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Research Article

Mitigating Congestion using Data Rate Control for MANET

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Abstract

In Mobile Ad hoc Networks (MANETs), congestion control and avoidance is a challenging issue due to node mobility and dynamic topology in networks. The occurrence of congestion is mainly due to bursty traffic, when incoming rate of data packets is higher than the sending rate of data packets at a node. Congestion leads to packet drop, long delay and wastage of network resources in the network. This paper proposes a technique for controlling and regulating the data sending rate from a sender based on the analysis of the dynamic queue length of intermediate nodes. Upon occurrence of congestion the intermediate nodes notify the source by using a distinct packet named "Congestion Indication Packet (CI Packet)". According to CI Packet, the sender eventually decline its sending data rate, so that congestion can be evaded before experienced by intermediate nodes and ensures a reliable communication within MANETs. By extensive simulation, our proposed protocol is implemented in NS2 and attains better results in packet delivery ratio, end-to-end delay than the existing protocol.

Keywords: *Mobile Ad hoc Networks (MANETs), Congestion Indication (CI) Packet, Queue length, Ad-Hoc on Demand Distance Vector (AODV).*

1. Introduction

Wireless is a new growing era that allows users to access and send information without any infrastructure use. Now days, mostly people use internet using wireless devices (e.g. Laptops, smart phones, palmtop). A Mobile Ad hoc Networks (MANETs) is a collection of independent mobile nodes in which mobile nodes can communicate to each other via wireless links (Dr S.S. Tyagi, 2013).

Congestion is the main problem in MANETs because the wireless links have significantly lower capacity than wired links. There are so many congestion control techniques that deals with TCP but they are not sufficient to handle congestion in ad hoc networks, because ad hoc networks involve special challenges like high mobility of nodes and frequent changes of topology. As we see in TCP, acknowledgement of packets will be there but in UDP packets there is no acknowledgment will be provided so don't know about how much routing data packets route in network. In TCP type traffic, congestion techniques are already provided but in other like CBR type traffic there is no congestion control mechanism.

In mobile ad hoc networks (MANETs), congestion can occur in any intermediate node, often due to limitation in resources, when data packets are being transmitted from the source to the destination. Congestion will lead to high packet loss, long delay and waste of resource utilization time. The primary objective of congestion control is to best utilize the available network resources and keep the load below the capacity. The congestion control techniques to deal with TCP have been found inadequate to handle congestion in ad hoc networks, because ad hoc networks involve special challenges like high mobility of nodes and frequent changes of topology.

A. Congestion in Manets

Congestion can be occur when data sending rate is exceeding than the data receiving rate so, it is crucial to adjust the data rate used by each sender in order not to overload the network, where multiple senders compete for link bandwidth. And we can say many packets are dropped while excessive amount of packets arrive at a network bottleneck and the lost packets often trigger retransmissions so more control packets arrive at a network that arises congestion (Soundararajan S. *et al*, 2012).

AODV

AODV is a reactive and on-demand routing protocol that is used for route establishment with small delay and based on DSDV (Destination-Sequenced Distance-Vector Routing) and DSR (Dynamic Source Routing) algorithms. To find a path to the destination, the source broadcasts a route request packet (RREQ). The neighbors broadcast the packet to their neighbors till it reaches the destination or till it reaches an intermediate node that has recent route information about the destination. The route request packet uses sequence numbers to ensure that the routes are loop free and to make sure that if the intermediate nodes reply to route requests, they reply with the latest

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information only. The route request can be broadcast, multicast but route reply always be a unicast. AODV minimizes the number of broadcasts by creating routes on-demand that maintains the list of all the reachable routes (Perkins, Charles E. *et al*, 1999).All routes are loop-free through use of sequence numbers and periodic HELLO messages are used to track neighbors.

