EDCAM: Early Detection Congestion Avoidance Mechanism for Wireless Sensor Network

Dr Helonde J B, GNIET, Nagpur, India
Dr. Wadhai V, MAE, Pune, India
Vivek Deshpande, MITCOE, Pune, India.
Shiv Sutar, MITCOE, Pune, India.

ABSTRACT
Wireless sensor network (WSN) has emerged as a promising technology thanks to the recent advances in electronics, networking, and information technologies. The data which flows through the wireless sensor network has great impact on the link load. The handling this data against the congestion, its reliability, and loss recovery is very tough task. In this paper we propose the scheme to detect and overcome the congestion (EDCAM). The main feature of proposed algorithm is early detection of the congestion. Rather to take the corrective action, here we prevent to happening the congestion.

KEYWORDS: EDCAM (Early Detection Congestion Avoidance Mechanism) Algorithm, HWM (High Water Mark Level), LWM (Low Water Mark Level), Channel Occupancy, Buffer Occupancy, Reporting Rate, Congestion Notification Bit (CN).

I. INTRODUCTION
Firstly, there is a lack of traffic analysis & modeling for WSNs. secondly; network Optimization for WSNs needs more investigation. Thirdly, the development of anomaly detection techniques for WSNs remains a seldom touched area. Among these three factors, the understanding regarding the traffic dynamics within WSNs provides a basis for further works on network optimization. In these applications, many low power and inexpensive sensor nodes are deployed in a vast space to cooperate as a network. [1].

It is suggested that WSN applications can be categorized as event-driven or periodic data generation. For periodic data generation scenarios, constant bit rate (CBR) can be used to model the data traffic arrival process when the bit rate is constant. When the bit rate is variable, a Poisson process can be used to model the data traffic arrival process as long as the data traffic is not bursty. For event-driven scenarios such as target detection and target tracking, bursty traffic can arise from any corner of the sensing area if an event is detected by the local sensors. A Poisson process has also been used to model the traffic arrival process in an event-driven WSN. Sequence relations exist in some kinds of packets. For example, a Routing Reply message always comes after a Routing Request message and that is specified by any ordinary routing protocol. There are many network optimization problems to be solved in WSNs, such as rate control, flow control, congestion control, medium access control, queue management, power control and topology control, etc. It is difficult to provide a complete overview in relation to all issues relating to network optimization in WSNs.

As WSN supports different data types like normal data that may in many to one or one to many topology. Event driven data is generated when particular event is happen. A large amount of data flows from sensors to sink. The emergency data flows through the network for management purpose or some emergency event when occurred. The traffic will be busrty for some application. Here huge amount of data is generated and which disseminated towards the base station. Depending on the application the data formats are different and there size of packets is also different. In that case the data traffic will not be same. The node must handle this traffic as well. All this different types of data will cause the congestion in the network. [2]

If data which is not passed further, it is assume that congestion is occurring. Congestion in a wireless sensor network (WSN) can lead to buffer overflow, wastage of resources and delay or loss of critical information from the sensor Network.

Root Cause of the Congestion
The congestion may occur if the data transmission rate of previous node is high than the data processing rate of this node [5]. So the nodes are provided with the buffers to hold the extra packets that are received from previous node and can be used for further processing to avoid the loss of packets. Congestion causes many problems when sensors receives more packets than that its buffer space, the excess packets has to be dropped energy consumed by sensor nodes on the packet is wasted. And if further packet has traveled, the more waste is, which in turn diminish the network throughput and reliable data transmissions. Congestion control studies how to recover from congestion. Congestion avoidance studies how to prevent congestion from happening for this we have to monitor the parameters which can helps us to avoid congestion in WSN.

Input buffer helps to node when incoming packets arrived at current node from previous node, will be stored in input buffer. When particular node is completed its data packet processing, the node pushes processed data packet into the output buffer. If rate of incoming packets is slow, then input buffer will accommodate the enough packets and then it will be given for processing. If processing time is good enough then packets will process and pushed into output buffer in normal flow. When link will free then buffered packets will be hauled into the output link.

The condition becomes worst when input packet flow rate is faster. Node may not be in position to process the incoming data packets at that faster rate. It will take some delay to process it. This will increase the queue in the buffer. If buffer is full then next arrived packets will be dropped or lost. At the same time when packets are process in node faster than earlier and link will be busy to transmit the data packets, then output buffer will be loaded. This situation will give rise to congestion. It will also increase the backpressure.

II. LITERATURE SURVEY:

There are three different methods are existing to detect the congestion. We are discussing those by having advantages and disadvantages of each other.

