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Improved QoS for the Sensed Data in the Wireless Sensor Network through Customized Priority Scheduling Scheme

[1]Hebziba Jeba Rani. S, [2]Deepika. N,
[1,2]Assistant Professor,[1,2]Department of Computer Science and Engineering,
[1,2]Sri Ramakrishna Institute of Technology,Coimbatore-641010
[1]hebzibajebarani.cse@srit.org, [2]deepika.cse@srit.org

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Abstract:
Abstract—Wireless sensor networks are mainly deployed to monitor the environmental conditions and to transfer the sensed data to the destination. The environmental conditions are monitored periodically to identify the abnormal activities in the environment. The timely detection of the environmental changes will protect the humankind from various calamities like earthquake, fire accidents etc. Thus these sensed data need to be transmitted to the destination within the short period of time only then timely countermeasures can be taken to protect the humankind. These time critical data need to suffer from no delay in the network. But the wireless network is prone to data loss due to the wireless nature and the mobility of the nodes. Thus to avoid the delay and the dropping of the sensed data, the sensed data can be scheduled before transmission. The scheduling can transfer the packets in some order avoiding the packet drop problems and the priority can be given to the packets. So the time constrained packets can be scheduled to transmit first. This avoids the delay of time sensitive data to be reached in the destination. This paper deals with the various scheduling schemes that can be opted in the wireless network and the pros and cons of using each scheduling scheme is also discussed. The proposed customized priority scheduling scheme improves the quality of service of the sensed data when compared with the other scheduling schemes.

Keywords: *Priority scheduling scheme, real time packets, Quality of service.*

I. INTRODUCTION

Wireless sensor network is a network of sensor nodes. A sensor node is situated in the network to sense or monitor the environment in which it is placed. The environmental conditions like the temperature level, vibrations, water level, sound level, movements in an area can be sensed by the sensor nodes. These senor nodes are also called as the mote. Thus a mote is a node in the network but not all nodes are motes. The senor node sensing the changes in the environment sends the sensed data to the base station via intermediate node or directly to the destination depending on the location of the sensor nodes [2]. The senor node sensing the environment may be of the size ranging from that of size of a box to the size of a small grain. Thus depending on the complexity and the functioning of the sensor node, the senor nodes vary in its size and cost. Sensor nodes also have constraints on the resources like the energy consumption, processing speed, memory etc. Each senor has several parts within it like a transceiver, microcontroller.The transceiver part of the sensor acts as both the transmitter and the receiver. To support this functionality internal antennas are used in the sensor nodes. Next the microcontroller in the senor node is a circuit which is responsible for coupling the sensors and the energy source. The energy for the working of the sensors may be through the utilization of the batteries which are

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fitted inside the sensor device or through the energy harvesting technique. The energy harvesting technique utilizes the external energy sources like the solar power, wind energy, thermal energy to grab the energy and the grabbed energy is then stored in small devices. This type of energy harvesting technique is mainly used in the areas like the wearable electronic devices and wireless sensor networks [9].

The initial development of wireless sensors networks came from the military applications where the senor nodes are deployed in the battle field to monitor the intrusion of the enemies. Later this wireless senor technology is deployed in various applications like the industrial monitoring, forest fire detection, landslide detection, health care monitoring etc.., [10],[7]. It is very clear that the sensor networks are widely used to monitor the sensitive and time constraint information like data regarding the earthquake, forest fire, machine failure. Thus the data gathered by the sensor nodes need to be transmitted to the destination without any delay and loss. Because of the delay and the loss ofthe time constraint data (e.g. data about the fire accident) may lead to dangerous consequences like the loss of human life. Thus these data need to be transmitted without suffering from any delay. The delay and the packet loss may occur due to the broadcast nature of the wireless environment, wireless medium accessed by many nodes, threats regarding the unauthorized access, energy constraints of the senor nodes, mobility of the nodes in the wireless environment. Thus to avoid the delay and the loss of the data, the data can be scheduled in the network. The data with high priority can be scheduled first to reach the destination. Thus the delay is considerably reduced for the high priority packets. Hence instead of simply transmitting the data, the scheduling scheme can be used to support the Quality of Service (QoS).

