

Improving the Energy Efficiency of Mobile Terminals Using Dynamic Multilevel Priority Packet Scheduling in Cooperative Communication

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Abstract—Cooperative communication is an efficient method for reducing the energy consumption of mobile terminal in wireless cellular network. However, it is hard to implement due to the lack of motivations for the Mobile terminals to cooperate. For this scenario as the benchmark case, where the information of the helping mobile terminals such as the channel and battery conditions is completely known by the source node terminal, the problem is formulated as a relay selection problem. Efficient algorithms based on dichotomous search and alternative optimizations are proposed to solve the problem for the cases of split and non-split data at the source MT, respectively. The cooperative communications scheme with pricing mechanism can decrease both the battery outages and communications for the mobile node, and can also increase the average battery level during the mobile terminals operation.

In this paper, we state a Dynamic Multilevel Priority (DMP) packet scheduling scheme. In the proposed system, each node, except those which are at the last level of the virtual hierarchy in the zone based topology of Wireless sensor network, have three levels of priority queues. Real-time packets are placed in the highest-priority queue and can preempt data packets in other queues. Non-real-time packets are placed in other two queues based on a certain threshold of their estimated processing time. Leaf nodes will have two queues for real-time and non-real-time data packets since they do not receive data from other nodes and so this reduce end to- end delay. The performance of the proposed Dynamic multilevel priority packet scheduling scheme through simulations for real-time and non-real-time data packet. Simulation results shows that the DMP packet scheduling scheme outperforms conventional schemes interms of average data waiting time and end-to-end delay.

Keywords—Wireless sensor network, preemptive priority scheduling, packet scheduling, non-preemptive priority

scheduling, real-time, non-real-time, data waiting time, FCFS.

I. INTRODUCTION

Among many network design issues, such as data aggregation and routing protocols, that reduce sensor transmission delay and energy consumption, packet scheduling (interchangeably use as task scheduling) at sensor nodes is highly important since it ensures delivery of different types of data packets based on their priority and fairness with a small latency. For instance, data sensed for real-time applications have higher priority than data sensed for non-real time applications. A sensed data have to reach the BS within a specific time period or before the expiration of a deadline. Real-time emergency data should be delivered to BS with the shortest possible end-to-end transmission delay. Hence, intermediate nodes require changing the delivery order of data packets in their ready queue based on their importance and delivery deadline

In this paper, we propose a Dynamic Multilevel Priority (DMP) packet scheduling scheme for WSNs in which sensor nodes are virtually organized into a hierarchical network structure. Nodes that have the same hop distance from the BS are considered to be located at the same hierarchical network level. Data packets sensed by nodes at different levels are processed using a Time division multiple access scheme. For instance, nodes that are located at the lowest level and one level upper to the lowest level can be allocated timeslots 1 and 2. Each node maintains three levels of priority queues. This is because we classify data packets as (i) real-time packet (priority 1), (ii) non-real-time data packet that are received from lower level nodes (priority2), and (iii) non-real-time data packets that are sensed at the node itself (priority 3). Non-real-time data local packet traffic with the same priority are processed

using the shortest job first (SJF) scheduler scheme since it is very efficient in terms of average task waiting time.

Reducing the energy consumption for the mobile terminal is of critical importance for resolving the energy shortage of the mobile terminals and improving the connectivity of the wireless networks. It has been shown that the communications modules constitute a large proportion of the mobile terminals energy consumption, for either the mobile terminals from the earlier 2G and 3G eras or the more modern 4G mobile phones. Therefore, this gives us a good motivation to investigate the energy saving for the mobile terminals in data communications.

