A Review on Congestion in Wireless Sensor Network

Dr. Preeti Gera[1], Sourabh Banga[2]

[1]*Department of Computer Science & Engineering Savera College of Engineering &Technology Gurgaon, India*

[2]M.Tech Scholar Savera College of Engineering &Technology Gurgaon, India

[1]preetigera@rediffmail.com, [2]Sourabh.banga07@yahoo.com

***Abstract*—There are so many applications areas of Sensor Networks. Data's generated in a network may not all alike, some data's are more important than other data's and they may have different delivery requirements. If congestion occurs in the Wireless Network, some or more important data's may be dropped. Congestion in wireless sensor networks not only causes packet loss, but also leads to excessive energy consumption. Therefore congestion in WSNs needs to be controlled in order to prolong system lifetime, improve fairness, and improve quality of service in terms of throughput and packet loss along with the packet delay**

Keywords-Wireless Sensor Network, Congestion

I.INTRODUCTION

Wireless sensor networking is an emerging technology that has a wide range of potential applications including environment monitoring, smart spaces, medical systems and robotic exploration. Such networks consist a large numbers of distributed nodes that organize themselves into a multihop wireless network.

Each node has one or more sensors, embedded processors, and low-power radios, and is normally battery operated. Typically, these nodes coordinate to perform a common task [1].A Wireless Sensor Network consists of group of nodes called sensor network. These nodes operate together in the area being monitored and collect physical attributes of the surrounding, say temperature or humidity.Data gathered by these sensor nodes can be utilized by various top level applications such as habitat monitoring, surveillance systems and systems monitoring various natural phenomenons.

These sensor nodes are often battery-powered and equipped with an on-board processor carrying out simple computation. Therefore the sensor nodes can only send out the required data to the data gathering sink. Because of the limited power supply on sensor nodes, energy consumption is often an important design consideration.

The phenomenon of congestion can be observed in different types of wired and wireless networks even in the presence of robust routing algorithms. Congestion in wireless sensor networks (WSN) mainly occurs because of two reasons -- when multiple nodes want to transmit data through the same channel at a time or when the routing node fails to forward the received data to the the next routing nodes because of the out-of-sight problem.

II.CONGESTION IN WIRELESS SENSOR NETWORKS

Congestion control is another important issue that should be considered in transport protocols. Congestion is an essential problem in wireless sensor networks. Congestion in WSNs and WMSNs that can leads to packet losses and increased transmission latency has a direct impact on energy efficiency and application QoS, and therefore must be efficiently controlled [2] [3]. Congestion not only wastes the scarce energy due to a large number of retransmissions and packet drops, but also hampers the event detection reliability [4]. Congestion may lead to indiscriminate dropping of data (i.e., high-priority (HP) packets may be dropped while low-priority (LP) packets are delivered). It also results in an increase in energy consumption to route packets that will be dropped downstream as links become saturated. As nodes along optimal routes are depleted of energy, only non optimal routes remain, further compounding the problem. To ensure that data with higher priority is received in the presence of congestion due to LP packets, differentiated service must be provided [3]. Two types of congestion could occur in sensor networks. The first type is node-level congestion that is caused by buffer overflow in the node and can result in packet loss, and increased queuing delay. Packet loss in turn can lead to retransmission and therefore consumes additional energy. Not only can packet loss degrade reliability and application QoS, but it can also waste the limited node energy and degrade link utilization. In each sensor node, when the packet arrival rate exceeds the packet-service rate, buffer overflow may occur. This is more likely to occur at sensor nodes close to the sink, as they usually carry more combined upstream traffic. The second type is link-level congestion that is related to the wireless channels which are shared by several nodes using protocols, such as CSMA/CD (carrier sense, multiple access with collision detection). In this case, collisions could occur when multiple active sensor nodes try to seize the channel at the same time [3]. Link level congestion increases packet service time, and decreases both link utilization and overall throughput and wastes energy at the sensor nodes. Both node level and link level congestions have direct impact on energy efficiency and QoS [4] [2].