Buffer Occupancy

According to Ying Ouyang et al. [4] by checking the buffer occupancy, we can detect the congestion. Every node is having its own input and output buffer. This buffer is required for temporary storage of the data packet. As node processes the current packet, next packet is ready for processing. Hence buffer plays very important role in storing the packets temporarily in queue. First in First out (FIFO) type of strategy is used by queue and 'Probability of loss packet' will be reduced. Buffer length (BL) is an important factor/parameter in Real Time Memory Consideration (RTMC). If BL is very small there will be many requesting packets sent out in the network, and the time to transmit a file will also be prolonged.(As these buffers have finite time resolution.)[7][8]. If BL is too large, there will be more redundancy in the header of the packets and therefore increases the overhead to transmit a file. However, BL should be selected according to the quality of the links. If the quality of the links is good and just a few packets are lost, the value BL can be a smaller integer. But if the quality of the links is not reliable, the value of BL should be a larger integer.

Channel Occupancy

Although WSN is a promising technology which can be used in many applications, there are still a few obstacles to overcome before it finally becomes a mature technology. One of the key obstacles is the energy constraint suffered by the most inexpensive sensor nodes, where batteries are the main source of power supply. Given this obstacle cannot be removed in the near future, optimizing the design of WSNs thus the minimum energy will be consumed is very important. In WSNs, communication is believed to dominate the energy consumption. Energy expenditure is less for sensing and computation. The energy cost of transmitting 1 Kb a distance of 100 meters is approximately the same as that for the execution of 3 million instructions by using a general-purpose processor. Thus, minimizing the energy consumption due to communication is the key for the relief of the energy constraint in WSNs. Currently, the knowledge about the communication in WSNs is still partial and vague, especially for traffic characteristics and communication patterns. Obviously, the knowledge about the traffic characteristics and communication patterns can aid in the understanding of the energy consumption and its distribution in WSNs [6].

Reporting Rate

In a WSN, the data traffic load is not evenly distributed over the nodes. For example, the sensors which are one hop away from the sink relay the entire network's data traffic. This imbalanced data traffic load distribution can degrade the network's lifetime and functionality. Then by adjusting the reporting rate of the node to the sink, we can somewhat reduce the non linearity in the traffic load. If reporting rate is very low, then it is assume that there may be chances of the congestion. ESRT [3] will give the reliability along with the congestion control with the use of the reporting rate.

III. PROPOSED WORK:

In most of the congestion detection mechanism the buffer occupancy is best suited as reliable method. This method gives the faster detection and feed back action taken place at right time. The aftermath of this is congestion is alleviated earlier.

We propose the Early Detection Congestion Avoidance Mechanism (EDCAM), which will gives us the intimation of the congestion somewhat earlier than normal. Consider the buffer as 100% queue size. We define two watermarks as a threshold level. High level is named as High Water Mark (HWM) and Low level is termed as Low Water Mark (LWM). For simplicity of the calculation, we consider the HWM is at 80% of the full buffer size and LWM is at 60% of full buffer size. This window is referred as Control window for the congestion. One can change these limits for the complexity purpose. But note that after changing the water marks levels, the behavior is going to change. This may lead to get different result.

The EDCAM algorithm behaves as follows:

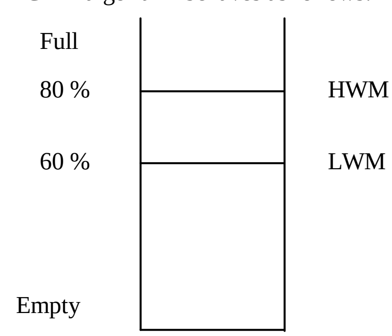

Figure1.

Algorithm1: EDCAM

1. Watch buffer occupancy consistently.
2. If due to the incoming flow of the packets, buffer is filled. Say Lr is the current buffer occupancy.
3. If Lr >= HWM, Set CN bit high.
4. Send this choke packet to previous node with α.
5. Previous node must decrease the flow rate
6. When Lr <=LWM, Reset CN bit low.
7. Previous node may increase the flow rate.

Accurate and efficient congestion detection plays an important role in congestion control of sensor networks. Several technologies have been proposed to detect congestion, but they are too energy consumed and complexity. There is a need for tradeoff between efficient and complexity. Recent work reports that, for a traffic pattern in which multiple sources send to a single sink, queue occupancy is a sufficiently accurate indicator of congestion. Therefore, we use the queue occupancy as our congestion detection symptom.

If due to incoming packets rate the buffer is filled to the level called by Lr (Current buffer occupancy). We check whether the Lr value is greater than HWM ($Lr \geq HWM$) i.e. High Water Mark Level then we set the congestion Notification (CN) bit high. And then we send this choked packet notification to the previous node to decrease the flow rate of the packets, (as the Lr is exceeding the HWM level) by the amount 'α'. Where the 'α' is the status of the buffer, $0 < \alpha < 1$ that is degree of congestion. We assume that the flow rate has been decreased by the previous node which is inversely proportional to the 'α'.

When Lr is less than ($Lr \leq LWM$) i.e. Low Water Mark Level then the buffer occupancy is lowered and we can reset the congestion Notification (CN) bit Low. Indicating that the buffer is not exceeding the threshold value defined and the flow rate of packet can be increased. So the previous node may increase the flow rate by 'α'.