II. RELATED WORK

It is noted that there are many methods are used to reduce the energy consumption of the mobile terminal in the literature [2]. In the optimal study it shows that beam forming designed to coordinate the interference in the cloud radio access for energy minimization [3]. A solve a weighted-sum transmitter and receiver energy minimization problem in the downlink of the orthogonal frequency division multiplexing based multiuser wireless system [4]. Later study shows that investigating user terminal cooperating in transmitting their data packet to the base station by exploiting the multiple network access interfaces [5]. The main aspects Green communication is to save energy consumption of the communication system as much as possible with user's quality of service [6]. Cooperative spectrum sharing is one of the important concept to save the energy consumption within the network and also effectively improve the spectrum usage [7]. Cooperative medium access control protocol can help extend the lifetime of machine to machine network. By using this concept the energy can be minimized and the network performances can be improved [8]. Game theory for power trading in cooperative wireless communication with quality of service constraints are used to reduce the network outage within the network [9]. There are many problems involved within the network one among them are the energy conservation of mobile terminal in multi cell TDMA network. To reduce this problem we decompose the overall problem into two sub problem such as intra cell energy optimization and inter cell interference control [10]. The full degree of freedom in mobile system depends on the energy provided by the mobile phone batteries. The Moore's law offers twice the processing power within the network [11]. In the case of real time sessions, we formulate the problem as a convex optimization and by solving it by an iterative fashion

exhibiting super linear convergences, where it reduces the output power level of mobile terminal [12]. The distributed game theoretical framework over multiuser cooperative communication network to achieve optimal relay selection and power allocation [13]. Different techniques based on stochastic geometry and the theory of random geometric graph including point process theory, percolation theory and probabilistic combinatorics have led to results on the connectivity [14]. The minimum energy relay selection mechanism jointly with transmission power control. The set of potential relay determines their needed transmission power to participate in the cooperative communication, while only best is chosen to minimize the overall energy consumption [15]. By using two systems such as uncoded system and coded system, while in uncoded system by optimizing the transmission time and modulation parameters. For coded system it shows that the benefit of coding varies with the transmission distance and also the modulation schemes [16].

The rest of this paper is organized as follows. Section III methodology .Section IV shows working of dynamic multilevel priority packet scheduling. Section V presents about implementation .section VI shows the result and the last section shows about the conclusion and the future work

III. METHODOLOGY

There are many problems involved in the existing system such as overhead, relay selection, load sharing and balancing, energy consumption and packet loss. Overhead is defined as the time spends for communication with your team instead of getting productive work done. Relay selection is where the source and destination are interconnected by means of some nodes. Load sharing problem comes when how much amount of data should be shared among the mobile terminal so as to avoid the data losses. Energy plays a vital role in networks. Energy consumption is the important problem in network. So that mobile should be charged frequently. Energy consumption should be reduced so that the network life will prolong. Figure 1 shows End to end delay refers to the time taken for a packet to be transmitted across a network from source to destination. Each node in a network will have a processing time to reach the destination. If the node is not reaching in the proper time, then it is said to be end to end delay.

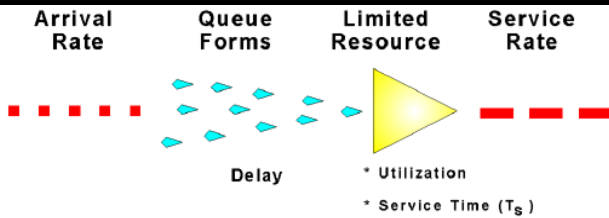


Figure 1 Queuing Delay

a) TERMINOLOGIES

There are various terminologies used in the proposed scheme to improve the energy efficiency of each node and also to reduce the processing overhead and long end to end data transmission delay.

1) PRIORITY

Packet scheduling strategy 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 1 starts execution, task 1 carries on even if a higher priority packet 2 than the currently running packet 1 arrives at the ready queue. Thus 2 have to wait in the ready queue until the execution of t1 is complete.

