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Analysis and Comparison between Congestion Control Techniques

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Abstract- Congestion is always a critical area to be tackled to prevent hindrance in successful communication between networks. Sharing of critical information is the foremost responsibility of assorted components of network. Due to sudden occurrence of congestion, all nodes in the Wireless sensor network have to work hard and more in retransmitting data packets to base station through intermediate sensor nodes due to their huge loss. Extreme energy consumption is also there which degrades all over performance and sometimes showing concomitant effects like packet loss in network. So, this congestion needs to be avoided to prevent network failure by improved design of Wireless sensor Network and making use of different congestion protocols as per the application in which it is required. In this paper, we will compare different congestion detection and control algorithms on the basis of protocols and parameters incorporate by them in their Wireless Sensor Network's topology to handle congestions.

Keywords- WSN's, Congestion Removal Techniques, Traffic Manager and Resource Manager

I. INTRODUCTION

WSN's has a lot of applications like animal tracking, military, health monitoring and many more in which sensor nodes are organized in different manners to assess ecological conditions. Base stations and hundreds of sensor nodes combine together to make WSN functional. These sensor nodes are placed in a geographical environment connected with each other so that they can easily share the information. Sensor nodes are basically target driven and route data from nodes nearby target to base stations through wireless connectivity. These base stations are the final destination from where the data is fetched. As WSN is a complex network [1], it faces much vulnerability amongst which Congestion is havoc and can occur at any time. Because traffic move upwards from sensor to sink nodes, congestion occur more towards base station. Due to congestion there is no utilization of existing channels and resources and also data packets are lost. It also decrease lifetime of sensor node's batteries. To avoid the loss, WSN makes use of different congestion detection and control algorithms [2] to deal with congestion by controlling resources and traffic so that data packets can flow in a normal and steady way. Congestion occurs if either buffer is full or simultaneously multiple user utilization of channel is done. In this paper, author performs a survey of Congestion control and detection techniques in WSN.

II. CONGESTION REMOVAL TECHNIQUES

As Wireless Sensor Network is a big and complex network, a lot of data packets move from source to destinations. Some of the packets can loose their destination address leaving them in loop forever if no time to live is defined. In such cases and many others, accumulation of data packets occur in the network leading to a serious condition called congestion. This congestion lead to loss of essential data packets, wastage of bandwidth and CPU utilization. But this congestion can be dealt by detecting and controlling the cause behind it. Two congestion removal techniques [3] are shown in Fig. 1.

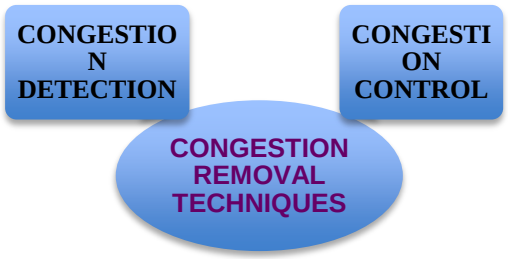

Figure 1. Congestion Removal Techniques

III. CONGESTION DETECTION

This technique refers to the way of noticing the root cause and place of congestion occurrence in networks. When the data packets in the channel are more than its capacity, it leads to gathering of lots of data. This demolishes the rule stated by quality of service for the network that there should be constant flows of data packets to prevent congestion as it will lead to wastage of data packets with other useful

resources. Congestion has to be detected to deal with [4]. It basically occurs in nodes as well as links. Node level congestion occurs inside node when the queue gets overflow and packets get assembled resulting in their discard. Link level congestion takes place when lots of packets took the same path at same time towards base station. They congest the path and the result is discarding of crucial information. They both create worse congestion affecting performance of network and energy-efficiency. Different algorithms using different protocols are used to detect congestion [5]. These algorithms make use of metrics to calculate the performance of network. The Fig. 2 below shows type of congestion and different metrics used by routing protocols.

