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DMP Packet Scheduling For Wireless Sensor Network

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ABSTRACT : *Most of the existing packet scheduling mechanisms of the wireless sensor network use First Come First Served (FCFS) non pre emptive priority and pre emptive priority scheduling algorithms. The above algorithms have high processing overhead and also long end-to-end data transmission delay. In FCFS concept the data packet which is entering the node first will go out first from the node, and the packet which will enter last will leave at last. But in FCFS scheduling of real time data packets coming to the node have to wait for a long time period.In non pre emptive priority scheduling algorithm there is starvation of real time data packets because once the processor enters the running state, it will not allow remove until it is completed, so there is starvation of real time data packets. In pre emptive scheduling, starvation of non real time data packets, due to continuous arrival of real time data. Therefore the data packets are to be schedule in multilevel queue. But the multilevel queue scheduling scheme is not suitable for dynamic inputs, and hence the scheme is designed for dynamically change in the inputs. The Dynamic Multilevel Priority (DMP) packet scheduling is the scheme for dynamically changes in the inputs. In this scheme each node except the last level of the virtual hierarchy in the zone based topology of wireless sensor network has three levels of priority queues. Real time data packets are placed into highest priority queue and can preempt the data packets in the other queues. Non real time data packets are placed into other two queues based on threshold of their estimated processing time. The leaf node have two queues, one for real time data packet and another for non real time data packet since they do not receive data from other nodes and thus reduces end to end delay. This scheme reduces the average waiting time and end-to –end delay of data packets.*

KEYWORDS : *Data waiting time, FCFS , non-preemptive priority scheduling,non-real-time, packet scheduling, pre-emptive priority scheduling,real-time, Wireless sensor network.*

1. INTRODUCTION

Scheduling of different packets at the sensor nodes is very important as ensures the delivery of the data packet on the priority basis. The sensed data may be real time or non real time. Highest priority should be given to the real time data sense by the node compare to non real time data packet.[1] Sometimes the nodes may be put to sleep mode, when there is no data packet available and as soon as the data packet arrives at the node is putted into wake mode. This reduces the sensor node energy consumption. In FCFS scheduling scheme the data packets are processed in order of their arrival time and therefore the data packet which is entering at the last will require a long time to reach to a base station .However the emergency real time data should be reach to the base station before the deadline expires. Since the emergency real time data packet should reach the base station with shortest possible end-to-end delay. But most of the packets scheduling algorithms are neither dynamic nor suitable for large scale applications as their scheduling is predetermine and they are static. Static means those cannot be change as per the application requirement.[2] In the proposed dynamic multilevel priority packet scheduling scheme hierarchical structure of node is used. The nodes that have same hop distance from the base station will be considered to be located at the same hierarchical level. Processing of the data packets is done by TDMA scheme. In TDMA scheme the time slot is assigned for each data packet. Three levels of priority queues are defined. First priority will be given to real time data packet, second priority will be given to non real time data packets that are sensed by remote node at lower level & third priority will be given to the non real time data packet that are local sensed at the node.

If the non real time data packets with same priority are arrived then they are processed using the shortest job first scheduler scheme. The advantages of wireless sensor networks (WSNs) have lately become interesting for industrial and factory automation, distributed control system, automotive systems and other kinds of network embedded systems. The need for reduced cabling, faster setup times for equipment, reliable communication in harsh areas and added mobility have triggered research on the use of wireless communication in industrial systems. Even if WSNs provide a lot of benefits in the context of industrial communication, they also suffer from a number of disadvantages. Wireless communication is characterized by its high error probability, leading to the risk of causing severe problems for applications with strict reliability and timing requirements. Lost or delayed data may cause industrial applications to malfunction. Transmission scheduling in the context of time division multiple accesses (TDMA) can achieve robust and collision-free communication. Meanwhile, the TDMA-based medium access control (MAC) protocols can provide quality of service (QoS) access to the wireless network. Therefore a TDMA-based scheme is preferred. In TDMA MAC protocols, time is slotted into intervals of equal length, which are called timeslots. The duration of one timeslot is equal to the time required to transmit a packet and return an acknowledgement (ACK). A collection of timeslots that repeat cyclically are grouped into super frames. The radio spectrum is divided into channels with small frequency bands, which can realize parallel transmissions and enhance network throughput. Although these TDMA-scheduling approaches can find minimum length schedule, minimum energy schedules or a fairness-based schedule, they do not account for reliability. However reliability in the WSNs is particularly significant. Reliability expresses the probability of successful packet delivery from a source node to the destination node. On each wireless link, a packet loss rate (PER) of 10–30% is common, which significantly decreases end-to-end reliability. An example shows that assuming 10% PER and three transmission attempts on each link, 99% packets are received over one hop. After ten hops, success probability is only 76 % [4] .An Energy aware Coverage based Node Scheduling scheme (ECNS) is proposed to provide protection for sensors and guarantees network connectivity and desired coverage level. ECNS enables each node to decide whether it is eligible to turn off to conserve energy through local information exchange with its neighbors. Simulation results show that ECNS improves network performance with respect to energy conservation, load balance and network lifetime. [6]

