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Optimal Routing Algorithm used in Wireless Mesh Networks for Energy Efficiency

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Abstract

Wireless networking has witnessed an explosion of interest from consumers in recent years for its applications in mobile and personal communications. As wireless networks become an integral component of the modern communication infrastructure, energy efficiency will be an important design consideration due to the limited battery life of mobile terminals. Power conservation techniques are commonly used in the hardware design of such systems. Low energy can lead to propagation delay. Wireless Mesh Networks (WMN) is commonly considered the most suitable architecture because of their versatility that allows flexible configurations. In this paper we implement Optimal routing algorithm for energy efficiency in wireless mesh networks. We can achieve energy efficiency by allocating constant bit rate in wireless mesh networks. As a result we can overcome propagation delay.

Keywords: Wireless mesh network, power conservation, energy efficiency, propagation delay, optimal routing algorithm, constant bit rate

Introduction

Wireless networking is a method by which homes, telecommunications networks and enterprise (business) installations avoid the costly process of introducing cables into a building, or as a connection between various equipment locations. Wireless telecommunications networks are generally implemented and administered using radio communication. This implementation takes place at the physical level (layer) of the OSI model network structure. Here we use wireless mesh network.

A wireless mesh network (WMN) is a communications network made up of radio nodes organized in a mesh topology. Wireless mesh networks often consist of mesh clients, mesh routers and gateways. The mesh clients are often laptops, cell phones and other wireless devices while the mesh routers forward traffic to and from the gateways which may, but need not, connect to the Internet. The coverage area of the radio nodes working as a single network is sometimes called a mesh cloud. Access to this mesh cloud is dependent on the radio nodes working in harmony with each other to create a radio network. A mesh network is reliable and offers redundancy. When one node can no longer operate, the rest of the nodes can still communicate with each other, directly or through one or more intermediate nodes.Fig.1 represent the mesh topology.

An increasingly popular type of wireless access is the so-called Wireless Mesh Networks (WMNs) that provide Wireless connectivity through much cheaper and more flexible backhaul infrastructure compared with wired solutions. The nodes of these dynamically self-organized and self-configured networks create a changing topology and keep a mesh connectivity to offer Internet access to the users. [4]

![Fig: 1 Mesh Topology](image)

Obviously, the use of wireless technologies also for backhauling can potentially make the issue of energy performance even more severe if appropriate energy saving strategies is not adopted.

The rapid expansion of wireless services such as cellular voice, PCS (Personal Communications Services), mobile data and wireless LANs in recent years is an indication that significant value is placed on accessibility and portability as key features of telecommunication [5]. Wireless devices have maximum utility when they can be used “anywhere at any time”. One of the greatest limitations to that goal, however, is finite power supplies. Since batteries provide limited power, a general constraint of wireless communication is the short continuous operation time of mobile terminals.


[417-420]
Therefore, power management is one of the most challenging problems in wireless communication, and recent research has addressed this topic [6]. Examples include a collection of papers available in [7] and a recent conference tutorial [8], both devoted to energy efficient design of wireless networks.

In this paper we use Dynamic routing mechanism. There are two distinct categories of dynamic routing protocols:

1. Distance-vector protocols
2. Link-state protocols

Examples of distance-vector protocols include RIP and IGRP. Examples of link-state protocols include OSPF and IS-IS. EIGRP exhibits both distance-vector and link-state characteristics, and is considered a hybrid protocol.

Distance-vector Routing Protocols: All distance-vector routing protocols share several key characteristics:

1. Periodic updates of the full routing table are sent to routing neighbors.
2. Distance-vector protocols suffer from slow convergence, and are highly susceptible to loops.
3. Some form of distance is used to calculate a route’s metric.
4. The Bellman-Ford algorithm is used to determine the shortest path.

A distance-vector routing protocol begins by advertising directly-connected networks to its neighbors. These updates are sent regularly (RIP – every 30 seconds; IGRP – every 90 seconds). Neighbors will add the routes from these updates to their own routing tables. Each neighbor trusts this information completely, and will forward their full routing table (connected and learned routes) to every other neighbor. Thus, routers fully (and blindly) rely on neighbors for route information, a concept known as routing by rumor. There are several disadvantages to this behavior. Because routing information is propagated from neighbor to neighbor via periodic updates, distance-vector protocols suffer from slow convergence. This, in addition to blind faith of neighbor updates, results in distance-vector protocols being highly susceptible to routing loops. Distance-vector protocols utilize some form of distance to calculate a route’s metric. RIP uses hop count as its distance metric, and IGRP uses a composite of bandwidth and delay.

