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Minimizing Congestion in Wireless Sensor Network Using ETRI Dual Queue Scheduler

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***Abstract*-In order to respond within a fraction of seconds in case of critical conditions like explosions, fire and leaking of toxic gases, there must be a system which should be fast enough to respond. A big challenge to sensor networks is a fast, reliable and fault tolerant channel during emergency conditions to sink (base station) that receives the events . When a particular event is detected, the sensor nodes become active and there is a sudden burst of traffic towards the sink. This may lead to buffer overflow at the nodes causing packet drops and finally degrades overall network performance. Congestion leads to wastage of energy and minimizes the lifetime of sensor nodes. In sensor networks more energy is spend for communication rather than for computation. Hence it is necessary to ensure that the drop rate of transit packets which travel many hops in the network is reduced. How to efficiently use energy, enhance information quality, and improve transmission performance are three key issues of today's wireless sensor networks. Packet scheduling for wireless communication subsystem is one of the most important methods to achieve these issues. In this paper, we propose an effective method that optimizes the energy consumption, packet scheduling, information quality etc by using the energy, time, reward, interest algorithm (ETRI) with the support of the dual queue scheduler. In this system we classify the dual queue scheduler and the ETRI method separately to make the proposed system much clear and verify its results for the further discussions**

***Keywords*: ETRI dual queue, Congestion, Packet drop, Reward value, throughput, First tier buffer (FTB), Second tier buffer (STB).**

INTRODUCTION

Sensor Network consists of a collection of autonomous sensor nodes that are spatially distributed and cooperatively monitor physical and environmental conditions. Such networks find increasing usage in diverse areas like military applications, health, agriculture, forestry etc .A large number of sensor nodes sense the phenomena and report the event through wireless links to the sink. A wireless sensor network (WSN) may consist of tens or thousands of sensor nodes scattered in an area. When an event is detected, there is a sudden outburst of data .The data generated by the nodes increases and the offered load exceeds available capacity and the network becomes congested. Congestion in WSN can be transient (link level congestion) or persistent (node level congestion).Transient congestion is caused by the temporary oversubscription of a link due to sudden burst of packets arriving at the switch or router buffer. It happens due to link variations. Persistent or sustained congestion occurs when the long term arrival rate at a link exceeds its capacity. This happens when the source data sending rate increases and the buffer over flows. While transient congestion only introduces a delay in data transmission, persistent congestion results in data loss. Congestion results in packet drops, increased delays, unreliability, lower throughput, wastage of communication resources, power, and eventually decreases lifetime of the WSN. Congestion control involves methods for monitoring and regulating the total amount of data entering the network to keep traffic

levels at an acceptable value. Congestion control in WSN has a rich history of algorithm development and theoretical study. Various schemes for congestion control have been proposed and implemented over the years. The existing works differ in the algorithms they use for adjusting source sending rate and techniques to deal with transient **[01].**

Sensor nodes gather and relay information to one or more sink nodes by monitoring the physical environment. Normally, the radio transmission range of the sensor nodes are the orders of magnitude smaller than the geographical extent of the entire network. Therefore, the data needs to be transmitted towards the sink node hop-by-hop in a multi-hop manner. If the amount of data which needs to be transmitted is reduced, then the energy consumption of the network can also be reduced. The factors which affect the performance and reduce the efficiency of the WSN are the computational power, data storage, battery lifetime and the communication bandwidth. It is necessary to consider in the WSN architecture, the network topology, power consumption, data rate and fault tolerance for avoiding the energy consumption and for improving the bandwidth utilization [05]. Energy efficiency is vital in the wireless sensor networks. The sensor nodes act as both data originator and data router. The data traffic follows a many-to-one communication pattern. The nodes which are nearer to the sink have to take heavier traffic load and thus the nodes which are around the sink may deplete their energy quickly which gives rise to energy hole around the sink. If the energy hole arises, then the data transmission to the sink is stopped. Therefore, the lifetime of the network is reduced **[04].**

Providing high quality information to users is another important issue of sensor networks. Generally a huge amount of raw data can be created by a large sensor network and sent back to base station. However, in most of the time only the raw data of some sensor nodes that relate to the user's purposes are really valuable. In other words, only those data that users are interested in are useful. In order to improve the quality of requested information, Interest is introduced as a threshold to reduce the unnecessary data as well as improve the information quality. The communication of wireless channel is the main consumer of battery energy compared with that of the computation of processor. If we can reduce the receiving and transmitting times by refusing or discarding the unnecessary data, then we can substantially reduce the energy consumption. Naturally, among a set of tasks of real time applications, some of them are more valuable than the others. Sometimes, instead of processing several unimportant tasks that just consume a small amount of energy, it is more meaningful to process one valuable task that will consume more energy.

