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Cross-layer Based Congestion Control and Scheduling for MANET

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Abstract

The emerging MANET is extending the scope of resources to mobile devices and sensors that are connected through unreliable networks. Nowadays the number of mobile device users is increasing dramatically and the mobile devices provide various capabilities such as location awareness that are not normally incorporated into fixed mobile resources. Nevertheless, the mobile devices exhibit inferior characteristics such as poor performance, limited battery life, and unreliable communication, compared to fixed Grid resources. While routing the network, packet loss occurs due to link failure and congestion. Focusing on packet drop due to link failure results in the loss of resources, hence packet loss due to congestion is given a vital importance. This paper proposes to develop a jointing scheduling and congestion control in a multi hop MANET First, this paper present a cross layered model of energy efficient congestion detection and control mechanism. By identifying the causes of MAC layer packet drops, unnecessary route error propagations and route re-discovery procedures can be avoided. Once a wireless link experiences packet loss at MAC layer due to signal interference, it can be inferred that the contention area in which the link resides is congested.

Key words-Congestion detection, Congestion control, flow control, link quality, link quality

Introduction

A Multihop Mobile Ad-hoc Network (MANET) is a group of self-organized mobile nodes, which are connected with relatively low bandwidth wireless links. Each node has its own area of influence, which is called a cell, only within which others can receive its transmissions. In MANET there are no fixed infrastructures so nodes are free to roam, the network topology may change rapidly and unpredictably over time, and nodes automatically made their own cooperative infrastructures [1] [2] [3]. There are various applications of MANET like video conferencing, rescue operations, military applications, Disaster Management etc. [2]. A MANET is a multi-hop wireless network that is fashioned dynamically by an addition of mobile nodes without the aid of a federal coordinator. In Multi-hop Mobile Ad-hoc Network, if two nodes are not in the radio propagation range, a multi-hop, via one or more intermediary node, is mandatory to forward packets [4].

Congestion control component controls the rates at which users insert data into the network in an attempt to ensure that they fall inside the capacity region of the network [7]. Congestion control can be simplified as a source-rate regulator, and queue lengths of links play the roles of Lagrange multipliers [8]. The main objective of congestion control is to limit the delay and buffer overflow caused by network congestion and provide better performance of the network [9].

Scheduling is the scheme by which threads, processes or data flows are given access to system resources. Scheduling describes the way in which resources are divided between customers (packets) and the order in which they are served. Scheduling mechanisms control the transmission process by indicating which packets must be transmitted and which packets must be dropped. Power Aware Scheduling minimizes the power consumption of the system. By using Power Aware Scheduling we can efficiently use the energy [5].

The node mobility and frequent disconnections affect the resource availability thereby causing unreliability for job scheduling [11][12]. Because of the inappropriate scheduling, it results in discriminating mobile devices with less performance but with the enormous number of population and also incurs the decrease of the Grid resources' utilization [12] .Time consumption can be more because the transmitted data packets visits the entire nodes, which comes in the way and it will wait till the reception process is completed [13].

Since scheduling provides data flows that are given access to system resources and control the transmission process by indicating which packets must be transmitted and which packets must be dropped. So by apply scheduling, we can save time and energy both, and congestion control component controls the rates at which users insert data into the network in an attempt to ensure that they fall inside the capacity region of the network so by jointing these two methods we can reduce the delay and energy consumption in transmission of data.

This paper propose to develop a jointing scheduling and congestion control in multi hop MANET First, this paper present a cross layered model of energy efficient congestion detection and control mechanism. By identifying the causes of MAC layer packet drops, unnecessary route error propagations and route re-discovery procedures can be avoided. Once a wireless link experiences packet loss at MAC layer due to signal interference, it can be inferred that the contention area in which the link resides is congested.

Literature Review

Phuong Luu Vo *et al.* [15] have discussed about how to inject the elastic traffic into the network to attain the maximum utility of elastic traffic. The authors present a framework of cross-layer design using node-centric formulation for multi-hop wireless networks with both inelastic and elastic traffic. The author proposed a joint algorithm for rate control, routing, and scheduling. The Greedy distributed scheduling is introduced to implement scheduling in a distributed sense. In this paper the rate control, routing and scheduling problems are decomposed by using the Duality method. This solution not only exploits the consumption of the capacity, but also guarantees the fairness of the elastic flows. Performance metrics like end-to-end delay and inelastic rate has been discussed in this paper. Max-weight scheduling needs the knowledge of not only weight of the entire links in network, but also all the possible scheduling policies in each calculation at each time-slot. Hence, the updates of the link weight information will overhead the network. It also needs to discuss the delay and energy consumption of the system.

