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A Study on Mitigating and Controlling Congestion using various protocols in Wireless Sensor Network

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Abstract— Wireless sensor networks comprises of numerous autonomous sensors which communicate each other through wireless links. Applications in wireless sensor network include medical applications, building automation, industrial application, home control .Several routing protocols are used in several applications. The major challenge in wireless sensor network is congestion. This paper surveys different routing protocols used in wireless sensor networks to mitigate and control congestion and to provide reliability for different applications.

Keywords— Wireless sensor networks, Congestion control, routing protocol, healthcare applications, mitigation.

I. INTRODUCTION

The infrastructure of sensor network contains sensing, computing, and communication elements that gives an administrator the ability to analyse, observe, and react to events and phenomena in a specified environment. There are four basic components in a sensor network which include an assembly of distributed or localized sensors; an interconnecting network; a central point of information clustering; and a set of computing resources. Today's sensors can be described as "smart" inexpensive devices equipped with multiple onboard sensing elements; they are low-cost low-power multifunctional nodes that are logically homed to a central sink node. Wireless sensors are used in various applications. In this paper a few routing protocols which is used in wireless sensor network are surveyed and compared their functionalities separately. The main problem in all the routing protocols is congestion and packet loss. There are mainly two types of congestion control algorithm – source based algorithm and network based algorithm. Source based algorithm is deployed at the host end where transport protocol are responsible for the detection of congestion. Network based algorithm is implemented in the intermediate network devices, especially routers. One of the two main factors that cause congestion are when the packet arrival rate is greater than the packet service rate, congestion occurs in the nodes closer to sink. The other factor is performance at the link level which includes collision and bit error which occurs at sink. The factors used to detect the congestion are the queue length, packet service time or ratio between service time and time between packets in an intermediate node and channel load.

II. LITERATURE SURVEY

A. Congestion Avoidance and Detection

An energy efficient congestion scheme for wireless sensor network called CODA (Congestion Detection and Avoidance) is used for congestion avoidance and control. It is comprised of three mechanisms (i) receiver-based congestion detection; (ii) open-loop hop-by-hop backpressure; and (iii) closed-loop multi-source regulation. CODA uses a combination of the present and past channel loading conditions, and the current buffer occupancy, to obtain accurate detection of congestion at each receiver with low cost. Open loop hop by hop backpressure is performed by broadcasting backpressure messages by a node as long as congestion is detected. In closed-loop, multi-source regulation, a source is more likely to contribute to congestion and therefore closed-loop congestion control is triggered. In CODA congestion is detected in many ways likewise buffer occupancy or queue length, channel loading method, report rate measurement method. CODA can be used to improve the performance of data dissemination applications such as directed diffusion by mitigating hotspots, and reducing the energy on sensing applications. Channel loading method gives us accurate information about the surrounding network, how busy the network would be. Reference [1] shows that CODA is capable of responding to a number of congestion scenarios that will be prevalent as the deployment of these networks accelerates. CODA is integrated to support data dissemination schemes.

B. Congestion control and fairness for many-to-one routing in sensor networks

Congestion control and fairness for many-to-one routing method is a distributed and scalable algorithm which eliminates the congestion in a wireless sensor network. It ensures a fair delivery of packets to a central node, or base station. Fairness is achieved when equal number of packets is received from each node. There are many sensors transmitting data to base station in many to one routing fashion. They can be extended from many to one routing to unicast or many to many routing. Sensors closer to the base station experience congestion as a result of theses routing structures, which inevitably cause packets originating from sensors further away from the base station to have a higher

probability of being dropped. The algorithm is designed to work with any MAC protocol in the data-link layer with minor modifications and it exists in the transport layer of the traditional network stack model. The solution is scalable; each sensor mote requires state proportional to the number of its neighbours. Finally, the method [5] demonstrates the effectiveness of the solution with both simulations and actual implementation in UC Berkeley's sensor motes.

The routing tree structure used to gather data in a sensor network is prone to greater loss of packets originating from motes more hops away from the base station. Such a many- to-one routing topology easily results in congestion around the root of the tree. This method shows that by measuring the effective available bandwidth and obtaining the size of the sub trees we can divide that bandwidth equally amongst all downstream nodes.

