A Study on Traffic Aware Routing Protocol for Wireless Sensor Networks

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Abstract

Wireless sensor network are event-driven network systems consist of collection of sensor nodes that are deployed to monitor physical and environmental conditions. In Wireless sensor network, whenever an event is detected, then the data related to the event need to be sent to the sink node (data collection node). While forwarding the data from the source node to sink node there may be chance for congestion due to heavy data traffic. Due to congestion, it leads to data loss, it may be important data also. Objective of this paper is to review various existing methods to detect and control the congestion. Different parameters that are used to measure the congestion also reviewed. Finally a comparison of various parameter measures was presented.

Keywords- Congestion control, Buffer overflow, Traffic rate, Wireless sensor networks.

I. Introduction

Wireless sensor networks are event-driven network system consist of collection of sensor nodes that are deployed to monitor physical and environmental conditions. The primary function of the wireless sensor network is to gather data, analyze the data and report to the sink node. Wireless sensor network is different from the traditional networks in which the sensor node has limited resources such as small memory, low processing power, limited energy and etc. In the delivery of events detected by the sensor nodes, the sensing data are delivered to a sink node via the routing path. To collect more information about the event, these sensor nodes begin to increase their data sensing rates. As a result of increased data traffic the load exceeds the available capacity that leads to congestion.

There are many sources that leads to congestion in WSNs. Congestion may occur due to buffer overflow, channel contention, packet collisions and many to one nature. Congestion are two types a) Node level congestion b) Link level congestion. Node level congestion is occurred due to buffer overflow, or when the number of incoming packets exceeds the available buffer space. Link level congestion may occur due to contention and bit error. Congestion may lead to packet loss and the dropped packets need to be retransmitted. To retransmit the dropped packets it requires more energy consumptions. So the issues of congestion need to be solved to improve energy efficiency as well as to prolong the network lifetime.

The rest of the paper is organized as follows: In Section II discusses the detailed description of the various congestion control techniques. Section III compares various congestion method parameters. Finally paper concludes the study on section IV.

II. Overview of various congestion control methods

To ensure the reliability of the data transmission in wireless sensor networks various congestion control methods have been proposed. In this section we are going to review some of those methods which have been developed in the recent years.

A. TARP : Traffic Aware Routing Protocol

In [1], Chongmyung Park et al presented traffic awareness routing protocol and lightweight genetic algorithm to distribute the data traffic congested in a specific sensor node to available neighbor sensor node. TARP used to find the neighbor node details of the congested node. Lightweight genetic algorithm used to find the best node among the neighbor node details of congested node to distribute their data traffic.

B. TADR : Traffic Aware Dynamic Routing

Fengyuan Ren et al proposed Traffic aware dynamic routing protocol in [2]. The congestion can be controlled by reducing the rate at source node which leads to decreases the throughput. But in this scheme, to improve the throughput and as well as to control the congestion the idle (or) under loaded nodes can be used sufficiently. TADR algorithm can be used to route the packets around the congestion area and distribute the excessive packets along multiple path consisting of idle and under loaded nodes. TADR which has two potential field a) Depth b) Queue length. The depth field can be used to find the shortest path for packets. Queue length potential field produces the sub optimal path. These two fields can be used to make routing decision dynamically.

C. Decoupling congestion control and fairness

In [3], Swastik Brahma et al proposed Decoupling congestion control mechanism. In this method each node has been assigned transmission rate efficiently. And each node monitors its aggregate output and input traffic rate. Based on the difference of the input and output traffic rate, it increases the traffic rate if the output rate is more. Else it decreases the traffic rate. This paper has been designed to achieve the following goals a) efficiency: to utilize the resources efficiently. If the input data traffic rate equal to link capacity, no queue builds and utilization is optimal. b) Flexible design: separate implementation of utility module and fairness module which offers flexible design of sensor network. c) Support concurrent application: each mote has the capability to support concurrent application such as motes deployed in building having both temperature sensor as well as vibration sensor.