- Latency of Non-Preemptive configuration

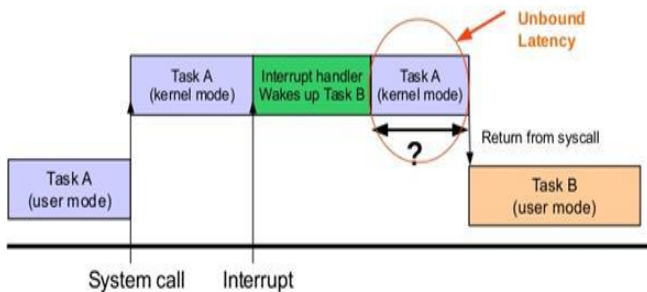


Fig.2: Non – preemptive scheduling diagram

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

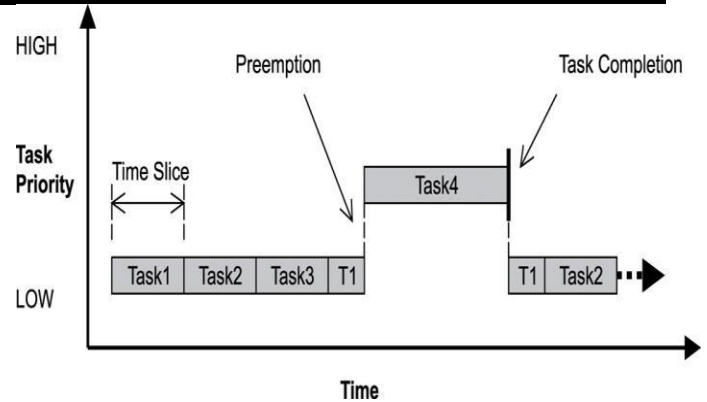


Fig.3: Pre Emptive scheduling

2) PACKET TYPE

Packet scheduling strategy 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 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 base station either using first come first serve or shortest job first basis when no real-time packet exists at the queue of a sensor node. These packets can be preempted by real-time packets.

3) QUEUE TYPE

Packet scheduling can also be classified based on the number of levels in the ready queue of a sensor node.

Single Queue: Each sensor node have a single ready queue and all types of data packets enter the ready queue and are Scheduled based on different criteria: priority, type, size, etc. Single queue scheduling has a high starvation rate.

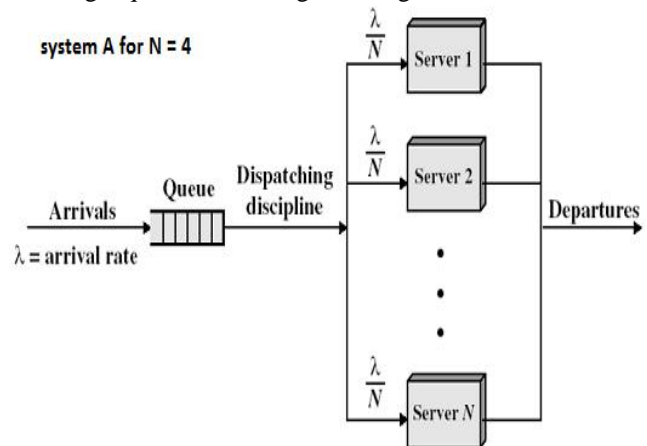


Fig.4: Single level queues

Multi-level Queue: Each node has two or more queues. Data packets placed into the different queues according to their priorities and types. Thus, scheduling has two phases such as allocating tasks among different queues.

The numbers of queues at nodes depend on the level of the node in the network. For instance, a node at the 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.

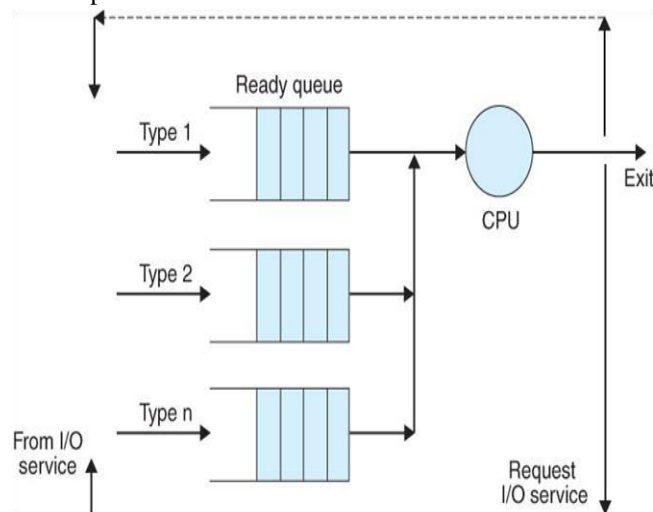


Fig.5: Multi level queues

b) METHODOLOGIES IN DYNAMIC MULTILEVEL PRIORITY PACKET SCHEDULING

The methods used in dynamic multi level priority packet scheduling are

- 1) Zone based routing protocols
- 2) TDMA(Time Division Multiple Access) scheme
- 3) Fairness
- 4) Priority

