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Enhanced Packet Scheduling Scheme for Wireless Sensor Networks

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ABSTRACT: In Wireless Sensor Networks (WSNs), a set of sensor nodes which have sensing, processing, and radio communication capabilities are scattered throughout a certain geographical region and collaboratively monitor the region of interest and track certain events and other phenomena. To the changing requirement of WSN applications since their scheduling policies are predetermined, most existing packet scheduling algorithms of WSN are neither dynamic nor suitable for large scale application and sometimes static which cannot be changed in the application requirement. In WSNs especially for real time applications efforts to reduce energy consumptions, end to end transmission delay must be considered. Though various ways like data aggregation are existing, packet scheduling is more important as it assures the delivery of various types of packets depending upon the priority. Mostly First Come First Served (FCFS) is one of the often used scheduling mechanisms in WSNs.

The proposed scheme is Dynamic Multilevel Priority (DMP) packet scheduling. In this scheme, each node maintains three levels of priority queues. Real time data packets will be placed at highest priority(priority 1)queue. Non real time packets that arrive from remote nodes is meant for second highest priority(priority 2)queue. Non real time packets which are sensed at the local node is given the least priority(priority 3).Through simulation it is inferred that proposed scheme outperforms the existing scheduling mechanism. 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. Deadlock avoidance algorithm is proposed to get rid of this drawback.

I. INTRODUCTION

In order to emphasis the ultimate requirement for the WSNs applications, energy consumption and transmission delay is the main concern. Real time data packets need to be sent with minimum delay to the corresponding base station, it is proposed to be placed in first priority queue. Applications related to the emergency events needs to be delivered before the expiry of the deadline, so that an application could be successful. Existing scheduling mechanisms like preemptive, non preemptive priority algorithms possess high processing overhead and results in starvation of real time as well as non real time packets in both the mechanisms. First Come First Served (FCFS) schedules the data packets according to the order of their arrival time leads to increased delay for reaching the base station .In FCFS many data packets arrive late experiencing long waiting times. Real time packets are given higher priority and processed with minimum possible delay. Real time packets can preempt lower priority non real time packets while processing. Since non real time packets are given lower priority it can be processed using FCFS. The main aim of choosing three queues are (i) for enhancing the transmission of real time packets (ii) non real time packets are larger than real time packets, so they are provided with two queues.

II. TERMINOLOGIES

(i)Levels: In a particular zone several levels are available indicating certain number of nodes. Nodes which are at the same hop distance from the base station are said to be located at the same level. Nodes which are placed at the lowest as well as highest level will be allocated with separate time slots.

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(ii)Priority: To achieve the overall goal of WSNs real time packets is being regarded as vital elements and given first priority. Based on the remotely sensed data and local data, non real time data packets are assigned. By assigning priority to the packets, real time data packet's transmission delay is minimized to appreciable level. To avoid starvation of non real time packets from local nodes, packets from remote nodes can be preempted for a certain period which leads to the assurance for fairness.

(iii)Queue: Each node has a ready queue in which different types of tasks are placed. Scheduling among various tasks takes place with the assistance of schedulers. number of queues in a particular node will be relying on the level of the node in the network. It can be understood that nodes that are available in lowest level will not receive packets from remote location and hence does not need more number of queues. Mostly, multi-level queue can able to avoid delay since it has several working phases like aligning the tasks among different queues and scheduling.

III. DYNAMIC MULTILEVEL PRIORITY SCHEME

Data packets at different nodes are processed using Time Division Multiplexing Access(TDMA).Data packets can be either real time or non real-time packets. Data from the lowest node will reach the base station through several intermediate nodes. Real-time data should avoid intermediate nodes from data aggregation, since these types of packets must be delivered with minimum possible delay.

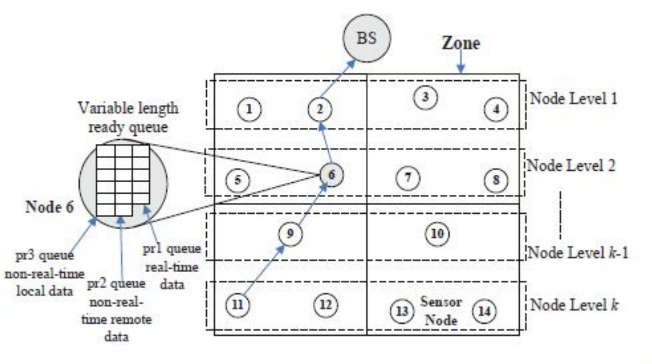

Figure 1: Dynamic Multilevel priority scheduling scheme[1]

If a node is processing a non real time data and it receives a real-time data ,then it preempts the non real time data giving priority to the real time packets .As discussed earlier each node has three queues in which real-time packets are placed in highest priority queue, non real time packets that are received from remote nodes will be in second highest priority, non real time local data are at the lowest level. Proposed DMP scheme is detailed in figure1.Priorities are assigned in terms of .By giving remote data more preference there is a reduction in average waiting time and simultaneously balances the delay. Since non real time packets occur frequently length of the highest priority is smaller than other queues. In DMP scheme, nodes are considered to be at different levels based on the hop counts from the base station. All the data packets are of same size. If packets from the same level are to be processed then smaller task will be processed first. Two same priority packets are at the ready queue then packet from the lowest level will be given higher priority.

