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An Improved Energy Efficient Optimized Link-State Routing Protocol for Mobile Ad-hoc Sensor Networks

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ABSTRACT

Mobile Ad-Hoc Network (MANET) is a collection of wireless mobile nodes forming a temporary network without using any centralized access point or infrastructure. In MANET each node acts as a router and forwards data packets to other nodes in the network. The main limitation of MANET is the restricted battery capacity. Since most mobile hosts in MANET operate on limited battery resources, power management become a critical issue. In this article we calculate and compare energy consumption of Optimized Link-State Routing (OLSR) with that of AODV and DYMO in different network scenarios taking into consideration the mobility factor and network size. Extensive simulations in ns-2 simulator environment show that OLSR outperforms AODV and DYMO in terms of energy consumption and network life time. Then we propose an improvement of OLSR in energy consumption aspect.

Keywords: *MANET, Wireless Sensor Network, OLSR, AODV, DYMO, Energy Efficient Routing, Transmission Power Control.*

1. INTRODUCTION

Now-a-days communication has become very important for people to exchange information anytime from and to anywhere. Mobile Ad- Hoc Networks (MANETs) plays an important role in today's communication. Mobile Ad- Hoc Networks (MANETs) have evolved rapidly in the field of wireless networks. These are infrastructure less networks where routers and hosts providing access points are not fixed. In MANETs each node communicates with other nodes directly or indirectly through intermediate nodes [1]. In order to provide communication throughout the network, the mobile nodes must cooperate to handle network functions, such as packet routing. The wireless mobile hosts communicate in a multi-hop fashion [7] [13]. In multi-hop wireless ad-hoc networks, designing energy-efficient routing protocols is critical since nodes have very limited energy, computing power and communication capabilities. 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.

Since the participating nodes in MANETs are not fixed it leads to dynamic change in MANET topology as per the availability of nodes. Also for transmission of packets intermediate nodes plays very important role, because transmission of whole information is with cooperation among the nodes which are engaged in transmitting and forwarding the packets. But in some situations cooperative behavior of nodes may be lost or a mobile node may be failed to cooperate other nodes in network. Such situations are moving out of the transmission range of its neighbors, exhausting battery power, malfunctioning in software or hardware, or even leaving the network [10]. Exhausting battery power affects efficiency of nodes the most. The nodes in MANETs depend on some means of energy or power. The energy resources are limited and can't be preserved for longer time as a result, nodes in MANET may stop transmitting and/or receiving for arbitrary time period [14]. In this paper we have given a comparative energy consumption analysis of OLSR, AODV and DYMO. Then we have given a proposal of an improved OLSR protocol which will consume less energy than existing OLSR, Energy-efficient Broadcast OLSR and Energy-Efficient OLSR.

2. ROUTING IN MANETS

Routing is the process of finding a path from a source to destination among randomly distributed routers. Routing protocols in MANETs are classified as follows-

Proactive Protocols

Proactive protocols route to all reachable nodes in network available also they have lower latency due to maintenance of routes all the time. For this it can have much higher overhead due to frequent route updates. The advantage of proactive type protocol is they have minimal initial delay for application. Examples: OLSR, DSDV, STAR.

Reactive Protocols

Reactive protocols have higher latency since the route have to be discovered when the source node initiate a route request. So this type of protocols has lower overhead since routes are maintained only on demand basis but there is a long delay for application when no route to the destination available. Examples: AODV, DSR, DYMO.

Hybrid Protocols

Hybrid routing protocols, which incorporate the merit of proactive (table driven) and reactive (on-demand) routing protocol. It combines the advantage from proactive protocol to find node's neighborhoods as well as reactive protocol for routing between these neighborhoods. Examples: ZRP, ZHLS.

OLSR

Optimized Link-State Routing (OLSR) is a proactive routing protocol [12], so the routes are always immediately available when needed. OLSR is an optimized 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) [2][12]. The idea of MPR is to reduce flooding of broadcasts by reducing the same broadcast in some regions in the network. The reduction of time interval for the control messages transmission can bring more reactivity to the topological changes. OLSR uses two kinds of the control messages: Hello and Topology Control. Hello messages are used for finding the information about the link status and the host's neighbors. With the Hello message the MPR Selector set is constructed which describes which neighbors has chosen this host to act as MPR and from this information the host can calculate its own set of MPRs. The Hello messages are sent only one hop away but the TC messages are broadcasted throughout the entire network. TC messages are used for broadcasting information about own advertised neighbors. The TC messages are broadcasted periodically and only the MPR hosts can forward the TC messages [5].