Beside the Energy and Time constraints, Reward is considered as the third constraint for each task. In this paper, we simply name their algorithm as ETR (Energy, Time, and Reward) scheduling algorithm. The purpose of ETR scheduling algorithm is to maximize the system value (reward) while satisfying the time and energy constraints. In other words, whenever a new task is accepted, it must have the highest reward value among these tasks, and its energy consumption should not exceed the remaining energy. In this paper we first present the Two Tiers Buffer (Buffer of sensor networks and Buffer in sensor node) model as the platform for energy aware packet scheduling in sensor networks. Which is named as ETRI (Energy, Time, Reward, and Interest) packet scheduling algorithm along with the priority issue i.e. the transit packets (data from other nodes) is been given the priority. Within this algorithm each packet has four parameters. They are (1) energy consumption of this packet, (2) deadline of this packet, (3) important level of this packet, and (4) interest level of this packet. Different from the ETR packet scheduling algorithm, we don't always use these four constraints at the same time, instead we dynamically combine these four constraints to filter and schedule packets for heterogeneous sensor nodes and diverse working purposes. By using ETRI packet scheduling algorithm with the Two Tiers Buffer model, we can achieve the following contributions: (1) providing threshold to control the coming packets to reduce the energy consumption; (2) providing diverse packet scheduling algorithms for heterogeneous sensor nodes to improve the whole network's performance; (3) using stricter constraints to provide higher quality information **[02]**.

RELATED WORK

One of the earlier works [05], CODA focuses on an energy efficient congestion control scheme, involving three mechanisms distributed across the network and MAC layer. It handles both persistent and transient congestion, but do not provide differentiated services to multiple class of traffic. There have been considerable efforts in developing congestion control schemes that give importance to high priority data or data with specific delay or QoS requirements in the event of congestion. The more recent ECODA [07] introduces three mechanisms to detect and control persistent and transient congestion. It uses the concept of dual buffer threshold. However to deal with persistent congestion it uses a technique based on overhearing which is coarse and unreliable. Also during extreme congestion when packets are dropped, no priority is given to the transit packets. Each node has the extra overhead of calculating the weighted buffer difference to identify high priority data which is costly considering the limited power of sensor node **[01].**

Standard AODV uses the hop-count routing metric and endeavors to minimize the path lengths. However, it does not take into consideration the other three characteristics. As AODV processes Route Request packets on a 'first come fist serve basis', the hop-count metric is often ignored in congestion scenarios. Therefore hop-count, without taking into account the other routing metric characteristics, is not a good path cost representative.

In ETRI algorithm, we provide Interest as one more constraint. When we use ETRI to process packets, we can choose the packets interested first, and then among these filtered packets, we can schedule them basing on their reward value while still satisfying the time and energy constraints. Dynamic Modulation Scaling that should be applied to the communication subsystems as a power management approach, which is the tradeoff between the energy consumption and the transmission delay. If the

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communication subsystem sends or receives data with a higher frequency, then more energy will be consumed. Therefore, the key idea of this approach is that it always transmits packet with the lowest frequency but still meet the deadline. The drawback of this approach is that it just considers the packets that already existed in the buffer, but does not provide the threshold to reduce the coming packets.

The date-centric approach is proposed for energy-efficient data routing, gathering and aggregation in wireless sensor networks. The key idea is that whenever users query some data from the sensor networks, they just query the data they are interested in. Moreover, by using the fusion circuit, several packets which have the similar information can be fused into one packet to reduce the packet number. Once the number of packets is reduced, sequentially, the energy consumption will be reduced. In their researches they simply consider all these packets that are of same importance, but actually among these interested packets, some of them may be more important than the others. For example, users are interested in the data of several sensor nodes used to monitor an object. The data created by the sensor nodes which are close to the observed object have more valuable information than the data created by the sensor nodes which are far from the observed object. Therefore, if we can introduce the Reward into these interested packets, we are able to select out and process the most important and valuable packet first. From these related researches, we find that a comprehensive packet scheduling algorithm is really necessary for wireless sensor networks. Before we introduce the ETRI packet scheduling algorithm, we first introduce the Two Tiers Buffer model to readers in the next section **[02].**