1) ZONE BASED ROUTING PROTOCOL

For the sake of energy efficiency and balance in energy consumption among sensor nodes, we visualize using a zone-based routing protocol. In a zone based type routing protocol, each zone in the network is identified by a zone head (ZH) and nodes follow a hierarchical structure, which based on the number of hops they are distant from the base station. 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. Each zone is also divided into a number of small squares in such a way that if a sensor node exists in square1, 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.

Zone routing protocol

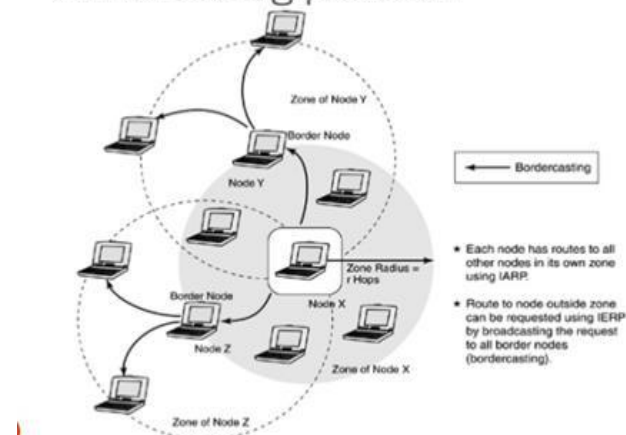


Fig.6: Zone based routing protocol diagram

2) TDMA SCHEME

Task or packet scheduling at each nodal level is performed using a TDMA scheme with variable-length time slots. Data are transmitted from the lowest level nodes to BS through the nodes at intermediate levels. Thus, nodes at the middle 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 lowest level nodes. On the other side, 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.

3) FAIRNESS

This metric 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 of the lower priority tasks waits for a long period of time for the continuous arrival of higher-priority tasks which fairness defines a constraint that allows the lower-priority tasks to get processed after a certain waiting time.

4) PRIORITY

Real time and emergency data should have the highest priority. The priority of non- local real-time data packets is assigned based on the sensed location and the size of the

data. The data packets which 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 packet data, they are preempted to allow low-priority data packets to be processed after a certain waiting period and those 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

IV. WORKING PRINCIPLE OF DYNAMIC MULTILEVEL PRIORITY PACKET SCHEDULING

In non-preemptive packet scheduling schemes (interchangeably use as task scheduling in this paper), real-time data packets have to wait for completing the transmissions of other non-real-time data packets. On the other side, in preemptive priority packet 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 type data to process. However, local data type packet can also be real-time or non-real time and should be thus processed according to their priorities. Or else, emergency real-time data traffic may experience long queuing delays till they could be processed. So that, we propose a Dynamic Multilevel Priority (DMP) packet scheduling scheme that ensures a tradeoff between priority and fairness.

In Figure 7. Data packets that are sensed at a node are scheduled among a number of levels in the ready queue. After that a number of data packets in each level of the ready queue are scheduled. Figure 2 demonstrates that the data packet, Data is scheduled to be placed in the first level, Queue1. Then, Data and Data of Queue1 are scheduled to be transmitted based of different criteria

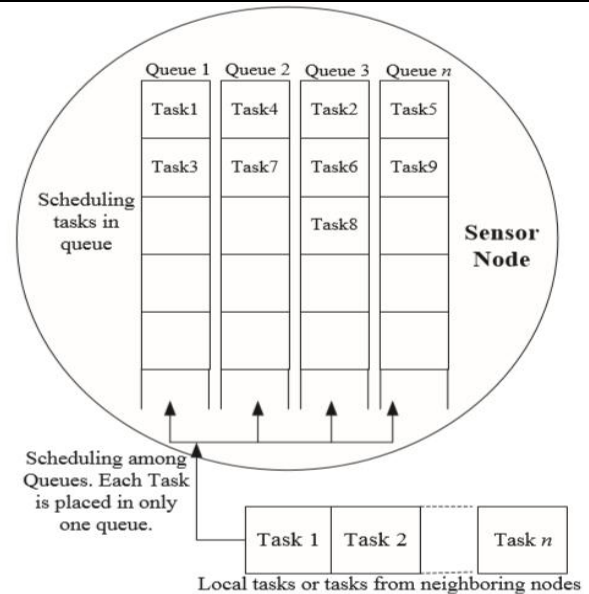


Fig.7: Scheduling data among multiple queues.

