Various Congestion Control Methods in WBAN – A Review

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Abstract —Wireless Body Sensor Networks is widely known technology where sensors nodes is placed, on the body, around the body or implanted inside the body. From the very beginning of the layered architecture of WBAN, several solutions have been proposed with respect to various issues present in this network. Among numerous issues, congestion is one of vital and serious problem in the transport layer. Regarding this fact, researchers are digging out for the solution to avoid the problem of congestion in the network for appropriate transmission of data from one node to another. This paper contributes for the same by providing a review about the techniques which have been proposed by the researchers. This paper presents the brief introduction to WBAN followed by the review on congestion control modules and methods which have been used for the solution. It has been presented that by using congestion control techniques the performance parameters such as throughput, battery life, data rate, delay, queue length, loss of packets, bandwidth can be improved.

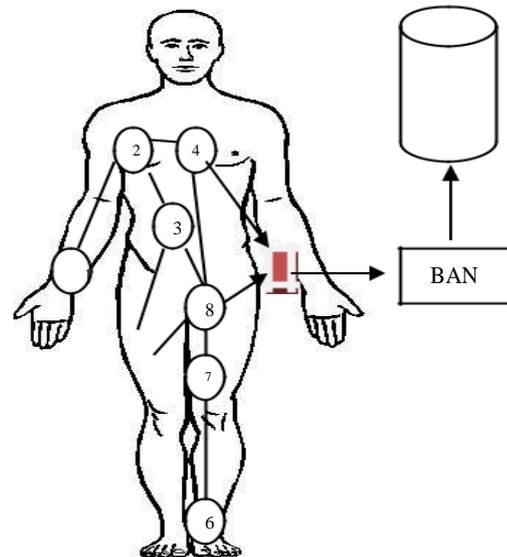*Keywords—WBAN, Congestion, Congestion control, priority based congestion control*

Fig. 1.   Representation of Wireless Body Area Networks [3]

I.   INTRODUCTION

WBAN is not a single terminology; it is a vast area which offers several applications such as environmental checking, combat zone, farming field checking and crafty homes. Basically, it was originated to monitor the health of the chronically ill patient. This network consisted of several sensors which have spotted in detecting region in order to screen field. It is a part of Wireless network which is considered to be an emerging technology of today's era. As it is stated earlier that, it was specifically designed for monitoring of health of the user so that's why it offers numerous applications regarding medical as well as non-medical applications [1]. The representation of wireless body area networks in which 8 sensor nodes are deployed on the human physique is shown in Figure 1. Each sensor node is connected through the communication line with each other to transmit the information to the BAN. The data is being transmitted by BAN coordinators from nodes to the central server in the network. This retrieved information has sent to the database to take the desirable actions by the corresponding physician.

For monitoring body of the patient, a sensor node has placed on the human body that continuously transmits the signal collected from user's body and sends it to the base station where physician checks the status of the patient's health. The parameters which can be considered for the examination are body temperature, blood pressure, heart rate etc. This method of screening reduces the frequent visit of patients to the hospitals. Moreover, patients do not need to stay in the clinic for longer period of time for regular examination or check up. They can stay at their homes while doing their routine tasks without any dilemma. This continuously sensed information is send to the medical server at the receiving end. In the network, sensor hubs are included which transmit the information from one sensor node to another. In this over all implementation, the main idea is to utilize the consumption of energy by the sensor nodes in transmission [2]. There are several techniques which have been proposed by different researchers to make it more effective with less time and energy consumption. It has been concluded by researchers that sensors which contain critical data should be placed nearer to the sink e.g. as ECG and Glucose level measurement sensors so that its information reached to the base station as soon as possible

in case of emergency. The information contained through these sensors is least condense, high unwavering quality as well as long life. Therefore, the data of these nodes will be directly send to the sink whereas the data of other sensor nodes that are not prior will send to the sink through forwarder node.

II. CONGESTION CONTROL

In wireless network system, these have to be numerous issues which are being faced and controlled during data transmission and reception. The essential issue of WBAN is congestion due to which huge packets are lost during communication. To the fact, on WBAN technology, there is a Remote Health Monitoring System that consists of number of sensor nodes attached to the body of the patient and collects physiological signals. In the wireless network, there is a gateway or a sink node that receives huge amount of data that comes from the sensor nodes and if this node consumes longer time then in that case congestion will definitely occur [3].

