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Improved QOS in wireless sensor networks deployed for health monitoring of plant operators

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Abstract. The monitoring of plant operators health parameters is vital owing to pollution and toxic gases level increase in the air atmosphere of the region of the industry. Wireless Body area networks helps to determine the essential parameters of the plant operators continuously with the use of sophisticated sensors embedded in body. However the nodes in the WBAN acquiring critical parameters of the human body need to deliver the information through neighbour nodes to the medical server. The nodes implanted in the body of operators who are moving in and around their work space may find data transfer to the neighbour nodes difficult. Therefore constraints such as packet delivery loss, jitters are reducing the sensor nodes activity and capability. This paper proposes a better queuing mechanism for single channel and multi channel in the architecture to enhance the performance of wireless sensor networks deployed in the vicinity of the industry by improving Quality of service parameters of the proposed network.

Keywords: wireless sensor networks, body area networks, wearable wireless body area networks, quality of service

1 Introduction

A sensor networks is a network of more number of sensor nodes that are deployed in such a manner which may be either it is very close of inside the field or at a region near to sensing part. Wireless sensor network (WSN) is a network of autonomous wireless computing elements to assess physical or ecological conditions using suitable sensors. Wireless sensor networks (WSNs) are very much useful in collecting data from physically challenging environment conditions. Techniques can be used to monitor air pollution data. The chimneys of factories in our state, however, have characteristics such as widespread distribution range and high altitude; the environment protection departments have some difficulties in monitoring the industry chimney, which causes that the large factory chimneys drain the polluted waste gas into the sky secretly and arbitrarily, and results in deterioration of the environment[10]. The events can be detected, collected, processed and sent to control room or sink by the suitable sensors deployed in WSNs. The nodes in WSNs are equipped with substantial processing capabilities of combining the data with nearby nodes, compressing the data, intelligent gathering and processing of sensed data, understanding and controlling the processes inherent to the system[14]. A neural network based straight forward hierarchical routing algorithm employing a single hidden layer feed forward neural network that guarantees a highly efficient computation has proposed. Due to its fastness the algorithm is highly suitable for routing in WSNs[17]. WSNs can be deployed on a global scale for the applications of military surveillance and reconnaissance in war field, search and rescue operations in case of emergency, infrastructure health monitoring in buildings, environmental applications in the forest and fields or even within human bodies for monitoring the conditions of patients[3]. Wearable technology has recently gained the interest of researchers and clinicians[9]. It is associated with long term monitoring of individuals

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in the home and community settings. The sensors become responsible for self organizing an appropriate network infrastructure with multihop connections among them. These sensors after initial deployment will tend to communicate to their neighbours by finding locations and forming network topology. Connectivity and coverage problems are caused by the limited communication and sensing range. Sensor deployment strategies play a vital role in providing better QOS. The integer programmed sensor deployment (IPSD) scheme can offer an enhanced coverage and connectivity in a wireless sensor network without the dependence on external infrastructure or complex hardware[8]. Mobile adhoc network (MANET) is a collection of mobile devices which form a communication network with no preexisting wiring or infrastructure[5, 6]. Swarm based distance vector routing protocol produces better performance than AODV in terms of Packet delivery ratio, throughput, end to end delay, energy and jitter[7].

There are many articles in wireless sensor networks which addressed the quality of service parameters improvement involving varied packet size. However, in this proposed methodology, the parameters of the plant operators to take decisions in case of emergency situations was considered and based on that simulation set up was carried out in order to ascertain the QOS improvement involving queuing mechanism. The scope of this paper is to propose a system based on integration of WSN and model computing technologies for remotely monitoring operators health without physical visit and this will be helpful for the medical professionals to decide in the right way for treatment. The paper is organized with the introduction of body area network, deployment of BAN for industrial operators health care related works and the proposed methodology with Qualnet simulation and the results obtained such as packets delivery ratio throughput and end to end delay represent in the graphical form for better results.

