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Congestion control using upstream data dissemination in WSN

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Abstract— A sensor network is an network consist of sensing and computing devices that gives ability to monitor and react to events and in a particuler environment. The effects of congestion in WSN are very worse as it affect the overall throughput of the system. The Packet delivery decreases to the great extend .There will be large number of packets will be lost with this and the delay will increase as the number of retransmissions increase so we must control the congestion Here in the paper we propose modified UHCC protocol i.e. Upstream hop by hop protocol and additional rate control mechanism based on the hop number is introduced. With rate control proposed protocol also considers the bandwidth adjustment based on the hop number as the need of general applications of WSN.

Index Terms— congestion control and detection, Resource control, Traffic control, wireless sensor network

1 Introduction

A sensor network is an network consist of sensing and computing devices that gives an ability to monitor and react to events and in a particuler environment.This network can be used in civil, commercial, governmental, healthcare and industrial applications. The general structure of wireless sensor network is like tree so what happens that all the data which is generated at the sensor nodes moves toward the sink node. Due to this nature of wireless sensor network there is very much chances that congestion will occur in near sink node. As congestion affects on different parameters like it can cause decreasing packet delivery ratio, decreasing overall throughput of system, causing retransmissions due to packet loss, Congestion control is very important and although MAC protocol can recover packets loss as a result of bit error, it has no way handling packet loss as a result of buffer overflow. So in wireless sensor network it is very important to mitigate congestion in wireless sensor network. There are major two types of congestion control. Traffic control and resource control. In traffic control, the data rate control is done to control the congestion. Generally at the congestion hotspot the buffer overflow occurs i.e. if we do not do the rate control at congestion hotspot the packets keep coming and getting dropped and the congestion scenario will become worse so in this strategy if there is congestion possibility based on any of the congestion detection parameters the rate is decreased so that the packets which are in queue will be serviced. In traffic control algorithm for congestion control many algorithms uses AIMD approach i.e. additive increase and multiplicatively decrease. In this approach if the rate is very less then it is increased additively by some constant factor as sharp rate addition may make the scenario congested. If congestion occurs then the rate is decreased multiplicatively to immediately decrease the rate to mitigate the congestion. Traffic control methods are very effective methods in transient overload conditions. Traffic control method is very simple and cost effective in comparison with resource control method. As in traffic control methods we are decreasing the rate i.e. we are minimizing the number of packets it is not advisable to use in all type of applications. For such applications such resource control method must apply.

There are two types of traffic control methods. End to end traffic Control and hop by hop traffic control. In end to end method the rate control is applied at the end nodes. Generally at the sink node the rate control of the entire nodes is decided by the sink node i.e. the decision of the rate adjustment is taken at either at the destination node or at the source node. In Hop to Hop Traffic control the rate adjustment is done at every hop. Though hop by hop approach introduce much delays n the system it is very good way to control the traffic as in end to end approach the service time to the congestion occurrence will be more as there will be many transmission delay even if we are using backpressure mechanism the response after congestion detection will take time so here in hop be hop approach every node which sends data to next hop it detects the congestion at the local level only and it is solved in between those hops. Upstream hop by hop congestion control strategy uses this type of congestion control. Traffic control way of congestion control offers good results but this technique is not suitable for all the applications. Traffic control technique adjusts the reporting rate i.e. it minimize the number of packets .In crisis state it is not desirable that we are decreasing the packets as the data generated is very vital in such a applications. So for such applications traffic control type of congestion control method is not suitable so resource

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control method is used. In resource control strategy extra resources are deployed at the congestion hotspot so that congestion will be mitigated. The resources which we can add at the congestion area can be anything like we can have extra nodes so that the traffic will use these nodes to distribute the traffic or we can give more bandwidth to such areas which tends to congest. Even many protocols are there which chooses the new route or even multipath routing can be done.

TARA, DalPAS, IMMR, TADR are some examples of the protocols which uses such techniques.

2 Related Work

There are different papers which discussed the different mechanism for congestion detection and control.

CCF in WSN [12] actually concentrate on the assigning fair and efficient transmission rate to each and every node .The average output traffic and average input traffic of each node is monitored. Here spare bandwidth in the network is allocated at the areas which tend to congest and average increase and average decrease decision is taken based on the difference between two traffics i.e. Rin and Rout. So the maximum utilization of the resources will be there. This has two different modules as Fairness module and utility module. And after the rate calculation the fairness control module decides the aggregate change required so that every individual flow achieve the required fairness. The main advantages of CCF in WSN are Changes in underlying topology and routing level changes do not affect the performance of CCF, support for concurrent applications and the spare bandwidth is utilization. But as it contains the feedback mechanism so it will introduce the delay for it.

