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Performance Evaluation of Routing Protocols in Wireless Sensor Networks

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ABSTRACT*-Wireless Sensor Networks(WSN) are used in event sensing and data processing technologies. Each sensor node in the network collects information from its surroundings and sends it to the base station from source to destination. In this paper, we have presented performance comparison of WSN routing protocols i.e. Dynamic Source Routing (DSR), Optimized Link State Routing (OLSR), and Dynamic MANET on-demand (DYMO) and Zone Routing Protocol (ZRP) using QualNet 7.3.1 network simulator. End to End delay (s), Average Jitter (s), Average Throughput and Total Packet Received are used as performance metrics.Upon comparative analysis, it was found that different routing protocol performsdifferently in different scenarios and good for specific performance metrics.*

Keywords-WSN, OLSR, DSR, DYMO, ZRP, QualNet 7.3.1

INTRODUCTION

WSN's are one of the most important technologies for the twenty - first century. The deployment of WSN's has grown dramatically during the recent years, as they are increasingly used in many applications. The medical, environmental and military sectors are some of the most important areas, where the recent developments in WSNs technology have seen a wide use. WSNs consist of inexpensive, low power sensor nodes, which collect and disseminate data [1]. It can be viewed as a network consisting of hundreds or thousands of wireless sensor nodes which collect the information from their surrounding environment and send their sensed data to Base Station or Gateway Sensor node[2].

Figure 1 shows the basic architecture of WSN Network. The important requirements of WSN are: Use large number of sensors, energy consumption is low, Self-organization capability, and Querying ability. (ii) Slower than wired networks (ii) Configuration is very complex when compared with Wired Networks.

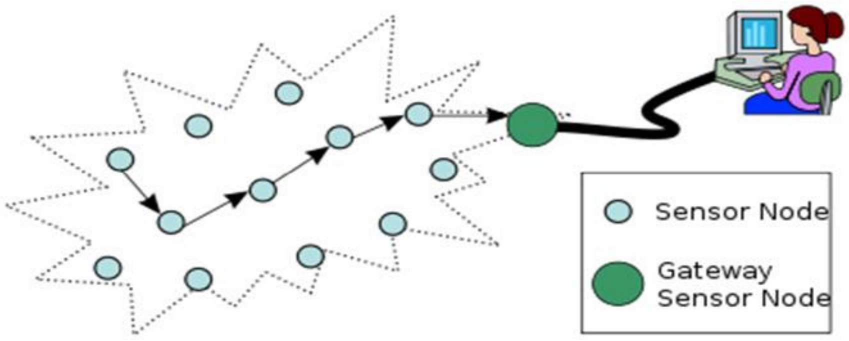

Figure 1: Wireless Sensor Network

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ROUTING PROTOCOLS IN WSN

Routing in WSN's differs from conventional routing in fixed networks having no fixed infrastructure and wireless links are not reliable as sensor nodes may fail at any instant of time. Various routing protocols are designed to fulfill the shortcomings of WSNs for effective data collection and dissemination of information.

WSN routing protocols can be subdivided into two broad categories, network architecture (structure) based routing protocols and operation (property) based routing protocols as shown in Figure 2.

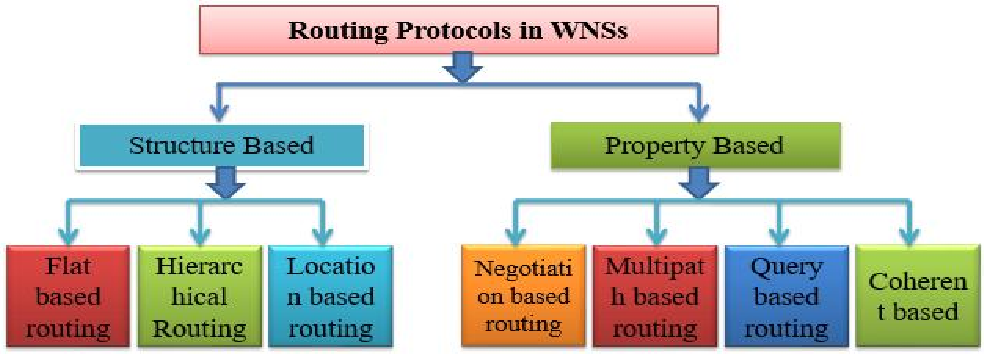

Figure 2: Classification of Routing Protocols in WSN

Architecture based Routing Protocols

Protocols are divided according to the structure of network which is very crucial for the required operation. The protocols included into this category are further divided into three subcategories according to their functionalities. Some examples of these protocols are:

