Advanced Dynamic Multilevel Priority Packet Scheduling Scheme

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***Abstract*—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 WSN use First Come First Served (FCFS), non-preemptive priority and preemptive priority scheduling algorithms. These algorithms incur a high processing overhead and long end-to-end data transmission delays. Moreover, these algorithms are not dynamic to the changing requirements of WSN applications since their scheduling policies are predetermined. Then there comes a method for scheduling packets dynamically for wireless sensor network. In this approach the packet is scheduled by prioritization. Initially packet has to classify according to packet type (i.e. real time and non-real time packets).The data packets that are received by a node from the lower level nodes are given higher priority than the data packets sensed at the node itself. Dynamic Multilevel Priority packet scheduling scheme that ensures a tradeoff between priority and reliability. In the Advanced Multilevel Priority packet scheduling scheme, each node except those at the last level has three levels of priority queues. According to the priority of the packet and availability of the queue, node will schedule the packet for transmission. Due to separated queue availability, packet transmission delay is reduced. Due to reduction in packet transmission delay, node can goes into sleep mode as soon as possible. And Expired packets are deleted at the particular node at itself before reaching the base station, so that processing burden on the node is reduced. Thus, energy of the node is saved. We evaluate the performance of the proposed Advanced Dynamic Multilevel Queue scheduling scheme through simulations for real-time and non-real time data. Simulation results illustrate that the Multilevel Priority packet scheduling scheme overcomes the conventional methods in terms of average data waiting time and end-to-end delay.**

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

I. INTRODUCTION

The communications in the WSN has the many-to-one property in that data from a large number of sensor nodes tend to be concentrated into a few sinks. Since multi-hop routing is generally needed for distant sensor nodes from the sinks to save energy, the nodes near a sink can be burdened with relaying a large amount of traffic from other nodes Sensor nodes are resource constrained in term of energy, processor and memory and low range communication and bandwidth. Limited battery power is used to operate the sensor nodes and is very difficult to replace or recharge it, when the nodes die. This will affect the network performance .Energy consumption and harvesting increase the lifetime of the network. Optimize the communication range and minimize the energy usage. Sensor nodes are deployed to gather information and desired that all the nodes works continuously and transmit information as long as possible. This addresses the lifetime problem in wireless sensor networks. Sensor nodes spend their energy during transmitting the data, receiving and relaying packets. Hence, designing routing algorithms that maximize the life time until the first battery expires is an important consideration designing energy aware algorithms increase the lifetime of sensor nodes. In some applications the network size is larger required scalable architectures. Energy conservation in wireless sensor networks has been the primary objective [2], but however, this constrain is not the only consideration for efficient working of wireless sensor networks. There are other objectives like scalable architecture, routing and latency. In most of the applications of wireless sensor networks are envisioned to handled critical scenarios where data retrieval time is critical, i.e., delivering information of each individual node as fast as possible to the base station becomes an important issue.

II. RELATED WORK

To fulfill the objectives of the thesis, understanding the basics of Wireless Sensor Networks and its characteristics is essential. Wireless Sensor Networks Technology, Protocols and Applications [2] (a john Wiley & sons Inc., Publication2007) was referred to understand the basics of wireless sensor networks and its characteristics. This book refers about the concept of wireless sensor networks, characteristics, and applications of the wireless sensor networks. And also refers about the routing protocols for wireless sensor networks. And also described about the different MAC protocols useful in wireless sensor network technology.
In this paper "RAP, new real-time communication architecture for large-scale sensor networks" [3], Authors (Chenyang Lu et al, Brian et al) proposed Velocity Monotonic Scheduling (VMS). VMS assigns the priority of a packet based on its requested velocity. A packet with a higher requested velocity is assigned a higher priority. VMS improves the number of packets that meet their deadlines because it assigns the "right" priorities to packets based on their urgencies on the current hop. But there is no detail for packet arrival distance.
And in this he paper [4], "Extending the Lifetime of Wireless Sensor Networks through Adaptive Sleep", when the queue is full, higher priority incoming packets overwrite lower priority ones. It may problem to be the low priority information. In the paper [4], author Giuseppe et al and Hong et al proposed an Adaptive Staggered SLEEP Protocol (ASLEEP) for efficient power management