In figure 8, 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 (pr1), priority 2 (pr2), and priority 3 (pr3) queues. Real-time data packets go to pr1, the highest priority queue, and are Processed using FCFS.

Non-real-time data packets that arrive from sensor nodes at lower levels go to pr2, the second highest priority queue. Finally, non-real time data packets that are sensed at a local node go to pr3, the lowest priority queue. The possible reasons for choosing maximum three queues are to process (i) real-time pr1 tasks with the highest priority to achieve the overall goal of WSNs, (ii) non real-time pr2 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 pr3 tasks with lower priority to achieve fairness by preempting pr2 tasks if pr3 tasks wait a number of consecutive timeslots.

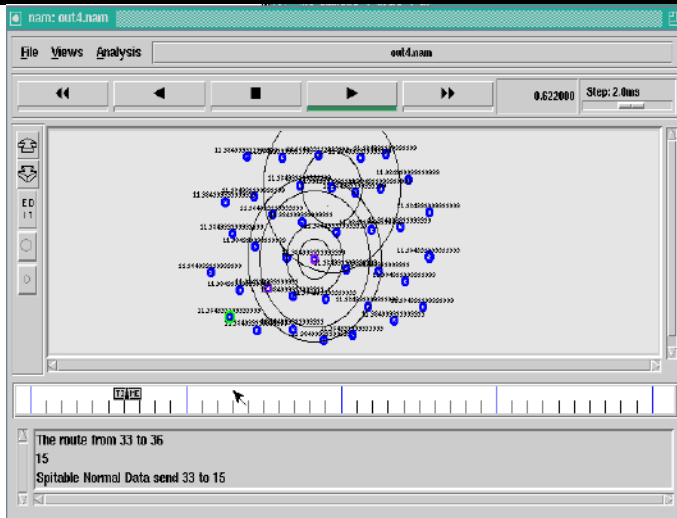


Fig.10: Data transfer from source to relay node

Figure 11 shows the emergency data in the network, the current data transfer will stop and it will provide the request to the emergency node to reach to their respective destination

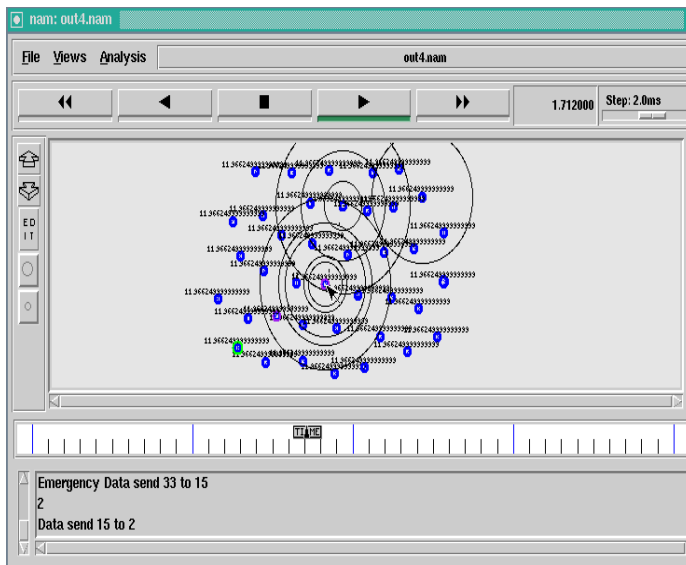


Fig.11: Emergency request

Figure 12 shows the data transfer from emergency node to destination node

The energy efficiency can be improved by using dynamic multilevel priority packet scheduling scheme. The limitation in exiting system such as processing overhead and long end to end delay can be reduced.