1.1 Body area network

A new generation of WSNs has emerged; the body area networks (BAN's). A BAN is a network of wearable on-body computing devices. It can also include implanted bio sensor devices. According to the IEEE 802.15 (task group 6), a BAN consist of low power devices operating on, in and around the human body to serve a variety of applications including medical electronics. Though BANs are essentially WSNs, data losing BANs could be significant as opposed to WSNs where nodes yield redundant informations. Therefore it may require additional measurements to ensure quality of service and real time data delivery, since reliability of measurements is a must in the medical domain[12].

The use of wearable wireless body area networks as a key infrastructure enabling unobstructive, continual, ambulatory health monitoring. This new technology has potential to offer a wide range of benefits to patients, medical personnel and society through continuous monitoring in a ambulatory setting, early detection of abnormal conditions, supervised rehabilitation and knowledge discovery through data mining of all gathered information[16]. A wearable wireless sensor network of physiological sensors integrated into a vest of the individual acquires the data and transmit to a remote monitoring system continuously, where the health status of the individual is monitored remotely. These systems are capable of monitoring the health status of individuals who perform very high risk jobs like soldiers in battle field, fire fighters and mine workers[9].

1.2 Deployment of BAN for industrial operators health care

The deployments of wearable sensors are done to monitor continuously the vital parameters for health care of plant operators. The architecture of wearable health monitoring system is shown in Fig. 1.

The physiological signals which are obtained through the use of wearable sensors are served using sensor nodes and by using wireless devices the transmission and reception of signals necessary for health care was done. With the use of suitable processor the data that are received are compared and if any abnormal conditions are noticed, an alarm signal by the unit to the ambulance will help medical personnel to reach the plant for medical assistance to the needy operator[18]. The WBANs implanted the number of operators will receive vital parameters and send them to rely notes for further processing.

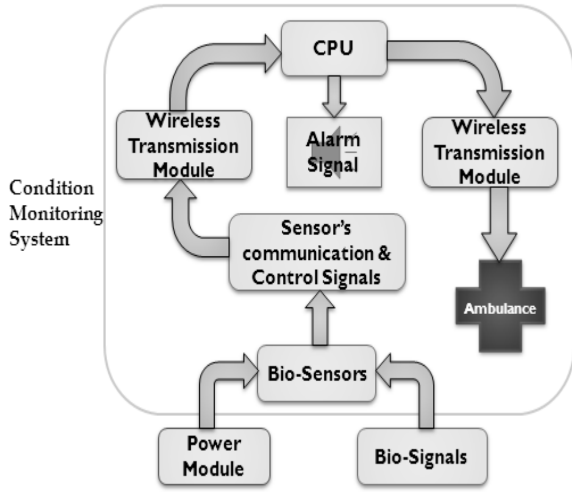

Fig. 1. Architecture of wearable health monitoring system

2 Related works

Rashmi Ranjan Rout[19] presented a technique titled enhancement of life time duty cycle and network coding in wireless sensor networks. The objective is to improve network life time. The sink node consists of relay sensors and due to the traffic created in the relay sensor a bottleneck is formed and this reduces network life time. Using network coding the traffic in the bottleneck region reduces and also the life time is improved leading to transfer of packets successfully[19]. Junjie Xiong[13] presented a paper "Congestion performance improvements in wireless sensor networks." It mainly deals with a congestion occurring in wireless sensor networks. The base station can hardly receive any data from farther sensor nodes while it receives a moderate amount of data from the nearby nodes. This will create a congestion[13]. Sang Hun Han[11] describes the performance analysis of wireless body area network in indoor off body communication. The basic objective of this work is to reduce the change of channel between the body surface and wireless access points which is caused due to the rotation of human body. More number of sensors are fitted along the human body (ondoor, off body, onbody). To overcome the channel variation a receiving antenna is attached to the back side of the human body additionally. By doing so, the variation channel can be avoided and the performance for each diversity scheme is evaluated[11]. Wang[21] presented a paper priority based congestion control in wireless sensor networks. This paper deals with the priority based congestion control protocol (PCCP) for wireless sensor networks. By using PCCP high efficiency is obtained. Also, the system fairness and quality of service (QOS) is improved. In this method the known priority is introduced to reflect the importance of each node. PCCP uses the packet arrival time along with the service time to measure the parameter defined as congestion degree[21]. Shah[20] presented a paper "Remote health monitoring through an integration of wireless sensor networks, mobile phones & cloud computing technologies." He described both wireless sensor networks and cloud computing technologies along with their applications in remote health monitoring for the benefit of humanity[20]. Alrajeh[4] has concentrated in his paper on the mechanism of multi-radio multi-channel utilization in WBAN. This paper analyzed the possibility of deploying multi-radio multi-channel scheme in health monitoring. Existing schemes suffers from many constraints such as significant signal loss due to absorption of electromagnetic waves in body fluid, fading, shadowing and interferences. Multi-radio multi-channel can address many of these limitations[4].

