ISSUES AND CHALLENGES OF QUALITY OF SERVICE IN MOBILE ADHOC NETWORK

Mukesh Kumar
Student (Ph.D)
Department of Computer Engineering
The Technological Institute of Textile and Science, Bhiwani-127021, Haryana – India

Rahul Rishi
Associate Professor
Department of Computer Engineering
The Technological Institute of Textile and Science, Bhiwani-127021, Haryana – India

D.K.Madan
Associate Professor
Department of Mathematics
The Technological Institute of Textile and Science, Bhiwani-127021, Haryana – India

ABSTRACT.

A Mobile Adhoc Network is a self configuring network of wireless devices connected by wireless links. Quality of service is more difficult to guarantee in ad hoc networks than in most other type of networks, because the network topology changes as the nodes move and network state information is generally imprecise. This requires extensive collaboration between the nodes, both to establish the route and to secure the resources necessary to provide the QoS. Issues like limited availability of resources, insecure medium make QoS provisioning very challenging in such networks. The traditional MANET routing protocol does not employ power aware routing as well as feasible security features making QoS provisioning difficult.

Keywords: ***MANET, Routing Protocols, AODV, DSR, QoS***

1. INTRODUCTION

The recent developments in various fields such as Medicine, Computer science and Information technology. In no other field has these developments been more evident than in field of wireless technology. There are two basic types of wireless networks that are of interest; the cellular concept and the Ad hoc concept. The cellular concept is basically the same as is used in cellular phone technology (GSM), and is a highly researched area. Though wireless systems have existed since the 1980’s it is only in recent times that wireless systems have started to make inroads into all aspects of human life. Mobile Ad hoc Network is an autonomous system of mobile nodes connected by wireless links. Each node operates as an end system and a router for all other nodes in the network. A mobile Ad hoc Network is a self configuring network of mobile routers connected by wireless links –the union of which forms an arbitrary topology. An Ad hoc network is often defined as an “infrastructure less” network means that a network without the usual routing infrastructure, link fixed routers and routing backbones.

A MANET is a distributed network that does not require centralized control, and every host works not only as a source and a sink but also as a router. This type of dynamic network is especially useful for military communications or emergency search and rescue operations, where an infrastructure cannot be supported. The nodes that make up a network at any given time communicate with and through each other. In this way every node can establish a connection to every other node that is included in the MANET. Examples of nodes can be personal devices like, our mobile phones, Laptops, Personal Data Assistants (PDA’s), etc. Smaller and simpler devices also use wireless ad-hoc networking, like wireless headsets, hands free, etc.

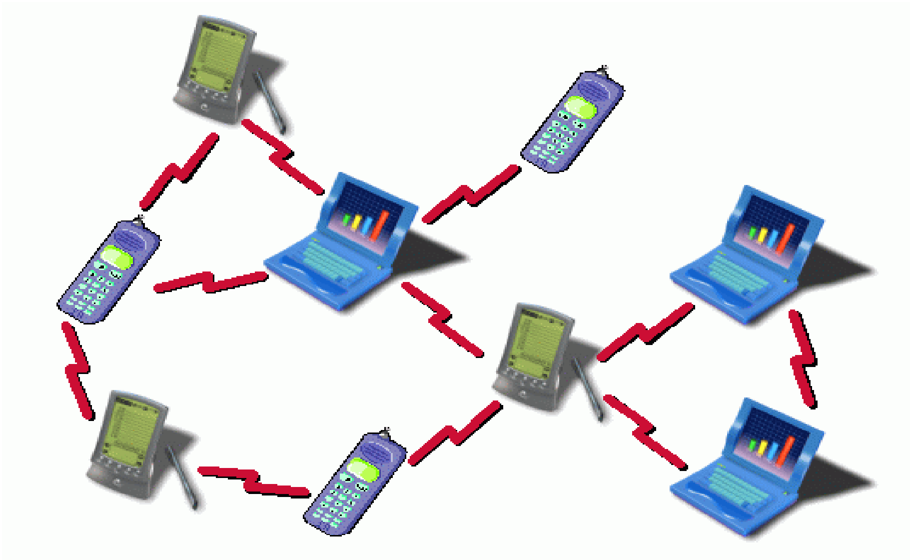

Fig. 1: Ad hoc network

The challenges of supporting QoS in ad hoc networks are how to reserve bandwidth and how to guarantee the specified delay for real-time application data flows. For wireless transmissions, the channel is shared among neighbors. Therefore, the available bandwidth depends on the neighboring traffic status, as does the delay. Due to this characteristic, supporting QoS cannot be done by the host itself, but cooperation from the hosts within a node's interference range is needed. This requires an innovative design to coordinate the communication among the neighbors in order to support QoS in MANETs. Furthermore, the distributed organization of MANETs brings additional challenges to collaboration for supporting QoS[1,5].

