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Exploring the Requirements for QoS in Mobile Ad hoc Networks

Shakeel Ahmed *
A K Ramani *
School of Computer Science, Devi Ahilya University, Indore INDIA

ABSTRACT

This paper presents a literature study on the requirements of Quality of Services (QoS) in Mobile Ad-Hoc Networks (MANET'S) which is universally growing area. MANET'S were initially proposed for use in military and battle field, due to the rapid expansion of the Multimedia Technology, Mobile Technology and civilian applications has to strictly adhere to QoS. The paper presents the description about the QoS and the issues of MANETS like Routing, Medium (or Channel) access, Mobility Management, Security and Reliability, and Power Consumption and also the current approaches including models and solution strategies. The focus of our paper is on those approaches that are relevant to our work.

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Keywords : Wireless networks, Mobile Ad-Hoc Networks (MANET'S) Quality of service (QoS), Routing, Medium (or Channel) access, Mobility Management, Security and Reliability, and Power Consumptio

1) INTRODUCTION

Wireless networks have become increasingly popular around 1970, in the network industry. Also, cheap availability of networking hardware have led to the rapid expansion of wireless services, cellular voice, PCS (personal Communication Services), mobile data and wireless LANs etc. In view of above, the Internet Engineering Task Force (IETF), the body responsible for guiding the evolution of the Internet, provided the definition of MANET as below (Brook Shrader, 2002):

A mobile Ad hoc network (MANET) is an autonomous system of mobile routers (and associated hosts) connected by wireless links. The routers are free to move randomly and organize themselves arbitrarily; thus, the network's wireless topology may change rapidly and unpredictably. Such a network may operate in a stand-alone fashion, or may be connected to the larger Internet.

A mobile Ad hoc network (MANET) is formed by a group of autonomous mobile nodes connected by wireless links, in which there is no backbone infrastructure. The system

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*Shakeel Ahmed : shakeel_rahi@yahoo.com
*A K Ramani : ramaniak@yahoo.com

may operate in isolation, or may have gateways to interface with a fixed network. The nodes (a router with multiple hosts and wireless communications devices) are free to move about and organize themselves randomly. These nodes may be located in or on airplanes, ships, trucks, cars, or on very small devices, and there may be multiple hosts per router. As a result, the network wireless topology may change rapidly and unpredictably. Such a network may operate in a standalone fashion, or may be connected to the larger Internet.

In general, Ad hoc wireless networks are self-creating, self-organizing, and self-administrating networks (V. Loscri). Hence, they offer unique benefits and flexibility for a variety of situations and applications. Because of these features, the Ad hoc networks are used where wired network and mobile access is either unproductive or not feasible. A few possible examples include: earthquake hit areas, where infrastructure is destroyed, military soldiers in a destructive environment; virtual classrooms, biological detection, tracking of rare animal, space exploration, and undersea operations.

2) QUALITY OF SERVICE

Quality of Service (QoS) is a generic term collectively used to assess the usefulness of any system with user's perspective. In computer networks, QoS involves adding mechanisms to control the network activity such as transmission and error rates, to assure certain level of service parameters. The main goal of QoS provisioning is to achieve a more deterministic network behavior, so that information carried by the network can be better delivered and network resources are better utilized.

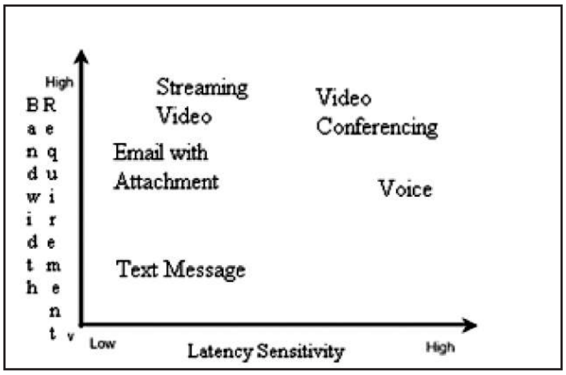
The network services can be characterized by a set of measurable pre specified service requirements such as minimum bandwidth, maximum delay, maximum delay variance (jitter), and maximum packet loss rate etc. After accepting a service request from the user, the network has to ensure that service requirements of the users flow are met, as per the agreement throughout the duration of the flow (a packet stream from the source to the destination). In other words, the network has to provide a set of service guarantees while transporting a flow.

