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Distributed Algorithm for Independent Fairness Management to Control the Congestion in Wireless Sensor Network

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***Abstract:*-Congestion in wireless sensor networks occurs when traffic load allocated to any sensor node is beyond its capacity. To support traditional quality of service like packet loss ratio, packet delay, wasting energy and throughput, congestion has to be controlled in the wireless sensor networks. To do this, a distributed congestion control algorithm is used for tree based communications. For each node, fair and efficient transmission rate is assigned. In this algorithm, aggregate output and input traffic rate is monitored in each node. Based on difference of the two, a node decides to increase or decrease the bandwidth allocable to a flow originating from itself and the flow is being routed through it. The design allows for the development of a generic utility and efficiency controlling module. Separation of efficiency and fairness controlling modules enable each one to use a separate control law, thereby providing a more flexible design. The working of congestion control is independent of the routing algorithm and is designed to adapt to changes in the underlying routing topology.**

***Keywords* –Wireless Sensor networks, Congestion Control, Fairness.**

I.INTRODUCTION

Wireless Sensor network (WSN) consists of multiple tiny, low powered, randomly distributed sensor nodes. WSNs can be used in many applications such as habitat monitoring [1], image sensing [2] medical applications and health monitoring [3, 4, 5]. In WSN, different types of data are generated and sent to the sink by nodes. Nodes may be mobile or stationary.WSN can be classified into two categories based on data collection and transmission. Large numbers of sensor nodes are simultaneously active in transmitting the information, data traffic increases beyond the capacity of network and this leads to congestion in the network. The congestion traffic is categorized into two such as downstream traffic and upstream traffic. The downstream traffic from the sink to the wireless sensor nodes is a one-to-many communication model. The upstream traffic from sensor nodes to the sink is a many-to-one communication model.

Symptom of congestion in sensor networks is the increase in buffer drop and packet delay. Another result of congestion in WSN is the degradation of radio channel quality. This also affects the energy efficiency of WSN. Furthermore, providing fairness to each flow is also highly desirable. Fairness is concerned with the throughput of flows sharing a resource.

A. OBJECTIVES

1) Providing distributed and adaptive techniques for controlling congestion in sensor networks.
2) To obtain optimal transmission rate for the nodes that is both fair and maximum efficient.
3) Allows modification of one of the modules without redesigning the other one.
4) The design should be independent of the underlying routing algorithm and adapt to changes in the underlying topology.
5) Provide flexibility to a greater extent.

II. RELATED WORKS

In wireless sensor networks, there are many congestion control techniques exists such as Interference Aware Fair Rate Control protocol(IFRC)[6] and Rate –based Fairness –Aware Congestion Control protocol(FACC)[7] control congestion and achieve fair bandwidth allocation and transmission rates for all nodes. But these techniques have disadvantages. IFRC uses queue sizes to detect congestion and suffers from stability. It detects congestion at a node by monitoring the average length of queue; it communicates congestion state to exactly the set of potential interferer. FACC control congestion based on queue occupancy and hit frequency. FACC which controls congestion and achieves approximately fair bandwidth allocation for different flows. Adaptive Rate control(ARC)[8] monitors the packets in the traffic stream as well as in the route –through traffic. Each nodes estimates the number of upstream nodes and bandwidth is divided equally between the route-through traffic and generated traffic

III. PROPOSED SYSTEM

The main objective of the proposed system is the decoupling of the fairness from utility (or efficiency) in the network, using two separate modules for controlling utility and fairness, modification of one of the modules without redesigning the other one independent of the underlying routing algorithm and adapt to changes in the underlying topology. Reduce the delay in delivering a packet to the sink. Finally, lower the queue size to achieve higher throughput.

IV. DISTRIBUTED CONGESTION CONTROL ALGORITHM (CCA)

CCA is a distributed and flexible algorithm that eliminates congestion within sensor networks and ensures fair delivery of packets to a sink node.CCA is designed to work with Mac (CSMA/CA) protocol in the data link layer. Further assuming that MAC layer provides link –layer transmissions.MAC protocol uses sensing the medium before sending the packet, if medium is busy then protocol performs random back off. Collisions are detected using ACK's [9]. If collision has occurred then packet is retransmitted. Consider a set of N wireless sensor nodes and each wireless sensor node has an infinite amount of data to be sent to a single destination. The nodes will create data traffic and route traffic through the other nodes. That is all the nodes can act both as a source and a router.