II. COMPARISON

Comparison of several existing WSN packet or task scheduling algorithms. The existing task scheduling algorithm are based on several factors such as Deadline: - Packet scheduling schemes can be classified based on the deadline of arrival of data packets to the base station (BS), which are as follows First Come First Served (FCFS): Most existing WSN applications use First Come First Served (FCFS) schedulers that process data in the order of their arrival times at the ready queue. In FCFS, data that arrive late at the intermediate nodes of the network from the distant leaf nodes require a lot of time to be delivered to base station (BS) but data from nearby neighboring nodes take less time to be processed at the intermediate nodes. In FCFS, many data packets arrive late and thus, experience long waiting times.

Earliest Deadline First (EDF): -Whenever a number of data packets are available at the ready queue and each packet has a deadline within which it should be sent to BS, the data packet. which has the earliest deadline is sent first. This algorithm is considered to be efficient in terms of average packet waiting time and end-to-end delay. Data, that have travelled the longest distance from the source node to BS and have the shortest deadline, are prioritized. If the deadline of a particular task expires, the relevant data packets are dropped at an intermediate node.

Packet Type: - Packet scheduling schemes can be classified based on the types of data packets, which are as follows.

Real-time packet scheduling: Packets at sensor nodes should be scheduled based on their types and priorities. Real-time data packets are considered as the highest priority packets among all data packets in the ready queue. Hence, they are processed with the highest priority and delivered to the BS with a minimum possible end-to-end delay.

Priority: Packet scheduling schemes can be classified based on the priority of data packets that are sensed at different sensor nodes.

Non-preemptive: In non-preemptive priority packet scheduling, when a packet t1 starts execution, task *t*1 carries on even if a higher priority packet *t*2 than the currently running packet *t*1 arrives at the ready queue. Thus *t*2 has to wait in the ready queue until the execution of *t*1 is complete.

Preemptive: In preemptive priority packet scheduling, higher priority packets are processed first and can preempt lower priority packets by saving the context of lower priority packets if they are already running.

Packet Type: Packet scheduling schemes can be classified based on the types of data packets, which are as follows.

Real-time packet scheduling: Packets at sensor nodes should be scheduled based on their types and priorities. Real-time data packets are considered as the highest priority packets among all data packets in the ready queue. Hence, they are processed with the highest priority and delivered to the BS with a minimum possible end-to-end delay.

Non-real-time packet scheduling: Non-real time packets have lower priority than real-time tasks. They are hence delivered to BS either using first come first serve or shortest job first basis when no real-time packet exists at the ready queue of a sensor node. These packets can be intuitively preempted by real-time packets.

Number of Queue: - Packet scheduling schemes can also be classified based on the number of levels in the ready queue of a sensor node. These are as follows.

Single Queue: Each sensor node has a single ready queue.

All types of data packets enter the ready queue and are scheduled based on different criteria: type, priority, size, etc.

Single queue scheduling has a high starvation rate.

