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A Survey on Congestion Control Techniques in MANETs

Bhupinder Kaur, Vaibhav Pandey
Department of Computer Science & Engineering,
PTU (Main Campus) Kapurthala,
Punjab, India

Abstract— Last decade has witnessed wide growth of Mobile ad-hoc networks (MANETs). Mobile ad-hoc network is self-configurable and adaptive. MANETs use wireless connections to connect various networks. There are number of issues and challenges in a mobile ad hoc network. Due to many number of nodes transmitting packets over the network, the chances of losing the packets over the network increases to a great extent. Also, with the increase in size of data packets, the congestion over the network increases which may lead to packet loses. The existing routing protocols for MANETs do not support congestion control as they are not congestion adaptive. There are many proposed techniques that are congestion adaptive and deals with the congestion over the network. In this paper, various congestion control techniques have been discussed. The purpose of this paper is to discuss and compare different proposed congestion control techniques in MANETs.

Keywords— MANET, Congestion-Control, Congestion, AODV

I. Introduction

Ad-hoc Network is defined as the collection of two or more wireless devices which have the capability of communicating with each other without the help of any centralized administrator. These networks are generally referred to as MANETs (Mobile Ad-hoc Networks). MANETs consists of collection of nodes which are free to move within the network and each node acts not only as a terminal but also as a router that has the functionality to forward the data. Mobile nodes can communicate directly via wireless link if they are within each other's radio range and if not, they rely on other neighboring nodes which act as routers to relay [1]. In MANET each node (Mobile Device) acts as a router, which helps in forwarding packets from a source to destination. MANET nodes can be personal devices such as laptop, mobile phones etc [2]. Mobile ad-hoc networks are suited for use in situations where an infrastructure is unavailable or deploy one is not cost effective.

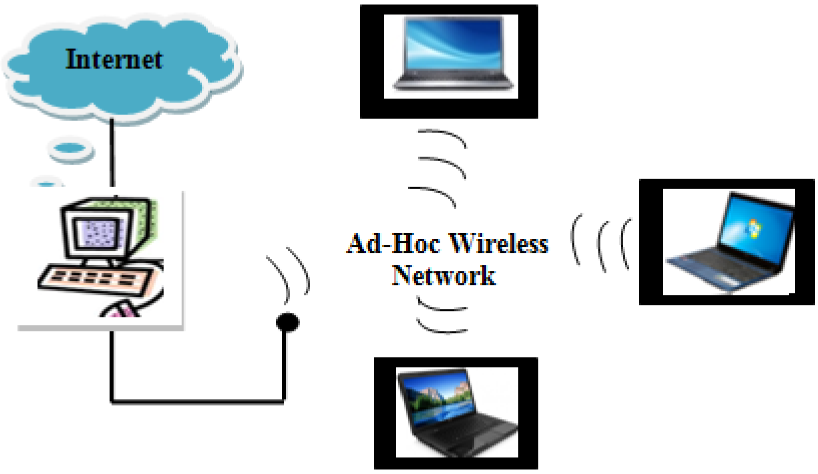

Fig. 1: Mobile Ad-Hoc Network

The designing of a reliable and efficient routing strategy is a very challenging problem in MANETs because of their mobile nature and limited amount of resources. In order to use these limited resources efficiently, an intelligent routing strategy is required which should also be adaptable to the changing conditions of the network, like, size of the network, traffic density and network partitioning [2]. Mobile ad-hoc network shows unexpected behavior with multiple data streams under heavy traffic load such as multimedia data when it is send to common destination. The main reason for packet loss, protocol overhead, and delay to find new route in MANET is due to congestion. So, In order to deal with all these issues, the routing in MANETs needs to be congestion adaptive due to these problems service quality is affected. This paper focuses on controlling congestion techniques in MANETs.

The rest of the paper is organized as follows. In Section II, Congestion and its types are described. Various congestion control techniques are illustrated in section III. Section IV concludes the paper.

II. CONGESTION AND ITS TYPES

A. ***CONGESTION IN MANET:*** Congestion is a situation in communication networks in which too many packets are present in a part of the subnet. Congestion may occurs when the load on the network (number of packets send to the network) is greater than the capacity of the network (number of packets a network can handle). Congestion leads to packet losses and bandwidth degradation and waste time and energy on congestion recovery [3]. In Internet when congestion occurs it is normally concentrated on a single router, whereas, due to the shared medium of the MANET congestion will not overload the mobile nodes but has an effect on the entire coverage area [4]. When the routing protocols in MANET are not conscious about the congestion, it results in the following issues**.**

Long delay: This holds up the process of detecting the congestion. When the congestion is more rigorous, it is better to select an alternate new path. But the prevailing on-demand routing protocol delays the route searching process.