3 Proposed methodology

In a wireless sensor networks the packet send from a node to base station will follows a basic algorithm. The packets will be send depending upon a queueing mechanism. In WSNs, packets coming from the upper layers will be queued at the network layer before being served by the MAC layer.

We focus on the first two of the three main factors that affect the queueing: (i) the data generation interval at each node in the application layer (Ti), (ii) the deadline of data freshness (Td) required in WSN applications, (iii) the queue size (Qs). In resource limited sensor node, we assume Qs is a constant value for two reasons the queue size is limited and not liable to be changed or adjusted. The main objective of the proposed method is to improve the fairness performance and to reduce the delay by FIFO. A sensor nodes and relay nodes receiving data will have to be sent to the server through different nodes and hence the possibility of congestion and loss of data packet are predicted. To overcome these queuing mechanisms were applied and the best queuing technique is suggested. For single queue and multi queue LIFO and FIFO mechanism is presented and simulation results are to be obtained so as to characterise the best queuing mechanism.

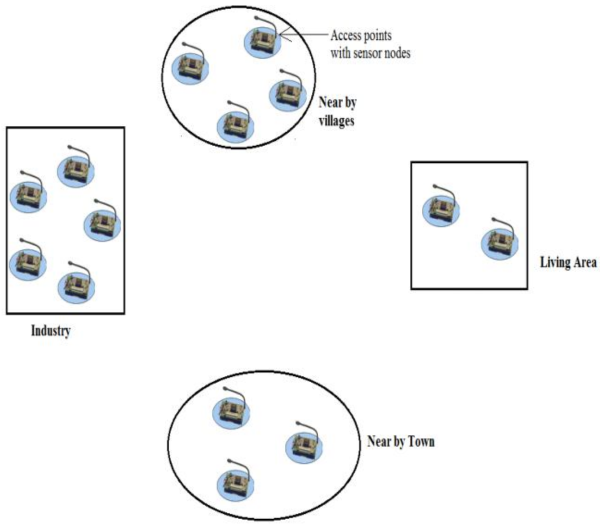

Fig. 2. Layout of sensor nodes

The layout of sensor nodes given in Fig. 2 with access points which includes a transmitter are located in vantage locations to carry out measurement activity of plant operators so as to monitor their health continuously. Sensor nodes are mounted in the adjoining areas of the industry where the mobility of operators is high in order to receive reliable medical information of the operators.

4 Qualnet 5.0

In the proposed method Qualnet 5.0 is being used. The reason for using Qualnet instead of NS2 is that the NS2 is not compatible with a complex network and also it is not that much accurate when compared to the Qualnet simulator. Also the Qualnet can give more reliable results both in wired and in wireless networks.

Qualnet is a rapid prototyping of protocols. A comparative performance evaluation of each layer can be done using Qualnet. The designing of each layer can be analysed well through Qualnet[1].

4.1 Qualnet kernel

The kernel of Qualnet provides the scalability and portability to run hundreds and thousands of nodes with high-fidelity models on a variety of platforms, from laptops and desktops to high performance computing systems. Users do not directly interact with the kernel, but use the Qualnet API to develop their protocol models.