in wireless sensor networks targeted to periodic data acquisition. This protocol dynamically adjusts the sleep schedules of nodes to match the network demands, even in time-varying operating conditions. It uses the CSMA scheme for process the data, but it may be not efficient in fixed WSN network and there is no detail to data management. In this paper [5], author presents how to place sensors by use of a minimal number to maximize the coverage area when the
Communication radius of the SN is not less than the sensing radius, which results in the application of regular topology.
In this paper [9], authors propose Q-MAC scheme that provides quality of service by differentiating network services based on priority levels. The priority levels reflect the criticality of data packets originating from different sensor nodes. The Q-MAC accomplishes its task through two steps; intra-node and inter-node scheduling. This paper effectively handled the priority scheduling, but this paper only considered the priority packets and it schedules the priority packet as the first non-priority as second. And in the case of node gives the first priority to own priority data compare than other nodes packet.
Author [10] developed scheme by designing the network with multiple-sized fixed grids while taking into account the arbitrary-shaped area sensed by the sensor nodes. In this paper [10], author Tarandeep et al considers the different initial energy level of sensors, and placed that sensor according to that energy level. So energy loss was avoided. But calculating different initial energy level and placing the node according to that energy level is difficult in real time.

III. Wireless Node Architecture and WSN

A wireless sensor node is capable of gathering information from surroundings, processing and transmitting required data to other nodes in network. The sensed signal from the environment is analog which is then digitized by analog-to-digital converter which is then sent to microcontroller for further processing.[5] The block diagram of a sensing node is shown in figure. While designing the hardware of any sensor node the main feature in consideration is the reduction of power consumption by the node. Most of the power consumption is by the radio subsystem of the sensing node. So the sending of required data over radio network is advantageous. An algorithm is required to program a sensing node so that it knows when to send data after event sensing in event driven based sensor model. Another important factor is the reduction of power consumption by the sensor which should be in consideration as well. During the designing of hardware of sensing node microprocessor should be allowed to control the power to different parts such as sensor, sensor signal conditioner and radio.
Depending on the needs of the applications and on sensors to be deployed, the block of signal conditioning can be replaced or re-programmed. Due to this fact a variety of different sensors with wireless sensing node are allowed for use. To acquire data from base station remote nodes uses flash memory.

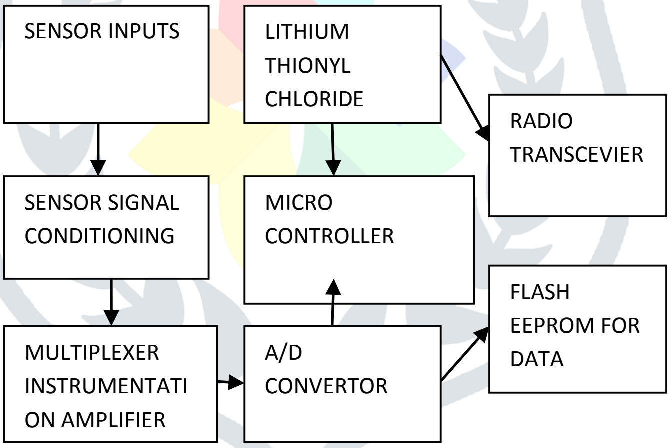

Fig 1. Sensor Node Architecture

Characteristics of WSN's:
WSN have the following distinctive characteristics:

- They can be deployed on large scale.
- Wireless sensor networks have the ability to deal with node failures.
- Another unique feature is the mobility of nodes.
- They have the ability to survive in different environmental surroundings.

1. Advanced Multi level Priority scheduling scheme
In non pre-emptive 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 pre-emptive priority scheduling, non real time data will be in the waiting state because of continuous arrival of real time data. This Advanced Multilevel Priority packet scheduling scheme ensures a trade off between priority and fairness. And in existing scheduling schemes, expired packets (Dead Packets) are removed after reaching the base station. But in this method, node will check for the expired packets while processing the data packets and it will delete those packets at the node itself.
Scheduling data packets among several queues of a sensor node is presented in Figure 2. In the Advanced Multilevel priority packet scheduling scheme, Nodes are virtually organized following a hierarchical structure. Nodes that are same hop distance from the bases station (BS) are considered to be the same level. Data packets of different levels at nodes are processed using the TDMA

Scheme. Nodes that are at lowest level and second lowest levels can be allotted time slots 1 & 2 respectively. In advanced multilevel priority packet scheduling scheme, node has three level of priority queue.
The three priority levels are

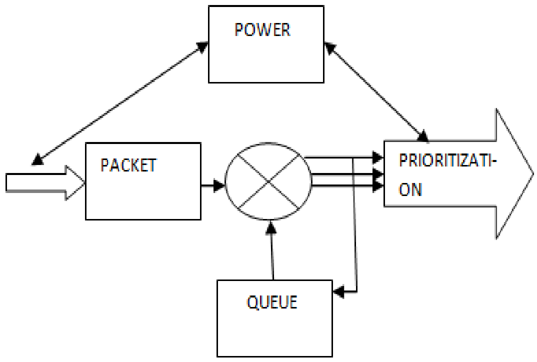

Fig2 Task scheduling

Real packets i.e. emergency data packets has to reach the base station (BS) as soon as possible so that these packets are given high priority compared to the other data packets. Thus, end to end delay for the real time packets is reduced. In the ready queue, Real time data packets are processed using FCFS (First come First serve) method.