As we know that sensors nodes are deployed in geographically distributed network and based on it there is different importance to the data sensed by each of the node. So in WFCC [14] the protocol assigns weight of each node. The weight of each node reflects the importance of each node. So WFCC guarantees weighted fairness so all the rate adjustment in WFCC is done considering the local weighted fairness of the node. WFCC protocol divides the total time into equal intervals and at each interval parent node of node I which is indexed as i-1 sends piggybacked information about incoming rate and its total fairness based on which node I calculate its sampling rate and total transmission rate considering the weighted fairness. By using these both rates it calculates its incoming traffic rate which will be piggybacked in a packet and broadcasted to the all the nodes. Now the child node of the I suppose j overhears this information which it use for calculation of sampling rate and transmission rate based on the weighted fairness. Then node j will calculate its incoming traffic rate which will be broadcasted with weighted fairness. This process repeats in each node after equal time interval T For congestion detection WFCC uses the mechanism of the ration of packet service time divide by packet interarraival time.The main advantage of WFCC is no sharp rate reduction is there in WFCC protocol as we have observed while adjusting the rate the factors are very small. Due to this throughput of the system is maintained. Even WFCC have extended the weighted fairness of the node till 0.95 on averageBut as we have seen that at each time interval T the parent node broadcast the packet contains weighted fairness and incoming traffic rate which the child node will overhear so here there are large overhead of feedback in each time interval.

Traffic control way of congestion control offers good results but this technique is not suitable for all the applications. Traffic control technique adjusts the reporting rate i.e. it minimize the number of packets .In crisis state it is not desirable that we are decreasing the packets as the data generated is very vital in such a applications. So for such applications traffic control type of congestion control method is not suitable so resource control method is used. TADR [15] proposes the traffic control solution in which we the dynamic route is find out to spread the traffic in case of congestion scenario. It consider potential filed model in which it consider the two forces. First is Queue length force and second is depth force. And superposition of these forces will take the decision who will the parent of the node to form the now topology. As TADR doesn't only considers the shortest path it focuses on fairness of all the nodes so there will be good utilization of recourses. As the main design goal of the TADR is that it should not drop the packets as data is vital in some applications so instead of decreasing the rate spread traffic in different routes so it provides good RPR (Receiving Packet Rate)in burst traffic also. The main disadvantage of TADR is that there can be routing loops because of the algorithm. So routing loops cannot be avoided here.

In UHCC hop by hop congestion control is done so every hop calculates the congestion index. Congestion index is a parameter for the congestion detection. The congestion index is the difference between the buffer unoccupancy and the current traffic rate of the node. And if the congestion index is negative there are chances of congestion as the buffer size is less than the packets which are coming to the node. UHCC then checks whether there will be congestion in child node in the next interval if we suppress the traffic from the child node to the parent node. And based on that congestion tendency is calculated. If the congestion tendency is negative then there may be chances of congestion. Based on the aggregate of these negative congestion tendency of child nodes congestion tendency of the parent is calculated. Now UHCC checks whether node have the traffic capacity to handle this condition for that it calculate the traffic capacity as the total of buffer unoccupancy and the traffic which will go to its parent in the interval. Now the difference between the traffic capacity and congestion tendency will tell you whether there will be congestion or not. If the value is negative it tells you that there will be congestion so the node doesn't allow its source traffic and rate adjustment on transit traffic will be done. Larger the value larger the traffic rate is allocated to the child node. If the congestion index is not negative the rate adjustment is done to improve the performance of the system. While doing the rate adjustment it always consider the source traffic priority. The main advantage of UHCC is that the congestion tendency is considered. i.e. whether congestion will occur in the next interval in the child node is checked and accordingly rate adjustment is done. So even if some node goes off it will not affect the overall network throughput. The packet drop ratio in UHCC is very less even if we change the buffer size as congestion tendency is considered.

3 Proposed Work

In the proposed protocol the congestion detection is done using the difference between buffer unoccupancy and the total traffic rate as in UHCC[10].For the congestion control rate adjustment is used as in UHCC protocol and to improve the performance, in proposed way we are using rate control as well as resource control. The mechanism of rate control as well as bandwidth adjustment based on hops is added here.