High overhead: More processing and communication attempts are required for a new route discovery. If the multipath routing is utilized, it needs additional effort for upholding the multi-paths regardless of the existence of alternate route.

Many packet losses: The congestion control technique attempts to minimize the excess load in the network by either reducing the sending rate at the sender side or by dropping the packets at the intermediate nodes or by executing both the process. This causes increased packet loss rate or minimum throughput.

B. ***CONGESTION TYPES:*** Congestion can be classified into four different types [5]:-

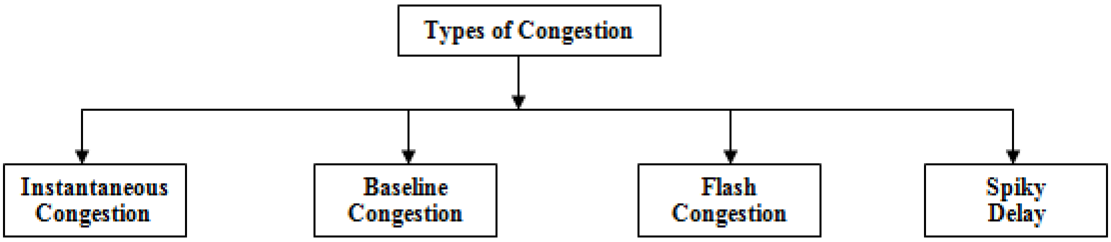

Fig. 2: Types of Congestion

1) ***Instantaneous Congestion:*** It is caused by mild bursts, created naturally by burstiness of IP traffic.
2) ***Baseline Congestion:*** It appears to be caused by systematic under-engineering of network or hop capacity (or alternatively due to simple source overflow described earlier).
3) ***Flash Congestion:*** It suggests frequent but momentary periods of overload in a highly utilized network, where bursts from individual sources add up to create significant packet loss hills.
4) ***Spiky Delay:*** It a condition where no packets are transferred for a long duration of time - the transit delay of packets shoots up from few milliseconds to tens of seconds during this period.

III. CONGESTION CONTROL TEHNIQUES IN MANETs

There are different congestion control techniques of MANETS. These techniques are as follows:

A. CBRRT (Congestion Based Route Recovery Technique) [5]: In this technique, each node estimates the parameters such as queue length, data rate, and medium access control (MAC) contention. The upper and lower limit of these parameters is compared and node is marked with the congestion status such as normal, medium or high level. When data is to be transmitted from the source to destination, the intermediate nodes along the path verify its congestion status. If the congestion status of any one node is high or congestion status of more than one node is medium, a warning message will be sent to the source. The source then selects the alternate congestion free path for data transmission. Congestion status of node can be categorized into 3 states: Normal (N), High (H) and Low (L). In this paper, three parameters are defined to control the congestion that is: Average queue length (L_q), Incoming Data Rate (R_{in}) and MAC Contention (T_{MAC}). This technique minimizes the packet drop and delay while increasing the packet delivery ratio.

B. CA-AODV (Congestion Adaptive AODV) [6]: CA-AODV is mainly designed to ensure for availability of primary routes as well as alternative routes and control the routes overhead. If congestion happens at any point of time between source and destination nodes n primary route, concerned node warns its previous node about congestion. The previous node uses a non congested alternative route to destination node. In this approach three steps are mainly used: Congestion Setup, Route Discovery and Route Maintenance Process. In congestion Setup Process, average discovery time and delay is to be calculated. In Route discovery process, based on congestion status route request is to send and in route maintenance process if any broken route find then route error message is to be generated. So this approach, this technique gives better overhead, less delay and less packet loss.

C. CFR (Congestion Free Routing) [7]: In CFR, dynamic mechanism defined used to monitor the congestion by calculating average queue length at node level. While using the average queue length, the nodes' congestion status divided into the three zones (safe zone, likely to be congested zone and congested zone). CFR utilizes the non-congested neighbors and initiates route discovery mechanism to discover a congestion free route between source and destination. This path becomes a core path between source and destination. To maintain the congestion free status, the nodes which are helping data packet transmission periodically calculate their congestion status at the node level. The predecessor core path node is aware of this situation and initiates an alternate path discovery mechanism to a destination. Finally it discovers a new congestion free route to the destination. So CFR improved packet delivery ratio, reduction of End to End delay and control packets.

