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Congestion in Wireless Networks - A Study

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ABSTRACT

One of the major problems in wireless networks is congestion and it occurs in all kinds of communication networks. The congestion in the wireless sensor network causes loss of packets and shortens the lifetime of the sensor nodes in the network. The packets will be retransmitted that were lost during congestion in the network consumes more energy of the sensor nodes and it results in reducing the throughput of the network. Controlling congestion in wireless sensor networks is necessary to sustain network lifetime and to achieve high-energy efficiency, packet loss ratio and channel utilization. The deployments of sensor nodes depend on the environment and on the application. In this paper, priority aware control method is proposed to extend the battery life of the sensor nodes as well as to improve the channel utilization and packet loss ratio.

Keywords: Wireless Sensor Networks, Congestion, Priority, Packets, Retransmission

I. INTRODUCTION

A wireless sensor network (WSN) is a network consisting of a huge number of sensor nodes connected with one or more base stations. The sensor nodes are located at different locations to monitor environmental or physical conditions such pressure, vibration, sound or pollution [1]. The wireless sensor nodes are cheap and possess limited resource capability such as processing power, memory, bandwidth compared to the conventional sensor nodes. The information gathered by the sensor nodes from the environment will be transmitted to the user through a wireless network. The wireless sensor nodes got worldwide attention with a progression of MEMs(Micro-Electro-Mechanical) technologies and development of different communication protocols lead to a great chance for utilization of wireless sensor network applications in near future[2][3]. The sensor nodes act independently with short-range wireless transmitters.

Monitoring and tracking are the two broad categories classified by the applications of wireless sensor networks. The Wireless sensor nodes due to their resource-constrained nature have faced many issues and one of the big concerns is the congestion in the network. The network is deteriorated by the congestion and it affects the battery life of the sensor nodes. When too many packets go through a limited capacity node or link it causes congestion. The congestion wastes bandwidth and consumes more energy of the sensor nodes and results in packet loss and decreasing the throughput of the system [4]. The congestion can be controlled by improving the capacity of the sensor nodes and bandwidth of the links. Three mechanisms such as detecting congestion, notifying congestion to the nodes in the network and flow control are the effective measures to control congestion. The research in wireless network aims to introduce new protocols, making the existing protocols better, formulating new algorithms and constructing new applications. The two broad categories of congestion control are (i) resource control (ii) traffic control.

In past research, there have been various investigations on the most proficient method for controlling congestion and to know whether congestion is originating from a node or from a link in a wireless sensor network. Mostly, the buffer overflow in the sensor nodes causes congestion at node level, which results in packet loss and queue delay. The link level congestion occurs due to the multiple sensor nodes competing to seize the channel at the same moment of time [1]. The link level congestion affects the throughput of the link and wastes the energy of the battery-powered nodes. The link level and node level congestion are effectively controlled to improve the throughput of the channel and to improve the battery life of the sensor node.

At present, there exist many algorithms in the literature to control congestion and for reliable transmission of packets in wireless sensor network. With respect to congestion control and avoidance, the algorithms between network and data link layer have used hybrid approaches. The proper utilization of data link layer improves the efficiency and battery life of the sensor nodes, while improper utilization of data link layer will result in loss of packets and increase buffer overflow [4]. The reliable transmission, for the most part, keeps running at transport layer will expand parcel misfortune and high cushion flood [4]. Then again, dependable information transmission approaches, for the most part, keep running at the transport layer. Few of them are end-to-end and utilize acknowledgment (ACK) or negative acknowledgment (NACK) for retransmissions.

