Traffic Control Based Comparative Study Of Congestion Control Protocols In Wireless Sensor Network

Mr. Anshul Jain
Assistant Professor
Amity University Madhya Pradesh

Mrs. Komal Jain
Research Scholar
Komal_jain2004@yahoo.com

Abstract-Today as the increasing demand of the wireless sensor network (WSN) because of their wide application areas, the congestion arise as main challenge to us. Because of the congestion the power loss, time delay, packet loss and energy waste increases abruptly that decreases the network performance. Limitation of WSN also involved life time of the network, the throughput, fairness and network efficiency. Many efforts keep going on from many years to mitigate or avoid the congestion. In this paper, we analyze, compare and presenting a view which classify the congestion control protocol on the basis of traffic control method.

Index Term---Wireless sensor network; congestion; traffic control; resource control; congestion control; congestion detection ; congestion mitigation.

I. INTRODUCTION

Wireless sensor network is a large network that consist of the devices which interfacing using the sensors. Each node of sensor act autonomously and having the capability to

sense the different physical and environmental condition. So, WSN are mainly used in sensing or monitoring the condition that are temperature, sound, motion, pollutants etc at various locations [1].Sensor nodes is small in size, light in weight and portable to carry. A wireless sensor device is operated on battery and used to sense physical events .It is also capable in data storage wireless communication and little computation. After sensing the environment by a sensor, event sends the sensing data in the form of packets of data from the source to the sink [3]. WSN collects the data from all sensor devices using one or more sinks. Through these sinks, the WSN are link with the outside world.

Due to the capabilities and the using of a large number of almost practical sensors, instead of deploying a little costly and unpractical sensing module, the application area of the WSN become large and large day by day. The application classification on the basis of data delivery requirement, objectives and traffic characteristics include

.**Data Gathering And Periodic Property**-This type include the gathering of data by the sink periodically.

2. **Sink Initiated Query**-This type includes the gathering of data by sink on query with some set of sensors.

3. **Tracking Based Application**-This type of application include the tracking or movement of an object.

The Structure of remaining paper are as follows. Section II presents the discussion on Congestion problem caused in the WSN. Section III presents the researched solution and their method that help to solve congestion. Section IV

gives comparison among all the described methods. At last, paper end with the conclusion and future work in Section V.

II.CONGESTION AND CONTROL IN WSN

The WSN is a network that comprises a large network of sensor nodes that are spread over the large area. These sensor nodes are autonomous and send their sensing data in the form of the data packet to the base station (or sink).Traffic pattern of these sensor nodes is depending on the sensing data that they sense. According to the event that they sense, a large set of data is generated which are transferred in the form of data packets to the sink. The high generation rate of data becomes uncontrolled to handle and cause congestion in the network. The congestion in WSN can be cause due to the following two basic types

A. Link Collision-When the several active nodes within the range starts sending the data simultaneously to the sink, collision are occur on the link due to the excess number of data packets on the link. This collision is called link collision or link level congestion.

B. Buffer Overflow –When a node is unable to handle the rate at which it receives the packet, it starts to drop the packet. This packet dropping leads to creating routing hole in the network and packet retransmission .This type of congestion is buffer overflow or node level congestion.

Congestion can also occur in the network due to its convergent nature, interface, and channel contention or when unpredictable events occur. This congestion abruptly decreases the performance of the network, that's why, it is necessary to control it .It can be control by avoid it or mitigate it. The congestion avoidance is to try to avoid the congestion and congestion mitigation is to take a reactive action to alleviate it. We review the mitigation protocol in this paper, these all considered a common procedure by different way to control the congestion. This scheme includes

A. Congestion Detection-The Congestion is detected by identifying any of the parameters that are buffer occupancy, channel load, buffer occupancy and channel load and packet service time.

B. Congestion Notification-The congested node can notify their neighbour nodes either by explicit notification or implicit notification.

C. Congestion Mitigation-There are any methods that are suggested to mitigate the congestion in the network after detecting it .But we consider the two effective methods that alleviate the congestion that are

(a) Traffic Control-In this method, sending traffic rate is adjusted to alleviate the congestion. This method is more efficient in the case of transient congestion and where the network is sparsely deployed. On the other hand, it degrades the life time of the network.

(b) Resource Control-In this method, the alternative multiple path is created by using redundant nodes in the network. This method is more efficient than resource control in term of throughput, power consumption and lifetime of the network. It keeps the rate of data packets stable.

(c) Traffic Control And Resource Control-In this method, the advantage of both the traffic control and resource control is taken.

In Section III, ,we discuss the various protocols that employs the traffic control methods to suppress congestion with their advantage and limitation.

III. PROTOCOLS USING TRAFFIC CONTOL

The protocols that follow the traffic control phenomenon are described below:

1. Congestion Detection And Avoidance (CODA)

This method is used for control both persistence and transient congestion. It uses the following three steps:

A. Congestion Detection-It uses the current buffer occupancy and a combination of the past and present channel loading condition, [8].For minimize the listening cost of channel locally it uses sampling channel that activates when only needed it.

