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RESEARCH ARTICLE

Modified AODV for Congestion Control in MANET

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ABSTRACT- An ad-hoc wireless network is a collection of wireless devices which for temporary network without the aid of any established infrastructure or centralized administration. Although traffic control seems to be an effective method for controlling congestion, it presents a number of drawbacks which are not easy to ignore. The most important drawback steams from the fact that higher traffic load occurs when the monitored event takes place. At this instance there is a higher probability of congestion occurrence in the network. "Congestion Control" is a mechanism which assures that resources are used optimally & the system has maximum throughput for the given condition. The main aim of the congestion control is to assure that system is running at its rated capacity even in worst condition (overload situation). By controlling the rate with which packets are injected in the network, the amount of information that reaches the data sinks reduces. This fact can jeopardize the purpose of the network. Moreover, network connectivity issues arise since in most cases, this approach utilizes the shortest path from source to sink. Thus, in case of heavy data load, this path of nodes can easily become power exhausted. To achieve this, we take advantage of the fact that mobile nodes are frequently redundantly and/or densely deployed. In this thesis, we focus on congestion detection and prevent the congestion using Ad hoc on demand routing protocol (AODV) using MATLAB.

I. INTRODUCTION

Mobile ad hoc networks consist of wireless hosts that communicate with each other in the absence of a fixed infrastructure. Routes between two hosts in MANET may consist of hops through other hosts in the network. [4] The task of finding and maintaining routes in MANET is nontrivial since host mobility causes frequent unpredictable topological changes.

Ad hoc mode is a method for wireless devices to directly communicate with each other in dynamic fashion without any infrastructure. They are self-organizing networks. All nodes act both as participants and establishing a short-lived network because as a router that has the functionality to forward the data. Ad hoc networking is equivalent to peer-to-peer networking and nodes are mobile. That means there is no need of any access point to connect to any other node in the network. [3]

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 packets [2]. Mobile ad-hoc networks can turn the dream of getting connected "anywhere and at any time" into reality.

The goal of mobile ad hoc networking is to extend mobility into the realm of autonomous, mobile, wireless domains, where a set of nodes, [2] which may be combined routers and hosts; they form the network routing infrastructure in an ad-hoc fashion.

A. Types of Ad-Hoc Routing Protocols

Basically there are two types of routing protocols. Other types of routing protocols are combination of the basic routing protocols.

- **i.** Proactive Routing Protocols:
- **ii.** Reactive or On Demand Routing Protocols:
- **iii.** Hybrid (both proactive and reactive) Routing Protocols
- **iv.** Hierarchical Routing Protocols
- **v.** Geographical Routing Protocols

B. CONGESTION CONTROL:

When the number of packets increases beyond the limit and capacity that can be handled by the network resources which results degradation in network performance is called congestion. Congestion is an unwanted situation where network face the problem of more traffic than its rated capacity. Congestion is overcrowding or blockage due to overloading.

The congestion occurs in MANET due to limited resources. Due to the shared wireless channel and dynamic topology packet transmissions suffer from interference and fading.

Transmission errors also cause burden on the network due to retransmissions of packets in the network.

Congestion control technique is the method by which the network bandwidth is distributed across multiple end to end connections [8]. Congestion can be rate based congestion control or buffer based congestion control.

II. RELATED WORK

D. E. Perkins performed a work on MANET and proposed an ad hoc on demand distance vector routing protocol (AODV). The bandwidth requirement of AODV is less as compared to others because of its on-demand nature.

D.A. Tran [14] proposed a new protocol named as Congestion–adaptive Routing Protocol (CRP) which prevents the congestion from occurring in the first place by using the bypass concept. A bypass is a sub-path connecting a node and the next non-congested node.

A. K. Gupta works on AODV, DSR and TORA with respect to packet delivery ratio and end-to-end delay and shows the performance evaluation. The results show that AODV performs best while DSR is preferable for networks with moderate mobility rate and TORA is fit for operation in large mobile networks with dense population of nodes.

H. Pingale [11] has discussed various congestion control protocols in his survey paper. He described Congestion Adaptive Routing Protocol (CRP which tries to prevent congestion to occur in the first place where every node on the route warns its previous node when it is prone to be congested. It uses the bypass for passing the congested area to the first non congested node. He discussed about various routing protocols. Amongst them, only CRP is based on AODV routing protocol. All others are based on proactive scheme.