2. ISSUES IN MANETS NETWORKS

There are several issues within ad hoc networks that make them very complicated to integrate with the existing global internet. The problems are addressed below.

2.1 Routing

Routing is one of the most complicated problems to solve as ad hoc networks have a seamless connectivity to other devices in its neighbourhood. Because of multi hop routing no default route is available. Every node acts as a router and forwards each other's packets to enable information sharing between mobile nodes.

2.2 Security

Obviously a wireless link is much more vulnerable than a wired link. The science of cracking the encryption and eavesdropping on radio links has gone on since the first encryption of radio links was established. The user can insert spurious information into routing packets and cause routing loops, long time-outs and advertisements of false or old routing table updates. Security has several unsolved issues that are important to solve to make the ad hoc network into a good solution.

2.3 Quality of Service (QoS)

QoS is a difficult task for the developers, because the topology of an ad hoc network will constantly change. Reserving resources and sustaining a certain quality of service, while the network condition constantly changes, is very challenging[3].

3. PROTOCOL TECHNIQUES FOR MANET

Portable devices have limited capacity (battery power, available memory, and computing power) that further complicates the protocol design. Several protocols for ad hoc networks have been developed. The protocols can perform well under certain situations that they are designed to solve, but they fail completely in other situations that can occur in the network[2].

The routing protocols for ad hoc networks have been classified as:

3.1 Proactive/table driven

In proactive routing, each node has one or more tables that contain the latest information of the routes to any node in the network. Each row has the next hop for reaching to a node/subnet and the cost of this route. Various table-driven protocols differ in the way the information about change in topology is propagated through all nodes in the network. The two kinds of table updating in proactive protocols are the periodic update and the triggered update. Proactive routing tends to waste bandwidth and power in the network because of the need to broadcast the routing tables/updates. Furthermore, as the number of nodes in the MANET increases, the size of the table will increase; this can become a problem in and of itself. e.g. Destination Sequenced Distance Vector (DSDV) [3], Optimized Link State Routing(OLSR)[4].

3.2 Reactive/On-demand

They do not maintain or constantly update their route tables with the latest route topology. Instead, when a source node wants to transmit a message, it floods a query into the network to discover the route to the destination. The discovered route is maintained until the destination node becomes inaccessible or until the route is no longer desired. The protocols in this class differ in handling cache routes and in the way route discoveries and route replies are handled. Reactive protocols are generally considered efficient when the route discovery is employed rather infrequently in comparison to the data transfer. Although the network topology changes dynamically, the network traffic caused by the route discovery step is low compared to the total communication bandwidth. e.g. Dynamic Source Routing Protocol (DSR) [5] , Ad hoc On-Demand Distance Vector routing protocol (AODV) , Temporally Ordered Routing Algorithm (TORA).

3.3 Hybrid

Both the proactive and reactive protocols work well for networks with a small number of nodes. As the number of nodes increases, hybrid reactive/proactive protocols are used to achieve higher performance. Hybrid protocols attempt to assimilate the advantages of purely proactive and reactive protocols. The key idea is to use a reactive routing procedure at the global network level while employing a proactive routing procedure in a node’s local neighborhood. e.g. Zone Routing Protocol (ZRP) [7], Hybrid Ad hoc Routing Protocol (HARP).

4. QUALITY OF SERVICE

Quality of Service (QoS) refers to a set of service requirements that needs to be met by the network while transporting a packet stream from a source to its destination [17]. Informally, it refers to the probability of a packet passing between two points in the network. The network is expected to guarantee a set of measurable pre-specified service attributes to the users in terms of end-to-end performance, such as delay, bandwidth, probability of packet loss, delay variance (jitter), power consumption etc.
The wireless communication was originally developed for army use, because of its ease of mobility, installation and flexibility; later on it was made available to civilian use also. With the increasing demand and penetration of wireless services, users of wireless network now expect quality of service and performance comparable to what is available from fixed networks. Some of factors that influence QoS of Wireless Network include:

1. **Throughput of Network**
   Represents the total number of bits (in bits/sec) forwarded from wireless LAN layers to higher layers in all WLAN nodes of the network.
2. **Retransmission Attempts**
   Total number of retransmission attempts by all WLAN MACs in the network until either packet is successfully transmitted or it is discarded as a result of reaching short or long retry limit.