P. K. Huang *et al.* [16] have discussed about problem related to end-to-end delay performance in Multihop wireless networks. The authors proposed a new joint congestion control and scheduling algorithm for multihop wireless networks with fixed-route flows operated underneath a common interference model with interference degree K. Their proposed algorithm combines window-based flow control with a new rate-based distributed scheduling algorithm. The proposed algorithm is completely distributed and needs a low per-node complication that does not enlarge through the network size. The performance metrics like end-to-end delay and throughput have been discussed in this paper. When the grid size is increased from 3 to 10, the average delay of proposed algorithm still increases roughly linearly with the number of hops, and, at all step sizes. It needs to analyze this algorithm in dynamic routing.

Fan Qiu *et al.* [17] have discussed about the problem of delay and channel perturbations in joint congestion control and scheduling. The authors proposed a robust joint congestion control and scheduling algorithm ROCS to solve the resource allocation predicament in time-varying multihop wireless networks with the existence of time delay. The basic idea behind ROCS is Capacity Space Mapping, that combines the slow time scale part of the original channel capacity and a margin estimated from the fast time scale part, to form a new capacity space. The problem of cross-layer resource allocation is solved by a control algorithm which encloses two closely coupled components: Link Scheduling and Congestion Control. Link Scheduling manages wireless link exploitation on a greatest weight basis, and Congestion Control assigns flow rates according to congestion feedback information. The performance metrics like t flow rate (sending rate), throughput (aggregate receiving rate), queue size and queue loss have been discussed in this paper. Since reducing of queue overflows carries significance in wireless communications so it should be discussed and reduced.

Zongrui Ding *et al.* [18] the authors discussed about joint problem of congestion control and scheduling with multi-class Quality of Service (QoS) requirements. The authors proposed two methods which is using per-next-hop-queue instead of per-destination-queue, which significantly condenses queuing overhead and a Sliding Mode (SM) approach to designing a distributed controller for the congestion control problem even as satisfying multi-class QoS necessities in the multi-path and multi-hop scenario. The performance metrics like transmission rate has been discussed in this paper. The simulation is done only for one hop transmission is should be analysed for multi hop transmission.

S. Jahromizadeh *et al.* [19] have discussed about problem of bounded packet end-to-end delay in multihop wireless networks. The authors proposed the current utility maximization-based rate control and scheduling solutions for multihop wireless networks. The authors proposed distributed algorithm that is integrated into their previously proposed rate control and scheduling algorithms. The proposed algorithm accomplishes fairness based on the delay constraints, and facilitates highest utilization of network capacity. The performance metrics like end-to-end delay and transmission rates has been discussed in this paper. The equilibrium end-to-end delay are approximately 154 and 160 milliseconds it need to be improve more and convergence speed is slower which also need to be improve.

Problem Identification and proposed methodology

A. Problem Definition

In [15], there is a problem of overhead due to updates of the link weight information. [16] has problem of increment of average delay when grid size is increased from 3 to 10. [17] needs to discuss queue overflows, [18] needs be analyzed for multi hop transmission and in [19] convergence speed is slower which also need to be improved.

Hence there is a need of minimizing the delay in multi-hop MANET by using joint scheduling and congestion control process. So in proposed solution this paper develops a Joint Scheduling and Congestion Control process to minimize the delay in multi-hop MANET.

This paper presents a cross layered model of energy efficient congestion detection and control mechanism. By identifying the causes of MAC layer packet drops, unnecessary route error propagations and route re-discovery procedures can be avoided. Once a wireless link experiences packet loss at MAC layer due to signal interference, it can be inferred that the contention area in which the link resides is congested.