S. Yin [12] proposed multipath adaptive load balancing. Congestion occurs because of improper balancing over the network. He explained that distributing traffic among multiple paths based on the measurement of path statistics for better utilization of the network resources.

L. Shrivastava [7] has described various congestion aware and congestion adaptive routing protocols in his survey paper. Some of such routing algorithms discussed are hop-by-hop congestion ware routing protocol for heterogeneous mobile ad hoc networks, dynamic load-aware routing (DLAR), congestion adaptive routing protocols (CRP), congestion aware distance vector (CADV), congestion aware routing protocol for mobile ad hoc networks (CARM), etc.

The paper suggests that the problem of congestion has to be solved by having compromised solution rather than elimination.

M. Ali [10] proposed congestion adaptive multipath routing protocol. In this, Bandwidth decreases as the existing path's average load increases beyond a set threshold and residual battery energy below a set threshold, the traffic is dispersed over fail-safe multiple routes in order to lower the congested link's traffic load.

H. Li [20] proposed a mobile agent based congestion control AODV. Routing information and congestion status of the node is stored in mobile agent according to which selection of less loaded neighbor node as the next hop occurs.

L. Xia [8] proposed an improved AODV protocol known as AODV-I in which congestion processing is added to the RREQ message which avoids selecting the busy nodes automatically during route establishment. He focused on route repair mechanism rather than new route discovery during congestion.

III. PROPOSED WORK

Figure 1 illustrates network performance as a function of the load. When the load is light, throughput is linearly proportional to the load and response time is almost unchanged. After the load reaches the network capacity (the knee point), throughput won't increase much with the load. Instead, packets will be queued and the response time will become longer in this period. The throughput may suddenly drop if packets get discarded due to buffer overflow, which is called the cliff point as shown in Figure 3.1. Congestion can be realized in many ways, but in simple terms one may say that, if, for any time interval, the total sum of demands on a source is more than its available capacity, the source is said to be congested for that interval. Mathematically speaking:

$$\sum \text{Demand} > \text{Available Resources} \qquad (1)$$

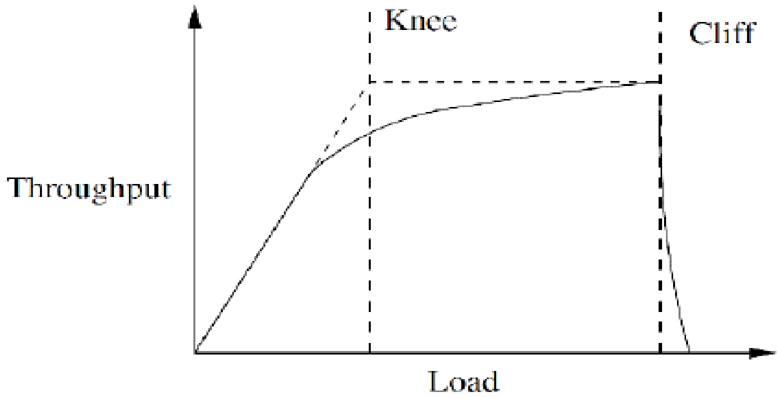

Figure 1: Effect of congestion on throughput

A. Objective

Our objective in this paper is to provide efficient data rate throughout the network operation, handling varying traffic rates. To satisfy this objective we propose techniques to detect congestion, and take action to maintain a constant traffic rate. Our aim is to try and maintain network in an ideal state in which it will deliver maximum packets allowed by network bandwidth consistently.

B. Congestion Detection

In our work we have proposed a congestion control technique. AODV routing protocol is used to make a route from source to destination. To show congestion multiple sources to single destination are used, which results in path of common nodes and congestion may occur in that path.

i) AODV

It is on demand protocol, when any node needs to send a message to sink then it broadcasts request to all nearby nodes which is broadcasted further if no destination node is found. At the destination acknowledgement message in form RREP is sent back following the same route from which it gets route request from source and source selects the minimum hopes path to send the message. An advantage of this approach is that the routing overhead is greatly reduced. A disadvantage is a possible large delay from the moment the route is needed (a packet is ready to be sent) until the time the route is actually acquired. When a node receives such a message and already has a route to the desired node, it sends a message backwards through a temporary route to the requesting node. The needy node then begins using the route that has the least number of hops through other nodes. Unused entries in the routing tables are recycled after a time.