2. Literature Survey

T.Senthilkumaran *et al* (2013) presented the Congestion free routing in ad hoc networks that is based on the estimations of the average queue length of a node. By seeing the average queue length, a node estimates the status of congestion and sends a warning message to its neighbors. The neighbors then find a congestion-free alternative path to the destination. This dynamic congestion estimate mechanism controlling the congestion in ad hoc networks and ensures reliable communication within the MANET.

Soundararajan *et al* (2012) presents approach that contains an adaptive rate control based technique in which the destination node copies the estimated rate from the intermediate nodes and the feedback is forwarded to the sender through an acknowledgement packet. Since the sending rate is adjusted based on the estimated rate, this technique is better than the traditional congestion control technique.

Li Xia *et al* (2009) proposes a approach in which according to the size of buffer queue, the intermediate nodes can judge their busy degree itself, and then decide how to deal with RREP. If the node is idle, the RREP will be sent immediately, otherwise, the RREP will be discarded, meanwhile, the intermediate nodes will not forward the RREQ any longer.

Nazia Zaman *et al* (2010) presents a router assisted approach, where routers send explicit feedback through which throughput can increase. By sending explicit feedback, the status of congestion can be detected and the sender also controls its sending data rate.

S. Das *et al* (2001) presents a new multi-path extension to AODV, it saves multiple disjoint paths towards same destination and uses them as backup for the primary path in case of link breaks. AOMDV improves the end to end delay and packet delivery by saving the time of route discovery in case of link breaks in primary paths.

S.Subburam *et al* (2012) presents predictive congestion control routing protocol for wireless Ad-hoc networks called as PCCAODV. Based on a congestion index, PCCAODV utilizes the upstream nodes and downstream nodes of a congested node and initiates route finding process Bi-directionally to find alternate non congested path between them for transmitting data. Suppose that the process find more non congested multi-paths and decides a finest single path for transmitting data.

3. Rate Based Congestion Avoidance Ad hoc On Demand Distance Vector (RBCA-AODV)

RBCA-AODV is a unicast protocol and congestion avoidance technique for MANET that prevents congestion before it is likely to occur. RBCA-AODV protocol consists of following components:

3.1 Scanning Congestion Status
3.2 CI Packet generation
3.3 Initiating sending data rate control

3.1 Scanning Congestion Status

Queue length of the mobile nodes is used as a routing metric to measure the traffic in the network. It is a queue management algorithm that makes use of a direct measurement of the queue length to identify the congestion status. To measure congestion status three ranges are set for detecting the level of congestion.

First range is set between 60% to 75% queue length which detects moderate congested node and thus class 1 action are to be taken, second one is set between 75% to 90% which detects high congested node and thus class 2 action are to be taken and third is set above 90% which detects severe congested nodes. The congestion sensing level of queue length need to be taken at a moderate level as if it is taken too less, the queue will remain empty and if taken too high, the queue will overflow before the congestion notification can be issued.

```
If (queue_length > =60% && queue_length < 75%) then
{
Send CI Packet to sources with Rate_class =1
}
Else if (queue_length > =75% && queue_length < =90%)
{
Send CI Packet to sources with Rate_class =2
 }
Else if (queue_length > 90%)
{
Send CI Packet to sources with Rate_class =3
}
```

A. CI Packet generation

After scanning the congestion status of the queue length, Congestion Indication packet generates if the congestion is detected. CI packet is of 64 bits and contains 4 fields that are Destination Address, Rate_Class, Type and Reserved.

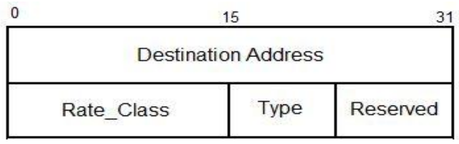

Fig. 1 Congestion Indication (CI) Packet

In Figure 1, Destination Address field is the address of the source that is transmitting the data, Rate_Class field is set to class 1, class 2 or class 3 depending upon the detected congestion level, Type field is CIP, Reserved field is for future use. Timer is set for the CI Packet on every intermediate node. A node can retransmit CI Packet to the destination address only if the timer expires.

