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Performance Analysis of Wireless Sensor Network by Varying Reporting Rate

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Abstract

Objective: To analyse the performance of QoS parameters of wireless sensor network by variation in reporting rate using NS-2. The performance metric considered as packet delivery ratio, throughput, delay, routing overheads, avg. energy consumed and avg. residual energy etc. **Methods/Analysis:** Using NSG tool, 50 nodes are deployed in 1000*1000 m*m area. The nodes 25, 31, 5 are considered as source node and node 3 as sink node. The AODV protocol is considered as packet transmission and CBR is used for traffic generation in network. **Findings:** To measure the performance of QoS parameters such as packet delivery ratio, throughput, delay, routing overheads, avg. energy consumed and avg. residual energy with 50 nodes were kept static. The graphs plotted by keeping performance metric at Y-axis and reporting rate on X-axis considered as 5, 10, 15, 20, 25, 30, 35, 40, 45, 50 etc. The analysis of performance of QoS parameters shows that for packet delivery ratio the ideal reporting rate is 20 packets per second. As the reporting rate increases delay increases gradually due to congestion. Also the throughput and routing overheads are increased with increasing reporting rate. Minimum energy consumption at 5 packets per second and maximum energy consumes at 50 packets per second. **Conclusion:** 20 pps is best reporting rate of transmission of packets for proposed network.

Keywords: Delay, Energy, QoS Parameters, Reporting Rate, Throughput, WSN

1. Introduction

Wireless sensor network is a complex network of wireless nodes. Several nodes are connected to each other wirelessly. These complex network is usually placed in a large area such as industries, farms, natural calamities area etc. Sensor nodes gather information according to their work and they pass it to other nodes majorly to the sink node. The sink node is the node which contains all the information of the nodes and also the information which is sent by all these nodes. The sink nodes thus send the information into the network. Figure 1 shows the different source nodes. These source nodes form a cluster and pass the whole information to the sink nodes which in turn pass it to the network which is the internet. Many applications of WSN which includes military surveillance, cargo service and structural monitoring etc.

Wireless Sensor Network consists many QoS parameters. These include throughput, packet delivery ratio (PDR), delay and energy consumption. The reporting rates are varied for each of these parameters. The packet delivery ratio is the ratio of number of packet received to the number of packets sent in network.

The PDR can be defined as ratio of signal to noise and ratio of signal to interference-plus-noise at the sensor and distribution of time in collision of all sent packets at sensor link[1].

Delay is defined as time required for transmission of packets from source node to sink node. This delay can be referred as End-to-End delay.

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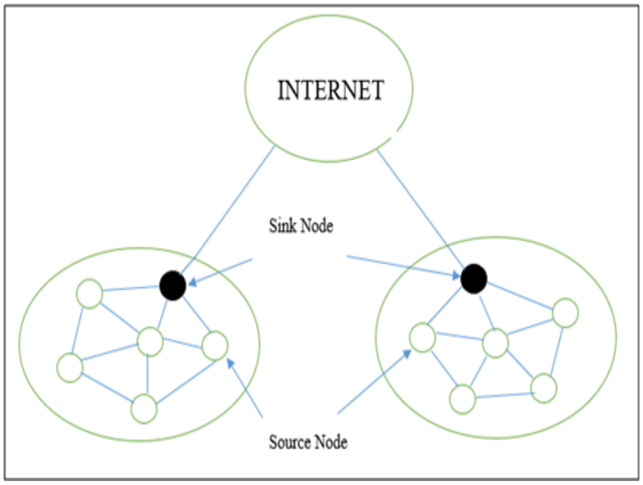

Figure 1. Wireless Sensor Network Architecture.

Congestion in network proposed to delay in network. This delays can be processing delay, transmission delay or queuing delay etc. End-to-End delay controlled by Spray and Focus algorithm used for the decreasing delay in WSN.

Throughput is the rate at which the messages are sent to the nodes in the network by the communication system. It defines the channel capacity and the channel utilization uses for data transmission[2].