3. **Data Dropped**
   Data dropped due to unavailability of access to medium.
4. **Medium Access Delay**
   It includes total of queuing and contention delays of the data.

4.1 QoS metrics

QoS metrics are base parameters of quality for a network. QoS parameters include bandwidth, delay, jitter, security, network availability, and battery life and packet loss. The important QoS metrics for multimedia applications are delay, jitter, loss, and throughput. End-to-end delay is the time between the arrival of a packet and its successful delivery to the receiver. Another metric, access delay, is the time between packet arrival and packet transmission by the sender. Jitter is the variation of delay and is an important metric for multimedia applications. Bandwidth is the measure of data transmission capacity and influences throughput, which is the amount of data successfully transmitted and received in unit time.

4.2 QoS Models in use

Both of the services mentioned below are commonly implemented into routers of wired networks to improve the QoS and there for of interest. Especially is the resource reservation technique of great influence for several MANET solutions.

4.2.1 Integrated services (int-serv)

Int-serv identifies three main categories of service concerning the integration: the traditionally best-effort services, real-time services and controlled link-sharing services.
Best-effort services are those we currently experience on the internet. They are characterized by absence of any QoS specifications. The network provides the quality that it actually can contribute. Examples of best-effort traffic are FTP, mail and FAX.
Real-time services are services that have very critical requirements in terms of end-to-end delay, probability of loss and bandwidth. They usually require a guarantee from the network.
Controlled link-sharing is a service that might be requested by network operators when they wish to share a specific link among a number of traffic classes. Network operators may set some sharing policies on the link utilization among these traffic classes; specifically some percentage of bandwidth may be assigned to each traffic class[4].
The int-serv QoS solution uses the resource reservation protocol (RSVP) to flood messages through the network, and reserves resources for every flow at every router hop from source to destination. Every router along the path must maintain soft states information. Int-serv requires a lot of signalling, therefore the overhead is a concern when the network scale increases.

4.2.2 Differentiated services (diff-serv)

Diff-serv is a light weight alternative to int-serv. The concept of diff-serv is to differentiate the user data from control and management information. A field in the header of the Internet Protocol (IP) Data Unit was designed for these purposes: the Type-of-Service (TOS) field. The octet dedicated to this field indicates the specific treatment that the packet expects to receive from the network. The TOS bits are divided up as follows:

- 3 bits dedicated to priority of the datagram
- 3 bits define the type of service (TOS) which correspond to QoS expected by the IP datagram
- 2 bits are reserved for future use.

Diff-serv does not maintain the state of each and every flow as Int-serv does, but rather discriminates the packets according to their priority. The edge routers classify the traffic type, while the individual routers that forward the data will decide the fate of the packets according to local policies of the packet types. Diff-serv is easier to maintain, more scaleable and has less signalling than int-serv.

4.3 Problems related to QoS in MANET

Because of the resource limitations and dynamic nature of MANET networks, it is especially important to be able to provide QoS. However the characteristics of these networks make QoS support a very complex process. QoS support in MANET includes issues at the application layer, transport layer, network layer, MAC layer and physical layer of the network infrastructure[6]. In Mobile multihop wireless networks, there are several unique issues and difficulties that do not apply to the traditionally wired internet infrastructure. The most important issues are listed below.

4.3.1 Unpredictable link properties

Wireless media is very unpredictable and packet collisions are an unavoidable consequence of wireless networks. Signal propagation faces difficulties such as fading, interference, and multipath cancellation. These properties of the wireless network make measurements such as bandwidth and delay of the link unpredictable.

4.3.2 Node mobility

Movement of nodes in the ad hoc network creates a dynamic network topology. Links will be dynamically formed when two nodes moves into transmission range of each other and are torn down when they move out of transmission range. Node mobility makes measurements in the network even harder and measurements as bandwidth is essential for QoS.

4.3.3 Limited battery life

There is limited power of the devices that establish the nodes in the ad hoc network due to limited battery life time. QoS should consider residual battery power and rate of battery consumption corresponding to resource utilization. The technique used in QoS provisioning should be power aware and power efficient.