C. Initiating sending data rate control

When CI Packet reaches to a destination address, destination decreases the rate according to Rate_Class field in the CI Packet. If the Rate_Class field having Class

Receiving of CI Packet
If (I am the destination of CI Packet)
{
If (rate_class ==1)
Decrease the rate to 25% of current rate

If (rate_class ==2)
Decrease the rate to 30% of current rate

If (rate_class ==3)
Decrease the rate to 35% of current rate
}
Else
Forward the CI Packet

1 then Rate decreases by 25%, if it lies in class 2 then rate decreases by 35% and if it lies in class 3 then rate decreases by 50%.

4. Simulation Results

The proposed protocol is experimented in the simulated environment with NS2. The MAC layer is based on IEEE 802.11 distributed coordination function. The channel Propagation model we used is the 2-ray ground reflection model. The radio range is 250 meters with bandwidth 2 Mbps. An interface queue at the MAC layer could hold 50 packets before they were sent out to the physical link.

Table 1 Simulation Parameters

Parameters	Value
Number of nodes	50
Topology Size	1000m X 1000m
Simulation time	600s
Mobility Speed	20m/s
Pause time	10s
Mobile Connections	20
Buffer Size	50
Traffic Type	CBR
Propagation model	Two-Ray Ground
Physical Layer	2 Mbps
MAC Layer	IEEE 802.11b

A routing buffer at the network layer could store up to 64 data packets. The data flow used constant bit rate (CBR), in which rate varies from 5 packets per second to 35 packets per second and the packet size is 512 bytes.

4.1 Performance Metrics

Packet Delivery Ratio: It is the ratio of the number of packets received successfully and the total number of packets transmitted.

Average end-to-end delay: The end-to-end delay is averaged over all surviving data packets from the sources to the destinations.

Packet Loss Ratio: It is ratio of total number of packet dropped and the total number of packet sent.

4.2 Results and Discussions

Figure 2, 3 and 4 shows the variation of throughput, packet delivery ratio, and end to end delay with respect to the threshold sets that are being used in the proposed algorithm.