- Flat-based routing protocols
- Hierarchical-based routing protocols
- Location-based routing protocols

i. Flat-based Routing Protocols

When huge amount of sensor nodes are required, flat-based routing is needed where every node plays same role. Since the number of sensor nodes is very large therefore it is not possible to assign a particular Id to each and every node. This leads to data-centric routing approach in which Base station sends query to a group of particular nodes in a region and waits for response. Examples of Flat-based routing protocols are[3,4]:

- Energy Aware Routing (EAR)
- Directed Diffusion (DD)
- Sequential Assignment Routing (SAR)
- Minimum Cost Forwarding Algorithm (MCFA)
- Sensor Protocols for Information via Negotiation (SPIN)
- Active Query forwarding In sensor network (ACQUIRE)

ii. Hierarchical-based Routing Protocols

When network scalability and efficient communication is needed, hierarchical-based routing is the best match. It is also called cluster based routing. Hierarchical-based routing is energy efficient method in which high energy nodes are randomly selected for processing and sending data while low energy nodes are used for sensing and send information to the cluster heads. This concept of hierarchical-based routing contributes greatly to the network scalability, lifetime and minimum energy. Examples of hierarchical-based routing protocols are[3,4]:

- Hierarchical Power-Active Routing (HPAR)
- Threshold sensitive energy efficient sensor network protocol (TEEN)
- Power efficient gathering in sensor information systems
- Minimum energy communication network (MECN)

iii. Location-based Routing Protocols

In this kind of network architecture, sensor nodes are randomly distributed in an area of interest and mostly known by the geographic position where they are deployed. They are located mostly by using GPS. The distance between nodes is estimated by the signal strength received from those nodes and coordinates are calculated by exchanging information between neighboring nodes. Location-based routing networks are [3,4]:

- Sequential assignment routing (SAR)
- Ad-hoc positioning system (APS)
- Geographic adaptive fidelity (GAP)
- Greedy other adaptive face routing (GOAFR)
- Geographic and energy aware routing (GEAR)
- Geographic distance routing (GEDIR)

Table 1: Architecture based Routing Protocols

Routing Protocol	Basic Principle	Advantages	Examples
Flat-based	Data- centric Routing Approach	Best suited for large amount of sensor nodes	SPIN.EAR, SAR, MCFA
Hierarchical-based	Cluster based routing approach	Energy efficient method, increased network scalability and lifetime	TEEN. MECN, HPAR
Location-based	Nodes are located by means of GPS	Best routing, reduce energy consumption, optimize the whole network	GEAR. GEDIR, APS

Operation based Routing Protocols

WSNs applications are categorized according to their functionalities. Hence, classification of routing protocols is done according to their operations to meet these functionalities. The main aim behind their classification is to achieve optimal performance and to save the scarce resources of the network. Protocols classified to their operations are:

i. Multipath Routing Protocols

As its name implies, protocols included in this class provides multiple path selection for a message to reach destination thus decreasing delay and increasing network performance. Network reliability is achieved due to increased overhead. Since network paths are kept alive by sending periodic messages and hence consume greater energy. Multipath routing protocols are[5]:

- Multi path and Multi SPEED (MMSPEED)
- Sensor Protocols for Information via Negotiation (SPIN)

ii. Query based Routing Protocols

This class of protocols works on sending and receiving queries for data. The destination node sends query of interest from a node through network and node with this interest matches the query and send back to the node which initiated the query. The query generally uses high level languages. Query based routing protocols are[5]:

- Sensor Protocols for Information via Negotiation (SPIN)
- Directed Diffusion (DD)
- COUGAR

iii. Negotiation based Routing Protocols

This case of protocols uses high level data descriptors to eliminate redundant data transmission through negotiation. These protocols make intelligent decisions either for communication or other actions based on facts such that how much resources are available. Negotiation based routing protocols are[5,6]:

