Journal of Theoretical and Applied Information Technology
31st July 2014. Vol. 65 No.3

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

# OPTIMIZED PRIORITY ASSIGNMENT SCHEME FOR CONGESTED WIRELESS SENSOR NETWORKS

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**ABSTRACT**

Congestion is a likely event in wireless sensor networks due to node density and traffic convergence. Congestion can decrease network lifetime and reduce information accuracy. Transferring crucial data during congestion is a challenging problem in wireless sensor network. To achieve this we have proposed a competent data delivery protocol called Optimized Priority Assignment Scheme for congested wireless sensor network (OPAS). It dynamically assigns priority to every data based on their time critical nature and drops highly correlated duplicate data by considering delivery probability and finally tend to forward high and low priority data on two mutually exclusive routes only on congestion. OPAS improves data delivery and decreases packet drop for a predominantly congested wireless sensor network.

**Keywords:** *Wireless Sensor Network, Priority Assignment Scheme, Redundant Data, Data Delivery Protocol.*

## 1. INTRODUCTION

A wireless sensor network is a fast evolving network because they are amenable to support a wide variety of real world application. Wireless Sensor Network (WSN) [1] is a collection of low cost sensor nodes called motes. In general a WSN can accommodate several hundreds to even thousands of motes. Each of these motes are equipped with one or more sensors, capable of interacting with the environment in which they reside. These nodes are employed for collaboratively monitoring and controlling, physical parameters associated with their deployed environment like temperature, humidity, acoustic, vibration etc. All nodes must in turn be aware of the data they intend to forward. This data transparency requirement is essential for in-network processing.

Any node on sensing the physical parameter, have to relay the sensed data to the appropriate destination with the assistance of intermediate nodes. Wireless sensor network are constrained with limited power and mobility of nodes though they are characterized by features like, ability to withstand harsh environmental conditions, ability to cope with node failure, scalability [2]. Moreover deployment of sensor nodes in the sensing environment varies from sparse to dense.

Event driven sensor network, exhibit low data rate or reduced traffic over a long period, until some event is noticed. Triggering of an event produces busty traffic within the environment leading to network congestion [3].On congestion, network links become heavily utilized, leading to dramatic increase in drop rates Dropping may result in losing some sensitive data, attained because of the occurrence of some critical event. Thus congestion must be controlled in an efficient manner.

Congestion detection plays a prominent role in controlling congestion. In WSNs, congestion can be detected using parameters like queue length, packet service time, packet inter arrival time etc. On detection, congestion can be notified to intermediate nodes or source nodes either explicitly or implicitly. In response to this, either congestion mitigation or congestion control schemes can be employed.

In general, sensor networks are exposed to two types of congestion namely, transient congestion and persistent congestion. Most of the existing works propose individual protocols, to handle each of the congestion related issues like congestion detection, congestion avoidance and congestion recovery.

The well known protocol Congestion Detection and Avoidance (CODA) [4] detects congestion by considering both buffer occupancy

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

and channel utilization. In [5], transient congestion is controlled using open loop backpressure. Here the congested node generates and broadcasts the back pressure message to its upstream node. This in turn reduces the sending rate to some percentage. This upstream node then decides whether or not to further propagate the backpressure upwards, based on its own local network condition [6]. Persistent congestion on the other hand adopts closed loop end-to-end multisource regulation, by adjusting the sending rate similar to AIMD.

The traffic characteristic in WSN is entirely different from the other entire network. Once the sensor nodes detect the occurrence of specified event, congestion is created around the event location. Traditional way to avoid congestion is to control the rate at which source nodes generate packets. As a result any packet in excess of the available buffer space is dropped. A node can make a intelligent dropping decision when it has importance of the packet. Existing protocol takes longer time to react to congestion states.

The best way to avoid congestion is to identify redundant packets and try rejecting replicated packets. This process assists in highly retaining the energy of the sensor node by increasing the lifetime of the node in addition to information accuracy.

This paper is organized as follows. Section 2 deals with all the related works followed by section 3 which explains our System overview. Section 4 deals with implementation results. Finally, section 5 concludes the paper.

