

# An Analysis: Congestion Control in MANET

Deepesh Nigam<sup>1</sup>, Sujeet Tiwari<sup>2</sup>, Raghvendra Kumar<sup>3</sup>

<sup>1</sup>M.Tech Student, LNCT Group of College, Jabalpur, MP, India  
deepeshngm@gmail.com

<sup>2</sup>Asst.Professor, LNCT Group of College, Jabalpur, MP, India  
sujeet.tiwari08@gmail.com

<sup>3</sup>Asst.Professor, LNCT Group of College, Jabalpur, MP, India  
raghvendraagrawal7@gmail.com

**Abstract:** *Mobile ad hoc network (MANET) is a type of ad hoc network that can change locations and configure itself on the fly. MANETs use wireless connections to connect various networks. There are number of issues and challenges in a MANET. Congestion control is a challenging task in MANET. Congestion occurs when the demand is greater than available resources. Different types of mechanisms have been proposed to overcome the congestion in the mobile ad hoc network. Congestion control mechanisms control congestion either before congestion occur or after congestion actually occurred. In this paper we give an overview of WLAN, WMN and MANET over existing methods. The purpose of this paper is to discuss different proposed congestion control mechanisms in MANET.*

**Keywords:** MANET, Congestion control, Congestion control in MANET, Congestion control algorithm

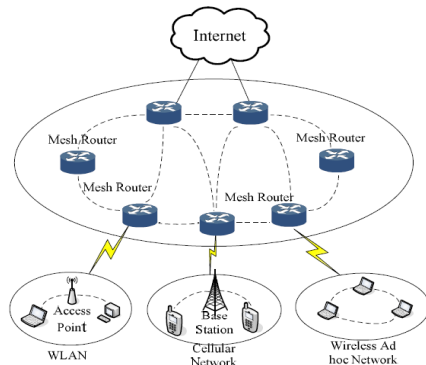
## 1. Introduction

The increased demands for mobility and flexibility in our daily life are demand that lead the development from wired LANs to wireless LANs (WLANs). Today a wired LAN can offer users high bit rates to meet the requirements of bandwidth consuming services like video conferences, streaming video etc. With this in mind a user of a WLAN will have high demands on the system and will not accept too much degradation in performance to achieve mobility and flexibility. This will in turn put high demands on the design of WLANs of the future. During the last few years Wireless mesh networking has become increasingly ubiquitous and the preferred mechanism to provide coverage to campuses, small towns, etc. In Wireless mesh networks a subset of the wireless nodes are connected to the wired backbone and provide connectivity to the other nodes in the network through multi hopping over the wireless links. As a natural extension to WLANs, the medium access mechanism of choice for these networks is the CSMA/CA based IEEE 802.11 distributed MAC protocol [1] [27] [28]. While IEEE 802.11 MAC protocol was designed for and provides a reasonable performance in a single hop network, it results in severe performance degradation in a multi-hop setting. In a single hop 802.11 network, all nodes contend for the channel with equal opportunity and act as greedy as possible to increase their one hop throughput which directly results in increase of the network aggregate throughput. In a multi-hop network, however, the greedy behavior of the nodes may result in service degradation as the packets transmitted by a source might not reach their final destination due to network congestion. In a congested network packets might be dropped in an intermediate node. Such a behavior will result in waste of the system resources used to deliver the packets to the intermediate node [2] [16] [17]. A congestion control scheme insures that the nodes place only as many packets on the wireless channel as can be delivered to the final destination. End-to-end schemes like TCP are the preferred solution in the Internet due to their scalability characteristics. In a wireless mesh network, however, a hop-by-hop

congestion control scheme can be more appropriate as such a network does not have the scalability problems of the large-scale Internet. A layer 2 hop-by-hop solution reacts more quickly to congestion and is effective regardless of the traffic type. Security of the nodes and data in a network are also required to be of high standards and is a big issue in MANET. Due to dynamic behavior of the nodes, security becomes a necessity in such a network to be considered at the top. The technology of Mobile Ad hoc Networking is somewhat synonymous with Mobile Packet Radio Networking, Mobile Mesh Networking and Mobile, Multi hop, Wireless Networking. There is current and future need for dynamic ad hoc networking technology. The emerging field of mobile and nomadic computing, with its current emphasis on mobile IP operation, should gradually broaden and require highly-adaptive mobile networking technology to effectively manage multi hop, ad hoc network clusters which can operate autonomously or, more than likely, be attached at some point(s) to the fixed Internet. MANET can be established extremely flexibly without any fixed base station in battlefields, military applications, and other emergency and disaster situation [2] [25].