Throughput is the rate of successful message delivery over a communication channel. The communication channel may be wired or wireless depending on the applications. In the wireless sensor networks the throughput firstly increases to a certain value. After the certain value that is the threshold value the throughput goes down.

Fairness is one of the important characteristics of QoS. Fairness means that the resources used by the nodes are equally distributed. When the resources are not able to satisfy the demands, they are fairly distributed among the nodes of the network[3].

Due to large deployment of nodes in the network unnecessary visits to nodes take place so Energy consumption is the key requirement considering the performance of system. As reporting rate increases congestion in the network increases so as Routing overhead. As Sensor nodes have limited resources, limited power and limited Energy when sensor receive more packets than its capacity then that packets are dropped and hence Energy Consumed is wasted[4]. This problem of wastage of energy affects throughput of the network. So to improve Energy Efficiency there are many Energy aware routing protocols are used in wireless sensor networks. AODV is one of the Energy aware routing protocols which is used to Minimize the energy consumption with the help of residual energy[5]. Aim of this protocol is to enhance the lifetime of the network.

Greedy network gives low packet delivery ratio and other aspects such higher end to end delay. Random topologies consumes all nodes in network for traffic variation and gives better performance than greedy network. Wireless Sensor Network cannot given better output for simple greedy network[6]. Different network topologies plays different roles in WSN. PDR comprises with reliability and congestion in network. The Congestion in WSN causes packet drop and increase in energy consumption. This congestion can be abated by controlling reporting rate. Retransmission of packets gives reliability in WSN[7].

Delay controlled by Spray and Focus algorithm used for the decreasing delay in WSN. And also the AODV protocol can be used for reducing delay in WSN. This delay mitigated by 20 times more than recent algorithms[8,9].

Wired networks are unicast links whereas the majority of the wireless links are the broadcast links. The wired links being unicast in nature do not interfere with each other. Wireless links being of broadcast type cause a lot of interference. Thus it causes a low throughput[10]. Throughput is nothing but the amount of data transferred from the source node to the destination node within certain amount of time. Using IEEE 802.11 the throughput can be increased Consumption[11]. Clustering is one of the main approaches for optimizing energy consumption in wireless networks[12]. Cluster can avoid unnecessary communication of nodes in the networks. Low Energy Adaptive Clustering Hierarchy (LEACH), Multihop LEACH, PEGASIS these are some protocols used for efficient energy consumption. LEACH consists of large number of nodes along with the cluster formation and associated cluster head (CH). All nodes send aggregated data to cluster head and cluster head send this data to Base Station. As transmission is done through cluster head so they require large energy to remain in the network and this problem is minimized by randomly selecting nodes as cluster head[13]. Cluster node acts as intermediator between source node and sink node which helps in reducing number of transmission so energy consumed is also reduced. While Multihop LEACH is same as that of LEACH, only difference is that transmission of data from source node to sink node takes place through multiple hops i.e. data transmits through multiple cluster heads and it chooses path with minimum hop count. PEGASIS is an improvement over LEACH protocol without formation of cluster heads. Among all these protocols LEACH is the best for efficient energy consumption. AODV and DSR protocols give best results at low packet size and less number of nodes. DSDV protocol gives very low PDR and high routing overheads as compared to AODV and DSR[14]. HEECA (Hybrid Energy-Efficient Clustering Technique) designed by[15] for achieving increase in network life. HEECA is a combination of EECA-F and H-PEGASIS protocols. It is a 41.7% efficient than EECA-F protocol. Network density also affects the selection of protocol in proposed network. For 100 nodes network AODV nth BR protocol is best protocol than other DSR, AODV BR protocol[16]. New approach called Apriori algorithm is used for increasing network lifetime. Apriori algorithm determines the different paths for forwarding data to sink node which minimize the energy consumption[17]. In applications of WSN, reduction of energy consumption is one of the important problems and MAC protocol is crucial aspect for reducing energy consumption in WSN[18].