AODV

Ad hoc On-demand Distance Vector Routing (AODV) is an on demand routing protocol as it determines a route to the destination only when a node wants to send data to that destination [3]. The source node broadcasts a route request (RREQ) packet when it wants to find path to the destination. The neighbors in turn broadcast the packet to their neighbors until it reaches a transitional node that has recent route information about the destination or until it reaches the destination. An already received route request packet is redundant by the nodes. The route request packet uses sequence numbers to ensure that the routes are loop free and that the intermediate node replies to route requests are the most recent. A node records the node from which request packet received first to erect the reverse path for route reply to source node. As the route reply packet traverses back to the source, the nodes along the path enter the forward route into their tables. Due to the mobile nature of nodes, route maintenance is required. If the source moves then it can reinitiate route discovery to the destination. If one of the intermediate nodes move then moved nodes neighbor realizes the link failure and sends a link failure notification to its upstream neighbors and so on until it reaches the source upon which the source can reinitiate route discovery if needed [3]. AODV has greatly reduced the number of routing messages in the network. AODV only supports one route for each destination. This causes a node to reinitiate a route request query when it's only route breaks. But if mobility increases route requests also increases.

DYMO

The Dynamic MANET On-demand (DYMO) routing protocol is a simple and fast routing protocol for multi-hop networks. DYMO, reactive by nature very well handles dynamic topology networks. Also, storage of active routes make their suitability for memory constrained networks like WSNs. DYMO comprises of two basic operations: Route Discovery and Route Maintenance [4]. In Route Discovery, originating node inject a RREQ (Route Request) message into the network to compute route to target. As the RREQ message travels from one hop to another each one set its path to originator. When target receives RREQ it responds with RREP (Route Reply) message. Each intermediate hop that receive RREP message set its path for target. When originator receives RREP message, route has been established in both directions. In route maintenance phase, each hop between originator and target keep an eye on route. Whenever target is unapproachable, originator is notified with RERR (Route Error) message; it deletes the existing route and disseminates a new RREQ message in search of a new route for that destination in network. Sequence number enables nodes to determine the order of DYMO route discovery messages, thereby avoiding use of stale information.

3. SIMULATION

We have used NS-2 (version- 2.34) as a simulator to model and simulate our scenario architecture [15][16]. We have designed various scenarios with nodes ranging from 10 to 50, pause time ranging 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
Simulator	NS-2.34
Routing Protocols	OLSR, AODV, DYMO
Simulation Space	500x500 m^2
Traffic Type	FTP
Packet Size	512 bytes
Mobility Model	Random Waypoint Mobility
Simulation Time	120s
Number of Nodes	10 to 50
Pause Time	2s to100s
Node Velocity	0 m/s to 40 m/s

Table 1: Simulation Parameters

4. SIMULATION RESULTS AND ANALYSIS

Performance Metric: We have used Average Remaining Energy as performance Metric. Average

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Remaining Energy is the mean of remaining energy of nodes.