Some applications of MANET technology could include industrial and commercial applications involving cooperative mobile data exchange. In addition, mesh-based mobile networks can be operated as robust, inexpensive alternatives or enhancements to cell-based mobile network infrastructures. There are also existing and future military networking requirements for robust, IP-compliant data services within mobile wireless communication networks many of these networks consist of highly-dynamic autonomous topology segments. Also, the developing technologies of "wearable" computing and communications may provide applications for MANET technology. When properly combined with satellite-based information delivery, MANET technology can provide an extremely flexible method for establishing communications for fire/safety/rescue operations or other scenarios requiring rapidly-deployable communications with survivable,

efficient dynamic networking [3] [12] [13] [14] [15]. There are likely other applications for MANET technology which are not presently realized or envisioned by the authors. It is simply put, improved IP-based networking technology for dynamic, autonomous wireless networks.



**Figure 1:** Architecture of Wireless Mesh Networks

While a network of only single-hop flows can also suffer from congestion due to overload, the focus of this work is on the congestion caused due to multi-hopping. We design a congestion control scheme which releases the resources that are wastefully used to transmit packets halfway through the network.

### 1.1 Wireless Local Area Network (WLAN)

A wireless local area network (WLAN) links two or more devices using some wireless distribution method (typically spread-spectrum or OFDM radio), and usually providing a connection through an access point to the wider internet. This gives users the mobility to move around within a local coverage area and still be connected to the network. A wireless LAN is based on a cellular architecture where the system is subdivided into cells, where each cell (called Base Service Set or BSS\*) is controlled by a Base station (called Access point or AP) [1] [5].

### 1.2 Wireless LAN Standards

Those are currently being explored in the field of communications technology [2] [3] [4] are:

1. IEEE 802.11
  - a. 802.11a
  - b. 802.11b
  - c. 802.11g
  - d. 802.11e etc.
2. HiperLAN/2.
3. Bluetooth.
4. HomeRF.

### 1.3 Wireless Mesh Network (WMN)

WMNs, generally described, consist of two types of nodes: mesh routers and mesh clients. The difference between a conventional router and a mesh router, apart from the mesh functionality, is that the latter can achieve the same coverage with lower transmission power through multi-hop communications. As regards to mesh clients, they also have necessary mesh functions and can thus behave as a router. On the other hand, gateway or bridge functions do not exist

in these nodes. Additionally, mesh clients have only one wireless interface [3] [8] [9] [10].

### 1.4 MANET

Wireless Ad Hoc network, with shared wireless channel to transmit messages, faces complicated wireless transmission environment, which will bring in a series of new problems, especially with routing, congestion being one of the problems. Generally speaking, for wireless Ad Hoc network, the calculation of the congestion control of one certain link should not just be based on the congestion of the link itself, instead, it should respond according to the general congestion message that interrupts the link. Therefore, to solve the routing congestion which might come up with the Ad Hoc network, the following issues should be taken into consideration:

1. The intrinsic properties of wireless multiple-hop links;
2. The time varying of network topology;
3. Dynamic end users. [6] [11]

More and more advancements in wireless communication technologies and availability of less expensive, small, portable computing devices led to mobile computing and its applications. A "mobile ad hoc network" (MANET) [8] [13] [14] [15] consists of mobile nodes connected by wireless links. The union of which forms an arbitrary graph. The nodes are free to move randomly thus, the network's topology may change rapidly and unpredictably. [7] [17]



**Figure 2:** Mobile Ad-Hoc Network

During the last few years Wireless mesh networking has become increasingly ubiquitous and the preferred mechanism to provide coverage to campuses, small towns, etc. In Wireless mesh networks a subset of the wireless nodes are connected to the wired backbone and provide connectivity to the other nodes in the network through multi hopping over the wireless links. As a natural extension to WLANs, the medium access mechanism of choice for these networks is the CSMA/CA based IEEE 802.11 distributed MAC protocol.

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results in increase of the network aggregate throughput. In a multi-hop network, however, the greedy behavior of the nodes may result in service degradation as the packets transmitted by a source might not reach their final destination due to network congestion. In a congested network packets might be dropped in an intermediate node. Such a behavior will result in waste of the system resources used to deliver the packets to the intermediate node.

A congestion control scheme insures that the nodes place only as many packets on the wireless channel as can be delivered to the final destination. End-to-end schemes like TCP are the preferred solution in the Internet due to their scalability characteristics. In a wireless mesh network, however, a hop-by-hop congestion control scheme can be more appropriate as such a network does not have the scalability problems of the large-scale Internet. A layer 2 hop-by-hop solution reacts more quickly to congestion and is effective regardless of the traffic type.

The idea of Ad Hoc Networking is gaining popularity with the recent proliferation of mobile computers like laptops and palmtops. Minimal configuration, absence of infrastructure and quick deployment make Ad Hoc Networks convenient for emergency operations. Since host mobility causes frequent and unpredictable topological changes, the formation and maintenance of Ad Hoc Network is not only a challenging task and also it is different from the wired networks.