There are two major categories of the type of the data. They are the real time data and the non-real time data. In general sense real time refers to something that does not suffer any delay and the results are produced within few seconds whereas the non-real time on the other hand have no timing constraints [1] i.e. the results are not produced immediately but suffers some delay. In non-real time results may be produced in several hours to several days. Similarly real time data are the data that are need to be processed immediately i.e. these data cannot tolerate the delay. For example consider a sensor monitoring the temperature in an industry. Consider a scenario where if the temperature in the industry goes beyond the particular threshold then due the high temperature, the machineries in the industry may get fired and may lead to fire accident. In this case the sensed data need to reach the controller room immediately after sensing, only then the abnormal temperature can be monitored and counter measures to avoid the fire accidents can be taken in timely way to save the human life and machines. Thus these types of time critical data are referred to as the real time data.

The non-real time data are the data where the data requires no immediate processing. For example consider the sensor sensing the number of products produced by a particular machine in an industry. This data is periodically sensed and delivered to the destination node. If any delay occurs in this scenario, it is tolerable and no major consequences occur like loss of lives or damage to machines. Thus these types of data requiring no immediate processing are referred to as the non-real time data. From the above given examples it is well clear that the real time packets need to be transmitted first without delay. Only then the deployment of the wireless sensor network will be a successful one else the purpose of the wireless senor network will be of no use. Thus to achieve the full advantages of wireless senor network, the scheduling concept need to be integrated in the senor network to deliver the real time data immediately without any delay [11]. Thus the

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various scheduling schemes that can be opted for the wireless environment and its advantages and disadvantages are discussed in this survey paper to find the optimal scheduling scheme for wireless senor network.

II. MAJOR PARAMETERS WHICH SUPPORTS QOS IN SCHEDULING

Scheduling is done based on some parameter. Not all scheduling schemes schedule the data in the same order but based on the different scheduling schemes, the order in which the data is transmitted to the destination also varies. This differentiation between various scheduling schemes is based on the parameter on which it is focusing. The major parameters for scheduling the packets may be based on the reliability, delay, jitter and bandwidth [6].

A. Reliability

Reliability refers to the trustworthiness. That is in wireless sensor networks, the sensed data which is received at the destination needs to be reliable without any false information. The data is said to be reliable if the received data is exactly the same as the sent data. This is achieved only through high security. The wireless network is vulnerable to the unauthorized users due to its broadcast nature and wireless nature. Thus security plays a major role in transferring the reliable data. For example in Email application, the email sent by the sender need to be reached at the receiver side without any modification or overhearing problem. Because the email message may carry sensitive information like account details, transaction details, business information, personal details like id, password, insurance details etc. Thus this type of data needs to be packaged in a tight security environment. In this case the delay is tolerable whereas the security issue is highly intolerable. So by keeping reliability as a major parameter the scheduling scheme should be chosen in such a way it should not compromise on security.

B. Delay

Delay refers to the time by which the data is postponed or late. For example in wireless sensor networks, a sensor sensing the changes in the temperature in the industrial environment needs to transmit the data to the controller room within 5 seconds. In this case if the data is not delivered within the 5 seconds and exceeds the threshold of 5 seconds then the data is said to suffer from delay which is not acceptable because if the temperature exceeds a particular limit there may occur fire accident in the industry due to the explosion of machinery parts. To avoid such fire accidents the temperature data needs to reach the controller room within limited time limit only then counter measures or the timely actions can be taken to avoid the accidents. In such environments the scheduling scheme should focus mainly on the delay parameter. Here if security is considered a major role, then due the security mechanisms delay arises. Time critical data received with highly secure way with delay is totally useless and leads to lot of damage. Thus the primary focus must on the delay parameter in such environments.