The wireless sensor nodes sense the information periodically and encode the information into data packets. The encoded information in the form of data packets are then sent to the sink. Let f_i be the flow originating from the node i and r_i be the rate at which the flow f_i is generated into the sensor network. It is assigned that the data flow is fair enough and the data rate is efficient. The rate does not include the rate at which node i forwards the traffic. When there is a collision on the link near the node i, then the node i and its neighboring nodes should reduce the channel utilization in order to prevent further link-level congestion. The protocol will improve the channel quality by including a phase-shifting effect among neighboring nodes.

The congestion control algorithm executed at each node every control interval. Control interval is defined as the time period over which a node takes a control decision regarding the increase or decrease in the transmission rates of the flows originated by the node itself and the flows being routed through the node.

The congestion control algorithm is invoked every control interval at the gateway nodes. A node is called a gateway node if it is one hop away from the sink.

Algorithm Requirements

The following are the congestion control algorithm requirements.

i. Measure the average aggregate output rate.
ii. Measure the average aggregate input rate.
iii. Computation of the total change in aggregate traffic required to control efficiency.
iv. Assign the total change in aggregate traffic into individual flows to obtain desired fairness.
v. Propagating the upstream rate.
vi. Measure the control interval.

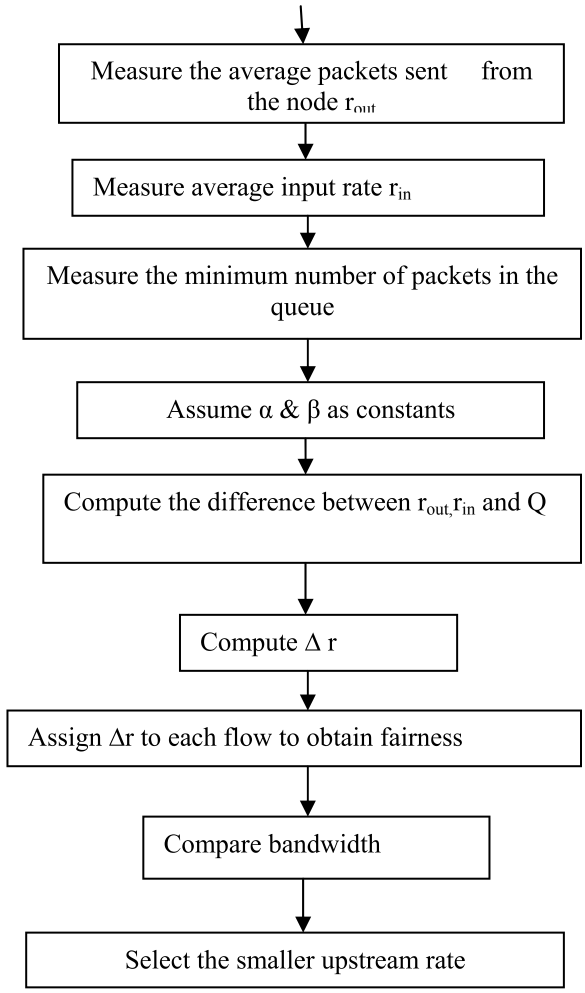

Fig .1: Flow chart of CCA

Congestion control algorithm

Congestion control algorithm[12] has the following steps to be executed at each node in every control interval.

Step 1

Measure the average rate (r_{out}) at which the packets are sent from the node, the average aggregate input rate (r_{in}), and the minimum number of packets in the output queue which is seen by an arriving packet in a control interval.

Step 2

Based on the difference between r_{out} and r_{in}, and Q, compute Δr. This is the total change in aggregate traffic.

$\Delta r = \alpha \text{ x } (r_{out} - r_{in}) - \beta \text{ x } (Q/\gamma)$.

Step 3

Assign Δr into individual flows to achieve fairness *Step 4*

Compare the bandwidth computed for each flow with the bandwidths. Use and propagate the smaller rate upstream.

A.Estimation of average output rate

Let t_{out} be the time to transmit a packet ,measuring from the time packet has sent from the network layer to the Mac layer to the time MAC layer notifies the network layer has transmitted the packet successfully. The effective rate rout packets per second is the inverse of the time interval t_{out}. The tout is obtained per packet at a particular instance of time taken to transmit the packet. Computing the average value using exponential moving formula,

$\overline{t}^{i}_{out} == (\alpha_{out}).T_{out} + (1 - \alpha_{out}).\overline{t}^{i-1}_{out}$

B. Estimation of average input rate

Let $t_{in}$the inter packet arrival time at a node ,measured from the time a packet was enqueued to the time next packet is successfully enqueued.The average value of $t_{in}$is calculated using exponential moving average formula,

$\overline{t}^{i}_{in} = (\alpha in) .T_{in} + (1 - \alpha_{in}). \overline{t}^{\,i-1}_{in}$