QoS is needed in mobile Ad hoc networks because different applications have different service requirements; for example, VoIP considers issues like delay, jitter and minimum bandwidth. While there is a high mobility of users and network nodes (in emergency and military operations), bandwidth and battery capacity are scarce resources, and will be the important consideration for QoS.

The United Nations Consultative Committee for International Telephony and Telegraphy (CCITT) Recommendation E.800 has defined QoS as: "The collective effect of service performance which determines the degree of satisfaction of a user of the service". (Jae-11 Jung, 1996) The network is expected to guarantee a set of measurable pre specified service attributes to the users in terms of end-to-end performance. The different QoS constraints are classified as: Time constraints– (Delay, jitter); Space constraints– (System buffer); Frequency constraints– (Network/system bandwidth); and Reliability constraints–(Error rate) (Aura Ganz, 2002).

Different Applications require different network performance, based on bandwidth needs and latency sensitivity. The needs of various applications in context to bandwidth and latency sensitivity requirements are shown schematically in Fig. 1. It can be observed that higher the latency sensitivity, higher is the bandwidth requirement; Data-transfers tend to have zero tolerances for packet loss and high tolerances for delay and jitter. Typical acceptable response times range from a few seconds for FTP transfers to hours for email. Bandwidth requirements in the order of Kbytes/sec are generally acceptable, depending on the file size. Voice and Video conferencing applications require both high bandwidth and high latency sensitivity.

Figure 1:
Different Applications and Network Requirements



Traffic behavior and QoS requirement for different applications vary also from one application to another application, as given Table 1 for Electronic Mail (SMTP), File Transfer (FTP)

and Remote Terminal (Telnet) the bandwidth requirement is low, since the data is transferred in the form of small batch files. In HTML web browsing, the bandwidth requirement varies, since the data is transferred in a series of bursty files. The bandwidth requirement is significantly high in streaming video application and very sensitive to delay / Jittler (Cisco.com).

Video/Voice streaming includes applications such as, Apple's QuickTime Streaming or Real Networks' Streaming video and voice products etc. Video/voice streaming tends to have low tolerances for packet loss and medium tolerances for delay and jitter. Typical acceptable response times are in the order of a few seconds, because of the well known fact that the server can pre-buffer multimedia data on the client to a certain degree. This buffer then drains at a constant rate on the client side, while simultaneously, receiving bursty streaming data from the server with variations in delay. Different issues of MANET'S are discussed further.

Table 1 :
Traffic Behaviour and QoS requirements

Applications	Traffic Behavior	QoS Requirements
Electronic Mail (SMTP) File Transfer (FTP) Remote Terminal (Telnet)	Traffic Behavior Small, batch file transfers	QoS Requirements Very tolerant of delay B/W requirement: low **Best effort**
HTML Web Browsing	Series of small, bursty file xfer	Tolerant of moderate delay B/W requirement: varies **Best effort**
IP-based Voice (VoIP) Real Audio	Constant or variable bit rate	Very sensitive to delay/jitter B/w requirement: low **Requires predictable delay/loss**
Streaming Video	Variable bit rate	Very sensitive to delay/jitter B/w requirement: High, variable **Requires predictable delay/loss**

3) ISSUES OF MANETS

There are several issues for realization of benefits from Ad hoc networking. Some of these issues include routing, medium (or channel) access, mobility management, power management, security, and quality of service (QoS) issues, mainly pertaining to delay and bandwidth management (Jun-Zhao Sun), and are briefly elaborated here.