C. Jitter

Jitter refers to the variation in the delay of the packets that are received. In some environments, the high jitter is not acceptable. For example consider the video streaming from the video sensors. The video from the video sensors need to reach the destination with synchronization to the audio and video. Lack of synchronization in the video streams makes the video meaningless and useless. For example in police department, the video sensor sensing the activities of the criminals in the prison has to reach the destination with proper synchronization of the audio to the lip movement of the criminal. Only then the important clues received from the video are acceptable and meaningful. Else chances are there for considering the video clip as a fake video. Thus for better understanding of the video, the

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synchronization is must which is only achieved through concentrating on jitter parameter.

D. Bandwidth

Bandwidth is referred to as the amount of data that is transmitted over the network in a given period of time. Bandwidth is often expressed in bits per second (bps). Consider the applications like remote surgery, video messaging requiring bandwidth constraints. The robots or the doctors may perform the surgery depending on the information received from remote physicians. This type of sensitive data needs high constraints on the bandwidth and also security. However in the commercial video broadcasting applications like TV broadcasting, high emphasis is given to the bandwidth rather than the security.

Thus depending on the application and the environment in which the sensors are deployed, the QoS parameter is chosen and based on the QoS parameter the scheduling scheme should be chosen appropriately.

III. VARIOUS PACKET SCHEDULING SCHEMES

The following section describes the various packet scheduling schemes that can be deployed in the wireless sensor networks. Not all the packet scheduling scheme produces the result of same ordering. Thus depending on the applications and constraints the appropriate packet scheduling scheme can be chosen [1], [11].

A. First Come First Serve (FCFS)

The first come first serve scheduling scheme is very simple and easy to understand. The packet that arrive the queue first is the packet that leaves the queue first. In this scheduling scheme, based on the arrival time of the packet, the packets are served. The packet that is arriving first is served immediately and so the packet arriving earlier reaches the destination without much delay whereas the packets that arrives late, have to wait till the packets that are queued before it are transmitted. Thus for packets that arrive late, the waiting time of those packets in the queue increases which leads to delay in reaching the destination. Thus using the first come first serve scheduling scheme suffers from delay in reaching the destination. Thus this scheduling method can be deployed for the applications which compromise on delay.

The major drawback in the first come first serve scheduling scheme is that this method does not bother about the urgency and the size of the packets. Thus whatever the constraints which are imposed on data, this scheduling scheme forwards packet only based on first come first serve. Emergency packets even have to wait in the queue till the processing of the packets which are queued before it. This leads to the emergency data to wait in the queue and so dangerous consequences may occur. Also if a small sized packet arrives the queue, whatever may be the queue length, the small sized packet have to wait in the queue for the processing of the packets placed before it. This leads to the waiting of the small sized packets behind the large packets leading to the delay in transferring the even small sized packets. Also if the capacity of the queue is exhausted, the new incoming packet that enters the queue will be dropped irrespective of its priority.Thus in wireless sensor environments with strict timing constraints on the sensed data, the first come first serve scheduling scheme cannot be adopted due to the limitations in giving priority to the data.

B. Earliest Deadline First (EDF) Scheduling Scheme

This is a priority based scheduling scheme where the priority is given based on the deadline of the packet. Instead of transmitting the packets in the order as it arrives, this scheduling scheme searches for the packet which is having the closest or the least deadline. The deadline indicates the expiration time of the packet. If the packet's deadline is exhausted the packet gets expired and transmitting the packet after the deadline is useless. Thus using this scheduling scheme the emergency data can be transmitted faster. It is

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because the emergency data will have strict timing constraints i.e. strict deadline. Thus these packets are transmitted first in this scheduling mechanism. Hence the waiting time of the emergency packets are considerably reduced leading to minimal delay.

If two packets arrive with the same deadline, then randomly one data packet is forwarded. This leads to problem if the destination of these two packets is different. Priority should be given to the data which needs to travel longer distance to reach the destination. But this type of priority is not supported in earliest deadline first scheduling scheme.

