A QoS Efficient Scheduling Algorithm for Wireless Sensor Networks

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Abstract*— *In Wireless Sensor Networks, it is needed to schedule different types of packets such as real time and non-real time packets. It is important to reduce sensors' energy consumptions. In this paper, we propose new packet scheduling algorithm and integrate with Wireless Sensor Networks to improve energy consumptions. Our proposed Dynamic Multi Threshold Priority packet scheduling algorithm ensures a decrease in loss ratio for the lower priority level data with acceptable fairness towards higher priority level data. Threshold algorithm is compared with the commonly used scheduling algorithms such as First-Come-First-Serve (FCFS) and fixed priority non-preemptive. Simulation results illustrate that the Dynamic Multi Threshold Priority packet scheduling algorithm can provide a better QoS for low priority packets while keeping the QoS levels for high priority packets at similar levels.

Index Terms*— *Dynamic Multi Threshold Priority Packet Scheduling; First-Come-First-Serve (FCFS); Non-Preemptive Priority Scheduling; QoS

I. INTRODUCTION

A Wireless Sensor Network (WSN) consists of tiny sensor nodes which are low-cost and low-energy and with sensing, data processing and communicating components. A WSN can be realized with many sensor nodes that are deployed closely. The feature of sensor networks is the cooperative effort of the sensor nodes. Sensor nodes are fitted with an onboard processor. Instead of sending the raw data to the nodes responsible for the fusion, they use their processing abilities to locally carry out simple computations and transmit only the required and partially processed data [1]. WSNs are used in various areas such as military, health and home. For military applications, the rapid deployment, self- organization, and fault tolerance characteristics of WSNs make them a very promising sensing technique for military command, control, communications, computing, intelligence, surveillance, reconnaissance, and targeting systems. In health, they are used for monitoring patients and assisting disabled patients with deployment of sensor nodes. Managing inventory, monitoring product quality, and monitoring disaster areas are some other applications where WSNs are used [1]. In WSNs, sensor nodes can be mobile and heterogeneous. They are scalable to large scale of deployment. Design of a WSN is cross-layer and it is becoming an important study area for wireless communications. Cross layer design is used for improving the transmission performance which is energy efficiency, data rate and Quality of Service (QoS).

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WSNs may be deployed in various environments and energy determines the lifetime of a WSN. Communication in sensor nodes is a key component and protocols and algorithms must satisfy the issues such as increasing of lifespan, self-configuration, robustness and fault tolerance. WSNs have a problem with energy consumption. Energy is the most important resource of WSN nodes [2],[3]. Scheduling is the strategy by which the system decides which task should be executed at any given time. Generally, it is used for load balance and system resources to be served effectively and with desired quality [4]. Scheduling algorithms are classified as preemptive and non-preemptive. In preemptive scheduling, arrival of high priority data suspends current lower priority data. In non-preemptive scheduling, the current lower priority data is processed until it is completed. Preemptive schedulers provide better performance for system utilization. Non-preemptive schedulers encounter the starvation problem [5]. Non-preemptive schedulers may give better performance and robustness on reduced systems [6]. The major scheduling algorithms for WSNs are FCFS and fixed priority non-preemptive scheduling. In FCFS algorithm, each priority level of data's loss ratio results are assumed to be the same since priority is not criteria in this algorithm [7]. In fixed priority non-preemptive scheduling algorithm, lower priority level data can get lost excessively and the higher priority level data are processed more quickly and there is a definite unfairness between priority levels [8].

In this work, we develop a new scheduling algorithm for WSNs which can provide a better QoS and resolve the disadvantages of the current algorithms. The proposed Dynamic Multi Threshold Priority packet scheduling algorithm tries to maximize the level of QoS provided to different priority packets by reducing the loss ratio and waiting times. Also, the proposed scheduling algorithm is non-preemptive due to structure of reduced system load of WSNs. The rest of the paper is organized as follows: Section II describes some of the most commonly used Queue Scheduling Algorithms for WSNs, Section III introduces our proposed Dynamic Multi Threshold Priority packet scheduling algorithm. Simulation results of the algorithms are shown in Section IV and finally Section V concludes this paper.

II. QUEUE SCHEDULING ALGORITHMS

The main scheduling algorithms for WSNs are FCFS and fixed priority non-preemptive scheduling.

A. First-Come-First Serve

FCFS algorithm has a disadvantage on very high loss ratio for higher priority real-time data. Data packets are ordered by arrival times and priority is not important criterion for ordering [7]. Also, real time packets might not receive timely service and cannot supply delay time guarantees.

B. Fixed Priority Non-Preemptive

In fixed priority non-preemptive scheduling algorithm, each arriving data packet has a defined priority level. The scheduler arranges the packets which are ready and ordered by their priority levels in queue [8]. Lower priority packets can be dropped excessively when higher priority packets arrive at the queue. Fixed priority non-preemptive scheduling algorithm has an advantage on higher priority real-time data packets in comparison to the similar packets in the FCFS algorithm. Loss ratio and average waiting time of higher priority data results are better than FCFS algorithm, but lower priority data's results encounters with problem. Lower priority data's are processed last and they can be lost with the arrival of higher priority data so that lower priority data can be lost excessively. Starvation of lower priority data occurs at the system and it is unfairness.