4.2 Qualnet model libraries

Qualnet includes support for a number of model libraries that enable you to design networks using SNT-developed protocol models. It includes the Developer Model Library; additional libraries for modeling wifi networks, mobile ad-hoc networks (MANET), military radios, WIMAX and cellular models are also

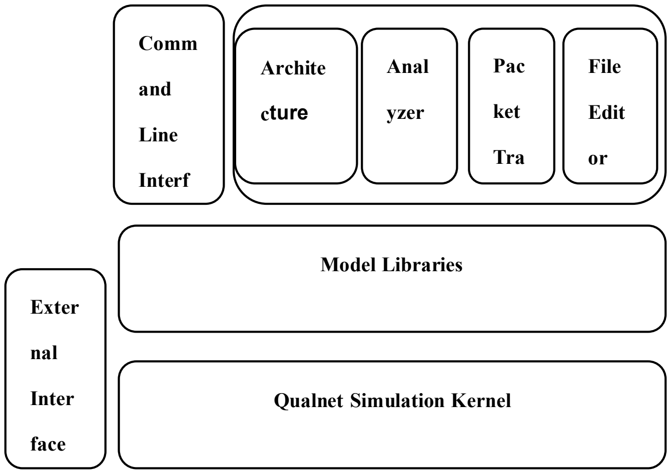

Fig. 3. Qualnet architecture

available[2]. The nodes corresponds to the source of the transmitting packets. In our Qualnet simulator more than 500 nodes can be added to a single network. The nodes can be selected in the devices option. To enhance the connectivity all the nodes should be connected to the access point. Two different nodes in different networks can be connected by connecting the both networks to the access point.

4.3 Links

To draw a link between two objects, select the link button from the toolset, left-click on one object on the canvas, drag the mouse to the other object and release it. A point-to-point link is created by connecting two units. A point-to-point link between two terrestrial units appears as a solid blue line.

A point-to-point link between a terrestrial unit and a satellite appears as a solid purple line. A device is made part of a wireless subnet by drawing a link between the device and the cloud icon representing the subnet. The link between a device and a wireless subnet is displayed as a dashed line. A device is made part of a wired subnet by drawing a link between the device and the hub icon representing the subnet. The link between a device and a wired subnet is displayed as a solid blue line.

5 Simulation

Simulation time is the maximum time allocated by the user for the transmission of packets in the designed network scenario. In our network 2000 seconds has been set as the simulation time. It means that the sending and receiving of packets should be finished within 2000 seconds. Even if the packets are not delivered within the simulation time, then the process will be stopped.

5.1 Simulation setup

The desire network topology is specified in the GUI environment. The basic parameters for the wireless sensor network are shown in Tab. 1. The desired network topology consists of sensor nodes implanted in the operator's body who are working in the plant and neighbor nodes which are there in the selected region will perform the activity of the data receiving and transfering for predicting the abnormalities in the operator and send the data transferring to the medical server room to handle emergency situations. The plant operators need to be monitored only for a change in their health parameters after certain duration of time which may be set for 2000 seconds or even less if necessity arises.

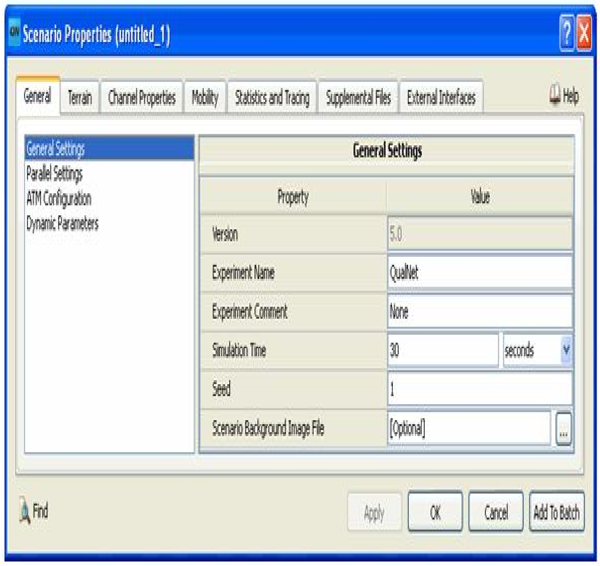

Fig. 4. Scenario properties editor

Table 1. Input parameters

Parameters	Values
Layer	Network Layer
Simulator	Qualnet 5.0
No.of Access Points	2
Network Area	1500m∗1500 m
No.of Nodes	50
Simulation Time	500 Seconds
No.of Networks	3
MAC Type	802.11
Packet Size	512
Time Interval	1 Seconds
No.of Packets	2000
Routing Protocol	AODV