C. Control efficiency

The efficiency controller computes the increase or decrease transmission rate of the traffic in the control interval(in packets).This is computed as:

$\Delta r = \alpha \times (r_{out} - r_{in})\beta \times (Q/t_{ci})$

Where t_{ci} is the control interval of the node, α and β are constant parameter. The quantity (r_{out}-r_{in}) can be positive, negative or equal to 0.If (r_{out}-r_{in}) >0 then the link is underutilized and transmission rates of the flows can be increased. If (r_{out}-r_{in}) < 0 then the link is congested and transmission rates of the flows need to be decreased. In case (r_{out}-r_{in}) equals to zero then input capacity matches the link capacity.

D. Controlling fairness

The task of the fairness module is to assign the feedback computed by the efficiency module into the individual flows.

E. Propagation of rate upstream

To propagate the congestion signal upstream, the broadcast nature of wireless medium is used which enables the child node to overhear the transmission rates of its parent.

F. Estimation of control interval

Control theory states that controller must react with the controlled signal in a meantime. Else, the controller will lag behind the system being controlled and it will be ineffective. Thus the controller of congestion control method makes the signal control decision on the every average feedback delay period.

V.IMPLEMENTATION

The work has been implemented in NS2. NS2 is discrete event simulator and works well for MAC layer protocols. MATLAB is a universal simulator for many research area. But it is unfortunately weak or does not support all networking components. Simulink MATLAB is useful and flexible to study the effect of different physical layer parameters on the performance of wireless sensor networks.NS2 is written using C++ language and uses object oriented tool command language (OTCL).The simulations are carried out using transmission range 1500 x 1500 dimension of topography.50 sensor nodes are deployed randomly for the simulation. The network topology used in this simulation is tree structure formation. Sensor nodes forms a tree structure using random wave mobility with a speed ranges from 0 m/s to 10 m/s and the buffer size is set to 512 packets

VI. RESULT ANALYSIS

The proposed algorithm tested on an NS2 simulator. The results indicate that the proposed congestion control mechanism can achieve high delivery ratio, low delay for all nodes in the networkThe distributed congestion control algorithm evaluate the network performance based on the metrics:

1.Throughput
2. Delivery ratio
3.Delay.

Throughput: Total number of packets sent from source and received at the destination.
Delivery ratio: Number of packets received at the destination without loss of data.

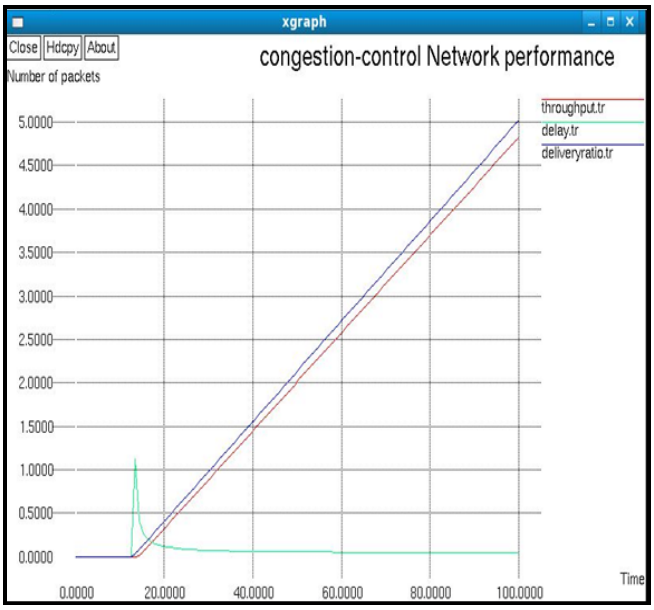

Fig 2: Congestion Control Network performance.

The above Xgraph shows that higher throughput is achieved, high delivery ratio and delay in delivering the packets to the sink node is reduced.

VII.CONCLUSION

The distributed algorithm for congestion control in wireless sensor networks that seeks fair and efficient rate to each node.The algorithm requires each node to monitor their aggregate input and output traffic rate, Each node decides to increase or decrease the transmission rates of itself and its upstreamnodes depending upon the difference.The results indicate that the proposed congestion control mechanism can achieve high delivery ratio, low delay for all nodes in the network, and can operate the network at an optimal point.The proposed algorithm has end-to-end delay in delivering packet to the sink is less compare to hop-to-hop flow control. The network life time of the proposed method is more compare to hop-to-hop flow control. Finally, proposed method is independent of the underlying routing algorithm and can adapt to changes in the routing topology. In future different fairness modules can be implemented.

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