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Congestion Control for Fault Tolerant Multicast Routing in MANET

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ABSTRACT

Mobile Ad hoc Network (MANET) is a collection of two or more devices or nodes or terminals with wireless communications and networking capability that communicate with each other without the aid of any centralized administrator a dynamic network consisting of several mobile nodes communicating wirelessly. MANET is an infrastructure less network and each member node is free to move in and out of the network in a random manner. Congestion may occur in any node when data packets travel from source to destination. Controlling congestion is critical to ensure adequate network operation and performance. Due to this mobile nature of the nodes in MANET, the possibility for the network to get congested is high. This may result in isolated nodes and reduced network performance. So in this paper, we proposed to develop a congestion control technique for fault tolerant multicast routing in MANET. In this technique, the congestion probability around the forwarding node is initially estimated and then according to the congestion level, the future transmission rates are adapted. The data transmission rate is varied dynamically to efficiently handle the congestion in the network. In this way, the network performance is enhanced.

Keywords:- Congestion, Channel busy ratio, Average delay, Queue length, Transmission control.

1. INTRODUCTION

A mobile ad-hoc network (MANET) is an independent network that is self-systemizing and this network consisting of mobile nodes can be formed quickly, where the nodes communicate with one another wirelessly [1]. Due to this node mobility, the network topology is highly dynamic. In MANET, the network features like bandwidth, battery, etc are highly restricted. The end users in MANET can be a laptop, PDA, mobile phones, etc [2]. Some of the applications of MANET are distance learning, gaming, multimedia conferencing and Military system [3].

Multicasting is a process of transmitting data packets to one or more host nodes. In case of group oriented network operation, the multicasting process is used. The nodes in MANET are highly mobile and can enter as well as exit the network group in random manner. In the network, there is no limitation on the number of nodes or the position of the nodes. Each node can be a member of more than one group. In order to forward a data packet, the host need not be member of the network group [4].

In MANET, congestion control is a major issue. Since the nodes are connected wirelessly, it is not possible to assure that the nodes are within the transmission range of one another. The conventional congestion control schemes employed in the wireless networks cannot be directly deployed in the MANET because of the special features of MANET. Some of these features of MANET are fading, interference; losses in channels because of noise, continuous path break [6].

2. RELATED WORKS

In this Reliable On-demand Multicast Routing with Congestion Control in wireless ad hoc networks. A new Broadcast Medium Window (BMW) MAC protocol is proposed which is responsible for successfully delivering the broadcasted data packets. Then the ODMRP is utilized to aid the congestion control operation on the basis of the feedback parameter which is the mean aggregate queue length. The instantaneous queue length is not used as the feedback metric because it will give wrong information of the network situation to the multicasting node when the traffic is non uniform and burst [7]. Congestion Controlled Adaptive Lightweight Multicast (CALM) protocol in Wireless Mobile Ad Hoc Networks. The CALM protocol is designed to attain consistent multicasting in MANET. This protocol dynamically itself to unpredictable network conditions with respect to the packet delivery ratio as well as the low end to end latency. But, this protocol does not ensure complete consistency, since in some cases data loss cannot be prevented such as in case of hidden terminal effect or data loss due to mobility [8].

The congestion control protocol called as Reliable Adaptive Lightweight Multicast (RALM) Protocol in Multimedia Multi-hop Networks. RALM is basically a transport protocol which is based on protocol similar to the TCP protocol. RALM offers consistency and congestion control. Reliability is achieved by ensuring reliable delivery of the data packets at a time to at least one multicast node in round robin fashion. Congestion control is achieved by utilizing a window scheme, in which the window size is adjusted dynamically according to the congestion present in the network system [9].In the dynamic congestion estimation and control routing technique, the variation in the network traffic volume is monitored continuously and the congestion level is classified accordingly. Based on the congestion level, backup paths are selected. This reduces the overall routing overhead. As the traffic in the network increases, the routing overhead will be comparatively maintained under control by the RALM protocol [10].The Fuzzy Adhoc Rate base Congestion Control (FARCC) Mechanism in MANETs. In this mechanism, suitable transmission rate is estimated prior transmitting data packets by the transmitting node. The congestion probability around each forwarding node is estimated based on fuzzy logic and then congestion level is confirmed. Accordingly the future transmission rate is adapted. This mechanism performs fair resource allocation to the system [11].