3.1 Routing: Because of the changing topology between any pair of nodes, the routing of packets between the nodes becomes a challenging task. Also, the routes among different nodes may potentially contain multiple hops, increasing the complexity of communication in comparison to single hop. (Elizabeth M. Royer). Protocols developed take in to consideration the issues about the power consumption, low bandwidth, and high error rates, in decision of routing.

Routing protocols may generally be categorized in to two classes (a) table-driven and (b) source-initiated on-demand driven (Hongqing Zhai, 2006). The table-driven routing protocols attempt to maintain constant, up-to-date routing information from each node to every other node in the network. These protocols require each node to maintain one or more tables to store routing information, and they respond to changes in network topology by propagating updates throughout the network in order to maintain a consistent network view.

A different approach from table-driven routing is source-initiated on-demand routing. This type of routing creates routes only when desired by the source node. When a node requires a route to a destination, it initiates a route discovery process within the network. This process is completed once a route is found or all possible route permutations have been examined. Once a route has been established, it is maintained by some form of route maintenance procedure until either the destination becomes inaccessible along every path from the source or until the route is no longer desired.

3.2 Medium (or Channel) access: Many protocols are defined to establish and maintain routing paths in Ad hoc mobile networks. Some of the MAC protocols defined are Carrier Sense Multiple Access (CSMA), Multiple Access with Collision Avoidance (MACA), Floor Acquisition Multiple Access (FAMA), and IEEE 802.11 MAC protocol which specifies a Distributed Coordination Function (DCF) (Wuh, 2002). The principal use of MAC is to manage the channel access among multiple nodes to achieve high channel utilization. In other words, the coordination of channel access should minimize or eliminate the incidence of collisions and maximize spatial reuse at the same time (Fullmer CL, 1997).

3.3 Mobility Management: In Ad hoc networks the nodes move freely from one place to another place. The location of the nodes must be identified before the data is transferred from one node to another node and a connection needs to be established. There are many mobility management schemes defined to support real-time and non-real-time application in the global Internet, both for inter-domain and intra-domain mobilityt. While providing support for personal, terminal and session mobility. Mobility management deals with storage, maintenance, and retrieval of the mobile host location information.

3.4 Security and Reliability: In addition to the common vulnerabilities of wireless connection, an Ad hoc network has its particular security problems due to dynamic topologies and membership, vulnerable wireless links, roaming in dangerous environment (L. Zhou, 1999) and there are few other reasons concerned with reliability problems like, broadcast nature of the wireless medium (e.g. hidden terminal problem), mobility-induced packet losses, and data transmission errors etc. Secure routing in networks such as the Internet has been extensively studied (R. Perlman, 1988) – (K.E. Sirois, 1997). Many proposed approaches are also applicable to secure routing in Ad hoc networks. To deal with external attacks, standard schemes such as digital signatures to protect information authenticity and integrity have been considered. For example, Sirios and Kent (L.M. Feeney, 2001) propose the use of a keyed one-way hash function with windowed sequence number for data integrity in point-to-point communication and the use of digital signatures to protect messages sent to multiple destinations.

3.5 Power Consumption: As wireless devices usually rely on portable power sources such as batteries to provide the necessary power, power management in wireless networks has become a crucial issue. It has been observed that energy is not always consumed by active communication in Ad hoc networks (R. Braden, 1994). Energy consumed by wireless devices in the idle state is comparatively less than that in the transmitting or receiving states. The different modes at which the network interface (at the receiver node) can operate are:

Transmit mode: The mode at a node when transmitting a packet. *Receive mode:* The mode at a node when receiving a packet. *Idle mode:* The mode generally used at a node with the node is neither transmitting nor receiving a packet. This mode consumes power because the node has to listen to the wireless medium continuously in order to detect a packet that it should receive, so that the node can then switch into receive mode. *Sleep mode:* Sleep mode has very low power consumption. The network interface at a node in sleep mode can neither transmit nor receive packets; the network interface must be woken up to idle mode first by an explicit instruction from the node. From the above it can be seen that power consumption is lower when the node is in sleep mode.