PROPOSED WORK

In this paper, we propose an effective method that optimizes the energy consumption, packet scheduling, information quality etc by using the energy, time, reward, interest algorithm (ETRI) with the support of the dual queue scheduler. In this system we classify the dual queue scheduler and the ETRI method separately to make the proposed system much clear and verify its results for the further discussions

Dual Queue Scheduler

The node in WSN can act as both source and forwarder. Based on this function there are two types of data, namely locally generated data and transit data. Locally generated data is the data produced from any node. The data at any source node, which it receives from a downstream node and generated data, which is its own sensed data. In a multi hop WSN, the sensed data has to travel many hops to reach the sink. Hence dropping of such transit data leads to more energy wastage and also the TTL (Time to Live) of packets is small in sensor networks, so it is necessary to route the transit packets immediately when compared with generated packets at a node. The equations that correspond to the energy is given below

$$E(L)=\frac{\text{¿}_0-E(E_w)}{P_c+\lambda E(E_r)} \qquad (1)$$

Where Pc is the constant continuous power consumption over the whole network, E[Ew] is the expected wasted energy (i.e., the total unused energy in the network when it dies), λ is the average sensor reporting rate defined as the number of data collections per unit time, and E[Er] is the expected reporting energy consumed by all sensors in a randomly chosen data collection.

It is implemented as a dual queue in which the generated traffic at the nodes and transit traffic are queued separately .Both queues are of the same length. It is considered that dropping of transit traffic leads to more energy wastage since it has travelled from many hops to reach the destination and in the event of buffer overflows the packets from generated traffic queue is dropped to make space for the transit traffic .The transit packet queue has dual thresholds. Buffer occupancy above the minimum threshold signals the onset of congestion and incoming packets from other nodes are queued in the generated packet queue .This is done to make space for transit traffic which is having high priority.

$$\varnothing=\frac{(\sum_{i=1}^{N} r_i)^2}{N\sum_{i=1}^{N} r_i^2} \qquad (2)$$

Hence the fairness ratio which is shown in equation 2 has to increase so as to increase the overall packet flow rate ratio of the network. The average rate of packets delivered from the ith sensor is denoted by r_i. N is the number of sensors in the network.

When the buffer occupancy crosses maximum threshold both queues are utilized for storing transit packets and all the generated packets are allotted a space in the buffer with some delay time introduced so that the transit packets does not pose any congestion. Once it is seen that the channel is free the generated packets are routed to next node instead of discarding it. As soon as the congestion is alleviated by the back pressure messages propagated to downstream nodes, the transit queue occupancy falls down minimum threshold and queues are used in normal way. The minimum threshold is set to half of the queue length and the maximum threshold is three fourth of the queue length. These values are considered ideal as the congestion control schemes will neither be initiated too early leading to neither excessive drop of generated packets nor too late causing drop of transit packets.

First tier buffer and second tier buffer

In wireless sensor networks, generally, a huge amount of data are collected by different sensor nodes and transmitted to the base station through the wireless communication. Different packets that are routed in sensor networks may have significantly different characteristics, such as the packet size, execution time, transmission time, energy consumption, etc. suppose that three nodes A, B, C are forwarding their data to analyzed sensor node simultaneously. They are sequentially forwarded to the cluster head since the three nodes belongs to a cluster. Many packets traversing from the three nodes to the cluster head are not yet processed and yet they have to be processed and hence are still held in the nodes and are waiting for their turn for the processing. Therefore, in sensor networks, all the sensor nodes which are going to send packets to the cluster head or ASN can be logically considered as a buffer, except the cluster head or ASN. Since all of these packets are waiting for the processing of cluster head or ASN. We regard this buffer as the First Tier Buffer (FTB).

For the FTB, different packets which are physically located in different sensor nodes and are waiting for the processing of the ASN or cluster head can be logically considered stored inside the FTB.The second tier buffer is the one that physically exists inside the sensor nodes or the cluster head. STB stores the different packets that have been received and stored inside the physical buffer are waiting for the processing of processor or radio. After sailing through the brief inspection of FTB and STB we will define the mission of each other **[02].**

ETRI –Dual Queue Method

Different packets are passing in the sensor network with heterogeneous energy consumption characteristics i.e. data packets utilize different energy and multimedia packets use different mount of energy. In order to maximize the total processed packet number for a fixed amount of energy; initially make sure that sensor nodes always accept the packet that has the smallest energy consumption first. This argument is suitable for some situation when the total energy consumption of flying packets is much larger than the remaining energy of whole sensor network which often happens in some high traffic or overloaded systems corresponding to maximization of processed packets and limiting the energy consumption.