## 2. RELATED WORK

Intelligent packet dropping algorithm for congestion control detects congestion by measuring the length of the queue [7]. The queue length increases when the Packet inter-arrival time is more than Packet inter-service time. Using queue length, the Buffer Occupancy is calculated. When the Buffer Occupancy increases, the congestion increases. Thus the network is prone to congestion. Congestion is controlled by assigning priority to the data packets. When the Buffer Occupancy increases, the data packets are dropped depending on priority assigned to the data packets

Priority based congestion control protocol (PCCP) prevents upstream congestion in wireless sensor network [8]. The PCCP creates priority table based an importance of each node, and then sends this information to all the nodes within the network. PCCP uses to control upstream congestion along with congestion degree and packet table. PCCP provides work for packet-based computation to optimize congestion control. It can work under both single path & multipath routing

Priority based congestion control for heterogeneous traffic in multipath wireless sensor networks handles different types of data [9]. The protocol allocates bandwidth proportional to the priority of many applications simultaneously running in the sensor nodes. Each sensor node route is own data as well as the data generated from other senor nodes. The parent node of each sensor node allocates the bandwidth based on the source traffic priority and transit traffic priority of the data from heterogeneous applications in the child nodes. Congestion is detected based on the packet service ratio and congestion notification is implicit.

Hop by hop congestion control and load balancing in wireless sensor networks [9] detect congestion in each node by considering the queue lengths and channel conditions observed in the one-hop neighborhood. Based on the estimated level of congestion, each node dynamically adapts its packet transmission rate and balances the load among the one-hop neighbors to avoid creating congestion and bottleneck nodes.

Differentiated services based congestion control algorithm for wireless multimedia sensor network [10] detects congestion by estimating the data rate. For this estimation it uses the node itself and its one hop away upstream neighbors. While estimating the data rate, the congested node considers the characteristic of the different traffic classes along with their total bandwidth usage.
Enhanced Congestion Detection and Avoidance (ECODA) [12] uses dual buffer thresholds and weighted buffer difference for congestion detection, flexible queue scheduler[13] to select next packet to send based on channel loading and packets priority. Similar to CODA it control transient congestion but in persistent congestion congested nodes can be identified and source sending rate can be dynamically adjusted.
Mitigating congestion by Fusion uses hop-by-hop flow control [14], rate limiting and prioritized MAC for distributed congestion control in WSN. The node that detects congestion sets a congestion bit in the header of each outgoing packet, and then the neighboring nodes stop forwarding packets to

Journal of Theoretical and Applied Information Technology
31st July 2014. Vol. 65 No.3

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

the congested node until the congestion is controlled.

Congestion avoidance based on light weight buffer management in sensor networks. [15] prevent data packets from overflowing the buffer space of the intermediate sensors. This approach automatically adapts the sensors' forwarding rates to nearly optimal without causing congestion to achieve congestion-free load balancing when there are multiple routing paths toward multiple sinks

Reducing congestion effect in wireless network by multipath routing consists of biased geographical routing and two congestion control algorithms. They are in-network packet scatter (IPS) and end-to-end packet scatter (EPS).IPS reduces congestion by spitting traffic before congested areas. EPS reduces the long term congestion by splitting the flow at the source. Biased routing forwards the packets along curves instead of shortest path.

Optimized priority assignment mechanism for biomedical wireless sensor networks dynamically schedule different types of data flows based on their time critical nature. It smartly assigns priority to individual data packets rather to particular service or flow by continuously monitoring queuing delay providing guaranteed end-to-end quality of service (QoS) without invoking any congestion control and avoidance mechanism

Priority-based packet scheduling method is discussed in[19]. It improves packet delivery ratio of important data packets. This paper presents three priority mapping schemes where priority is determined on different parameters. In the first scheme, relative importance of the packet is determined on the basis of distance of the source sensor node from the event. The nearer the source sensor node from the event the higher is the priority of the packet generated by that source sensor node and vice versa. This scheme requires each node to determine its event distance in advance. In the second scheme, the relative importance or priority of the packet is determined on the basis of signal strength of a sensor node to an event. The third scheme is based on timestamp and priority is assigned on the basis of how early an event is detected by the source node.

