Various Techniques Use In Wireless Sensor Network For Congestion Control

Prof. Sachin Patel
M.Tech(IT),Ph.D Pursuing
HOD(Information Technology)
PCST,Indore

Prof. Rakesh Pandit
M.Tech(IT),M.Phil(Comp.Sc.)
Assistant Professor
PCST,Indore.

Mr. Abhijeet Rathod
M.Tech (Final Year, I T)
PCST,Indore
RGPV University

Abstract

In WSN, usually tens or thousands of sensor nodes are deployed, scattered way in an area with one or more sinks. Moreover, for achieving reliability and load balancing, several multipath routing protocols have been proposed. But the limitation of these protocols is traffic overhead. Thus the occurrence of congestion in this situation is more likely.[3] The situation becomes worse when congestion occurs in multiple paths. In order to achieve the desired rate of heterogeneous traffic by the sink the congestion control over multiple paths is indispensable.

In this paper we focus on Congestion detection, congestion notification and congestion mitigation through rate control to avoid congestion in a network and we also propose an efficient scheme to perform multipath congestion control for heterogeneous traffic which avoids packet loss and thus enhances the probability of achieving the desired throughput of heterogeneous traffic. Our congestion detection mechanism is chosen based on packet service ratio and congestion notification is implicit. As many reasearchers in wireless sensor network worked on the problem of congestion and propose a technique such as priority based congestion control protocol, congestion detection and avoidance in sensor netwroks.

Keywords: - *Congestion Control, Rate control Network Performance,*

I. INTRODUCTION

Wireless Sensor Network consists of one or more sinks large number of sensor nodes scattered in an area. The downstream traffic from the sink to the sensor nodes usually is a one-to-many multicast. The upstream traffic from sensor nodes to the sink is a many-to-one communication. Due to the focused nature of upstream traffic, congestion more probably appears in the upstream direction. Congestion control is achieved by distributing the network bandwidth across multiple end-to-end connections.

Network congestion happens when offered traffic load exceeds available capacity at any point in a network. In wireless sensor networks, congestion causes overall channel quality to degrade and loss rates to rise, result in buffer drops and increased delays as in wired networks, and tends to be grossly unfair toward nodes whose information needs to traverse a larger number of radio hops.

Two types of congestion could occur in WSNs they are node-level congestion and link-level congestion. The node-level congestion that is common in conventional networks. It is caused by buffer overflow in the node and can result in packet loss, and enhanced queuing delay [4]. Two general approaches to control congestion they are network resource management and traffic control. Network resource management tries to extend network resource to mitigate congestion when it occurs. In wireless network, power control and multiple radio interfaces can be used to increase bandwidth and weaken congestion. In this approach, it is necessary to guarantee precise and exact network resource adjustment in order to avoid over provided resource or under-provided resource.

There are two general methods for traffic control in WSNs:

a. ***The hop-by-hop congestion control:*** The hop-by-hop congestion control has faster response. It is usually difficult to adjust the packet-forwarding rate at intermediate nodes mainly because packet forwarding rate is dependent on MAC protocol and could be variable.
b. ***The end-to-end control:*** The end-to-end control can impose exact rate adjustment at each source node and simplify the design at intermediate nodes, it results in slow response and relies highly on the round-trip time (RTT)

Prior work in the sensor networks literature has checked out at two qualitatively different problems: *congestion mitigation*, and *congestion control*. Broadly speaking, mitigation tries to solve the following problem.

Consider a sensor network in which each sensor is tasked to periodically transmit samples at some fixed rate. When the aggregate sensor traffic exceeds network capacity, how should nodes *regulate* their transmissions such that the network good put and fairness *degrade* gracefully rather than exhibit congestion collapse at a point close to network capacity? This is qualitatively different from congestion control, which seeks to *find* an optimal fair rate allocation to sensor nodes that is also maximally *efficient* so that, when nodes send at this rate, the network is fully utilized, and per node throughput is close to the sending rate.