Table 1: Parameters

Parameters	Value
Number of Sensor nodes	200
Range of transmission	50m
Size of packet	66 bytes
Power used for transmitting signal	5.85e-5 watt
Threshold for receiving the signal;	3.152e-20 watt
Size of control packet	6 bytes
Number of Queues	6
Each Queue size	20 packets

II. Literature Review

Congestion detection refers to finding and detecting congestion in the wireless network [9]. Congestion occurs because the node or link is carrying data more than its capacity and the quality of service of the network is debilitated. The congestion in the network makes the packets to drop, increases the delay in processing the packets and reduces the network throughput. A single parameter value cannot be sufficient to predict congestion. Parameters such as network topology, application and bandwidth usage are considered for detecting the congestion in the network. The length of the queue, service time of the packet, time interval of the packet, drop rate of the packet at the base station, length of the queue and state of the channel are used by the recent works for congestion detection mechanisms.Table1 shows the parameter values used by authors in the simulations. There is a necessity for a new detection mechanism for congestion in the network, which lowers the consumption of the battery life of the sensor node and complexity of the computation Congestion detection simply refers to the process of detecting, finding the existence and the area of congestion in WSNs [9]. Congestion occurs in a network when the QoS of the network deteriorates because the node or link is carrying so much data. It can result in packet loss, queuing delay or increase/decrease in the networks throughput. In many cases, single parameter cannot accurately detect congestion [10]. Parameters should be selected relating to some factors as shown in table 1.

Two types of congestion occur in WSN, node level congestion that occurs within a particular node. It is caused by buffer overflow in the node and can result in packet loss, and increased queuing delay [7]. This type of congestion can lead to increase in queuing delay, packet loss and retransmission of packet, which consumes energy. Link level congestion occurs when multiple active sensor nodes within same range attempt to transmit packet simultaneously [7]. The buffer overflow and link congestion as shown in the below Figure 1.

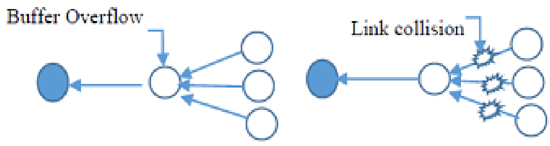

Figure 1: Congestion in wireless sensor networks

As a result of collision, packets may fail to reach the next hop when transmitted. This type of congestion increases packet service time and decreases both link utilization and overall throughput and wastes energy at the sensor node. Both the node and link level congestions can occur at the same time thereby having a direct impact on the network performance and energy efficiency.

Majority of the algorithms have been founded on some congestion control measurements to assess the execution of their protocols. A portion of the regular measurements utilized by the congestion control conventions are throughput, fairness, packet delivery ratio, hop-by-hop delay, packet loss rate, buffer size, lifetime of network, consumption of energy.

- Throughput: It is a parameter used to define the sum of the number packets per unit time successfully received by the sink node. To achieve an efficient algorithm, the value of the throughput received should be high.
- Packet delivery ratio: This parameter is used to measure the number of packets delivered to the sink divided by the total number of packets generated by the source nodes. When the packet delivery ratio is nearly 100%, it means the algorithm is efficient. This parameter is mostly used metric in WSNs.
- Packet loss rate: This is defined as the as the rate at which packets are lost or dropped due to buffer overflow divided by the total number of packets delivered to the sink node.
- Fairness: It refers to the degree of variation in data sending rate. An algorithm that achieves fairness in all the source nodes transmitting packets, the protocol is desirable.
- Node to the time taken to reach the sink node generated it. High delay indicates there is congestion due to retransmission of packets while low delay indicates increased performance.
- Hop-by-hop delay: It measures the efficiency of the algorithms in terms of congestion.
- Energy consumption: It measures the quantity of energy consumed by the sensor nodes in the transmission of packets, receiving packets and forwarding of the packets in the WSN. When the value of energy consumption is low, it means the algorithm achieves high-energy efficiency, which is good for the protocol.
- Network lifetime: This parameter is a function of energy wasted on the transmission of packets in WSN.

- Buffer overflow: It is based on the queue length or packets reaching the specified threshold in the network.