Basically, there are two reasons due to which congestion occurs and these are nodes collision and occurrence of butter's overflow. In the first case, when two or more number of nodes competes for the carrier allocation for transferring the data simultaneously, problem is occurred. And in another scenario, a node holds the packet before any transmission causes the problem of butter's overflow. In addition to this, congestion occurs at two levels such as node level and sink level. The problem of butter overflow occurs at the node level which results into more time consumption and loss of packets. Whereas, nodes collision occurs at the link layer that reduces utilization of link as well as overall throughput of the network. On the whole, occurrence of these situations in the network decays the performance of the network which leads to increase in consumption of energy and time delay. Congestion problem in the network places a negative impact on the performance of the system and to this problem lost packets are send again during transmission. The battery's lifetime of the sensor nodes are directly affected by this. A definite congestion control approach is required for solving the problems such as loss of important information, wastage of energy consumption, and interruption caused at destination during the arrival of packets and degradation in the capacity of the channel [4]. There are different methods and mechanisms, which can be used and applied for congestion control.

Typically, the problem of congestion can either be prevented before it occurrence or can be resolved after occurrence of congestion in the network. The main modules, which have been used for the control of congestion in the network, are mentioned below.
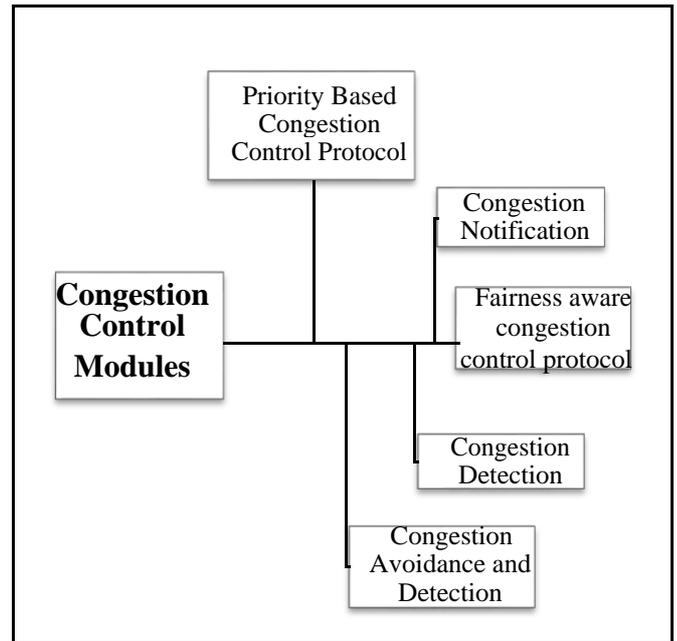

Fig. 2.   Different modules of Congestion Control

These modules are explained as below:

2.1 Congestion Detection:
In this phase, initially the congestion has been detected in the network and identified. Basically, there are two types of congestion control detection techniques as stated below:

1) Local congestion detection, which appears at the intervening nodes by seeing the queue's condition and carrier as the indicator of the congestion.
2) At sink nodes, global congestion detection occurs, that analyzes the congestion by commonly observing the loss of packet and amount of delay.

2.2 Congestion Notification:
By this phase, it means that congestion has occurred in the network. In order to express the congestion, two types of notifications are expressed such as implicit mechanisms or explicit Mechanisms. In implicit mechanism, there is no need of transmitting any control messages. It directly sets the data header by one bit in network to address the congestion. Whereas, in the explicit mechanism, a distinctive control packet is sent to other sensor nodes by the starting node to alert them about congestion.

2.3 Congestion Avoidance and Detection:
To identify the congestion in the network, buffer length of sensor nodes as well as load on the wireless channel is observed. In any case, these characteristics exceed the threshold value which is pre-defined then transmission rate is reduced. This reduction occurs when sensor node notifies its neighbor. Before transmitting any packet through the

channel, the channel is divided into a fixed period by the sensor nodes. In some cases when the channel is busier than the time which is defined priory, control bit is sets to inform the base station about the congestion.

2.4 Priority Based Congestion Control Protocol:

This type of protocol assigns the priority to individual node based on their location and operation. The nodes which are nearer to the sink have higher priority. For identifying the congestion, packet sending rate and packet arrival rate is important. If the value of ratio is low then congestion is Present in the network. The information about the congestion is stored in the priority index. The sending rate is adjusted based on the congestion at a particular node. The packet loss in the network can be condensed by achieving the weighted fairness transmission for the multipath as well as for the single path routing.

2.5 Fairness aware congestion control protocol:

The congestion in the network can be controlled with fair allocation of bandwidth for individual flow of data. Packet drop rate at the sink node can be seen to detect the congestion. The nodes in the network are basically of two type's i.e. near source node and near sink node. This categorization is done based on their position in the network. If a packet is lost, a generated cautioning message is send to the nearer origin node by adjacent sink node. And a nearer source node sends control message to the nearer sink node. Once the control message has been received, flow rate will be tuned on the basis of latest calculated sending rate.

