Improvement of Handoff Performance in Wireless Mesh Networks

Fahim Masud Choudhury

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Abstract

Chapter 1

Introduction

1.1 Motivation of the Work

1.2 Contribution of the Work

The objective of this thesis is to evaluate the performance of wireless mesh networks using AODV, DSDV and OLSR protocols in terms of different parameters. An improved OLSR protocol is also proposed and it's performance has been analyzed. Finally, different graphs are generated to evaluate the performance with specified parameters.

1.3 Organization of the Project

The remainder of the report is organized as follows. In the next chapter, an overview of our project related terminologies are explained and contains brief discussion on previous works that is already implemented with their limitations. Chapter 3 describes the working procedure of our proposed system. In Chapter 4, we have illustrated our implementation of the project in details. Chapter 5 focuses on the experimental result of the proposed system. The thesis concludes with a summary of research contributions and future plan of our work in chapter 6. This thesis contains an appendix intended for persons who wish to explore the source code.

Chapter 2

Literature Review

2.1 Wireless Mesh Network

As various wireless networks evolve into the next generation to provide better services, a key technology, wireless mesh networks (WMNs) has emerged recently. In WMNs, nodes are comprised of mesh routers and mesh clients. Each node operates not only as a host but also as a router, forwarding packets on behalf of other nodes that may not be within direct wireless transmission range of their destinations. A WMN is dynamically self-organized and self-configured, with the nodes in the network automatically establishing and maintaining mesh connectivity among themselves.

Conventional nodes, e.g., desktops, laptops, PDAs, PocketPCs, phones, equipped with wireless network interface cards (NICs) can be connected directly to wireless mesh routers. Customers without wireless NICs can access WMNs by connecting to wireless mesh routers through, for example, Ethernet. Thus, WMNs will greatly help users to be always- on-line anywhere anytime. Moreover, the gateway/bridge functionalities in mesh routers enable the integration of WMNs with various existing wireless networks such as cellular systems, wireless sensor networks, wireless-fidelity (Wi-Fi) systems and worldwide inter-operability for microwave access (WiMAX)networks.

2.1.1 Network Architecture

WMNs consist of two types of nodes: mesh routers and mesh clients. Other than the routing capability for gateway/repeater functions as in a conventional wireless router, a wireless mesh router contains additional routing functions to support mesh networking. To further improve the flexibility of mesh networking, a mesh router is usually equipped with multiple wireless interfaces built on either the same or different wireless access technologies.

Mesh clients also have the necessary functions for mesh networking, and thus can also work as a router in WMN. However, gateway or bridge functions do not exist in these nodes. In addition, mesh clients usually have only one wireless interface. As a consequence, the hardware platform and the software for mesh clients can be much simpler than those for mesh routers. Mesh clients have a greater variety of devices compared to mesh routers. They can be a laptop/desktop PC, pocket PC, PDA, IP phone, RFID reader, BACnet (Building Automation and Control network) controller, and many other devices

The architecture of WMNs can be classified into three main groups based on the functionality of the nodes.

Infrastructure/Backbone WMNs

Infrastructure/Backbone WMN includes mesh routers that form an infrastructure for clients that connect to them. The WMN infrastructure/backbone can be built using various types of radio technology, in addition to the heavily used IEEE 802.11 technology. The mesh routers form a mesh of self-configuring, self- healing links among themselves. With gateway functionality, mesh routers can be connected to the Internet. This approach, also referred to as infrastructure meshing, provides backbone for conventional clients and enables the integration of WMNs with existing wireless networks, through gateway/bridge functionalities in mesh routers.