Real time data packets are placed in pre-emptive priority queue. Thus these packets on arrival preempt the processing of non-real time data packets. And priority2 packets are placed in preempt-able queue. The processing of priority1 reduces the end to end delay for the real time packets. If the low priority data do not get processed for a long time then it can preempt the high priority tasks and then starts processing of high priority tasks. [7] And node also monitors the lifetime of the non-real time packets, if the lifetime of the packet is less than half of its actual lifetime then node starts processing of those packets to improve the packet delivery probability. The amount of real time tasks is very low when compared to other tasks because real time or emergency data will occur rarely. The operation at the node is shown in the figure3.

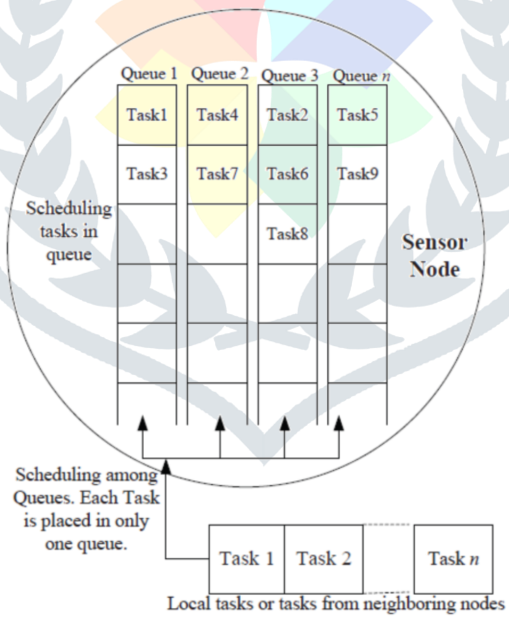

Fig 3 Queue and task scheduling.

Each packet has an ID which consists of Level ID and Node ID, when two equal priority packets arrive the node at same time, node process the packet which is coming from the lowest level. Level will be identified by the Level ID. If the two packets having same priority reach the node at the same time, then node starts processing of the packet which is having less size. Node has to process and forward most of the data sensed at the node itself and also the data which is coming from below levels in its allocated time slot to reduce the probability that the ready queue at the node becomes full and also probability of packet drops. And remaining data will be sent in further timeslots. Time slot comprised of data sensing time, data transmission time and CPU Speed. The remaining time of a timeslot at a particular node will be assigned to other queues. So the presence of data packets at queue is low. The quality of service is improved. If processing of data is completed before expiration of its allocated timeslot, then node goes into sleep mode. So that energy efficiency is improved.

Dead Packet Removal

Node compares the life time of the packet with the time packet needs to reach the base station, if it is less than then those packets are considered as dead packets and automatically node deletes those packets at node itself so that energy efficiency is improved. End to End delay for the remaining packets will be improved by deleting the dead packets.

IV. ALGORITHM (for packet scheduling)

The main aim of this algorithm is how send task (packet) according to their priority in three types of queue. Considering level also, if data comes from lowest level then giving more priority than local data (which is sensed at intermediate level) then finally consider time slot at particular level.

```
While (task (k,i))
//task means any packet receiving that node i and K means level
{
If (that is real time data)
{
Put that is in PR1 queue
}
Else if (node at which data sensed that's not at lowest level) //data also non real data
{
If (data is non local) //check whether it came from lowest level node
{
Put in PR2 Queue
} else {
Put in PR3 Queue // local data sensed at that node itself
}
} else {//data sensed at lowest level
Put in PR2 Queue
}
//Some time slot given to level consider total time slot is Tk at k level
Consider data sensing time Ts
Remaining time T1(K) = Tk –Ts
Let total real time task at (NODE)i at level at Level k - nk(pr1)
Proctime(Pr1)k is total time for pr1
If (Proctime (Pr1)k <T1(k))
{
All pr1 tasks of node (i) at l (k) are processed as FCFS
Remaining Time T2 (k)= T1(k)-ProcTime(Pr1)k
Proctime (Pr2)k is total time for pr2
If (Proctime(Pr2) k < T2(K)) {
All pr2 tasks are processed as FCFS pr3 tasks are processed as FCFS for the remaining time, only pr1 tasks are processed for T1(k) time no pr2 and pr3 tasks are processed
}
If (pr1 queue is empty and pr2 task are processing some time Y since T(K) < Proctimepr2(K))
{
At that time if pr3 task are coming then Pr2 task are pre-empted
If (any pr1 task coming in this )
{
Pr3 task pre-empted and giving priority to Pr1....
Context are transferred again for processing pr3 tasks }
If( reach_time > Reamining_time)
{ Drop that packet at node itself
}
} //end of if
}//end of while
```

