A Survey on Priority based Packet Scheduling in Wireless Sensor Networks

Benitha Christinal.J

Abstract—Wireless sensor networks (WSN) have extensive range of application such as environmental monitoring, traffic analysis, tactical systems and industrial process monitoring. Developing packet scheduling algorithms in wireless sensor networks can efficiently enhance delivery of packets through wireless links. Packet scheduling can guarantee quality of service and improve transmission rate in wireless sensor networks. It is the process used to select which packet to be serviced or which to be dropped based on the priority such as real time packet and non-real time packet. This paper deals with various packet scheduling algorithms. Wireless sensor network has a different packet scheduling strategy and each has their own advantage and disadvantage. This paper brings a survey on algorithm which provides priority based scheduling and its application.

Index Terms— Wireless sensor network, data waiting time, packet scheduling, non-preemptive priority scheduling, preemptive priority scheduling, real-time, non-real-time.

I. INTRODUCTION

Wireless sensor networks is an vast area of research and has many design issues like data aggregation from source node to base station and routing protocols which deals with data transmission, data packet scheduling, sensor energy consumption. Based on above criteria we talk about important concept, Data packet delivery based on priority and fairness with minimum latency. In this paper we will be dealing mainly with packet scheduling based on priority. According to the application, real-time data packet should be given higher priority and non real-time data packet should be given less priority. Packet scheduling is a process defined as decision making to select or drop the packet. Dropping of packet will depends on some the characteristics of network such as packet size, bandwidth, packet arrival rate, deadline of packet. Scheduler is used to schedule the packets. Schedulers will have hard time to handle when all packets coming in with high packet rate, when bandwidth is too low and packet size is large. The scheduler will make decision to select the packets based on various algorithms. It is by default that not all packets may reach the base station or destination. Some of the packets may be dropped along the way with respect to the above previously mentioned effect of network characteristics. So some the algorithms have been selected for the survey based on various factors like priority, preemptive, non-preemptive, deadline, packet type and number of queues. Various Packet scheduling algorithms are applied mainly to guarantee packet data quality of service and transmission rate in wireless sensor networks [1].

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The remaining of the paper is organized as follows. In section II we will discuss all related algorithms for scheduling packets in wireless sensor networks and other related factors affecting the delivery of packets. In section III literature survey and analysis of various packets scheduling algorithms is done. The section IV concludes the further future work for implementation of scheduling algorithm for wireless sensor networks.

II. LITERATURE REVIEW

Scheduling data packets at sensor nodes are important to prioritize applications of wireless sensor nodes. Scheduling data packets as real-time and non-real time at wireless sensor nodes decreases the processing over-head, reduces the end-to-end data transmission delay and saves energy consumptions of packets [9]. Data sensed as real-time application are given high priority than non-real time data. There exist wide range of study and research on scheduling the sleep-wake times of sensor nodes have been performed [1]–[18], but only a small number of studies subsist in the literature on the packet scheduling of sensor nodes that schedule the dealing out of data packets presented at a sensor node and also reduces energy consumptions[19]–[22]. But, most commonly used task scheduling algorithm in wireless sensor networks is First Come First Served (FCFS) scheduler algorithm in which the progression of data packets takes place based on arrival time and thus it takes more amount of time to be delivered to a appropriate base station (BS). However, to be clearer, the sensed data should reach the base station within exact time period or before the expiration of a deadline. In Addition to that, real-time emergency data should be delivered to base station with the minimum possible end-to-end delay. Hence, the intermediate nodes call for changing the delivery order of data packets in their ready queue based on their significance such as real or non-real time data packet and delivery deadline of packet. But First Come First serve algorithm is inefficient with regard to end-to-end delay and sensors energy consumptions. In existing wireless sensor networks task scheduling algorithms do not accept traffic dynamics since intermediate nodes need data order delivery change in their ready queue based on priorities and delivery deadlines.

Management of bandwidth is also important and necessary to avoid network congestion and poor performance. Packet scheduling technique maximizes bandwidth utilization. The Scheduler for packet scheduling ensures that packets are transmitted from the queue buffer. There are wide ranges of scheduling techniques which include random scheduling, round robin scheduling, priority scheduling and weighted fair queuing scheduling. It emphasizes rules in link-bandwidth sharing. Wireless sensor networks use fair queuing scheduling algorithms for a share of link capacity to guarantee multiple packet flow [5]. The buffer helps the queuing system, where data packets are stored until transmission takes place. In fair queuing scheduling technique it accounts for data packet sizes thereby ensures that each flow has equal chance in transmitting equal amount of data in network. Weighted fair queuing is one of the fair queuing scheduling techniques used in packet scheduling that allows different scheduling priorities to statistically multiplexed data flows here. So weighting is achieved through multiplication of packet size considered by fair queuing algorithms with weight inverse for a related queue. Packet scheduling algorithm technique and active queue management service improves network Quality of Service. Furthermore, most existing packet scheduling algorithms of wireless sensor networks are neither dynamic nor suitable for wide range of applications since these schedulers are predetermined and not dynamic but static, and cannot be changed immediately to response for change in the application requirements or environments [24]–[26]. For example, in a lot of real-time applications, a real-time priority scheduler cannot be changed dynamically at some point in the function and it is statically used in wireless sensor network applications.

