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WSN Performance Evaluation of Power Consumption Analysis of DSR, OLSR, LAR and Fisheye in Energy Model through QualNet

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Abstract— The expansion in information technology and the need for large scale communication infrastructures has triggered the area of Wireless Sensor Networks (WSNs). Network is a collection of wireless nodes these are communicates with each other without using any offered infrastructure, access point or centralized administration. Wireless sensor networks may consist of hundreds or even up to thousands of small dense devices, equipped with sensors (e.g. acoustic, seismic or image), that form a wireless network. Each sensor node in the network collects information from its surroundings and sends it to a base station, either from source sensor node to destination sensor node, i.e. multi-hop, or directly to the base station. This paper presents performance comparison of four popular wireless sensor network routing protocols i.e. Dynamic Source Routing (DSR), Optimized Link State Routing (OLSR), Fisheye State Routing Protocol (FSR) and Location - Aided Routing (LAR) in variation of nodes and random waypoint mobility. We used well known network simulator QualNet 5.0 from scalable networks to evaluate the performance analysis of above protocols. The metrics used for performance analysis of End to End delay (s), Average Jitter (s), Power consumption in receive mode, transmit mode, idle mode and battery consumption.

Index Terms— DSR, Fisheye, OLSR, LAR, QualNet version 5.0.1

I. Introduction

Wireless Sensor Networks (WSN) has wide and varied applications. A smart sensor is a collection of integrated sensors and electronics. When these types of sensors are used in WSNs, very powerful, versatile networks can be created and used in situations where traditional wired networks fail. These sensor networks can be used for emission monitoring systems in the harsh environment of automobile drain systems or in large buildings for more consistent climate control. Research is already being conducted with respect to low-power dissipation for deep space missions. While the space station research is focused on direct networks, this would be an excellent case were the flexibility of wireless networking could be aptly applied [1] [2].

There are also countless medical applications, including monitors and implantable devices, such as a retinal prosthesis. Biomedical WSNs have unique constraints that must be addressed before they are feasible for human use. These implants are intended for long-term placement in the body and, therefore, cannot dissipate amounts of heat that would damage the surrounding tissue. They would also require a constant, renewable source of energy. This alleviates many constraints placed on other WSNs that have finite amounts of non-renewable energy [3]. Uses such as these, where the network topology is nominally fixed, are of particular interest. Before we can use WSN in these applications, however, we need to overcome several obstacles, including limited energy, computational power, and communication resources available to the sensors in the network [5].

With a proper analysis of battery consumptions, light weight applications, efficient network protocol and interface power consumption of wireless network can be properly addressed. Flooding based routing protocols rely on message forwarding by broadcasting the message. This mechanism consumes a major portion of battery power at node level also affect the longevity of the network. Power efficient routing protocols apply some techniques to reduce flooding mechanism by some probabilistic and heuristic based approach but are suffered with increase end-to-end delay and decrease network throughput. For this reason there must be some threshold between power consumptions and other network parameters while designing routing protocols for WSN. In the literature different techniques are proposed to find the energy efficiency of routing protocol, but network lifetime is not properly addressed at different network traffic, load and mobility [4] [5] [6]. Focusing on these three parameters we made an attempt to determine the power consumption and network lifetime of DSR, Fisheye, OLSR, and LAR at mobility and load.

II. PERFORMANCE CHARACTERSTICS OF ROUTING PROTOCOLS

In this session, we present the various performance characteristics are analyzed which may influence the performance of the system with regards to network, users and applications [7].

Power Efficiency
Average End-to-End Delay
Average Jitter
Average Throughput
Network Lifetime
Power consumption in transmit, receive and idle modes

A. *Power Efficiency:*

Reducing the amount of data transmitted across the network.

- Duty cycle range lowers the transceiver.
- Power management techniques is strictly implementation
- Reduce redundant transmission.
- Frequency of data transmission is lower.
- Overhead frame is reducing.
- Computation overhead reduces.

By using a powerful routing protocol, the number of retransmission across the network can be controlled efficiently. By utilizing successful routing algorithm, network life time and energy will be conserved and redundant transmission will be reduced [8].

B. *Average End-to-End Delay:*

Average End-to-End delay is a metrics used to measure the performance with time take by a pack to travel across a network from a source node to the destination node. Each sensor node with sensed data has to wait for the neighbour sensor node to turn it to active mode from sleep mode. End to end delay evaluates latency when data send by sensor nodes and received by destination node. An end to end delay includes all possible delay caused during route discovery, retransmission delay, queuing delay and relay time [7] [9].