So whenever rate adjustment is done for non congested as well as congested scenario the reporting rate given to the node is calculated as

$$R_{new} = R_{old} - ((N-h) * R_{old})/N)$$

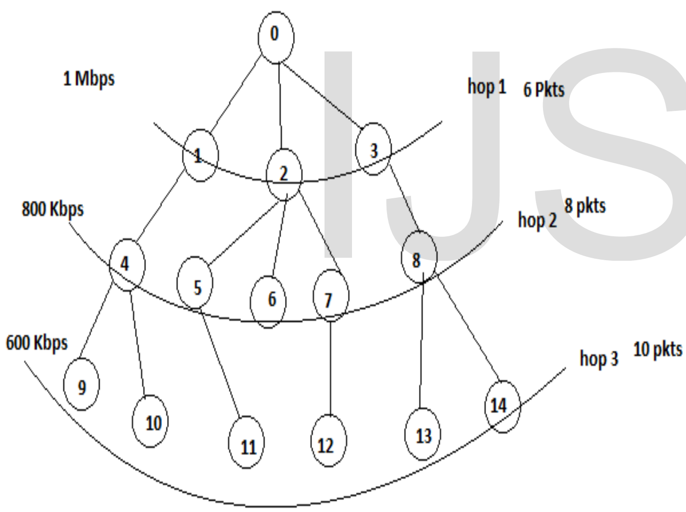

Fig 1: Network model for proposed algorithm

With the rate adjustment we are adding mechanism of bandwidth control as the near sink node has to face large traffic as it has its own traffic as well as it has to carry the traffic of the child nodes the bandwidth requirement of the near sink node is far more than the bandwidth requirement of the nodes which are in the farther hops.so as shown in the fig we are ensuring the maximum bandwidth to the near sink node and then at the mac layer based on the hop knowledge we calculate the bandwidth.

$$BW_{new} = BW_{max} - (h*(BW_{max}/N))$$

Where BW_{new} is the new bandwidth of the node. BW_{max} is maximum bandwidth allotable to the node for the MAC layer protocol it uses.N is the total number of hops in the current topology.h is the hop number from the sink of the current node in the network.Every time while adjusting the bandwidth if the new calculated bandwidth is lesser than 250 Kbps then we are assuring it bandwidth of 250 Kbps which is minimum requirement and generally assigned to the leaf nodes.

4 Results and Analysis

4.1.1 Experimental setup

TABLE II
EXPERIMENTAL SETUP FOR UHCC, MODIFIED UHCC COMPARISON

Parameter	**Value**
MAC Layer Protocol	**IEEE 802.11**
Packet Size	**512 bytes**
Number of Nodes	**20**
Reporting Rates	**15pkts to 50 Pkts**
Environment Size	**500 m × 500 m**
Routing protocol	**UHCC**
Simulator	**NS 2.32**

4.2.2. Packet Delivery Ratio Vs Buffer Size:

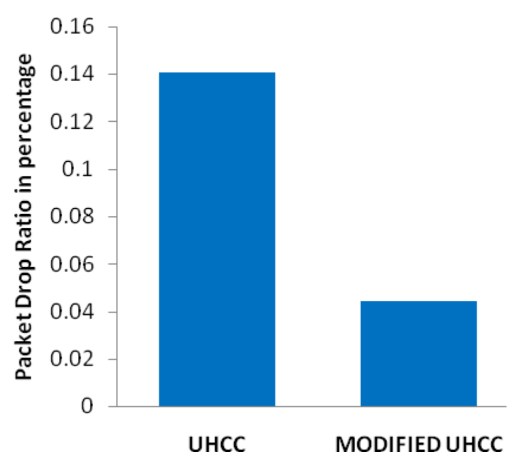

Fig 6: Packet Delivery Ratio Vs Buffer Size

Fig 6 is the graph of packet loss ratio in percentage verses buffer size. As we know when the buffer size increases the packet loss decrease as buffer can hold the maximum packets. But in if you observe the Modified UHCC's packet loss even if the buffer size is small it drops very less number of packets as in UHCC there is the mechanism of to detect con-

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gestion based in the congestion tendency in the next interval the rate adjustment component can alleviate the congestion very actively. In near sink node there is more requirement of bandwidth so we are doing the same here as we are giving the bandwidth where exactly it requires so we are getting the better result in modified UHCC.

4.2.3.Packet Delivery ratio vs reporting rate:.