2. Network Scenario

The performance analysis of proposed network NS-2 (Network Simulator version 2) is used. In proposed network architecture 50 sensor nodes are simulated in random manner area 1000*1000 m^2 through NSG 2.1 tool. Nodes are simulated in such a manner such that all the nodes are totally consumed in network. All nodes are static and one of them is sink node. In proposed network architecture considered as 3 UDP nodes and other 46 nodes are relay nodes. And a CBR (Constant Bit Rate) is used for traffic generation in network. AODV (Ad-hoc On-Demand Distance Vector) protocol is used for transmission purpose.

All simulation parameters and nodes configuration for proposed network architecture are listed in Table No. 1

3. Protocol Overview

AODV stands for Ad-hoc on demand distance vector routing protocol as name suggest it creates route to destination on demand. In order to send data to destination source node broadcasts RREQ request message to its neighbours. If neighbours receive RREQ message it create route to source and if receiver is not destination then it forwards RREQ message to other neighbours. When destination node receives RREQ message it sends RPEP that is reply message to source through route generated while transmission from source to destination. If multiple RREP message is received by source then it chooses the path with shortest hop count. When transmission of data flow breaks then RERR message is sent to source node.

Table 1. Simulation Parameters and nodes configuration of various network topologies

Sr. No.	Parameter	Details
1	Channel type	Channel/Wireless Channel
2	Radio propagation model	Propagation/Two Ray Ground
3	Network interface type	Phy / Wireless Phy
4	MAC type	Mac/802_11
5	Interface queue type	Queue/Drop Tail / PriQueue
6	Link layer type	LL
7	Antenna model	Antenna/Omni Antenna
8	Routing protocol	AODV
9	X dimension of topography	2521
10	Y dimension of topography	100
11	Time of simulation end	10.0
12	Initial energy in Joules	5
13	Traffic Type	CBR
14	Topology of Network	Random

4. Result Analysis

Figure 2 shows Packet Delivery Ratio as a function of Reporting Rate. Initially when number of packets in the network are less, Packet Delivery Ratio (PDR) increases slightly as no packets are dropped and at reporting rate of 20 pps, packet delivery ratio is maximum.

For the reporting rate of 20pps routing overhead is minimum (Refer Figure 5) and hence PDR is maximum. Routing overhead increases thereafter which leads to number of packets drop and eventually Packet Delivery Ratio decreases.

Least PDR is for reporting rate of 50 pps, as routing overhead is maximum at that point (Figure 5). Hence, 20 can be considered as ideal reporting rate for achieving maximum Packet Delivery Ratio.

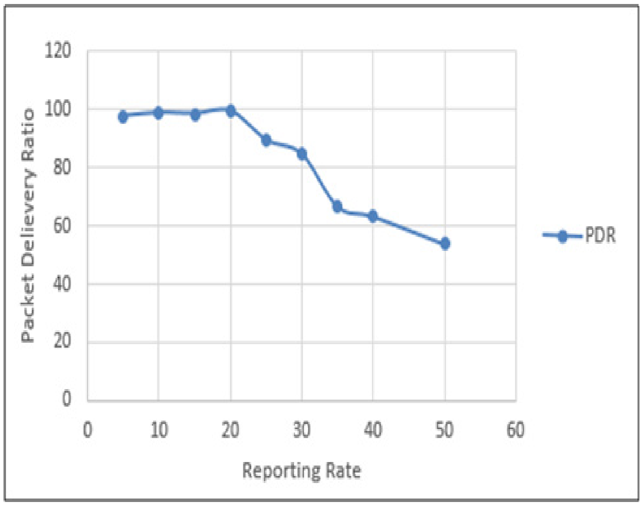

Figure 2. PDR as a function of Reporting Rate.