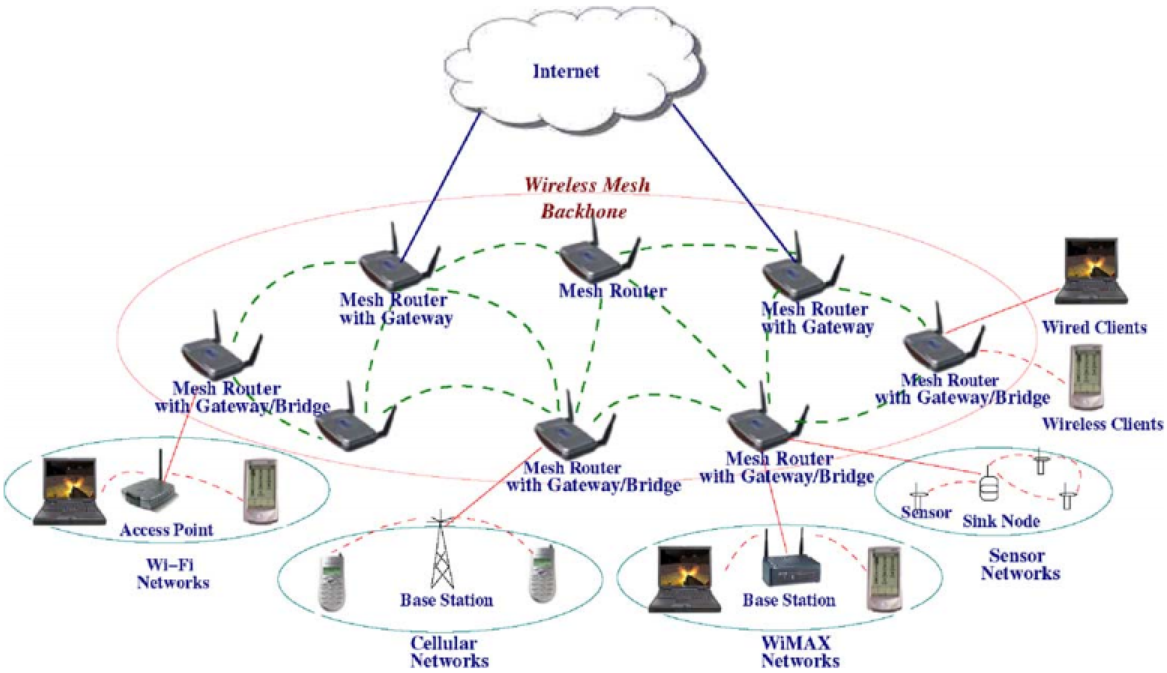

Figure 2.1: Infrastructure/Backbone WMN

Infrastructure/Backbone WMNs are the most commonly used type. For example, community and neighborhood networks can be built using infrastructure meshing. The mesh routers are placed on the roofs of houses in a neighborhood, and these can serve as access points for users in homes and along the roads. Typically, two types of radio are used in the routers, i.e., for backbone communication and for user communication. The mesh backbone communication can be established using long- range communication techniques including, for example, directional antennas.

Client WMNs

Client meshing provides peer-to-peer networks among client devices. In this type of architecture, client nodes constitute the actual network to perform routing and configuration functionalities as well as providing end-user applications to customers. Hence, a mesh router is not required for this type of network.

Hybrid WMNs

This architecture is the combination of infrastructure and client meshing. Mesh clients can access the network through mesh routers as well as directly meshing with other mesh clients.

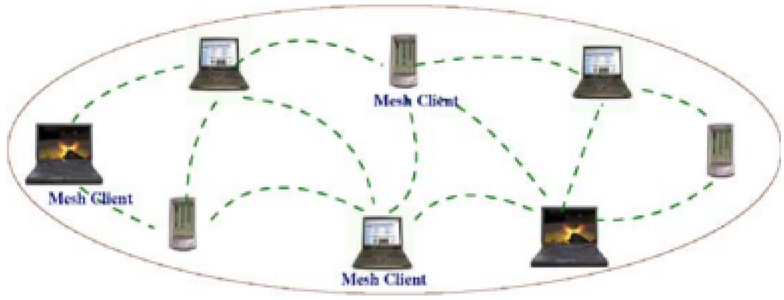

Figure 2.2: Client WMNs

While the infrastructure provides connectivity to other networks such as the Internet, Wi-Fi, WiMAX, cellular, and sensor networks, the routing capabilities of clients provide improved connectivity and coverage inside the WMN.