III. CONGESTION CONTROL IN WIRELESS SENSOR NETWORKS

Congestion happens mainly in the sensors-to-sink direction when packets are transported in a many-to-one manner. Therefore, most of the proposed congestion control mechanisms are designed to lighten congestion in this direction [5]. In [6], the authors propose Congestion Detection and Avoidance (CODA). CODA uses severalmechanisms to alleviate congestion. In open-loop hop-by-hop backpressure, when a node experiences congestion, it broadcasts back-pressure messages upstream towards the source nodes, informing the mof the need to reduce their sending rates. In closed-loop multi-source regulation, the sink asserts congestion control over multiple sources. Acknowledgement (ACKs) is required by the sources to determine their sending rates when traffic load exceeds the channel capacity. In general, open-loop control is more appropriate for transient congestion, while, closed loop control is better for persistent congestion. In [7], the authors propose the event-to-sink reliable transport protocol. ESRT allocates transmission rates to sensors such that an application-defined number of sensor readings are received at the sink, while ensuring the network is uncongested. The rate allocation is centrally computed at the base station. ESRT monitors the local buffer level of sensor nodes and sets a congestion notification bit in the packets it forwards to the sink if the buffer overflows. If a sink receives a packet with the congestion notification bit set, it infers congestion and broadcasts a control signal informing all sources to reduce their common reporting frequency. However, this approach suffers from a few drawbacks. Firstly, since the sink must broadcast this control signal at a high energy to allow all the sources to hear it, an on-going event transmission can be disrupted by this high powered congestion signal. Moreover, rate regulating all sources as proposed in [7], is fine for homogeneous applications, where all sensors in the network have the same reporting rate but not for heterogeneous ones. Even with a network where all the sources have a uniform reporting rate, ESRT always regulates all sources regardless of where the hotspot occurs in the sensor network. The control law used by ESRT is based on empirically derived regions of operation, and does not attempt to find a fair and efficient rate allocation for the nodes. Fusion [9] is a congestion mitigation technique that uses queue lengths to detect congestion. Fusion uses three different techniques to alleviate congestion, viz, hop-by-hop flow control, rate limiting, and a prioritized MAC. Hop-by-hop flow control prevents nodes from transmitting if their packets are only destined to be dropped downstream due to insufficient buffer spaces. Rate limiting meters traffic being admitted into the network to prevent unfairness towards sources far away from the sink. A prioritized MAC ensures that congested nodes receive prioritized access to the channel, allowing output queues to drain. Fusion focuses on congestion mitigation and does not seek to find an optimal transmission rate for the nodes that is both fair and efficient. In [10], the authors proposed the Interference Aware Fair Rate Control protocol (IFRC). IFRC is a distributed rate allocation scheme that uses queue sizes to detect congestion, and further shares the congestion

state through overhearing. Congestion Control and Fairness for Many-to-one Routing in Sensor Networks [11] is another rate allocation scheme that uses a different mechanism than IFRC. Both IFRC and [11] are attempt to find optimal transmission rates for all nodes, such that, congestion collapse is avoided. Note that, our algorithm has greater flexibility than IFRC and [11], since many different traffic allocation policies can be implemented in our congestion control scheme, without changing the basic congestion control module (the utility controller). IFRC suffers from the additional drawback of having sophisticated parameter tuning for stability, unlike ours. In [12], the authors propose the Rate Controlled Reliable Transport protocol (RCRT). This protocol is built for loss-intolerant applications that require reliable transport of data from the source nodes to the sink. RCRT uses end-to-end explicit loss recovery by implementing a NACK based scheme. RCRT places all congestion detection and rate adaptation functionality in the sinks, thereby producing a centralized congestion control scheme. The authors in [13] proposes a congestion control mechanism, in which, the buffer in each node is adjusted according to the transmitting downstream nodes in order to minimize packet drop; the algorithm automatically adjusts a node's forwarding rate to avoid packet drops due to congestion. The algorithm resolves the fairness problem by allocating equal bandwidth to the sources. The