On the whole, all congestion control mechanism shares a common objective to control the congestion while transmission and reception of data. With the application of these techniques, several parameters such as delay and queue length can be eliminated and system can become more effective. Apart from this, there are several mechanisms which need to be encountered for recovery of packets as loss of congestion control information.

III. CONGESTION CONTROL METHODS

Congestion control is considered as a prevention method used to prevent the system from the congestion being occurred in the network. And in case, if congestion has occurred then congestion control methods detect where it has been occurred, monitor its status and then control it [5]. In case of buffer overflow scenario, the data sending rate has been reduced on the nodes or re-transmission of data packets is done through alternative paths. A congestion control algorithm can be applied over the link collisions to overcome the congestion. These algorithms focus on the MAC layer which can be used to coordinate the network access among the nodes.

There are basically three main categories which can be used to classify the congestion control mechanisms these are:

- Congestion Control
- Congestion Avoidance
- Reliable data transmission protocols

This classification is based on the different ways like how congestion is detected in the network, the way they notify the other nodes after occurring congestion and how they solved this problem. The detection of congestion using these protocols is done by different methods such as:

1. By checking the level of buffer occupancy at the nodes in the network.
2. By measuring the load level of the channel
3. By counting the timing of packet service and inter-arrival time of the packet.
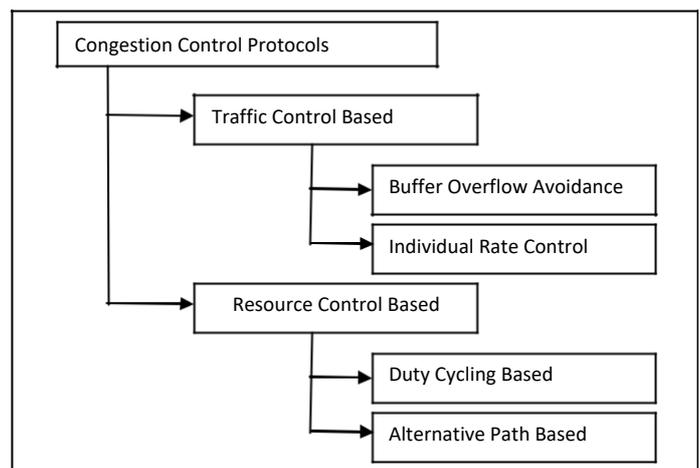

Fig. 3.   Different Categories of congestion control Protocols

The congestion control protocols are divided into two parts such as traffic control based and resource control based and these protocols are further categorized into two different categories and this has been represented in Figure 3.

IV.   LITERATURE SURVEY

Several researchers have focused on the congestion control techniques in WBAN. This section discusses different techniques that have been proposed in terms of controlling the congestion in WBAN.

In [1] authors proposed a congestion control mechanism which automatically adjusts the patterns of the traffic and did not leak any of the important information about the communication. In this technique, packet loss was avoided as the sending rate of the control mechanism does not change immediately while packet loss was detected. The mechanism worked like estimating the current packet loss rate and based upon that sending rate was adjusted. Experiments based on the measurements have been performed. From the results acquired, it has been concluded that proposed approach was able to avoid congestion in the network. Moreover, it also protects TCP flows in order to acquire high throughput and smooth flow of traffic.

In [2] authors proposed a new methodology which worked upon the transport layer. In the transport layer mainly four

factors are important. These are Queue Length, Packet loss, Delay and Bandwidth. The proposed technique worked on two of them considering queue length and packet loss. The two main phases used by the proposed methodology was fast begin and congestion management module.

In [3] authors reviewed several congestion control protocols which were used to analyze the congestion over the transport layer. Out of these protocols, some of them have also worked on the MAC layer in wireless networks. The basic idea of wireless networks and the reason behind occurrence of congestion has been reviewed. By the authors, the concept of congestion in the network and the reason of congestion in wireless network are also reviewed. The control strategies of congestion and their requirement in the wireless sensor network were also discussed. A comparative analysis has also been presented depending upon their performance parameters such as traffic direction, efficiency and energy conservation characteristics etc.

In [4] authors aimed at bandwidth consumption in order to avoid the congestion in the network. The proposed technique worked on the basis of priority which means that high priority information along with low priority information forwarded to the base station based upon the bandwidth capabilities. The process of packets sent depends totally upon the size of the data bits. Based upon the total size of the bandwidth, packets have sent to the destination. Priority has always been given to the high priority information packets but less priority information packets can also be headed if in case the bandwidth is available for it. The experiments have been performed on this idea and the results assured that bandwidth has been consumed effectively.

In [5] authors proposed routing protocols considering their advantages as well as drawbacks. The comparison has been performed between different routing protocols to conclude the performance of the proposed routing protocol. The authors examined the drawbacks of the traditional techniques and tried to resolve these issues such as quality of service, techniques used, and routing algorithms. From the analysis, it has been confirmed that proposed routing protocol was able to eliminate the issues in the existing routing protocols. Moreover, the proposed technique also resolved the critical factors related to m-heath application.