5.2 AODV routing protocol

The routing protocol used for the scenario is AODV (ad-hoc on demand distance vector protocol). In AODV, the network is silent until a connection is needed. At that point the network node that needs a connection broadcast a request for connection. Other AODV nodes forward this message, and record the node that they heard it from, creating an avenue of temporary routes back to the needy node. When a node receives such a message and already has a route to the desired node, it sends a message backwards through a temporary route to the requesting node.

The needy node then begins using the route that has the least number of hops through other nodes. Unused entries in the routing tables are recycled after a time. When a link fails, a routing error is passed back to a transmitting node, and the process repeats. Much of the complexity of the protocol is to lower the number of messages to conserve the capacity of the network. For example, each request for a route has a sequence number.

Nodes use this sequence number so that they do not repeat route requests that they have already passed on. Another feature is that the route requests have a “time to live” number that limits how many times they can be retransmitted. Additional feature is that if a route request fails, another route request may not be sent until twice as much time has passed as the timeout of the previous route request.

The advantage of AODV is that it creates no extra traffic for communication along existing links. Also, distance vector routing is simple, and doesn’t require much memory or calculation. However AODV requires more time to establish a connection, and the initial communication to establish a route is heavier than some other approaches.

5.3 Single queue and multi queue FIFO

The network model designed for single-queue FIFO is shown below.

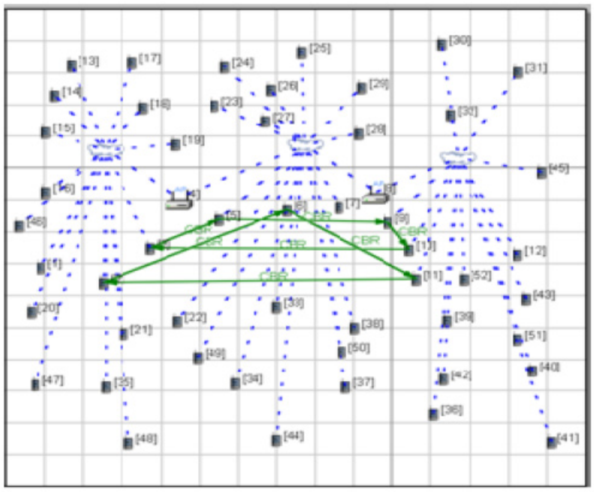

Fig. 5. Designed scenario for single-queue and multi-queue FIFO

The proposed network is designed as a wireless sensor networks which consists of a number of nodes. As shown in the parameter table (Tab. 1) the environment of the network scenario is created under the dimension of 1500×1500 meters. Three individual wireless sensor networks are placed in the environment and each network has a number of nodes on their own. To initiate the communication between the nodes of different wireless networks the access points are used and connection between different nodes of different wireless networks is not possible.

6 Simulation results

The simulation is done and a number of results were examined. The simulation for different sets of nodes in various environment is done to ascertain the performance.

6.1 Total packets send in single-queue and multi-queue FIFO

The number of packets send by each node for single-queue and multi-queue is shown below.

It is shown that every node sends 500 packets each to their respective base stations. Here simulation time is set as 500sec and so every node sends 500 packets respectively.

6.2 Total packets received in single-queue and multi-queue FIFO

From the Fig. 6, it is shown that the receiving of packets varies based on queuing employed and near the client the packets were received according to the routing protocol. Every node receives a packet depending upon their location with the base station.