AODV Properties

- Floods RREQs with unique IDs so duplicates can be discarded.
- Each node maintains backup route(s) in alternative route table.
- Distance-vector protocol so only destination, next hop and number of hops known.
- Alternative route (backup) route(s) or other routes which are discovered while route discovery used when primary fails.
- No multiple complete routes available.
- Alternative route(s) determined in RREP phase.
- Alternative route(s) by overhearing RREPs to other nodes.
- No complete route(s) information known at source.

The packet format sent to neighboring nodes which keep on adding their ID to it is shown in table 1. Every nodes follow this format and add their information and extract previous information to check whether they are destined to receive the packet or not.

Table 1: Proposed Packet Format

Source ID	Destination ID	Hop Count	MAC	OCS	Queue length	C_{act}

The proposed packet is shown in table 1. It contains source id, destination id occupies 2 bytes. Source id is used to identify the node, which is ready to discover the route. Destination node verifies the packet received from route, which contains source id.

- The Hop count is incremented once the packet is successfully sent. It occupies 1 byte field. Hop count determines number of nodes is connected to the particular node.
- Medium Access Control (MAC) is for accessing the particular channel.

- Overall Congestion Standard is used to verify the congestion aware route. It occupies 4-byte field.
- Queue length occupies 2 bytes field, which verifies the packet dropping ratio.
- Channel activity Cact is used to verify the occupation of the channel, which occupies 2 bytes field.

ii) Congestion detection algorithm

Figure 2 shows the path shared by two sources. At node number 34 sharing of paths started as indicated by a blue circle in the figure. The channel bandwidth in WSN is always fixed and can't be altered so nodes have to transmit message within that limit. When message from source 1 is transmitted to destination and after same time source 2 transmits then it senses the path is already acquired by other and no space to transmit the new message to destination. It will wait for some moment at node 34, if this waiting time is high then source node may consider the loss of packets as no feedback from sink node is received within expected time and again new packet will be lost if path is still engaged.

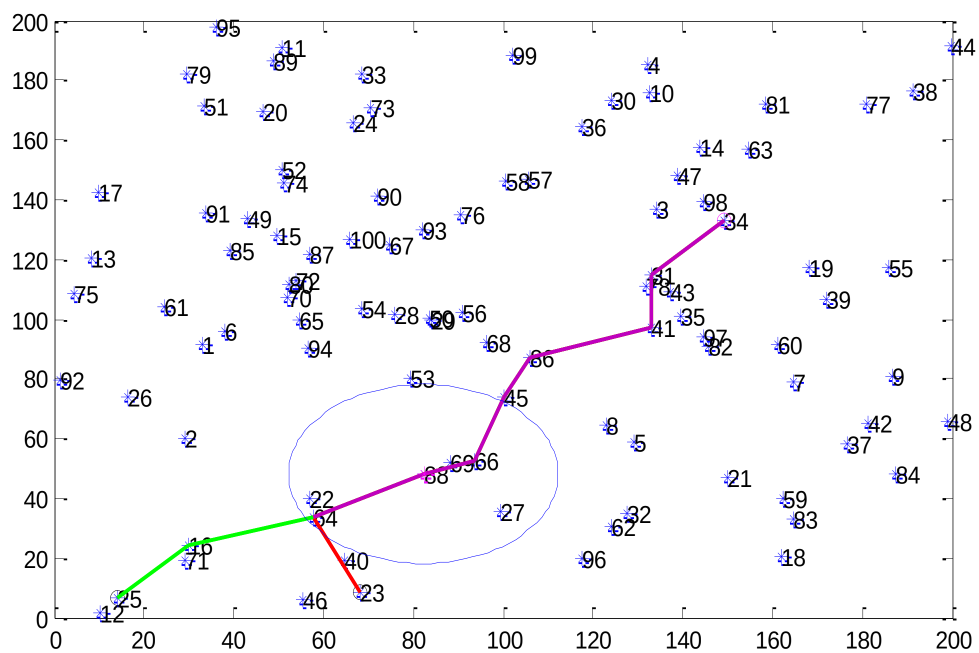

Figure 2: Common path for two sources to destination

So our algorithm will work on common node, in above case at node 34. Common node will keep a track of bandwidth usage of channel, when it receives message from other source then it will check for the space in the channel, if there is space to transmit the partial packets or all packets, then it will transmit otherwise hold the message up to a specified time, that time is called waiting time. The time of process is calculated by the following formula:

- $T_{min} = T_R + T_C + 3T_S + T_A$ (1)
- Where T_R = Time consumed on RTS
- T_C = time consumed on CTS
- T_S = SIFS period
- T_A = time consumed on data acknowledgement

Thus the MAC overhead is computed by including the time taken owing to contention for the channel using the following equation.

