and data traffic of File Transfer Protocol (FTP) was applied between source and destination. Each simulation was carried out for 120 seconds.

Parameter	Value
Network Simulator	NS-2.34
Protocols Studied	AODV, OLSR, DYMO
Simulation Area	500x500 m^2
Traffic Sources	FTP
Packet Size	512 bytes
Node Movement Model	Random Waypoint Mobility
Simulation Time	120s
No. of Nodes	10,20,30,40,50
Pause Time	2s, 20s, 40s, 60s, 80s, 100s
Node Mobility	Min- 0 m/s, Max- 40 m/s

Table 1: Simulation Parameters

Performance Metrics

Throughput is the measure of the number of packets or data successfully transmitted to their final destination via a communication link per unit time. It is measured in bits per second (bps) or Mega bits per second (Mbps).

Total Energy Consumption is the summation of consumed energy by all nodes.

Maximum Energy Consumption is the highest energy consumed by a particular node.

Average Remaining Energy is the mean of remaining energy of nodes.

IV. SIMULATION RESULTS AND ANALYSIS

We performed our experiment with different scenarios like varying node density, varying pause time and varying node mobility.

A. Different Node Density

In this scenario, all the three routing protocols are evaluated in different number of nodes (10, 20, 30, 40, 50), keeping other factors fixed and the four performance metrics – Throughput, Total Energy Consumption, Maximum Energy Consumption and Average Remaining Energy are evaluated.