B. **Open-loop, hop-by-hop backpressure**-Whenever congestion is detected, a node broadcast a backpressure message propagated in the direction of source. A node throttled the packet or drops the packet to adjust the rate on receiving backpressure message. If the congestion is remaining, then the backpressure message is propagated to the source according to the local congestion condition.

C. Closed loop multi source regulation-The source set the regular bit in each packet to take back the acknowledgement (ACK) from the sink to know about the congestion. If the rate of the packet reception becomes low in the sink, it is the indication of the congestion and the sink stop to send the ACK to the source. If the ACK does not receive by the source, it reduces the rate of the packets.

Due to the use of ACK and explicit notification CODA consume additional energy and bandwidth. The loss of ACK leads to wrong indication to the source about the congestion. It also does not focus on per-source fairness.

2. Enhanced Congestion Detection And Avoidance (ECODA)

This method uses hop-by –hop method for transient congestion and bottleneck node based source data sending rate control for persistent congestion. It follows the three given steps:

A. Use Dual Buffer Threshold And Weighted Buffer Difference for Congestion Detection-In this approach, buffer state is defined as “accept state”, ”filter state” and ”reject state”. Two thresholds are used to border them. In different state, different strategies are adopted to accept or reject packets [9].

B. Flexible Queue Scheduler And Weighted Fairness-In this approach, the unfairness problem is solved by using two types of priority that are static and dynamic priority. The static priority packet defined by an integer and the lowest static priority packet value is 0. When the buffer of any sensor node is full, then the packet in the buffer is dropped that have lower priority. The dynamic priority changes with the number of hop and delay [9].

C. Bottleneck-node-based source sending rate control and multipath loading balancing-This approach include two methods to solve the congestion.

(i) Determining routing path status from a certain node to sink [9].

(ii)Bottleneck node detection and source data sending rate control [9].

In the first method, the status of the path from the node to the sink is determined by taking maximum on compare the data forwarding delay of the parent node and child node which are piggybacked in the header of the packet.

After the receiving of the packet at the source, the piggybacked information is extracted by the source and adjusts its sending rate as the reciprocal of the maximum of the parent data forwarding delay in the second method.

Due to the use of implicit report control scheme, the energy and bandwidth wastage are reduce [3].It is more robust and give better fairness than CODA [8].But the packet with higher priority than others, in the forwarding queue from the same source, have to wait due to round robin cycle [2].

3. Priority based Congestion Control (PCCP)

PCCP is a hop by hop upstream congestion control protocol. It consists of three components [10].

A. Intelligent Congestion Detection (ICD)-In this approach to detect the congestion at the node or link, PCCP uses a parameter i.e. 'congestion degree' which is the ratio of the packet service time and packet inter arrival time.

B. Implicit Congestion Notification (ICN)-In this component, the parent node broadcast the packets towards the sink in order to notify the child about congestion by piggybacked the congestion information in the header of the packet.

C. Priority Based Rate Adjustment-In PCCP, one for source traffic and other for transit traffic between the network layer and MAC layer. It uses the priority based rate algorithm for adjust the schedule rate and source rate. PCCP uses two variables GP (i) i.e. Global Priority Index to update scheduling rate and SP (i) i.e. Traffic Priority Index to find out the source rate of the node i. The traffic rate is adjusted on the basis of:

(a) the node have same traffic priority index get the same source rate.

(b) the node have the greater traffic priority traffic priority index get the higher source rate and higher bandwidth.

PCCP improves the fairness in the network and gives high link utilization. It gives better efficiency due to the low packet drop due to small queue length. The local congestion is control by PCCP by traffic rate adjustment of last hops, but it do not take into account about the congestion occur in the next time interval [12].

4. FUSION

This algorithm uses three techniques to control the congestion. These are:

A. Hop-by-hop flow control-In this technique, each sensor node sets a congestion bit in the header of every outgoing packet gives the notification to all nodes in the neighborhood. Due to this there is no need of the explicit control message, so the bandwidth of the channel is saved. Hop-by-hop control has two components:

(a) Congestion Detection-In this the congestion detection is based on the buffer size .If the buffer size is less than a variable α, the bit in the header of the packet is set, otherwise bit is not set.

(b) Congestion Mitigation-In this, when a child get a packet with bit is set, from its parent node, it stop the forwarding the data until the queue of its parent become not empty.

B. Rate Limiting-This approach is used to limit the sending rate of each node by using bucket scheme. In this scheme, the node finds the total number of children node of its parent and accumulates one token at every overhear of its parent packet forwarding. The node only allowed sending, when its token count is above than zero.

C. Prioritized MAC layer-In this scheme, the CSMA MAC layer is used. The congested node has the higher priority than the congested node. The back off window of congested node becomes one-fourth of the non-congested node to empty the buffer and control the congestion.

FUSION [11] reduces the energy wastage and bandwidth wastage .But fairness does not ensure by FUSION [11] because of the rate limiting factor is not flexible.

