Chapter 1

Introduction

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INTRODUCTION

The ability to communicate from anywhere and at any time is mankind's dream for a long time. Wireless is the only medium that can fulfill this need. With the recent advances in the technologies and the mobility of the wireless systems it is possible for "anyone, anywhere, anytime" paradigm of mobile ad hoc network to become reality.

1.1 BACKGROUND: WIRELESS MOBILE NETWORKS

A wireless ad-hoc network[1] is a collection of mobile/semi-mobile[11] nodes with no pre-established infrastructure, forming a temporary network. Each of the nodes has a wireless interface and communicate with each other over either radio or infrared. Laptop computers and personal digital assistants that communicate directly with each other are some examples of nodes in an ad-hoc network. Nodes in the ad-hoc network are often mobile, but can also consist of stationary nodes, such as access points to the Internet. Semi mobile nodes can be used to deploy relay points in areas where relay points might be needed temporarily.

Figure 1.1 shows a simple ad-hoc network with three nodes. The outermost nodes are not within transmitter range of each other. However the middle node can be used to forward packets between the outermost nodes. The middle node is acting as a router and the three nodes have formed an ad-hoc network.
An ad-hoc network uses no centralized administration. This is to be sure that the network won’t collapse just because one of the mobile nodes moves out of transmitter range of the others. Nodes should be able to enter/leave the network as they wish. Because of the limited transmitter range of the nodes, multiple hops may be needed to reach other nodes. Every node wishing to participate in an ad-hoc network must be willing to forward packets for other nodes. Thus every node acts both as a host and as a router. A node can be viewed as an abstract entity consisting of a router and a set of affiliated mobile hosts (Figure1.2). A router is an entity, which, among other things runs a routing protocol. A mobile host is simply an IP-addressable host/entity in the traditional sense.

Ad-hoc networks[5] are also capable of handling topology changes and malfunctions in nodes. It is fixed through network reconfiguration. For instance, if a node leaves the network and causes link breakages, affected nodes can easily request new routes and the problem will be solved. This will slightly increase the delay, but the network will still be operational.
Wireless ad-hoc networks take advantage of the nature of the wireless communication medium. In other words, in a wired network the physical cabling is done a priori restricting the connection topology of the nodes. This restriction is not present in the wireless domain and, provided that two nodes are within transmitter range of each other, an instantaneous link between them may form.

Figure 1.2: Block diagram of a mobile node acting both as hosts and as router.

**Usage**

There is no clear picture of what these kinds of networks will be used for. The suggestions vary from document sharing at conferences to infrastructure enhancements and military applications.

In areas where no infrastructure such as the Internet is available an ad-hoc network could be used by a group of wireless mobile hosts. This can be the case in areas where a network infrastructure may be undesirable due to reasons such as cost or convenience. Examples of such situations include disaster recovery personnel or military troops in cases where the normal infrastructure is either unavailable or destroyed.
Other examples include business associates wishing to share files in an airport terminal, or a class of students needing to interact during a lecture. If each mobile host wishing to communicate is equipped with a wireless local area network interface, the group of mobile hosts may form an ad-hoc network.

Access to the Internet and access to resources in networks such as printers are features that probably also will be supported.

**Characteristics**

Ad-hoc networks are often characterized by a dynamic topology due to the fact that nodes change their physical location by moving around. This favors routing protocols that dynamically discover routes over conventional routing algorithms like distant vector and link state. Another characteristic is that a host/node have very limited CPU capacity, storage capacity, battery power and bandwidth, also referred to as a "thin client". This means that the power usage must be limited thus leading to a limited transmitter range.

The access media, the radio environment, also has special characteristics that must be considered when designing protocols for ad-hoc networks. One example of this may be unidirectional links. These links arise when for example two nodes have different strength on their transmitters, allowing only one of the host to hear the other, but can also arise from disturbances from the surroundings. Multi hop in a radio environment may result in an overall transmit capacity gain and power gain, due to the squared relation between coverage and required output power. By using multi hop, nodes can transmit the packets with a much lower output power.
Based on the hop distance of packet transfers, wireless networks can be classified into two types: single-hop and multi-hop. The single-hop network generally requires preconfigured, fixed infrastructures. The multi hop network, on the other hand, does not rely on a fixed infrastructure, thus can provide a more flexible service, for example, in a rural area. These two different wireless networks are detailed below.

1.1.1 The Single-Hop Wireless Network

In a single-hop wireless network as shown in Figure 1.3, the whole service area is divided into several smaller service regions called cells [4]. In each cell, at least one base station is allocated to provide network service to mobile hosts in the cell.