B. Proposed Solution

Congestion detection can be done at MAC, network and transport layers and the cumulative result is considered as level of congestion. Congestion detection is carried out by measuring degree of congestion at the above 3 layers [20]. Actually, congestion is determined by the channel condition and interference metrics at MAC layer, packet drop rate and delay metrics from network layer and buffer utilization and packet loss at transport layer. The degree of congestion at each relay hop together decides the degree of congestion at path level traffic from source to destination node.

i. Congestion Detection Phase

The aim of the proposed congestion detection mechanism is to capture degree of congestion at relay hop level node with maximal accuracy. In proposed model, the detection mechanism is decoupled from other activities of the MAC layer such as link reliability analysis and buffer size analysis. The detection model extended to detect the congestion at traffic level, which is based on the degree of congestion measurement at relay hop level node.

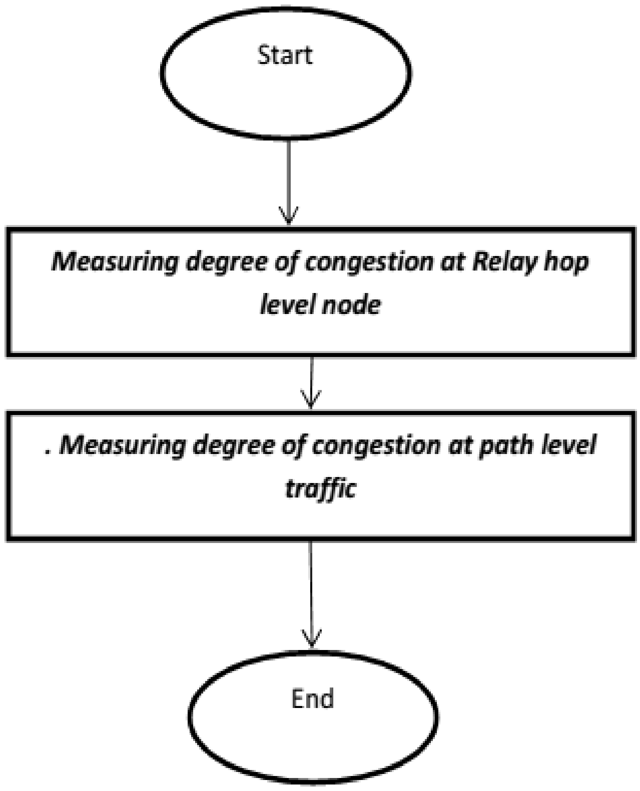

Figure-1 modular diagram

a. Measuring degree of congestion at Relay hop level node

Nodes in the ad hoc network exhibit a high degree of heterogeneity in terms of both hardware and software configurations. The heterogeneity of the relay hop nodes reflect as assorted radio range, maximum retransmission counts, and buffer capacity. The degree of channel loading, packet drop rate, and degree of buffer utilization at relay hop level node is minimum combination to find the degree of congestion. The usage of these three functional values supports to decouple the congestion measuring process.

The degree of channel loading, packet drop rate and degree of buffer utilization together provide a scope to predict the congestion due to inappropriate ratio between collision and retransmission count. When retransmissions compared to collision rate are significantly low then egress delay of relay hop node will increase proportionally and this leads to congestion and reflected as congestion due to buffer overflow.

The formulas are as follows-

Channel loading=$CH_l = CH_c/CH_{av}$ (1)

Where CH_c= channel requirement coming

CH_{av}=channel available.

Packet drop rate=$P_{dr}= P_s/P_r$ (2)

Where P_s=packet send

P_r= packet received

Buffer utilization=B_u

Retransmission =RT

Collision rate= CR= $(CH_l+ P_{dr})/2$ (3)

If (RT-CR)>$\mathbf{B_u}$

Generate OVERFLOW;

b. Measuring degree of congestion at path level traffic

The degree of congestion at each relay hop together helps to identify the degree of congestion at path level traffic from source to destination node. Each relay hop level node receives the degree of congestion from its ingress initiator. The destination node, which is last node of the routing path, is not egress the congestion status. The destination node initiates to measure the degree of congestion at path level traffic. The periodic updates of congestion status at each relay hop level node to its successor in routing path are significantly energy consuming activity. To conserve the energy, the congestion update strategy considers two conditional activities, which follows:

1. Degree of congestion $d_c(h_i)$ (eqn-3)at relay hop level node h_i will be sent to its successor h_{i+1} if the $d_c(h_i)$ " is greater than the node level congestion threshold $d_c(\tau)$. Hence the energy conserves due to conditional transmissions.
2. If degree of congestion at path level traffic that received by node from its ingress initiator is smaller than then $d_c(h_i)$ it updates the $d_c(rp)$ else it remains same, hence energy conserves due to avoidance of $d_c(rp)$ update.