V. RESULTS

The below parameters are assumed while simulation:

No. of mobile nodes = 15
Simulation end = 5sec
Packet size = 1000 bytes
Initial energy of the node = 1000 joules
Queue length = 50 packets

Channel Access scheme = MAC-TDMA

AODV protocol is used for creating the nodes. And minimum distance between the nodes will be calculated to form the route between the sources to destination via nodes.

Results of the Advanced Multilevel Priority Packet scheduling scheme are observed by comparing with the FIFO, multi priority, and hop based multi priority scheduling schemes.

A. Dead Packet Removal

In this scheduling scheme, node monitors the reach time and life time of the packets. And if the reach time is less than the remaining lifetime then node treat them as expired packets and immediately node deletes those packets because there is no use of those packets, their lifetime will be completed before reaching the base station. So that this scheduling scheme provides good performance in terms of end to end delay and waiting time of the packets and energy saving when compared to other schemes. Deletion of expired packets is shown in the figure 5.5.Reach time is calculated by using the below equation,

Reach time = remaining hop count *10ms

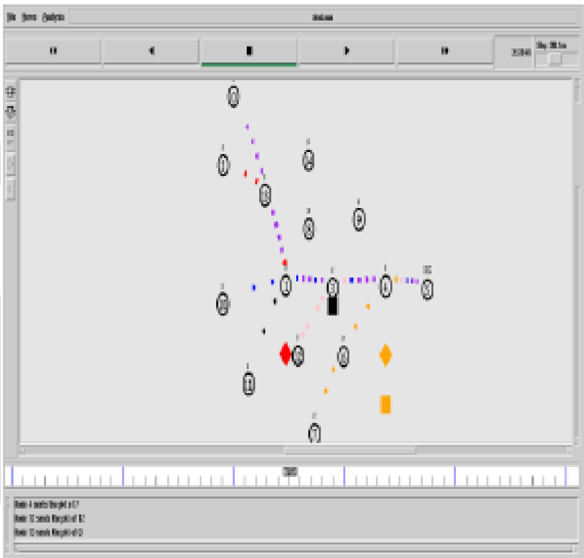

Fig 4 Dead Packet Removal

B. Non Real Time Packet delay

Scheme	Non Real Time Packet delay
FIFO scheme	300 ms
Priority Based scheme	350 ms
Hop Based Multi Priority scheme	360 ms
Advanced Multilevel Priority Scheme.	260 ms

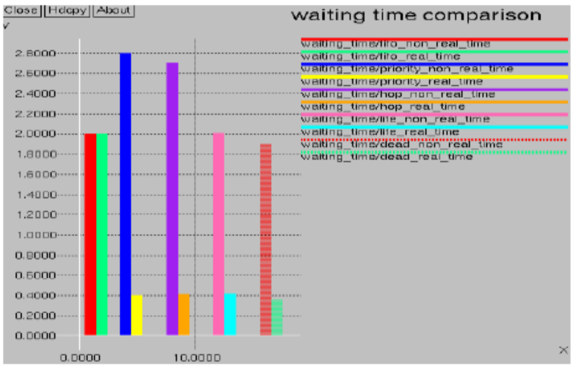

Fig 5 Energy Consumption

C. Energy Consumption

Scheme	Energy Saving (%)
FIFO scheme	88
Priority Based scheme	88
Hop Based Multi Priority scheme	88
Life Time Priority scheme	88
Advanced Multilevel Priority Scheme.	90

VI. CONCLUSION AND FUTURE SCOPE

Advanced Multilevel Priority (DMP) packet scheduling scheme for Wireless Sensor Networks (WSN's). 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 End-to-End Delay of all Tasks (microSec) 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. It assigns the priority based on task deadline instead of the shortest task processing time.
As a Future enhancement, by forming the nodes into zones (consisting node levels) based topology, end to end delay further can be reduced and also by using other channel access techniques, deadlock situation can be avoided further.

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