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Longer Distance Hop Count based Priority Congestion Control Technique for Wireless Sensor Networks

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LONGERDISTANCEHOPCOUNTBASEDPRIORITYCONGESTIONCONTROLTECHNIQUEFORWIRELESSSENSORNETWORKS

Strictly as per the compliance and regulations of:

Longer Distance Hop Count based Priority Congestion Control Technique for Wireless Sensor Networks

Neelu Rajput [α] , Dr. Dharm Singh [σ] & Dr. Naveen Choudhary [ρ]

Abstract- Wireless Sensor Network consists of large number of tiny sensor nodes (Tsodes) distributed in an area, having insufficient processing power, communicating over a network. These Tsodes are circulated in given network environment so that they gather data, process that data and send it to the destination. Rising large applications need to transport massive data packets to the sink node from different sensor nodes without having much loss of data packets in the network. Network must be escaped from the congestion, occurs usually at the Tsodes nearer to base station / sink node. Congestion not only causes packet loss, but also leads to unnecessary energy consumption as well as delay. Therefore, in order to extend network lifetime and improve fairness and provide better quality of service, developing a novel solution for congestion estimation and control is important to be considered. This paper proposes a approach of packet level priority for controlling the congestion in WSN. It uses the hop count value and the distance vector among sink and Tsodes. The technique avoids the congestion faster and improves the overall network throughput and delay too for WSN.

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I. Introduction

A wireless sensor network (WSN) is a network of hundreds or thousands of Tsodes(tiny sensor nodes), where each node is capable of sensing, processing the data and communicating with other Tsodes through the components such as transmitter and receiver. Usually these Tsodes are found in the form of accelerometer, temperature sensors , acoustic, thermal and visual sensors, these are used for sensing the environmental characteristic like lightning condition, sound, direction or size of any object. A typical WSN is usually installed for the task requiring very precarious duty but at the same time the system must be able to operate automatically without necessitating human caution while extending the lifetime of whole network. These WSNs devices are very small in size but the network puts some constrains on Tsodes like the limited computation capability, limited battery life and off course the limited memory or space of each Tsode. Hence, in order to deploy such network i.e. a WSN, these constraints must be considered before creating the network. The autonomous Tsodes of WSNs communicate with each other to exchange and to forward the data gathered by sensing the environment and its physical condition parameters.

Typically, WSNs are considered as the network of lighter operations, but sometime network may undergo the sudden fluctuations of large, massive and immediate synchronized needs of data, these needs may suddenly result in congestion. Alternatively, some Tsodes may be the reason of constant generation of data streams. And this data is transmitted towards a single sink/Base Station. These large numbers of packets at sudden instance of time make the network condition unbalanced as such traffic load is uncontrollable for limited link capacity. Various other reasons like single intermediate Tsode failure and security attacks can also make the condition worsened. The network must be protected from such congestion building situations in WSN environment. This paper explores the problems faced by various congestion controlling protocols in WSNs. We propose a new packet level priority-based congestion control protocol (PPCCP). We aids following:

1. We use hop count value and distance vector to decide the priority of every node in order to control the congestion while data is being transmitted from Tsodes to Base Station(Sink).

Hop count is the number of intermediate nodes between source and sink node in route while transmitting the upstream data.The distance vector is the distance(in meters) between source and sink node. It is more about avoiding the congestion rather than handling it.

2. It recognizes the priority dependent fairness among Tsodes so that high throughput can be achieved by controlling congestion at each node.
3. It avoids the high buffer occupancy. As a result it achieves the low packet delay and high link utilization.

The research paper is organized as follows: Section II gives a short description of congestion and their controlling phases for WSNs. Section III presents the priority based congestion controlling approach for WSNs. In Section IV, the existing techniques have been presented, and then in troducinga new technique to

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mitigate the congestion in WSNs. Simulation results, conclusion and references are presented in the completion section.