In this paper's implementation, this is achieved by using a maximum matching based scheduling policy. One remarkable difference between this paper's scheduling algorithm and the scheduling algorithm used in is that this paper uses a virtual capacity, consisting of the slow time scale component and an estimated component, instead of using the original capacity directly. This paper's design is capable of not only adjusting rate allocation under time-varying channels, but also handling delay effects.

Algorithm-

Step-1-get the network parameters as inputs.

Step-2-first *Measuring degree of congestion at Relay hop level node is being done.*

Step-3-then *Measuring degree of congestion at path level traffic* is applied.

Step-4-give the out puts to Congestion control Phase.

ii. Congestion control Phase

After detecting congestion, congestion control and scheduling is performed [17]. Here, the optimization problem can be solved by using scheduling algorithm by utilizing the virtual rates. In congestion control, each source node adjusts its sending data rate and in scheduling a link weight is assigned for each link based on the degree of congestion measured. Then the links with minimum weight are found and scheduled.

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The end to end delay can be overcome by flow control algorithm where a window W_m is maintained at source node during each flow. If window size is larger than the amount of network packets for the flow, then new packets are inserted. This reduces buffer over flow and the window size maintain the trade-off between delay and throughput.

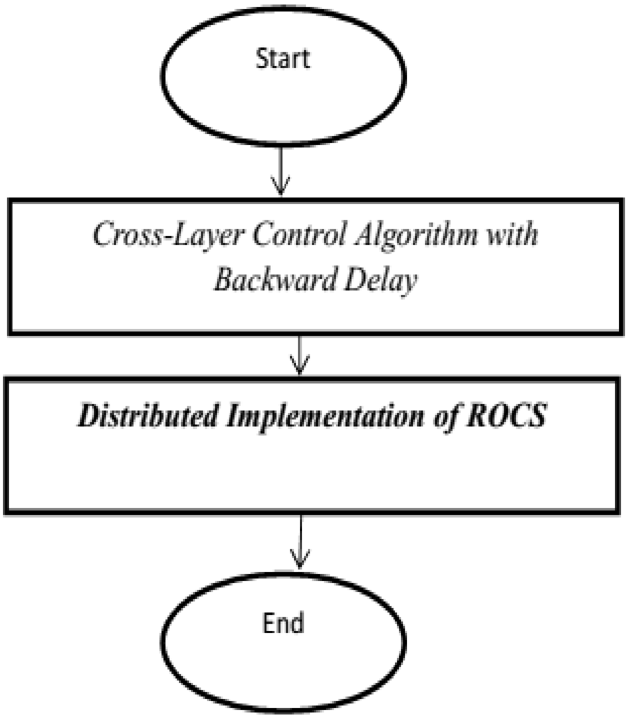

Figure-2 modular diagram

a. Cross-Layer Control Algorithm with Backward Delay

By employing *CSMA*, this paper formulate a cross-layer congestion control problem *W_* over the new capacity space ˜Λ(*t*) generated from the capacity space mapping algorithm.

$$W^{!} : \max \sum_{8\in S} U_8(\chi_8(t)) \qquad (4)$$

$$s.t \sum_{8\in S} (\chi_8(t)) \leq \hat{c}(t), l \in L \qquad (5)$$

$$\hat{c}(t) \in \tilde{\wedge}(t)$$

over

$$\tilde{\wedge}(t) = CSMA(c(t)) \qquad (6)$$

Since *CSMA* can effectively mitigate the *forward delay* effect (it also reduces the *backward delay* effect) incurred by flow rate information delay and channel perturbation, this paper ignores the *forward delay* in this section and only considers the *backward delay*. Then the joint control algorithm *J* is as follows.

$$\dot{x}_8(t) = \lambda_8[U^{!}_8(\chi_s(t)) - q^{d}_8(t)] \qquad (7)$$

$$\dot{p}_l(t) = [\gamma_l(y_l(t) - \hat{c}_l(t))]+ \qquad (8)$$

$$\hat{c}_l(t) = \arg \max_{\hat{c}_l(t)\in\wedge(t)} (\sum_{l\in L} p_l(t)\hat{c}_l(t) \qquad (9)$$