Average End-to-End Delay = N (Transmission delay + Propagation Delay + Processing Delay)

C. *Average Jitter:*

Average jitter is a performance characteristics used to measure deviation from true periodicity eventually of immobility in packet across a specific network [10].

- Network congestion in the receiver end a delay may occur this delay causes a deviation from the jitter.
- Due to data congestion or route changes can cause jitter.
- Average Jitter in a network increases indefinitely due to improper queuing techniques or configuration errors [12].

D. *Average Throughput:*

In a WSN, throughput is measured in terms of successful delivery of data packet within the threshold time. The data may utilize different routes and passes across multiple intermediate nodes to reach the destination [9] [10]. Throughput is measured using number of bits of packet received per unit time. The following are major factors affecting throughput:

- In network congestion may packet loss
- Existing bandwidth
- Number of Users in the Network
- Data loss due to bit errors
- Inappropriate queuing techniques used
- Slow start and multiple decreasing techniques are used

E. *Network Lifetime:*

Lifetime of the WSN depends on the life of the sensor nodes. In WSN, sensor nodes have data to send to a base station. It is more essential to reduce the total energy consumed by the system to maximize the network lifetime of the network. With the implementation of effective routing protocol, power consumption per node can be balanced; network lifetime can be significantly increased.

F. *Power consumption in transmit, receive and idle modes:*

Wireless sensor networks are power constrained network. One of the major design issues in WSN is preservation of the power accessible at each sensor node. The lifetime, scalability, response time and effective sampling frequency all parameters of the wireless network depend upon the power. Power failure often because breakage in network. Energy required maintaining the individual health of the node, during receiving the packets as well as transmitting the data both [10] [15].

G. *ROUTING PROTOCOLS:*

1) *Dynamic Source Routing (DSR):*

DSR is a simple and efficient routing protocol designed specifically for use in multi-hop wireless ad-hoc networks of mobile nodes. In Dynamic Source Routing (DSR) the routing technique in which the sender of a packet determines the complete sequence of nodes through which the packet has to pass; the sender decided the lists this route in the packets header, identifying each forwarding “hop” by the address of the next node to which to transmit the packet on its approach towards the destination host. It also computes the routes when required and then maintains them. The protocol is self-possessed of the two main mechanisms of "Route Discovery" and "Route Maintenance", which work together to allow nodes to discover and maintain routes to random destinations in the network. All aspects of the protocol operate entirely on demand, allowing the routing packet overhead of DSR to scale automatically to only what is needed to react to changes in the routes currently in use [13].

2) *Optimized Link State Routing (OLSR):*

OLSR is a proactive routing protocol where the routes are always available when needed. OLSR is an optimized version of a pure link state protocol. 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 multipoint relays (MPR) are used. Reducing the time interval for the control messages transmission brings more reactivity to the topological changes. OLSR uses two kinds of the control messages namely hello and topology control. Hello messages are used for finding the information about the link status and the host’s neighbours. Topology control messages are used for broadcasting information about its own advertised neighbors, which includes at least the MPR selector list [13].

3) *Fisheye State Routing Protocol (FSR):*

Fish eye is a proactive and hierarchical routing protocol. FSR uses the technique followed by a fish eye. Fish eye normally observers and focus with high detail on the object very close to its focal point. When the object distance increases from the focal point the detail decreases. The same principle is used in Fisheye State routing. FSR maintain topology map at each node.FSR will not flood or broadcast to evaluate the route. Instead, nodes maintain a link state table based on updated information from the neighbour. A full topology map will be stored in each node of the network. The topological map will be utilized to route discover and route maintenance [11] [15] [10].

4) Location - Aided Routing (LAR):

The Location - Aided Routing Protocol uses location information to decrease routing overhead of the wireless sensor network. Normally the LAR protocol uses the GPS (Global Positioning System) to get this location information.