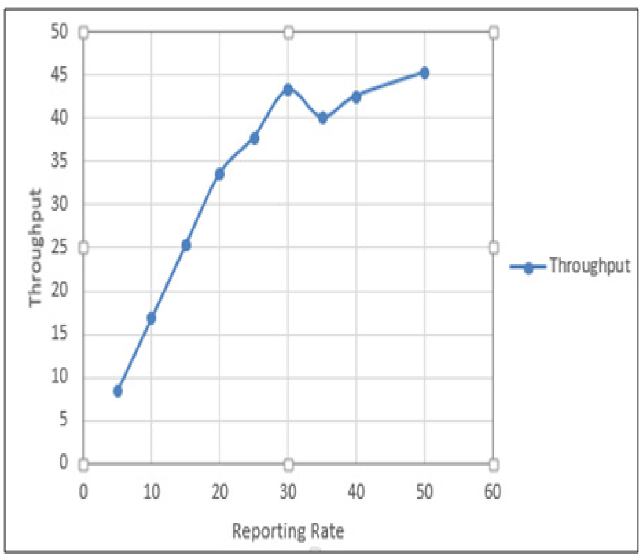

Figure 3. Throughput as a function of Reporting Rate.

Figure 3 throughput as a function of Reporting Rate. From the graph it is observed that with the increase in the reporting rate throughput increases. As the number of packets in the network increases, packets processed by each node per unit time also increases which eventually increases throughput. Throughput is nothing but the traffic generated by the source nodes. Throughput is maximum for reporting rate of 50 pps and least for 5pps.

Figure 4 shows Delay as a function of Reporting Rate. As reporting rate increases delay increases accordingly. When the number of packets in the network are less, delay is very small. But as the traffic in the network increases by increasing the reporting rate delay is observed to increase. Delay can also be introduced because of congestion in the network.

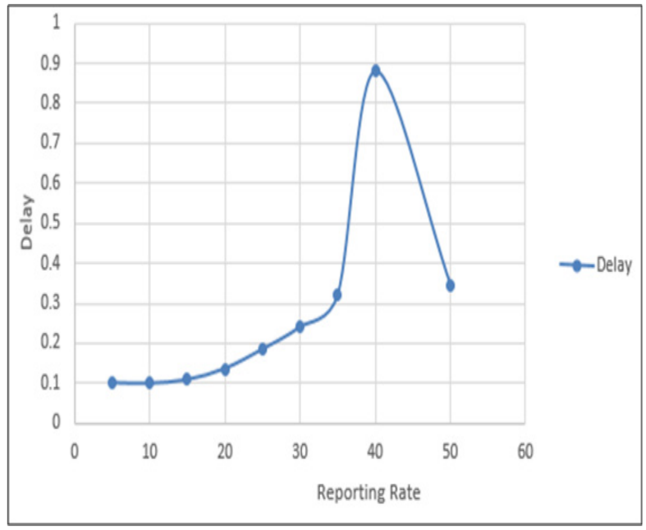

Figure 4. Delay as a function of Reporting rate.

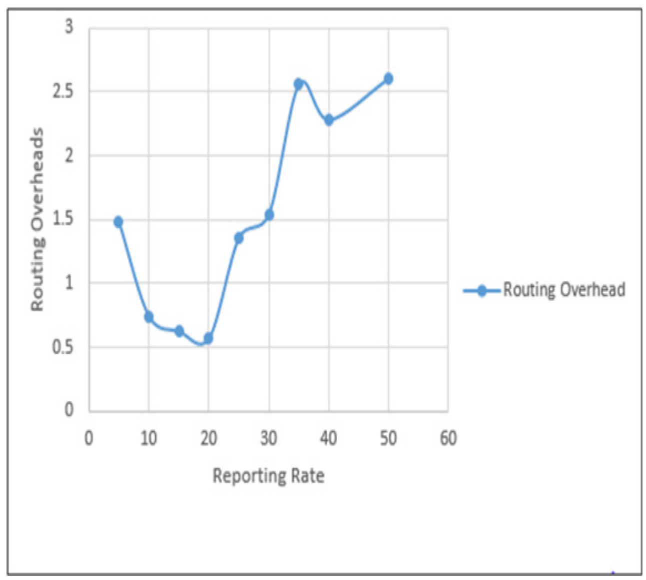

Figure 5. Routing Overheads as a function of Reporting Rate.