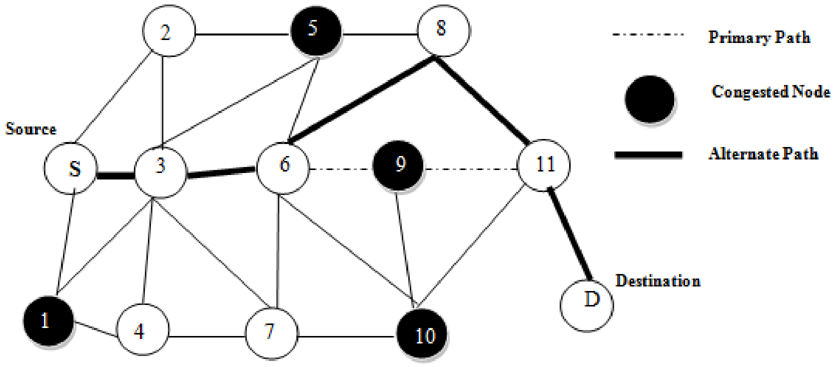

Fig. 3: Alternate path Finding process in CFR

D. LSRP (Link State Routing Protocol) [8]: In LSRP, whenever congested node sent congestion control packet which received by source node, it executes the congestion control algorithm. At first, the source node stops the forwarding of packets over the active paths. The source node sets a timer for the duration at which this new rate will be activated. During this period, if the source node does not receive any congested packet, if the link qualities of any of the active paths deteriorate, eventually the source node starts to load at the lowest possible rate over that path. In this case, the source attempts to switch the congested path with the backup path if possible. Consider residual energy and battery power in paths selection and the energy balance in data transmission to maximize the lifetime of networks. LSRP protocol which is effectively reduces the degradation of packet loss and faulty nodes. Although this approach produces routes with more hops, it allows minimizing the congestion on the link.

E. CARP (Congestion Adaptive Routing Protocol) [9]: Congestion Adaptive Routing is a congestion adaptive unicast on-demand routing protocol for MANETs. It tries to prevent congestion from occurring in the first place. Here every node that appears on the route warns its previous node when likely to be congested. So, CRP uses the additional paths called as bypass for bypassing the congestion creating traffic to the first non-congested node appearing on primary route. It reduces packet delay. But, at the same time CRP tries to minimize bypass to reduce protocol overhead. Hence, the traffic is split over bypass and so it reacts adaptively to network congestion. It consist of six components: congestion monitoring, primary route discovery, bypass discovery, traffic splitting and congestion adaptability, multipath minimization and failure recovery. Hence, power consumption is efficient, congestion is resolved beforehand and at the same time there is small packet loss rate.

F. AODV-I (Improved AODV) [10]: AODV-I is the Improved Ad-Hoc On-demand Distance Vector Routing protocol based on congestion aware and route repair mechanism. In AODV-I, in which congestion processing is added to the RREQ message which avoids selecting the busy nodes automatically during a new route establishment. The routing repair mechanism is also added to the RREQ message instead of initiating a new routing discovery whenever the route appears to be busy. In AODV, if source request node find a route whose destination sequence number is bigger or whose hop count is smaller, the new route replace the previous one absolutely, and the load of the previous will be transmit to the new. And if the new route is already busy, the traffic transmit from the previous node will make the new route more congested, which could increase the packet loss rate and data packet latency, then reduce the performance of the network. But AODV-I improves the traditional AODV by improving and repairing the route which is congested. This improvement reduces the packet loss rate, end-to-end latency and the utilization rate of the network resources.

G. ABCC (Agent Based Congestion Control Protocol) [11]: In this technique, the information about network congestion is collected and distributed by mobile agents (MA). A mobile agent based congestion control AODV routing protocol is proposed to avoid congestion in ad hoc network. Some mobile agents are collected in ad-hoc network, which carry routing information and nodes congestion status. When mobile agent movements through the network, it can select a less-loaded neighbor node as its next hop and update the routing table according to the node's congestion status. With the support of mobile agents, the nodes can get the dynamic network. The MA brings its own history of movement and updates the routing table of the node it is visiting. The MA updates the routing table of the node it is visiting. In this technique, the node is classified in one of the four categories depending on whether the traffic belongs to background, best effort, video or voice AC respectively. Then MA estimates the queue length of the various traffic classes and the channel contention of each path. Then this total congestion metric is applied to the routing protocol to select the minimum congested route in the network. This proposed technique attains high delivery ratio and throughput with reduced delay.