III. MOBILITY AND ENERGY MODELS

H. Mobility and Energy Consumption Modes:

1) Mobility Mode: (Random Waypoint)

In random waypoint mobility model, the nodes randomly selects a position, moves towards it in a straight line at a constant speed that is randomly selected from a range, and pauses at that destination. The node repeats this, throughout the simulation. In the simulation, Constant Bit-Rate (CBR) traffic flows are used with 4 packets/second and a packet size of 512 bytes. The performance of generic network traffic and the CBR model collects the following statistics [14] [16]:

- Time when source to destination node session is started
- Time when source to destination node session is closed
- Number of bytes sent
- Number of bytes received
- Throughput

2) Energy Consumption Modes: (Receive, Transmit & Idle)

The mobile nodes in wireless sensor networks are connected between sources to destination nodes. These nodes are free to transmit (Tx) and receive (Rx) the data packet to or from other nodes and require energy to such activity. The total energy of nodes is used up in following modes: These modes of energy consumption are described as: (1) Transmission Mode (2) Reception Mode (3) Idle Mode.

a) Transmission Mode:

A node is supposed to be in transmission mode when it communicate data packet to other nodes in network. These nodes need energy to transmit data packet, such energy is called Transmission Energy (Tx) of that node. Transmission energy is depended on size of data packet which is transmitted (in Bits), if the size of a data packets is increased the required transmission energy is also increased. The amount of energy spent in transmitting and receiving the packets is calculated by using the following equations:

$$\text{Energy Tx} = (330*\text{Packet Size})/2*10^6$$

Where, Packet size is specified in bits, Tx is transmission Energy.

b) Reception Mode:

When a node communicates and receives a data packet from other nodes then it is called Reception Mode and the energy taken to receive packet is called Reception Energy (Rx). Then Reception Energy can be given as:

$$\text{Energy Rx} = (230*\text{ Packet Size})/2*10^6$$

$$PR = Rx/Tr$$

Where Rx is Reception Energy, PR is Reception Power, Tr is time taken to receive data packet [14] [15].

c) Idle Mode:

In this mode the node is neither transmitting nor receiving any data from source to destination. But in this mode node consumes power because the nodes communicate in wireless medium continuously. Because communication the node detects a data packet may it receive or transmit, so that the node can be switch into receive mode from idle mode. Idle energy is an exhausted energy that should be reduced or eliminated. The power consumed in Idle Mode is:

$$PI = PR$$

Where PI is power consumed in Idle Mode and PR is power consumed in Reception Mode [14].

IV. PROBLEM STATEMENT

The objective of this work is to investigate power consumption of four routing protocols DSR, OLSR, RIP and ZRP using mobility and Energy models (Random Waypoint mobility model) for wireless sensor networks. The objectives of this paper are outlined as follows:

- To investigate the impact of mobility and energy (random waypoint mobility model) on different routing protocols.
- To create different simulation scenarios with number of nodes.
- To conduct the performance analysis of random waypoint mobility model and energy model on four routing protocols, DSR, Fisheye, OLSR and LAR by evaluating parameters viz., end-to-end delay, average jitter and power consumption in transmit, receive and idle modes.
- To investigate the performance of routing protocols by graphical representation.

V. SIMULATION ENVIRONMENT AND PERFORMANCE EVOLUTION SETUP

QualNet is network simulation and modeling software that predicts performance of networks through simulation and emulation. Simulation software can supports real-time simulation for models of 4000 nodes. Simulator having the Model Fidelity facility it can offers highly detailed models of all aspects of networking. In this work QualNet 5.0 network simulator [10] [17].The physical medium used is 802.11 PHY with a data rate of 2 Mbps. The MAC protocol used is the 802.11 MAC protocol, configured for wireless mode. In this work wireless module of IEEE 802.11b is used to enable mobility of the wireless nodes. IEEE 802.11b support more accurate wireless models for propagation, path loss, multipath fading and reception on wireless networks. The simulations are carried out for network densities of 45 nodes respectively. The area considered is 1500m X 1500m for stationary nodes and nodes with mobility of 30mps. Simulations are configured for the performance evaluation of different routing protocols with the metrics like battery capacity & energy consumed at the destination for stationary nodes with mobility of 30mps respectively [18]. Comparisons of routing protocols constant bit rate (CBR) traffic patterns are used. The network contains variable CBR traffic connections and packet size of 512 bytes. Packets are sending from source nodes in the 0.30s interval. We used four different quantitative metrics to compare the performance of DSR, Fisheye, OLSR and LAR routing protocol. They are End to End delay (s), Average Jitter (s) and energy consumption in transmit, receive and idle modes. Figure 1 Snapshot of 45 Varying Nodes Placement network in QualNet 5.0 Simulator [17] [18].

TABLE I

SIMULATION PARAMETERS FOR WSN PERFORMANCE EVALUATION OF POWER CONSUMPTION ANALYSIS OF DSR, DYMO, RIP AND ZRP PROTOCOLS.