![Figure 1.3: Single-Hop Network]
The mobile host connects to the network by establishing a wireless connection to the base station. The connections among base stations are usually provided by high speed wired backbone.

Example 1[10]: Consider the network depicted in Figure 1.4 In this example, the central node, referred to as a server, needs to deliver four packets p1, . . . , p4 to four clients c1, . . . , c4; packet pi needs to be received by client ci. Each client ci has an access to some of the packets overheard from prior transmissions. This set is referred to as its “has” set. It is easy to verify that all clients can be satisfied by broadcasting two packets p1+p2+p3 and p1+p4 (all additions are over GF(2)). Since without network coding all packets p1, . . . , p4 are needed to be transmitted, network coding allows to reduce the number of transmissions by 50%.

Fig 1.5 Figure showing a wireless network with single-hop traffic.
All packets $A^d_s$, transmitted on link (s,d) are exogenous and are queued ($Q_{s,d}$ denotes the queue length). All the links that interfere with link (g,h) are shown.

In a wireless system[8], users compete for accessing a shared transmission medium. Since link transmissions cause mutual interference, the medium access layer (MAC) is needed to schedule the links carefully so that packets can be transmitted with minimal collisions. Many scheduling policies have been studied at the MAC layer with the objective of maximizing throughput. These schemes are often called throughput optimal scheduling schemes. However, the delay analysis of these systems has largely been limited. To simplify the analysis we, in common with related work restrict the traffic model to single-hop traffic. Under the single-hop traffic model, all packets transmitted on a link (s,d) are generated by an exogenous arrival process $A_{s,d}$ at the source node s. As shown in Figure 1.5, the exogenous arrivals waiting to be transmitted at each link are queued in their respective queues. This approach has also been adopted in the literature while studying the throughput performance of scheduling policies for wireless networks. This allows us to study the effect of scheduling policy on the delay of the system, independent of routing. We note that this model allows for simultaneous transmissions as long as they satisfy the underlying interference constraints. Such systems are more general than the cellular type systems where the system is divided into non-interfering cells. The results presented here work for any underlying model for interference constraints.

On the other hand, simple, single hop structures have also numerous advantages:

1) No need for routing considerations, implying simpler protocol stack and no
2) overhead traffic for routing support
3) Low delay
4) Simpler time synchronization

5) Possibility to use centralized media access control (MAC) schemes (like pooling)

6) Possibility to use centralized application algorithms

1.1.2 The Multi-hop Wireless Network

The drawback of a single hop network is that it requires a pre-established communication backbone, which is infeasible under certain circumstances for example, battle-field, disaster (flood, fire, and earthquake) recovery, search and rescue, or exploration of an unpopulated area, etc [22].

Figure 1.6: Multi-hop Wireless Network

Shown in Figure 1.6 Multi-hop wireless networks are the networks where applications require an instant infrastructure to carry multimedia information. The multi-hop[14-16] wireless mobile network, also called "ad hoc" network, serves this need because it relies merely on the wireless communication and allow host mobility.

1.2 MOBILE AD HOC NETWORKS

Mobile Ad hoc Networks can be defined as "An autonomous system of mobile routers 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"

Mobile Ad Hoc Networks (MANETs) are self-organizing, and highly dynamic networks formed by a set of mobile hosts connected through wireless links. These networks can be formed on the fly, without requiring any fixed infrastructure or central coordinator that will manage the whole network. Even though ad hoc network works in absence of any fixed infrastructure, recent advances in wireless network architecture reveals interesting solution that enables it to function in the presence of infrastructure. As these are infrastructure less wireless networks, each node should act also as a router. 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 standalone fashion, or may be connected to the larger Internet where all network activities including discovering the topology and delivering messages must be executed by the nodes themselves. As a router, the mobile host represents an intermediate node which forwards traffic on behalf of other nodes. If the destination node is not within the transmission range of the source node, the source node takes help of the intermediate nodes to communicate with the destination node. Tactical communication required on battlefields, among a fleet of ships, or among a group of armored vehicles is some of the military applications of these networks. Civilian applications include peer-to-peer computing and file sharing, collaborated computing in a conference hall, and search and rescue operations.
With the evolution of Multimedia [39] Technology, Quality of Service in MANETs became an area of great interest. Besides the problems that exist for QoS [20-25] in wire-based networks, MANETS impose new constraints. This is due to the dynamic behavior and the limited resources of such networks.