- Sensor Protocols for Information via Negotiation (SPAN)
- Sequential assignment routing (SAR)
- Directed Diffusion (DD)

iv. QoS based Routing Protocols

In this type of routing, network needs to have a balance approach for the QoS of applications. In this case the application can delay sensitive so to achieve this quality of service, metric network have to look also for its energy consumption which is another metric when communicating to the base station. So to achieve better QoS, the cost function for the desired QoS also needs to be considered. Example of such routing are [5,6]:

- Sequential assignment routing (SAR)
- SPEED
- Multi path and Multi SPEED (MMSPEED)

v. Coherent Data Processing Routing Protocols

Coherent data processing routing is used when energy-efficient routing is required. In this routing scheme, nodes perform minimum processing (typically, time-stamping, suppression etc) on the raw data locally before sending for further processing to other nodes. Then it is sent to other nodes called aggregator for further processing known as aggregation [5, 7].

Data processing in non-coherent processing involves three phases. In first phase target detection, its data collection and preprocessing of its data takes place. Then for the cooperative function the node needs to enter in phase 2 where it shows its intention to neighboring nodes. Here all neighboring nodes must be aware of the local network topology. Finally, in step 3 a center node is selected for further refined information processing. Therefore central node must have enough energy resources and computation abilities [5].

Table 2: Operation based Routing Protocols

Routing Protocol	Basic Principle	Advantages	Examples
Multipath-based	Multiple path selection	Decrease delay , increase network performance	MMSPEED,SPIN
Query- based	Sending and receiving of queries for data	Self-adaptive, reduced average delay	COUGAR, DD, SPIN
Negotiation-based	Eliminate redundant data transmission	Efficient computation, scope of optimization	SPAN,SAR, DD
QoS- based	Balance approach for QoS	Better quality of service	SAR, SPEED, MMSPEED
Coherent	Minimum processing on raw data	Energy efficient routing	–

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SCENARIO

The simulator used to record the performance parameters is Qualnet 7.3.1 developed by SCALABLE Network Technologies. In the Architecture mode of the simulator the scenario is designed in an area of 1500m x 1500m. Number of nodes is kept as 100. Network traffic type is chosen as CBR (Constant Bit Rate) type, we have used 10 CBRs. The node mobility model is set up as Random Waypoint Mobility. The routing protocols are set as AODV, DYMO, OLSR and ZRP to compare the simulation data.

Table 3: Scenario Parameters

Parameters	**Values**
Area Size	1500m x 1500m
Routing Protocols	DYMO,DSR,OLSR,ZRP
No. of Channels	1
Network Protocol	IPv4
Number of nodes	100
Number of CBR	10
Mobility Model	Random Waypoint Model
Node Placement	Random
Radio Type	802.11b
Traffic Type	CBR
Packet Size	512 bytes

Figure 3 shows the network scenario designed using Qualnet simulator.