Multi-level Queue: Each node has two or more queues. Data packets are placed into the different queues according to their priorities and types. Thus, scheduling has two phases: (i) Allocating tasks among different queues, (ii) scheduling packets in each queue. The number of queues at a node depends on the level of the node in the network. For instance, a node at the lowest level or a leaf node has a minimum number of queues whilst a node at the upper levels has more queues to reduce end-to-end data transmission delay and balance network energy consumptions. Figure 1 illustrates the main concept behind multi-level queue scheduling algorithms

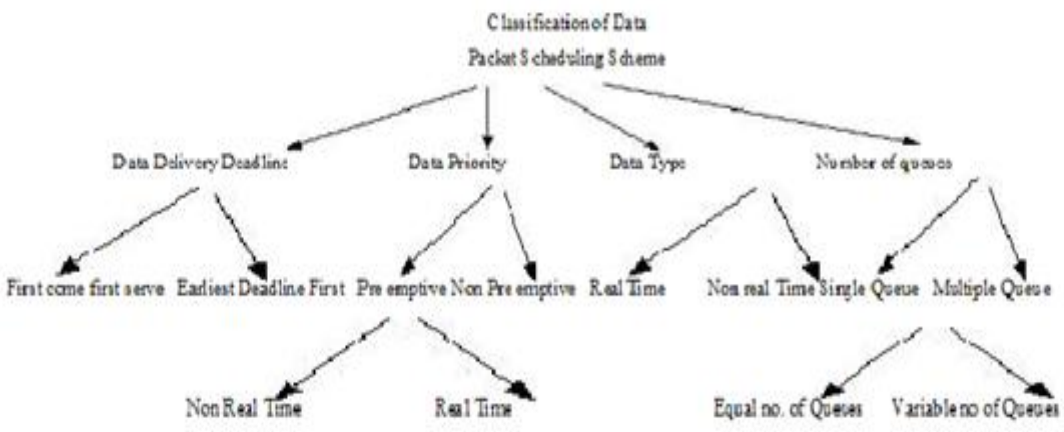

Fig.1 Classification of Packet Scheduling Schemes.

III. ASSUMPTIONS

The following assumptions are made to design and implement
DMP packet scheduling scheme.

• Data traffic comprises only real-time and non-real-time data, e.g., real-time health data sensed by body sensors and non-real-time temperature data.

• All data packets (real-time and non-real-time) are of same size.

• Sensors are time synchronized.

• No data aggregation is performed at intermediate nodes for real-time data.

• Nodes are considered located at different levels based on the number of hop counts from BS.

• Timeslots are allocated to nodes at different levels using TDMA scheme.

• The ready queue at each node has maximum three levels or sections for real-time data (pr1) non-real-time remote data (pr2) and non-real-time local data (pr3). The length of data queues is variable. For instance, the length of real-time data queue (pr1) is assumed to be smaller than that of non-real-time data queues (pr2 and pr3). However, the length of the non-real-time pr2 and pr3 queues are same.

• DMP scheduling scheme uses a multichannel MAC protocol to send multiple packets simultaneously.

IV. TERMINOLOGIES

In this section, we define the following terminologies and factors that are used in designing the DMP packet scheduling scheme.Routing Protocol: For the sake of energy efficiency and balance in energy consumption among sensor nodes, we envision using a zone-based routing protocol [8,9]. In a zone based routing protocol, each zone is identified by a zone head (ZH) and nodes follow a hierarchical structure, based on the number of hops they are distant from the base station (BS). For instance, nodes in zones that are one hop and two hops away from the BS are considered to be at level 1 and level 2, respectively. Each zone is also divided into a number of small squares in such a way that if a sensor node exists in square S1, it covers all neighboring squares. Thus, this protocol reduces the probability of having any sensing hole in the network even if the neighboring squares of a node do not have any sensor node.TDMA Scheme: Task or packet scheduling at each nodal level is performed using a TDMA scheme with variable-length timeslots. Data are transmitted from the lowest level nodes to BS through the nodes of intermediate levels. Thus, nodes at the intermediate and upper levels have more tasks and processing requirements compared to lower-level nodes. Considering this observation, the length of timeslots at the upper-level nodes is set to a higher value compared with the timeslot length of lower-level nodes. On the other hand, real-time and time critical emergency applications should stop intermediate nodes from aggregating data since they should be delivered to end users with a minimum possible delay. Hence, for real-time data, the duration of timeslots at different levels is almost equal and short.Fairness: This factor ensures that tasks of different priorities get carried out with a minimum waiting time at the ready queue based on the priority of tasks. For instance, if any lower priority task waits for a long period of time for the continuous arrival of higher-priority tasks, fairness defines a constraint that allows the lower-priority tasks to get processed after a certain waiting time.Priority: The priority of non-real-time data packets is assigned based on the sensed location (i.e., remote or local) and the size of the data. The data packets that are received by node *x* from the lower level nodes are given higher priority than the data packets sensed at the node *x* itself. However, if it is observed that the lower priority non-real-time local data cannot be transmitted due to the continuous arrival of higher priority non-real-time remote data, they are preempted to allow low-priority data packets to be processed after a certain waiting period. Nevertheless, these tasks can be preempted by real-time emergency tasks. In case of two same priority data packets the smaller sized data packets are given the higher priority.