D. HTAP : Hierarchical Tree Alternative Path

In [4], Charalambos Sergiou et al presented HTAP algorithm which is based on resource control that attempts to avoid congestion in wireless sensor networks by creating dynamic alternative paths to the sink. HTAP consist of the following schemes. a) Topology control b) Hierarchical tree creation c) Alternative path creation. Maximum number of possible routes can be obtained through topology control. In the second phase, the path can be created with the help of level discovery packet. The entire source node itself assigned level 0 and it sends the level discovery message to its neighbor and set as level 1. This procedure iterates until all nodes assigned a level and stops when the level discovery packets reach the sink. Alternative path creation algorithm runs when congestion is about to occur at a specific node. When an upstream node informed congestion through a specific downstream node then it searches its neighbor to find the next downstream node to transmit the packets.

E. Local cross layer congestion control

Mehmet Vuran and Ian F.Akyildiz proposed a method based on buffer occupancy in [5], Generated packets and relay packets are two types of input to the buffer. A sensor node has two duties. a) Sensor duty b) Relay duty. During sensor duty the sensed data to be transmitted. Relay duty node receive packet from its neighbor and forward towards the sink. The following two measures can be used to control the congestion. a) Explicitly control the rate of generated packets in sensor duty. b) Relay node regulates the congestion based on current load.

F. Rate optimization scheme

In [6], Prabakaran.N et al presented a method based on the node level congestion and rate based adjustment technique. Except source and sink all the node will participate in forwarding packets. The congestion can be detected as a result of buffer overflow. When an intermediate node detects congestion then it sends a warning message to the source node to reduce the traffic rate. As a result of reducing traffic rate the congestion will be avoided.

G. CCBT : Congestion Control Based on Triangle module fusion operator

Congestion control based on triangle module fusion operator proposed by Sun Yi et al in [7]. This method consists of three phases i) congestion detection ii) broadcasting iii) rate control. In this method triangle module operator is used to combine the buffer occupancy and retention rate (queue waiting time). Fusion judgment (fj) has been obtained with the help of triangle module operator. Each node ensures the congestion if fusion judgment is more than that threshold value. Once the congestion is detected then the congested message will be broadcast to the upstream nodes (source node), then the upstream node reduces the traffic rate to relieve the congestion. The upstream node will not increase the traffic rate until congestion is relieved.

H. ACCS : Adaptive Congestion Control Strategy

In [8], Runze Wan et al presented Adaptive congestion control strategy. In this method the relay node has two types of buffer which often for different traffic flow. For high priority traffic flow, more bandwidth can be allocated. Each node periodically checks the packet rate of its upstream neighbors to detect whether the congestion is occurred in the next intervals. If congestion is occurred these upstream nodes decreases their traffic rate to relieve the congestion.

I. Queue reloading scheme

In [9], Shanmugaraja.B et al proposed a method based on node level congestion. While forwarding data exceeds the node capacity then incoming packets are stored in queue, at certain stage due to high volume of data the queue also becomes full then the incoming packets are dropped. In this method to address these problems an additional queue has been dispatched as many as possible. So the overflowed data will be stored in the additional queue and that data can be reloaded to the original queue when it becomes available.

J. Differentiated services based congestion control

In [10], Muhammad Omer Farooq et al proposed differentiated services based congestion control algorithm. It consists of the following phases a) traffic classes b) congestion detection c) procedure for calculating the modified bandwidth share for upstream nodes. In the first phase traffic class is differentiated based on their generating data. In the second phase, each node monitors its buffer occupancy, when the queue occupancy exceeds a threshold level then we can ensure that the congestion is occurred. In the last phase, the congested node calculates the modified bandwidth for all one hop away upstream nodes to alleviate the congestion. While calculating the modified bandwidth it considers the traffic class along with their bandwidth usage.

III. Comparison of congestion methods parameters

This paper collected various congestion control mechanisms for wireless sensor networks. In this section the comparisons of various congestion control methods have been listed. Table I shows the comparisons of various congestion control method parameters discussed in the section II. Generally the congestion control methods have some common characteristics which are congestion detection, congestion notification and traffic rate adjustment. Among the various congestion methods discussed in section II some of them uses buffer occupancy (queue overflow, queue length) to detect the congestion. And some of them uses traffic rate adjustment technique to control the congestion. Table I present the comparisons of the congestion control methods discussed in section II with the help of these parameters (buffer occupancy, traffic rate adjustment).