To improve the functioning of routing protocols it is required to evaluate the factors that affect its performance. Such evaluation is carried out with the help of response metrics. Two kinds of evaluation are possible: single-response and multi-response. By varying single factor at a time, the effect on the protocol performance is measured through response metrics individually. It is referred as single-response metric analysis. On contrary, the effects of such variation are quantified through more than one response metrics simultaneously and it is referred as multi-response analysis. The most important factor is the optimal number of copies which have been evaluated using adaptive fault tolerant replication strategy [12].

In this scheme to achieve efficient queuing in the buffer of a centrally communicating MANET node through an active queue management strategy by assigning dynamic buffer space to all neighboring nodes in proportion to the number of packets received from neighbors and hence controlling packet drop probabilities. The proposed scheme is a way to improve the buffer management for packet queues in MANET nodes in terms of packet loss ratio, transmission efficiency, and some other important system parameters [13].

In ad hoc networks, a large number of data packet loss due to high bits error rate, nodes mobility, etc. At a consequence, the conventional TCP congestion control mechanisms are not appropriate for the wireless ad hoc networks and to large extent reduce the network performance. To analyze the major factors affecting TCP performance in ad hoc networks, give several typical improved congestion control approaches, and compare the network performance of these different approaches. This approach achieves higher fairness and throughput in ad hoc networks [14].

In this implemented improved Watchdog protocol called as I-Watchdog protocol with Destination-Sequenced Distance-Vector Routing (DSDV) routing protocol that provides efficient and secure routing with prevention of denial of service attack as well as detection of congestion in the network background. In this proposed I-Watchdog procedure does proficient recognition of the presence of malicious nodes in a mobile ad hoc network as well as it finds the genuine reason of the happening of loss of packets. Additionally, analysis the improved performance of mobile ad hoc network in the presence of DSDV with I-Watchdog protocol in provisions of packet drop ratio (PDR), throughput along with end-to-end delay [15].

This proposes an early congestion detection and adaptive routing in MANET called as EDAPR. Initially EDAPR constructs a non-congested neighbours (NHN) neighbours list and finds a route to a destination through an NHN node. All the primary path nodes periodically calculate its queue status at node level. While using early congestion detection technique, node detects congestion that is likely to happen and sends warning message to NHN nodes. The ancestor NHN node is aware of this situation and finds an alternate path to a destination immediately by applying adaptive path mechanism. Thus, EDAPR proves performance in terms of reducing delay, routing overhead and increases packet delivery ratio without incurring any significant additional cost [16].

The proposed CafRep, an adaptive congestion aware protocol that detects and reacts to congested nodes and congested parts of the network by using implicit hybrid contact and resources congestion heuristics. CafRep exploits localized relative utility based approach to offload the traffic from more to less congested parts of the network, and to replicate at adaptively lower rate in different parts of the network with non-uniform congestion levels [17]. This paper attempts to resolve this issue by designing a dynamic source routing (DSR)-based routing mechanism, which is referred to as the cooperative bait detection scheme (CBDS), that integrates the advantages of both proactive and reactive defense architectures. CBDS method implements a reverse tracing technique to help in achieving the stated goal. [18].

In this propose developed a efficient fault-tolerant routing protocol. It enables a relay node to quickly and efficiently identify the next shortest path from itself to the destination based only on node IDs upon routing failure, rather than relying on retransmission from the source. Kautz graph based works in that it does not need an energy-consuming protocol to find the next shortest path and it preserves the consistency between the overlay and physical topology. Further improve routing in REFER by multi-path based routing and energy-efficient multicasting within and between Kautz graph cells, respectively [19].