- $T_{MAC} = T_{min} + T_{ac}$ (2)
- Where, T_{ac} is the time taken due to access contention.

We have considered this time for each packet transmission. Packet overhead has been tabulated in table 1. at the common node message bandwidth of both paths is added and checked for the violation limit. Mathematically it can be represented as

- $Path1_{bandwidth} + path2_{bandwidth} < channel_{bandwidth}$ (3)

iii) Pseudo Code for Congestion detection

```
Begin
{
Check whether path is engaged
If yes
        Calculate the bandwidth requirement of both sources
       If  Path1bandwidth+path2bandwidth< channel bandwidth
       no congestion, transmits the message
       else
       no space for the new message in  the path, wait for 0.15 seconds
       path is free-> No
       feedback to source, congestion in path, look for another path
}
End
```

Once congestion is detected then nodes in the path are removed from the network temporarily and using AODV protocol a new route is searched and packets are transferred through that. This results in increase the packet delivery ratio.

IV. SIMULATION PARAMETERS

In this work AODV routing protocol has been modified and based on the channel bandwidth and waiting time congestion in the network is found. For the same work MATLAB as a tool is used to simulate the AODV MANET environment because it provides many toolboxes which helped in simulating the environment of network. Initial parameters considered for it are tabulated in table 2 below.

Table 2: Initialization parameters considered for the network

Parameters	**Specifications**
Area Size	100x100 mtr
No. of Nodes	100
Mac	802.11
Mobility Model	Random Way Point
Protocol	AODV
Transmission Range	30mtr
Packet Size	512 bytes
Pause time	Yes
Traffic Source	CBR
Radio Range	250m
Simulation Time	50 sec
Channel Bandwidth	2Mbps

The AODV use route request and route repeat request to confirm the route and once route is confirmed, it keeps on constantly send message on that route until congestion occurs as shown in figure 3. we have considered two sources selected randomly and one common destination to show congestion in the path. Their two different paths are shown by green and red colored lines. We have taken care of no congestion condition too. It's not mandatory that everytime congestion occurs in the path. The condition for congestion is either data sent by source should exceed the channel bandwidth or waiting time should be more than threshold.