III. ANALYSIS ON DATA PACKET SCHEDULING ALGORITHMS

The In this section, we present existing packet or task scheduling schemes by classifying them based on several factors as is illustrated in Figure 1.

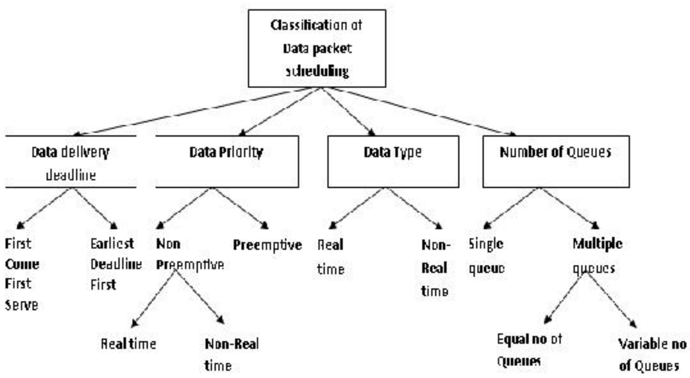

Fig. 1. Packet scheduling scheme classifications

Packet scheduling schemes can be classified based on various factors such as deadline, priority, types of packets and number of queues. Here in this analysis we will discuss all these factors.

A. Deadline

We need to resourcefully schedule a set of incoming packets so that every packet can be transferred to its destination earlier than its deadline. If there is no such a schedule exists, then there is need to find one that allows a maximum number of packets to meet their deadlines. Packet scheduling schemes can be classified based on the deadline of arrival of data packets to the base station (BS).

First Come First Served (FCFS): Most presented wireless sensors networks applications uses First Come First Served (FCFS) schedulers that process data in the order of their arrival times at the ready queue. Basically, there is a single queue of ready processes. Relative significance of jobs calculated only by arrival time (poor choice). The execution of the FCFS policy is simply managed with a First In First Out (FIFO) queue. When the process is ready it enters the ready queue, its Process Control Block is linked on to the tail of the queue. In First Come First Serve, data that arrives late to 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, these packets experience long waiting times.

Earliest Deadline First (EDF): It is a dynamic algorithm for scheduling used in real time operating system to place processes in priority queue. 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 Base Station, the priority queue will check for the process with nearest deadline and the data packet which has the earliest deadline is sent first. This algorithm is considered to be efficient and optimal in terms of average packet waiting time and end-to-end delay.

We study from the research work done by Lu C. et al.[28] proposes a real-time communication architecture for large-scale sensor networks, whereby they use a priority-based scheduler. Data, that have travelled the longest distance from the source node to Base Station 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. Though this approach reduces network traffic and data processing overhead, it is not efficient since it consumes resources such as memory and computation power and increases processing delay. The performance of the scheme can be improved by incorporating FCFS.

Mizanian et al. [29] proposed RACE, packet scheduling policy and routing algorithm for real-time large scale sensor networks that uses a loop-free Bellman-Ford algorithm to find paths with the minimum traffic load and delay between source and destination. RACE uses the Earliest Deadline First (EDF) scheduling concept to send packets with earliest deadline. It also uses a prioritized MAC protocol that modifies the initial wait time after the channel becomes idle and the back-off window increases the function of the IEEE 802.11 standard. Priority queues actively drop packets whose deadlines have expired to avoid wasting network resources. However, local prioritization at each individual node in RACE is not sufficient because packets from different senders can compete against each other for a shared radio communication channel.

B. Factor: Priority

Packet scheduling schemes can be classified based on the priority of data packets that are sensed at different sensor nodes in ready queue. Priority scheduling can be classified into two types as preemptive and non-preemptive scheduling. When a packet data arrives at the ready queue of the scheduler, its priority is compared with the priority of the currently running data packet in the queue.

Non-preemptive scheduling: In non-preemptive priority packet scheduling, when a packet p1 starts execution, task p1 carries on even if a higher priority packet p2 than the currently running packet p1 arrives at the ready queue. Thus p2 has to wait in the ready queue until the execution of p1 is complete.