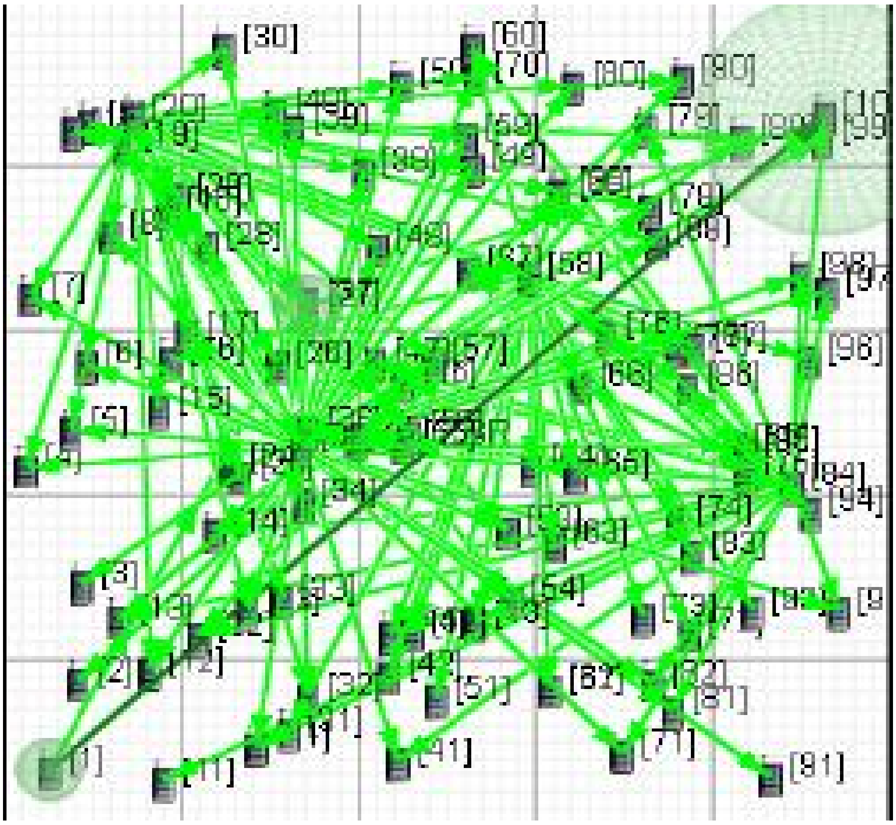

Fig. 3 Simulation Scenario

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RESULTS AND DISCUSSION

i. Jitter

Jitter is the variation in delay by different data packets that reached the destination and can seriously affect the quality of audio/video. Here we can see that the average jitter is fairly high in the case of DYMO, then, it is DSR, ZRP and least is in the case of OLSR.

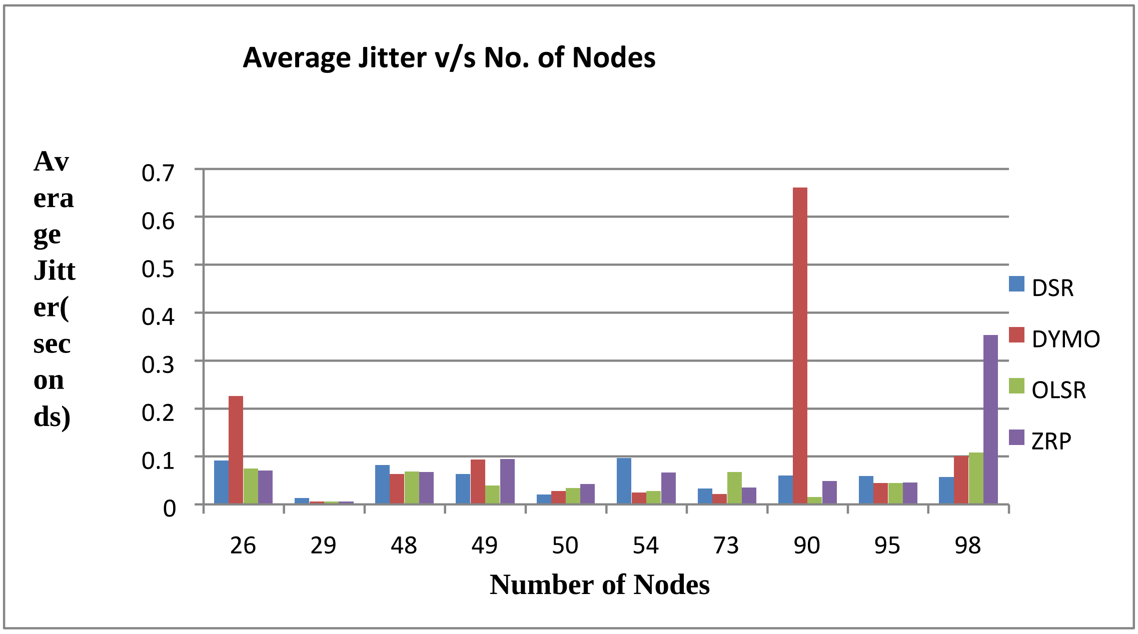

Fig. 4Performance comparison of DSR, DYMO, OLSR and ZRP protocols with respect to average jitter with varying no. of nodes