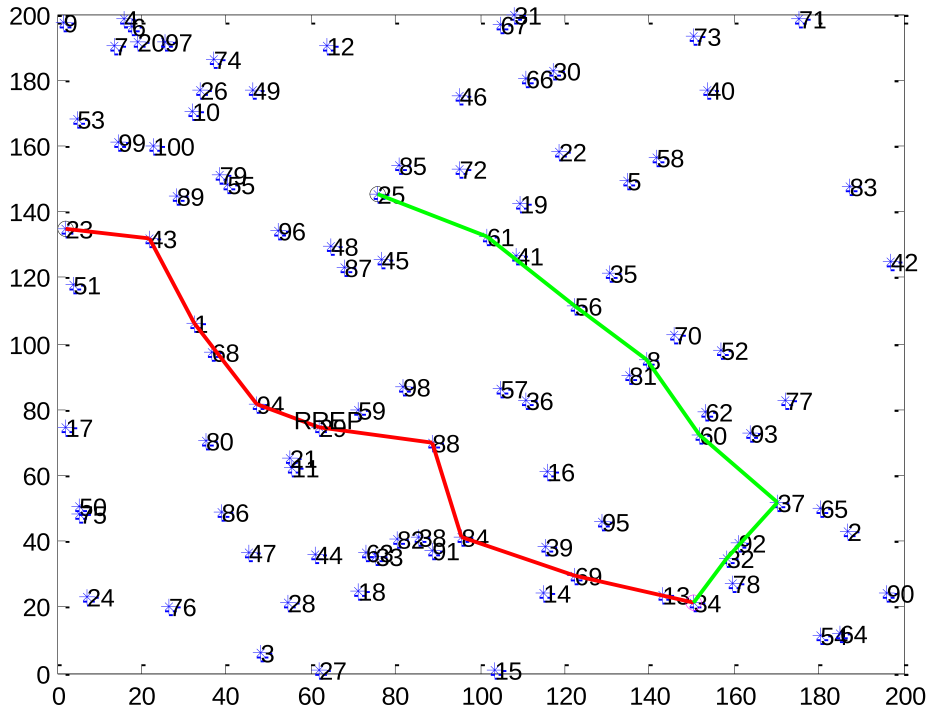

Figure 3: route confirmed by AODV protocol

The simulation time for the algorithm has been set to 50 seconds, for 50 seconds congestion in the path may occur for some time intervals.

V. RESULTS AND DISCUSSION

The congestion profile for 50 seconds in shown in figure 4. when congestion occurs the value is set to 1 otherwise it is 0. Figure shows that maximum continuous congestion time is 43-50 seconds. During this time a new congestion free route is searched by the affected source node. That route doesn't include the affected nodes or nodes already present in present route. To see the congestion condition at respective time intervals a graph for channel bandwidth and total bandwidth requirement for both data channels is plotted in figure 5 it shows that when limit is violated and waiting time exceeded, congestion occurred.

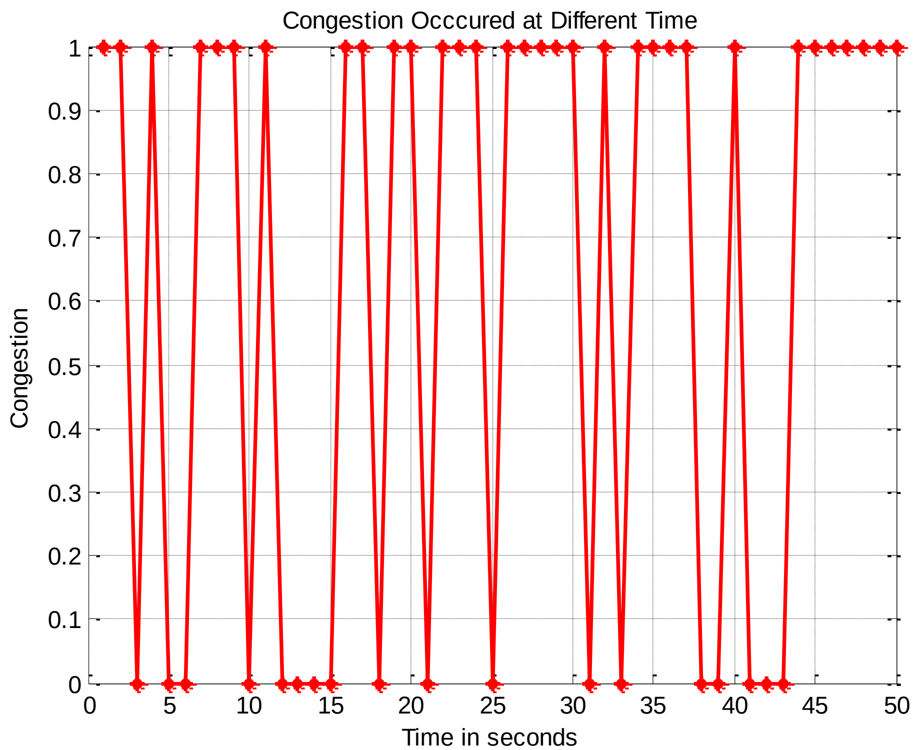

Figure 4: congestion profile for the network.

When channel bandwidth is exceeded by 4000 then node may send congestion signal to source node. Figure 5 shows that individual path bandwidth requirement is exceeded at few time intervals but since there are some common nodes in the path so, at that node bandwidth requirement will get added and it crosses the channel bandwidth frequently at may time intervals. Then waiting time is checked as shown in figure 6 and congestion is confirmed. In our work we have considered 0.15 seconds as waiting time. MAC time is calculated by the equations as discussed in previous chapter.