The algorithm jointly adjusts flow rate allocation and link utilization, in order to achieve a global optimum, where the aggregate network utility is maximized. The two components of the algorithm, congestion control and scheduling, implicitly interact with each other: flow rate allocation determines link congestion prices and therefore affects the scheduling results. Scheduling determines the effective link capacities, and hence affects flow rate allocation. One central property of the control algorithm is stability. With the presence of backward delays *{τl,s, l ∈ L, s ∈ S}*, the network system is not be stable unless some conditions are met, as will be discussed in the following subsection.

b. Scheduling

This paper's cross layer design differs from these works in that this paper employ a capacity space mapping algorithm, such that the cross-layer control algorithm runs over a newly built capacity space. Since a link capacity series usually possesses some unchanging statistical characteristics, these characteristics can be profiled from a sample sequence. At the beginning of *ROCS*, this paper profiles the link capacities and obtains ***ω*** by using *SCFS*. The cutoff frequency vector can also be obtained online: the time series of the sampled link capacity is periodically updated and fed into *SCFS*. When *ROCS* is running, the link states are monitored and the channel decomposition algorithm is applied to generate the new capacity space. The scheduling policy should maximize the aggregate link weight $\sum_{l\in L} p_l \hat{c}_l$ *l∈L pl ˆcl* across the network. In this paper's implementation, this is achieved by using a maximum matching based scheduling policy, as introduced in [4]. One remarkable difference between this paper's scheduling algorithm and the scheduling algorithm used in [4] is that this paper uses a virtual capacity, consisting of the slow time scale component and an estimated component, instead of using the original capacity directly. This paper's design is capable of not only adjusting rate allocation under time-varying channels, but also handling delay effects.

Algorithm-

Step-1-get the inputs form the section Congestion detection phase

Step-2-then apply Cross-Layer Control Algorithm with Backward Delay.

Step-3-. Go for *Distributed Implementation of ROCS.*

Step-4-end the process.

Simulation Results

Cross-layer Based Congestion Control and Scheduling (CBCCS) is evaluated through NS-2 simulation. A random network deployed in an area of 1000 X 1000 m is considered. Initially 125 nodes are placed in square grid area of 1000x1000m. The simulated traffic is CBR with UDP source and sink. Table 1 summarizes the simulation parameters used.

TABLE 1: Simulation Parameters

No.of Nodes	125
Area Size	1000 X 1000
Mac	802.11
Simulation Time	50 sec
Traffic Source	CBR
Packet Size	512 bytes
Rate	250 to 1000 kb
Transmission Range	150m
Antenna	OmniAntenna
No.of Flows	2,4,6,8, and 10

A. Performance Metrics

The performance of CBCCS technique is compared with JCCS technique. The performance is evaluated mainly, according to the following metrics.

- **Average end-to-end delay:** The end-to-end-delay is averaged over all surviving data packets from the sources to the destinations.
- **Average Packet Delivery Ratio:** It is the ratio of the number .of packets received successfully and the total number of packets transmitted.
- **Drop:** It is the number of packets dropped during the data transmission.
- **Overhead:** It is the number of control packets exchange in the network

B. Results

a. Based on Rate

In our initial experiment, we vary the transmission sending rate as 250, 500, 750 and 1000 Kb for CBR traffic.

From figure 4, we can see that the delay of our proposed CBCCS is 9% less than the existing JCCS technique.

From figure 5, we can see that the delivery ratio of our proposed CBCCS is 55% higher than the existing JCCS technique.

From figure 6, we can see that the packet drop of our proposed CBCCS is 51% less than the existing JCCS technique.

From figure 7, we can see that the overhead of our proposed CBCCS is 51.02% higher than the existing JCCS technique.