## 3. SYSTEM OVERVIEW

Transferring high priority during congestion is a big challenge in wireless sensor network. The proposed system OPAS is designed to meet this challenge. It consists of four main components and they are data differentiation, redundant removal, sub queue formation and flexible routing protocol. In event driven sensor network, nodes which are closer to the phenomenon detect the event and generate higher event value. The threshold value of the event is predefined in accordance with the application initially. Optimized priority to data is obtained by comparing the observed even value with the threshold value and also with the distance between sink and source. Consequently intermediate node segregates the data based on priority and enqueues it in appropriate sub queue. The scheduler schedules data based on priority. Finally the flexible routing protocol simultaneously uses both single path and dual path routing protocol based on the congestion information. High priority and low priority packets are forwarded in the same path in single path routing. But in dual path routing high priority and low priority packets are routed separately.
Normally nodes in sensor network can act as both source and forwarder, based on this there are two types of packets exist namely locally generated packet and transit packet or route through packet. The packet generated from any source node is called locally generated packet. The generated data which is received from any node for forwarding becomes a transit packet.

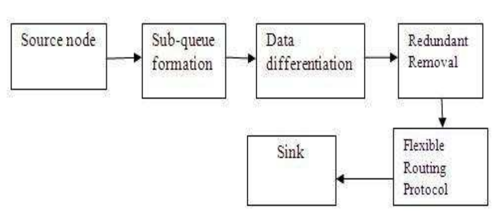

Figure.1 Overall architecture

Our proposed system optimized priority assignment scheme for congested sensor network consists of four components namely sub queue model, data differentiation, redundant removal and flexible routing protocol.

### 3.1 Sub Queue Model

Journal of Theoretical and Applied Information Technology
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ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Each sensor node has two equal sized queues for handling high priority data packets Ph and low priority data packets Pl separately. For this reason queue in each node is logically divided into sub-queues. The division facilitates a portion of queue to handle the high priority data separately. The queue which handles high priority data ph are known as priority queue PQ. Similarly the queue which handles low priority data pl are known as normal queue NQ. The data from PQ will be served more than NQ. A classifier in the network layer is used to classify data either high priority or low priority.

The queues are assigned appropriate thresholds called as buffer threshold Tb, based on the queue size. The queue levels are managed by a queue handler single handed. The main aim of sub queue formation is to maximize the number of high priority data's getting enqueued. The number of high priority data packets dropped by implementing the queuing system with sub-queues is greatly reduced as opposed to the existing system implementing the single level queuing system. The sub-queue system depicts a gradual decrease in the number of packet drops with the increase in the number of sources.

The efficiency of the proposed system decreases the packet loss to a large extent. If the incoming packet Pin has high priority data Ph then the buffer threshold Tb of priority queue PQ is checked. If it has a space then Ph is queued otherwise it is enqueued at the head of NQ. Similarly if the incoming data is Pl then the corresponding buffer threshold Tb of NQ is checked. If it has a space then Pl is queued else drop Pl.

If priority queue is empty then the normal queue data packets are schedules. The scheduler schedules the data packets from queues according to the queue priority.

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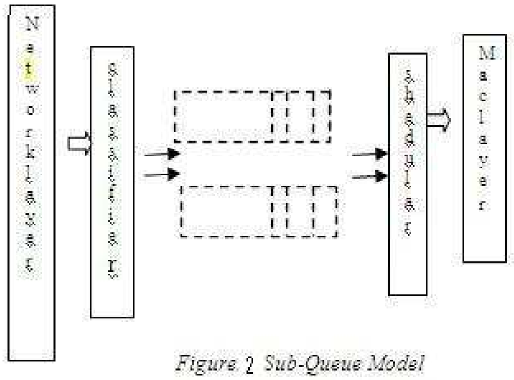


*Figure 2 Sub-Queue Model*

OPAS algorithm

Input

Pin= incoming packets

Variables

PQ= priority queue

NQ=normal queue

ph= high priority data packet

pl= low priority data Packet

Te=event threshold

Tb =buffer threshold

```
If (Pin = Ph)
    {
    If (PQ < Tb)
        {
        Queue  Ph in PQ
        }
    Else
        {
        Queue  Ph in NQ head
        }
Else
    {
    If  (NQ < Tb)
        {
        Queue  Pl in NQ
        }
        Else
```

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

{

Drop packet Pl.