Author	Method	Buffer occupancy to detect the congestion	Traffic rate adjustment to control the congestion	Throughput
Chongmyung Park et al. [1]	TARP	No	No	More
Fengyuan Ren et al. [2]	TADR	Yes	No	More
Swastik Brahma et al. [3]	Decoupling congestion control and fairness	No	Yes	Less
Charalambos Sergiou et al. [4]	HTAP	Yes	No	More
Mehmet Vuran and Ian F.Akyildiz. [5]	Local Cross Layer Congestion Control	Yes	Yes	Less
Prabakaran.N et al. [6]	Rate optimization scheme	Yes	Yes	Less
Sun Yi et al. [7]	CCBT	No	Yes	Less
Runze Wan et al. [8]	ACCS	No	Yes	Less
Shanmugaraja.B et al. [9]	Queue reloading scheme	Yes	No	More
Muhammad Omer Farooq et al. [10]	Differentiated services based congestion control	Yes	Yes	Less

Table I: Comparison of Congestion Methods Parameters

The following figure shows an analysis report of various congestion control methods discussed in section II.

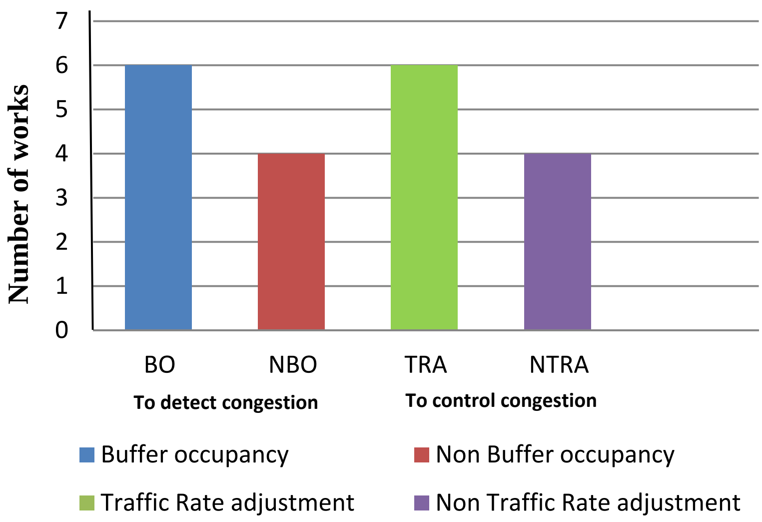

Fig. 1. Methods used by authors to detect and control congestion

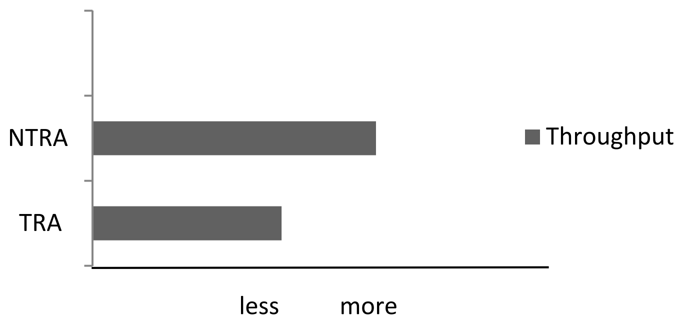

Fig. 2. Throughput

IV. Conclusion

In this paper various congestion control methods discussed in section II have been studied. And comparisons of those methods were presented in the table1. Finally paper observed that when a congestion control methods uses traffic rate adjustment technique to control the congestion then it produces less throughput when compared to the methods that doesn't uses the traffic rate adjustment technique to control the congestion. Instead of reducing traffic rate to control the congestion, distribution of data traffic through the neighbor nodes or under loaded nodes can achieve good throughput. Hence this paper concludes that traffic rate adjustment not sufficient to increase throughput.

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