Network congestion, which is quite common in wireless networks, occurs when offered load exceeds available capacity or the link bandwidth is reduced due to fading channels. Network congestion causes channel quality to degrade and loss rates rise. It leads to packets drops at the buffers, increased delays, wasted energy, and requires retransmissions. Moreover, traffic flow will be unfair for nodes whose data has to traverse a significant number of hops. This considerably reduces the performance and lifetime of the network. Additionally, wireless sensor networks (WSN) have constraints imposed on energy, memory and information measures.

Therefore, energy efficient data transmission protocols are required to mitigate congestion resulting from fading channels and excess load. In particular, a congestion control mechanism is needed in order to balance the load, to prevent packet drops, and to avoid network deadlock.

Sources and Causes of Congestion

A Wireless Sensor Network consists of tens or thousands of sensor nodes scattered in an area with one or more sinks. As the data traffic generated by such nodes grows, the offered load exceeds available capacity and the network becomes congested. The main sources of congestion include buffer overflow, channel contention, interference, packet collisions and many-to-one nature. Buffer overflow occurs when the number of incoming packets is greater than the available buffer space. Contention occurs between different flows and different packets of a flow. Interference is caused by simultaneous transmissions along multiple paths within physical proximity of each other [5]. Packet collisions indicate lower level congestion and leads to packet drops. The many-to-one nature of event communication between multiple sources and sink causes bottleneck around sink. Therefore network congestion causes channel quality to degrade, loss rate raises and leads to packet drops at buffers, increased delays and requires retransmissions. Congestion is detrimental to sensor networks because it lowers the throughput called fidelity. It also causes waste of communication resources, waste of energy, and hampers event detection reliability at the sink.

II. TECHNIQUES FOR CONGESTION CONTROL

Congestion control is a method used for monitoring the process of regulating the total amount of data entering the network to keep traffic levels at an acceptable value. It concerns controlling traffic entry into a network, so as to avoid congestive collapse by attempting to avoid over subscription of any of the processing or link capabilities of the intermediate nodes and networks and taking resource reducing steps, such as reducing the rate of sending packets. Congestion control has to consider network capacity and application requirements. A number of schemes were proposed to address these challenges:

A. Local Cross Layer Congestion Control

This method is based on buffer occupancy. Input to buffer is of two types: a) Generated packets and b) Relay packets. A sensor node has 2 duties.

a) Source duty.
b) Router duty.

During source duty, the sensing unit of the node senses the event and generates packets to be transmitted. A node as a part of router duty receives packets from its neighbors to be forwarded to sink [7]. It has two measures:

a) It explicitly controls the rate of generated packets in source duty.
b) It regulates the congestion in router duty based on current load on node.

B. ***Adaptive Duty Cycle based Congestion Control***

Adaptive Duty Cycle based Congestion Control (ADCC) is energy efficient and lightweight congestion control scheme, with duty cycle adjustment for wireless sensor networks. It uses combined mechanism of resource control scheme and traffic control scheme. ADCC periodically calculates the required service time using incoming packet information of child nodes and infers there is congestion or not based on calculated service time. If the congestion degree is below a certain threshold, this scheme adjusts its own duty cycle to reduce congestion. On the other hand if the congestion degree is above threshold, it notifies child nodes of congestion so that transmission rates of child nodes can be adjusted.

C. ***Receiver Assisted Congestion Control***

In Receiver Assisted Congestion Control (RACC) method sender performs loss based control and receiver performs delay based control. Receiver maintains 2 timers, one for recording the packet inter arrival time and other for measuring RTT. Sender uses this information from receiver to adjust the congestion window. The receiver can estimate the rate the sender should adapt to make best use of measured bandwidth based on packet inter arrival timer. The RTT timer at receiver times the arrival of the next packet and detect packet drop if timeout occurs. Since receiver detects packet drop earlier than sender, it can send ACK to inform sender thereby reducing the waiting time of sender to retransmit a lost packet.

