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Priority And Lifetime Based Packet Scheduling Scheme In Wireless Sensor Networks

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Abstract: A wireless sensor network (WSN) is a computer network consisting of spatially distributed autonomous devices using sensors to cooperatively monitor physical or environmental conditions such as temperature, sound, vibration, pressure, motion or pollutants, at different locations. The development of wireless sensor networks was originally motivated by military applications i.e. battlefield surveillance. However, wireless sensor networks are now used in many civilian application areas, including environment and habitat monitoring, healthcare applications, home automation, and traffic control. Scheduling different types of packets, such as real-time and non-real-time data packets, at sensor nodes with resource constraints in Wireless Sensor Networks (WSN) is of vital importance to reduce sensors energy consumptions and end-to-end data transmission delays.

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: Wireless sensor network, packet scheduling, pre- emptive priority scheduling, non-pre-emptive priority scheduling, real-time, non-real-time, data waiting time, FCFS.

INTRODUCTION

A wireless sensor network (WSN) is a computer network which consists of spatially distributed autonomous devices using sensors to look after physical or environmental conditions like temperature, vibration, sound, pressure, motion or pollutants in various locations. Military applications gave motivation for the development of wireless sensor networks i.e. in battlefield. Now a days wireless sensor networks are used in many civilian applications, healthcare applications, home automation and in traffic control. Scheduling is the most widely used concept in WSNs because it determines the order of transmission of number of data packets based on their data priority and transmission deadline. For instance, real time data packets are given the highest priority when compared to that of non-real time data packets. Some of the available or existing scheduling mechanisms in wireless sensor networks are First Come First Serve, Premptive Priority and Non prepmtive Priority algorithms. The major drawbacks of using these algorithms are that the end-to-end transmission delay will be more and processing overhead will be high. Dynamic refers to the system which is active and undergoes progress frequently. Multilevel priority indicates that instead of single queue, multiple queues are used to assign different priorities to the incoming packet. Packet scheduling 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. Packet scheduling can guarantee quality of service and improve transmission rate in wireless sensor networks The proposed scheme Dynamic Multilevel Priority (DMP) packet scheduling is for the processes where the inputs changes dynamically. In this scheme, zone based topology is used where the nodes are organized in virtual hierarchy. All the nodes except the last level has three different levels of priority queues. Real time data packets are placed into highest priority queue and can preempt the data packets in the other queues. The leaf node has only two queues. One is for real time data packets and other is for non-real time data packets because it will not receive any data from lower level nodes. Hence this scheme reduces average waiting time and end-to-end transmission delay.

RELATED WORK

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 neighbouring nodes take less time to be processed at the intermediate nodes. In FCFS, many data packets arrive late and thus, experience long waiting times.

A. Deadline

First Come First Serve: This may be the simplest way for a scheduler to schedule the packets. In fact, FCFS does not consider the QoS parameters of each packets, it just sends the packets according to the order of their arrival time. Thus, the QoS guarantee provided by FCFS is in general weak and highly depends on the traffic characteristic of flows. For example, if there are some flows which have very bursty traffic, under the discipline of FCFS, a packet will very likely be blocked for a long time by packets burst which arrives before it. In the worst case, the unfairness between different flows cannot be bounded, and the QoS cannot be no longer guaranteed. However, since FCFS has the advantage of simple to implement, it is still adopted in many communication networks, especially the networks providing best effort services. If some level of QoS is required, then more sophisticated scheduling algorithm is needed.

Earliest Deadline First (EDF): For networks providing real-time services such as multimedia applications, earliest deadline first (EDF) is one of the most well-known scheduling algorithms. The concept behind EDF is straightforward. It essentially schedules the packets in a greedy manner which always picks the packets with the closest deadline. Compare with strict priority discipline, we can regard EDF as a scheduling algorithm which provides time-dependent priority to each eligible packet.

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.

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 t1 carries on even if a higher priority packet t2 than the currently running packet t1 arrives at the ready queue. Thus t2 has to wait in the ready queue until the execution of t1 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.

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.

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, e.g., nodes at the lowest level, lk are assigned timeslot 1. Details of timeslot allocation are explained in the "Terminologies" subsection.
• 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.

TERMINOLOGIES

In this section, we define the following terminologies and factors that are used in designing the DMP packet scheduling scheme.