3. CONGESTION CONTROL FOR FAULT TOLERANT MULTICAST ROUTING IN MANET

Apart from route failures and node failures, there are also chances of congestion or overload of data due to which important multicast data may be lost by the receivers. So, as an extension to previous works, in this paper we propose to design a congestion control mechanism for multicast traffic in MANETs. In this mechanism, the congestion probability is estimated at each intermediate nodes along the fault tolerant multicast tree, based on the parameters average queue length [10], average delay, channel busy ratio for each multicast session. Then the intermediate node buffers the data in its local buffer and transmits the congestion probability as a warning message to the multicast source. The source intern will apply the rate control based on the congestion probability [11]. In the meantime, the multicast receivers will receive the buffered data from the intermediate nodes in order to reduce the loss and delay.

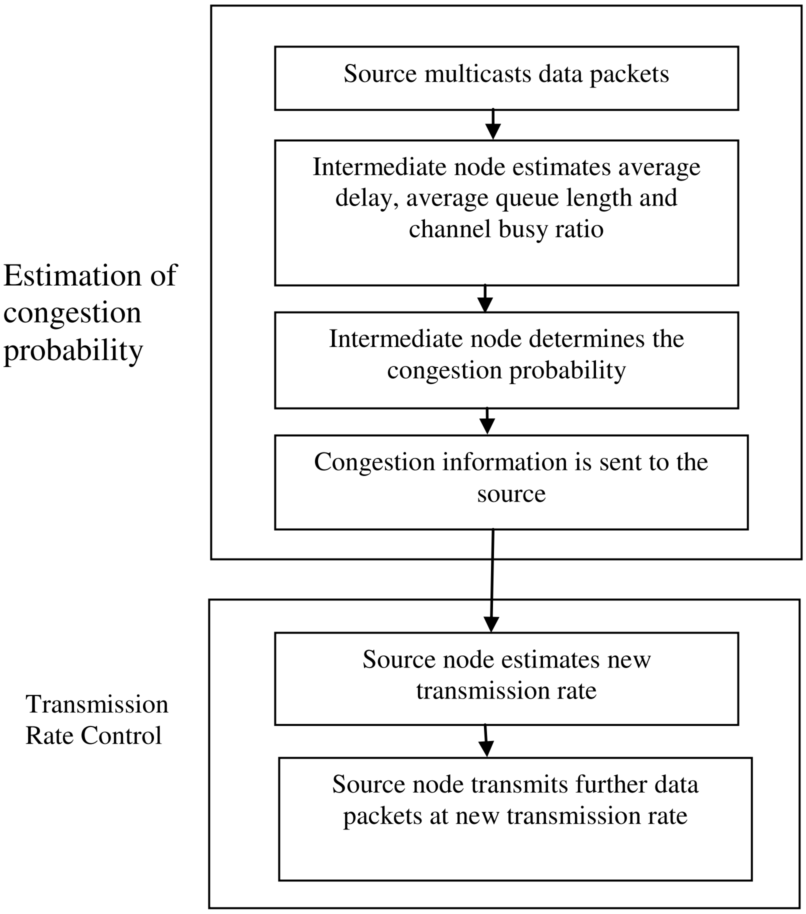

Fig: 1 Block Diagram

A. Estimation of Congestion Probability

When a source node multicast the data packets to certain destination nodes the transmitted data packet passes through several intermediate nodes. On receiving the data packet, each intermediate node along the multicast path estimates the congestion probability. The process of congestion probability estimation is described in algorithm 1.

Algorithm 1

- The source node S multicasts its data packet.
- The data packet traverses several intermediate nodes in the multicast tree before reaching its destination node D.
- On receiving the data packet, each intermediate node estimates Average Queue Length $QLen_{avg}$, Average Delay D_{avg}, and Channel Busy Ratio CBR for each multicast session.
- The Average Queue Length $QLen_{avg}$ is estimated according to equation (1).

$$QLen_{avg} = (1 - Q_{wgt}).QLen'_{avg} + QLen_{inst}.Q_{wgt} \quad (1)$$

  Where Q wgt is the Queue weight time constant dependent on the Low Pass Filter, $QLen'_{avg}$ Average Queue Length of previous multicast session and $QLen_{inst}$ Instantaneous Queue Length.