The priority level of the packet is another important factor, processing two or more unimportant packets which, though relatively consume a small amount of energy, we would like to process one important packet which may consume relatively larger amount of energy. Reward value is used to denote the priority level of packet. A packet with a larger reward value means that these packets is more important and pose higher priority. Therefore, the sensor nodes always accept the packets which have the highest priority or reward value. Thus, we can guarantee that the most important packets can be processed first. Hence the number of packets with higher priority can be compared with lower priority slots by the following equation given below.

$$W=(lp-1)+\sum_{h\in hp(l)}\left(\frac{W}{P_h}\right).lp \qquad (3)$$

The number of instances of a higher priority query h that interfere is upper-bounded by $\left(\frac{W}{P_h}\right)$ where hp (l) is the set of queries with priority higher than or equal to l's priority and lp indicates the slots with lower priority.

Here in this particular method we are proposing we give our highest priority to the transit packets rather than the generated packets because transit packets would have travelled multiple hops to reach the sink rather than the generated packets which have been born at the source node itself.

In sensor networks' data gathering and aggregation is also an primary level task, hence sensor nodes can distinguish packets based on their Content and will not accept if the content is not as important. Interest value is used to denote the interest level of packet in other words the priority level of the packet content the more the packets are accepted, the better information quality will be obtained. By reducing the incoming packet number, but still providing enough information for applications.Another aspect in STB is the packet discarding principle. Corresponded to the we have the following three discarding principles respectively: 1) always discard the packet that has the largest energy consumption; 2) always discard the packet that has the smallest reward value first; To be more precise the transit packets have to get the highest level of priority and generated packets will be allocated in the buffer space for a period of time this condition is true only when the energy consumption by the packet is more the total remaining energy of the network. However the algorithm we designed does not make a way to this limitation instead it implements dual queue scheduling .in this method the generated packets are stored in a queue called generated queue while the transit packets are stored in the transit queue provided both are of same size **[02].**

Algorithm of the proposed system

Variables:

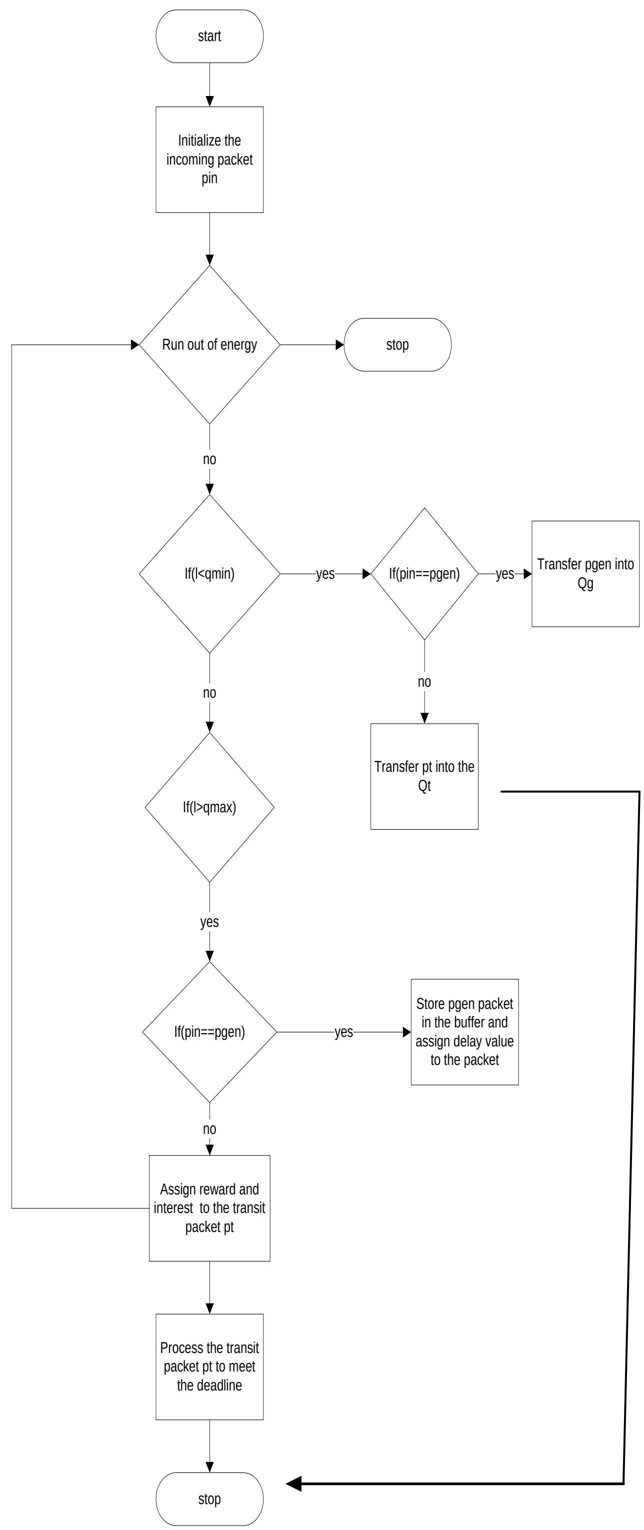
Qg =Queue for generated packets (Drop tail)
Qt=Queue for transit packets(Droptail)
Qmin=minimum threshold of **Qt**
Qmax=maximum threshold of **Qt**
L=current length of Qt
Pt=transit packet
Pgen=generated packet
Pin=incoming packet
d(t)= delay time in seconds
dcritical=critical delay
ch=channel