V. PROPOSED DMP PACKET SCHEDULING SCHEME

In non-preemptive packet scheduling schemes real-time data packets have to wait for completing the transmissions of other non-real-time data packets. On the other hand, in preemptive priority scheduling, lower-priority data packets can be placed into starvation for continuous arrival of higher priority data. In the multilevel queue scheduling algorithm [], each node at the lowest level has a single task queue considering that it has only local data to process. However, local data can also be real-time or non-real time and should be thus processed according to their priorities. Otherwise, emergency real-time data traffic may experience long queuing delays till they could be processed. Thus, we propose a Dynamic Multilevel Priority (DMP) packet scheduling scheme that ensures a tradeoff between priority and fairness.

Working Principle: Scheduling data packets among several queues of a sensor node is presented in Figure 2. Data packets that are sensed at a node are scheduled among a number of levels in the ready queue. Then, a number of data packets in each level of the ready queue are scheduled. For instance, Figure 2 demonstrates that the data packet, *Data*1 is scheduled to be placed in the first level, Queue1. Then, *Data*1 and *Data*3 of Queue1 are scheduled to be transmitted based of different criteria. The general working principle of the proposed DMP scheduling scheme is illustrated in Figure 3.

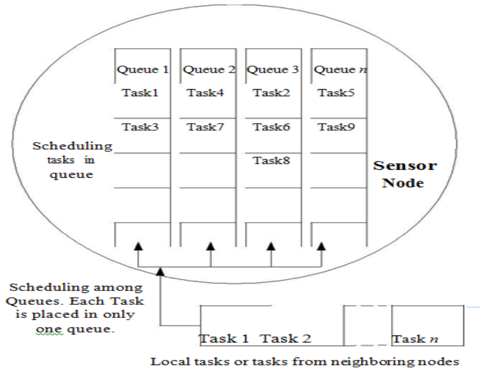

Fig. 2 Scheduling data among multiple queues.

The proposed scheduling scheme assumes that nodes are virtually organized following a hierarchical structure. Nodes that are at the same hop distance from the base station (BS) are considered to be located at the same level. Data packets of nodes at different levels are processed using the Time-Division Multiplexing Access (TDMA) scheme. For instance, nodes that are located at the lowest level and the second lowest level can be allocated timeslots 1 and 2, respectively. We consider three-level of queues, that is, the maximum number of levels in the ready queue of a node is three: priority 1 (*pr*1), priority 2 (*pr*2), and priority 3 (*pr*3) queues. Real-time data packets go to *pr*1, the highest priority queue, and are processed using FCFS. Non-real-time data packets that arrive from sensor nodes at lower levels go to *pr*2, the second highest priority queue. Finally, non-real time data packets that are sensed at a local node go to *pr*3, the lowest priority queue. The possible reasons for choosing maximum three queues are to process (i) real-time *pr*1 tasks with the highest priority to achieve the overall goal of WSNs, (ii) non real-time *pr*2 tasks to achieve the minimum average task waiting time and also to balance the end-to-end delay by giving higher priority to remote data packets, (iii) non-real-time *pr*3 tasks with lower priority to achieve fairness by preempting *pr*2 tasks if *pr*3 tasks wait a number of consecutive timeslots processed using FCFS. Non-real-time data packets that arrive from sensor nodes at lower levels go to *pr*2, the second highest priority queue