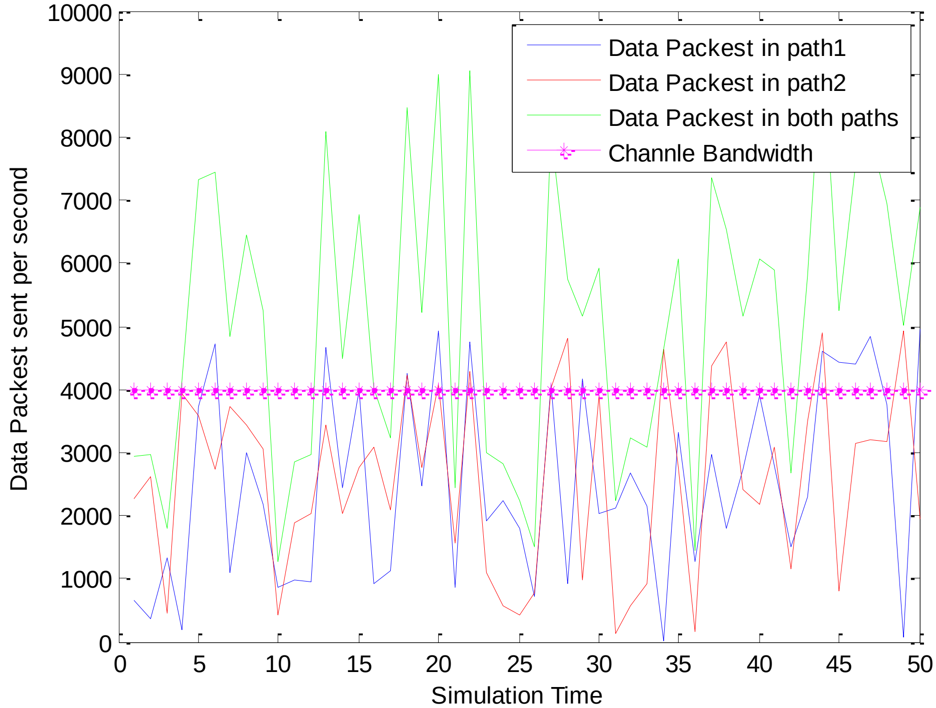

Figure 5: channel bandwidth and total packets sent per second in the channel

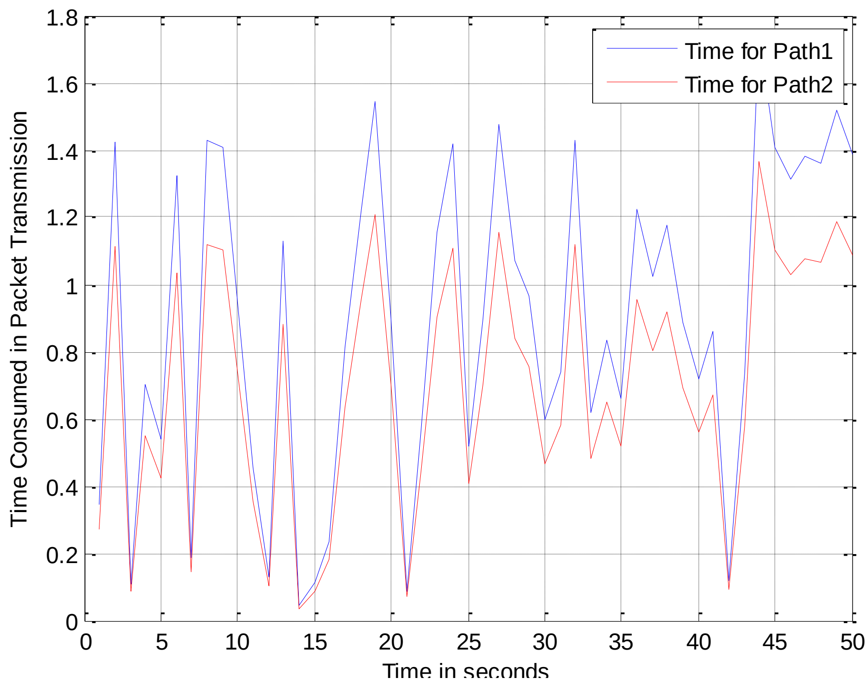

Figure 6: Time taken to traverse the packets through channel

To calculate the waiting time we have used MATLAB's toolbox command 'pause' and when Tmac is violated the waiting time, a warning message to source node is sent by congestion node so that data losses can be avoided. Source node then reconstructs an alternative route as shown in figure 7