II. Congestion in WSN

Congestion is an additional problem that must be considered carefully in transport protocols because the impacts of congestion are very drastic in terms of both packets and energy loss. And these influence the overall network delay, through put and efficiency of WSN. Congestion cannot be neglected when the priority of traffic is high as sometimes in some critical areas the loss packets and delay can bring down the system to failure permanently. It is also a major reason for cost concern. WSN needs very high attention towards the congestion control as:

Energy (Transmission of one KB data)

=Energy(Execution of three million instructions)

The above statement shows that the loss data/ packets is not simply affordable in WSNs. Network must be protected from congestion.

Packets are discarded because the network is not adopting any fairness among Tsodes; sometimes the higher priority traffic is compromised and discarded unselectively. Network is needed to afford high energy consumption for communicating the data and this flooded data causes the failure of channels. These over flooded channels make the life of whole network diminished. The problem of congestion increases when some nodes are ideal but still they are wasting the energy by occupying the routes worthlessly. The drastic impacts of congestion cannot be ignored, an effective step is needed to control the congestion while there are various schemes have been coined to mitigate the congestion, these schemes are usually found in the form of differentiated and priority based technique.

Each Tsode has a limited battery life; the undesired retransmission of packets requires the higher power consumption, which is worthless when the packet drops increases above a threshold value. Because, the life of network has already been deteriorated.

Typically sensor networks suffer from two types of congestion. One of them is node level congestion that is triggered by node's queue or buffer overflow and results in high packet loss, and high queuing delay also. The lost packets are required to be retransmitted and therefore it requires more or additional energy.

When the architecture of network is consisted of a simple flat topology, a single sink/base station node design, the probability of occurring congestion is higher at the node deployed nearer to the base station. These nodes are called as intermediate nodes also, having higher probability of congestion because all data is routed through these nodes.

Congestion of packets at such nodes causes the high packet loss as sometimes the number of source Tsodes connected to intermediate nodes is very high. The energy consumed in such dropped packets is also worthless after congestion. The problem increases when large number of Tsodes attempt to access the same medium or channel at the same time for packet transmission. The number of packets goes beyond the capacity of channel and this state makes the network condition worsened. It drops the channel utilization factor by great extent. Consequently it decreases the overall network throughput. The congested WSN is not efficient in terms of energy as well as in terms of QoS, makes the network unreliable also.

III. Congestion Control in WSN

a) *Congestion*

Congestion occurs mainly in the sensor to sink way when packets are transmitted in a many to one direction. Therefore mainly various congestion control techniques are invented to lighten the congestion in this direction only.

Congestion control generally goes through three phases: Detection of Congestion, notification, and congestion handling i.e. rate adjusting. The proficiency of any wireless sensor network can be determined by considering the following qualifying parameters: 1.System must be energy efficient; loss of power consumption is undesirable for such networks.2. Each Tsode must be treated impartially, fairness should be maintained to avoid the unwanted packet loss, and queue management is also an essential feature for any node. 3. Network must be responsive about the overall throughput, delay and packet loss rate, it is very important to be cautious about the networks Qos all the time.

IV. Priority based Congestion Control Technique-an Overview

The section presents the scheduling rate based priority congestion control technique for WSNs. Usually WSN is considered as the network of light load or slighter capacity but sometimes large number of nodes try to transmit the packet to a single sink node or a single intermediate node. .Congestion occurs mainly in the sources to sink directions when packets are transmitted in a many to one way. Therefore, many congestion controlling techniques usually aim toward this direction only.

PCCP(Priority Based Congestion Control Protocol) is designed to acquire following goals : i) In every WSN ,each sensor node might have different priorities due to their functionality or their location. So a PCCP technique is required to guarantee the biased equality among all nodes where each intermediate node gets a biased fair throughput from all Tsodes. 2) Network must have such congestion controlling techniques that should be able to improve energy efficiency and various Qos must not be compromised at any stage of transmission.

PCCP tries to confine the packet loss rate as low as possible by allowing the biased fairness for all Tsodes and it is also responsible for controlling the overhead of multipath routing. PCCP operates in three stages: Detection of Congestion, Congestion Notification Implicitly, and congestion handling/priority based flow rate adjustment.

First stage analyses the packet service time and packet inter arrival time to detect the congestion. It results in congestion detection by using this ratio, and therefore it provides very helpful and rich congestion detection information.