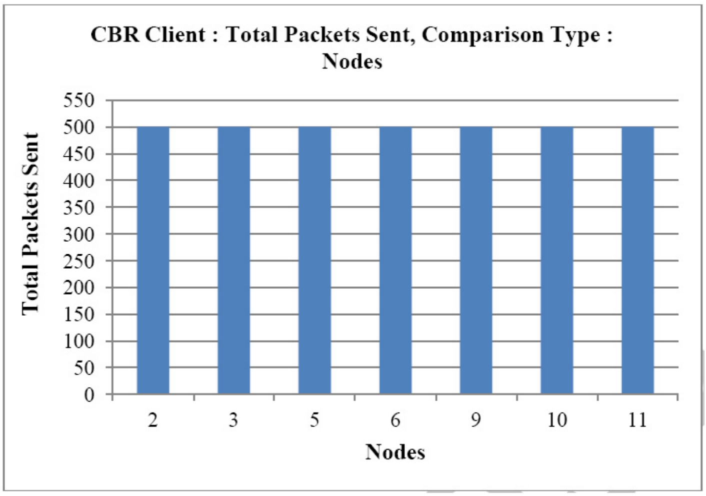

Fig. 6. Single-queue FIFO and multi-queue FIFO

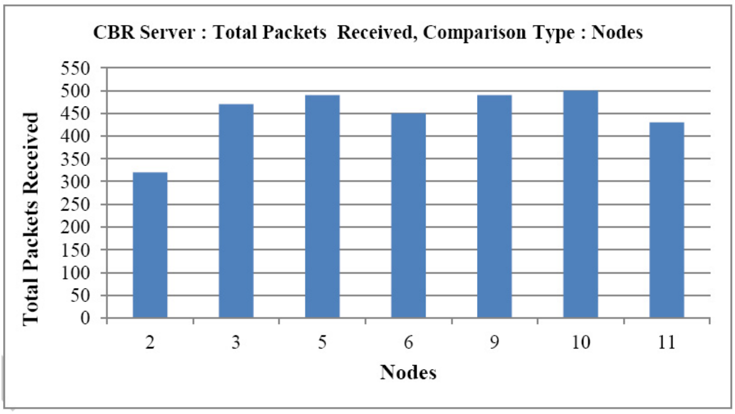

Fig. 7. Packets received in single-queue FIFO

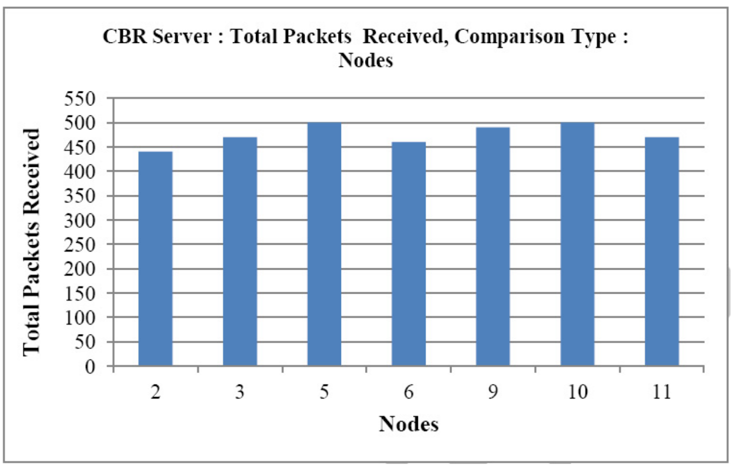

Fig. 8. Packets received in multi-queue FIFO

6.3 Packets received in multi-queue FIFO

The packets received in multi-queue FIFO is high when compared to the single-queue FIFO because the multi-queue FIFO consists of a number of channels and also every node can send the packets depending upon the available channel. Thus the packets received from far away nodes are high when compared to the single-queue technique.

Figs. 7 and 8 give information about the delivery of packets in a single and multiqueue FIFO. From the above, it is shown that packet delivery from farther nodes is high when compared to single queue. Though simulation is done for 500 nodes, the packets delivered at the destination node is only shown.

7 Quality of service parameters

To determine the best and efficient MAC layer for congestion control the simulation is carried under different scenario. In every scenario the simulation model is kept constant and the MAC layer only changed in order to determine the packet loss.There are a number of MAC layer protocols present in the Qualnet simulator 5.0.The simulation is done under three MAC layer mediums namely 802.11, 802.11e and ALOHA. Depending upon the obtained simulation results the graph is plotted and the efficient MAC layer for congestion control is determined.