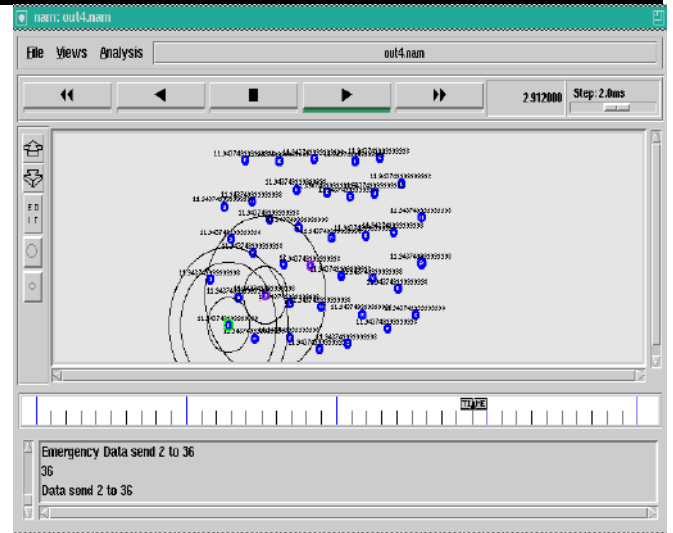


Fig.12: Destination path

VI. RESULTS

The below given graphical representation are the comparison of the packet received, network connectivity delay, energy efficiency between standard data, split table, Non split table and dynamic multilevel priority scheduling in cooperative network.

i. PACKET RECEIVED

Figure 13 shows the maximum number of packet is reached to the destination in the form of graph. The graph shows the packet received in terms of "TIME" in X-label and "PACKET" in Y label.

$$\text{Packet delivery ratio} = \frac{\text{Number of packet received}}{\text{Number of packet transmitted}}$$

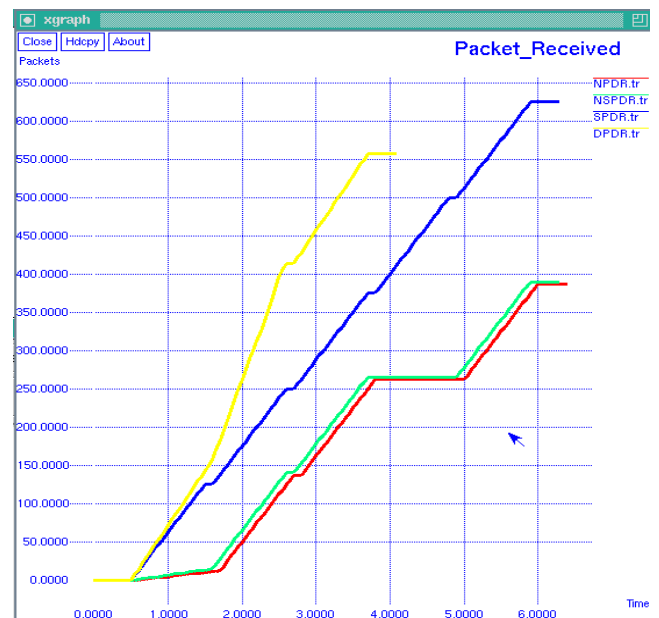


Fig.13: Packet received

ii. DELAY

The average delay is defined as the time difference between the current packets received and the previous packet received.