According to [11], the heftiness of the buffer and its development incline is regularly checked by sensor nodes through the increment of length of the queue in 13 nodes. Here it has been assumed by an algorithm that protocol of the data link layer able to keep away from packet collisions in the medium. One of the negative remarks buffer overflow is that it depends excessively on the data link layer. In the event that more than one node sending packets to the similar node there will be a collision in the medium and the network isn't conceivable to distinguish congestion.

2.1 Buffer Occupancy

According to [11], sensor nodes through the increment of length of the queue regularly check the heftiness of the buffer and its development incline. Here it has been assumed by an algorithm that protocol of the data link layer able to keep away from packet collisions in the medium. One of the negative remarks buffer overflow is that it depends excessively on the data link layer. In the event that more than one node sending packets to the similar node there will be collision in the medium and the network isn't conceivable to distinguish congestion.

The augmentation of packets can be ascertained by an exponential weighted moving normal. Essentially the length or buffer size can fill in as a decent sign of congestion in light of the fact that every node has a buffer. The buffer size can be utilized as a threshold specified in [9] [10] [11] [12], the authors accepted that a fixed threshold and the congestion is flagged promptly the buffer size surpasses the threshold value. The developing of queue demonstrates that the rate of approaching packets is more prominent than the rate of outgoing packets. In [6], the authors demonstrated through NS2 simulation using IEEE802.11 that the buffer tenancy cannot be used as a reliable indication of congestion.

A sensor node includes limited sized buffers in wireless sensor networks because of memory hindrance. The packets are dropped because of immoderate incoming traffic as the network load increases. In WSNs, contention level is elevated with the increase in the number of sensor nodes due to the fact that network buffer size controls contention degree [8]. The data packets use buffer tenancy as a transient storage whilst the present nodes within the buffer are being processed, the following packet is waiting and getting equipped for processing. The variety of non-empty queues can indicate the extent of the congestion for this reason buffer performs a critical function in storing the packets quickly in a queue. whilst the packets are chosen by the data link layer for retransmission, the link competition could be meditated thru the buffer tenancy and when congestion occurs, the variety is bigger than zero (0) and the quantity will increase with network load [7,8].

2.2 Channel Utilization

Channel utilization absolutely describes the usage of the channel and congestion in the channel indicates that the load of the channel exceeds a predefined threshold. In [6], authors referred to that a sensor node is caused to measure the channel loading while its buffer isn't empty. Their algorithm detects congestion by initiating action if the delivery of the packet ratio decreases drastically even as the channel load reaches the maximum accomplishable channel usage or exceeding some predefined threshold value is reached by the transmission of a single packet. In [9], the usage of the channel provides updated information about how busy the channel is, and the interference of the surroundings, which exhibits whether or not the channel is prepared to transmit and receive packets without ensuing in congestion. The sensor node in listening to the channel consumes excessive energy and as a result, the sensor network is degraded. In [8], authors proposed to monitor the channel at the precise time intervals using the sampling scheme to minimize the energy of the sensor node whilst estimating the accurate conditions.

The channel actions induced by the wireless transmission are measured by the channel utilization. The node activates channel monitoring by means of receiving a packet to forward. The channel to indicate whether it is free or occupied uses a specific value. The sampling function reflects the occupancy of the wireless channel and indicates the frequency of the busyness of the channel [10] [6].

The high channel load does not mean that the current node is affected, however, shows that channel is busy with some activity. The channel measurement is done by using the throughput because it quantifies the number of successful packets transmitted. Even though the issue of the congestion in the buffer is solved by channel utilization, the drawback is that it cannot react speedily when buffers are completely occupied which causes indiscriminately dropping of packets.

2.3. Queue length and Wireless Channel Load

The good indication of congestion detection is the queue length and channel load. Congestion can be detected either at the buffer occupancy or at the medium [9]. The problem of medium collisions can be solved by wireless channel load however, it won't solve the problem of buffer overflow and packets being dropped from the network. In this case, the buffer occupancy described above can be used here to solve the problem and algorithm can be used to measure congestion through the traffic intensity. When the packet collision rate in the MAC increases and after unsuccessful retransmission, packets are dropped. In obtaining an accurate congestion detection generated from high-rate traffic, a hybrid approach should be considered [4]. This method has been adopted and used by most researchers because comparing to other methods, it is easy to implement and it consumes less power.