Here we wish to use the Token Bucket Flow Rate Control. The number of tokens cashed to the bucket is adjusted to control the output flow rate. These numbers of tokens are inversely proportional to the degree of congestion reported from the congested node.

Actually when we set congestion notification bit high to decrease the flow rate by 'α' and intimate to the previous node about congestion that might occurring , the control bit will not get processed with highest priority which may lead the congestion and we may eventually loss the important packets and information. So we have to send the priority bit (P) highest priority. That's why we modify the EDCAM algorithm with priority bit.

Algorithm2: Modified EDCAM with Priority Bit (P)

1. Watch buffer occupancy consistently.
2. If due to the incoming flow of the packets, buffer is filled. Say Lr is the current buffer occupancy.
3. If Lr >= HWM, Set CN bit high and set priority bit (P) high.
4. Send this choke packet to previous node along with P and α.
5. Previous node must decrease the flow rate.
6. When Lr <=LWM, Reset CN bit low and set priority bit (P) low.
7. Previous node may increase the flow rate.

Here the proposed algorithm EDCAM has limitation that the congestion notification bit send may not be processed with highest priority, which may still send the data without changing the flow rate and possibly we may loose the packets at the receiving end because the buffer occupancy is almost full. To handle this situation we have to give the highest priority to the notification send to the previous node, and make sure that this notification is processed first to avoid further loss of packets. This notification is hop by hop notification in multi-hop network.

IV. EXPECTED RESULTS:

We are going to discuss some results that are expected. These results are expected after the actual simulation of the algorithm. Simulation tool that we are going to use is NS2.

1. Graph of packet delivery ratio (number of packets received/Total number of packets sent) to offered load (packets per second)

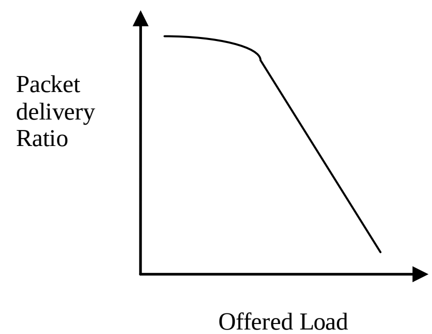

Figure2.

Packet delivery ratio is defied by the ratio of Number of packets received by particular node to the Total number of packets sent by the previous nodes.

$$\text{Packet delivery ratio} = \frac{\text{Number of Packets Received}}{\text{Total Number of Packets Sent}}$$

Offered load can be defined by the Total number of packets processed per second.

The graph of packet delivery ratio to offered load signifies that, initially when number of packets processed by node is less then probability to receive the packet successfully is sufficient enough to flatten the curved graph. Afterwards when offered load increases Drop packet probability will increase and finally Packet delivery ratio decreases. After simulating actually, we will get the exact behavior of the curve whether it will drop linearly or exponentially.

2. Graph of Buffer occupancy to Offered load

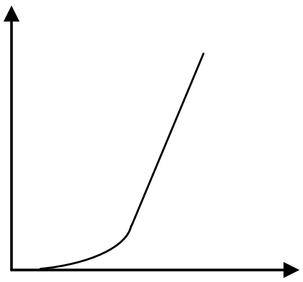

Figure 3

When offered load is moderate, then there won't be any large pressure on the buffer. Node itself has some capability to process the packets at this moderate rate. When offered packet load increases or crosses some limit threshold (generally called as Knee point), then buffer may built rapidly. Therefore graph shows the sharp rise in the slope.

3. Graph of Token bucket flow rate to the Degree of Congestion

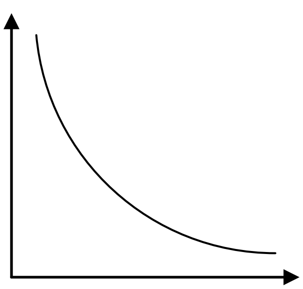

Figure 4

How intelligently the algorithm works and how it gives feedback to the previous nodes, will be tested in this graph. As proposed system will be the close loop system, the flow rate must be adjusted as and when previous node receives the choke packet information. The number of tokens will be cashed to the bucket for the flow control. As degree of congestion increases, the number of tokens offered for the control must be decreased. This in turn lower downs the flow rate.

V. CONCLUSION AND FUTURE WORK:

By having early detection of the buffer, we can initiate the process of the feedback to control the congestion. This scheme is better as compare to the waiting for congestion to happen and then to take corrective action. The modified EDCAM will be still better as we have included the priority bit along with the congestion notification bit. This will aid the conveyance of the choke packet to reach up to the neighboring nodes. After simulating the algorithm, we are going to compare the expected results to the simulated results. We are going to compare the buffer occupancy congestion control results with the other available methods such as reporting rate control and channel occupancy congestion control.

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