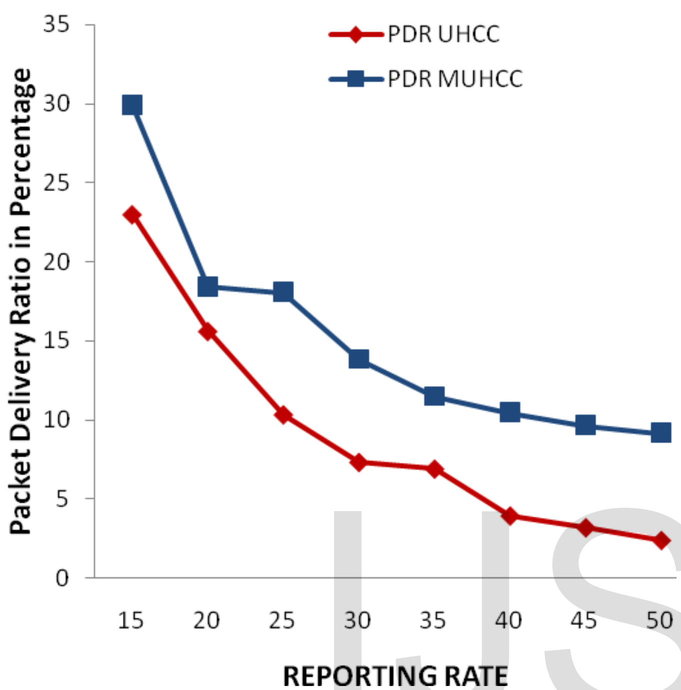

Fig 7: Packet Delivery ratio vs reporting rate

The figure 7 plots the graph of packet delivery ratio in percentage verses the reporting rate.The reporting rate varies from 15 packets per second to 50 packets per second. The graph shows that modified UHCC has better packet delivery ratio by 5 to 8 percentage. The improvement in the result is mainly because of the bandwidth adjustment. Due to employing high bandwidth at the near sink node where actually need is it reflects this into the improvement in performance.

4.2.4. Throughput vs. reporting rate:

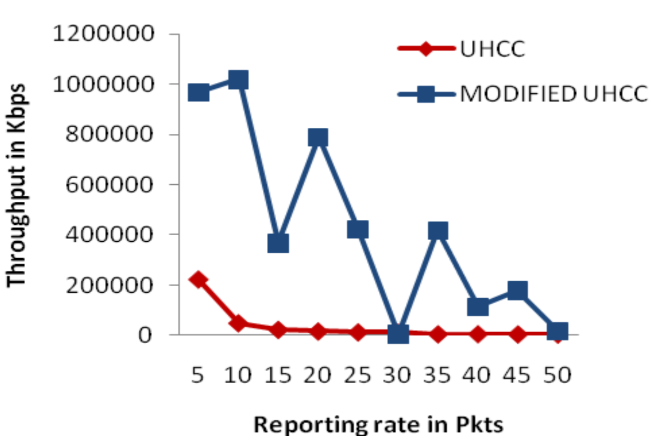

Fig 8: Throughput vs. reporting rate

The fig 8 plots the graph of throughput in Kbps as a function of reporting rate. The throughput of the system is defined as how many bits which were sent are received in one second. Here in UHCC as well as in modified UHCC with increase in reporting rate decreases the overall throughput of the system. We are getting the modifications till 80 percentages. As in modified UHCC the traffic requirement is fulfilled so less number of packets will drop and maximum bits will receive in 1 second so the throughput of the system has improved.

4.2.5. Throughput Vs. node density:

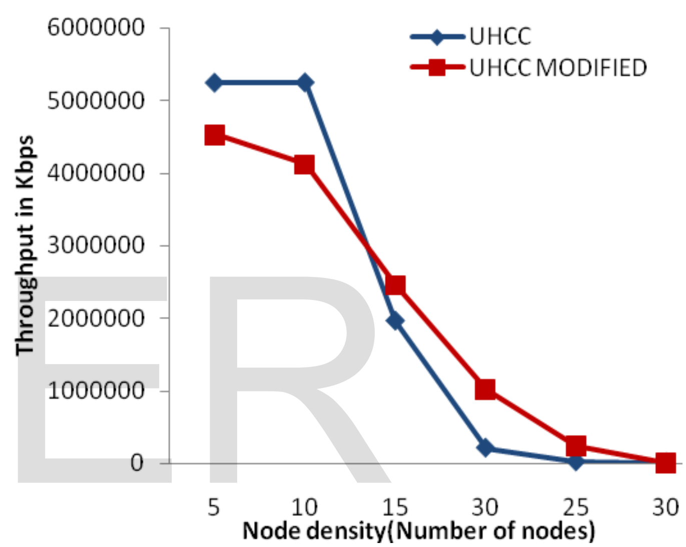

Fig 9 : Throughput verses node density

The fig 9 plots the graph of throughput in Kbps as a function of node density. From the graph we can say that that in sparsely deployed network UHCC is showing better performance than modified UHCC. With less number of packets the bandwidth adjustment doesn't show the effect which will be more visible when the number of nodes increases.

5 Conclusion

Proposed work is mainly for controlling the congestion in WSN. The effect of congestion in WSN is very worse as it affect the overall throughput of the system. The Packet delivery decreases to the great extend .There will be large number of packets will be lost with this and the delay will increase as the number of retransmissions increase so we must control the congestion.As improved UHCC consider the bandwidth, rate adjustment based on hops and congestion tendency so even on failure of node it gives good throughput and good PDR.

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