Protocol Used

The Zone Routing Protocol (ZRP) aims to address the problems by combining the best properties of both approaches. ZRP can be classed as a hybrid reactive/proactive routing protocol. ZRP reduces the proactive scope to a zone centred on each node. In a limited zone, the maintenance of routing information is easier. Further, the amount of routing information that is never used is minimized. Still, nodes farther away can be reached with reactive routing. Despite the use of zones, ZRP has a flat view over the network. In this way, the organizational overhead related to hierarchical protocols can be avoided. First hybrid routing protocol with both a proactive and a reactive routing component. IARP periodically computes the route to all intra zone nodes (nodes that are within the routing zone of a node) and maintains this information in a data structure called IARP routing table. In order to know about a node's direct neighbours and possible link failures, IARP depends on a neighbour Discovery Protocol (NDP) provided by the MAC layer. IERP is a family of reactive routing protocols like DSR or AODV that offer enhanced route discovery and route maintenance services based on local connectivity monitored by IARP. For route discovery by IERP, the notion border casting is introduced.

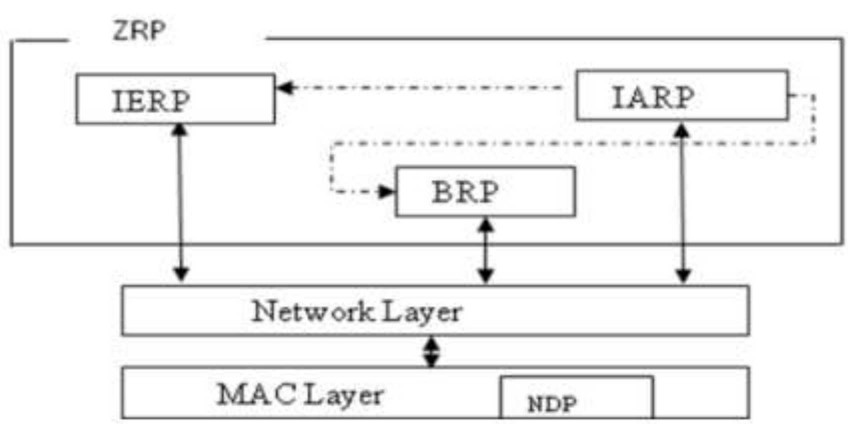

Fig 1: ZRP Architecture

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 neighbouring squares. Thus, this protocol reduces the probability of having any sensing hole in the network even if the neighbouring squares of a node do not have any sensor node.

PROPOSED DYNAMIC MULTILEVEL PRIORITY 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 trade off between priority and fairness.

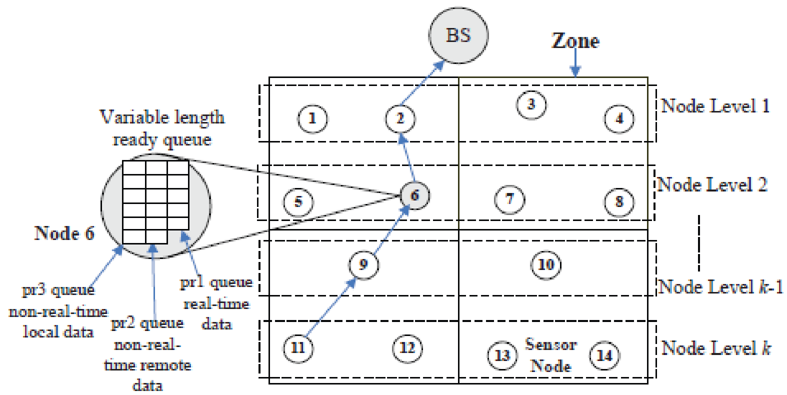

Fig 2: Dynamic Multilevel priority scheduling scheme

Among many network design issues, such as routing protocols and data aggregation, that reduce sensor energy consumption and data transmission delay, 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 minimum latency. For instance, data sensed for real-time we propose a Dynamic Multilevel Priority (DMP) packet scheduling scheme for WSNs in which sensor nodes are virtually organized into a hierarchical structure. Nodes that have the same hop distance from the BS are considered to be located at the same hierarchical level. We consider a network then divide it into zones. Each zone has a zone head which is used for routing. Zone head are used for routing data to the destination i.e. to the base station. Data are transmitted with the help of zone head. Other member nodes are not used for routing. They only transmit data to their zone head within the zone. Within a zone data are sending through Intra-zone routing and outside the zone data are sending through inter-zone routing.