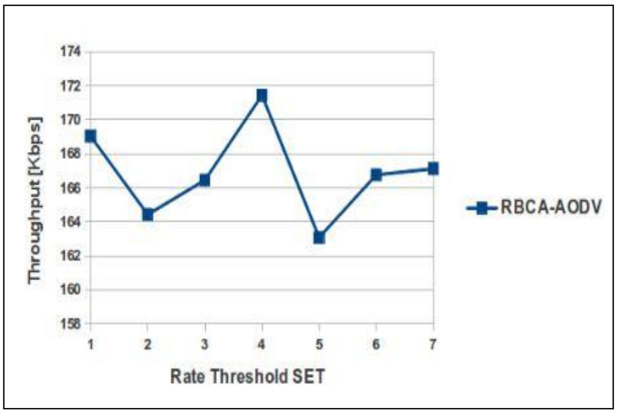

Fig. 2 Throughput Vs Rate Threshold Set

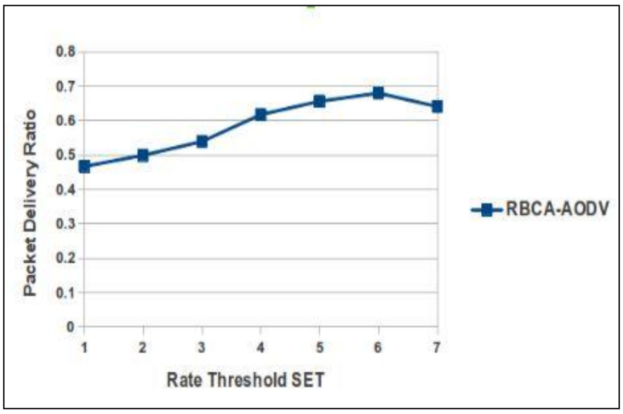

Fig. 3 Packet Delivery Ratio Vs Rate Threshold Set

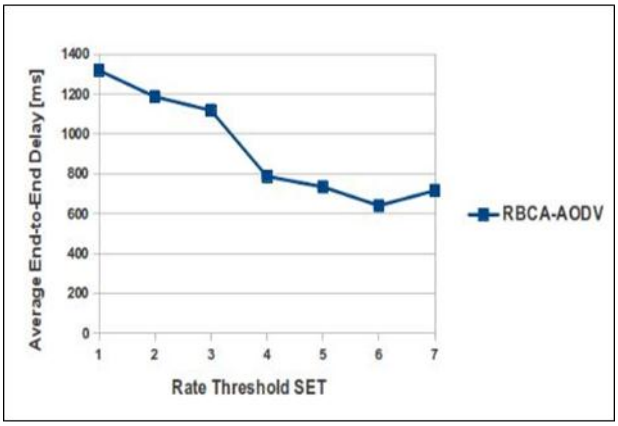

Fig. 4 Average End to End Delay Vs Rate Threshold Set

The optimal value is considered as the one with the best throughput because the rate control mechanism degrades the throughput of the network, so the value that has least effect on the throughput is considered as the optimal threshold set. The end to end delay and packet delivery ratio keep getting better as the percentage of rate decrease factor increases.

If the rate decreasing percentage is too high then it can lead to under utilization of the resources so the threshold must be set to the values which does not effects the throughput and also keeps the moderate level of packet delivery ratio.

Table 2 Description of Rate Threshold Set

Rate Threshold Set	Rate Decrease Values [%]	
1	Class 1 Class 2 Class 3	10% 15% 20%
2	Class 1 Class 2 Class 3	15% 20% 25%
3	Class 1 Class 2 Class 3	20% 25% 30%
4	Class 1 Class 2 Class 3	25% 30% 35%
5	Class 1 Class 2 Class 3	30% 35% 40%
6	Class 1 Class 2 Class 3	35% 40% 45%
7	Class 1 Class 2 Class 3	40% 45% 50%

Table 2, shows the rate threshold set details used in simulations to determine the optimal threshold values.

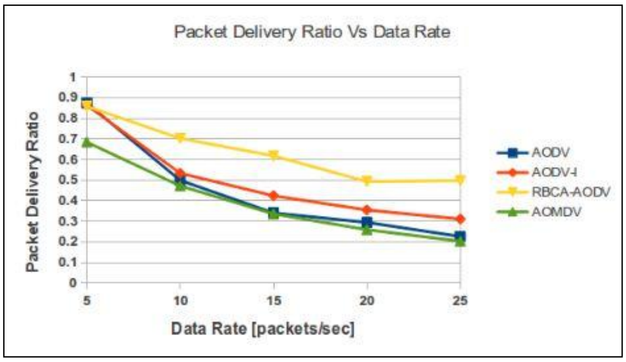

Fig. 5 Packet Delivery Ratio V/s data rate

In figure 5, the results of packet delivery ratio of different routing protocol is shown, as we increase the data rate in the network, the level of congestion in the network increases which leads to the degradation in the packet delivery ratio, but RBCA-AODV detects the level of congestion in the network and decrease the data rate of the sources that are causing congestion due to which packet delivery ratio of RBCA-AODV is better than the rest of the protocols.

AODV-I uses admission control at the time of route discovery based on current queue length but it does not work dynamically during data transmission, so it is not able to control the congestions occurring during the data transmission.

