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# Simulation and performance comparison among different routing protocols for Wireless Sensor Networks

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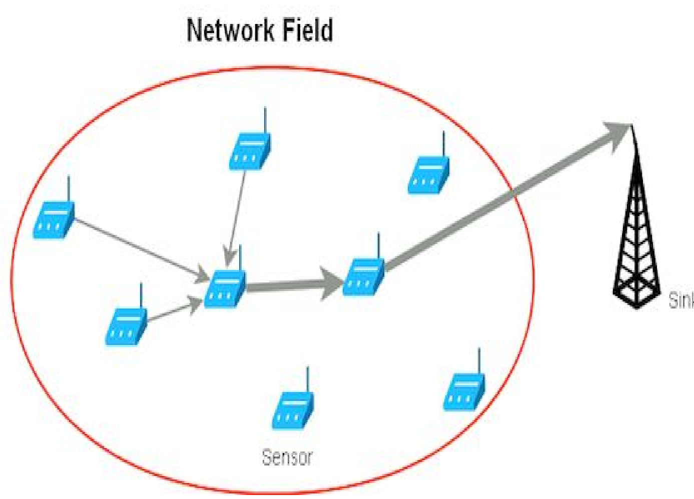
**Abstract**— WSN is emerging as a major research field in computer networks over the last years due to its wide variety of embedded real time applications.These networks consists of tiny, autonomous sensor nodes. Nodes of these networks functions as a hosts and routers which discover and maintains the routes to other nodes in the network. Nodes are also able to move and synchronize with the neighbors. Due to mobility, connections in the network can change dynamically and nodes can added and removed at any time. in this paper, we are going to compare wireless sensor network's routing protocols OLSR(Optimized Link-State Routing protocol), DYMO(Dynamic Manet On demand) and ZRP(Zone Routing Protocol) using NS - 2(network simulator - 2.34). Several simulations were carried out under varying size of network and offered load for performance evaluation and comparison of protocols is reported in terms of average end-to-end delay, throughput and jitter..

**Index Terms**— WSN, OLSR, DYMO, ZRP, NS-2, End-to-End Delay, Throughput, Jitter

## 1 Introduction

A Wireless Sensor Network(WSN) is a network of many sensor tiny nodes, having wireless channel to communicate with each other(Picture 1). Without any centralized control and predefined communication link, it can tranfer signals to the exterior world. All nodes of this network are capable to act as source or sink node at the same time and distributed over a geographical region. So, they can respond to a particular event in a monitored environment. Recent studies, shows that the employment of WSNs for industrial applications is expected to increase at an exponential pace in coming years with their intrusion in the fields of logistics, automation and control. They have emerged as a new class of large scale networks of embedded systems with limited communication, computation and energy resources.Sensors aim at collaborative effort to gather and share information about a particular phenomenon and forward the processed information to sink node. Sink nodes acts as a gateway between sensors and end user. End user can retrieve information by querying WSN or gathering information from sink nodes. However, main constraint is finite energy supply because sensor operates on battery and deployed over hostile and difficult locations, causing it very much difficult to recharge exhausted battery, end up partitioning from network. Thus, it is critical and challenging to design long lived WSN with the energy constraints. Routing in this network is difficult due to their infrastructure less deployment. Routing protocol as an indispensable part of the ad hoc network takes on the responsibility to assist these sensor nodes to discover multi-hop paths and forward packages correctly and smoothly to destinations. Many different routing protocols have been proposed in the past decade based on different assumptions and intuitions. Since the routing protocol is one of the determinant factors of the performance of ad hoc networks, the research that compares different protocols in a realistic setting is necessary and valuable. In this paper, we conduct a set of simulating experiments to analyze and compare the performance of three prevalent ad hoc routing protocols in WSN i.e. OLSR, DYMO and ZRP using Network Simulator 2 simulation software. The metrics adopted in experiments include average end-to-end delay, throughput and jitter. The rest of this paper is organized as follows: In section 2, we briefly introduce the routing protocols. In section 3, the simulation and performance analysis. Section 4 discusses the experiments. Section 5 concludes the experimental results.




Picture 1. A Wireless Sensor Network

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## 2 Routing Protocols

### 2.1 Routing in Wireless Sensor Networks

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.
So routing protocol is the routing of packets based on the defined rules and regulations. Routing protocols in WSNs depends on network architecture and application. Sensors nodes have limited available power. So that energy efficient routing protocols is truly crucial for life of WSN. Therefore, while traditional networks aim to achieve high quality of service (QoS) provisions, sensor network protocols must focus primarily on power conservation. To deal with this, an extensive amount of research was done and still going on towards the optimization of data dissemination for sensor networks. Sheer numbers of inaccessible and unattended sensor nodes, which are prone to frequent failures, make topology maintenance a challenging. This implies that routing protocol must also possess self-adaptation capabilities to frequently varying network topology and link status. On the basis of route determination, routing protocols are categorized in three ways: proactive (Table driven), reactive (On Demand) and hybrid routing protocols. Proactive protocol discovers the network topology and computes the routes are pre-determined well earlier than it is actually required. WSN dynamic topology necessitates revision of all routing tables periodically. On other hand, a reactive protocol doesn't require prior route discovery or knowledge of network topology for data dissemination; route is setup only when traffic flow has been started addressed to a destination. Hybrid protocols amalgamate advantages of proactive and reactive protocols.