WORKING PRINCIPLE

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 as shown in figure 5.1.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 as shown in below figure 3.2. 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.

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 re- source constraint sensor networks, the size of the ready queue for preemptive priority schedulers is expected to be smaller than that of the preemptable 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 (pr1 queue) and can pre-empt 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 preemptable priority queue (pr2 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 pr3 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. Timeslots at each level are not fixed. They are rather calculated based on the data sensing period, data transmission rate, and CPU speed. They are increased as the levels progress through BS. However, if there is any real-time or emergency response data at a particular level, the time required to transmit that data will be short and will not increase at the upper levels since there is no data aggregation.

The remaining time of a timeslot of nodes at a particular level will be used to process data packets at other queues. Since the probability of having real-time emergency data is low, it is expected that this scenario would not degrade the system performance. Instead, it may improve the perceived Quality of Service (QoS) by delivering real-time data fast. Moreover, if any node x at a particular level completes its task before the expiration of its allocated timeslot, node x goes to sleep by turning its radio off for the sake of energy efficiency.

METHODOLGY OF THE PROPOSED SYSTEM

Methodology of the proposed system requires the following parameters

A. Network Initialization

In the network design the nodes 'n' are deployed randomly in the networks. The node which is in the centre of the network is chosen as the base station. And the communication range of the node is set to 250m.Area where the nodes are deployed is divided into number of zones and for each zone, zone head is chosen.

B. Packet Classification

Packets are classified based on the priority levels. Packet 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 minimum latency. For instance, data sensed for real-time applications have higher priority than data sensed for non-real-time applications. The processing of data packets available at a sensor node and also reduces energy consumptions

.C. Task Scheduling

Allocation is done for task schedulers. Based on the priority queue packets are scheduled. Real time packets which are given the higher priority are scheduled using FCFS. Non real time packets with other two lower priorities are processed using SJF

D. Performance Evaluation

Evaluating the performance of this system gives positive results on minimum average waiting time and reduction in end-to-end delay while transmission. We compare results obtained from DMPPS with that of FCFS and obtain simulation results.

SIMULATION RESULTS

The simulation model is implemented using the NS2 programming language. 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. 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.

Here the nodes are assigned priorities that is 0 and 1. Priority 0 means highest priority and 1 means lower priority. Packets originating from these nodes will have respective priorities. When packet 0 arrives at a node it will check the priority of the packets. The packet having priority 0 is forwarded first to the destination (BS).