3.6 Quality of Service (QoS): The issue of providing different quality of service levels to the user in a constantly changing environment is to achieve a more deterministic network behavior, The objective is that the Information carried by the network can be successfully delivered and resources can be better utilized in terms of parameters like end-to-end delay statistics, available bandwidth, and probability of packet loss etc., For obtaining QoS (Quality of Service) on a MANET, it may not be sufficient to provide a basic routing functionality, other aspects may also be taken into consideration such as, bandwidth constraints due to shared media, dynamic topology, since MNs are mobile and the topology may change and power consumption due to limited batteries.

After accepting a service request from the user, the network has to ensure that service requirements of the users flow are met, as per the agreement, throughout the duration of the flow (a packet stream from the source to the destination). In other words, the network has to provide a set of service guarantees while transporting a flow. After receiving a service request from the user, the first task is to find a suitable loop-free path from the source to the destination that will have the necessary resources available to meet the QoS requirements of the desired service. This process is known as QoS routing. After finding a suitable path, a resource reservation protocol is employed to reserve necessary resources along that path (T.B. Reddy). QoS guarantees can be provided only with appropriate resource reservation techniques.

4) QOS MODEL CLASSIFICATION

Many QoS models have been introduced in the literature.

In this report we classify QoS models into the following three major groups:

- Integrated Services (IntServ) where framework provides explicit end-to-end reservations.
- Differentiated Services (DiffServ) architecture which offers hop-by-hop differentiated treatment of packets.
- Flexible QoS Model for MANETS (FQMM).

5) INTSERV

The philosophy behind IntServ is that routers have to reserve resources to provide special QoS for specific user packet streams. IntServ (R. Braden, 1994 - Alberto Lopez, 1999) model merges the advantages of two different paradigms: datagram networks and circuit switched networks. A datagram is a self-contained packet, one which contains enough information in the header to allow the network to forward it to the destination independently of previous or future datagram's. A packet consists of three elements: the first element is a , which contains the information needed to get the packet from the source to the destination, and the second element is a area, which contains the information of the user who caused the creation of the packet. The third element of packet is a trailer, which often contains techniques ensuring that errors do not occur during transmission. Circuit switching network is one that establishes a dedicated circuit (or channel) between nodes and terminals before the user may communicate. Each circuit that is dedicated cannot be used for other users until the circuit is released and a new connection is set up. If no actual communication is taking place in a dedicated circuit then that channel still remains unavailable to other users. Channels that are available for new calls to be set up are said to be idle. The Resource Reservation Protocol (RSVP) is designed as the primary signaling protocol to setup and maintain the virtual connection. Routers finally apply corresponding resource management schemes to support QoS specifications of the connection. Based on these mechanisms, IntServ provides quantitative QoS for every flow.

The implementation of IntServ relies on four components: the signaling protocol which is the Reservation Protocol (RSVP), admission control routine, the classifier, and the packet scheduler. It also relies on a routing protocol generally provided by the router and a management agent, also provided by the router in advance. IntServ was originally designed for fixed networks and it is not suitable for MANETs due to the following constraints:

1. Keeping flow state in each node may imply large storage and processing overheads depending on the number and the duration of the flows.
2. The utilization of RSVP signaling packets consumes bandwidth in MANETs. Signaling overhead also increases as the network becomes more dynamic.
3. Every node must do admission control, classification, scheduling, and routing. This can place heavy demands on the resource-limited nodes in MANETs.

In spite of all these constraints, the main idea of the IntServ approach can be taken and modified to be supported in MANETs. Thus, the routing process can operate with a QoS routine to provide QoS routing without the need of a separate signaling protocol such as RSVP (Oscar Salazar Gaitan, 2003.