III. DYNAMIC MULTI THRESHOLD PRIORITY PACKET SCHEDULING ALGORITHM

A. Overview

Algorithm developed for this work is Dynamic Multi Threshold Priority Packet Scheduling (DMTPS). In DTMPS algorithm, packets are placed into the waiting queue according to their priorities and each priority level has its own threshold value. The basic threshold is shown in Figure 1.

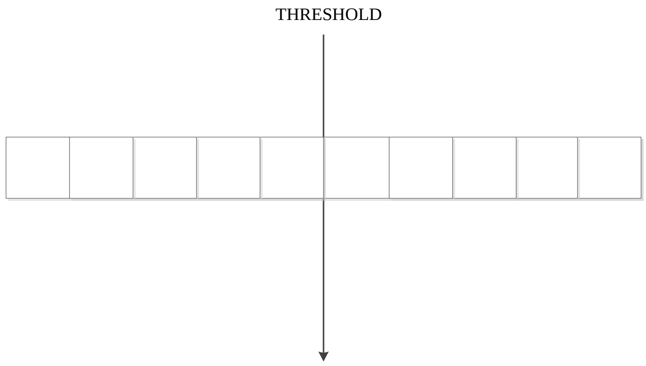

Fig. 1 - Basic threshold structure at the waiting queue.

The main objective of the DMTPS algorithm is to order different priority level packets according to their threshold. The most important operation of the DMTPS algorithm is to locate lower priority packets and replace with higher priority arrival packets at appropriate own threshold value.

B. Design

The threshold values for each priority level are specified with different values. Priority levels are described as the high, medium and the low level. Each packet has proper priority and assignment of packet's priority operation is similar with fixed priority non-preemptive scheduling algorithm.

Priority – 1 (The high priority level): %k of capacity in the waiting queue.

Priority – 2 (The medium priority level): %m of capacity in the waiting queue.

Priority – 3 (The low priority level): %n of capacity in the waiting queue.

Threshold values are specified as n> m > k. These values can be changed depending on the traffic situation in the network. The high priority level data's own threshold value is described as k and it should be lower than lower priority level data's own threshold values which are m and n. It should have a lower value because fairness of higher priority level data towards the lower priority level data. Each priority level has a unique threshold level. Higher priority levels' assigned threshold level can change with lower priority level's assigned threshold level if higher priority data could not get into assigned threshold level. Figure 2 shows the representation of initial values of threshold values.

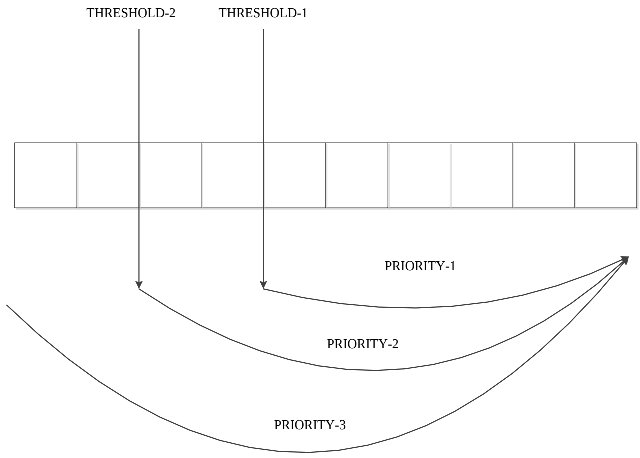

Fig. 2- Multi-threshold system for multi-priority events on waiting queue.

In DMTPS algorithm, if front of appropriate threshold is full and lower priority packet is found, then it is changed with the higher priority. Higher priority packets are not just ordered with assigned threshold level. If there is not any place at the higher priority packets' assigned threshold, it can be checked at lower threshold levels. For example, Priority-1 (the high priority level) packets are arrived and there is not any place at assigned threshold (Threshold-1), then it can be looked at lower threshold (Threshold-2) to get in the waiting queue. The higher priority packets (Priority 1 and Priority 2) are checked to their own threshold and if there is not any place to get in, lower threshold levels are used for them. Thus, changing of higher priority level's assigned threshold levels provides that higher level of priority packets to enter to the waiting queue. Dynamic thresholds are used for loss efficiency of higher priority level packets.