C. Velocity Monotonic Scheduling (VMS)

In the earliest deadline first scheduling algorithm, the order in which the data should be forwarded is merely based on the deadline of the data not focusing on the distance of the destination node from the current node. Thus if two data packets arrive with the same deadline, one packet is chosen as random and forwarded. But this in scenario, there may be a case where one of the packets has longest distance to travel to reach the destination whereas the other packet has to travel shorter distance to reach the destination. In this case, even though both of the packets have the same deadline, the packet that needs to travel longer distance to reach the destination needs to be forwarded first then the packet with shorter distance to destination should be transmitted. It is because the packet having longest distance to reach destination have to spend more time in the network and have to reach destination within its deadline. Thus packet that has the longest distance to travel to reach the received should be forwarded. This type of priority is given in velocity monotonic scheduling.

In this scheduling scheme, if two packets arrive with the same deadline, then this scheduling calculates the velocity in which each of the packets has to be transmitted. The packet which is having the highest velocity through which it should be transmitted is scheduled first. To calculate the velocity in which the packets are to be transmitted, the scheduling scheme utilizes the time till the deadline of the packet expires as well as the distance between the current node and destination node. Thus based on time and distance, the velocity is calculated (d/t). The velocity can be calculated in static manner at the source or in a dynamic way at each intermediate hop node and the highest velocity packet is given highest priority.

D. RACE Scheduling Scheme

This RACE scheduling scheme attempts to find the path which is having the minimum traffic load and the minimum end to end delay between the source and destination. This scheduling scheme utilizes the bellman ford algorithm to find the path with the minimum load between the source and destination. Thus the use of this scheme minimizes the delay through the selection of the path with minimum traffic load. Thus to reduce the end to end delay the RACE algorithm can be used. The Earliest Deadline first algorithm is used for scheduling the packets and the ford algorithm is used to find the path with minimum load between source and destination.

Still in this scheduling scheme the packets are not scheduled based on the location of the nodes just like the earliest deadline first scheduling algorithm but this RACE algorithm reduces the delay through path selection.

E. Adaptive Task Balancing Scheduling Scheme

The wireless sensor network consists of many nodes each of which have its own task of sensing the environment and transmitting the sensed data to the base station through the intermediate nodes. Thus apart from sensing the environment reach node has to forward its own data and forward the data received from other nodes. Thus the tasks in the sensor network are broadly classified into the sensing task and the network task. The sensing task involves the sensing of environment, processing of signals and encoding of the data to

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be transmitted. The networking task involves the transmission of the packets, reception of the packets and the forwarding of packets. But major if the time most of the nodes are becoming busy with the networking tasks and their sensing tasks are thus affected. That is the forwarding operations are given more priority than the own sensing operations. Thus to overcome this problem the adaptive task balancing scheduling scheme is used to switch the priorities between the networking and sensing tasks.

The priority is given based on the depth of the node (number of hops to the base station). It is because the node which is nearer to the base station will have more networking task as it need to forward many of the packets from other nodes to the destination base station. Each node in the senor network monitors its depth and if the node moves and goes close to the base station i.e. if the depth of the node is less, then its sensing task is given more priority for a particular period of time. This time can be defined based on the network size, type of data to be sensed. And when the time expires the priority switches from the sensing tasks to the network task. Thus priority is given for both the network and the sensing tasks.

F. Dynamic Multilevel Priority (DMP) Scheduling Scheme

The dynamic multilevel priority scheduling scheme utilizes three queues for forwarding the packets that are received. The first queue is placed with the real time packets whereas the remaining two queues are placed with the non-real time packets. The second and third queues are differentiated based on the location of the sensor nodes. The non-real time packets that are coming from the remote location are put in the second queue whereas the non-real time packets coming from the local nodes and from that transmitting node itself is placed in the third queue. The first queue is given the highest priority. The second queue is given the next highest priority and the third queue is given the least priority. Thus only when the first queue becomes empty, the second queue begins its transmission and then the third queue. While the low priority queues are transmitting, if the highest priority real time data packet enters the first queue, the first queue pre-empts the other queues and begins its own transmission.