D. ***Congestion Avoidance and Fairness (CAF).***

CAF is a congestion avoidance algorithm which uses the topology information to control congestion [2]. It detects congestion based on the buffer occupancy. In CAF every node calculates its *Characteristic Ratio (CR),* which is defined as the ratio of the number of downstream nodes to the number of upstream node. If the CR value is less than one that means there are more upstream nodes than downstream nodes. It uses this information to adjust the rate of its upstream nodes by sending the congestion notification.

E. ***Light Weight Buffer Management (LWBM).***

LWBM strives to avoid explicit rate signaling between the sensors. In LWBM, every node piggybacks it buffer status to the neighbor nodes. This way, the buffer status of all the nodes is propagated to their neighbor. A node will send data only when the buffer of the receiver node is not full. This way, it adapts the forwarding rate of sensor nodes to near-optimal without causing congestion. It gives how to implement buffer based congestion in different MAC schemes particularly in CSMA with implicit ACK.

III. DESIGN GUIDELINES FOR CONGESTION CONTROL IN WIRELESS SENSOR NETWORK

An effective congestion control scheme contains three major functions: *Congestion Detection, Congestion Notification* and *Rate Adjustment.*

A. ***Congestion Detection*:**

In order to control congestion, first we have to find the place which is congested. In traditional networks congestion is detected using end-to-end timeout mechanism or by redundant acknowledgement. In WSNs, to detect the congestion more proactive mechanism like buffer occupancy, channel load and packet service time can be used.

B. **Congestion *Notification*:**

Once congestion has been detected the sensor node has to propagate that information to the sink or to the upstream neighbor of the node. The information can be a single bit or it can be rich information like allowable data rate and congestion degree etc. Another issue is how to send the congestion notification. There are two ways of doing this:

1. Internal congestion notification
2. External congestion notification.

In internal congestion notification, congestion information is piggybacked in the packet header so no need to send a separate control packet. In external congestion notification a separate control packet is sent to notify the source.

C. ***Rate Adjustment* :**

After receiving congestion notification, source will adjust its sending rate. The new sending rate depends on the type of information provided in congestion notification. For example if single CN bit is set, AIMD (Additive Increase Multiple decrease) scheme or its variant can be used or if more information is provided the source can adjust its rate to some exact value.

Massive and random placement of sensor nodes on a monitored field renders node communication a difficult task to be achieved. Interference, congestion, and routing problems are possible to arise at any point in such networks. Routing challenges in WSNs stem from the unique characteristics of these networks, such as limited energy supply, limited computing power, and limited bandwidth on the wireless links, which impose severe restrictions on the design of efficient routing protocols. A number of routing challenges and design issues like, among others, node placement and energy consumption, can affect routing process in WSNs.

Thus, topology control, in conjunction with routing challenges, becomes an important issue that has to be carefully considered in order to achieve proper network operation. Generally, congestion control algorithms in WSNs employ two methods in order to control and avoid congestion. The first method is called traffic control and the second resource control. Algorithms that employ the traffic control method, adjust the rate with which sources inject traffic to the network in order to control congestion. On the other hand, resource control algorithms employ redundant nodes, which are not in the initial path from source to sink, in the process of forwarding data. Thus, algorithms that employ this method do not control the data rate of the sources but the paths though which the data flows Different node placements create a

variable number of paths which are important for the proper operation of these algorithms.
Placement of nodes in Wireless Sensor Network (WSNs) is often massive and random. Permitting all nodes to transmit concurrently without any control will result in high interference, high energy consumption, and reduced network lifetime. Topology control algorithms focus in lowering the initial network topology, by reducing active nodes and links, thus saving resources and increasing network lifetime. Employing tree structures as topology control algorithms in WSNs has been widely adopted, since it is an efficient and robust solution. The overwhelming majority of algorithms in WSNs construct shared, core-based trees, with the sink as a root. On the other hand, trees that initiate from each source, called source-based trees, are avoided, since each source must create its own routing tree, a fact that creates significant overhead to the network.

Conclusion

In this paper we have presented techniques for congestion control which minimizes congestion in the network and various guidelines for congestion control in wireless sensor network. These techniques have made significant effort to tackle the problem of congestion in wireless sensor networks from different aspects and in different situations

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