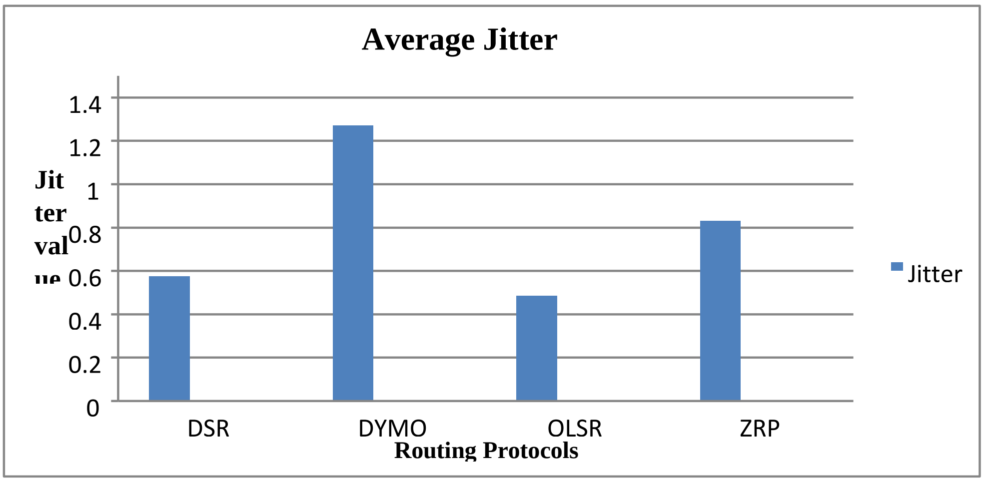

Fig. 5 Average Jitter

ii. Total Number of Packets Received

Total number of packets received at the destination. Its count tells us the total number of packets received out of total number of packets sent. The graph shows the best protocol to deliver the data packets to the destination are DSR and DYMO in comparison to OLSR and ZRP.

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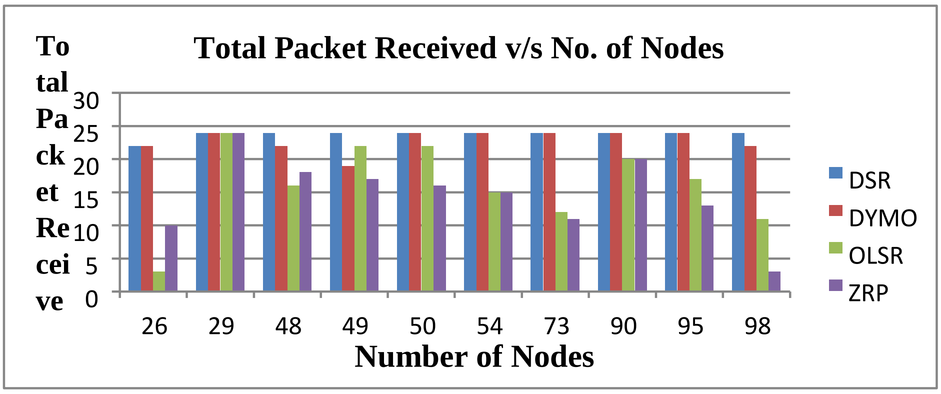

Fig.6 Performance comparison of DSR, DYMO, OLSR and ZRP protocols with respect to Total Packet Received with varying no. of nodes