### 2.2 Routing Protocols Categories

1. On-Demand or Reactive protocols, which construct only necessary routes on demand. In these protocols the routes are created only when source wants to send data to destination. This strategy is suitable for large, high mobility networks. The major representative protocols are AODV, DYMO and DSR.

2. Table-driven or proactive protocols, where each node maintains routing information for every possible destination. They usually use link-state routing algorithms for flooding the link information. In proactive routing, each node has one or more routing tables that contain the latest information of the routes to any node in the network. These protocols are not suitable for larger networks, as they need to maintain node entries for each and every node in the routing table of every node. This causes more overhead in the routing table leading to consumption of more bandwidth. DSDV and OLSR are the main representative protocols(Ianetal2004).

3. Hybrid protocols, which combine on-demand and proactive routing, like Zone Routing protocol (ZRP).

### 2.3 Routing Protocol Analysis

a.OLSR

OLSR (Optimized Link-State Routing protocol) is a proactive protocol and 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 of this protocol 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. This significantly reduces the overhead caused by flooding in link state routing protocol. OLSR is characterized by two types of control messages: neighbourhood and topology messages, called respectively Hello messages and Topology Control (TC) messages. HELLO messages are used to identify local topology information. So, nodes perform distributed election to elect a set of MPRs from its neighbours based on fact which neighbour provide shortest forwarded path to all of its 2 hop neighbours.To diffuse topology information, nodes periodically exchange Topology Control (TC) message [12] with their neighbours. 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.

b.DYMO

The Dynamic MANET On-demand (DYMO) routing protocol is a fast and simple routing protocol for multi-hop networks.
DYMO reactive by nature very well handles dynamic topology networks. Moreover, storage of active routes make their suitability for memory constrained networks like WSNs. DYMO comprises of two basic operations: Route Discovery and Route Maintenance. In Route Discovery, the originating node inject a RREQ (Route Request) message into the network to compute route to the target. As the RREQ message travels from one hop to another each one set its path to originator. When the target receives RREQ it responds with a RREP (Route Reply) message. Each intermediate hop that receive RREP message set its path for the target. When the originator receives RREP message, route has been established in both directions. In Route Maintenance phase, each hop between the originator and the target keep an eye on route. Here, the target is unapproachable, the originator is notified with a RERR (Route Error) message. This message 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.

c.ZRP

Zone Routing Protocol belongs to the class of hybrid routing Protocols and is the first hybrid protocol that uses both proactive and reactive routing protocols when sending information over the network. This routing protocol comprises of two sub-protocols: IERP(Inter-zone Routing Protocol) which uses a reactive protocol, and IARP(Intra-zone Routing Protocol) which uses a proactive protocol.IERP is used between routing zones while IARP is used inside routing zones. IARP uses a routing table. Since this table is already stored, this is consid-

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ered a proactive protocol. Any route to a destination that is within the same local zone is quickly established from the source's proactively cached routing table by IARP. Therefore, if the source and destination of a packet are in the same zone, the packet can be delivered immediately. Most existing proactive routing algorithms can be used as the IARP for ZRP.

## 3 Simulation and Performance Analysis

### 3.1 Simulation Environment

We have designed various scenarios with nodes ranging from 3 to 150 deployed in field configuration of 2000x2000 m2. We have used IEEE 802.15.4 MAC and physical radio. Antenna Model is Omni-directional and height is 1.5m and 0 dB antenna gain.The source node generates constant bit rate (CBR) traffic of 100 packets of 72 bytes. Traffic load is variable in each scenario because of varying number of CBR (Constant Bit Rate) traffic sources.Table 1 summarizes the simulation parameters.

| Parameter | Values |
|---|---|
| Routing Protocols | ZRP, OLSR, DYMO |
| Simulation Area | 2000 X 2000 m2 |
| Pathloss Model | Two-Ray |
| Shadowing Model | Constant |
| Data packet Rate | 100 packets/sec |
| Data packet size | 72 bytes |
| Propagation Limit | -111.0 dBm |
| Modulation Scheme | O-QPSK |
| MAC Protocol | 802.15.4 |
| Placement Model | Random |
| Simulation Time | 100 sec |
| Traffic Type | Constant Bit Rate |

Table 1. Simulation Parameters

### 3.2 Performance Metrics

In order to evaluate the performance of sensor network's routing protocols, the following metrics were considered:

1. Average End-to-end delay refers to the time taken for a packet to be transmitted across a network from CBR source to application layer of destination.
2. 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 (bit/s or bps).
3. Average Jitter refers to variation in the delay of received packets even if they are sent at same time. This may be due to network congestion, improper queuing, or configuration errors.