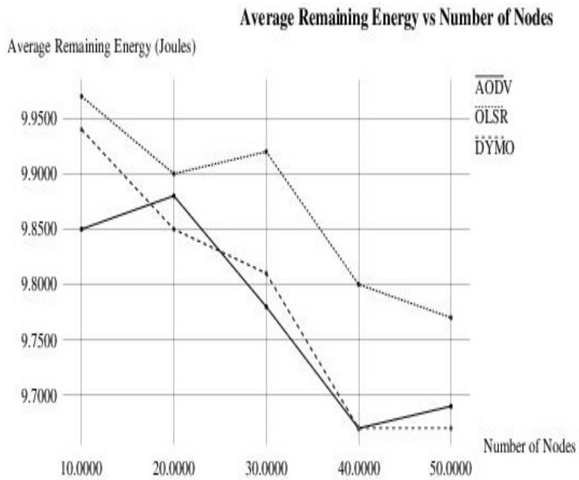

Figure 1: Average Remaining Energy vs No. of Nodes

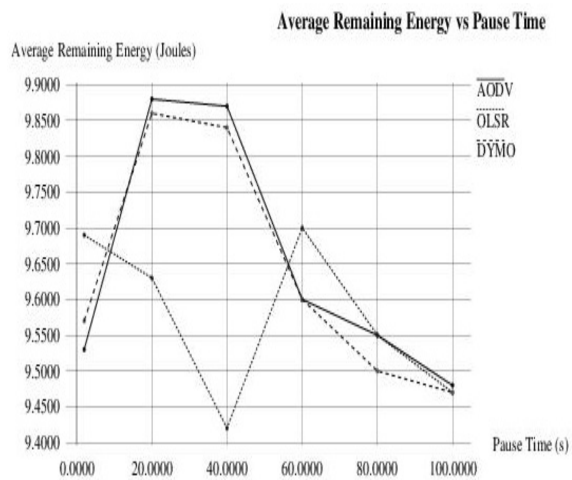

Figure 2: Average Remaining Energy vs Pause Time

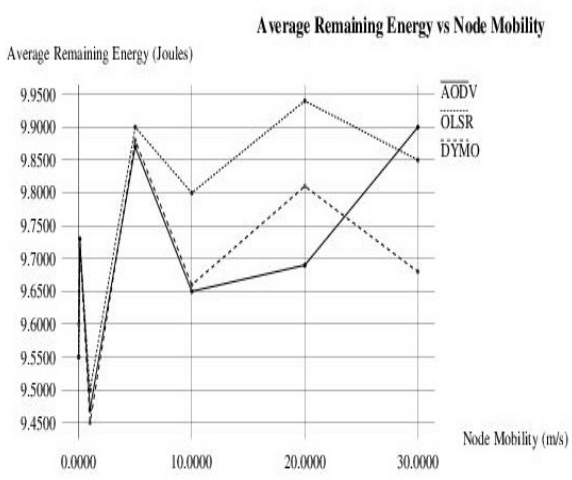

Figure 3: Average Remaining Energy vs Node Mobility

Figure-1 shows that Average Remaining Energy of OLSR is higher than AODV and DYMO for both lower and higher number of nodes. That is OLSR consumes less energy than AODV and DYMO in small, medium and large networks. Figure-2 shows that pause time does not make significant changes in energy consumption. From Figure-3 we can see that when mobility of nodes is faster, Average Remaining Energy of OLSR is higher than AODV and DYMO. That is OLSR performs well than AODV and DYMO in energy consumption aspect for highly moving nodes. So we can conclude that OLSR consumes less energy and lasts more long time than AODV and DYMO in all scenarios.

Now we are going to propose a further improvement of OLSR protocol so that it can be more efficient in term of energy consumption and the network lasts longer time. Before that we want to discuss some issues.

5. ENERGY EFFICIENCY OVERVIEW

For wireless networks, the devices operating on battery try to pursue the energy efficiency heuristically by reducing the energy they consumed, while maintaining acceptable performance of certain tasks. Using the power consumption is not only a single criterion for deciding energy efficiency. Actually, energy efficiency can be measured by the duration of the time over which the network can maintain a certain performance level, which is usually called as the network lifetime. Hence routing to maximize the lifetime of the network is different from minimum energy routing [8][13].

Minimum energy routes sometimes attract more flows, and the nodes in these routes exhaust their energy very soon; hence the whole network cannot perform any task due to the failure on these nodes. In other words, the energy consumed is balanced consumed among nodes in the networks. Routing with maximum lifetime balances all the routes and nodes globally so that the network maintains certain performance level for a longer time [9]. Hence, energy efficiency is not only measured by the power consumption but in more general it can be measured by the duration of time over which the network can maintain a certain performance level.