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

Min Y.U. et al. [30] present packet scheduling mechanisms that are used in Tiny OS [25], [31] - the widely used operative system of WSN and classify them as either cooperative or preemptive. Cooperative scheduling schemes can be based on
a dynamic priority scheduling mechanism, such as EDF and Adaptive Double Ring Scheduling (ADRS) [32], that uses two
queues with different priorities. The scheduler dynamically switches between the two queues based on the deadline of newly arrived packets. If the deadlines of two packets are different, the shorter deadline packet would be placed into the
higher-priority queue and the longer deadline packet would be placed into the lower-priority one. Cooperative schedulers in TinyOS are suitable for applications with limited system resources and with no hard real-time requirements. On the other hand, preemptive scheduling can be based on the Emergency Task First Rate Monotonic (EF-RM) scheme. EF-RM is an extension to Rate Monotonic (RM), a static priority scheduling, whereby the shortest-deadline job has the highest priority. EF-RM divides WSN tasks into Period Tasks, (PT) whose priorities are decided by a RM algorithm, and nonperiod tasks, which have higher priority than PTs and can interrupt, whenever required, a running PT.

C. Factor: 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.

Though packet scheduling mechanisms of TinyOS are simple and are used extensively in sensor nodes, they cannot be applied to all applications: due to the long execution time of certain data packets, real-time packets might be placed into starvation. Moreover, the data queue can be filled up very quickly if local data packets are more frequent that causes the discard of real-time packets from other nodes. To eliminate these drawbacks, Zhao Y. [24] proposed an improved priority-based soft real-time packet scheduling algorithm. Schedulers traverse the waiting queue for the data packets and choose the smallest packet ID as the highest priority to execute. Each packet is assigned an Execute Counter, EXECUTE MAX TIME, i.e., the largest initial task execution time. The management component compares the current packet ID with the previous packet ID. If it is the same, the system executes it and decrements the counting variable. Otherwise, if the counting variable is null, the management component terminates this packet and other packets get the opportunity to be executed. However, packet priorities are decided during the compilation phase, which cannot be changed during the execution time. If high priority packets are always in execution, the low priority packets cannot be implemented. If low-priority packets occupy the resources for a long time, the subsequent high-priority packets cannot get response in time.

D. Factor: 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.

To eliminate problems in [24] Lee et al. [27] propose a multilevel queue scheduler scheme that uses a different number of queues according to the location of sensor nodes in the network. This approach uses two kinds of scheduling:
simple priority-based and multi-FIFO queue-based. In the former, data enter the ready queue according to priority but this scheduling also has a high starvation rate. The multi-FIFO
queue is divided into a maximum of three queues, depending on the location of the node in the network. If the lowest level is , nodes that are located at level have only one queue but there are two queues for nodes at level . Each queue has its priority set to high, mid, or low. When a node receives a packet, the node decides the packet's priority according to the hop count of the packet and accordingly sends it to the relevant queue. The work done by Karimi E. and Akbari B. [33] also proposes a priority queue

scheduling algorithm for Wireless Multimedia Sensor Nodes. In this scheduling scheme, buffer space of intermediate nodes is divided into four queues to hold three different types of video frames and one regular data frames. Data in the first three queues have the highest priority and are scheduled in round robin scheduling fashion. Data in the fourth queue is transmitted when the first three queues are empty. However, these scheduling schemes do not consider variable number of queues based on the position of sensor nodes to reduce the overall end-to-end delay.

Thus we have made a survey on various Packet scheduling mechanisms available for wireless sensor networks based on various factors available. From the analysis we have studied the above mentioned algorithms are not feasible and dynamic to varying requirements of wireless sensor networks. Since their scheduling polices are predetermined and static.

IV. Dynamic multilevel priority packet scheduling

We propose a Dynamic Multilevel Priority packet scheduling technique. In the proposed technique, each node excluding those at the last level of the virtual hierarchy in the zone based topology of Wireless Sensor Network (WSN), has three levels of priority queues. Real-time packets are sited into the highest-priority queue and can preempt data packets in other queues. Non-real-time packets are sited into two other queues based on a certain threshold of their expected processing time. Leaf nodes contain two queues for real-time and non-real-time data packets since they do not get data from other nodes and thus, decrease end-to- end delay [35].

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V. Conclusion

Wireless sensor networks provide more convenience, ease of use and easy maintenance than conventional wired network. In this survey various packet scheduling algorithms have been evaluated. Each algorithm aims at providing different QoS parameters such as maximizing fairness, minimizing end-to-end delay, maximizing throughput and successful packet transmission. Packet Scheduling using multiple queues is the analyzed and future work proceed with implementation and simulation work of dynamic multiple queue scheduling algorithm.

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