Simulator Parameters	
Mac Type	IEEE 802.11
Protocols	DSR, Fisheye, OLSR and LAR
Transmission range	800m
Node movement model	Random
Traffic type	CBR
Propagation model	Two Ray Ground
Channel Frequency	2.4 GHz
Node Speed	20m/s
Scenario Parameters	
Number of nodes	45
Topology area	$1500m^2 X 1500m^2$
Node placement	Random
Item Size bytes	512
Item to send	75
Simulation time	30 Seconds
Battery Charge Monitoring Interval	60 Seconds
Full Battery Capacity	1200 (mA,h)
Performance Metric in Application Layer	End to End Delay, Average Jitter
Performance Matrices in Physical Layer (in mjules)	Energy consumed in transmit mode Energy consumed in received mode Energy Consumed in ideal mode

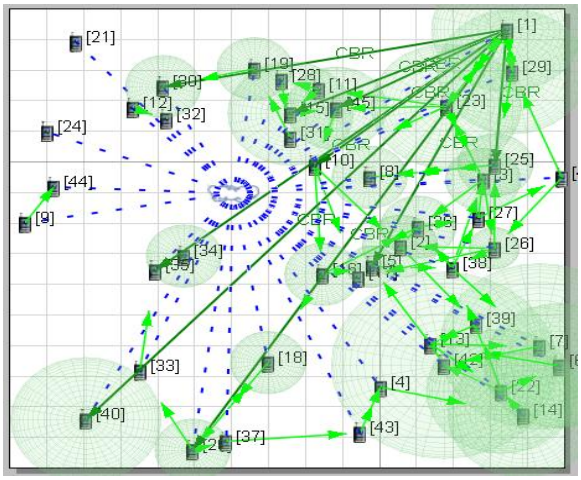

Figure 1. Snap shot of QualNet Animator in Action for applying LAR Protocol using 45 nodes.

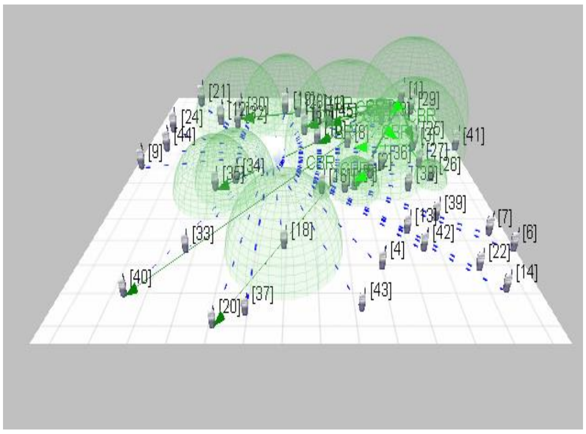

Figure 2. Snap shot of QualNet Animator in x-y position when applying DSR Protocol using 45 nodes.

VI. RESULT ANALYSIS WITH GRAPHS

I. *Average Jitter(s):*

Average Jitter is the variation in the expected time of arrival of packets. Average jitter is caused by network congestion and delays in the packet network. To minimize the delay variations, a jitter buffer are implemented which temporarily stores arriving packets [10] [16].

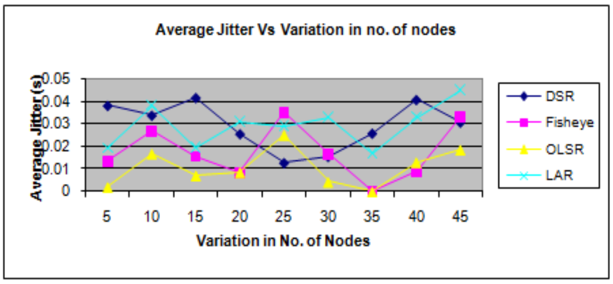

Figure 3. Average jitter vs. Number of Nodes

Performance of different routing protocol based on average jitter is explained in the Figure 3 with node destinations 5, 10,15,20,25,30,35,40.45 nodes. The average Jitter result shows that OLSR protocol outperforms all other protocols. LAR protocol shows higher jitter while other protocols average Jitter values were not stable as LAR protocol.

J. *Average End-to-End delay(s):*

The average end to end delay of a data packet is calculated by subtracting time at which first packet was transmitted by source from time at which first data packet arrived to destination [16].