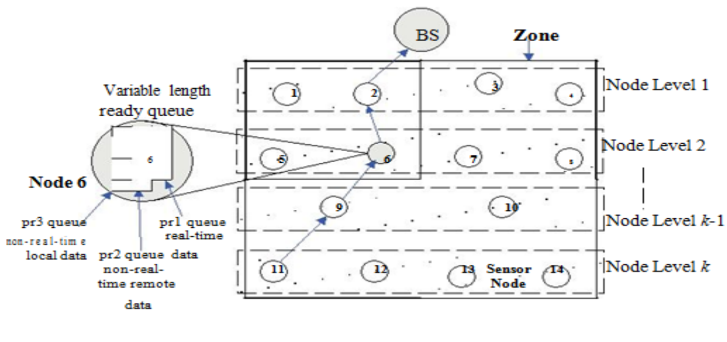

Fig.3. Proposed dynamic multilevel priority scheduling scheme.

Finally, non-real time data packets that are sensed at a local node go to *pr*3, the lowest priority queue. The possible reasons for choosing maximum three queues are to process (i) real-time *pr*1 tasks with the highest priority to achieve the overall goal of WSNs, (ii) non real-time *pr*2 tasks to achieve the minimum average task waiting time and also to balance the end-to-end delay by giving higher priority to remote data packets, (iii) non-real-time *pr*3 tasks with lower priority to achieve fairness by preempting pr2 tasks if *pr*3 tasks wait a number of consecutive timeslots. In the proposed scheme, queue sizes differ based on the application requirements. Since preemptive priority scheduling incurs overhead due to the context storage and switching in resource constraint sensor networks, the size of the ready queue for preemptive priority schedulers is expected to be smaller than that of the preempt able priority schedulers. The idea behind this is that the highest-priority real-time/emergency tasks rarely occur. They are thus placed in the preemptive priority task queue (*pr*1 queue) and can preempt the currently running tasks. Since these processes are small in number, the number of preemptions will be a few. On the other hand, non real time packets that arrive from the sensor nodes at lower level are placed in the pre emptable priority queue (*pr*2 queue). The processing of these data packets can be preempted by the highest priority real-time tasks and also after a certain time period if tasks at the lower priority *pr*3 queue do not get processed due to the continuous arrival of higher priority data packets. Real-time packets are usually processed in FCFS fashion. Each packet has an ID, which consists of two parts, namely level ID and node ID. When two equal priority packets arrive at the ready queue at the same time, the data packet which is generated at the lower level will have higher priority. This phenomenon reduces the end-to-end delay of the lower level tasks to reach the BS. For two tasks of the same level, the smaller task (i.e., in terms of data size) will have higher priority. Moreover, it is expected that when a node *x* senses and receives data from lower-level nodes, it is able to process and forward most data within its allocated timeslot; hence, the probability that the ready queue at a node becomes full and drops packets is low. However, if any data remains in the ready queue of node x during its allocated timeslot, that data will be transmitted in the next allocated timeslot.

VI. PERFORMANCE EVALUATION

The simulation model is implemented using the java programming. It is used to evaluate the performance of the proposed DMP packet scheduling scheme, comparing it against the FCFS, and Multilevel Queue scheduling schemes. The comparison is made in terms of average packet waiting time, and end-to-end data transmission delay. We use randomly connected Unit Disk Graphs (UDGs) on a surface of 100 meter × 100 meter as a basis of our simulations. The number of simulated zones varies from 4 to 12 zones. Nodes are distributed uniformly over the zones. The ready queue of each node can hold a maximum of 50 tasks. Each task has a Type ID that identifies its type. For instance, type 0 is considered to be a real-time task. Data packets are placed into the ready queue based on the processing time of the task. Moreover, each packet has a hop count number that is assigned randomly, and the packet with the highest hop count number is placed into the highest-priority queue. We run the simulation both for a specific number of zones, and levels in the network until data from a node in each zone or level reach BS. Simulation results are presented for both real-time data and all types of data traffic. Table I presents simulation parameters, and their respective values.