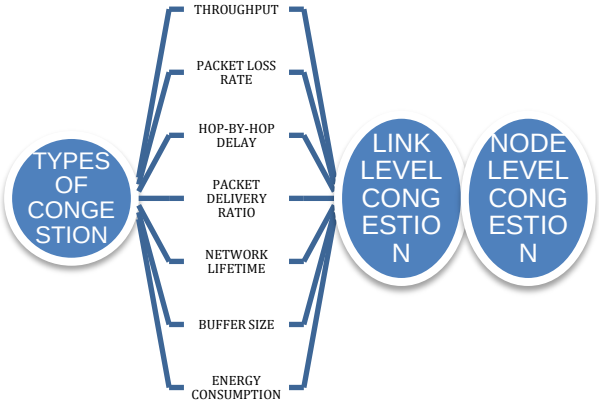

Figure 2. Types of Congestion and Metrics Used

A. Congestion Detection Techniques

To make the flow of packets smooth and sound in Wireless Sensor Networks, we need to search the root cause and location of congestion. There are different Congestion Detection techniques used as shown in Fig. 3. In Buffer Full approach, buffer process stored data packets one by one. It accumulate packets temporarily but if these packets arrives from more than one node simultaneously then this will lead to congestion as they will collide with each other. An algorithm is proposed to implement MAC protocol that helps to avoid collisions. These kinds of collisions are not easy to detect. Only, when buffer gets full serves as a good indication of congestion in such a complicated network. A threshold is set and when size of buffer surpasses value of threshold, it signals possibility of congestion in that network. In channel usage, the load of channel is calculated by using an algorithm that directs sensor nodes to calculate threshold value of channel and if it again crosses the set threshold value, it implies congestion. To find out congestion during transmission of packet, the algorithm proposed finds out the difference between packet service time and packet inter-arrival time. If the first one exceeds the second, packets in the queue will accumulate and delay others too.

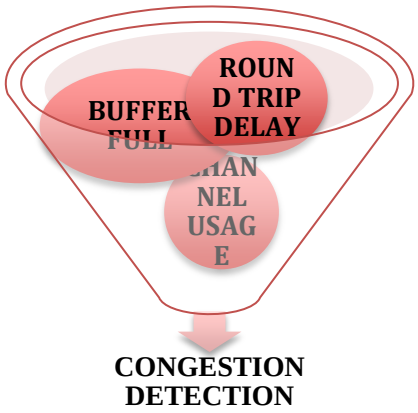

Figure 3. Congestion Detection Techniques

IV. CONGESTION CONTROL

It is essential to avoid congestion in a network to maintain and improve its quality of service. The best way is to ask source to stop or slow down in sending the packets that will prevent consumption of useful energy of network. Some of the packets have to be smartly discarded by sensor nodes upon receiving notification of congestion. The congestion notification is transmitted hop by hop in the network making them alert to adjust transmission speed of packet. In paper [6], the outgoing packet rate is controlled by altering the scheduling rate that helps in avoiding congestion. The different methods of congestion control are discussed in sections below [7].

A. Traffic Manager

Congestion can be most easily avoided by controlling the traffic rate by source and in-between nodes. The congestion can be controlled either by the both extreme ends or by the intermediate nodes [8]. The extreme source and destination have to wait for any notification of congestion to collect all packet information to retransmit the lost ones. Non-receiving of acknowledgement from destination serves as the important factor of congestion occurrence. But in case of congestion controlled by intermediated nodes, retransmission of packets done is faster. All the in-between nodes between extreme ends track the status of buffer [9]. If buffer gets full, the intermediate node controls the data rate. Some of the traffic control protocols are discussed below.

- *ADAPTIVE RATE CONTROL (ARC):* It increases the speed of packets through intermediate nodes when packets are successfully received by sink node.

- *CONGESTION DETECTION AND AVOIDANCE (CDAA):* This protocol makes use of backpressure to indicate about congestion resulting in slowing down of packets.

- *ECDAA:* It detects congestion through three mechanisms-dual buffer thresholds, flexible queue schedulers and bottle neck

- *FUSION:* It detects by checking if status of buffer-full or empty. If full, the intermediate nodes will stop forwarding will stop forwarding the packets.