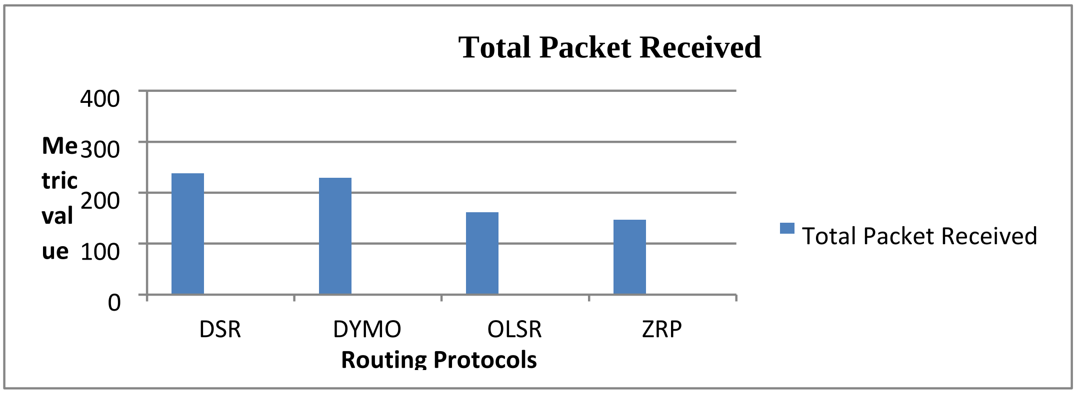

Fig. 7 Total Packet Received

iii. End-to-End Delay

The delay of the packet is the time it takes the packet to achieve the destination after it leaves the source. In this analysis it is observed that the expected delays are more for ZRP in comparison to OLSR. OLSR performs better than DSR and DYMO routing protocols. The end-to-end delay of OLSR is less because it has reduced routing overhead and queuing delay. OLSR shows least delay thus it is better among three.

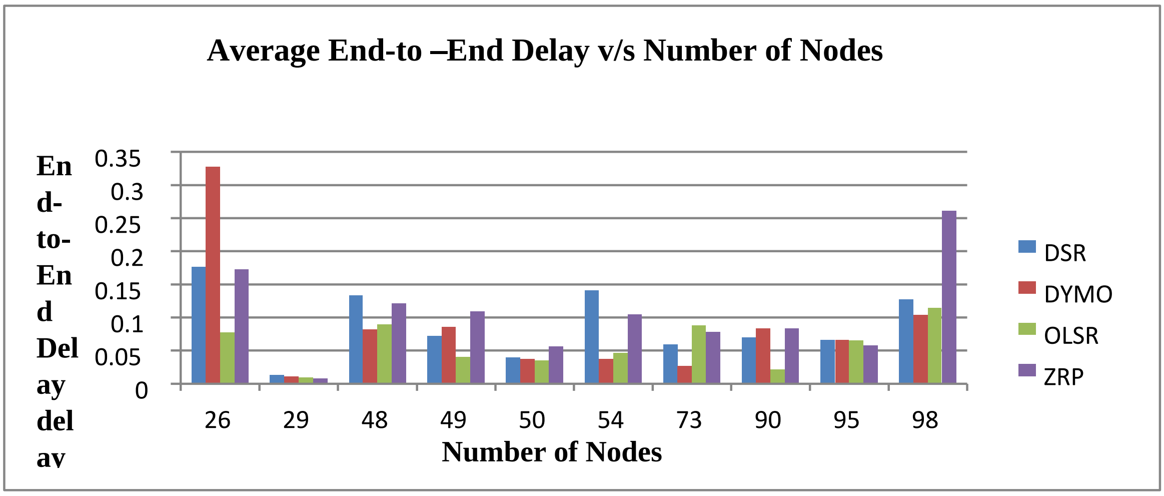

Fig.8 Performance comparison of DSR, DYMO, OLSR and ZRP protocols with respect to average end-to-end delay with varying no. of nodes

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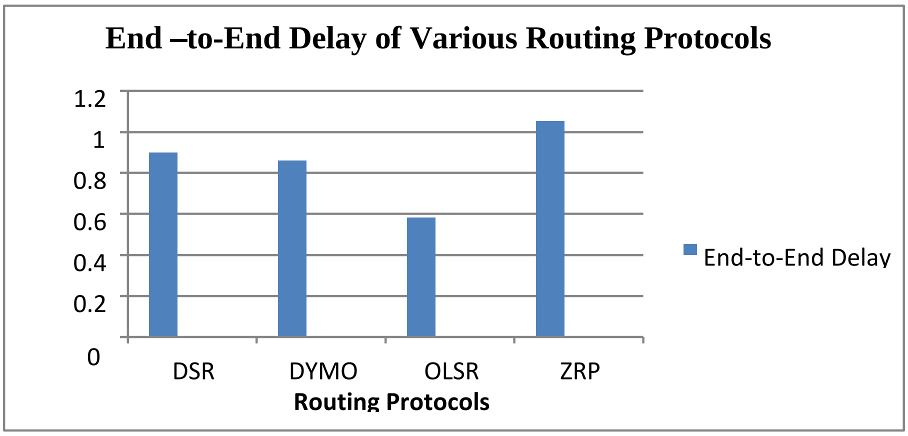

Fig. 9 Average End-to-End Delay

iv. Throughput:

It is the ratio of successfully transmitted data per second. The throughput is analyzed with CBR data traffic. According to our simulation results better performance is shown by DSR at high mobility using CBR data traffic compared to other protocols. It shows that DYMO performance is also nearer to DSR protocol. Thus DSR performs better and performance of ZRP is least in this cases.