C. Queue based Congestion Control Protocol with Priority Support.

A new Queue based Congestion Control Protocol with Priority Support (QCCP-PS), uses the queue length as an indication of congestion degree. A new application made possible by the rapid improvements and miniaturization in hardware has motivated recent developments in Wireless Multimedia Sensor Networks (WMSNs). Multimedia applications produce high volumes of data flow which require high transmission rates. As multimedia traffic is usually of high speed it may cause congestion in the sensor nodes, leading to poor quality of service (QoS). Congestion control is an important feature of the transport layer in WMSNs. To meet the QoS requirements of multimedia applications a reliable and fair transport protocol is mandatory. The rate assignment to each traffic source is based on its priority index as well as its current congestion degree. The key feature which makes it an efficient congestion control protocol for multimedia traffic in WMSNs is that it has a good achieved priority close to the ideal and near-zero packet loss probability. The scarce energy is wasted by congestion due to a large number of retransmissions and packet drops. It can be avoided with the help of the [3] proposed QCCP-PS protocol which can save energy at each node, by reducing the number of retransmissions and packet losses.

D. ECODA: enhanced congestion detection and avoidance for multiple class of traffic in sensor networks

A novel energy efficient congestion control scheme for sensor networks, called ECODA (Enhanced congestion detection and avoidance) comprises of three mechanisms: 1) Use dual buffer thresholds and weighted buffer difference for congestion detection; 2) Flexible Queue Scheduler for packets scheduling; 3) A bottleneck-node-based source sending rate control scheme. ECODA achieves efficient congestion control and flexible weighted fairness for different class of traffic. Therefore higher energy efficiency and better QoS in terms of throughput, fairness, and delay is achieved by ECODA. In ECODA, we incorporate the following key ideas:

1) ECODA adopts a technique to measure congestion, which uses dual buffer thresholds and weighted buffer difference for congestion detection. The method is different from traditional single buffer threshold method; it could differentiate congestion level and dealt with them correspondingly.

2) The flexible queue scheduler can dynamically select the next packet to send. Moreover, it adopts a novel method to filter packets according to channel loading and packets priority when congestion happens.

3) Transient congestion and persistent congestion are differentiated and are dealt differently. For transient congestion, hop-by-hop implicit backpressure manner is used. For persistent congestion, bottleneck node based source sending rate control and multi-path loading balancing are [2] proposed. Unlike, this method does not need explicit ACK from sink. Using the method, bottleneck nodes can be identified and source sending rate can be dynamically adjusted more accurately.

E. ESRT: event-to- sink reliable transport in wireless sensor networks

Wireless sensor networks are event based systems that relies on the effects of numerous sensor. The event-to-sink reliable transport (ESRT) protocol is a new reliable transport scheme for WSN to detect the events. It is a new transport solution .It detects the event in WSN with minimum energy expenditure. Congestion control component of ESRT serves the dual purpose of conserving energy and achieving reliability. The most importantly, the algorithm of ESRT mainly runs on the sink. It makes use of minimum functionality required at resource constrained sensor nodes. The current network state [4] determines the ESRT protocol operations based on the reliability achieved and congestion condition in the network. ESRT detects the congestion based on the local buffer level monitoring. ESRT adjusts the reporting frequency of source nodes aggressively if the event-to-sink reliability is lower than required, in order to reach the target reliability level as soon as possible. ESRT reduces the reporting frequency conservatively if the reliability is higher than required, in order to conserve energy while still maintaining reliability. This nature of self-configuring makes the ESRT robust to dynamic, random topology in WSN.

F. Mitigating congestion in wireless sensor network

A congestion control scheme called *Fusion* integrates three mechanisms – hop by hop flow control, rate limiting and prioritizing MAC. The combination of the three techniques is called Fusion, which can improve network efficiency by a factor of three under realistic workloads. Reference [7] presents an experimental evaluation of three complementary congestion control strategies for wireless sensor networks. It shows that unless a sensor network operating under load has some means of controlling congestion, it will face significant degradation in efficiency and fairness. As network load increases, or when channel variations cause fluctuations in achievable bandwidth, nodes must modulate their send rates based on local congestion feedback or the network will go into congestion collapse. It evaluates three techniques for mitigating congestion both in isolation and in concert. The results show that hop-by-hop flow control with a simple queue

occupancy-based congestion detection method offers substantial efficiency improvements for all types of workloads and utilization levels. This finding holds because a successful wireless transmission requires both the sender and receiver to be contention-free with respect to both the wireless channel and queue space. Finally, MAC enhancements support the operation of hop-by-hop flow control.