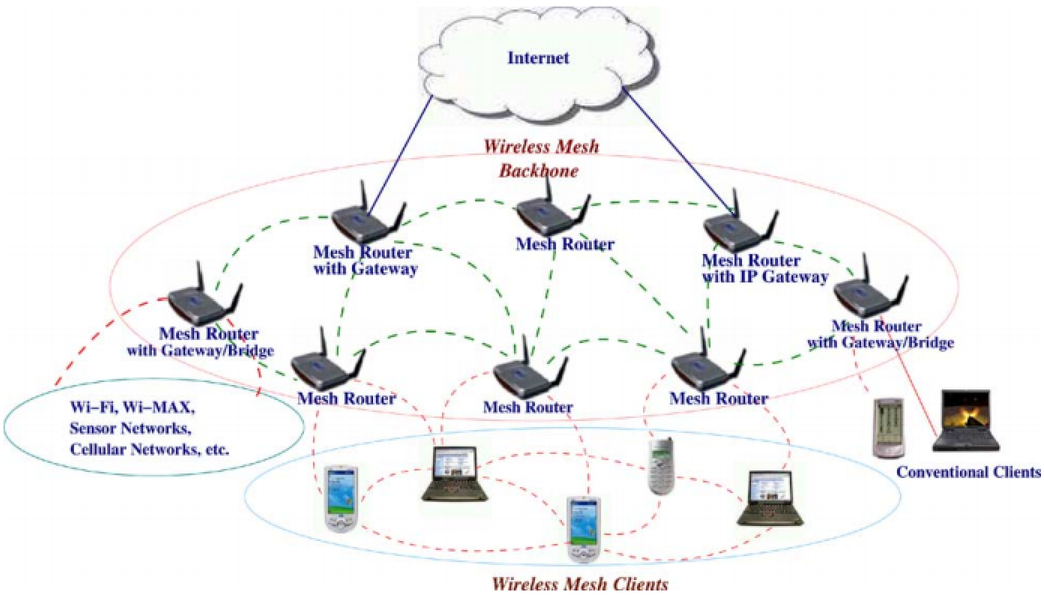

Figure 2.3: Hybrid WMNs

2.1.2 Application

Research and development of WMNs is motivated by several applications which clearly demonstrate the promising market, but, at the same time, these applications cannot be supported directly by other wireless networks such as cellular systems, ad hoc networks, wireless sensor networks, standard IEEE 802.11, etc. In this section, we discuss these applications.

- Broadband home networking
- Community and neighborhood networking
- Enterprise networking
- Metropolitan area networks (MAN)
- Transportation systems

- Building automation
- Health and medical systems
- Security surveillance systems

In addition to the above applications, WMNs can also be applied to spontaneous (emergency/disaster) networking and P2P communications. For example, wireless networks for an emergency response team and firefighters do not have in-advance knowledge of where the network should be deployed. By simply placing wireless mesh routers in desired locations, a WMN can be quickly established. For a group of people holding devices with wireless networking capability, e.g., laptops and PDAs, P2P communication anytime anywhere is an efficient solution for information sharing. WMNs are able to meet this demand. These applications illustrate that WMNs are a superset of ad hoc networks, and thus, can accomplish all functions provided by ad hoc networking.