Packet Transmission Time

The transmission time of packet refers to the time distinction among packet transmitted at the MAC level and its transmission time [6]. The packet transmission time is actually achieved based on the length of the queue and it continuously adjusts the packets-incoming rate. But, the demerit of a program transmission time is really it depends on the behavior of the wireless medium which hints that packets could be dropped for various motives like environmental factors or bodily factors. In [5], the set of rules makes use of packet carrier time; time length required to process one packet at the node and packet inter-arrival time; time interval among two sequential arriving packets perhaps from the source or perhaps possibly from the transit web site visitors. on every event the packet provider time exceeds the packet inter-arrival time, the queues build up and packets will similarly be not on time. Using this circumstance, the packet transport time may be taken into issues because it's a lot the time take for a program to move from a buffer node to the subsequent buffer node.

When congestion occurs, the packets will be lost in various ways [8]. They are classified as follows:

Case 1: Packets may be misplaced in numerous approaches when congestion occurs [7]. We can classify them as follows:

Case II: The attenuation of the signal is caused due to the transmitting node is located very far from the receiving node and hence the packets were lost.
Case III: Interference happening at the listening node located within the range of the transmitting node when a couple of sensor mote is transmitting simultaneously.
Case IV: Multipath called Rayleigh fading effects cause self-interference at the receiver. The node's transmission interferes with itself at the receiver. Buffer overflow at node causes dropping of packets.

III. PROPOSED METHOD

Priority -aware control method assures that the node with higher priority index receives greater bandwidth, while the nodes with same priority index will be allocated the same bandwidth. Nodes that generate more packets will get more bandwidth than the nodes that generate less number of packets. This is implemented in the protocol PCCP [10]. If the base station is more interested in getting the data from a particular sensor node, then that node would be assigned higher precedence index and consequently will have higher bandwidth. Three parameters can be used to define the priority index [6].

- Static priority: The data value of the sensor node is used to assign the priority. Static priority will depend on the specific application and it is independent of the location in which the sensor nodes are deployed. The packets whose data value is greater than a threshold value are marked as highest priority and the remaining packets are assigned low priority as per the architecture provided by the authors [4]. In case of congestion, the low priority packets will be dropped and the highest priority packets will be forwarded to the base station.

- Dynamic priority (DP): The number of hops between the sources of information and the sink is used to assign the priority. A Packet is assigned with higher priority, which has a large number of hops to reach the sink. The Dynamic priority packets are routed via intermediate forwarder to reach the base station to keep away from energy wastage of nodes and losing of packets and adjustments in priority even as dynamically routing via hops.
- Global priority (GP): The relative significance of dynamic and static priority at each node is considered as the global priority.

In [3], the priority aware control mechanism is able to make use of two types of priorities; intra queue priority and inter queue priority.

Inter-queue priority: In this kind of priority, the gateway node assigns priorities for packets and each node has its own priority. The packets service order is actually scheduled by the queues and the management of the schedulers is based on the priorities.

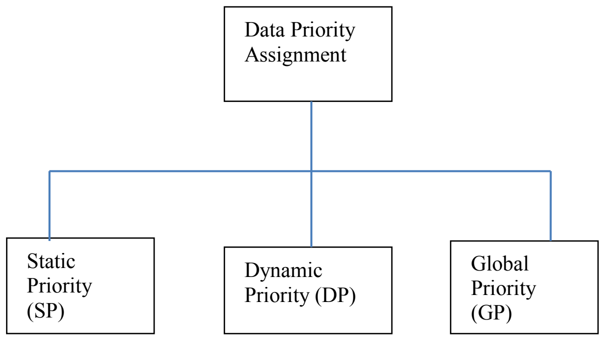

Figure 3: Assignment OF data Priority

With this situation, the data packets get higher service rate with higher priority. Inter-queue priority can be discussed in Figure 4.