Priority based techniques introduces a sensible approach for notifying the congestion to network, called as implicit congestion notification. It does not need the extra overhead of notification bit explicitly. Information of congestion is implanted in the header field itself.

Finally, the PCCP technique aims to design the most promising approach for controlling the traffic scheduling rate at each Tsode to make sure that no impartiality is found among Tsodes. Throughput or fairness is not compromised for any Tsode. Here each Tsode/source is allotted a priority value. The rate adjustment algorithm is designed to sure that:1 Large Channel Bandwidth is allotted to the Tsode having higher priority value all the time. 2. No impartiality for two Tsodes having equal priority. 3. Another aspect for maintaining the fairness among all Tsodes is to ensure that more bandwidth should be allotted to the node having higher traffic generation capability. The use of three types of priority index makes the PCCP with highly flexible in weighted fairness.

a) Proposed Technique

i. Network Model

The upstream congestion controlling approach for a WSN has been proposed in the paper. It maintains the single-path routing. In Fig. 1, Each Tsode (Tiny Sensor Node) generates its own continuous source traffic and these all Tsodes form many-to-one convergent stream of traffic towards the upstream path. We assume that they are implementing CSMA-like MAC protocol. Each Tsode is founded to have two categories of traffic: source and transit. The first is generated at each Tsode(Tiny sensor node) locally , while the second one is streamed from other intermediate nodes. Hence each Tsode can play the role of a source node or intermediate node or both. The intermediate node of a specific Tsode can be elucidated as the node through which the traffic of this specific source node is being routed .Fig 1 shows that, the Tsode A has 4 intermediate nodes and node B has 2 intermediate nodes so Tsode B play two roles of both source and intermediate node, concurrently.

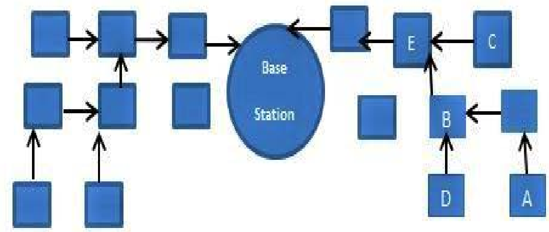


Figure 1 : Network Model

Fig 2 Depicts that by introducing a new scheduler between the network and MAC layer, the approach claims to adjust the traffic scheduling rate below a threshold value so that congestion can be avoided atthe prior stage only. Traffic scheduling rates are found in the form of origin and transit traffic rate.

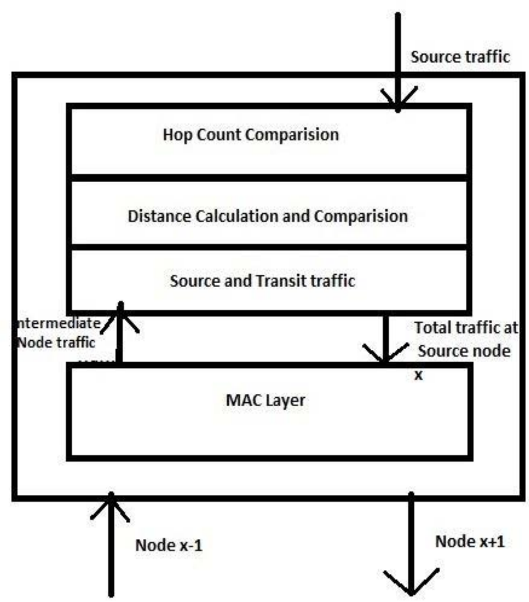


Figure 2 : Node Model

V. Longer Distance Hop Count Prioritization Congestion Controlling Approach

To avoid the congestion, we assign the priority to each node on the basis of their hop count value i.e the number of hops between the source node and Base Station (Sink). When two or more nodes have number of hop count value then the node with the longest distance is assigned higher priority to send the packets first.

To handle the congestion, whenever congestion is detected at any node, the approach says that the packets from higher priority nodes must not be dropped. The higher priority packets are transmitted first without being dropped.

