International Journal of Information Technology and Knowledge Management
July-December 2010, Volume 2, No. 2, pp. 471-474

A CLUSTER BASED CONGESTION CONTROL PROTOCOL FOR MOBILE ADHOC NETWORKS

S.Karunakaran[1] & P.Thangaraj[2]

In mobile ad hoc networks (MANETs) congestion occurs with limited resources. Congestion leads to packet losses and bandwidth degradation and also wastes time and energy on congestion recovery. In this paper, we present a Cluster Based Congestion Control (CBCC) protocol that consists of scalable and distributed cluster-based mechanisms for supporting congestion control in adhoc networks. The distinctive feature of our approach is that it is based on the self-organization of the network into clusters. The clusters autonomously and proactively monitor congestion within its localized scope .Our protocol consists of clustering mechanism, traffic rate estimation and traffic rate adjustment. By extensive simulation, we show that our CBCC protocol is highly efficient in dealing multiple flows by achieving good delivery ratio and throughput with low delay.

1. INTRODUCTION

A mobile ad-hoc network (MANET) is composed of mobile nodes without any infrastructure. Mobile nodes self-organize to form a network over radio links. Specially configured routing protocols are engaged in order to establish routes between nodes which are more than a single hop. Due to the shared wireless channel and dynamic topology, packet transmissions suffer from interference and fading, in such networks. The network load is burdened through the transmission errors. There is an increasing demand for support of multimedia communications in MANETs, recently. The large amount of real-time traffic is involves high bandwidth and liable to congestion. Congestion leads to packet losses and bandwidth degradation and also wastes time and energy on congestion recovery. A fair amount of research work has been published on Congestion control in MANET. Michael Gerharz, Christian de Waal, and Matthias Frank [3] have taken a practical view on the Quality-of-Service capabilities of wireless ad hoc networking technologies. Xiaoqin Chen, Haley M. Jones, A .D .S. Jayalath [4] propose a congestion-aware routing protocol for mobile ad hoc networks which uses a metric incorporating data-rate, MAC overhead, and buffer delay to combat congestion. Hongqiang Zhai, Xiang Chen, and Yuguang Fang [5] first illustrate that severe medium contention and congestion are intimately coupled, and TCP's congestion control algorithm becomes too coarse in its granularity, causing throughput instability and excessively long delay. Yung Yi and Sanjay Shakkottai [6] develop a fair hop-by-hop congestion control algorithm with the MAC constraint being imposed in the form of a channel access time constraint, using an optimization-based framework. Tom Goff, Nael B. Abu-Ghazaleh, Dhananjay S. Phatak and Ridvan Kahvecioglu [7] present a class of algorithms that initiates proactive path switches when the quality of a path in use becomes suspect. Xuyang Wang and Dmitri Perkins [8] present a cross-layer hop-by-hop congestion control scheme designed to improve TCP performance in multihop wireless networks. Dzmitry Kliazovich, Fabrizio Granelli [9] presents the problem of performance degradation of transport layer protocols due to congestion of wireless local area networks. Duc A. Tran and Harish Raghavendra [10] propose in the current designs, routing is not congestion-adaptive.

In this paper, we present a Cluster Based Congestion Control (CBCC) protocol that consists of scalable and distributed cluster-based mechanisms for supporting congestion control in adhoc networks. The distinctive feature of our approach is that it is based on the self-organization of the network into clusters. The clusters autonomously and proactively monitor congestion within its localized scope. By exchanging small amount of control packets along the paths, adjustment of node rates and co-operation between cluster nodes are achieved. Clustering helps to determine the interactions between the flows. When compared to end-to-end techniques, our approach improves the responsiveness of the system

2. PRESENT WORK

In Figure 1 we present an overview of the CBCC network structure. Nodes in the network are grouped into clusters, as shown in the figure. Message exchanges consist of regular data packets, intra {node update packets) and inter (cluster head update packets). Nodes within a cluster periodically report their locally computed estimation of the traffic load

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School Computer Technology and Applications, Kongu Engineering College, Perundurai, Tamilnadu
Email: karunakarans@kongu.ac.in

(dashed lines). This information is processed by the cluster head and a collective cluster level load estimate is communicated to the cluster heads towards the source clusters (dotted lines).