In [6] authors proposed an efficient congestion control protocol that consisted of the principle of cross layer approach to support the congestion control in the overcrowded traffic. The technique used by the proposed methods was multi-path routing scheme in which the optimized route has been found in order to reduce the length of the queue that correspondingly controls the congestion in the network. By using the proposed protocol, the channel capacity has been diversified equally over the nodes to bring uniformity and utilized the capacity of the channel appropriately. The proposed and exiting protocol has been compared with existing ones to evaluate the performance and results assured that performance of technique outperforms.

In [7] authors reviewed several applications of wireless body area networks. This network is basically worn by the chronically ill patient for the continuous monitoring. In this, the body of the patient sends signal to the health care center where there is no need for the patient to stay at hospital 24*7 and moreover, the doctor can monitor the patient frequently. Wireless body area networks have number of applications due to its special features like mobility and feasibility. One of the critical issues of this network is security. In order to save the data from being corrupted, several encryption based algorithm have been used before transmission. This paper mainly focused on the various applications of wireless body area network along with its uses. At last, research issues have been also mentioned in this paper.

In [8] authors developed a WBAN network based model in order to control the congestion in the network. The proposed method takes several input parameters such as number of nodes with number of cluster heads and controlling the speed and iteration to control the congestion among nodes. The proposed method has been divided into different phases where initially the network was designed and then the nodes or cluster heads were deployed in that network. In the deployed network, the intrinsic communication occurs between defined cluster heads. Each node in the network was defined with its speed and number of iterations to be performed. Lastly, communication was established between the nodes and then control parameters were defined. After performing the experiments, the consumed energy by the nodes and traffic load was evaluated to check the performance of the proposed technique. It has been concluded that proposed technique outperforms in terms of different parameters such as Traffic load, Power Density Function, Power consumption and Cumulative Density Function.

In [9] authors discussed several congestion control techniques, which have been proposed till yet. In WBAN, there are various applications, which have been used to monitor the signals coming from the suspect body. Moreover, this technology is related to the body so there are various safety issues involved. One of the major issues which needs to be considered i.e. congestion. Due to its rapid increase, there is large amount of data, which is increasing day by day, so it is important to control the congestion or data traffic. Congestion is controlled at the transport layer of WBAN. To handle this problem, there are several protocols that can be studied for the problem of congestion.

In [10] authors reviewed mechanisms based on congestion control. The ideas behind the paper are to recognize the real aspects of ECG signals as well as to know the current scenario based upon the mechanism of congestion control. Thus, there is a requirement of proposing a best congestion control mechanism and needs to develop a user-friendly body sensor that suits the body of the user.

In [11] authors mentioned several techniques and MAC protocols, which have been used for WBAN. Apart from

this, many concepts, which are considered to best appropriate are also mentioned in this paper.

In [12] authors explained the basic methods of WSN and WBAN. This paper also described the difference between WSN and WBAN. Furthermore, the idea behind improving the health care systems using information technology have also discussed in this paper. The sensors that are involved in this network are wearable and can be implanted on the body of the patient. This method does not affect the mobility of the patient as the whole concept is wireless. This paper explained the applications of wireless body area network, which have been using multiple sensor nodes. At the end of this paper, several new trends were discussed.

In [13] authors proposed a congestion control mechanism, which automatically adjust the patterns of the traffic and did not leak any of the important data about the communication. In the proposed technique, packet loss was avoided, as the sending rate of the control mechanism does not change immediately while packet loss was detected. The proposed mechanism worked like estimating the current packet loss rate and based upon that sending rate was adjusted. In this paper, experiments based on the measurements have performed. From the results acquired, it has been concluded that proposed approach able to avoid congestion in the network. Moreover, it also protected TCP flows in order to acquire high throughput and smooth flow of traffic.

In [14] authors discussed the treading area of research. There are several applications of this technology such as medical and non-therapeutic applications, military applications and safety application. In field of health monitoring, several protocols as well as techniques were used by Wireless Body Area Networks that have been discussed in this paper. Additionally, this paper also described the existing work proposed by several authors.

V. CONCLUSION

This paper started with the introduction to the wireless body area networks followed by the discussion on congestion control modules. This paper also provided a review on the congestion control techniques. From the survey, it is concluded that congestion is one of the biggest issues in wireless body area network that restricts the normal transmission of data. Thus, to avoid this problem, several methods and protocols developed by the researchers have also been briefed upon. It has been concluded that, the congestion can be controlled at earlier stage as well as after the congestion initiated in the network. Both ways can be used as according to the requirement of the network for the effective performance of the network.

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