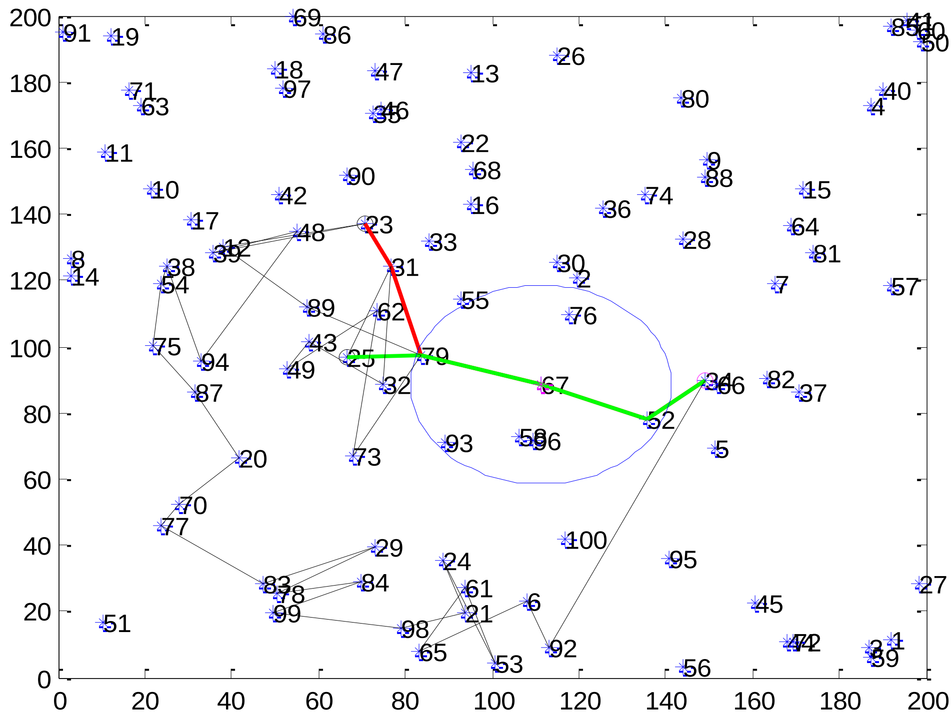

Figure 7: New route constructed by source node after congestion in the path

The route may be longer than original and to measure the efficiency of algorithm, data packets received is calculated. In this we have not considered the energy loss of data packets in travelling a long distance. This has been kept for future work. A comparison of packet delivery ratio is shown in figure 8 it is the ratio of total number of packets received to total number of packets sent. In this case some packets sent by second path could accommodate in the channel bandwidth and rest raise alarm for congestion in the path. If figure 8 is compared with figure 4, it shows the congestion is removed by proposed method only when congestion was in the path and packet delivery ratio is highest at that time.

Figure 8: Percentage of Packet delivery ratio for proposed algorithm

VI. CONCLUSION

Initially in this paper we prove that traffic bottleneck is a major issue in MANET and that queue formation starts very early when bottlenecks appear in the network. Thus, in order to avoid queue formation the data rate of the incoming flow must be severely reduced. In case that this action is omitted, buffer fill-up is going to happen, while the time that passes until the nodes' buffers fill-up depends on the difference between incoming and outgoing flows. As the nodes in MANET has limited buffer space, queue and bandwidth. So it becomes necessary to distribute the traffic among the mobile nodes and it became essential to control or to prevent the congestion to increase the throughput of the network. It also increases the packet delivery ratio, network performance, nodes transfer.

In order to solve this issue congestion control algorithms needs to be applied. These algorithms can be based either on traffic or resource control. According to the results of this paper, the traffic control method is an effective method for transient congestion occurrences but can be proven inappropriate when application needs all data to be transferred to sink. For this reason we base our proposed algorithms to the resource control method, a method that has not attracted a lot of interest due to the overhead that it creates.

VII. FUTURE WORK

In our work we have not considered the energy concept at nodes, but in actual the congestion detection is done at node which takes energy of node in processing, decreasing the alive time of node. In future work, energy can be considered as a constraint in the algorithm as it may happen as with our case, after 50n seconds congestion detection, energy residual are not enough to send an alarm to source node about congestion in the path. That will increase the packet drop ratio.

Our work is lacking with the effective new path searched after congestion. It's a path with many hopes. These should be decreased so that energy of packets doesn't reduce much.

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