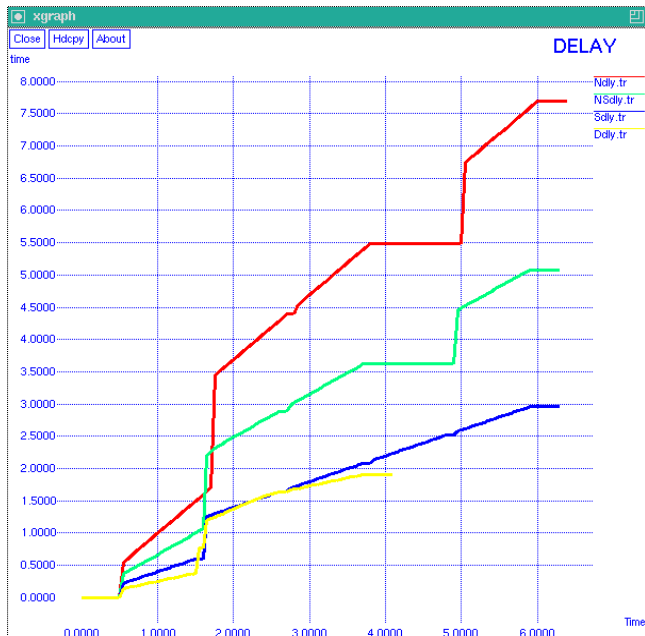


Fig.14: Delay

Figure 14 shows the delay between the NORMAL DATA, NON SPLIT-DATA and SPLIT DATA, where the delay is high in the NORMAL DATA. The delay is less in the DYNAMIC DATA. So by using the DYNAMIC DATA delay can be reduced and they are having a high packet received and also the energy consumption for DYNAMIC DATA is less compared NORMAL DATA and NON SPLIT-DATA.

DELAY =AMOUNT OF DATA RECEIVED IN A GIVEN AMOUNT OF TIME

iii. ENERGY EFFICIENCY

Figure 15 shows the energy remaining between the NORMAL DATA, NON SPLIT-DATA, SPLIT DATA and DYNAMIC DATA. The remaining energy is more in the DYNAMIC DATA. Hence by using the DYNAMIC DATA the energy saving is more.

$$\text{ENERGY (J)} = \text{COULOMB(C)} * \text{VOLTAGE (V)}$$

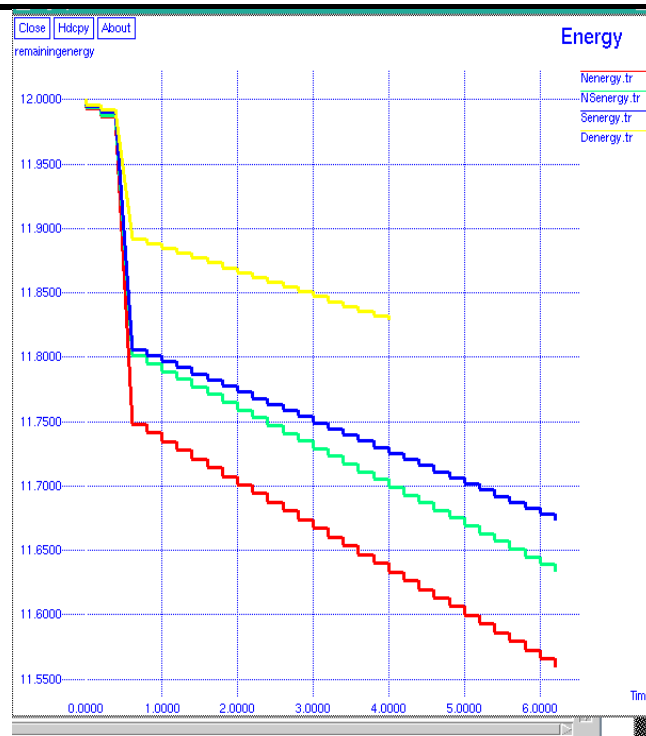


Fig.15: Energy efficiency

VII. CONCLUSION AND DISCUSSION

Dynamic Multilevel Priority (DMP) packet scheduling scheme for Wireless Sensor Networks (WSNs). The scheme uses three-level of priority queues to schedule data packets based on their types and priorities. It ensures minimum end-to-end data transmission for the highest priority data while exhibiting acceptable fairness towards lowest-priority data. Experimental results show that the proposed DMP packet scheduling scheme has better performance than the existing FCFS and Multilevel Queue Scheduler in terms of the average task waiting time and end to- end delay.

As enhancements to the proposed DMP scheme, we envision assigning task priority based on task deadline instead of the shortest task processing time. To reduce processing overhead and save bandwidth, we could also consider removing tasks with expired deadlines from the medium. Furthermore, if a real-time task holds the resources for a longer period of time, other tasks need to wait for an un defined 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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