- The average delay D_{avg} is the transmission delay of the data packet which is calculated in accordance with equation (2)

$$D_{avg} = \alpha .D'_{avg} + (1 - \alpha).D_{queuing} \quad (2)$$

  Where D'_{avg} average delay in the previous session, α delay constant and $D_{queuing}$ queuing delay.

- The Channel Busy Ratio CBR is determined based on the occupancy of the channel.
- After the estimation of these three parameters, the Congestion Probability CP is collectively determined as

$$CP = W_1 * Qlen_{avg} + W_2 * D_{avg} + W_3 * CBR \quad (3)$$

Where W_1, W_2 and W_3 are the weight values such that $W_1 + W_2 + W_3 = 1$.

- Then the intermediate node transmits the congestion probability as a warning message to the multicast source.

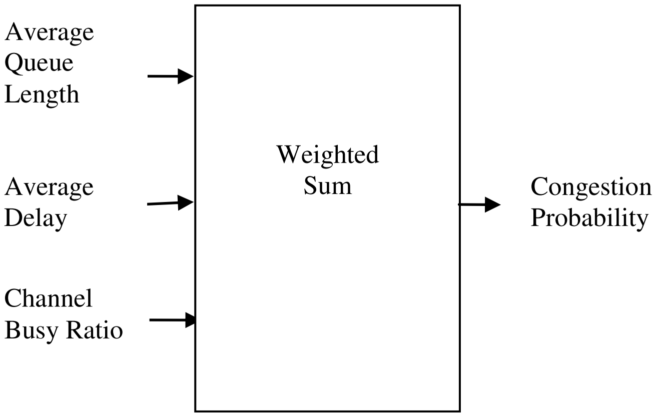

Fig.2: Estimation of Congestion Probability

Thus based on the congestion status at the intermediate node and the related channels, the data packet is either transmitted or buffered temporarily. If the congestion probability is high, then after buffering the data, a warning message is sent to the source node.

B. Rate Control based on congestion probability

On receiving the message from the intermediate node, the source node retrieves the congestion probability level value. Based on the level of congestion probability, the source node accordingly performs the calculation of the new transmission rate to efficiently handle the network congestion. This process is described in algorithm 2.

Algorithm: 2

- When the source S receives the warning message from the intermediate node, the source node retrieves the congestion probability value.
- The congestion probability level is Low L, Medium M and High H.
- If the congestion probability level is L then it indicates that the data packet transmission can be performed successfully.
- To increase the throughput, the source performs the multiplicative increase operation on then current Transmission Rate $T\_Rate_{current}$.
- The new Transmission Rate T_Rate_{new} is estimated based on the multiplicative increase operation and is given by equation (4).

$$T\_Rate_{new} = T\_Rate_{current} * \frac{Thru-CBR}{avg(CBR)} \quad (4)$$

Where thru is the Throughput, CBR is the channel busy ratio and avg (CBR) is the average channel busy ratio.

- If the congestion probability level is M, then the source node performs the additive increase operation on the $T\_Rate_{current}$.
- The T_Rate_{new} is estimated based on the additive increase operation and is given by according to equation (5).

$$T\_Rate_{new} = T\_Rate_{current} + \frac{1}{D_{avg}} \quad (5)$$

Where D_{avg} is the Average Delay.

- If the congestion probability level is H, then the source node performs the multiplicative decrease operation on the $T\_Rate_{current}$.
- The T_Rate_{new} is estimated based on the multiplicative decrease operation and is given by equation (6).

$$T\_Rate_{new} = \frac{T\_Rate_{current} * avg(CBR)}{D_{avg} * (Thru - CBR)} \quad (6)$$

- After the estimation of the T_Rate_{new}, the source node compares the T_Rate_{new} with the $T\_Rate_{current}$
- If the difference between the two transmission rate is high, then theT_Rate_{new} is selected by the source node.
- Then the intermediate node forwards the data packet which was stored in the buffer to the destination, reducing the delay and loss involved.
- The further transmissions from the source is carried out at theT_Rate_{new}.
- Based on the congestion information received from the intermediate nodes, the source node estimates new transmission rate. Thus the source node will dynamically change the transmission rate to efficiently handle the congestion in the network.

