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An Assessment of Various Types of Congestion Control Techniques in WSN

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ABSTRACT

Wireless Sensor Networks (WSNs) are expected to have a wide range of applications and increase their deployment in the modern decades as they provide a low cost solution for maintenance and installation. WSNs are usually distributed self-governing sensors that are attached to each other for monitoring atmospheric physical conditions. In WSNs there are one or more sink or base stations and many Sensor Nodes (SNs) distributed over wide area. Since, a large number of SNs are engaged in data transmission, the network can be congested. Congestion is one of the critical issues in WSNs since it has direct effects on SNs energy efficiency and device performance. Also, the congestion reduces overall channel capacity and increases the risk of packet loss. In order to handle these problems, effective congestion control techniques are required. This paper presents a survey on different congestion control techniques developed by previous researchers in WSN. Also, the limitations in these techniques are addressed in order to suggest further improvements in the congestion control.

***Keywords*:-** Wireless sensor network, congestion control, congestion control mechanism, energy efficient.

I. INTRODUCTION

Wireless Sensor Network (WSN) is an autonomous sensor for spatially distributed regulation of physical and atmospheric environments such as temperature, humidity, heat and so on. These networks play an important role in various applications, such as defense, infrastructure, educational etc. SN is a node in the sensor network, which are inexpensive, easy to be using, battery powered, self configuration capacity, node failure management and tough environmental conditions. Such nodes collect information by application type and transmit the data to the sink node. When a huge number of sensor nodes are occupied in data transmitting, there is a possibility of congestion occur in the network which subsequently cause packet drop. Usually there are two types of congestion in WSNs, namely link level congestion and node level congestion. Node level congestion occurs at buffer overflow when the packet interval time exceeds the scheduling time, resulting in packet loss; maximize queuing delay and requiring packet re-transmission. Link level congestion can occur when more than a pair of nodes share wireless channels. At this time, the sensor node compute for available channels at the same time, congestion is likely happen. To control the packet drop in the WSN, the congestion control techniques is used. Congestion control is most significant for increasing the QoS performance in terms of link utilization, reduction of packet loss rate and reducing packet transmission delay. Congestion control techniques [1] are broadly classified into two categories such as Open Loop Congestion Control (OLCC) and Closed Loop Congestion Control (CLCC). The OLCC strategy is applied for preventing the congestion before it occurs. The congestion control is managed either by the source or the destination. The CLCC strategy is used for manage or reduce the congestion after it occurs [2]. The main intention of this survey is studying the detailed information of various congestion control techniques in WSN. In addition, their limitations are addressed to further improve the increases the network lifetime and reduce the congestion in the network.

The rest of the article is organized as follows: Section II provides the previous researches related to congestion control techniques. Section III compares the network life and congestion control Section IV concludes the survey that reviews an entire discussion.

II. STUDY ON PRIORITY BASED CONGESTION CONTROL TECHNIQUES IN WNS

Banimelhem & Khasawneh [3] proposed a Grid-based Multipath with Congestion Avoidance Routing protocol (GMCAR) based on the three steps such as grid formation, routing table's creation and data transmission. Initially, the entire network was split into grids for constructing the diagonal routes from each grid to the sink. Then, all available paths were used to construct the routing table and the node's density was used as the decision factor to transmit the data from each grid to the sink.

Sergiou et al. [4] proposed a Hierarchical Tree Alternative Path (HTAP) protocol to control the congestion in WSN by using an alternative path. The protocol transmitted the excess packets to the sink via alternative routes when there was congestion in the network, using nodes that are not in the initial path from the sources to the sink. The successful and efficient functionality of protocol was based on a topology control scheme that created initial network connectivity and a hierarchical tree scheme that discovered all possible upstream routes from the sources to the sinks when an event takes place.

