Study on QoS Frameworks for Mobile Ad-Hoc Networks

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***Abstract*— A Mobile Ad hoc NETwork (MANET) is a collection of mobile hosts forming a temporary network on the fly, without using any fixed infrastructure. Characteristics of MANETs such as lack of central coordination, mobility of hosts, dynamically varying network topology, and limited availability of resources make QoS provisioning very challenging in such networks. In this paper a comprehensive review on some Quality of Service issues in MANET has been presented.**

***Keywords*— Wireless Ad hoc, QoS Models, Mobile Nodes, Routing, QoS Component**

I. Introduction

Mobile Ad hoc NETworks (MANET) are zero configuration, self organizing, and highly dynamic networks formed by a set of mobile hosts connected through wireless links. Due to the frequent changes in network topology and the lack of the network resources routing in such networks experiences link failure more often. Hence, a routing protocol supports QoS requires to consider the reasons of link failure to improve its performance. Link failure stems from node mobility and lack of the network resources. Furthermore, the routing protocols must be *adaptive* to cope with the time-varying low-capacity resources. For instance, it is possible that a route that was earlier found to meet certain QoS requirements no longer does so due to the dynamic nature of the topology. In such a case, it is important that the network intelligently adapts the session to its new and changed conditions.

This paper proposes a comprehensive review on QoS Models and QoS routing protocols for MANET.

II. Quality of Service Models

Quality of service (QoS) is the performance level of a service offered by the network to the user. Also, the QoS model specifies the architecture for providing some kind of services in the network. A QoS model for MANETs should consider the challenges of MANETs, e.g., dynamic topology and time-varying link. Some of QoS models are:

A. Integrated Service

IntServ or integrated services is an architecture that specifies the elements to guarantee quality of service (QoS) on networks [1]. IntServ can for example be used to allow video and sound to reach the receiver without interruption. IntServ architecture allows sources to communicate their QoS requirements to routers and destinations on the data path by means of a signaling protocol such as RSVP. Hence, IntServ provides per-flow end-to-end QoS guarantees. IntServ defines two service classes: guaranteed service and controlled load, in addition to the best effort service. The guaranteed service class guarantees to provide a minimum end-to-end delay, and is intended for applications with strict delay requirements. Controlled load guarantees to provide a level of service equivalent to best effort service in a lightly loaded network. IntServ is not appropriate for mobile ad hoc networks, because the amount of state information increases proportionally with the number of flows, which results in scalability problems.

B. Differentiated Services

Differentiated Services or DiffServ is a computer networking architecture that specifies a simple, scalable and coarse-grained mechanism for classifying and managing network traffic and providing Quality of Service (QoS) on modern IP networks[2]. DiffServ can, for example, be used to provide low-latency to critical network traffic such as voice or streaming media while providing simple best-effort service to non-critical services such as web traffic or file transfers. DiffServ architecture avoids the problem of scalability by defining a small number of per -hop behaviors (PHBs) at the network edge routers and associated a different DiffServ Code Point (DSCP) in the IP header of packets belonging to each class of PHBs. Core routers use DSCP to differentiate between different QoS classes on per-hop basis. Thus, DiffServ is scalable but it does not guarantee services on end-to-end basis. This is a drawback that hinders DiffServ deployment MANET.

C. Flexible QoS Model

It is the first QoS Model proposed for MANETs in 2000 by Xiao et al. The flexible QoS model for mobile ad hoc networks (FQMM) [3] considers the characteristics of MANETs and tries to take advantage of both the per-flow service granularity in IntServ and the service differentiation in DiffServ. A source node, which is the originator of the traffic, is responsible for traffic shaping. Traffic shaping is the process of delaying packets belonging to a flow so that packets conform to a certain defined traffic profile. Traffic profile contains a description of the temporal properties of a flow such as its mean rate (i.e., rate at which data can be sent per unit time on average) and burst size (which specifies in bits per burst how much traffic can be sent within a given unit of time without creating scheduling concerns). FQMM model provides per flow QoS guarantees for the high priority flows while lower priority flows are aggregated in to a set of service classes as illustrated in Fig.1. This hybrid QoS model is based on the assumption that the percentage of flows requiring per flow QoS guarantees is much less than that of low priority flows which can be aggregated into a set of QoS classes.