6) DIFFSERV

DiffServ or differentiated services is a method of trying to guarantee QoS on large networks such as the internet. DiffServ deals with bulk flows of data rather than single flows and single reservations. DiffServ is designed to overcome the difficulty of implementing and deploying IntServ and RSVP in the Internet backbone and differs in the kind of service it provides (D. Black, 2000 - Zeinalipour - Yazti, 2001 - Kui WU). While IntServ provides per-flow guarantees, Differentiated Services (DiffServ) follows the philosophy of mapping multiple flows into a few service levels.

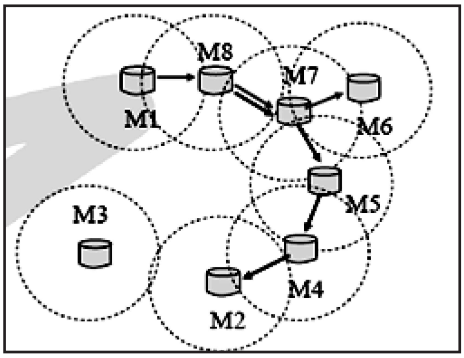
A "DiffServ cloud" is a collection of DiffServ routers. The differentiated services architecture is based on a simple model where traffic entering a network is classified and possibly conditioned at the boundaries of the network, and assigned to different behavior aggregates by marking a special DS (Differentiated Services) field in the IP packet header. Each behavior aggregate is identified by a single differentiated service codepoint. Within the core of the network, packets are forwarded according to the per-hop behavior (PHB) associated with the DSCP (Differentiated Service Code Point).

7) FLEXIBLE QOS MODEL FOR MANET (FQMM)

Flexible QoS Model for MANETS (FQMM) (Kee Chaing Chua) is the first QoS Model for mobile Ad hoc networks. The idea of this model is to combine knowledge from the solutions offered in the wire-based networks and apply them to a new QoS Model. This model selectively uses the per-flow state property of IntServ, and the service differentiation of DiffServ. That is to say, for applications with high priority, per-flow QoS guarantees of IntServ are provided. On the other hand, applications with lower priorities are given per-class differentiation of DiffServ. This model is based on the assumption that not all packets in the network are actually seeking for highest priority, because then this model would result in a similar model with IntServ which have per flow provisioning for all packets. Therefore, FQMM applies a hybrid provisioning where both IntServ and DiffServ scheme are used separately.

The FQMM hybrid model defines three types of nodes, exactly as in DiffServ: a) Ingress node, b) interior node and c) egress node. An ingress node which sends data, an interior node which forwards data to other nodes, and an egress node which is the destination. Each node may have multiple roles as shown in the

Fig. 2.
Multiple Number of Nodes



In the above Fig. 2, there are two connections: one is from node M1 to M6, the other is from node M8 to M2, and the roles of the nodes are listed in Table 2. The nodes have dynamic roles in FQMM. in Fig. 2, eight nodes are moving about and a route is established for communication from node M1 to M6. When data is sent from M1 to M6, M1 behaves as an ingress node. Nodes M3, M4 and M5 along the route from M1 to M6 behave as interior nodes forwarding data via certain per hop basis (PHB) defined by the DiffServ field. M6 is the egress node which is the destination of the traffic. In this model, a MANET represents one DiffServ domain where traffic is generated by applications running on an ingress node and terminating in an egress node.

Table 2:
Roles of nodes in FQMM

Connection	Ingress Node	Interior Node	Egress Node
C1	M1	M8,M7	M6
C2	M8	M7,M5,M4	M2

8) CONCLUSION

In this report we have tried to provide a brief overview on the Quality of Service model issues and solution given in the wire-based IP network, where much more progress has been done and Signaling, Routing protocols can not be directly mapped to MANETS, because of the bandwidth constrains and dynamic topology of such networks. We also discussed about the FQMM model for MANET, but several issues are still under study and new models are being developed to solve issues such as decision upon traffic classification, allotment of per flow or aggregated service for the given flow, amount of traffic belonging to per flow service. A great deal of work remains to be done in this area until it reaches the human society in an easy form

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