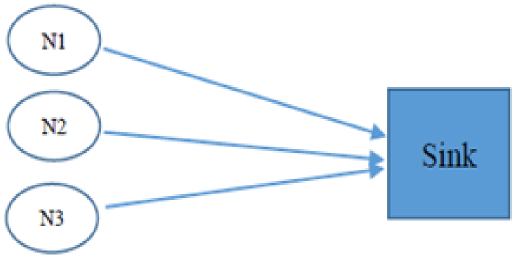

Figure 4: Inter -Queue Priority

Intra-queue priority: The priority uses Intermediate nodes to forward packets to the sink. The priority to the originating node is assigned by the intermediate node by seeing the source address in the packet header. The intermediate node acts as the relay node to send packets to the sink node which is received from the originating node. Figure 5 describes the scenarios of intra-queue priority.

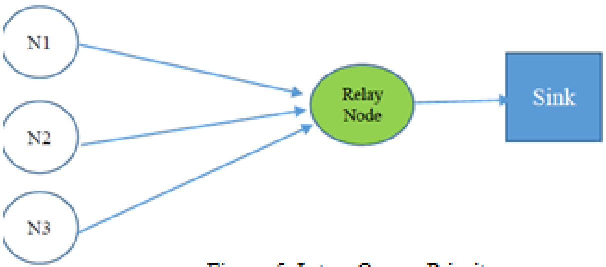

Figure 5: Intra -Queue Priority

Several of the priority aware protocols and their mechanisms utilized in wireless sensor networks are reviewed below.

Priority-based congestion management process (PCCP): The experts proposed a process which employs packet based computation to enhance congestion influence for WSN in[3]. It describes a new adjustable, congestion amount as a ratio of typical packet service time over typical packet inter-arrival period at each and every sensor node. PCCP works under both single path routing and multipath routing scenarios and engages a hop-by-hop speed feature technique known as priority-based amount feature (PRA) to correct the scheduling fee as well as the source price of every sensor node in a single path routing WSN. PCCP utilizes a hybrid layer optimization and also includes intelligence congestion detection based on packet inter-arrival time as well as packet service time. The present level of congestion amount of each sensor node is actually attained through congestion amount. The entire information flow produced by a resource node will successfully pass through the nodes as well as links along with the sole routing path. Sensor nodes learn a number of upstream data sources within the network as well as determine the optimum downstream forwarding rate. Last but not least, they estimate the per source price grounded on priority index of every resource node. PCCP is essentially a node goal based congestion management allowing sensor nodes to receive priority dependent throughput.

Prioritized heterogeneous traffic oriented congestion management process for WSNs (PHTCCP): In [2], PHTCCP ensures effective speed influence for prioritized heterogeneous visitors by making use of a node goal based hop-by-hop powerful rate adjustment technique. The protocol uses inter-queue and intra-queue priorities along with weighted good queuing for ensuring achievable transmission rates of heterogeneous details. The packet service ratio that is the ratio of typical packet service fee and packet scheduling rate utilizes its packet program ratio to determine the congestion amount at each and every sensor nodes. PHTCCP guarantees effective link utilization by utilizing powerful transmission rate feature that is managed by modifying the scheduling rate. In order to manage congestion, the scheduling fee is actually reduced to the importance of packet service fee and the bigger link utilization is actually attained by benefiting from the extra link capacity. We are able to say that PHTCCP is actually powered efficient, feasible in the terminology of memory needs and also offers lower delay. This particular kind of forwarding packets using priority to the sink node by using intermediate nodes. The source address in the packet header is evaluated by the intermediate node to assign priority between the originating node and sink node. The intermediate node acts as the relay node and sends packets to the sink node which is received from the originating node.Figure5 shows the working of Intra queue priority.