IV. PROPOSED CUSTOMIZED PRIORITY SCHEDULING SCHEME

The proposed scheme focuses on achieving the Quality of Service in sending the sensed data to the destination. In order to achieve Quality of Service, channel selection along with data scheduling is concentrated. Incoming packets from the sensor are prioritized first based on the scheduling scheme and after prioritizing the data, based on the type of sensed data, appropriate channel is chosen thereby leading to QoS achievement.

The Customized Priority Scheduling scheme works by first reading the packet header of the incoming packet. This scheduling scheme runs in each and every node in the sensor network. Thus the sensor node sending its own sensed data or forwarding the incoming packet first checks the packet header for splitting the data based on its priority level. That is according to the priority attribute it schedules the incoming data. The QoS parameters specified in the header includes the delay, security, packer delivery ratio. This customised scheduling scheme helps to achieve the Quality of Service based on the customized data priority.

The Customized Priority Scheduling scheme works with multilevel queues for better prioritization of data based on the QoS parameters. Where in the first queue the data with strict timing constraints are placed and the second queue the data that are to be sent with more security is placed and in the third other QoS parameter specified data are placed for example the data that requires high packet delivery ratio. This scheduling scheme checks the incoming

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packet for its priority. If the data is an emergency data it places in the Queue 1. Else it leaves the first queue as empty and moves to the next queue. If a packet received is not mentioned as emergency it splits the packet to be placed in the remaining queues based on its parameter.

V. PERFORMANCE EVALUATION

The simulation is carried out within the Network Simulator 2 in Linux operating system with Ubuntu as the interface tool. The mobility model uses the random waypoint model. There are 50 nodes defined in a simulation area of size 1000m x1000m. The mobility of nodes is limited to 5ms. The traffic model chosen is Constant Bit Rate (CBR) connections with packet size of 1000 bytes to emulate traffic over the network. The simulation parameters for the sensor network are as follows:

a) Sensor nodes are randomly deployed in the given area

b) Initial energy of each sensor node is 2 Joule

c) Each experiment is conducted for 2 simulation scenarios and the average is used for documentation

d) Sink node is located at the centre of the sensor network is used in simulation

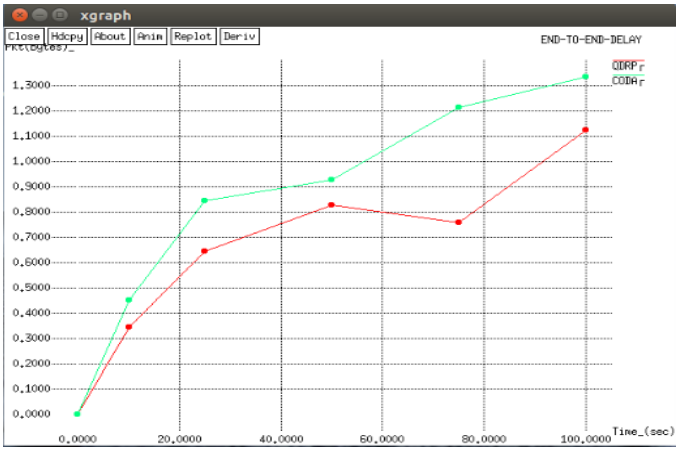

Figure 1 Performance graph on delay

Figure 1 demonstrates the end-to-end delay of data traffic over a number of zones and levels.From these results, we find that the customized priority scheduling scheme outperforms Multilevel Queuescheduler in terms of end-to-end data transmission delay.

VI. CONCLUSION

Wireless sensor network plays a wide area in recent wireless environment. The sensed data to be sent to the receiver are to be transmitted at faster rate with minimal delay and effective utilization of resources. Thus an effective scheduling scheme should be used for transmitting the packets. Based on the application and the environment in which the sensors are placed, the customized priority sensor scheduling scheme can be used. The various scheduling schemes that can be used in wireless sensor networks and its importance are discussed. By comparing all of these scheduling schemes, Customized Priority scheduling scheme is preferred to perform better in wireless sensor environment.

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