4. SIMULATION RESULTS

The proposed Congestion Control for Fault Tolerant Multicast Routing (CCFTMR) protocol is simulated in Network Simulator-2 (NS-2) and compared with Fuzzy Adhoc Rate base Congestion Control (FARCC). The performance is evaluated based on Average Packet Delivery Ratio, Packet Drop, Latency and Energy Consumption.

The simulation settings and parameters are Number of nodes 50, Simulation area 1500 m X 300 m, Number of receivers 20 and 50, MAC protocol 802.11, Simulation time 50 Sec, Traffic, Constant Bit Rate (CBR), Rate100, 150, 200, 250 and 300 Kb/sec, Omni directional antenna, Initial Energy 10 Joules, Transmit Power 0.665 W, Receiving Power 0.395 W and Speed of the nodes 10, 20, 30, 40 and 50 m/sec.

A. Results and Analysis

Congestion is triggered in the network when the data arrival rate or number of flows increases in the network. Hence we increase the data rate from 100 Kb/sec to 300 Kb/sec in order to analyse the performance of the protocols in presence of congestion.

Case-1 Results for 20 Receivers

Figures 3 to 6 show the results of delivery ratio, packet drop, latency and residual energy for 20 receivers by varying the CBR data sending rate from 100 Kb/sec to 300 Kb/sec.

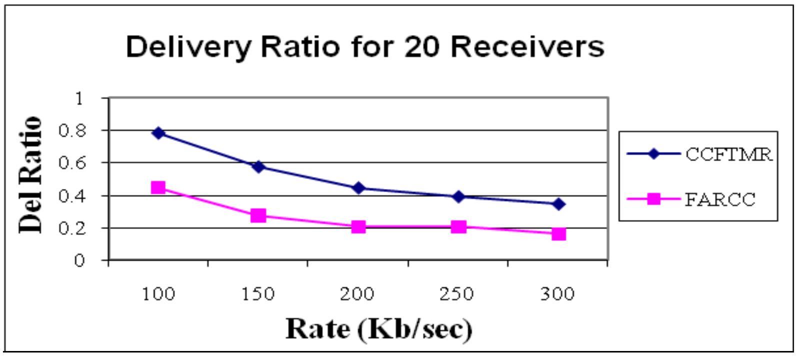

Fig.3 Rate Vs Delivery Ratio

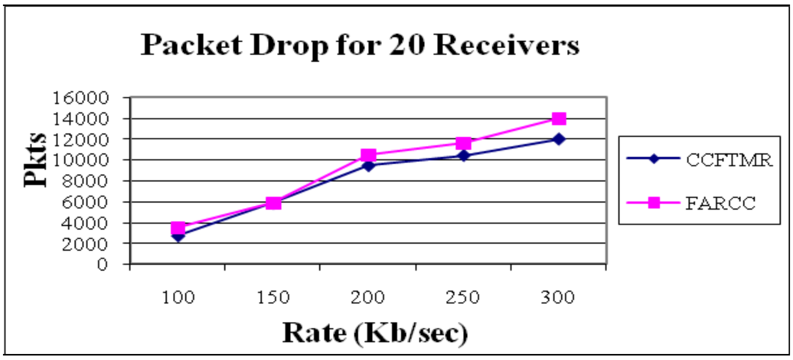

Fig. 4 Rate Vs Packet Drop

Figures 3 and 4 shows the results of packet delivery ratio and packet drop verses rate. Since the congestion probability increases at high data rates the packet loss increases and delivery ratio decreases, linearly. However CCFTMR considers average queue length also in the estimation of congestion probability, in addition to delay and channel busy ratio when compared to FARCC. Moreover, apart from losses due to congestion, CCFTMR handles the losses due to mobility and faults. Hence CCFMTR outperforms FARCC in terms of delivery ratio by 50% and in terms of packet drop by 12%.