IV. SIMULATION RESULTS

The simulation of proposed algorithm is performed using Discrete Event System Simulation in Java. The simulation result is illustrated with figure which shows the loss ratio. The throughput of a system is a factor that has impact on value of loss ratio results. The value of loss ratio increases with the increase of value. Capacity of waiting queue is a factor - such as - that it has very high impact on value of loss ratio. The total loss ratio value decreases with the increase of capacity. Throughput of a system is assigned as 0.99. Capacity of waiting queue is assigned with values between 20 and 100.Threshold level's values are described at Section III. k, m and n values are assigned as 60, 80 and 100 respectively. Results of the selected priority level are shown in the figure. For example, loss ratio result of the Priority-2 level (medium priority level) data in fixed priority non-preemptive scheduling algorithm is defined as Priority-2 and loss ratio result of the Priority-3 level (low priority level) data in DMTPS algorithm is defined as DMTPS-3 in Figure 3.

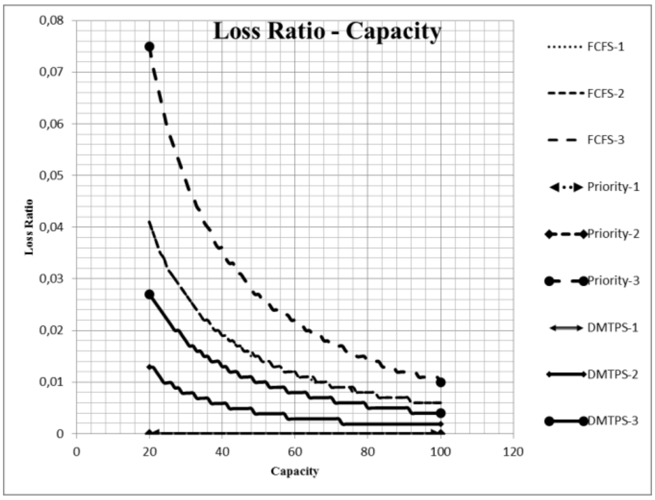

Fig. 3 - Loss Ratio - Capacity graph for all algorithms within each priority levels.

Loss ratio results of all algorithms within each priority levels are shown in Figure 3. In FCFS algorithm, all loss ratio results of priority levels are similar with each other. Because, priority value of packet is not important for FCFS algorithm. In fixed priority non-preemptive scheduling algorithm, the higher priority packets whose priorities are 1 and 2 level's loss ratio are less than packets which have the lowest priority level. Because priority is important at the fixed priority non-preemptive scheduling algorithm and order is specified according to packet's priority. In fixed priority non-preemptive scheduling algorithm, the lowest priority packets loss is very high. Dynamic Multi Threshold Priority packet scheduling algorithm is assumed as higher QoS for the lowest priority according to fixed priority non-preemptive scheduling algorithm. Loss ratio results of packets which are higher priority level (Priority-1 and Priority-2) are similar with fixed priority non-preemptive scheduling algorithm and the lowest priority level packets loss ratio results are similar with the FCFS algorithm. Threshold algorithm improves loss ratio results and provides efficiency to all priority levels. The significant alteration is observed at the lowest priority level packets loss ratio results.

V. CONCLUSIONS AND FUTURE WORK

All algorithms are experimented and analyzed for improving various packet scheduling algorithm's QoS. In this paper, we propose Dynamic Multi Threshold Priority packet scheduling algorithm for WSNs. This algorithm ensures to decrease in loss ratio for the lower priority levels with acceptable fairness towards higher priority data. Dynamic Multi Threshold Priority packet scheduling algorithm has better performance than the existing FCFS and fixed priority non-preemptive scheduling algorithm in term of the loss ratio. All algorithms are analyzed according to contribution of QoS. The results show that proposed algorithm improves the QoS of selected attribute. Threshold optimization factor is another factor that can be improved for future works.

REFERENCES

1. B. Ian F. Akyildiz, W. Su, Y.Sankarasubramaniam, E. Cayirci, "A Survey on Sensor Networks", Georgia Institute of Technology, IEEE Communications Magazine, August 2002
2. M Bernard T. and Fouchal H., "A low energy consumption MAC protocol for WSN", IEEE communication conference, ICC 2012
3. S.Kim, Y. Kim, "An energy efficient priority-based MAC protocol for wireless sensor networks", International Conference ICT Convergence (ICTC),2012.
4. K. Ramamritham, J.A. Stankovic, "Scheduling Algorithms and Operating Systems Support for Real-Time Systems", University of Massachusetts, Amherst, 1994
5. A. Iqbal, A. Zafar, B. Siddique, "Dynamic Queue Deadline First Scheduling Algorithm for Soft Real Time System", IEEE International Conference on Emerging Technologies, 2005
6. Aloysius K. Mok, Wing-Chi Poon, "Non-Preemptive Robustness under Reduced System Load", Proceedings of the 26th IEEE International Real-Time Systems Symposium, 2005
7. L. XinYan, L. PingPing, "Research and Improvement of Real-Time Queue Scheduling Algorithm", International Forum on Information Technology and Applications, 2010
8. C. Taddia, G. Mazzini, "On the Jitter Performance of FIFO and Priority Queues mixture", The 17th Annual IEEE International Symposium on Personal, Indoor and Mobile Radio Communications, University of Ferrara, Italy, 2006