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Review

Review of multicast routing mechanisms in mobile ad hoc networks

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ABSTRACT

Frequent interactions among the group members of distributed wireless network environment may be facilitated with the help of Mobile Ad Hoc NETworks (MANETs). Some of the group-oriented applications include disaster management, battlefields, audio/video conferencing, e-commerce, e-education, etc. Group communication demands dynamic construction of efficient and reliable multicast routes under user mobility and varying channel conditions. Multicast routing mechanisms in MANETs have been consistently improved by researchers considering various performance measures such as energy efficient route establishment, packet delivery ratio, quicker and faster proactive route recovery, network life time, reliability, Quality of Service (QoS) based on bandwidth, delays, jitters, and security. The paper focuses on most recent reliable and QoS based multicast routing mechanisms that helps in multimedia communication over MANETs. The mechanisms are considered under different topological routing categories such as mesh, tree, zone and hybrid. We provide an overview of existing multicast routing mechanisms based on routing categories and point to directions for future research and development.

Contents

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1. Introduction

Mobile Ad hoc Networks (MANETs) are a class of wireless communication networks without a fixed infra-structure. The MANET concept has basically evolved to tackle the disaster situations like tsunami, earthquake, terrorist activities, battlefields, landslides, etc. Later, the concept has been extended to include applications such as online education, gaming, business, etc. Several applications in MANETs need group communication to manage the situations. The MANET nodes do not provide reliable services and QoS (Quality of Service) guarantees as compared to other wireless networks such as WiFi, WiMAX, GSM and CDMA. The main sources of unreliability in MANETs are due to limited battery capacity, limited memory and processing power, varying channel conditions, less stability under unpredictable and high mobility of nodes. The QoS parameters to be guaranteed for multimedia group communication are bandwidth, delay, packet loss, jitters and bandwidth-delay product.

The measure of unreliability increases when we need to communicate real-time multimedia traffic where a stringent Quality of Service (QoS) parameters are to be satisfied. QoS is one of the significant components to evaluate MANET performance since QoS restricts the bounds on bandwidth, delay, bandwidth delay product, jitter and packet loss. The violation of these parameters degrades the overall performance of an application. Reliable multicast routing include the mechanisms such as error detection, signaling of error messages to source and destination and retransmission method of lost packets (Petitt, 1997; Kunz, 2003).

Some of the parameters that can be considered for reliable communication are node stability, link stability, route stability, survivability, mobility, etc. *Node stability* in MANET depends on parameters such as mobility, battery life, memory, data transmission rate and number of interfaces currently being used. A node becomes less stable and looses its connectivity with higher mobility. Longer battery life provides more stability to the node under higher data transmission rates since energy is spent for every packet transmitted. A node will be overloaded with increase in number of neighbors since the node is connected to each neighbor through an interface that drains more energy, consumes buffer space and requires higher processing capability.

Link stability depends on wireless link characteristics such as link failures, packet loss rate, channel sensing rate, channel fading rate, bit error rate, bandwidth fluctuations, environmental effects, etc. Fluctuating wireless channel triggers packet loss resulting into link failures and degrades link reliability. The failure in channel sensing and channel fading increase bit errors that triggers large variation in available bandwidth. Imperfect channel sensing degrades the system performance. Existing communication systems use checksum and sequence numbering for error control and some form of negative or missing positive acknowledgement with packet retransmission for error recovery. If checksum formation and verification is not performed properly, it can affect system performance drastically. *Route stability* relies on the performance of source, destination and intermediate nodes and the wireless channel connecting end-to-end route. If the lifetime of a route decreases, the reliability of end-to-end delivery may be enhanced with alternate routes between source and destination. To enhance the route stability, there is a necessity of mesh based and multipath routing techniques. *Network survivability* reflects the ability of a network to continue to functioning during and after failures. Network survivability may be perceived as a composite measure consisting of both network failure duration and failure impact on the network. Now let us define the various QoS parameters such as bandwidth, delay, jitter, bandwidth delay product and synchronization.

Bandwidth is defined as data transmission rate, i.e., the amount of data to be transferred every second. For example, consider bits required for a sequence of pictures in a movie which have to be transferred from source to a destination in a distributed system environment. Real time applications require guaranteed bandwidth for better quality and continuous presentation.

Delay incurred between multimedia data generation at a source and its presentation at a destination is subjected to have stringent bounds. These bounds are expressed by the transfer delays. End-to-end delay may be split into at least four contributing delays: (1) source compression and packetization delay, (2) transmission delay, (3) end system queueing and synchronization delay and (4) sink decompression, depacketization and output delay. Among these delays, the second one is random delay and remaining are assumed to be fixed delays.

Bandwidth delay product is an important parameter in MANETs since it provides a measure of end-to-end network pipe in multi-hop networks. Bandwidth delay product is well understood concept in wire-line systems. It helps in defining enough number of in-flight packets to fill the network pipe. However, the wireless connectivity instigates fluctuating end-to-end network pipe, wherein it becomes difficult to maintain end-to-end connectivity for bandwidth delay product bounded multimedia applications.

Jitter is defined as the difference between the inter-arrival times and inter-generation times of adjacent packets. Jitters are introduced due to random network delays incurred by the sequence of packets of a continuous multimedia stream. Jitters can be reduced in the end systems by the use of buffers. However, these buffers are very large and they require huge memory resources. Thus it is better to have the jitter already controlled by the network itself. During data transmission, we may come across two types of jitters, namely, negative and positive jitters. Negative jitter indicates the inter-arrival time of the packet gradually reducing whereas the positive jitter indicates the inter-arrival time of a packet gradually increasing. A sequence of negative jitter may result in downstream node congestion and consecutive packet loss. On the other hand, a sequence of positive jitter may result in significant delays. A large sequence of negative and positive delays have significant effects on performance of QoS for multimedia.

Synchronization and resynchronization of multimedia streams is a crucial task to be solved throughout running of a multimedia application for a smooth and efficient playout. It is necessary to address synchronization problem to facilitate better quality of presentation to the users. Multimedia applications require two types of synchronization techniques: intra-stream and inter-stream synchronization. Synchronization of media streams in MANETs is most complicated issue because of the nature of connectivity and unpredictable and random mobility of nodes.

As different applications have different requirements, their level of QoS and associated QoS parameters also differ from application to application. For example, in multimedia applications, the bandwidth and delay are the key parameters, whereas military applications have additional requirement of security and reliability. For defense applications, finding trustworthy intermediate hosts and routing through them can be a QoS parameter. For applications such as emergency search and rescue operations, availability is the key QoS parameter.

Group communication in MANETs poses many challenges and issues such as resource management, routing management, synchronization, power management, etc. The members of a group communicate by means of multicast routing mechanisms that discover and maintain multicast routes. Providing reliable and QoS supported multicast communication among group members becomes necessary for real time and non-real time applications. Researchers have proposed a variety of multicast routing