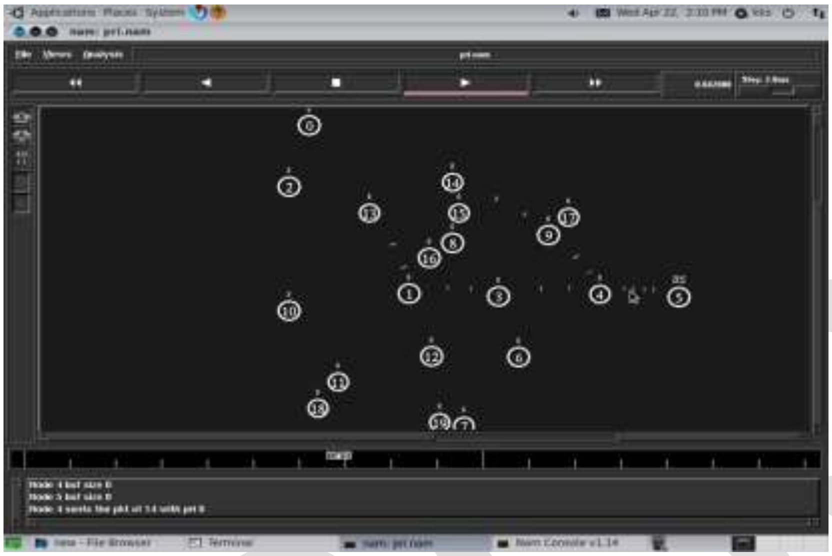

Fig 3: DMP Packet scheduling

In the DMP task scheduling approach, the source of a data packet is used to define the priority of data packets other than real-time. The priority of non-real time data packet will be more if it is sensed at remote node rather than the current sending node. Moreover, when no real-time tasks are available, pr3 tasks can preempt pr2 tasks if they are in starvation for a long time. This allows the processing of different types of tasks with fairness. The memory is also dynamically allocated to three queues and the size of the highest-priority queue is usually smaller than the two other queues since pr1 real-time tasks do not occur frequently compared to non-real-time tasks. As the memory capacity of a sensor node is limited, this also balances memory usages. Moreover, tasks are mostly non-real-time and are processed in the pr2 and pr3 queues. Non-real-time tasks that a node x receives from the lower level nodes are known as non-real time remote tasks and processed with higher priority (pr2) than the non-real- time local tasks that x senses. Thus, non-real time remote tasks incur less average waiting time. In addition, the average waiting time will not be affected for real-time tasks that are processed using FCFS scheduling, since these real-time tasks occur infrequently with a short processing time.

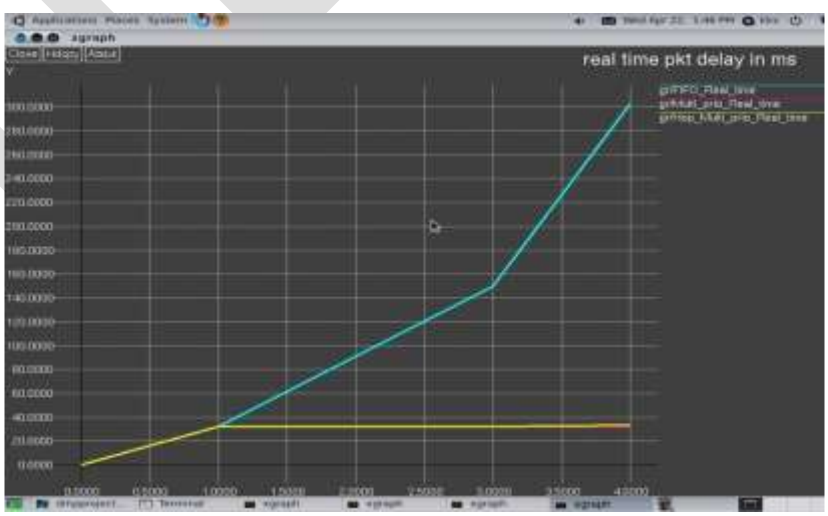

Fig 4: Real time packet delay comparison

The figure shows the comparison between the real time packet delays of DMP packet scheduling scheme, comparing it against the FCFS, and Multilevel Queue scheduling schemes.

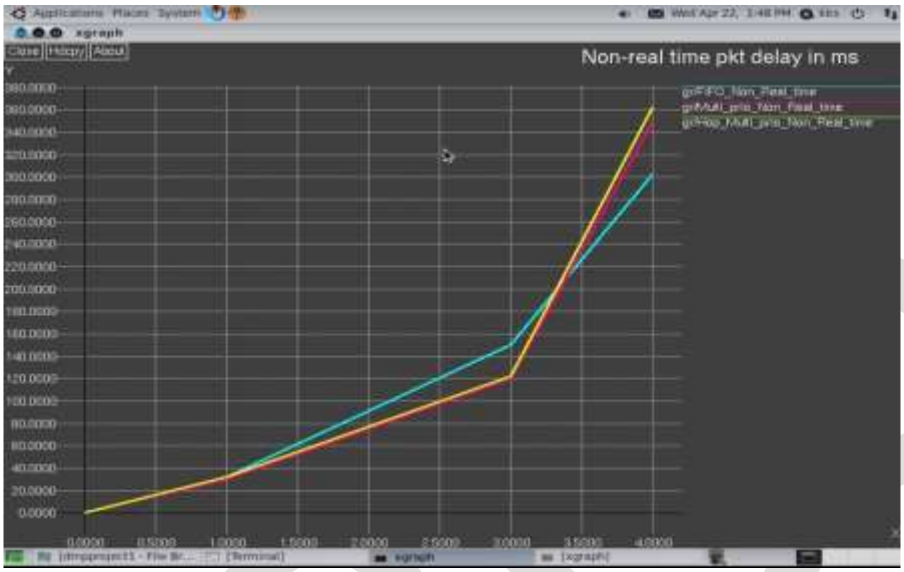

Fig 5: Non Real time packet delay comparison

The figure shows the comparison between the non-real time packet delays of DMP packet scheduling scheme, comparing it against the FCFS, and Multilevel Queue scheduling schemes.