Two novel approaches were coined for congestion control:

The first is AIMD(Additive Increase and Multiplicative Decrease) this approach uses the principle of detecting the congestion first and then it tries to solve the problem. It is being employed for TCP protocol. The information about congestion is propagated through congestion notification message bit. Unfortunately, AIMD is found to be inefficient as network has already made much loss of packets and the traffic scheduling rate adjustment procedure is not quite effectual after the congestion has already been detected. The congestion notification message does not contain the adequate information about the congestion. Sometimes the approach starts to work after the channels /links have already been declared failed by the network protocols.

To overcome the problem of AIMD, a new approach named as PRA(Priority Rate Adjustment) was introduced; the approach is capable to control the congestion to a great extent. Before the congestion is detected at any node, we can follow the given priority decision procedure to avoid the congestion .

Priority_Decision():

(1)Initialization with default values

(2)flag=0,i=0,node=-1,I=0,maximum=2500,Distance=0,ThresholdDistance=0,Packet_Size=256,Interval=0.05,count=0,p=1

(3)IF Packet_Type==Broadcast then

(4)Src=SourceNodeId, rd=Receiver,Maxn=src,time=Total Time for Broadcasting,fsnk=Final Sink ,fsnd=Final Source ;

End If

(5)If Packet_Type ET Upstream Then

(6)If NodeId GTET 0 AND NodeId ET 100 Then

(7)If Node NOTET NodeId Then

(8)flg=0 End If

(9)IF flg==0 Then

(10)Node=NodeId,flg=1

(11)s[i,1]=NodeId AND s[i,2]=Node_X_Coordinate AND s[i,3]=Node_Y_Coordinate

(12)Increment i by 1

(13)to(16)End If

(17)x1=s[src,2] AND y1=s[src,3] AND x3=s[fsnk,2] AND y3=s[fsnk,3]

(18)whileMaxNNotETFsink /* MaxN is the Node_ID having longest distance

(19) for each integer j ET 0 AND j LT i

(20)If j NOTET src Then

(21)x2=s[j,2] AND y2=s[j,3]

(22)d= Distance between intermediate/Neighbour node and Source/Tsodes node /* coordinate values(x1,y1) & (x2,y2) are used to calculate the distance

(23)IF d LTET 160 Then

(24)If(s[j,1] ET fsnk) Then

(25) MaxN=s[j,1] AND Distance=d ; break ; End if

(26) Else ni=s[j,1] AND x21=s[ni,2] AND y21=s[ni,3]

(27) dn=Distance between Neighbour/Intermediate node and sink node

(28) If max GTdn Then

(29) maximum=dn AND MaxN=ni AND Distance=d

(30)End If; End Else

(31) and (32) End If

(33) Increment I by 1 ; End For loop

(34)Maximum=2500

(35)src=MaxN /*Now the Node With the Highest distance is source,which goes first

(36)x1=s[MaxN,2] AND y1=s[MaxN,3] AND m[I]=Src AND Increment I by 1

(37)ThresholdDistance=ThresholdDistance+Distance

(38)Distance=0 AND Increment count by 1

(39)If count GT Maxn Then

(40)I=-2 BREAK

(41)End If ; End While ;

(42)END Priority_Decision

First the paper considers it to be a single-path routing, where each packet is routed through the chain of Tsodes connected in single parent fashion.

1) The nodes within in the range of 160 meters from any particular node are considered as neighbouring nodes. Among all these neighbouring nodes, the node which is at longest distance from Base Station is chosen to send the Packets as First Source Tsode.

2) The traffic generated by the highest distance node is given the priority to be scheduled first.

3) The decision of priority can be taken through the hop count value of each packet also at initial stage . Higher the hop count value, obtains the highest priority to schedule the traffic first.