7.1 Jitter

Jitter is defined as the variation in the time between packets arriving, caused by network congestion. Jitter causes delay in packet delivery. As the number of packets increases the jitter also increases.

In mobile communication the jitter causes the crosstalk error and in jitter can cause a display monitor to flicker which affects the ability of the processor in a personal computer from performing an intended work.

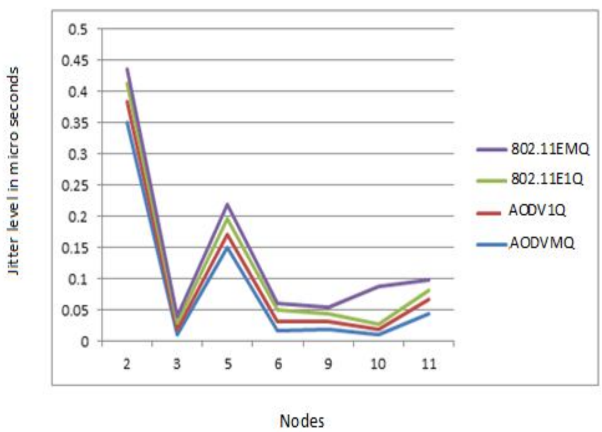

Fig. 9. Jitter level of different MAC layers

Jitter may be termed as the variation in delay or packet delay variation. The value of Jitter is calculated from the end to end delay. Measuring delay is helpful in determining the performance of the network and the QOS the network offers.

$$\text{Jitter} = \frac{\sum\limits_{i=0} \text{square}(\text{Delay}_1 - \text{Delay})}{N}.$$

A relative simulation is done by varying the MAC layer of the network. Depending upon the obtained results a graph is plotted as in Fig. 8. It is observed that the jitter occurring in 802.11 AODV is less when compared with 802.11e. Therefore the 802.11 multi-queue FIFO will cause less deviation in time when compared with the 802.11e AODV in both single-queue and multi-queue FIFO technique.

7.2 Packets delivery ratio (PDR)

Packet delivery ratio is defined as the ratio of the average number of data packets received by the destination node to the number of data packets transmitted by the source node.

$$\text{PDR} = \frac{\sum_{i=1}^{n} \text{Number of packets delivered}}{\sum_{i=1}^{n} \text{Number of packets sent}}.$$

Call success ratio is defined as the ratio of number of calls generated by the source to the number of calls accepted by the destination node.

$$\text{Success ratio} = \frac{\sum \text{Number of valid calls accepted}}{\sum \text{Number of calls generated}}.$$

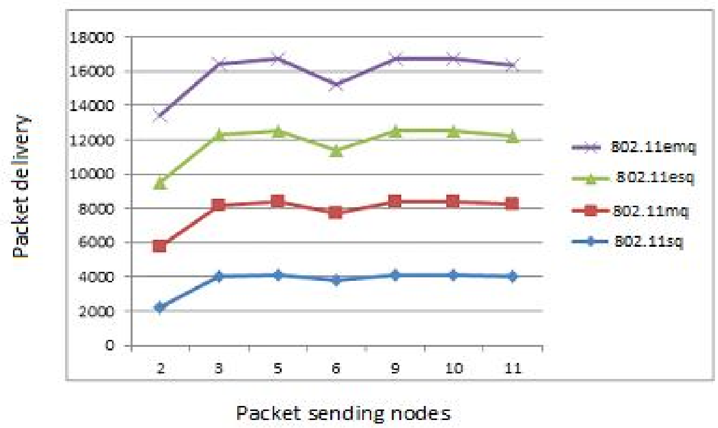

Fig. 10. Packets delivery ratio in different MAC layers

The packets received in a AODV routing protocol with different MAC layers is shown in Fig. 9. It is seen that the packets received in multi-queue 802.11 AODV is more efficient than 802.11 single-queue and 802.11e single-queue and multi-queue FIFO technique.

7.3 Throughput

Throughput of different MAC layers by using AODV as the routing protocol is simulated and Fig. 10 shows the variation in throughput for various techniques. From the plot it is clear that 802.11 multi-queue FIFO techniques are more efficient in throughput when compared with the 802.11e techniques.