Pseudo code

```
If (L < Qmin )
{
        If (Pin=Pgen)
                Queue in Qg
        Else
                Queue in Qt
}
Else if (L > Qmax)
{

        If (Pin==Pgen)
    {
                Pgen=d(t)
                if (d(t)>dcritical)
                {
              if (congestion occurs)
                        {
                 Pgen=d(t)
                        }
                        Else if (ch is free)
                        {
                  Set the priority (reward) value
                Set the interest value;
                  Send the packet (p)
                        }
                }
     }
   Else
   {
            Set the priority (reward) value
                Set the interest value
                Transfer the packet at the transit queue (Qt)
   }
}
```

E. Flow chart of proposed system



RESULTS AND DISCUSSIONS

The simulation of proposed protocols in carried out in the NS2 network simulator. As the initial step towards the implementation of the congestion control protocol, the interface queue between the Network and MAC layers is modified. The proposed ETRI dual queue scheduler will ensure that during congestion generated packets are stored in generated queue and delay is assign to packet until channel is free. If transit packet is not out of maximum threshold and incoming packet is transit packet then process the transit packet based on reward value. The graph given below in Fig 1 clearly depicts the performance advantage gained through the ETRI dual queue. Less transit packets are dropped and hence the energy of sensor nodes is also saved and also overall improvement of energy consumption and throughput is achieved.

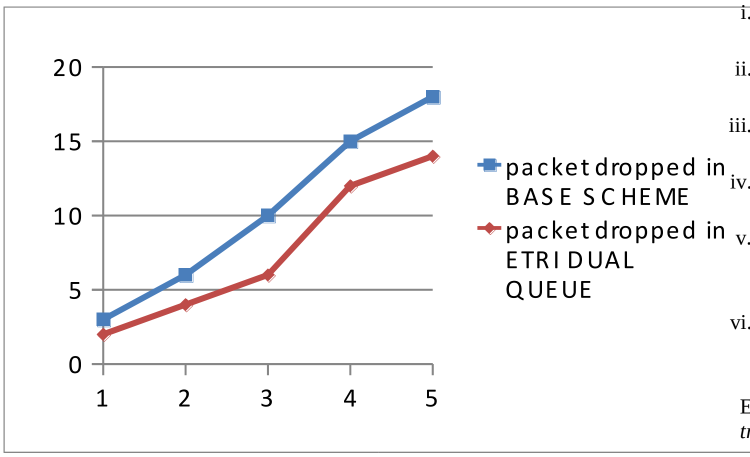


Fig 2: Comparison of performance with Base scheme and ETRI dual queue

CONCLUSION

By using the ETRI dual queue scheduling method Battery operated heterogeneous sensor network will result in a good lifetime, packet scheduling and can provide high quality information to users. In ETRI dual queue method, all the generated packets are allotted a space in the buffer with some delay time introduced so that the transit packets do not pose any congestion. Once it is seen that the channel is free the generated packets are routed to next node instead of discarding it. Hence network throughput is increased.

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ECODA*: Enhanced congestion detection and avoidance for multiple class of traffic in sensor networks*