Ad Hoc Routing Protocols are classified into Proactive and Reactive type. Proactive routing protocols use the periodic update of information to know about the current topology while the reactive routing protocols create a route to a destination on demand basis. Few of the proactive protocols are DSDV [10], WRP [11], DBF [12] etc. while DSR [13], AODV [14], ABR [15] are few examples of reactive protocols. Even though no protocol is superior to the other, but the previous studies indicate that in general reactive protocols exhibit better performance than proactive protocols. [9]

A wireless sensor networks (WSNs) is a formation of number of nodes (even hundred of it) that communicates with each other to perform sensing process. Normally each node equip with a battery to power it up, a main board with a chip and memory that acts as a CPU for the nodes. Each node has sensing capabilities thus to able sense the environment information (temperature, earthquake and etc) and process the information to be send through the network. Nodes can be hundred (even thousand of it) and each of the nodes connects each other to form a network communication. All the nodes will be monitor and control by a base station or sink which responsible to receive all information sensed by the nodes. In recent years, wireless sensor networks have been applied into real time application such as environment monitoring, health monitoring and military where the data in this application is considered as critical.

## **Applications of MANET**

1. Personal area networking - Cell phone, laptop, ear phone, wrist watch
2. Military environments - Soldiers, Tanks, Planes
3. Civilian environments - Taxi cab network, Meeting rooms, Sports stadiums, Boats, Small aircraft
4. Emergency operations – Search and rescue, Policing and fire fighting

## **Limitations of MANET**

Limitations of the Wireless Networks are:

1. Packet loss due to transmission errors
2. Variable capacity links
3. Frequent disconnections/partitions
4. Limited communication bandwidth
5. Broadcast nature of the communications
6. Limitations Imposed by Mobility
7. Dynamically changing topologies/routes
8. Lack of mobility awareness by system/applications
9. Limitations of the Mobile Computer
10. Short battery lifetime
11. Limited capacities

## **Effect of Mobility on the Protocol Stack**

1. Application - New applications and adaptations
2. Transport - Congestion and flow control
3. Network - Addressing and routing
4. Link - Media access and handoff
5. Physical - Transmission errors and interference

## **1.5 Security of Nodes on Mobile Ad-hoc Network**

Security is a major problem in MANET and therefore it is being addressed regularly by the researchers. Security algorithms offered for the MANET are addressing this problem in multiple ways and is applied using following:

1. Symmetric Key Cryptography
2. Public Key Cryptography
3. Authentication and Digital Signatures.
4. Hash and Message Authentication Codes (MAC)

MANETs are much more vulnerable to attack than wired network. This is because of the following reasons:

1. Open Medium - Eavesdropping is easier than in wired network.
2. Dynamically Changing Network Topology – Mobile Nodes comes and goes from the network, thereby allowing any malicious node to join the network without being detected.
3. Cooperative Algorithms - The routing algorithm of MANETs requires mutual trust between nodes which violates the principles of Network Security.
4. Lack of Centralized Monitoring - Absence of any centralized infrastructure prohibits any monitoring agent in the system.
5. Lack of Clear Line of Defence - The only use of I line of defence - attack prevention may not suffice. Experience of security research in wired world has taught us that we need to deploy layered security mechanisms because security is a process that is as

secure as its weakest link. In addition to prevention, we need II line of defence - detection and response.

The possible security attacks in MANETs can be divided into two categories:

1. Route Logic Compromise: Incorrect routing control messages are injected into the network to damage routing logic.
2. Traffic Distortion Attack: All attacks that prohibit data packets to transfer from the source to the destination, either selectively or collectively comes under the category of Traffic Distortion Attack. This type of attack can snoop network traffic, manipulate or corrupt packet header or contents, block or reply transmissions for some malicious purposes.

The list of some of the attacks in MANETs is as follows [24]:

1. Jamming.
2. Snooping.
3. Flood Storm attack.
4. Packet Modifications and Dropping.
5. Repeater attack.
6. Identity Impersonation.
7. Black Hole attack.
8. Wormhole attack.
9. Rushing attack etc.

## 2. 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 [5]. 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 [16]. When the routing protocols in MANET are not conscious about the congestion, it results in the following issues.

1. Long delay
2. High overhead
3. Many packet losses

## 3. Congestion Control Algorithms

Congestion control mechanisms have improved over time. In this section we will give an overview over congestion control mechanisms. Many researchers performed valuable research in the field of congestion control. First we will discuss TCP variants for congestion control after that we will give an overview over existing congestion control algorithms.

1. TCP TAHOE
2. TCP RENO
3. TCP NEW RENO

## 4. Conclusion

In this Survey paper gives an overview over different congestion control algorithms. We can conclude that there is no single algorithm for congestion control in mobile ad hoc network. Nodes in MANET have limited bandwidth, buffer space, queue etc. So it is essential to distribute the traffic among the mobile nodes. In MANET, to improve the performance, it is very essential to balance the traffic congestion. Main objective of any congestion control algorithm is to balance the traffic to increase throughput of the network. Also it is possible to maximize nodes transfer, packet delivery ratio, and minimizes traffic congestion, end-to-end packet delay and network performance can be improved. In our future work we will propose dynamic queue management concept for the MANET to solve the problem of congestion in MANET.

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