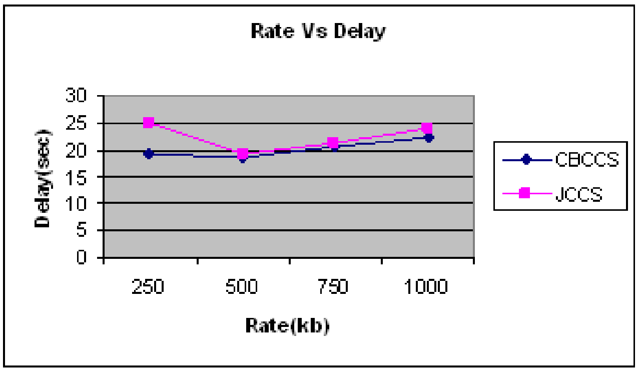

Fig 4: Rate Vs Delay

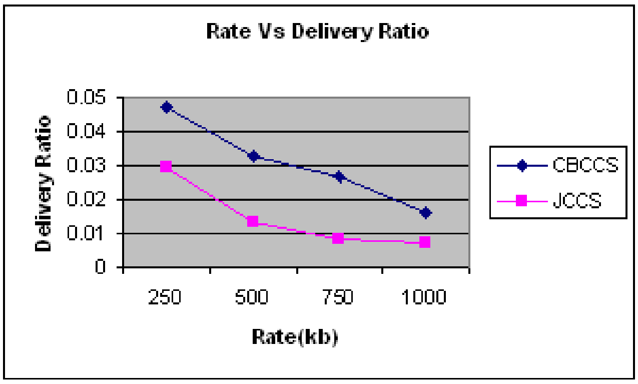

Fig 5: Rate Vs Delivery Ratio

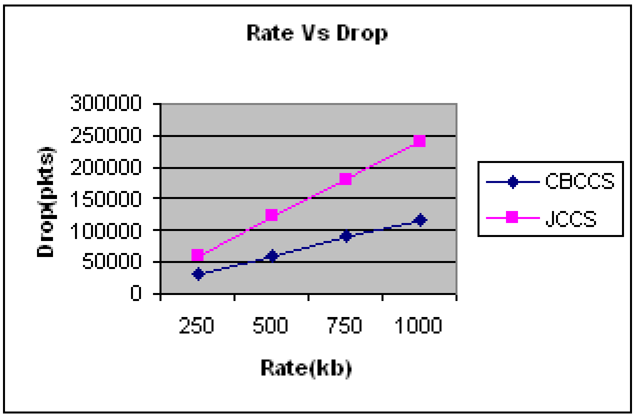

Fig 6: Rate Vs Drop

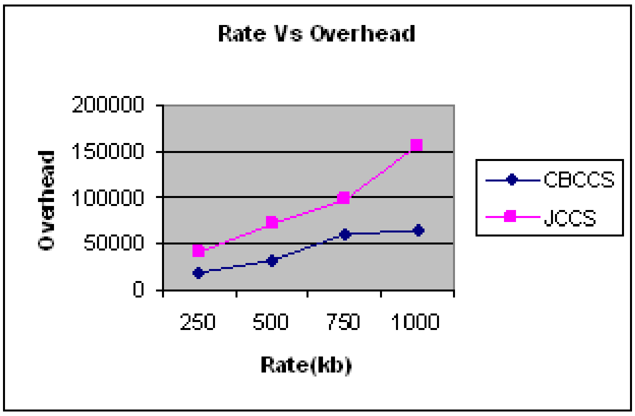

Fig 7: Rate Vs Overhead

b. Based on Flows

In our second experiment, we vary the number of flows as 2, 4, 6, 8 and 10 for CBR traffic.

From figure 8, we can see that the delay of our proposed CBCCS is 9% less than the existing JCCS technique.

From figure 9, we can see that the delivery ratio of our proposed CBCCS is 37% higher than the existing JCCS technique.

From figure 10, we can see that the packet drop of our proposed CBCCS is 51% less than the existing JCCS technique.
From figure 11, we can see that the overhead of our proposed CBCCS is 47% higher than the existing JCCS technique.

