Performance Analysis of QoS Parameters of WSN by Varying Density of the Network

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Abstract

Objective: Performance analysis of QoS parameters of wireless sensor network by varying the density of the network (Number of Nodes) using NS-2. The performance metrics considered are packet delivery ratio, throughput, delay, routing overheads, average energy consumed and average residual energy etc. Methods/Analysis: Using NSG tool, scenarios with varying density are formed in 1000*1000 m² area. NS2 is used to simulate the working of a network. AODV protocol is used for routing and CBR is used for traffic generation in network. Results: Packet delivery ratio decreases and routing overhead, delay increases as the number of nodes in the network increases. Throughput initially increases but starts decreasing after threshold point i.e, 50 nodes. It can be said that energy consumption decreases and residual energy increases with increasing density. Conclusion: From all the results it can be said that for constant reporting rate and packet size, 50 nodes scenario gives optimum result for all the parameters.

keywords: Density, QoS parameters, WSN

1. Introduction

Wireless Sensor Network is nothing but group of sensor nodes, which are used to sense or analyse physical parameter such as temperature, humidity, pressure, etc. WSN is vastly developing field, for real time purposes or application such as weather forecasting, animal habitation, military purpose, building and home automation and many more. All type of sensing information is send to sink or destination node by the source nodes, which generate traffic. These collected data can be further used for analysing various environmental or physical condition.

Throughput can be defined as packet transmitted or received per unit time. For maximum utilization of resources networks throughput should be as high as possible.

Throughput is affected because of congestion or delay in the network.

Throughput can then be defined as the amount of information delivered to the sink instead of number of packets.

Packet Delivery Ratio (PDR) can be defined as ratio of number of packets delivered to the number of packets sent.

The WSN with the higher PDR is obviously considered as the better one as it delivers more number of packets and the loss incurred is less. PDR can also depict how reliable the network is. As the number of packets delivered is more so there is satisfactory usage of all of resources in WSN, which are less. If packets are dropped, there is loss of information which is not at all accepted by any network. Reliability is the assurance of packets being transmitted to the destination node. The higher the PDR, higher is the reliability.

Delay can be defined as extra time required to transmit or receive data in network. It can also be defined as amount of time required to reach the destination. Delay is introduced due to congestion in the network. Congestion is nothing but, there is increase in number of packets for transmission or receiving in such a way that sensor nodes are unable to process it and transmit the data within required time and hence delay comes into picture. Mainly delay is introduced in networks due to congestion or traffic¹. It must be low for efficient data transmission.

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Basically delay is mainly dependent on arrangement of nodes means structure of network. Routing overhead is nothing but the overhead required for sending the request and reply packets in the network to find the path from source to destination (AODV). The more the number of nodes in a network, more are the request (RREQ) and reply (RREP) packets generated. Hence, more is the routing overhead. Some routes are generated in routing table which leads to routing overhead. Focus should be on energy consumption as in WSN there are less number of resources available. If resources are properly distributed, energy consumption can be minimized. The nodes in the network can be mobile. There are three approaches for reducing energy consumption if node are mobile they are mobile base station— It is a sensor node that collects the data by moving around the network, data mules— Data is picked from sensors and is transported to sink, and mobile relays. Energy consumption also depends on routing protocol used.

2. Related Work

Congestion is an important issue which leads to various other problems such as delay, minimizing throughput, packets drop, energy consumption and many more. Basically it affects QoS parameters in WSN. Hence it is important to control the congestion and improve the performance of WSN. To minimize the congestion, in reference\textsuperscript{1}, it has been proposed that congestion can be minimized using Congestion Control and Packet Scheduling (JCCPS) mechanism that enhances the network efficiency throughput with the help of Space-Time Division Multiple Access (STDMA)\textsuperscript{1}.

Network is said to be congested when the traffic in the network is very high beyond the potential of the network to process it\textsuperscript{1}. When the parameters like throughput, energy consumption are better in a resource constrained environment, there is an improvement in the performance of WSN.