}

End;

### 3.2 Data Differentiation

In event driven sensor network congestion is a likely event due to its node density and traffic characteristic. Congestion can be controlled by assigning priority to the packets. During congestion it is better to drop low priority packet than high priority one. Therefore data differentiation is must in wireless sensor network. Data can be differentiated using priority assignment scheme. This scheme assigns priority to packets based on two methods

First method assigns priority to data based on event value which are sensed at the source node. Event value at the source nods is compared to threshold value of the event with the sensed value observed. Based on the comparison, severity of the event value priority is assigned. The data which contains more event values than the threshold is assigned with high priority and vice-versa.

Second method assigns priority to data based on the distance between the source node and sink. In wireless sensor network, data transit through multiple hops to reach the destination. Hence data can also be categorized based on the distance traversed. The data from nearby nodes can be easily attained than from afar nodes. This leads to data's from nearby nodes to be less prioritized when compared with that from afar nodes.

The proposed optimized priority assignment scheme differentiate data based on event value Ve and Distant value Vd .The value of event value Ve ranges from 0 to 0.8 and distant value Vd ranges from 0 to 0.2. It is given by the following equation

$$0 \leq Ve < 0.8 \quad [1]$$

$$0 \leq Vd < 0.2 \quad [2]$$

Therefore priority value Vp can be assigned to the data by considering summation of both event value Ve and distant value Vd. It is given by

$$Vp = Ve + Vd \quad [3]$$

The value of priority value Vp ranges from 0 to 1 which is given by

$$0 \leq Vp < 1 \quad [4]$$

Now categorise data which have priority value Vp more than 0.75 is marked as imperative data or high priority data Vph. The value of Vph lies between 0.75 to1.

$$0.75 \leq Vph < 1 \quad [5]$$

Non imperative data or low priority data Vpl varies between 0 to 0.75.

$$0 \leq Vpl < 0.75 \quad [6]$$

### 3.3 Redundant Removal

In event driven sensor network the same phenomenon can be sensed by many redundant deployed sensor nodes and report highly correlated data. For this reason, there would be more number of duplicate packets created than the network can carry. Due to congestion, network starts to drop packets randomly. This will reduces the information accuracy and also the redundant packet increases the total amount of packets that has to be communicated. Hence increases the energy consumption of the network.

To avoid random dropping our proposed packet dropping algorithm drop packets based on event threshold Te and buffer threshold Tb. For n subsequent packets it drops the m redundant or highly correlated packet using packet delivery probability. The delivery probability varies from application. To do this each data is attached with one new field called as counter. The initial value of the existing count field for the data is set to 1. A node encounters a packet that already exists in its buffer, before it filters the packets by not letting it to enter into the queue increment the count value.

Also, it uses neighborhood buffer check. In this method if the sender finds that the intermediate nodes in the transmission route have a copy of the packet, then the packet gets discarded. This approach allows smooth transition of packets throughout the network during congestion.

N = No of packets with duplicates
M = No of packets without duplicates
Qp = set of packets in the queue containing different values
Pin = incoming packets
If (Pin ≠ Qp)
Queue in Pin
Else
Drop duplicate packet.

Existing packet count is set to 1 for first incoming packet in buffer;
If ( Incoming Packet == Ph) || ( Incoming Packet == Pl)

{

For ( all packet in buffer)

{

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ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

```
If ( Existing packet == Ph) || ( Existing packet == Pl)
    {
        Count ++;
        Drop redundant incoming packet
        }
    }
}
```

3.4 **Flexible Routing Protocol**

Most of the existing congestion control algorithms use single path routing. It does not provide efficient data delivery in wireless sensor network. In order to increase the data delivery OPAS uses both single and dual path routing protocol. Based on congestion OPAS uses either single path or dual path routing.

In event driven sensor network before the event occurrence buffer occupancy of the nodes in the network is less. This can be learnt through control packets. When the buffer occupancy of the nodes in the network is within the buffer threshold, OPAS preferred to choose single path routing otherwise OPAS dynamically switches into dual path routing. Both high and low priority packets are routed in the same path in single path routing. Data differentiation does not take place in single path routing.

Dual path routing protocol constructs two paths named as primary path and secondary path. Primary path is the one through which packets can reach the sink node with minimum delay. It always have less number of hops and also contain nodes with less queue length. Therefore high priority packets are routed through primary path. This gives decreased time to delivery and increased delivery ratio for high priority packets.