The overall performance of 802.11 MAC layer is proven to be the efficient method for congestion control and the AODV is the efficient routing protocol for congestion control. Therefore AODV along with 802.11 MAC layer is used for controlling congestion and to reduce the delay.

The value of throughput must be high or else it affects the intended purpose for which the system is installed.

$$\text{Throughout} = \frac{\sum_{i} \text{packets delivered}}{\sum_{i} \text{packets arrival} - \text{packet start time}}.$$

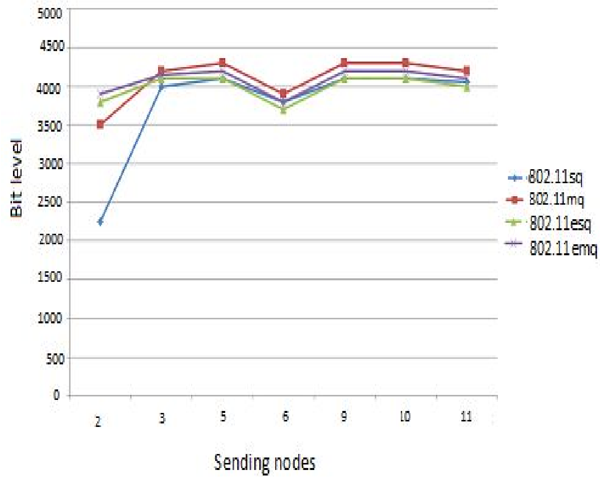

Fig. 11. Throughputs of different MAC layers

7.4 End-to-end delay

It is defined as the average of the time taken by all the multicast packets to reach its destination. First, for each source destination pair, average delay for packet delivery is computed. Then the whole average delay is determined from each paired average delay.

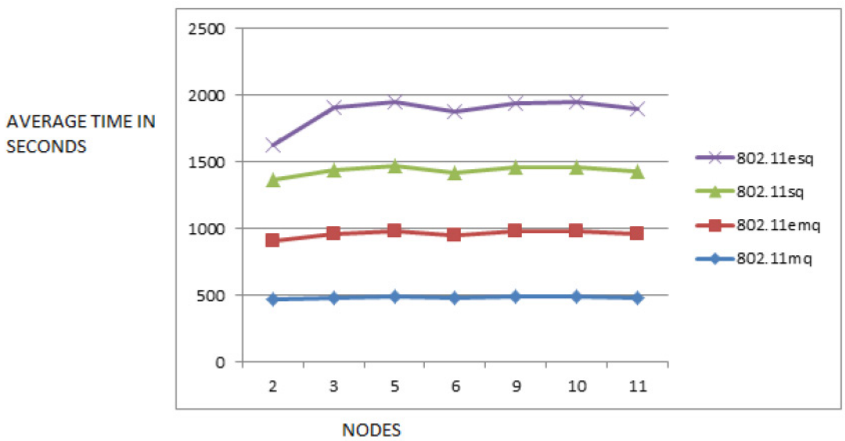

Fig. 12. End-to-end-delay of different MAC layers

8 Conclusion

This research reduce the delay and improve the fairness performance of congested WSNs deployed for health care monitoring by the implemented multi-queue-FIFO mechanism instead of single-queue-FIFO mechanism. Firstly it is proved that the multi-queue FIFO provides better delay and fairness performance than the single-queue FIFO in congested WSNs. Then to further improve fairness, it is also implemented with a multi-queue algorithm by dividing the real queue of a node into multiple sub-queues and adjusting the serving probability for packets from different sub-queues. A clear simulation done by using the Qualnet simulator shows that multi-queue-FIFO mechanism is better than single-queue-FIFO mechanism. On comparing the simulation results of multi-queue-FIFO mechanism with the single-queue-FIFO mechanism, it confirms that multi-queue-FIFO-reduces delay and improves the fairness performance while maintaining similar throughput than the single-queue FIFO mechanism deployed for health care monitoring of the plant operators. As a future scope of work different areas such as surveillance in battle field and environmental monitoring where the deployment of network is different and can be tested for performance enrichment.

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