authors in [14] propose a rate-based fairness-aware congestion control (FACC) protocol, which controls congestion and achieves approximately fair bandwidth allocation for different flows. Their congestion control is based on probabilistic dropping based on queue occupancy and hit frequency. In [10], the authors propose a hop by hop predictive congestion control scheme for WSNs. Their algorithm detects the onset of congestion using queue utilization and a channel estimator algorithm that predicts the channel quality. Flow control is then achieved by a back off interval selection scheme. The authors in [15] propose a cross-layer optimization scheme for congestion control in multi-hop wireless networks. They implement a differential backlog based MAC scheduling and router-assisted backpressure congestion control scheme using real off-shelf radios. In the authors focus on fair bandwidth sharing between endto-end flows, while maintaining an efficient overall throughput in the network. They propose a dynamic rate allocation solution that is based on a simple radio sharing model. In the next section, we will formulate our problem and also discuss the rationale behind our solution approach. Various congestion control methods have been studied for wireless sensor networks. Among them, most popular techniques are CCF, PCCP and DCCP.

CCF exactly adjusts traffic rate based on packer service time along with fair packet scheduling algorithms, while Fusion in performs stop-and-start non-smooth rate adjustment to mitigate congestion. CCF was proposed in as a distributed and scalable algorithm that eliminates congestion within a sensor network and ensures the fair delivery of packets to a sink node. CCF exists in the transport layer and is designed to work with any MAC protocol in the data-link layer. In the CCF algorithm, each node measures the average rate r at which packets can be sent from the node, divide the rate r among the number of children nodes, adjust the rate if queues are overflowing or about to overflow and propagate the rate downstream. CCF uses packet service time to deduce the available service rate. Congestion information is implicitly reported. It controls congestion in a hop-by-hop manner and each node uses exact rate adjustment based on its available service rate and child node number. It can be shown that CCF guarantees simple fairness. CCF has two major problems. The rate adjustment in CCF relies only on packet service time which could lead to low utilization when some sensor nodes do not have enough traffic or there is a significant packet error rate. Furthermore, it cannot effectively allocate the remaining capacity and as it uses work-conservation scheduling algorithm, it has a low throughput in the case that some nodes do not have any packet to send [4] [3].

PCCP is designed with such motivations: 1) In WSNs, sensor nodes might have different priority due to their function or location. Therefore congestion control protocols need guarantee weighted fairness so that the sink can get different, but in a weighted fair way, throughput from sensor nodes. 2) Congestion control protocols need to improve energy-efficient and support traditional QoS in terms of packet delivery latency, throughput and packet loss ratio. PCCP tries to avoid/reduce packet loss while guaranteeing weighted fairness and supporting multipath routing with lower control overhead. PCCP consists of three components: intelligent congestion detection (ICD), implicit congestion notification (ICN), and priority-based rate adjustment (PRA). PCCP uses implicit congestion notification to avoid transmission of additional control messages and therefore help improve energy-efficiency. In ICN, congestion information is piggybacked in the header of data packets. Taking advantage of the broadcast nature of wireless channel, child nodes can capture such information when packets are forwarded by their parent nodes towards the sink. PCCP designs a novel priority-base rate adjustment algorithm (PRA) employed in each sensor node in order to guarantee both flexible fairness and throughput, where each sensor node is given a priority index. PRA is designed to guarantee that: (1) The node with higher priority index gets more bandwidth; (2) The nodes with the same priority

index get equal bandwidth. (3) A node with sufficient traffic gets more bandwidth than one that generates less traffic. The use of priority index provides PCCP with high flexibility in weighted fairness. For example, if the sink wants to receiver the same number of packets from each sensor node, the same priority index can be set for all nodes. The Datagram Congestion Control Protocol (DCCP) is a message-oriented transport layer protocol. DCCP implements reliable connection setup, teardown, Explicit Congestion Notification (ECN), congestion control, and feature negotiation. DCCP was published as RFC 4340, a proposed standard, by the IETF in March, 2006. RFC 4336 provides an introduction. DCCP provides a way to gain access to congestion control mechanisms without having to implement them at the application layer. It allows for flow-based semantics like in Transmission Control Protocol (TCP), but does not provide reliable in-order delivery. Sequenced delivery within multiple streams as in the Stream Control Transmission Protocol (SCTP) is not available in DCCP. DCCP is useful for applications with timing constraints on the delivery of data. Such applications include streaming media, multiplayer online games and Internet telephony. The primary feature of these applications is that old messages quickly become stale so that getting new messages is preferred to resending lost messages. Currently such applications have often either settled for TCP or used User Datagram Protocol (UDP) and implemented their own congestion control mechanisms, or have no congestion control at all. While being useful for these applications, DCCP can also be positioned as a general congestion control mechanism for UDP-based applications, by adding, as needed, a mechanism for reliable and/or in-order delivery on the top of UDP/DCCP. In this context, DCCP allows the use of different, but generally TCP-friendly congestion control mechanisms [8].