Fig. 6 Average End- to-End Delay V/s Data Rate

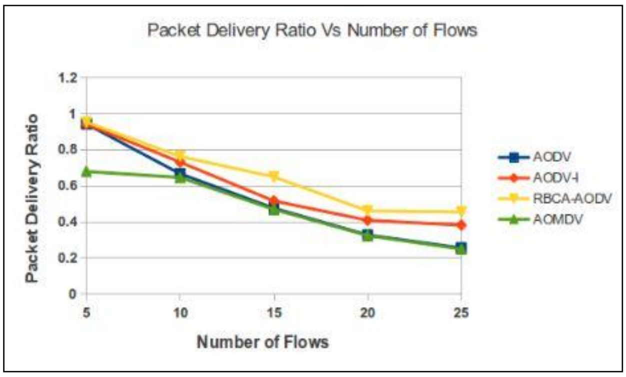

Fig. 7 Packet Delivery RatioV/s Number of Flow

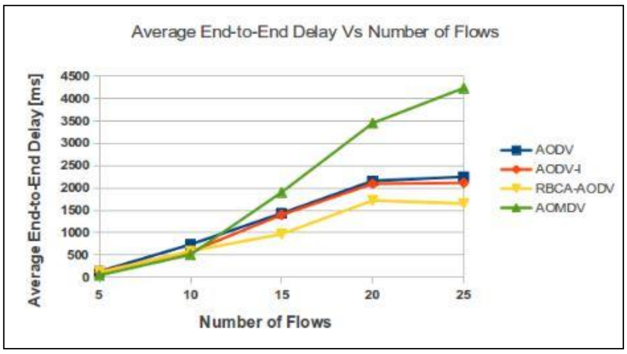

Fig. 8 Average End-to-End Delay V/s Number of Flows

This affects the packet delivery ratio. AOMDV uses multiple paths for data transmission. It uses backup paths in case of path failure in between the data transfer but it does not provide any control over the data rate in congested environment or any other congestion control mechanism for congested environment.

Similarly, figure 6 shows the result of average end-to-end delay in which data rate of RBCA-AODV from 5 to 15 packets/sec has slightly less delay difference but as we increase the data rate, we can see from results, the RBCA-AODV has less delay than AODV, AODV-I and AOMDV.

AOMDV is very effective in case of end to end delay when links breaks are occurring frequently as it does not need to initiate discovery until all the backup paths are invalid, but when path breaks are less and AOMDV fails to decrease the delay in the networks, AODV-I takes more time in route discovery as it has to check the node queue length. RBCA-AODV controls the congestion due to which the queue delay decreases for the packets and hence the end to end delay decrease.

Figure 7 shows the results of packet delivery ratio V/s number of flows. Flows varies from 5 to 10 RBCA-AODV is slightly better in packet delivery ratio than others protocols but as the number of flows increases the network carries more traffic, because when more data source sending the data packets, congestion is incurred in network due to less resources, RBCA-AODV eventually decreases the rate of the data sources so that at the intermediate nodes congestion can be evaded due to which the performance of the proposed protocol performs better than AODV in packet delivery ratio.

Similarly, figure 8 shows the result of average end-to-end delay in which number of flows varies from 5 to 10 of has slightly less delay difference but as we increase the number of flows, we can see from results, the RBCA-AODV has more less delay than other protocols.