Congestion control using priority-based protocol (CCPP): The congestion is controlled by employing packet based computation in wireless sensor networks[1]. The ratio of average service time of the packet to the average interarrival time of the packet is defined as congestion degree at each sensor node. It defines a new variable, congestion degree as a ratio of average packet service time over average packet inter-arrival time at each sensor node. Both single path and multipath routing use CCPP and rate adjustment are employed at every hop. This technique called priority-based rate adjustment (PRA) changes the scheduling rate as well as the source rate of each sensor node in a single path routing WSN. The hybrid layer optimization is used by CCPP for detecting congestion intelligently with the use of packet arrival time and packet service time.

The congestion degree indicates the current level of congestion at each sensor node. The data generated by the source node passes through intermediate nodes and links to reach a destination in the single path routing. Sensor nodes measure the maximum allowable downstream forwarding rate by learning the number of upstream data sources in the network. The priority index of each source node is calculated by the algorithm which enables sensor nodes to receive priority dependent on throughput.

Prioritized heterogeneous traffic oriented congestion control protocol for WSNs (PHTCCP): In [3], PHTCCP ensures efficient rate control for prioritized heterogeneous traffic by using a node priority based hop-by-hop dynamic rate adjustment technique. The protocol uses inter-queue and intra-queue priorities along with weighted fair queuing for ensuring feasible transmission rates of heterogeneous data. The packet service ratio which is actually the ratio of average packet service rate and packet scheduling rate uses its packet service ratio to measure the congestion level at each sensor nodes. PHTCCP guarantees efficient link utilization by using dynamic transmission rate adjustment which is actually controlled by adjusting the scheduling rate. In order to control congestion, the scheduling rate is actually decreased to the value of packet service rate and the higher link utilization is actually achieved by taking advantage of the excess link capacity. We are able to say that PHTCCP is actually energy efficient, feasible in terms of memory requirements and provides the lower delay.

Congestion control using Dynamic Prediction (CCDP): In [7], CCDP is able to expect congestion in sensor nodes and dynamically and fairly broadcasts the traffic on the network. This protocol is honestly an upstream congestion control mechanism which supports single path routing and nodes are really purported to create continuous data. Throughput is enhanced by DPCC and loss of packets will be reduced while making sure allotted priority based totally fairness with decrease manipulate overhead. This protocol introduces the congestion index which detects congestion by reflecting the current congestion level at every sensor node decided on its unoccupied buffer size and rate of traffic at data link layer. CCDP protocol consists of three additives which might be added to an obligation for unique congestion discovery and weighted fair congestion control.

Adaptive congestion control compression technique (ACCT): In [11], ACCT makes use of discrete wavelet transform (DWT), adaptive differential pulse code modulation (ADPCM), and run length coding (RLC) because of the compression method. The information is first transformed from the time domain to the frequency domain by the ACCT reduces the range of facts by way of using ADPCM, after which reduces the number of packets with the assist of RLC before transferring the records to the source node. The protocol introduces the DWT which classifies information into 4 groups with many different frequencies and it is used for priority based congestion control. Priorities are assigned through The ACT to those facts agencies in an inverse share to the respective frequencies of the information corporations and define the quantization step length of ADPCM in an inverse share to the priorities. The authors have experimentally demonstrated that ACT will increase the network performance and guarantees fairness to sensor nodes, in comparison with other existing strategies and additionally, it exhibits a really excessive ratio of the effectively available information in the sink. inside the relaying node, the ACT reduces the quantity of packets by using incrementing the quantization step size of ADPCM in case of congestion. RLC generates a smaller wide variety of packets for a facts organization with a low precedence and so as to facilitate the returned stress, the queue is really managed adaptively in keeping with the congestion nation.