There are lots of ways to categorize routing algorithms. However, now we classify them into 3 types. One is flooding and broadcast routing, which is often necessary during the operation of the wireless network, such as to discover node failure and broadcast some information. The second kind is multicast routing, which is very common in wireless networks, to communicate in a one-to-group fashion. The last is unicast, which is always in an end-to-end fashion and the most common kind of routing in networks. It goes without saying that node failure is very possible in the wireless network. Hence saving energy when broadcasting in order to recover from the node failure or to re-routing around the failed nodes is essential [6]. By the same token, multicast has the same challenge to achieve the energy efficiency. For unicast, it is highly related to the node and link status, which require a wise way to do routing as well. Sometimes, shortest path routing is possibly not the best choice from the energy efficiency point of view.

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OLSR is an optimization of classical link state routing protocol. Key concept here is MPRs (Multipoint Relaying). Instead of allowing each node to broadcast topology messages only selected nodes (MPRs) are used to broadcast topology information during flooding process. There are two improved versions of OLSR protocol: Energy-efficient Broadcast OLSR (EBOLSR) and Energy-Efficient OLSR (EEOLSR) [14]. In EBOLSR energy efficient MPR selection is done by the residual energy of nodes. In this protocol we consider the weighted residual energy of energy efficient MPR candidate and its 1 hop neighbors. EEOLSR is another enhancement of OLSR. Two mechanisms are used in this protocol- EA-Willingness Setting mechanism and Overhearing Exclusion mechanism. In EA-Willingness setting mechanism we consider the energy state of the node in MPR selection. Every node shows the willingness for being an MPR heuristic value of the node (default, high, low) is used to determine which node can work as an MPR. The heuristic value is calculated with the help of battery capacity and predicted lifetime of a node. If the battery charge is low that node will have LOW heuristic value whereas if the battery is highly charged and there exist a low traffic in that node then the node will have HIGH heuristic value. In the overhearing Exclusion device is turned off when neighborhood nodes exchanges message with each other. This method saves significant amount of energy.

6. OUR PROPOSAL

Our proposed energy efficient OLSR protocol concerns the following issues:

Discovery of Minimum Energy Routes

The main aim of proposed scheme is to discover the minimum power-limitation route. The power limitation of a route is decided by the node which has the minimum energy in that route. A node can have multiple neighbors (1-hop) as candidate for MRP. From those neighbors the node will select the neighbor which has high Energy Factor.

Let

EF= Energy Factor of a node

RE= Remaining Energy of the node

IE= Initial Energy of the node

Energy Factor (EF) is calculated using the following formula:

$$EF = RE / IE$$

The selection of candidate for MRP is not fixed in manner. That is Energy Factor (EF) will be updated continuously. So every time a node is willing to send a packet it will compute the neighbor’s Energy Factor and will select the neighbor which has high Energy Factor. Then it will search all shortest paths, then path having minimum energy level is chosen and to perform this task route request is generated that consist of two piece of information hop count and energy consumption. Hop count is updated at every intermediate node level. Another thing is that a device will be turned off when its neighborhood nodes exchanges messages with each other.

Route Maintenance

A node uses a Hello message, which is a periodic local broadcast by a node to inform each mobile node in its neighborhood to maintain the local connectivity. Instead of flooding Hello messages to all the neighbors a node will use Hello messages if it is part of an active route.

Transmission power control

This mechanism can be implemented by modifying the routing header of the data-packet to include the power at which the packet was transmitted by the source node. There will be a minimum power level for successful reception of a packet. The minimum power level required for a successful reception will also be included in the routing header of the data-packet. Then each node forwarding the packet can simply look up the next hop in the source route and the minimum power required getting there and transmits the packet at the controlled power level.

7. CONCLUSION

Mobile Ad- Hoc Networks (MANETs) have evolved rapidly in the field of wireless networks. But due to limited battery power, nodes die out early and affect the network lifetime. So it is very important to manage the network in energy efficient way. In this paper energy consumption behavior of three routing protocols (OLSR, AODV and DYMO) is analyzed. We have considered different scenarios in terms of size of networks, pause time and mobility of nodes. From the analysis it is found that OLSR performs well in term of energy than AODV and DYMO in all scenarios. Then we propose a further improvement of OLSR. We have proposed a proper process of discovering minimum energy routes, maintaining routes and controlling transmission power, that will give energy efficient and long lasting communications.

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