TABLE I
Simulation Parameters And Their Values

Parameter	**Value**
Network Size	100m X 100m
Number of Nodes	Maximum 200
Number of Zones	4 - 12
Base station position	55m X 101m
Transmission Energy Consumptions	50 n Joule/bit
Energy Consumption in free space or air	0.01 n Joule/bit/m2
Initial Node Energy	2 Joule
Transmission Speed	250*Kbps*
Propagation Speed	198 × 106 meter/sec

VII. RESULT

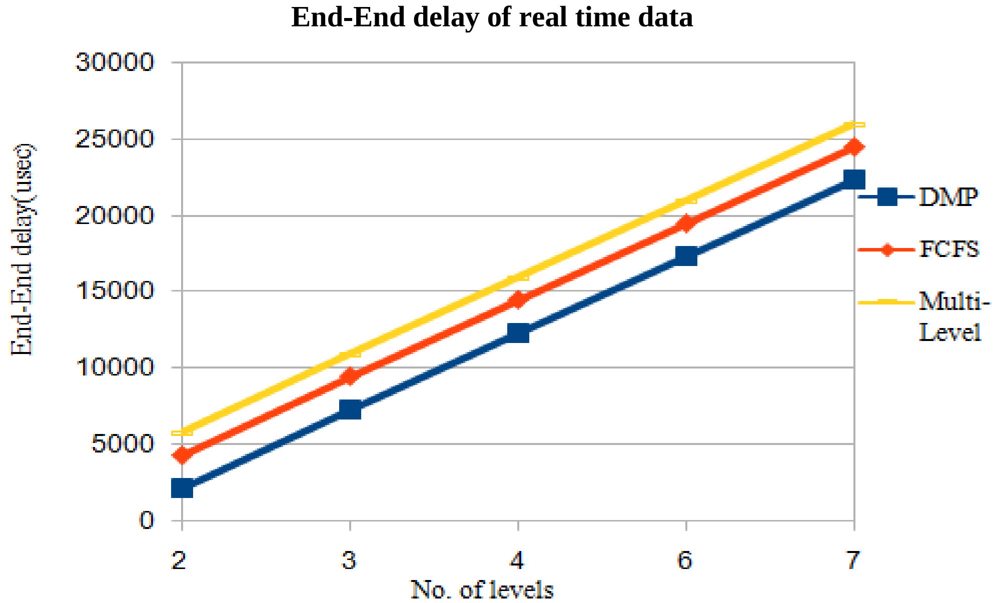

Figure 4. End-to-end delay of real-time data over a number of zones

Figures 4. Demonstrates the end-to-end delay of all types of data traffic over a number of zones and levels. From these results, we find that the DMP task scheduling scheme outperforms FCFS, and Multilevel Queue scheduler in terms of end-to-end data transmission delay. This is because in the proposed scheme, the tasks that arrive from the lower level nodes are given higher priority than the tasks at the current node. Thus, the average data transmission delay is shortened. Furthermore, the average waiting time of a task contributes largely to the experienced end-to-end data transmission delay. We are assigning task priority based on task deadline instead of the shortest task processing time. To reduce processing over-head and save bandwidth, we could also consider removing tasks with expired deadlines from the medium.

VIII. CONCLUSION AND FUTURE WORK

DMP task scheduler has better performance than the FCFS, and Multilevel Queue scheduler in terms of average task waiting time, both for real-time tasks, and all types of tasks. Using the concept of three-level priority queues at each node, the proposed DMP task scheduling scheme allows different types of data packets to be processed based on their priorities. Since real time and emergency data should be processed with the minimum end-to-end delay, they are processed with the highest priority, and can preempt tasks with lower priorities located in the two other queues. On the other hand, in existing multilevel queue schedulers, a task with the highest hop count is given the highest priority. Hence, real-time tasks are prioritized over other task types only if their hop counts are higher than those of non-real-time tasks. Moreover, in FCFS and multilevel queue schedulers, the estimated processing time of a task is not considered when deciding the priority of a task. Thus, FCFS and Multilevel Queue schedulers exhibit longer task waiting times and end-to-end delays, in comparison to the DMP task scheduling scheme. If a real-time task holds the resources for a longer period of time, other tasks need to wait for an undefined period time, causing the occurrence of a deadlock. This deadlock situation degrades the performance of task scheduling schemes in terms of end-to-end delay. Hence, we would deal with the circular wait and preemptive conditions to prevent deadlock from occurring.

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