Chapter 20
Quality of Service (QoS) Routing in Mobile Ad Hoc Networks

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ABSTRACT

A Mobile Ad hoc NETwork (MANET) consists of a collection of mobile nodes. They communicate in a multi-hop way without a formal infrastructure. Owing to the uniqueness such as easy deployment and self-organizing ability, MANET has shown great potential in several civil and military applications. As MANETs are gaining popularity day-by-day, new developments in the area of real time and multimedia applications are increasing as well. Such applications require Quality of Service (QoS) evolving with respect to bandwidth, end-to-end delay, jitter, energy etc. Consequently, it becomes necessary for MANETs to have an efficient routing and a QoS mechanism to support new applications. QoS provisioning for MANET can be achieved over different layers, starting from the physical layer up to the application layer. This chapter mainly concentrates on the problem of QoS provisioning in the perception of network layer. QoS routing aims at finding a feasible path, which satisfies QoS considering bandwidth, end-to-end delay, jitter, energy etc. This chapter provides a detailed survey of major contributions in QoS routing in MANETs. A few proposals on the QoS routing using optimization techniques and inter-layer approaches have also been addressed. Finally, it concludes with a discussion on the future directions and challenges in QoS routing support in MANETs.

1. INTRODUCTION

The recent developments in the information super highway have made connectivity possible between users at anytime and anywhere in the world. From the Advanced Research Project Agency NETwork (ARPANET) to the present day 4G networks, Communication Networks have greatly influenced every facet of human life like commerce, industry, defence, government, home, recreation. Networking solutions have become an integral part of modern living. Mobile networks are required to support the

seamless delivery of data, high quality voice and video. The mobile communication is generally and widely supported by wired fixed infrastructure. The mobile devices use single-hop wireless radio communication to access a base station that connects it to the wired infrastructure. In contrast, MANET does not use any fixed infrastructure. Mobile ad hoc networks are formed by autonomous system of mobile hosts connected by wireless links with no supporting fixed infrastructure or central administration.

The nodes of MANET intercommunicate through single-hop and multi-hop paths in a peer-to-peer fashion. Communication between these nodes are either direct or through intermediate nodes acting as routers. Thus, the nodes operate as both hosts as well as routers. Due to the limited range of transmission and several nodes may be needed to route a packet to its destination. Since the nodes are mobile, the creation of routing paths is altered by the addition and deletion of nodes. The topology of the network changes rapidly and unexpectedly. The concept of MANET is used in many application environments without requiring any infrastructure support.

1.1 Quality of Service (QoS)

QoS is defined as a set of service requirements that needs to be met by the network while transporting a packet stream from a source to its destination. The network is expected to assurance a set of measurable specified service attributes to the user in terms of end-to-end delay, bandwidth, probability of packet loss, delay variance (jitter), etc.

The QoS metrics can be classified as additive metrics, concave metrics and multiplicative metrics. Let $m(u,v)$ be the performance metric for the link (u,v) connecting node u to node v and path $(u,u_1,u_2 \ldots u_k,v)$ a sequence of links for the path from u to v. A constraint is additive if $m(u,v) = m(u,u_1)$ $+ m(u_1,u_2) + \ldots + m(u_k,v)$. The end-to-end delay is an additive constraint because it is the accumulation of all delays of the links along the path.

A constraint is concave if $m(u,v) = \min\{m(u,u_1), m(u_1,u_2), \ldots, m(u_k,v)\}$. The bandwidth $bw(u,v)$ requirement for a path between node u and v is concave. To find a QoS feasible path for a concave metric, the available resource on each link should be at least equal to the required value of the metric.

A constraint is multiplicative if $m(u,v) = m(u,u_1) \times m(u_1,u_2) \times \ldots \times m(u_k,v)$. The probability of a packet $prob(u,v)$, sent from a node u to reach a node v, is multiplicative, because it is the product of individual probabilities along the path. Bandwidth and energy are concave metric, while cost, delay, and jitter are additive metrics. Bandwidth and energy are concave in the sense that end-to-end bandwidth and energy are the minimum of all the links along the path. The reliability or availability of a link is a multiplicative metric (Baoxian & Hussein, 2005).

To support QoS, the link state information such as delay, bandwidth, jitter, cost, loss ratio and error ratio in the network should be available and manageable. However, receiving and managing the link state information in a MANET is difficult, because the quality of a wireless link changes with the surrounding circumstance. In addition, the resource limitations and the mobility also add to the complexity. These networks have certain unique characteristics that pose several difficulties in provisioning QoS. Some of the characteristics are

Dynamic Topology

Nodes can be extremely mobile as a result the topology of the network changes frequently and dynamically. Topology information has a limited lifetime and must be updated frequently to allow data packets to be routed to their destinations. Because the nodes have do not have any restriction on mobility, the network changes dynamically. Hence the admitted QoS sessions may suffer due to frequent path breaks, thereby requiring such sessions to be re-established over new paths. The

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