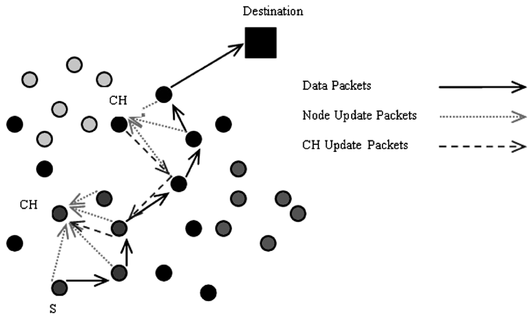

Figure 1 An Overview of CBCC Network Structure

The received value is considered together with the local estimation and a new estimate is produce which incorporates the traffic conditions in the vicinity of clusters along the path, towards the destination. Therefore, nodes at the clusters that generate traffic are able to produce aggregate traffic estimates from the sources to the destination, and thus, adjust their sending rates based on the current congestion level.

2.1. Traffic Rate Estimation

After the cluster formation the level of local congestion is determined within each cluster.The estimated information is sent as feedback so that the sources of the data flows can suitably control their sending rates. The traffic rates both within and across multiple clusters has to be determined to find the level of congestion in the network.The traffic rate is significantly affected by i) the number of new incoming flows, ii) the number of existing flows, iii)the density of the nodes in the network, iv) Communication abilities of nodes.

Our goal is to acquire macroscopic network statistics using a heuristic approach Using the above model, we compute the traffic rate as follows: Let the value l_i represent the offered load at the queue of node i; this is defined as

$$l_i = \frac{a_i}{s_i}$$

where a_i is the aggregate arrival rate of the packets produced and forwarded at node i while s_i is the service rate at node i, i.e., $s_i = 1/T$ where T is the computed exponentially weighted moving average of the packets' waiting time at the head of the service queue. The distribution of the queue size PR (Q_k) (essentially this is the probability that there are Q_k packets in the queue) at the node is computed as $PR(Q_k) = (1-l_i)\, l_i^k$. For N distinct queues, the joint distribution is the product [12]

$$PR(Q_{k1}, Q_{k2}, \ldots.. Q_{kN}) = \prod_{i=1}^{N} (1-li)li^{ki} \qquad (1)$$

We thus, define the Traffic Rate estimate in a cluster IE, to be the probability that at least one of the nodes in the cluster has a non-empty queue:

$$IE = 1-\prod_{i=1}^{N} 1-li \qquad (2)$$

Given the above definitions, each node i estimates its local load l_i within a specific time interval, and reports it to its cluster head via a local broadcast. Note here that these estimates are made based on real time observations of packet arrivals and departures. Upon collecting the values l_i, from all of the nodes, where, $1 \le i \le N$, in the cluster, the cluster head calculates the collective estimate IE for the cluster. Similarly, an aggregate estimate of the traffic rate on an entire path from a set of sources to a destination is calculated via the exchange of the IE values between the cluster head on the path.Let IE_i represent the calculated IE value for cluster i. For cluster i we define the upstream clusters to be the clusters from which packets are received by nodes in i, while the downstream cluster is defined to be the cluster towards which packets are forwarded from nodes in i. The cluster heads of these clusters are correspondingly called upstream and downstream cluster heads.Let us now consider a specific flow initiated at a cluster SC, SC > 0. Cluster SC is called a source cluster, i.e., it contains one or more nodes that transmit data to destination. Let the destination be defined as cluster D. For cluster D we define $IE_D = 0$. Let j be a cluster along the path from SC to the destination, $SC \ge j > 0$. For cluster j (with N members), j receives estimation from a downstream cluster j – 1. The total path traffic rate is calculated by simply including the IE_{j-1} value received at the upstream cluster head j, i.e.,

$$IE_{j-1} = [1-(1- IE_{j-1}) \prod_{i=1}^{N} 1-li] \qquad (3)$$

Contention for the wireless channel at each sending and receiving node affects the traffic rate. If contention is high then, a packet that reaches the head of a queue takes a longer time to receive service and, eventually, is sent out to the next node. We need to define a threshold value IE_{tres} beyond which the cluster is considered to be congested.

2.2. Rate Adjustment

After estimating the traffic rate along a path, our objective is to control the sending rate of the source nodes. Prior to the initialization of flows, cluster head do not have any knowledge of where updates are to be sent. The cluster head need to send updates to upstream clusters since traffic flows from the source clusters to the destination.