2.2 Routing Protocols

A routing protocol for WMNs can be proactive or reactive. For proactive routing, a routing path between two nodes is established before any traffic flow is initiated between them. A reactive routing starts to set up a routing path for two nodes only after traffic is generated between these two nodes. A routing protocol can be static or dynamic depending whether or not the network experiences variations in topology, link quality, traffic load, and so on. In a wired network, there exist many scenarios where static routing can find many applications. For a multihop wireless network like a WMN, routing usually needs to be dynamic owing to node mobility, link instability, topology change, traffic variations, etc. Two popular dynamic routing schemes are distance vector routing and link state routing, which were proposed for wired networks and have become the cornerstone of many dynamic routing protocols of MANETs and WMNs.

2.2.1 Reactive Protocols

Reactive protocols seek to set up routes on-demand. If a node wants to initiate communication with a node to which it has no route, the routing protocol will try to establish such a route. Reactive protocol searches for the route in an on-demand manner and set the link in order to send out and accept the packet from a source node to destination node. Route discovery process is used in on demand routing by flooding the route request (RREQ) packets throughout the network. Examples of reactive routing protocols are the dynamic source Routing (DSR), ad hoc on-demand distance vector routing (AODV).

2.2.2 Proactive Protocols

Table-driven or proactive routing protocols establish routes in advance, i.e., these protocols assume that it is more efficient to determine routes regularly; as soon as a node tries to send data packets, the reasonable assumption (hope) is that the route needed has already been discovered. They maintain lists of available destinations and up-to-date routes to those destinations in the network by sending periodic routing in- formation. These information keeps routing tables consistent. Due to having existing routes available, when a traffic packet arrives, transmission will occur with no delay. As a consequence, these types of protocols could be in principle more efficient with respect to time needed to deliver data packets. Some examples of proactive protocols are the Better Approach To Mobile Adhoc Networking (B.A.T.M.A.N.) protocol, the Optimized Link State Routing (OLSR) protocol and Destination-Sequence Distance Vector (DSDV) protocol.

2.2.3 Adhoc On-demand Distance Vector Routing Protocol (AODV)

Ad hoc On-Demand Distance Vector (AODV) Routing is a routing protocol for mobile ad hoc networks (MANETs) and other wireless ad hoc networks. The AODV Routing Protocol uses an on-demand approach for finding routes, that is, a route is established only when it is required by a source node for transmitting data packets. It employs destination sequence numbers to identify the most recent path. In AODV, the source node and the intermediate nodes store the next-hop information corresponding to each flow for data packet transmission. In an on-demand routing protocol, the source node floods the *RouteRequest* packet in the network when a route is not available for the desired destination. It may obtain multiple routes to different destinations from a single *RouteRequest*. The major difference between AODV and other on-demand routing protocols is that it uses a destination sequence number (*DestSeqNum*) to determine an up-to-date path to the destination. A node updates its path information only if the *DestSeqNum* of the current packet received is greater or equal than the last *DestSeqNum* stored at the node with smaller hopcount.

2.2.4 Destination Sequence Distance Vector Routing Protocol (DSDV)

DSDV is a proactive (Table-Driven) unicast routing protocol based on classical Bellman-Ford algorithm. Each node in the network has a routing table which contains information on all possible destinations within the network that means its a table-driven routing scheme. Sequence numbers are used to distinguish stale routes from fresh ones. To maintain Consistency, routing table must be updated periodically throughout the network. If two updates have same sequence number then the path with smaller metric is used to optimize the path. DSDV protocol only supports bi-directional links. Another main disadvantage is even if there is no change in the network topology, there is still traffic overhead. It also maintains routes which are never used.