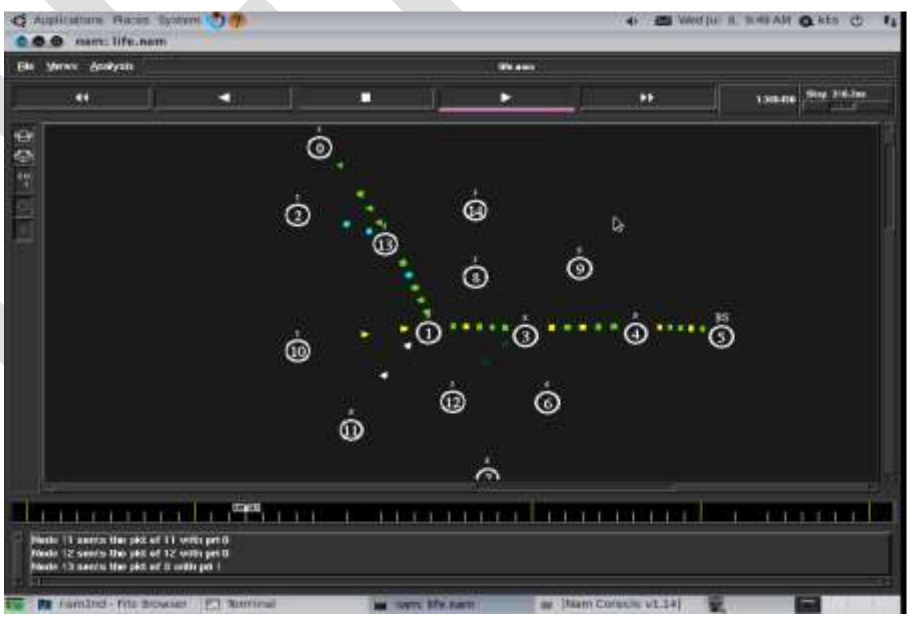

Fig 6: Life time based packet scheduling

Here packets are assigned priorities according to their life time. Packets having shorter life time will be given higher priority than the packet having longer life time. The aim of life time based packet scheduling is to deliver the data packet before the expiration of its life time.

Figure 7 shows that in networks dead packets causes congestion. The dead packets are the packets whose life time has been expired.

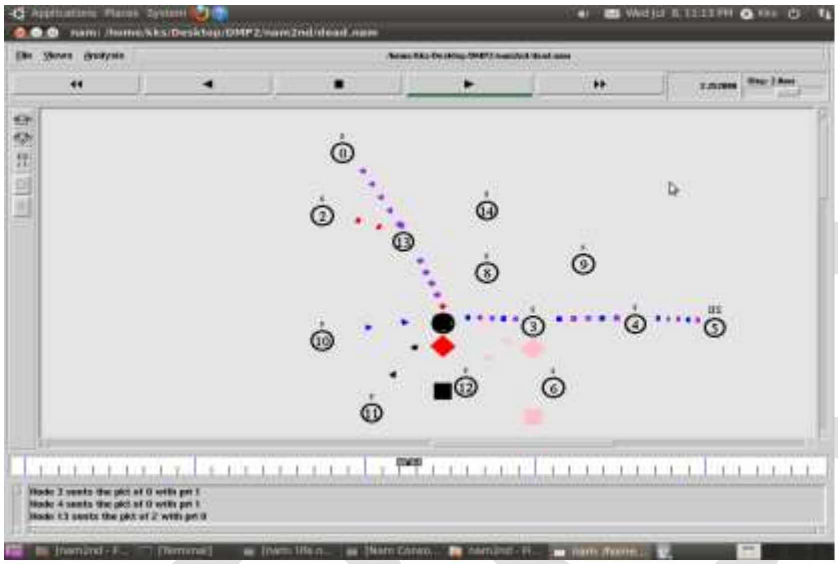

Fig 7: Dead packet dropping

CONCLUSION

We have discussed the hybrid Zone Routing Protocol in this paper, which is the combination of reactive and proactive routing protocols and have advantages of both type of protocols. The ZRP protocol is suitable for large networks and is not an independent protocol but rather a routing framework. It is especially well adapted to large networks and diverse mobility patterns and also we propose a 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.
Also here we are scheduling the packets base on life time, which ensures that the delivery of data packets before the expiration of its life time. Dead packet dropping reduces the network congestion and makes this scheduling most suited for real time applications.

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