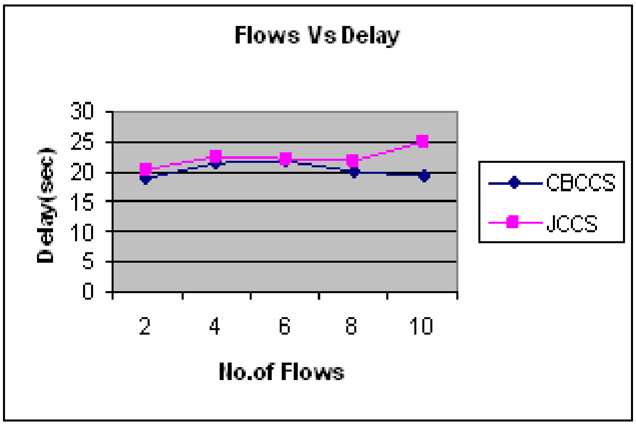

Fig 8: Flows Vs Delay

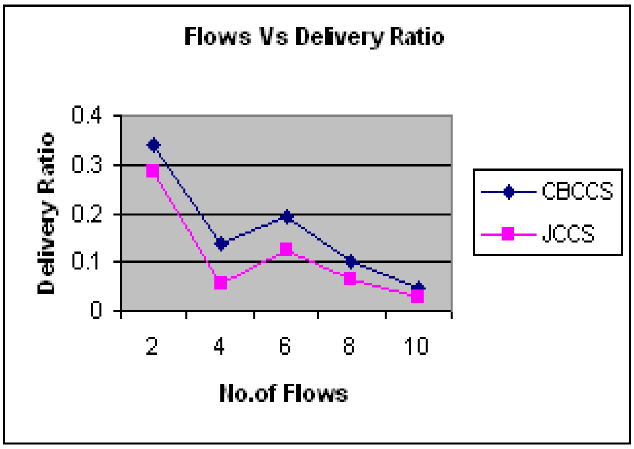

Fig 9: Flows Vs Delivery Ratio

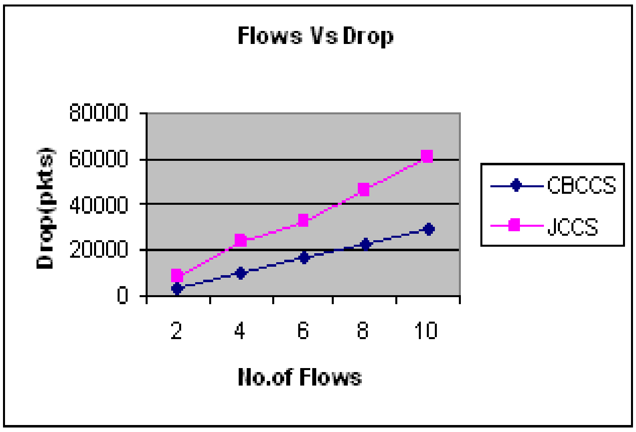

Fig 10: Flows Vs Drop

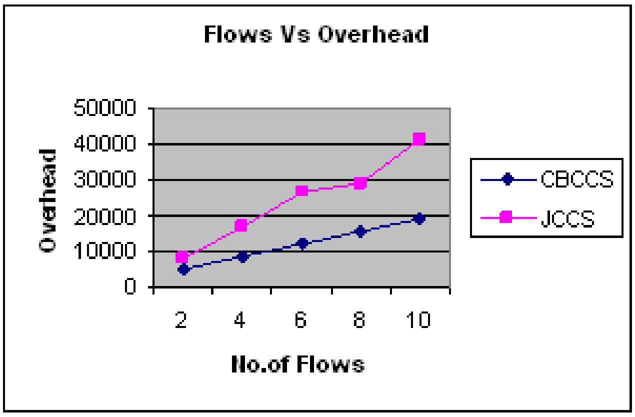

Fig 11: Flows Vs Overhead

Conclusion

this paper propose to develop a jointing scheduling and congestion control in multi hop MANET First, this paper present a cross layered model of energy efficient congestion detection and control mechanism. By identifying the causes of MAC layer packet drops, unnecessary route error propagations and route re-discovery procedures can be avoided. Once a wireless link experiences packet loss at MAC layer due to signal interference, it can be inferred that the contention area in which the link resides is congested. The paper work starts with a suitable introduction describing about issues and bandwidth reservation technique in the section one. In second section; this paper is giving literature work that supports this paper’s proposed methodology. This paper describes a suitable proposed method with detail architecture and problem definition that is described in section three. The last section carries a suitable conclusion for this paperwork.

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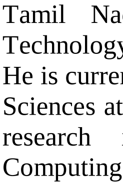

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