5. Upstream Hop-By-Hop Congestion Control (UHCC)

UHCC [12] is based on the cross layer design of network. It detect the congestion at each node by calculate the size of unoccupied size of buffer and transfer rate at MAC Layer [12] and then adjust the rate of traffic at network layer to prevent the node from congestion. So, UHCC consist two components:

A. Congestion Detection-In this, the congestion index i.e. CI_i is calculate by subtracting traffic rate at MAC Layer from unoccupied buffer size. If $CI_i < 0$, then overflow may occur .While $CI_i \geq 0$, then congestion may not occur at node i and can accept the upstream traffic. So, through calculating CI_i , the congestion level of node i can be detected.

B. Rate Adjustment-The congestion index and traffic capacity is piggybacked in the header of the packet to adjust the rate at each node. The traffic rate is adjusted by taking different parameter in consideration such as source traffic priority, total traffic priority, congestion tendency and congestion index.

UHCC [12] adjust the rate at each node by using different parameter at each time interval, that's why UHCC [12] ensure better priority based fairness and throughput and reduces the packet loss ratio than PCCP [10].

IV COMPARISION BETWEEN THE DISCUSSED PROTOCOLS

Protocol/ Mechanism	**Congestion Detection**	**Congestion Notification**	**Fairness**	**Application Type**	**Lost Recovery**	**Compared With**
CODA[8]	Buffer Occupancy And Wireless Channel Load	Explicit	Not Present	Event	No	No Congestion Protocol, Open Loop Control
E-CODA[9]	Dual Buffer Threshold And Weighted Buffer Difference	Implicit	Based On Priority	Periodic	No	CODA
PCCP[10]	Packet Interarrival/Service Time	Implicit	Based On Priority	Event, Continuous	No	CCF
FUSION [11]	Buffer Occupancy And Wireless Channel Load	Implicit	Not Present	Hybrid	No	Alone
UHCC [12]	Buffer Occupancy And Wireless Channel Load	Implicit	Based On Priority	Periodic	No	PCCP,CCF

V. CONCLUSION AND FUTUREWORK

Due to the increases uses of the wireless sensor network, it becomes necessary to remove the problems that can degrade the performance of the WSN. The main problem is congestion in the network. We discuss some protocol with their significance and limitation that try to eliminate the congestion and increase the overall performance of the network. This study could be used to do comparative study different protocols and use it for further enhancement to reduce the congestion. In future, the work could be done on the discussed protocol to minimize their limitations and increase their significances.

REFRENCES

[1] C. Sergiou, P. Antoniou and V. Vassiliou, "A Comprehensive Survey of Congestion Control Protocols in Wireless Sensor Networks" in IEEE COMMUNICATION SURVEYS & TUTORIALS, VOL. 16, NO. 4, FOURTH QUARTER ,pp.1839-1859, 2014

[2] M.A. Kafi,D. Djenouri,J.Ben-Othman and N. Badache " Congestion Control Protocol in Wireless Sensor Networks: A Survey" in IEEE COMMUNICATION SURVEYS & TUTORIALS, VOL. 16, NO. 3, THIRD QUARTER, pp.1369-1390, 2014

[3] Neha Pant, M.P. Singh and Prabhat Kumar , "Traffic and Resource based methods for Congestion Control in Wireless Sensor Networks: A Comparative Analysis" in IEEE, 2014

[4] D.F. Jenolin Flora, V.K. Kavitha And M. Muthuselvi "A Survey Control Techniques in Wireless Sensor Network" in IEEE ,2011,pp. 1146-1149

[5] Yingshu Li, My T. Thai, "Wireless Sensor Networks and Applications," in Springer Science & Business Media, Feb. 2008.

[6] Waltenegus W. Dargie, Christian Poellabauer, "Fundamental of Wireless Sensor Network, Theory And Practice," in Wiley Publication.

[7] Feng Zhao, Leonidas J. Guibas, "Wireless Sensor Networks:An Information Processing Approach," in Morgan Kauffman.

[8] C.Y. Wan, S.B. Eisenman, A. T. Campbell, "CODA: Congestion detection and avoidance in sensor networks", in Proc. ACM SenSys,Nov.2003.

[9] L. Q. Tao and F. Q. Yu, "ECODA: Enhanced Congestion Detection andAvoidance for Multiple Class of Traffic in Sensor Networks", IEEE Transactions on Consumer Electronics, Vol. 56, No. 3, August 2010.

[10] Chonggang Wang1, Kazem Sohraby1, Victor Lawrence2, Bo Li3,Yueming Hu, "Priority-based Congestion Control in Wireless Sensor Networks", The IEEE International Conference on Sensor Networks,Ubiquitous, and Trustworthy Computing (SUTC'06) 0-7695-2553-9/06.

[11] B. Hull, K. Jamieson, and H. Balakrishnan, "Mitigating congestion in wireless sensor networks," in Proc. 2nd Int. Conf. Embedded Netw. Sen-Sys, 2004, pp. 134–147.

[12] C. Wang, B. Li, K. Sohraby, M. Daneshmand, and Y. Hu, "Upstream congestion control in wireless sensor networks through cross-layer optimization,"IEEE J. Sel. Areas Commun., vol. 25, no. 4, pp. 786–795,May 2007.