CONCLUSION

In this paper we reviewed congestion in wireless sensor network and different congestion control techniques for the avoidance of congestion in WSN.A lot of work has been done in the area of congestion and its avoidance. But a lot of work can be done for the improvement of the wireless sensor network. So that efficiency can be increased by reducing dropping rate of the packets in an efficient way.

REFERENCES

[1] QingchunRen,Qilian Liang, Texas Univ., “An Energy-Efficient MAC protocol for Wireless Sensor Networks”, Global Telecommunication Conference,2005. GLOBECOM’05. IEEE Arlington, TX, USA, vol. 1, 28 Nov.-2 Dec.2005.

[2] Ian F. Akyildiz ,TommasoMelodia, and Kaushik R. Chowdhury, “A survey on wireless multimedia sensor networks”, Computer Networks, Vol. 51, pp. 921–960, 2007

[3] Mohammad HosseinYaghmaee and Donald Adjeroh, “A New Priority Based Congestion Control Protocol for Wireless Multimedia Sensor Networks”, IEEE 2008.

[4] [Chonggang Wang, KazemSohraby, Victor Lawrence, Bo Li and Yueming Hu, “Priority-based Congestion Control in Wireless Sensor Networks” , Proceedings of the IEEE International Conference on Sensor Networks, Ubiquitous, and Trustworthy Computing, 2006

[5] Pang, Q., Wong, V.W.S. and Leung, V.C.M. ‘Reliable data transport and congestion control in wireless sensor networks’, Int. J. Sensor Networks, Vol. 3, No. 1, pp.16–24.2008.

[6] Qinghua Wang. Traffic Analysis, Modeling and Their Applications in Energy-Constrained Wireless-Sensor Networks-On Network Optimization and Anomaly Detection.Phd, Information Technology and Media Mid Sweden University, Sundsvall, Sweden, 2010.

[7] Zawodniok M, Jagannathan S. Predictive congestion control protocol for wireless sensor networks. IEEE Transactions on Wireless Communications 2007; 6: 3955-3963.

[8] Swastik Brahma, MainakChatterjee, Kevin Kwiat, Pramod K. Varshney. Traffic management in wireless sensor networks: Decoupling congestion control and fairness. Computer Communications 2012; 35: 670-681.

[9] Wikipedia, The free encyclopedia en. Backpressure Routing.http://en.wikipedia.org/wiki/Backpressure_routing.

[10] Yin X, Zhou X, Huang R, Fang Y, Li S. A fairness – aware congestion control scheme in wireless sensor networks. IEEE Transactions on Vehicular Technology 2009; 58: 5225-5234.

[11] Akyıldız IF, Su W, Sankarasubramaniam Y, Çayırcı E. Wireless Sensor Networks: Survey. Computer Networks 2002; 38: 393-422.

[12] HarjotBawa, Parminder Singh, Rakesh Kumar," An Efficient Novel Key Management Scheme for Enhancing User Authentication in A WSN", IJCNIS, vol. 5, no. 1, pp. 56-64, 2013.

[13] Mattsson N. A DCCP module for ns-2.MSc, Luleå University of Technology, Luleå, Sweden, 2004.

[14] Zawodniok M, Jagannathan S. Predictive congestion control protocol for wireless sensor networks. IEEE Transactions on Wireless Communications 2007; 6: 3955-3963.

[15] OzlemDurmazInce. A survey on multi-channel communication in wireless sensor networks. Computer Networks 2011; 55: 3081-3099.

SP