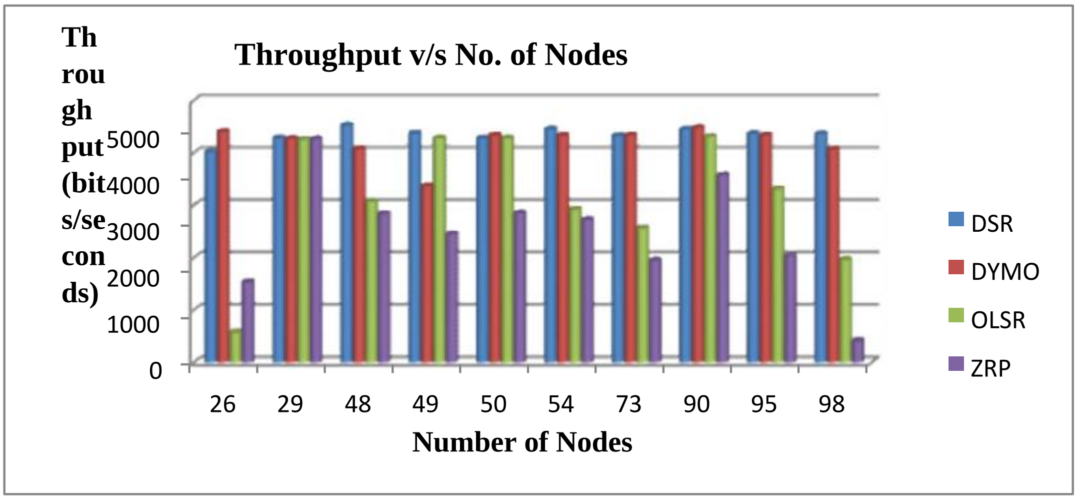

Fig. 10 Performance comparison of DSR, DYMO, OLSR and ZRP protocols with respect to average throughput with varying no. of nodes

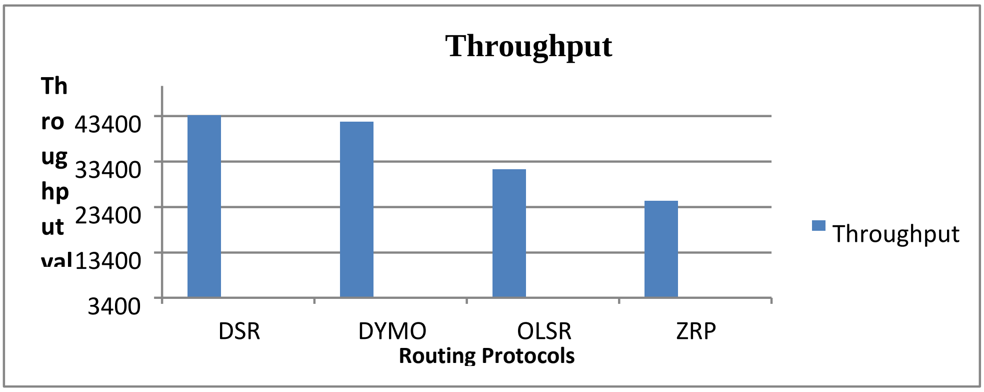

Fig.11 Average Throughput

CONCLUSION

In this paper, we have evaluated the performance of WSN’s using different Routing Protocols i.e. DSR, OLSR, DYMO and ZRP using QualNet 7.3.1 network simulator. Simulative analysis shows that OLSR has the least end-to-end delay and jitter. DSR has the highest received throughput and total packet received compared to OLSR, DYMO and ZRP. DSR is better choice in high mobility case if higher throughput is required. While for better jitter and end-to-end delay performance OLSR outperforms other routing protocols.

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