4.3.4 Hidden and exposed terminal problem

In a MAC layer with traditionally carrier sense multiple access (CSMA) protocol, multihop packet relaying introduces the “hidden terminal” problems. The hidden terminal problem happens when signal of two nodes, say A and B, that are out of reach of each other’s transmission range, collide at a common receiver, say node C. With the same nodal configuration, an exposed terminal problem will result from a scenario where node B attempts to transmit data (to someone other than A or C) while node C is transmitting to node A. In such a case, node B is exposed to the transmission range of node C and thus defers its transmission even though it would not interfere with the reception at node A. Carrier sense multiple access with collision avoidance (CSMA/CA) reduces the effect of hidden terminal problem, but there is no solution for the exposed terminal problem today. Hidden and exposed terminal problem is not only a QoS problem, but is a recurring problem through the aspect of the MANET network.

4.3.5 Route maintenance

The dynamic nature of the network topology and the changing behaviour of the communication medium make the precise maintenance of network state information very difficult. Because of this, the routing algorithms in MANET must operate on imprecise information. Since the nodes can join and leave the ad hoc network environment as they please, the established routing path may be broken at any time even during the process of data transfer. Thus, the need arises of routing paths with minimal overhead and delay. Since the QoS-aware routing would require reservation of resources at the routers (nodes), the problem of a heavily changing topology network might become cumbersome, as reservation maintenance with updates along the routing path must be done.

4.3.6 Security

Without adequate security, unauthorized access and usage may violate QoS negotiations. The nature of broadcasts in wireless networks potentially results in more security exposure. The physical medium of communication is inherently insecure, so it is important to design aware routing algorithms for MANET. Because of the difficult properties of mobile wireless networks there has been a suggestion of using soft QoS. The definition of Soft QoS is that after a connection setup, there may exist transient periods of time when QoS specifications is not honoured. However we can quantify the level of QoS satisfaction by the fraction of total disruption time over the total connection time. This ratio should not be higher than a threshold. SWAN uses this technique and is discussed later in this paper. QoS adaptation can be done in several layers. The physical layer should take care of changes in transmission quality, for example by adaptively increasing or decreasing the transmission power. Similarly, the link layer should react to the changes in link error rate, including the use of automatic repeat request (ARQ). A more sophisticated technique involves an adaptive error correction mechanism that increases or decreases the amount of error correction coding in response to changes in transmission quality of desired QoS. As the link layer takes care of the variable bit error rate, the main effect observed by network layer will be a change in effective throughput (bandwidth) and delay. Again the SWAN protocol is a good example of these statements.

CONCLUSION

The challenges increase even more for those ad hoc networks that, like their conventional wireless counterparts, support both best effort services and those with QoS guarantees, allow different classes of service, and are required to interwork with other wireless and wireline networks, both connection-oriented and connectionless. Algorithms, policies, and protocols for coordinated admission control, resource reservation, and routing for QoS under such models are only beginning to receive attention. The general issue of QoS robustness is yet uncharted territory. The same is also true for accommodating traffic with multiple priorities, including preemptive priorities. We have not even mentioned the issue of network management for ad hoc networks with QoS in the main text; to our knowledge, neither has anyone else. Much work remains to be done on cost-effective implementation issues to bring the promise of ad hoc networks within the reach of the public.

References

[1] Guerin R., Orda A., “QoS-based routing in networks with inaccurate information: Theory and algorithms”, in Proc. IEEE INFOCOM’97, Japan,pp. 75-83.
[2] J. L. Sobrinho and A. S. Krishnakumar, “Quality-of-Service in ad hoc Carrier Sense Multiple Access Wireless Networks,” *IEEE JSAC*, vol. 17, no. 8, Aug. 1999, pp. 1353–1414.
[3] T. Chen, M. Gerla, and J. T. Tsai, “QoS Routing Performance in a Multi-Hop, Wireless Network,” *Proc. IEEE ICUPC ’97*.
[4] C. R. Lin and J.-S. Liu, “QoS Routing in Ad Hoc Wireless Networks,” *IEEE JSAC*, vol. 17, no. 8, Aug. 1999, pp.1426–38.
[5] Broch J., Johnson D., Maltz A., “The Dynamic Source Routing Protocol for Mobile Ad Hoc Networks”, draft-ietf-manet-dsr-03.txt, work in progress. October 1999.
[6] A. Iwata *et al.*, “Scalable Routing Strategies for Ad hoc Wireless Networks,” *IEEE JSAC*, vol. 17, no. 8, Aug. 1999, pp. 1369–79.
[7] R. Ramanathan and M. Steenstrup, “Hierarchically Organized, Multihop Mobile Wireless Networks for Quality of Service Support,” *Mobile Network and Apps.*, vol. 3, 1998, pp. 101–19.