Jan et al. [5] proposed a Priority-based Application Specific Congestion Control Clustering (PASCCC) protocol to combine the heterogeneity of the nodes and mobility to detect the congestion in the network using a queuing model. The protocol detected WSN congestion based on the collected data type and priority. CHS preferred distance-based packets; the farther nodes taken priority over neighbouring nodes. It also ensured effective utilization of the extra resources consumed by farther nodes. Because of their timeliness requirements priority packets were diverted to BS during congestion, and non prioritized packets were lost.

Jayakumari & Senthilkumar [6] proposed a protocol to conserve power and prevent congestion during multicast traffic. This protocol was developed to provide full coverage and connectivity by mobile nodes which were organized dynamically into clusters. Using linear and binary feedback methods, the protocol calculated congestion intra-cluster level and inter-cluster level. Every node in the cluster had a suitable queuing model to schedule the prioritized packet and avoid the congestion without any packet loss.

Yaakob & Khalil [7] proposed a proposed a congestion technique for preventing the data loss during the real-time healthcare data transfer. The main idea was to integrate the existing relaxing theory (RT) rate control system using the Max-Min Fairness (MMF) framework to achieve improved performance. RT-MMF methodology, which minimized transmission over limit levels, led to an overall Wireless Body Sensor Networks (WBSN) efficiency reduction of packet losses.

Ahmed & Paulus [8] proposed a protocol to develop the congestion control and reduction technique in WSN. In this protocol, the path was selected based on the distance between the sender and receiver, Relative Success Rate (RSR) value of node and buffer occupancy of a node. Based on the above parameter, a utility function was defined and it was applied to each neighbour of a transmitter node. Hence the transmitter node was chosen the highest U-valued node as its next step hop node among its neighbors in packet forwarding. Therefore, by selecting non-congested nodes as their next-hop node, the congestion was avoided.

Shelke et al. [9] proposed a Packet Priority Intimation-based (PPI) congestion control method for handling the traffic and providing the congestion-free data transmission in the network. High priority packets have been transferred within the minimum delay as the principal objective of this method. A PPI bit was introduced to reflect its meaning by this method in each packet.

Sarode & Bakal [10] proposed a novel priority-based algorithm for the appropriate classification, and categorization of sensitive delay and delay tolerant applications of data packets at the actuator node. In this algorithm, the Real Time Priority-Based Scheduler (RTPS) was proposed to simultaneously manage heterogeneous data flows depending on the type of transmission. Priority-based data delivery was a primary research topic for multi-event networks with low rates. A priority metric was designed to track dynamically different types of traffic-based flows of product size, latency and buffer transfer time considerations.

Bouazzi et al. [11] proposed a priority-based queuing and transmission rate management protocol using a fuzzy logic controller in WSNs. The main objective of this protocol was introduced a fuzzy logic-algorithm to solve problems for SNs that are hard to deal with traditional techniques, such as delay, consistency and battery life. Fuzzy logic was worked by filling in the queue length and the traffic rate at each node in the Carrier Sense Multi-access with Collision Avoidance Mechanism (CSMA / CA).

Aslam et al. [12] proposed a new device Initial Constant Congestion Window (ICCW) to managing the bottleneck link congestion. This algorithm was based on the enhancement of the TCP at its slow start and congestion avoidance phases. Based on this algorithm, the new transmission rate was controlled for effective use of the link capacity by using different threshold values in the TCP process.

Gholipour et al [13] proposed a new model to regulate the transmit rate, leading to prevent congestion in WSNs. This model measured buffer occupancy ratio and determined downstream node congestion degree. This information was sending to the present node. The present node changed the transmission rate to resolve the congestion problem, increase network efficiency through the use of multi-classification obtained by Support Vector Machines (SVMs). This method obtained the re-transmitting value by using the defined values of the buffer occupancy ratio, congestion degree and each of the numerous transmission rate values. For tuning SVMs parameters, a genetic algorithm was used.