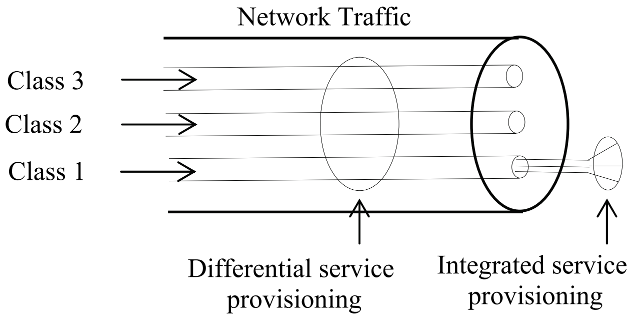

Figure 1. FQMM Model

D. CLIASM

Venkata Krishna et. al., proposed a cross layer QoS model called CLIASM for MANET [4]. This model proposes a back and forth flow mechanism for sharing information. A Shared database is being utilized to enable layers share information though each layer is performing different function. Between two layers two interfaces are created to enable flow of information on both sides. The model is implemented based on the division of network features according to layers as Application Layer Metrics (ALM), Transport Layer Metrics (TLM), Network Layer Metrics (NLM) and MAC Layer Metrics (MLM). But in deploying several cross layering approaches, one has to keep in mind the possibilities of occurrence of unintended interactions and side effects. Conflicting interactions may create stability problems and result performance degradation. In [5], an adaptive bandwidth management system for large scale ad-hoc networks has been proposed. A soft QoS reservation mechanism has been employed in [5]. Similar to SWAN, in this model too intermediate nodes are relieved from the responsibility of maintaining per flow or aggregate state information and all work is done by source nodes only.

E. SWAN

Ahn et al. proposed a distributed network model called Stateless Wireless Ad hoc Networks (SWAN) that uses a rate control mechanism to deliver service differentiation in MANETs [6]. The SWAN model considers TCP traffic as best-effort traffic and UDP traffic as real-time traffic requiring QoS assurances. The SWAN model includes a number of mechanisms used to support rate regulation of best-effort (BE) traffic and admission control regulation of real-time (RT) traffic. It uses feedback based control mechanisms to regulate real-time traffic at the time of congestion in the network. In [7], a comparative study on SWAN is done using proactive routing and reactive routing protocols to establish that SWAN is good toward end to end delay. However, reduction of average delay of the real time traffic is achieved at the cost of best effort traffic. Even though this model is scalable, it cannot provide hard QoS guarantees due to lack of resource reservation at the intermediate nodes. As best-effort traffic serves as a buffer zone for real-time traffic, this model does not work well in scenarios where most of the traffic is real time in nature.

III. PROBLEMS FACING THE PROVISION OF QOS IN MANETS

The following is a summary of the major challenges to providing QoS guarantees in MANETs.

- *Unreliable wireless channel*

The wireless channel is prone to bit errors due to interference from other transmissions, thermal noise, shadowing and multi-path fading effects. This makes it impossible to provide hard packet delivery ratio or link longevity guarantees.

- *Node mobility*

The nodes in a MANET may move completely independently and randomly as far as the communications protocols are concerned. This means that topology information has a limited lifetime and must be updated frequently.

- *Lack of centralized control*

The major advantage of an ad hoc network is that it may be set up spontaneously, without planning and its members can change dynamically. This makes it difficult to provide any form of centralized control.

- *Channel contention*

In order to discover network topology, nodes in a MANET must communicate on a common channel. However, this introduces the problems of interference and channel contention.

- *Limited device resources*

This factor has a major impact on the provision of QoS assurances, since low memory capacity limits the amount of QoS state that can be stored, necessitating more frequent updates, which incur greater overhead. Additionally, QoS routing generally incurs a greater overhead than best-effort routing in the first place, due to the extra information being disseminated. These factors lead to a higher drain on mobile nodes' limited battery power supply.

IV. QOS ROUTING MANET

MANETs characterized by limited resources like dynamically varying network topology, lack of precise state information, shared radio channel, hidden terminal problem and insecure medium make it more challenging for providing QoS in such networks. In the literature lot of QoS aware routing protocols have been proposed [4, 6, 8_10].

In [8] an Ad hoc QoS on Demand Routing protocol (AQOR) has been proposed. Hear, a route request RREQ is sent from the source to the destination through flooding. RREQ consists of information about the bandwidth available and delay requirement. Admission decision is made according to the requirement. If the request is accepted an entry is made in the routing table and the request is rebroadcast to its neighbor. If the explored node does not receive the reply within a stipulated time, the route entry is deleted from the table. When the destination node receives the request it sends the reply back along the reverse route. When each intermediate node receives the reply computes its bandwidth availability. If accepted route status is updated and route is registered. The method however, is poorly scalable.

In [6], a congestion avoidance routing protocol has been proposed. Here the main idea is to distinguish between different types of traffic and so that response can be different i.e.; routing decision can be varied according to the type of traffic. Most of the routing protocols were based on advertisement where consideration was not given to status of the queues. This will effect in longer delays or packet drops. So the authors have considered the status of the queue in route discovery process. If a RREQ is received then the node checks its queue and if the queue is empty or has delay insensitive traffic it will send a RREP. The mechanism aims to leave out the nodes with delay sensitive traffic or nodes that are busy from route discovery process and expects the performance to be better.

In [10], the existing OLSR protocol has been modified by adding delay and bandwidth metrics to propose a new algorithm for selection of multipoint relays based on QoS metrics. The smaller the MPR set, the more efficient the protocol is, compared with the pure link state protocol. However, the proposed protocol assumes that all nodes have GPS system for synchronization purpose. Besides increasing the cost, the assumption may be unrealistic for many MANET applications.

V. COMPARISON OF SIMULATION RESULTS

In this section, we will be comparing the simulation results of the different works discussed in this paper. The performance of protocols is compared based on two metrics: data packet delivery ratio, average end-to-end delay. By comparing the simulation results obtained from [5] and [8], it has been found that with increased mobility, the end-to-end delivery ability of the network decreases. This is because the routes are broken easily under high moving speed. Figure 1 shows that AQOR performs better than the other two.