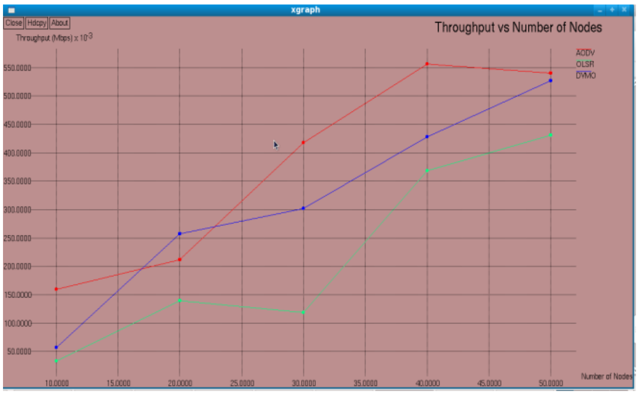

Figure 1: Throughput vs No. of Nodes

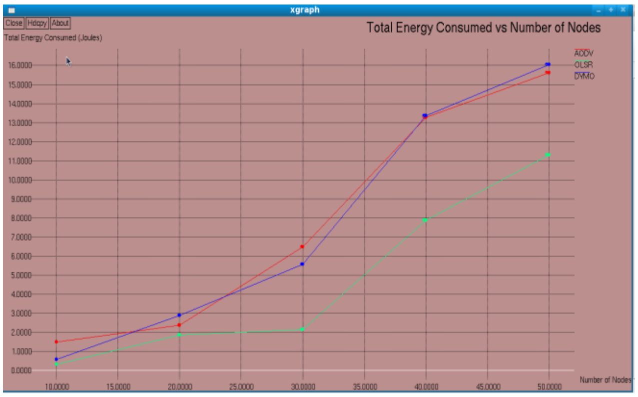

Figure 2: Total Energy Consumption vs No. of Nodes

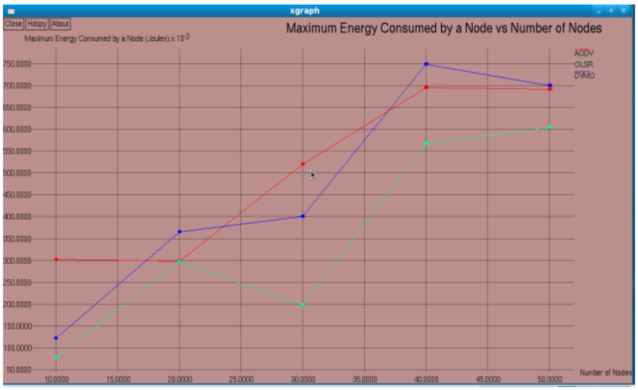

Figure 3: Maximum Energy Consumption vs No. of Nodes

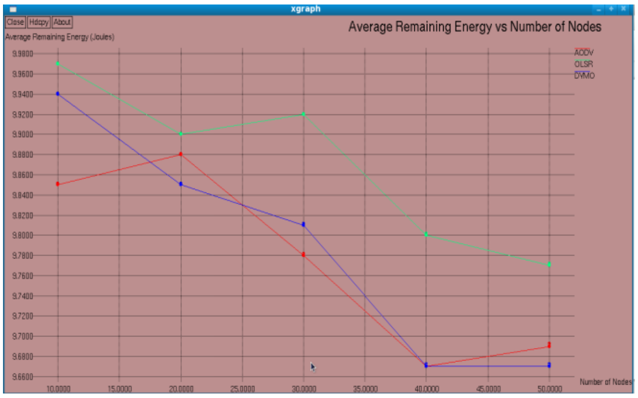

Figure 4: Average Remaining Energy vs No. of Nodes

From the above graphs we see that if the number of nodes increases throughput increases, because total number of sent or received packets increases. The throughput of OLSR is low with respect to AODV and DYMO. AODV performs well in terms of throughput with high node density.

The total energy consumption increases as the number of node increases. This is because more nodes send or receive more packets and consume more energy. OLSR consumes less energy with respect to AODV and DYMO. Maximum energy consumption of a particular node increases when number of nodes increases, because when number of nodes increases it is probable that one of the nodes may have more adjacent neighbors than before. So that node consumes more energy than before while transmitting more packets to neighbors. Here OLSR performs well than others. OLSR has more average remaining energy than AODV and DYMO.

B. Different Pause Time

In this scenario, all the three routing protocols are evaluated in different pause time (2s, 20s, 40s, 60s, 80s, 100s), keeping other factors fixed.

Figure 5: Throughput vs Pause Time

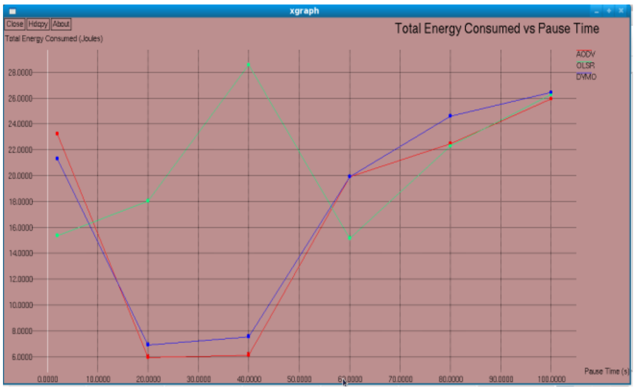

Figure 6: Total Energy Consumption vs Pause Time

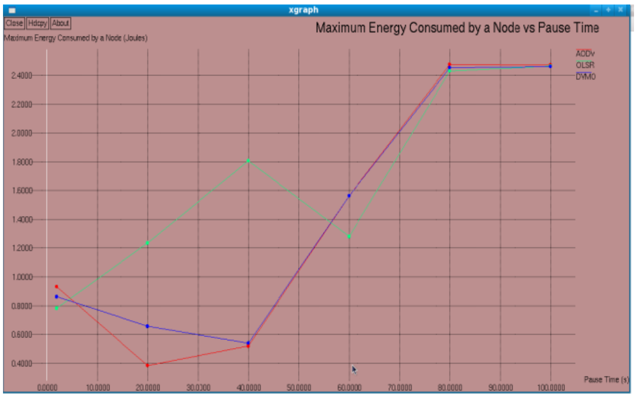

Figure 7: Maximum Energy Consumption vs Pause Time

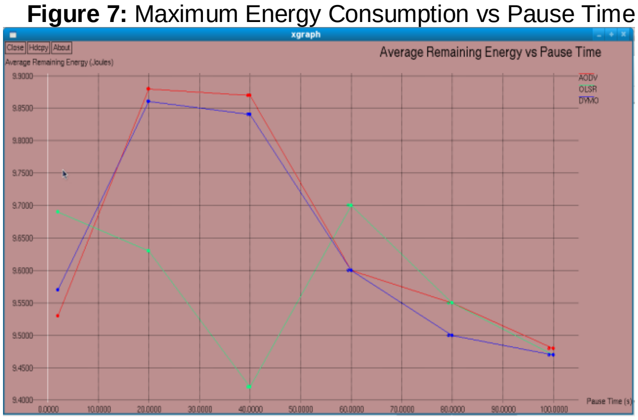

Figure 8: Average Remaining Energy vs Pause Time

Above graphs show that throughput increases when node position changes slowly. More frequent change of node position gives low throughput. When nodes move more frequently energy consumption is higher and remaining energy per node decreases. Here there are no significant changes in energy consumption of three protocols.