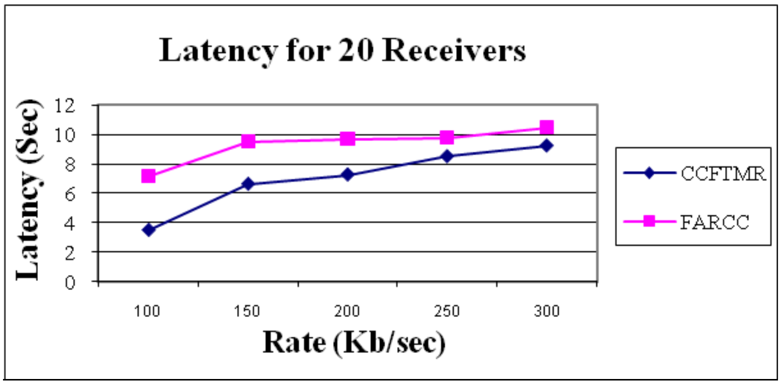

Fig. 5 Rate Vs Latency

Figure 5 shows the results of latency by varying the CBR data sending rate. Since the congestion probability increases at high data rates the latency also increases linearly, as depicted in the figure. However, CCFMTR has 26% reduced latency than FARCC, since CCFTMR considers average queue length also in the estimation of congestion probability, in addition to delay and channel busy ratio when compared to FARCC.

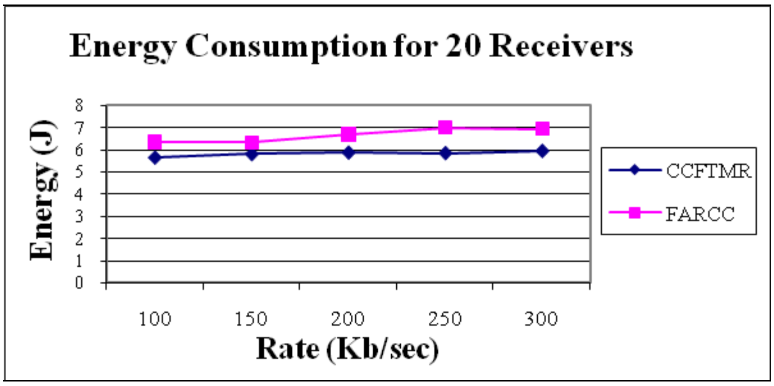

Fig. 6 Rate Vs Energy Consumption

Figure 6 shows the average energy consumption of both the protocols, when the rate is increased. Since CCFTMR handles all types of losses, the energy consumed in route maintenance and retransmission is reduced. Hence CCFTMR has 12% reduced energy consumption, when compared to FARCC

Case-2 Results for 50 Receivers

Figures 7 to 10 shows the results of delivery ratio, packet drop, latency and residual energy for 50 receivers by varying the CBR data sending rate from 100 Kb/sec to 300 Kb/sec.