Figure 5 represents Routing Overhead as a function of Reporting Rate. The Itdoes not show any particular trend but still it can be said that routing overhead does not increase up to the reporting rate that the network can bear.

Once, the number of packets in the network starts increasing i.e., traffic in the network increases, then the routing overhead also increases accordingly.

Routing overhead is maximum for reporting rate of 50pps. It is minimum for 20 pps. Hence, reporting rate of 20 can be considered as an ideal reporting rate.

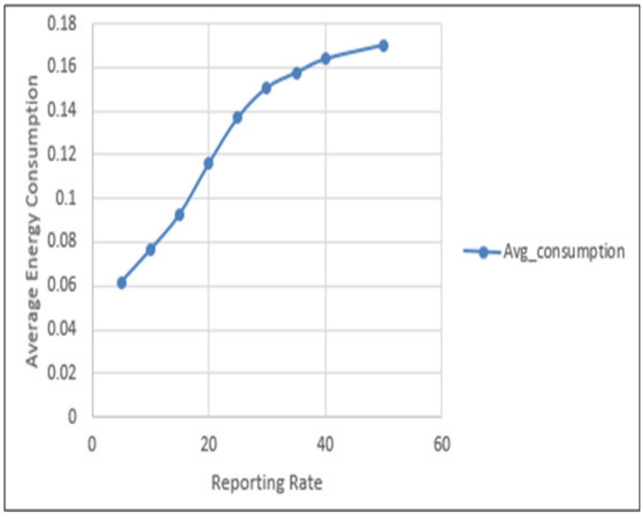

Figure 6. Avg. Energy Consumption as a function of Reporting Rate.

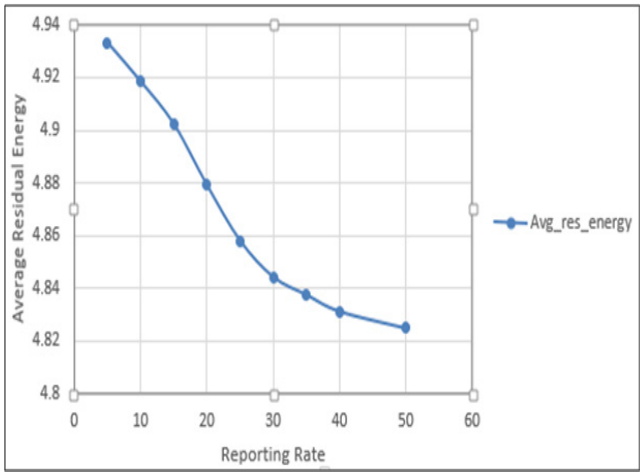

Figure 7. Average Residual Energy as a function of Reporting Rate.

Figure 6 shows the average energy consumption as a function of reporting rate. As the reporting rate increases the average energy consumption increases. As the number of packets in the network increases energy consumed by the nodes to transmit and receive the packets also increases.

Least energy is consumed when reporting rate is 5 Packets per second, as packets in network is less whereas maximum energy is consumed when reporting rate is 50 pps.

Figure 7 shows the average residual energy as a function of reporting rate. As the reporting rate increases the average residual energy decreases. As the number of packets in the network increases energy consumption increases, so the residual energy decreases.

Residual Energy=Initial Energy - Consumption Energy

So, the graph is exactly opposite in nature to that of average energy consumption.

For, reporting rate of 5 pps average residual energy is more as the average energy consumption was very less.

5. Conclusion

With the increase in the reporting rate, the throughput of the network increases considerably. But after a threshold value, the value of the throughput decreases. This because of the congestion or delay into the network. The 20 packets per second is ideal reporting rate for proposed network because the congestion in network is very less. Delay in the network increases as the number of packets in the network increases. Thus congestion is one of the reasons why delay is introduced into the network. The routing overhead fluctuates as the number of packets increase but in general it is observed that it increases. The energy consumption of the network increases just because of the number of packets in the network.

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