2.2.5 Optimized Link State Routing Protocol (OLSR)

Optimized link state routing (OLSR) is a proactive routing protocol for MANETs. This protocol has the benefit of having the routes available when needed because of its proactive nature. The underlying mechanism of this protocol is the periodic exchange of messages to find routes. Since OLSR reduces the control packets size and minimizes flooding of this control traffic, it is known as optimization of a pure link state protocol. Moreover, this protocol does not generate extra control traffic in response to link breakage or failure. Every node stores the routes to all destinations in the network. As a consequence, it is applicable where a large subset of nodes are communicating with each other or nodes are changing with time. The protocol is specifically appropriate for large and dense networks as more optimization is achieved. OLSR works in a completely distributed manner without depending on any central entity. A reliable transmission is not needed for its control messages, since sending these messages occurs periodically

HELLO Message

OLSR makes use of "Hello" messages to find its one hop neighbors and its two hop neighbors through their responses. The sender can then select its multipoint relays (MPR) based on the one hop node that offers the best routes to the two hop nodes. Each node has also an MPR selector set, which enumerates nodes that have selected it as an MPR node. A HELLO message contains:

- the list of addresses of the neighbors to which there exists a valid bi-directional link
- the list of addresses of the neighbors which are heard by this node (a HELLO has been received) but the link is not yet validated as bi-directional link. If a node find its own address in a HELLO message, it considers the link to the sender node as bi-directional.

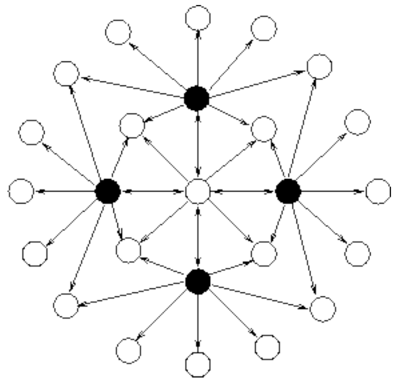

Figure 2.4: Flooding a packet in a wireless multi-hop network from the center node using MPRs(black)

Topology Control (TC) Message

OLSR uses topology control (TC) messages along with MPR forwarding to disseminate neighbor information throughout the network. TC messages are forwarded like usual broadcast messages in the entire network. A TC message is sent periodically by each node in the network to declare its MPR Selector set, i.e., the message contains the list of neighbors who have selected the sender node as a multipoint relay. The sequence number associated to this MPR Selector set is also attached to the list.The information diffused in the network by these TC messages will help each node to build its topology table. A node which has an empty MPR Selector set, i.e., nobody has selected it as a multipoint relay, may not generate any TC message.

Core Functionality

Nodes in the network start working by broadcasting HELLO messages to their neighbors to detect direct one-hop neighbors and also two-hop neighbors. Then, nodes will try to create and send their TC message in the entire network. These messages then allow nodes to update their routing tables for different nodes in the network. To construct the routing table of a node, a shortest path algorithm is used. It means that this routing protocol selects shorter paths by applying Dijkstra's algorithm. Every routing table consists of destination addresses, next nodes along the path to the destination, distance from the node to the destination, etc.

After broadcasting HELLO and TC messages regularly and if the network does not change, all nodes have the topological information of the entire network, such as distance from different nodes, one-hop neighbors of every node, next node to the destination, etc.

2.3 Related Works

Chapter 3

Methodology

3.1 Proposed Methodology

Chapter 4

Implementation

4.1 Implementation Tools

4.2 Implementation Details

4.3 Simulation Parameters

4.4 Simulation Visualization

Chapter 5

Simulation Results and Analysis

5.1 Parameters for Evaluating Simulation Model

The following parameters are needed for evaluating our simulation:

Average Throughput Number of bits received divided by the difference between the arrival time of the first packet and the last one.

Average Packet Delivery Fraction (PDF) Number of packets received divided by the number of packets transmitted.

Average end-to-end delay The sum of the delay of all received packets divided by the number of received packets.

5.1.1 Performance Analysis of AODV, DSDV and OLSR Protocol

Packet Delivery Fraction

Throughput

End-to-end Delay

5.1.2 Performance Analysis of OLSR and Proposed OLSR

Packet Delivery Fraction

Throughput

End-to-end Delay

5.2 Overall Performance Analysis

Chapter 6

Conclusion

6.1 Findings of the Work

6.2 Future Improvements