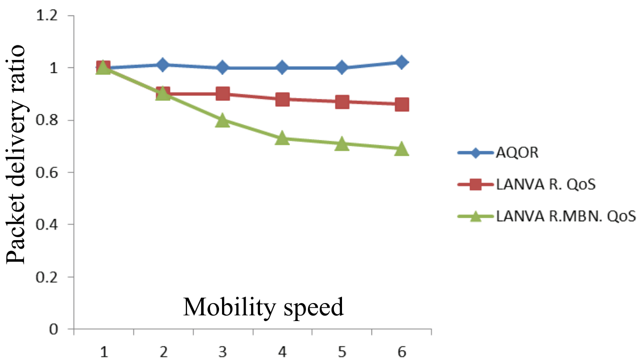

Figure 1. Mobility Speed VS Packet delivery ratio

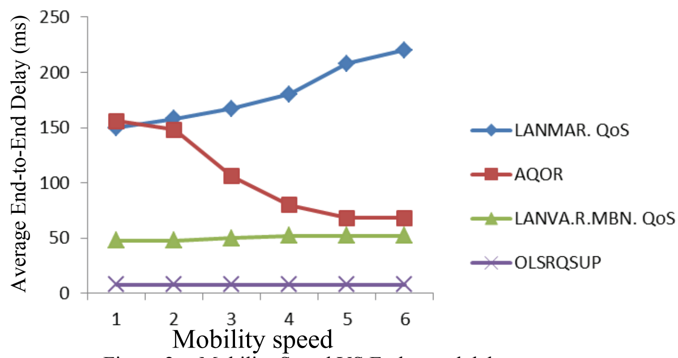

Figure 2. Mobility Speed VS End to end delay

Figure 2 illustrates the average end-to-end delay versus node mobility. The average end-to-end delay increases as the mobility speed increases in [5, 10] and in [8] the average end to end delay is decreased when the nodes moves faster. Figure 3 shows the experimental results of throughput under different traffic loads for TSA, FUZZY MARS and SWAN.

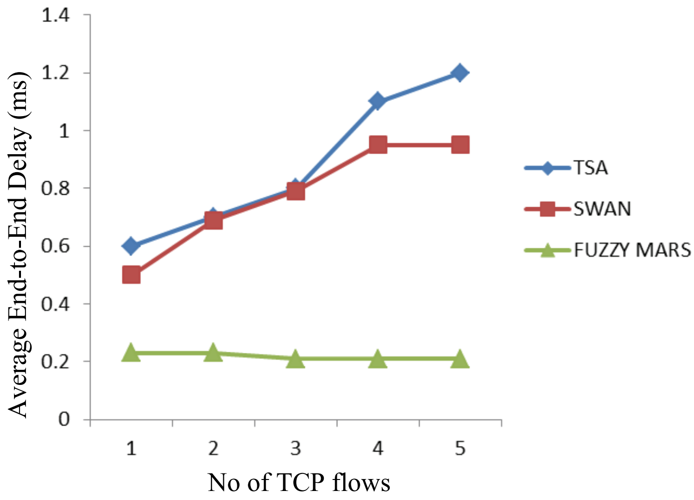

Figure 3. No of TCP flows VS Average End to end delay

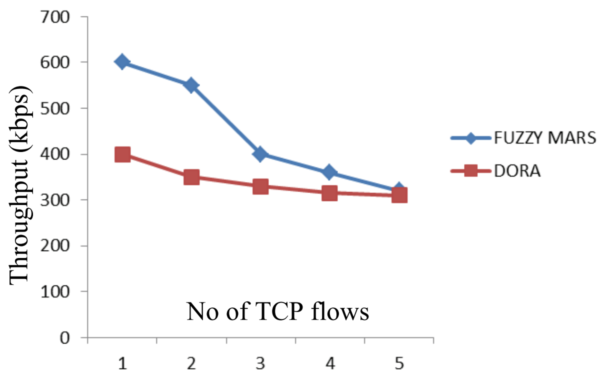

Figure 4. No of TCP flow VS throughput

By comparing their simulation result in [7, 6, 11], we find that as the number of TCP flows increased the average end to end delay also increased generally(Figure 4). This is because when flows increased, medium contention also increases. (i.e., the traffic load increases). Network throughput falls behind when the traffic increases. It is shown from the comparative analysis that throughput gets decreased as no of TCP flows increases. It is shown that in terms of throughput the performance of DORA is better than FUZZYMARS.

VI. CONCLUSION

In this paper several solutions proposed in the literature for QoS provisioning in MANETs are discussed. Although all of the research focuses on different problems, they are highly related to each other and have to deal with some common difficulties, which include mobility, limited bandwidth and power consumption. In the MANET environment, as a whole, the above difficulties constitute the main challenges for QoS support in MANETs. In this review paper, the authors have made conscious effort to highlight the limitations of the references cited to identify the scope of future QoS solutions on mobile, ad-hoc networks.

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