Another path called secondary path is a node and link disjoint of the primary path. When compared with primary path, secondary path forwards packet with higher delay and have more number of hops. The low priority packets are routed through this path with increased time to delivery and decreased delivery ratio. The advantage of using secondary path is to share the traffic load between two paths and extend the lifetime of the sensor network during congestion. This can be done with event threshold.

## 4. IMPLEMENTATION RESULTS

We have done extensive simulation to evaluate the performance of OPAS with the Normal Scheme(NS) in ns-2. In OPAS, datas are prioritized and routed to sink from appropriate sub-queue using flexible path . NS comprises non prioritized datas, single queue model and single path routing. The sensors were randomly deployed in the sensor field. The total queue length for a node was 20 packets. Therefore each sub-queue was set to hold maximum of 10 packets. The simulation parameters are given in Table 1.

*Table 1: Simulation Parameters*

| PARAMETERS | VALUES |
|---|---|
| Number of nodes | 50 |
| Topology | Random |
| Number of sources | 1,2,3,4 |
| Number of sinks | 1 |
| Node type | Static |
| Sensor field area | 500*500 |

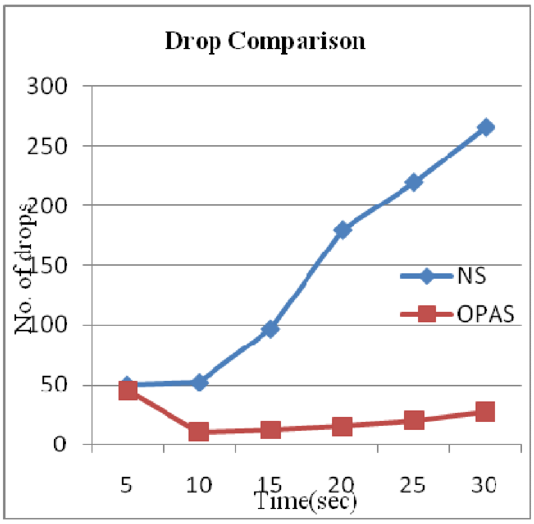


*Figure 1: Drop Comparison*

Journal of Theoretical and Applied Information Technology
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ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

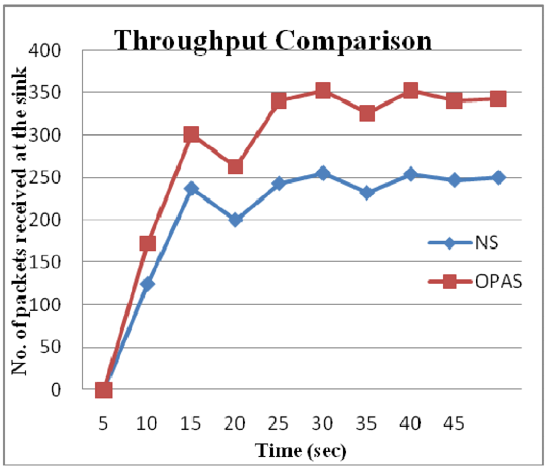
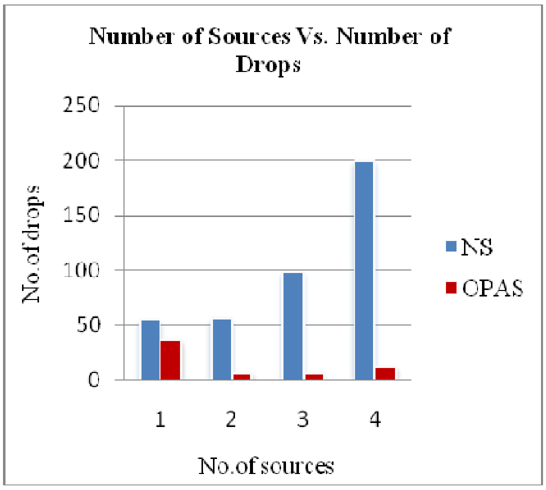



*Figure 2: Throughput Comparison*




## 5. CONCLUSION:

In our proposed OPAS congestion control algorithm data are categorized and are queued separately in sub-queue of individual sensor nodes. Based on congestion data are routed to the sink node either using single or dual path with minimum transmission delay. Here priorities are dynamically assigned to data based on the threshold values of both the event value and the distance being taken into account. Moreover removal of redundant packets reduces congestion to a large extent. This can be further enhanced to nodes present within a mobile environment.

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