## 4 Experimental Results

Different scenarios are executed to evaluate how well routing protocols scale to varying network size and offered load. Scenarios are designed using Random waypoint model and results are compiled from 5 different simulations, where each scenario has variable number of node and traffic sources. Simulation results for routing protocols are as shown in Figure 1, Figure 2 and Figure 3 for above mentioned metrics:

Average End to End Delay: Figure 1 shows average end to end delay by varying number of nodes and traffic sources. Simulation result demonstrates end to end delay remains negligible for small number of nodes. As number of nodes rises to 90, it drives significant increase in delay. DYMO definitely has the lowest delay of 30sec as compared to OLSR and ZRP with delay of 35 sec and 38 sec, respectively. This may be due to frequent changes in network topology resulting in prior route discovery under proactive scheme.

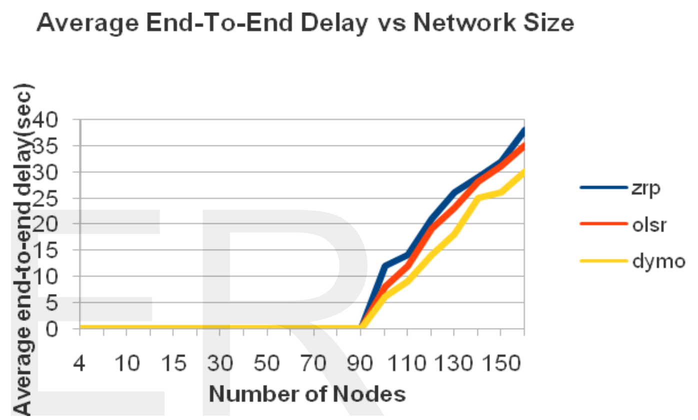


Figure 1. Average End To End Delay

Throughput: Figure 2 shows throughput as a function of network size and traffic sources, all protocols follow decrease in throughput. Although, DYMO prevail over other two protocols, its throughput drops significantly after 120 nodes. OLSR and ZRP perform well upto 40 nodes; results in sharp drop as further increase in network size introduces lot of control overhead due to their proactive nature.

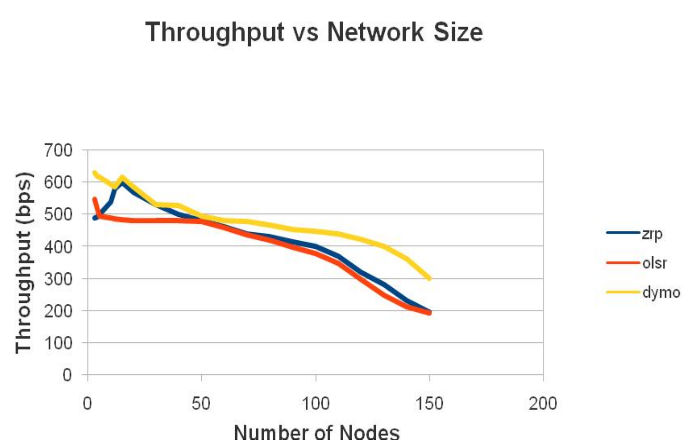


Figure 2: Throughput

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Average Jitter: Figure 3 Here, again DYMO comes up as best performer from other two protocols. As we can observe that after scaling network upto 60 nodes, instant rise in jitter for all the protocols. This is due to that fact that as network size increases so is control overhead of Query messages, consumes more time to reconfigure the route.

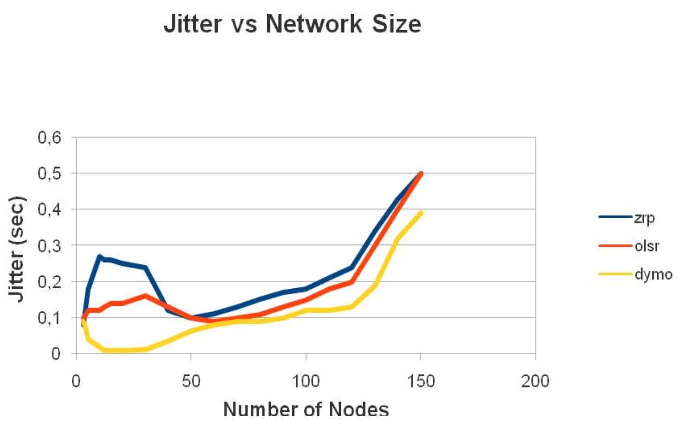


Figure 3: Average jitter

## 5 Conclusion

This paper demonstrates routing protocols evaluation and comparison for WSNs through the Network Simulator 2. To test efficiency of routing protocol, we analyzed and compared relative performance of OLSR, DYMO and ZRP on the basis of parameters average end to end delay, throughput and average jitter as a function of network scalability and offered load. From simulation results, we concluded that DYMO comes up as best routing protocol for WSNs, outperforming both OLSR and ZRP because of its simplicity and reactive nature. We observe that performance of OLSR and ZRP was not up to the mark throughout all metrics because of their control overhead associated with their proactive component.

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