1.2.1 Efficient Wireless Routing
In MANETs it is critical for a routing protocol to consider all the reach ability, scalability and connection quality for multimedia services. Therefore, the goals of our research in wireless routing are: firstly, the routing scheme has to be efficient and it should provide continuous connection to the destination node even if the link breaks, and secondly the delay parameter which is required QoS parameter to be considered carefully when focusing on multimedia applications.

1.2.2 Support of Renegotiable QoS
Multimedia applications place stringent requirements on networks for delivering multimedia content in real-time. Compared to the requirements of traditional data-only applications, these new requirements generally include high bandwidth availability, low packet loss rate, and a low variation in packet delivery time [9]. Unfortunately, in a wireless environment, no guarantee on these requirements can be safely made in the fact of mobility. Therefore, in order to maintain same level of acceptable quality over such networks, is to take a new look at QoS support.

1.3 ASSUMPTIONS
The assumptions that are to be considered in this thesis are the following.

- The nodes are the portable devices with the limited battery life. This feature can impose restriction on the computation and the communication (transmitting and receiving) at every node in the MANET.
All the nodes have the equal capability of processing power, transmission range and the other features of the device.

Connection between the nodes is not transitive.

Nodes are identified by fixed ID's.

Nodes are free to move in the network without any restriction and can leave or join the network at any time.

The route availability defined in the thesis is limited to the range of transmission of all the nodes that comes in the path from source to destination.

All the nodes trust each other by using predefined keys or because it is known that there are no malicious intruder nodes.

Packets may be lost or corrupted during transmission on the wireless network.

The routing protocol is tested with the assumption that the mobility is not very high.

1.4 PROBLEM STATEMENT

The transmission of real-time, multimedia or any type of data to the wireless medium introduces many technical obstacles. The protocols available for the wired medium cannot be easily migrated to the wireless network because of the error-prone medium and the mobility of the devices. This is true for Mobile Ad Hoc Networks (MANETs) where mobile devices move in an unpredictable manner and at arbitrary time with random mobility.

Video or multimedia transport over wireless ad hoc networks is a challenging subject, since the wireless links are unreliable and have limited bandwidth. Typical
multimedia applications, such as streaming, may require higher reliability connections than that provided by a single link. In a network consisting of mobile nodes, the connection between a source and destination may break down and has to be updated regularly. Although, when a path fails, one could switch over to an alternative path; this may take an unacceptably long period of time, causing a temporary disruption in the multimedia signal. Instead of transporting a multimedia stream through a "single" communication pipe, the stream is split up into multiple sub-streams, each of which takes a separate route through the network. At the destination all sub-streams received properly are merged in a clever way.

In this thesis the network layer protocol for the transmission of multimedia data is focused more. The main idea is to provide continuous connection to the destination even when the path breaks. Continuous connection is provided by establishing multiple paths from source to destination, so that when one of the paths breaks than also other paths are available through which the data can be transmitted.

1.5 THESIS CONTRIBUTION

The Quality of Service is a challenging task for any type of network whether it is wired or wireless. The task becomes even more challenging when it comes to the mobile ad hoc network. The thesis contribution is to provide at least minimum QoS requirements for the multimedia application. Although all the layers are equally responsible for the QoS provisioning for any type of service, the thesis contribution is towards the network layer i.e. the routing protocol of mobile ad hoc network for multimedia application. The brief introduction to the new routing protocol for the multimedia application is given below.
When stared the thesis, the routing protocols that were commonly used were AODV, DSR and DSDV. With the studies of these routing protocols and looking at the advantages and the disadvantages a new routing protocol for multimedia application is to be designed. As the DSR lacks in scalability, and the AODV with the control packets dissemination into the network, a new multipath routing using the AODV approach for the routing table update mechanism along with route discovery and maintaining the continuous path from source to destination.
1.6 OUTLINE OF THESIS

The remaining chapters are organized as follows. The second chapter starts with the literature survey that consists of design issues and challenges, routing fundamentals and different types of routing used for the MANETs. After this is the evaluation of different routing protocols used for the MANETs are discussed. Next is the performance comparison of the routing protocol with their tested implementation and results and then at last the concluded part of these routing protocols.

Chapter third includes the various control packet formats that are used in Multipath routing protocol. The new routing protocol implementation, the routing table building up and the timers used in the protocols is defined in the fourth chapter.

The fifth chapter introduces about the NS2 tool that is used for the simulation which covers the background of NS2 and about how to add a new routing protocol in ns2. It also includes the trace format that is used in ns2.

At last the simulation results with the new Multipath routing protocol is studied and the results compared with the AODV, DSR and DSDV routing protocol.

1.7 References


http://www.cse.wustl.edu/~jain/cse574-06/