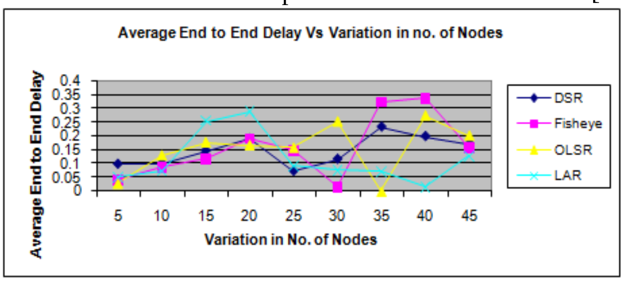

Figure 4. Average end to end delay vs. variation in number of Nodes

Figure. 4 shows the different routing protocols with random way point mobility and variation in nodes. While examining end to end delay routing protocols were performing more or less equal when node density was less than 0.25. When node deployment number increased few protocol shows drastic variation. While comparing results with different node densities LAR, Fisheye faces heavy delay. DSR and OLSR perform better in varying situations.

K. Power consumed in Transmit Mode:

Wireless sensor networks are power constrained network. One of the major design issues in WSN is preservation of the power accessible at each sensor node. In any case, power is a very critical resource and must be used very sparingly. Sensor nodes have to limit the transmission and computation to prevent ultimate utilization of energy resource. In such scenario, routing algorithm has to be designed to reduce packet broadcast during learning curve and to update the route [10] [16].

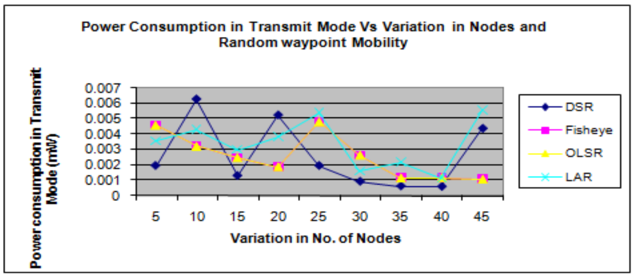

Figure 5. Graph for energy consumed in transmit mode

L. Power consumed in Receive Mode:

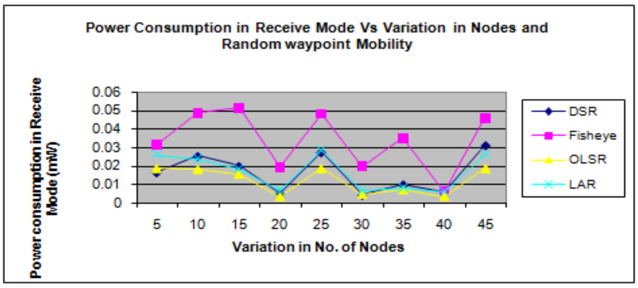

Figure 6. Graph for energy consumed in receive mode

On analyzing the results for energy consumption in transmit and receive mode it has been concluded that Fisheye consumes maximum energy while energy consumption for the rest three protocols is almost same when increasing no. of nodes.

M. Power consumed in Idle Mode:

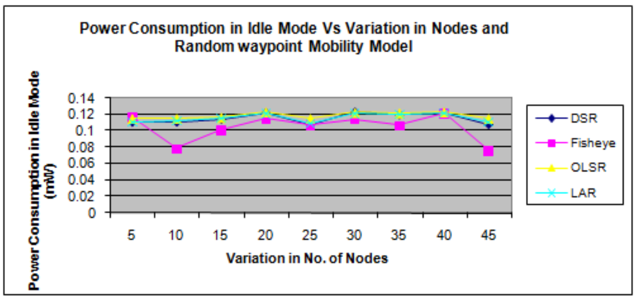

Figure 7. Graph for energy consumed in idle mode

On analyzing the results for energy consumption in idle mode it is noted that there is minimum consumption in fisheye followed by DSR, OLSR and LAR and maximum in LAR.

VII. Conclusion

We observed that power saving is an important optimization objective in wireless sensor network, the power consumed during communication is more dominant than the power consumed during processing because of Limited storage capacity, Communication ability, computing ability and the limited battery are main restrictions in sensor networks. As the lifetime of the network is depend on the battery life of the nodes, the design of power efficient routing protocols is must. By the observations we compare that the impact of power constraints on a nodes in physical layer and application layer of the networks that DSR offers the best combination of power consumption and average end to end delay performance. It has been observed that OLSR has better network lifetime than other.

Future work, we can reduce the waste power consumption of the nodes by reducing the number of routing control packets and reducing the power consumed by nodes in a large network to increase the life time of network.

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