PDR can also be defined theoretically as the function of SNR, SINR and collision time distribution of a link in sensor network. In order to increase the reliability and packet delivery ratio, adaptive packet sizing techniques is used in 802.11\textsuperscript{2}. The design issues of sensor nodes also has an important role in developing congestion and reducing performance of the network\textsuperscript{1}. Sensor nodes have limited memory hence if the number of incoming packets are more and the node is unable to process them then the packets are dropped. If the nodes are not transmitting or receiving the packets then the nodes moves itself to the sleep state.

Measurement of throughput on the basis of number of packets received is quite misleading\textsuperscript{1}. It is because that the packets received is the result of aggregation of number of packets .Two different packets may carry altogether different amount of information. It proposes the entropy-information based throughput measurement. Throughput can also be defined as the data packets generated by the source nodes per unit time. After load reaches its threshold (Peak point) then because of congestion or delay, it stop to increase or even in some cases start to decrease\textsuperscript{4}.

Reference\textsuperscript{4} concluded that with the help of some technique and algorithm, throughput in the Network can be optimized. Initial work on analysis of QoS parameters of WSN, concluded that throughput increases initially when the load at the base station increases because of increasing packet size or the reporting rate. Higher throughput also can be achieved if the connectivity is preserved. For a WSN to be efficient throughput should be as high as possible. In the sensor networks many nodes are connected to each other for data transmission. WSN perform various node to sink communication activity with the help of different path or link\textsuperscript{5}. But most of the time complex conditions occur due to congestion. When there is increase in number of packets for transmitting or receiving then traffic get introduced. Delay may be introduced due to multi hop routing. Multi-hop routing means sending signal through multiple stops or hop instead of one pathway. Delay can be reduced to 20 times more compare to existing spray and focus algorithm\textsuperscript{6}. Routing overhead actually arises while finding path. To find path between different entities, many routing protocols have been proposed in literature. In general routing protocols are either table driven (pro-active) or on demand (reactive)\textsuperscript{7}. Routing overhead can be reduced by using reactive routing protocol by varying density too in smart grid network\textsuperscript{8}. Different routing strategies can be used within a cluster and neighbouring clusters. Cluster structure of nodes readily decreases routing overhead and scale to an increase node density using various cluster structure\textsuperscript{9}. Smart grid network provide automation over electrical infrastructure.

Results for energy consumption, effect of transmission power on energy consumption are presented in\textsuperscript{10}. Various algorithms which help reducing the energy consumption for different deployment strategies like grid or random are proposed in Comparative Study of Energy Consumption for Wireless Sensor Networks based on Random and Grid

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Deployment Strategies. To conserve energy the information is aggregated at intermediate sensor nodes. It can also be done by applying certain aggregation function on the data received. Aggregation reduces the amount of network traffic which is useful in reducing the energy consumption on sensor nodes. In battlefield, the WSNs are prone to attacks, where the data is attacked, leading to large amount of energy consumption and may lead to exit of a node from work. Energy efficiency of sensor node as well as correct modeling of energy consumption are research issues yet to be explored. A key challenge faced is to minimize the energy consumption so that all the data generated within the lifetime of application can be transmitted to destination. Lifetime of the sensor nodes matter a lot as they are deployed in remote areas and mainly operated using battery of limited power. Energy should be managed properly and carefully as each node contains non rechargeable power.

To overcome the issues in wireless sensor network artificial neural network is also used. The proposed system in provides low complexity using ANN compared to other artificial intelligence techniques. It reduces the computation cost and time as WSN has less resource like memory and energy etc. We can use several MAC protocol to reduce energy consumption. MAC protocol in WSN is the most important aspect in WSN energy performance.

Proactive Source Routing Protocol is proposed to reduce the Overhead to a fraction amount and improve the low Packet Delivery Ratio with high mobility nodes. It also help to reduce end to end delay and to increase throughput. The rate of energy consumption for sensors in a Wireless Sensor Network depend on the protocols used by the sensors for communication purpose. In terms of energy consumption, the DSR performs better than AODV and DSDV. Even though DSR uses source routing and AODV uses hop-by-hop routing, DSR gives better performance as compared to AODV. Comparison between AODV, DSDV and DSR implies that DSDV protocol is not good if packet delivery is compared. DSDV protocol has high control overhead as compared to DSR and AODV protocols. AODV protocol performs well only in some cases but performance of DSR is better than AODV protocol.