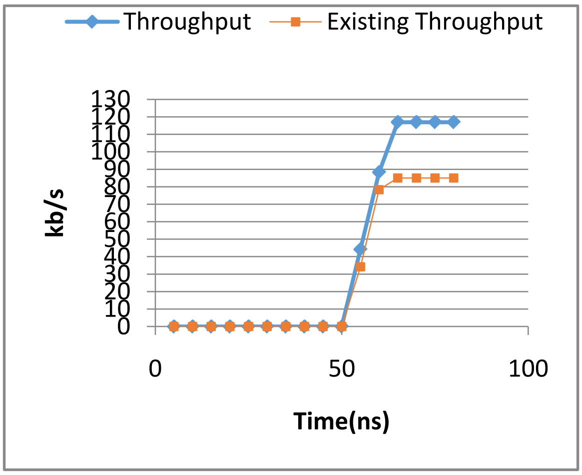
However if congestion is detected at any node then it can be handled in the similar fashion. For e.g. If any intermediate node x gains the information of congestion about the Tsodes connected to this through the congestion notification. Node x then tries to mitigate congestion by altering the transit traffic rate or Tsode source traffic generation rate.

VI. Simulation Results

Even though PCCP could be affordable in terms of time, space complexity and consumed energy to mitigate the congestion in network, but the proposed approach shows that how PCCP can be extended to mitigate the congestion while showing the improvement in terms of various performance parameters like throughput, delay and number of packet drops.

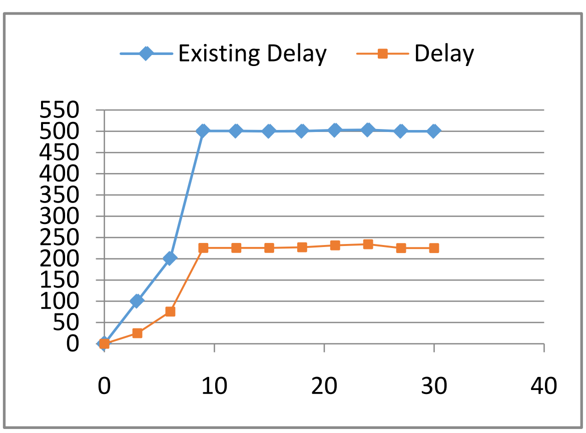
a) Throughput

The following graph shows that how at simulation time=50 ns , the throughput is increased from 80 kbps to 120 kbps. This is because some nodes always gets the higher priority to send the data and the packet drop of such nodes is always avoided so this can be seen here that the throughput is constant for such approach and higher than existing technique i.e. PCCP.



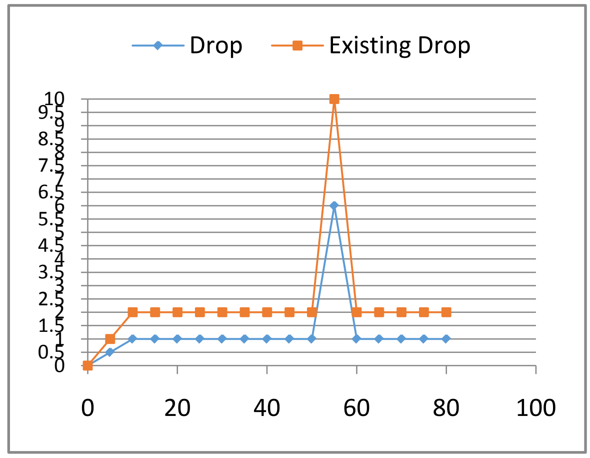
b) Delay

The following graph shows the overall network delay. Delay decreases dramatically as fairness is always maintained, the node at highest distance claims to be the first sender, the delay for such nodes is lowest and other nodes also gets their transmission on low delay because they are not so far from base station , it does not take high delay for such nodes.



c) Packet Drop

The proposed approach claims to minimize the number of packet drops because the traffic generated at higher priority node will never be allowed to compromise at any instance of time. Longer the distance of source node from sink, gets higher priority and in this way the packet transmitted from such nodes are never dropped. The following graph shows the number of packet drops at different-different instance of simulation time.



VII. Conclusion

The proposed longer distance hop count based approach for Wireless Sensor Networks works on the principle of packet level priority for each node. The results show that how it can be proved better than the existing one, when it is used to extend the PCCP. Simulation results show that: (1) Proposed approach achieves high throughput; (2) It claims to avoid/reduce packet drop and therefore improves energy-efficiency, and graphs show the lower delay than existing one.

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