Timeslots at each level are not fixed. They are calculated based on the data sensing period, data transmission rate and cpu speed. Timeslots are increased as the levels progress through base station. In a particular level if there is any

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emergency data, the time required to transmit that data will be short and will not increase at upper levels too because there is no data aggregation. So the remaining time is used to process data packets at other queues. This leads to the improvement of Quality of Service (QOS) by delivering the emergency data faster. For energy efficiency, when a node completes its process before the expiry of the timeslot then it is activated to sleep mode.

Moreover, when there is no real-time data packet to be sent priority 3(pr_3) tasks can preempt the priority 2(pr_2) tasks if they are waiting for long time. The memory for three queues is dynamically allocated and the size of the highest priority queue is usually smaller than the other two queues.

IV. MODULES

END TO END DELAY

- Real-time Priority 1 Queue data

A node which is placed at the level l_k say x transmits a real-time data to the base station through l_{k-1} intermediate levels. When this data reaches the upper level node say w in which a non real time data is being processed .So the data delivery at w is preempted to send real-time data. The end to end delay for sending a real-time data satisfies equation 1

$$delay_{pr1} \geq l_k \times \left(\frac{data_{pr1}}{s_t} + pr1_{proc}(t)\right) + \frac{d}{s_p} + (l_k \times t_o) \qquad (1)$$

Transmission time which is required to place a node into the medium from a node is $\frac{data_{pr1}}{s_t}$ where $\frac{d}{s_p}$ is the propagation time to transmit data from the source to destination . d is the distance from the source node to base station. s_p denotes the propagation speed over the wireless medium.

- Non-real time priority 2 queue data

In addition to transmission delay of the real time priority data packet, transmission time of pr_2 is included which is equal to $\frac{data_{pr2}}{s_t}$. If the real time tasks are completed before the expiry of the timeslot then pr_2 task can be processed for remaining time.

$$delay_{pr1} \geq l_k \times \left(\frac{data_{pr1}}{s_t} + \frac{data_{pr2}}{s_t} + pr1_{proc}(t) + pr2_{proc}(t)\right) + \frac{d}{s_p} + (l_k \times t_o) \qquad (2)$$

Overhead in terms of context switching and queuing time is t_o.

- Non-real time priority 3 queue data

When the real-time tasks are not available then pr_2 task can be preempted by pr_3 tasks.This is applicable for α consecutive timeslots there is no task at the pr_1 queue but there are tasks available at the pr_2 queue.then the end to end delay for processing pr_3 tasks will be exceeding

$$\alpha \times t(k) + l_k \times \left(\frac{data_{pr3}}{s_t} + pr3_{proc}(t)\right) + \frac{d}{s_p}) + (l_k \times t_o) \qquad (3)$$

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B.AVERAGE WAITING TIME

Assuming that real-time and emergency tasks rarely occur and require a very short time to get processed, $pr_1(t)$ is less than the timeslot. All the n_1 tasks in the pr_1 queue complete processing and tasks in the pr_2 and pr_3 queues are processed for the remaining timeslot.

$$\text{Average waiting time } pr_1(t) = \frac{\sum_{j_1=1}^{n_1-1}\sum_{m=1}^{j_1} pr_{1,m}(t)}{n_1} \quad (4)$$

If pr_2 tasks are not preempted by pr_1 tasks and can be completed within the same timeslot for the processing pr_1 tasks,the average waiting time for pr_2 tasks can be expressed as

$$\text{Average waiting time } pr_2(t) = \frac{\sum_{j_2=1}^{n_2-1}\sum_{m=1}^{j_2} pr_{2,m}(t)}{n_2} \quad (5)$$