Narawade & Kolekar [14] proposed an Adaptive Cuckoo Search Based Rate Optimization (ACSRO) protocol to avoid and control the congestion in WSN. The congestion control and avoidance were focused on recovering the SNs from packet loss and preventing the occurrence of early congestion. The optimized rate adjustment was made based on the proposed algorithm, thus relieving the network congestion free of traffic charges. The rate was determined that the child node share rate in the parent node was conceived using an optimized object formulation function algorithm that includes number of nodes, priority number, bandwidth, sending rate and maximum rate, optimum congestion control and avoidance. Based on this algorithm, the optimized rate adjustment was done, making the network free of congestion irrespective of the traffic load.

Farsi et al. [15] proposed a protocol for reducing the congestion issue in the network. The protocol was designed to decrease the end-to-end delay and extended the network life by selecting the appropriate Primary Cluster Head (PCH) and Secondary Cluster Head (SCH). This protocol consisted of two steps, the process of configuration and transmission. In this protocol, small setup process was used for removing dead nodes and solving dead cluster problems in rounds other than first round.

Swain et al. [16] proposed a two rate control algorithm to congestion avoidance and thus reduced loss of transmission. In the Difference of Differential Rate Control (DDRC) algorithm was developed based on the deviation of differential rate between sink node and the given node. Higher-order derivative rate control was the basis for the DDRC algorithm, which overcomes network congestion. An additional Weighted Priority Difference of Differential Rate Control (WPDDRC) protocol was proposed, based on the combination of the Traffic Class weighted priority and the differential node rate difference to handle real-time data, as well as consolidated data for real time and non-real-time.

Table 1 tabulates the advantages and disadvantages of above discussed technique.

Table 1 Comparison of priority based congestion control protocols in WNS

Ref. No.	Protocols Used	Advantages	Disadvantages
[3]	GMCAR	Minimize the delay in the network.	Does not consider the traffic priority in GMCAR
[4]	HTAP	HTAP is a simple and efficient solution for dealing with overload situations in densely deployed WSNs.	But, the delay was affected due to the determination of the possible route based on the congestion in each hop-by-hop communication.
[5]	PASCCC	Better transmission in terms of network lifetime, utilization of	Excessive delay occurs during setup phase.

		energy, data transmission.	
[6]	Linear and binary feedback method	Prolong the network lifetime.	Time delay is slightly high in dynamic clustering.
[7]	RT-MMF	Reduce the packet drop.	It needs to be analyzing the trade-off between fairness and energy consumption for avoiding the buffer overflow.
[8]	CAM	Reduce packet drop and increase the packet delivery ratio	High energy consumption in CAM
[9]	PPI	More efficient for congestion control.	High average delay.
[10]	RTPS	Dynamically controls various types of traffic.	It needs beacon priority based protocol for improving the performances.
[11]	CSMA/CA	Better performance in terms of energy consumption.	Still needs improvement in terms of computational complexity.
[12]	ICCW	Prolong the network lifetime.	QoS parameter is not effective
[13]	SVM	Decreases the end to end delay in the network.	Required excess memory for classification in many cases and involves high complexity.
[14]	ACSRO	More efficient in rate optimization scheme in congestion management mechanism.	At the time of the retransmission, the lost packets are traced back but the power usage of the network exceeds, results in poor network efficiency.
[15]	PCH, SCH	Decreases the data overflow, and then the network bandwidth usage is reduced.	By transmitting the undesirable data the energy consumption is high.
[16]	DDRC, WPDDRC	Minimize the loss of packet.	For improving the rate control, need the combined notion of fair allocation of bandwidth and traffic class priority.

III. CONCLUSION

In this article, a detailed view of various techniques for congestion control in WSN is presented with their merits and demerits. It is obvious all researchers have tried in different techniques to control congestion in WSN for increasing the network lifetime and reducing the congestion in the network. From the analysis of various congestion control techniques, it is observed that the WPDDRC technique promotes network lifetime and decrease the congestion than other techniques. The WPDDRC algorithm requires the combined notion of the traffic class priority and the fair allocation of bandwidth for improving the rate control. Also, it needs to use the notion of adaptive queue management for congestion avoidance rate control. In future, the above mentioned requirement is taken into consideration for developing an efficient congestion control technique.

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