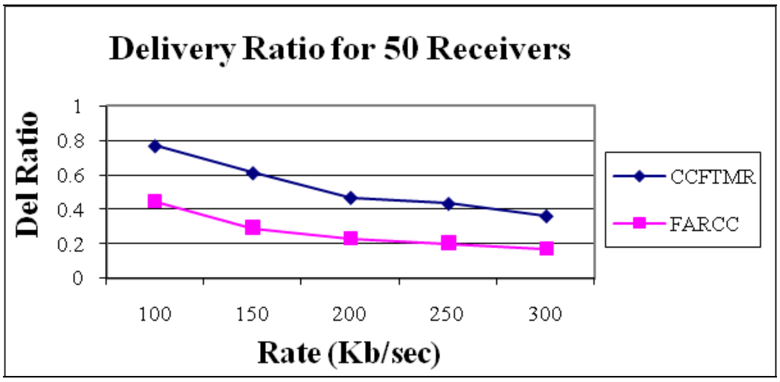

Fig. 7 Rate Vs Delivery Ratio

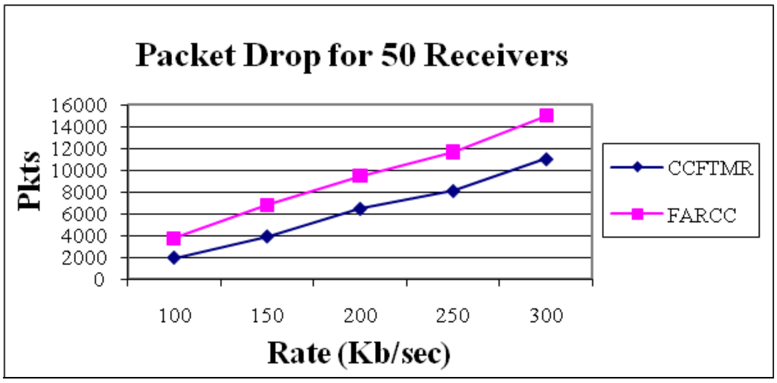

Fig. 8 Rate Vs Packet Drop

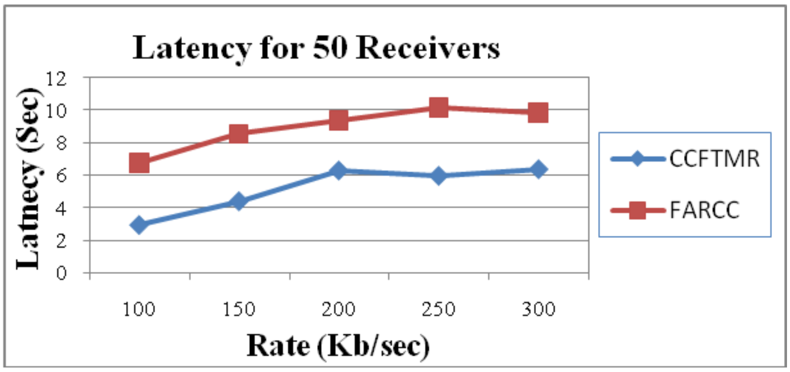

Fig. 9 Rate Vs Latency

Figures 7, 8 and 9 shows the results of packet delivery ratio, packet drop and latency verses rate. Since the congestion probability increases at high data rates the packet loss increases and delivery ratio decreases, linearly. However CCFTMR considers average queue length also in the estimation of congestion probability, in addition to delay and channel busy ratio, when compared to FARCC, The CCFTMR handles the losses due to mobility and faults. Hence CCFMTR outperforms FARCC in terms of delivery ratio by 50%, in terms of packet drop by 36% and reduced latency by 42%.

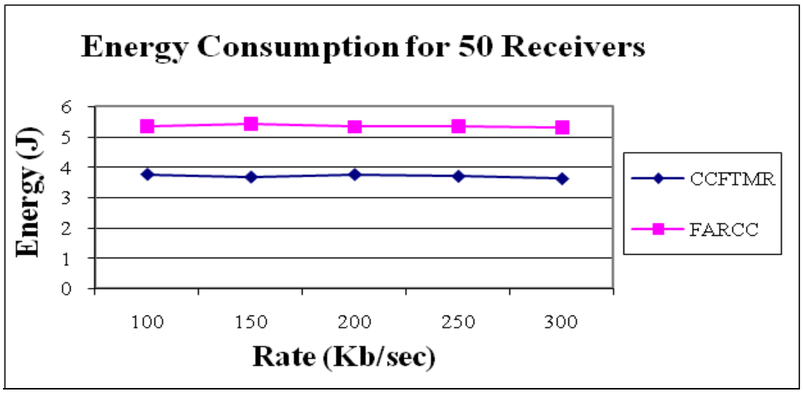

Fig. 10 Rate Vs Energy Consumption

Figure 10 shows the average energy consumption of both the protocols, when the rate is increased. Since CCFTMR handles all types of losses, the energy consumed in route maintenance and retransmission is reduced. Hence CCFTMR has 30% reduced energy consumption compared to FARCC.

5. CONCLUSION

In this paper the Congestion Control technique for Fault Tolerant Multicast Routing is proposed for MANET. In this protocol, the congestion probability is estimated at each intermediate node based on the queue length, delay and channel busy ratio transmitted to the source. Based on the received congestion probability information, the source node estimates new transmission rate suitable to handle the network congestion. Simulation results show that the proposed protocol has reduced packet drop and latency while increasing the packet delivery ratio in presence of congestion.

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