Predictive Hybrid layer active congestion control (PHLACC): In [12], PHLACC applies queuing concept to assess single node data flows based on its memory quality combined with the average occupied memory size of packets in the network thus by improving the performance of the networks. PHLACC evaluates regional networks by evaluating the trends in the current data changes for the projecting and adjustment of the sending rate of the node. The fairness in the networks of IEEE802.11 can be achieved by increasing the neighbor nodes and reducing the waiting time. The priority of the sending node can be adjusted dynamically improves the fairness of lifetime of the networks.

Fuzzy logical controller (FLC): In [9],The output transmission rate of the parent node is estimated by FLC referring to load traffic parameter (LTP) with a weighted exponential based priority rate (WEBPR) which uses traffic load of each child node for assigning appropriate transmission rate with considerations given to the diverse portions of packets being transmitted.Varying transmission data types can be controlled by LTP and QoS of the network can be adequately achieved by decreasing the consumption of network resource. Probability loss and delay of the packets are certainly decreased.

Some of the priority-aware protocols used in wireless sensor networks are reviewed below and their mechanisms.

Priority based congestion control protocol (PCCP): In [1], the authors proposed a protocol which employs packet-based computation to optimize congestion control for WSN. It defines a new variable, congestion degree as ratio of average packet service time over average packet inter-arrival time at each sensor node. PCCP works under both single-path routing and multi-path routing scenarios and employs a hop-by-hop rate adjustment technique called priority based rate adjustment (PRA) to adjust the scheduling rate and the source rate of each sensor node in a single-path routing WSN. PCCP utilizes a cross-layer optimization and includes intelligence congestion detection according to packet inter-arrival time and packet service time. The current level of congestion level of each sensor node is attained through congestion degree. The whole data flow generated by a source node will pass through the nodes and links along with the single routing path. Sensor nodes learn the number of upstream data sources in the sub tree roots and measure the maximum downstream forwarding rate. Finally, they calculate the per-source rate based on priority index of each source node. PCCP is basically a node priority based congestion control which allows sensor nodes to receive priority-dependent throughput.

Prioritized heterogeneous traffic-oriented congestion control protocol for WSNs (PHTCCP): In [3], PHTCCP ensures efficient rate control for prioritized heterogeneous traffic by using a node priority based hop-by-hop dynamic rate adjustment technique. The protocol uses intra-queue and inter-queue priorities along with weighted fair queuing for ensuring feasible transmission rates of heterogeneous data. The packet service ratio which is the ratio of average packet service rate and packet scheduling rate uses its packet service ratio to measure the congestion level at each sensor nodes. PHTCCP guarantees efficient link utilization by using dynamic transmission rate adjustment which is controlled by adjusting the scheduling rate. To control congestion, the scheduling rate is decreased to the value of packet service rate and the higher link utilization is achieved by taking advantage of the excess link capacity. We can say that PHTCCP is energy efficient, feasible in terms of memory requirements and provides lower delay.

Dynamic prediction congestion control (DPCC): In [7], DPCC can predict congestion in sensor nodes and dynamically broadcast the traffic on the entire network fairly. This protocol is an upstream congestion control mechanism which supports single path routing and nodes are supposed to generate continuous data. DPCC enhances throughput and reduces packet loss while guaranteeing distributed priority-based fairness with lower control overhead. This protocol introduces the congestion index (*C*ii) which detects congestion by reflecting the current congestion level at each sensor node I determined on its unoccupied buffer size (*UBS*i) and traffic rate at MAC layer. DPCC protocol consists of three components which are introduced with responsibility for precise congestion discovery and weighted fair congestion control; backward and forward nodes selection (BFS), predictive congestion detection (PCD) and dynamic priority-based rate adjustment (DPRA).