C. Different Node Mobility

In this scenario, all the three routing protocols are evaluated in different node mobility (0 m/s, 0.1 m/s, 1m/s, 5m/s, 10m/s, 20m/s, 30m/s), keeping other factors fixed.

Figure 9: Throughput vs Node Mobility

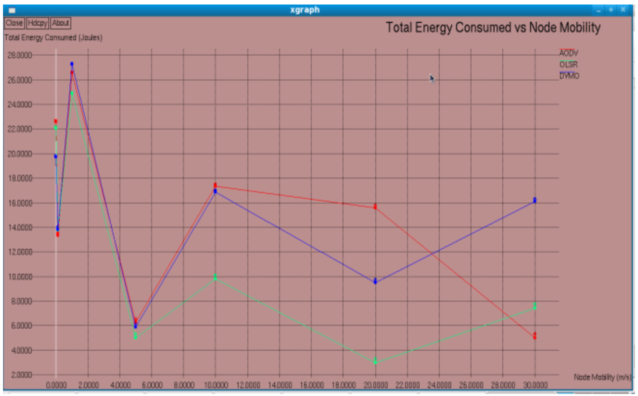

Figure 10: Total Energy Consumption vs Node Mobility

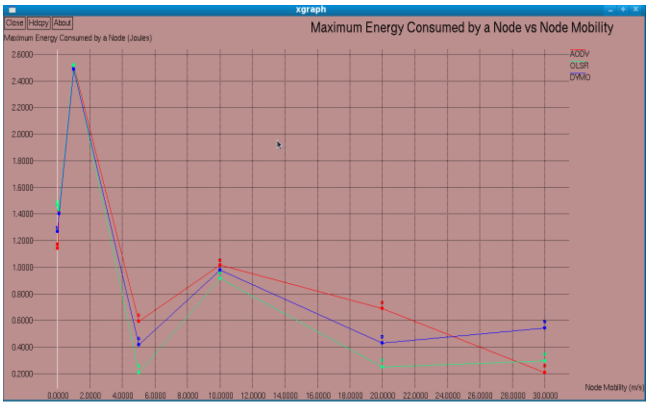

Figure 11: Maximum Energy Consumption vs Node Mobility

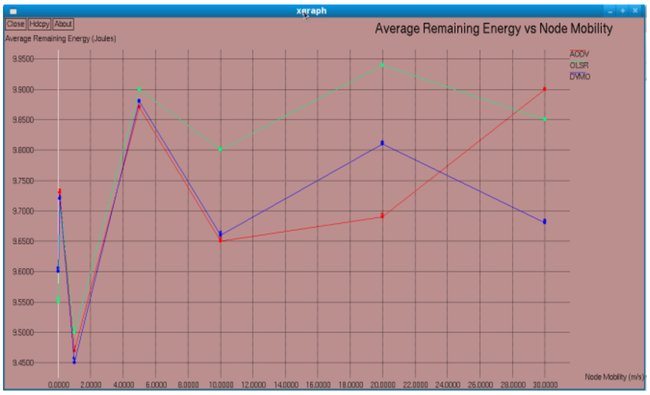

Figure 12: Average Remaining Energy vs Node Mobility

Above graphs show that throughput decreases as mobility of nodes increases. This is because packet drop increases when mobility of nodes increases. OLSR gives low throughput than others. Energy consumption does not change significantly as mobility of nodes changes. This is because for high mobility of nodes, packet-drop increases, so less energy is required for receiving packets. But as node moves more speedily more energy is consumed by nodes for moving. That makes no significant changes in total energy consumption. OLSR consumes less energy and has more average remaining energy than AODV and DYMO.

V. CONCLUSION

This study has evaluated three ad-hoc routing protocols in different network environment taking into consideration node density, pause time and node mobility. The analysis of results shows that number of nodes, pause time and node mobility have effects on energy consumption. While configuring a network we have to keep in mind of these factors. Overall, the findings show that the energy consumption in small size networks does not reveal any significant differences. For medium and large size networks OLSR consumes less energy than AODV and DYMO. So the average remaining energy is higher in OLSR and that makes networks last more long time. OLSR also saves energy than the other two when node movements are frequent and fast though the throughput of OLSR is lower than that of AODV and DYMO.

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