Intra and Inter-Cluster Communication: Nodes within a cluster periodically estimate their current load l_i. In order to save energy, a node transmits its computed value to the cluster head only if it exceeds a preset threshold to impact whether or not there is congestion on the path.

Rate Self-Adjustment at the Sources: To end with, in response to the received messages, the packet sending rate of the source is to be adjusted. In order to control the congestion level in the network, an adaptive adjustment mechanism is a preferable solution. We suggest an adaptive scheme that is applied to each flow and follows an adjustment policy .In our technique, if packets of higher importance exist along the path followed by the source's flow or upon estimating congestion then packets of low importance is dropped to a minimum, minrate. The default maximum rate (maxrate) is reached or the cluster traffic rate exceeds IE_{thres}, during the rate increase, then the rate is again dropped to the minimum. Thus our scheme look forward the injection of dynamic flows in the network and proactively adjusts the rate while waiting for congestion feedback.

3. EXPERIMENTAL RESULTS

Table 1
Simulation Parameters

No. of Nodes	100
Area Size	1000 X 1000
Mac	802.11
Simulation Time	100 sec
Traffic Source	CBR
Packet Size	512
No. of Servers	10
Speed	5 m/s
Pause time	5 s
Transmission Range	250m

We compare our Cluster Based Congestion Control (CBCC) protocol with the AODV [13] and CARM [4] scheme. The numbers of rates are varied as 200, 500…1000.

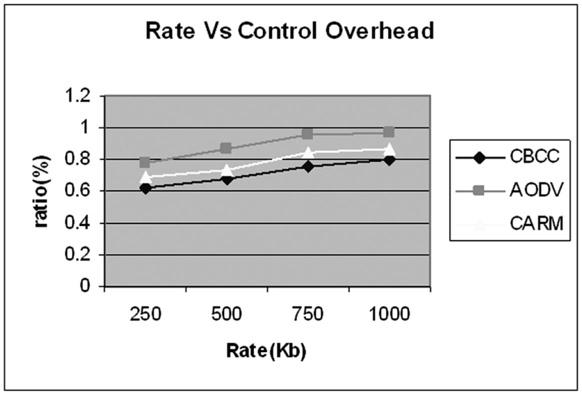

Fig. 2: Rate Vs Control Overhead

Figure 2 shows CBCC outperforms AODV and CARM by the results of control overhead.

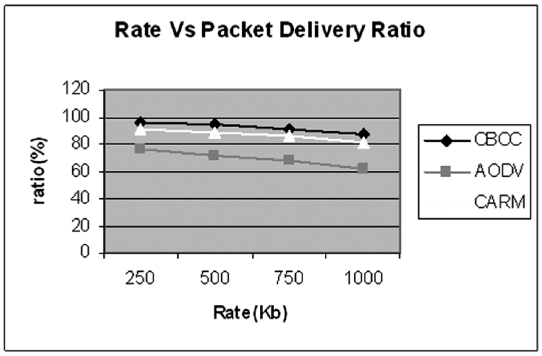

Fig. 3: Rate Vs Packet Delivery Ratio

Figure 3 shows CBCC outperforms AODV and CARM by the results of packet delivery ration.

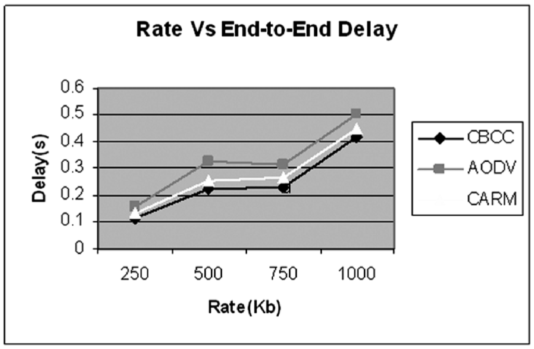

Fig. 4: Rate Vs Delay

Figure 2 shows CBCC outperforms AODV and CARM by the results of delay.

4. CONCLUSION

The present approach improves the responsiveness of the system when compared to end-to-end techniques. After estimating the traffic rate along a path, the sending rate of the source nodes is adjusted accordingly. Thus our protocol look forward the injection of dynamic flows in the network and proactively adjusts the rate while waiting for congestion feedback. By extensive simulation, we have shown that our CBCC protocol is highly efficient in dealing multiple flows by achieving good delivery ratio and throughput with low delay.

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