Adaptive compression-based congestion control technique (ACT): In [7], ACT uses discrete wavelet transform (DWT), adaptive differential pulse code modulation (ADPCM), and run-length coding (RLC) as the compression technique. The ACT first transforms the data from the time domain to the frequency domain, reduces the range of data by using ADPCM, and then reduces the number of packets with the help of RLC before transferring the data to the source node. The protocol introduces the DWT which classifies data into four groups with different frequencies and it is used for priority-based congestion control. The ACT assigns priorities to these data groups in an inverse proportion to the respective frequencies of the data groups and defines the quantization step size of ADPCM in an inverse proportion to the priorities. The authors have experimentally demonstrate that ACT increases the network efficiency and guarantees fairness to sensor nodes, as compared with other existing methods and it also exhibits a very high ratio of the available data in the sink. In the relaying node, the ACT reduces the amount of packets by incrementing the quantization step size of ADPCM in case of congestion. RLC generates a smaller number of packets for a data group with a low priority and in order to facilitate the back pressure, the queue is controlled adaptively according to the congestion state.

Cross-layer active predictive congestion control (CL-APCC): In [48], CL-APCC applies queuing theory to evaluate data flows of a single-node according to its memory quality, combined with the analysis of the average occupied memory size of local networks. It also improves the performance of the networks. CL-APCC evaluates the present data change trends of local networks to project and actively adjust the sending rate of the node in the next period. In achieving fairness in the network, IEEE 802.11 protocol was improved based on the waiting time, the number of nodes neighbors and the original priority which adjusts the sending priority of node dynamically. Fairness is improved as well as the lifetime of networks.

Fuzzy logical controller (FLC): In [49], FLC estimates the output transmission rate of the parent node relating to traffic load traffic parameter (TLP) with an exponential weighted priority-based rate (EWPBRC) which then assigns a suitable transmission rate based on the traffic load of each child node with considerations given to the different amounts of data being transmitted. FLC can control different transmission data types adequately and also can achieve the QoS requirements of the system while decreasing network resource consumption. Delay and loss probability are reduced.

IV. SUMMARY

Congestion is inevitable in wireless sensor networks due to the fact there were increasing wireless sensor network applications. Industries, military, hospitals, and surroundings in our daily existence use applications of wireless sensor networks. Congestion based totally on the applications and the locations can arise in the source node, intermediate node or sink node.

This paper targeted on the state of the art survey and aimed about the troubles of congestion detection and a way to efficiently manage the congestion without degrading the lifetime of the network and as well reap throughput and battery performance that's the goal of the studies completed. Congestion can arise because of buffer overflow or collision in the channel. The strategy utilized in detecting congestion can be from buffer occupancy, channel usage, an aggregate of a length of the queue and channel load and packet time transmission. The life of the wireless sensor network can be enhanced when each of these detection strategies implemented properly.

Immediately after detecting congestion, notification message about the congestion in the network will be sent by the source node to all nodes. This notification message may be implicit or explicit. The implicit notification is normally and ideally used in a maximum of the protocols due to the fact information is piggybacked in the header. The information broadcasted by using the explicit notification consumes the energy of the sensor nodes due to the fact the sensor nodes could be listening maximum of the times to pay attention towards the message.

The idea behind formulating these protocols is that they could be used efficiently to reduce congestion in the wireless sensor network. There are special control mechanisms which include controlling the flow of packets in the network, resource control, restricted queue control, transport control and priority-aware control. The source node will be prioritized with the highest priority in the priority aware protocols when two or more nodes send packets to the sink using the possible shortest path in a congested area and rerouted safely without the packets being lost. The aim of these studies is mechanisms for controlling congestion and to find out the control mechanism that may reduce the end-to-end delay and enhance the lifetime of wireless sensor networks.

This paper presents a survey and review of varying congestion control mechanisms in wireless sensor networks in showing the capabilities, benefits, disadvantages and the overall performance metrics used within the assessment of the protocols. The goal of the algorithms is to minimize the loss of packets in a network by discovering the location at which congestion occurred and to maximize the values of evaluation parameters such as throughput and extending the energy of the sensor nodes. This research also showed that we can't observe the equal type of congestion control mechanisms to all nodes because there is probably small packet drop or huge packet drop and that could arise in different locations.

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