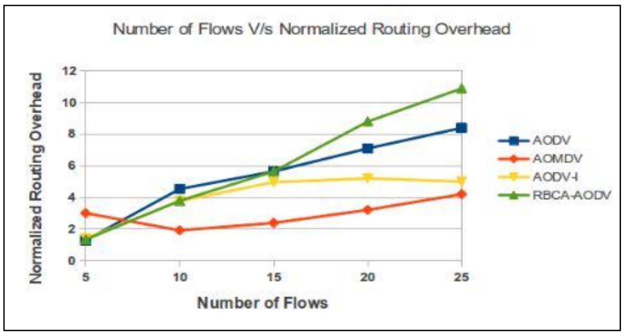

Fig. 9 Normalized Routing Overhead V/s Number of Flows

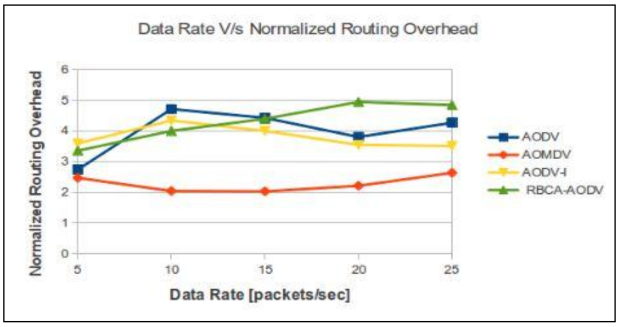

Fig. 10 Normalized Routing Overhead V/s Data Rate

Figure 9, 10 shows the Normalized Routing Overhead with Number of Flows and Data Rate of different routing protocols, RBCA-AODV has considerably higher overhead than other protocols as it introduces a new routing packet which is sent frequently by intermediate node on occurrence of congestion at the node, therefore the number of routing packets in the network increases and the overhead increases. The overhead can be neglected as the congestion of the network is handled by these packets which helps in better packet delivery ratio. CIP timer is also used to control the sending of CI Packet, as no node can send a CI packet before CIP timer expires.

Table 3 Performance Analysis

Performance Metrics	AODV	AODV-I	AOMDV	RBCA-AODV
Packet Delivery Ratio	Moderate	Moderate	Low	High
Average End-to-End Delay	Moderate	Moderate	High	Low
Packet Loss Ratio	Moderate	Moderate	High	Low

Table 3 shows the performance analysis of different protocols, RBCA-AODV has high packet delivery ratio and has less average end-to-end delay and packet loss ratio than AODV, AODV-I and AOMDV. AOMDV has less packet delivery ratio and high delay, packet loss ratio than AOMDV and AODV-I.

Conclusions

With increasing traffic problems like congestion and route failure need to be detected and remedied with a reliable mechanism. To solve the congestion problem Rate Based Congestion Avoidance-Ad hoc On Demand Distance Vector (RBCA-AODV) protocol is presented that could analyze the traffic fluctuation and categorize the congestion status perfectly. After detecting the congestion status by seeing the CI packet information, the data source regulating and controlling their data sending rate. As the result shows that the proposed protocol is performing better than existing AODV routing algorithm in case of packet delivery ratio, packet loss ratio and average end to end delay so we can say that RBCA-AODV does solves the problem of congestion in the network and hence increases the overall performance of the network.

References

S.S.Tyagi (2013), Study of MANET: Characteristics, Challenges, Applications and security attacks, *International Journal of Advanced Research in Computer Science and Software Engineering In Proc IEEE*,Vol. 3(5), pp. 252-257.

Senthilkumaran, T., and V. Sankaranarayanan (2013), Dynamic congestion detection and control routing in ad hoc networks, *Journal of King Saud University-Computer and Information Sciences 25*, Vol. 1, pp. 25-34.

Soundararajan, S., and Raghuvel S. Bhuvaneswaran (2012), Multipath load balancing & rate based congestion control for mobile ad hoc networks (MANET), *In Digital Information and Communication Technology and it's Applications (DICTAP), IEEE*, pp. 30-35.

Xia, Li, Zhaohui Liu, Yue Chang, and Peng Sun (2009), An improved AODV routing protocol based on the congestion control and routing repair mechanism, *In Communications and Mobile Computing. CMC'09* ,Vol. 2, pp. 259-262.

Zaman, Nazia, Kazi Chandrima Rahman, and Syed Faisal Hasan (2010), Explicit rate-based congestion control for multimedia streaming over mobile ad hoc networks, *International Journal of Electrical & Computer Sciences IJECS-IJENS 10*, Vol. 4, pp. 28-40.

Perkins, Charles E., and Elizabeth M. Royer (1999), Ad-hoc on-demand distance vector routing, *Mobile Computing Systems and Applications*. Proceedings. WMCSA'99. Second IEEE Workshop on. IEEE,.

Marina, Mahesh K., and Samir R. Das (2001), On-demand multipath distance vector routing in ad hoc networks, *In Network Protocols, 2001 Ninth International Conference*, pp. 14-23.

Subburam, S., and P. Sheik Abdul Khader (2012) Predictive congestion control mechanism for MANET, *Ind. J. Comput. Sci. Eng*, pp. 640-651.