G. HOCA: Healthcare Aware Optimized Congestion Avoidance and control protocol.

The major challenge in wireless sensor network is to mitigate congestion. HOCA is a protocol used in healthcare application. In healthcare application most of the data send across the network are sensitive. Due to congestion, loss of data may occur and it may cause the death of the patient. HOCA helps in mitigating and controlling the congestion for healthcare application. HOCA considers two type of traffic a sensitive traffic and a non-sensitive traffic. HOCA make use of multipath routing to avoid congestion. It contains four phases, the first phase is request dissemination phase, second phase is event report phase, the third phase is route establishment phase and the final phase is data forwarding phase. The data is transmission is done the four phases. HOCA [8] considers two types of routing table a low priority routing table and a high priority routing table, the sensitive data is stored in high priority routing table and non-sensitive data is stored in low priority routing table. When an sensitive data has to be transmitted it uses the high priority routing table to transfer the sensitive data, thus avoiding congestion and data packet loss. Thus congestion is mitigated and controlled in healthcare application using multipath routing and HOCA protocol.

III. COMPARISON STUDY

A comparative study is done based on the different methods used by different routing protocols. The different functionalities, advantages and disadvantages of the above mentioned protocols are compared .

TABLE I
COMPARISON OF CONGESTION CONTROL PROTOCOL

Title	**Methodology**	**Advantage**	**Disadvantage**
CODA	1.Receiver-based congestion detection 2. Open-loop hop-by-hop backpressure; 3. Closed-loop multi-source regulation.	1.Energy efficient 2.Congestion control 3.mitigating hotspots 4.reducing the energy tax with low fidelity	Not reliable
ECODA	1) Use dual buffer thresholds and weighted buffer difference for congestion detection; 2) Flexible Queue Scheduler for packets Scheduling 3) A bottleneck-node-based source sending rate control scheme.	1.energy efficient, 2.reduced delay 3. better QoS 4.better throughput and fairness	Lack of packet recovery
CCF	1. A distributed and scalable algorithm that eliminates congestion within a sensor network	1. Distributed and scalable algorithm 2. Do not require the need for additional control packets. 3.Reliable	1.Low throughput 2. Low utilization
Mitigating congestion in wireless sensor network.	1.hop-by-hop low control 2. rate limiting source traffic when transit traffic is present . 3. a prioritized medium access control (MAC) protocol. 4.Fusion	1. improve network efficiency 2.reduced delay 3.low loss rate	1.Causes interference between disjoint set of nodes 2.Application of these technique is difficult in wireless domain
QCCP	1.Queue based Congestion Control Protocol with Priority Support (QCCP-PS) 2.Rate assignment (based on	1. reliable and fair transport protocol 2.low packet loss 3. efficient	It does not have any mechanism for handling prioritized data

	priority index & congestion degree)	congestion control	
ESRT	1. reliable transport scheme for WSN, the event-to-sink reliable transport (ESRT) protocol 2. achieve and maintain operation in state OOR((Optimal Operating Region)	1.Event- to-Sink Reliability 2.Congestion Control 3.Energy Conservation 4. reliability 5. self-configuring nature 6. Biased Implementation	All sensor nodes are controlled at once ,treating all regions in the same way
HOCA	Mitigating and controlling congestion using multipath routing and HOCA protocol	Avoids congestion , make use of two routing table, for sensitive and non-sensitive data.	Congestion is not avoided for non-sensitive data

IV. CONCLUSION

This paper surveys different wireless sensor routing protocols for congestion control, reliability and packet loss. Both the factors of congestion control and reliability helps in reducing packet loss, which results in an energy efficient operation of the network, which is a key factor in increasing the lifetime of the sensor network. Another factor to be taken into account by the transport protocols is the limited resources of the node devices. Although these congestion control techniques are promising there are still many challenges to solve in wireless sensor network to handle congestion control efficiently. And more research efforts are needed to continue to improve congestion control in WSNs.

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