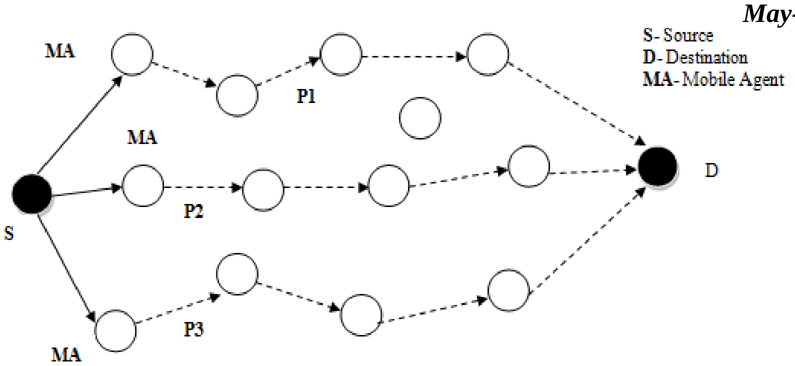

Fig. 4: Agent Based Congestion Routing Structure

H. CBCC (Cluster Based Congestion Control) [12]: A Cluster Based Congestion Control (CBCC) protocol that consists of scalable and distributed cluster-based mechanisms for supporting congestion control in ad-hoc 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 .This protocol consists of clustering mechanism, traffic rate estimation and traffic rate adjustment. 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. In CBCC network structure, nodes in the network are grouped into clusters.. Message exchanges consist of regular data packets, intra {node update packets) and inter (cluster head

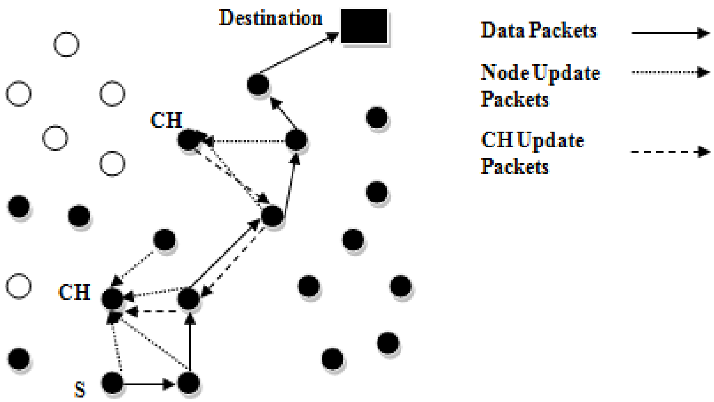

Fig. 5: CBCC Network Structure

update packets). Nodes within a cluster periodically report their locally computed estimation of the traffic load. This information is processed by the cluster head and a collective cluster level load estimate is communicated to the cluster heads towards the source. When compared to end to- end techniques, our approach improves the responsiveness of the system.

Table I: Comparison of congestion control techniques based on simulation parameters

Sr. No.	Simulation Parameters	CBRRT [5]	CA-AODV [6]	CFR [7]	LSRP [8]	CARP [9]	AODV-I [10]	ABCC [11]	CBCC [12]
1.	Packet Drop								
	• Based on Flows	Reduced			Low				
	• Based on Packet Size	Decrease							
	• Based on Packet Rate (Per Sec)		Higher						
2.	Packet Delivery Ratio								
	• Based on Flows	Higher		Increase	Good		Increase	Increase	Good

	• Based on Packet Size	**Increase**		**(20-28 %)**					
	• Based on Packet Rate (Per Sec)		**Slightly More**	**Improve (22-26 %)**		**Improve (23-53 %)**		**Improve**	
3.	**End to End Delay (Second)**								
	• Based on Flows	**Higher**		**Reduce (28 %)**	**Reduce**		**Lesser**	**Reduce**	
	• Based on Packet Size	**Less**							
	• Based on Packet Rate (Per Sec)		**Less (20%)**	**Reduce (22-26 %)**		**Reduce (28-48%)**		**Less**	**Low**
4.	**Routing Overhead**								
	• Based on Flows								
	• Based on Packet Size	**Lesser**		**Lesser (23%)**			**Lesser**		
	• Based on Packet Rate (Per Sec)			**Reduce (22-26 %)**		**Reduce (50 %)**			
5.	**Energy Consumption (Joules)**	**Less**				**Less (22-26 %)**			

IV. CONCLUSION

We have seen a great development in the field of wireless networks (infrastructure based) and in the field of Mobile ad hoc network (infrastructure less network). In MANET congestion is occurs when transmit the packets is greater than capacity of the network. Due to congestion performances of the network have to be decreased. The congestion control increase the packet delivery and decrease the end to end delay, packet loss .Network performance can be increased by controlling the congestion in MANET. In this paper number of congestion control techniques have discussed. Comparisons of congestion control techniques have discussed based on different simulation parameters. There are various challenges that need to be met, so these networks are going to have widespread use in the future.

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