3. Result Analysis

For performing the analysis of WSN, considered a 25 nodes scenario initially where the nodes are randomly placed to start with. AODV is used as the routing protocol. Initial energy of the nodes in the network is 5 Joules. AODV stands for Ad Hoc On Demand Distance Vector routing protocol. Density of node is varied from 25 to 125. WSN being application dependent number of node vary from application to application. For e.g., more number of nodes might be required in a battlefield for military purpose to get an exact idea of the scenario. Earlier results gives optimized values of reporting rate and the packet size. The optimized reporting rate comes out be 20 whereas the packet size is 50. Keeping this two parameters, reporting rate and packet size constant and varying the density from 25 to 125, behavior of each of the parameter like throughput, PDR, delay, routing overhead, energy is analyzed. Table 1 gives an idea of the network.

The results obtained for each parameter are represented separately by using graphs.

| Channel Type                  | Wireless Channel       |
|-------------------------------|------------------------|
| Radio-propagation model       | Propagation/Two Ray Ground |
| Network interface type        | Phy/Wireless Phy       |
| MAC type                      | Mac/802.11             |
| Interface queue type          | Queue/DropTail/PriQueue |
| Link layer type               | LL                     |
| Antenna model                 | Antenna/OmniAntenna    |
| Routing protocol              | AODV                   |
| X dimension of topography     | 2521                   |
| Y dimension of topography     | 100                    |
| Time of simulation end        | 10.0                   |
| Initial energy in Joules      | 5                      |

Figure 1. Packet Delivery Ratio as a function of Density
The graph in the Figure 1, depicts Packet Delivery Ratio as a function of density of network. Because of increase in the number of nodes in network number of packets delivered decreases i.e., number of packets dropped increases, so packet delivery ratio decreases. For a 25 node scenario we get better PDR i.e., no packet is dropped. For a 125 node scenario packets drop is more.

The next parameter considered is the routing overhead. The graph in Figure 2, explains Routing overhead as a function of density. Routing overhead increases with the increase in the number of nodes. With the increase in the number of nodes, the request and reply packets generated are more, in case of AODV, which leads to increase in overhead for routing packets from source to destination. For a 125 node scenario routing overhead is the highest and it is least for 25 nodes as less number of non-data packets (Request/Reply) are generated.

Graph in Figure 3, is throughput as a function of density of network. Generally throughput increases with respect to increase in number of nodes as traffic generated is more. Throughput is maximum for the 50 node scenario i.e. 22.52kb. After 50 nodes throughput decreases and almost remains constant thereafter. For network with large density, number of packets delivered to sink node is less because of congestion or delay in the network. So, for 125 node scenario throughput comes out to be the least i.e. 20kb. Throughput after 75 nodes does not change much it almost remains constant.

Graph in Figure 4, is delay as a function of density. As the density of nodes in a network increases, delay generally increases but at some point it may decrease as in the above case it decreases at 100 density. Delay also depends on the routing protocol used. Overall it can be said that delay increases with the increase in the number of nodes.

Graph in Figure 5, is average energy consumption as a function of density of network. Initial energy was 5J before starting the simulation.

Initial Energy = Average Energy Consumed + Average residual Energy.

Energy consumption is maximum for a 50 node scenario as all nodes are able to process the traffic generated. It reduces a bit for 75 nodes and then increases again. The values of energy consumed does not differ a lot for all the densities. Values slightly vary. It can be said that average energy consumption decreases with respect to increase in
4. Conclusion and Future Work

As density of network increase throughput initially increases, but after threshold point i.e., 50 it decreases because of congestion or delay in the network. PDR decreases as density of network increases because of increment in the number of packet drops. Maximum PDR is obtained at 25 nodes and least at 125 nodes. Routing overhead also increases as density increases. It is maximum for 125 nodes scenario and least for 25 nodes. Delay generally increases as density of network increases but for some point it might decrease but can't be considered as a trend. Average energy consumption should decrease generally with increasing density. Routing protocols may also affect the values of consumption and residual energy. Average Energy consumption is maximum for 50 nodes scenario. In future, above QoS parameters can be analyze by varying different routing protocols AODV, DSR, DSDV, etc. Routing Protocols have an effect on delay, energy along with other parameters. This effect can be studied by the above work. It will help to know the pros and cons of various routing protocols with respect to each parameter.

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