The lowest level nodes only have the pr_1 and pr_2queues, so pr_2 tasks are not preempted by pr_3tasks at the lowest level. Let us assume that the pr_3 tasks require φ timeslots to complete their tasks and during these timeslots the pr_3 tasks are preempted by pr_1 tasks for $\sum_{m=1}^{\varphi}\gamma_m$ period. The average waiting time for pr_3 tasks at a node, average waiting time $pr_3(t)$ exceeds

$$\text{Average waiting time } pr_3(t) \geq \frac{\sum_{j_{31}=1}^{n_{31}}\sum_{m=1}^{31} pr_{3,m}(t)}{n_{31}} + \frac{\sum_{j_{32}=n_{31}+1}^{n_{32}}\sum_{m=1}^{32} pr_{3,m}(t)}{n_{32}} + \cdots + \frac{\sum_{j_{3,\varphi-1}=n_{(3,\varphi-2)}+1}^{n_{3,\varphi-1}}\sum_{m=1}^{j_{3,\varphi-1}} pr_{3,m}(t)}{n_{3,\varphi}} + (\varphi\times\tau) + \sum_{m=1}^{\varphi}\gamma_m + \left(\alpha \times \sum_{j=1}^{k} t(j)\right) \quad (6)$$

V. DEADLOCK AVOIDANCE METHOD

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. This requires that the system has some information available up front. Each process declares the maximum number of resources of each type which it may need. This method is concerned about the number of available and allocated resources, and the maximum possible demands of the processes. When a process requests an available resource, the system must decide if immediate allocation leaves the system in a safe state.

VI. RESULT

The performance of the proposed DMP packet scheduling scheme is evaluated, comparing it against the FCFS. The comparison is made in terms of average packet waiting time and end-to-end data transmission delay. 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. Every individual task has an separate ID and real-time task will preside over the first task. To give importance to the non real time tasks and avoid the massive delay, deadlock avoidance method is proposed. Needed resources is found from the available and allocated .

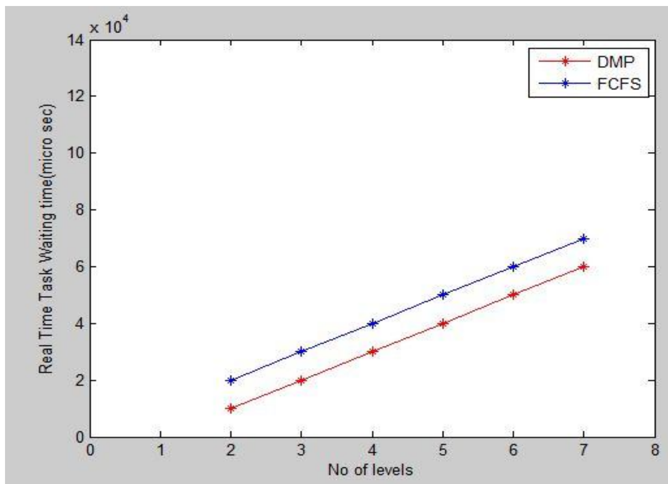

Figure 2: End to end delay of real-time data over a number of zones

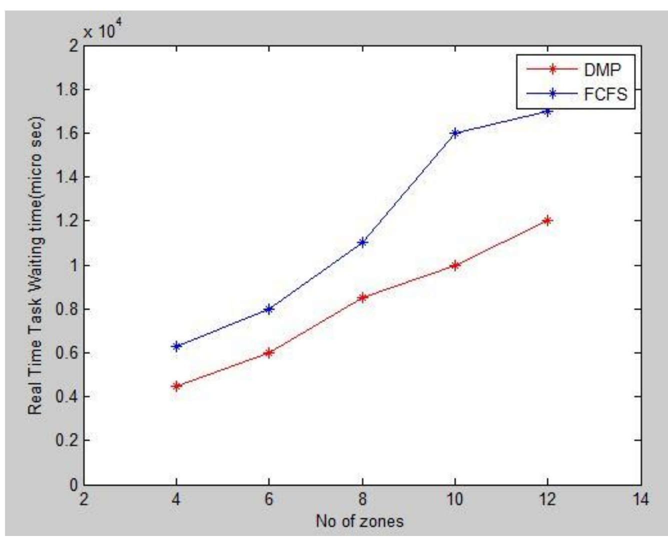

Figure 3: Waiting time of real-time data over a number of zones

```
Enter the Available Value[3 3 2]
Enter the Maximum Value for the Process:[7 5 3;3 2 2;9 0 2;2 2 2;4 3 3]
Enter the Allocation Value for the Process:[0 1 0;2 0 0;3 0 2;2 1 1;0 0 2]
Safe Sequence is :
i =

     2

Safe Sequence is :
i =

     4

Safe Sequence is :
i =

     5

Safe Sequence is :     3
```

Figure 3:Deadlock avoidance method

VI. CONCLUSION

The proposed DMP task scheduling is accompanied for the increased demand for WSN-based solutions that efficiently support real-time emergency applications and ensure them minimum average task waiting time and end -to-end delay. Thus, the comparison between DMP scheme and existing scheduling algorithms are made. Dynamic multilevel priority scheduling scheme outperforms the rest of its competitors. Deadlock avoidance scheme is suggested to overcome the non-real time tasks waiting time.

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