- *CONGESTION CONTROL AND FAIRNESS (CCAF):* In this protocol, congestion is detected by intermediate nodes by using hop-hop manner approach.

B. Resource Control

The nodes in the network should have control over resources in advance to find out alternate path in case of congestion. Redundant links have the advantage to carry traffic with other routes to the destination in such conditions [10]. So, changing the data path utilizing different resources in order to avoid congestion is practiced by various resource control protocols as discussed in Fig. 5.

- *DYNAMIC ALTERNATIVE PATH SELECTION (DAPAS):* It uses a flag decision algorithm to choose the most appropriate path.

- *TOPOLOGY AWARE RESOURCE ADAPTATION (TARA):* This protocol detects congestion base upon status of buffer and load of channel.

- *ADAPTIVE DUTY CYCLE BASED CONGESTION CONTROL (ADCCC):* This protocol works by adjusting the transmission rate to avoid congestion.

- *FLOCK BASED CONGESTION CONTROL (FCC):* This protocol helps packets to form flocks and fly towards destination fighting against all congestion.

- *HIERARCHIAL TREE ALTERNATE PATH (HTAP):* This protocol detects collision by looking into size of queue and incoming-outgoing flow of data packets.

V. COMPARISONS OF CONGESTION MANAGER PROTOCOLS

Different congestion control protocols help in maintaining quality of service of networks by detecting congestion using different algorithms. Table 1 shows comparison between different congestion managing protocols upon various statics including performance factors, congestion type, time-span, and different congestion control and detection methods. Some of the protocols use methods that are based on factors like number of packets in temporary storage, length of queue, maximum value of packet hold by any node, round-trip delay taken by data packets, bandwidth used by data, extra load on the channel. These methods are based upon some time span categorized as nonstop (Continuous), trigger-based and periodic.

Table 1: COMPARISON BETWEEN CONGESTION MANAGER PROTOCOLS

Protocol Name	**C. Detection methods**	**C. Control methods**	**Performance Factors**	**Congestion Type**	**Time Defined**
ARC	No. of Packets queued	Traffic Manager	Less energy consumption,evenhandedness	Node by node	Nonstop and Occurrence based
CDAA	Length of temporary storage and bandwidth	Traffic Manager	Less energy consumption,evenhandedness.	Node by node, link by link	Nonstop
ECDAA	Dual buffer thresholds and weighted buffer differences	Traffic Manager	Evenhandedness, throughput	Node by node	Episodic
FUSION	Length of temporary storage and bandwidth	Traffic Manager	Network efficiency, productivity, evenhandedness and frame loss	Node by node	Nonstop and Occurrence based
CCAF	Packet round-trip time	Resource Manager	Evenhandedness, utilization, energy maintenance	Node by node	Occurrence based
DAPAS	Queue length and channel status	Resource Manager	Less energy consumption, evenhandedness	Node by node	Nonstop
TARA	Length of temporary storage	Resource Manager	Energy efficient	Link by link	Nonstop

	and bandwidth				
ADCCC	Adaptive period and required service time	Resource Manager	Loss rate, packet reception rate	Node by node	Episodic
FCC	No. of Packets queued	Resource Manager	Productivity	Node by node	Nonstop
HTAP	Length of temporary storage	Resource Manager	Packet loss, network efficiency, round trip delay	Node by node	Occurrence based
GMCAR	No. of Packets queued	Traffic Manager	Less energy consumption, round trip delay	Node by node	Nonstop

VI. CONCLUSION

WSN's are used in broader regions nowadays. Its application areas are far more spread, as it was earlier. Due to large and complex network, occurrence of congestion is a common problem whenever a stream of packets passes through the intermediate nodes towards base station. Congestion degrades the quality of network, productivity and lead to retransmission of lost data packets. The same network now works with more resources with more power depletion. To prevent such a great loss, some congestion managing techniques are discussed with protocols using different algorithms. It helps network to avoid congestion to some extent and maintain its quality of service.

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