Link-state routing protocols were developed to alleviate the convergence and loop issues of distance-vector protocols. Link-state protocols maintain three separate tables:

1. Neighbor table – contains a list of all neighbors, and the interface each neighbor is connected off of. Neighbors are formed by sending Hello packets.
2. Topology table – otherwise known as the “link-state” table, contains a map of all links within an area, including each link’s status.
3. Shortest-Path table – contains the best routes to each particular destination (otherwise known as the “routing” table)

Link-state protocols do not “route by rumor.” Instead, routers send updates advertising the state of their links (a link is a directly-connected network). All routers know the state of all existing links within their area, and store this information in a topology table. All routers within an area have identical topology tables. The best route to each link (network) is stored in the routing (or shortest path) table. If the state of a link changes, such as a router interface failing, an advertisement containing only this link-state change will be sent to all routers within that area. Each router will adjust its topology table accordingly, and will calculate a new best route if required. By maintaining a consistent topology table among all routers within an area, link-state protocols can converge very quickly and are immune to routing loops. Additionally, because updates are sent only during a link-state change, and contain only the change (and not the full table), link-state protocols are less bandwidth intensive than distance-vector protocols. However, the three link-state tables utilize more RAM and CPU on the router itself. Link-state protocols utilize some form of cost, usually based on bandwidth, to calculate a route’s metric. The Dijkstra formula is used to determine the shortest path.

Propagation delay is the amount of time it takes for the head of the signal to travel from the sender to the receiver. It can be computed as the ratio between the link length and the propagation speed over the specific medium. Propagation delay is the major problem due to the lower energy in the network. To overcome the propagation delay we implement Optimal routing algorithm in wireless mesh network. So we can achieve energy efficiency by allocating constant bit rate in wireless mesh networks.

**Background**

Mesh networks which are of most commercial interests are characterized as fixed backbone WMNs where mesh nodes (routers or access points) are generally static and are mostly supplied by a permanent power source. Such a wireless mesh network architecture is illustrated in Fig:2, consisting of mesh routers, clients, and gateway nodes. Mesh routers (MR) communicate with peers in a multi hop fashion such that packets are mostly transmitted over multiple wireless links (hops). Therefore, nodes forward packets to other nodes that are
on the route but may not be within direct transmission range of each other. Routers which are connected to the outside world are called gateway nodes (GWN). These GWNs carry traffic in and out of the mesh network. The collection of such routers and gateway nodes connected together in a multi hop fashion form the basis for an infrastructure WMN (also called backbone mesh). Moreover, the multi hop packet transmission in an infrastructure WMN extends the area of wireless broadband coverage without wiring the network; thus WMNs can be used as extensions to cellular networks, ad hoc networks (MANET), sensor and vehicular networks, IEEE 802.11 WLANs (Wi-Fi), and IEEE 802.16 based broadband wireless (WiMax) networks[9].

Wide Area Network: As the term implies, a WAN spans a large physical distance. The Internet is the largest WAN, spanning the Earth. A WAN is a geographically-dispersed collection of LANs. A network device called a router connects LANs to a WAN. In IP networking, the router maintains both a LAN address and a WAN address. A WAN differs from a LAN in several important ways. Most WANs (like the Internet) are not owned by any one organization but rather exist under collective or distributed ownership and management. WANs tend to use technology like ATM, Frame Relay and X.25 for connectivity over the longer distances.

LAN, WAN and Home Networking: Residences typically employ one LAN and connect to the Internet WAN via an Internet Service Provider (ISP) using a broadband modem. The ISP provides a WAN IP address to the modem, and all of the computers on the home network use LAN (so-called private) IP addresses. All computers on the home LAN can communicate directly with each other but must go through a central gateway, typically a broadband router, to reach the ISP. We use optimal routing algorithm [11] in this mesh networks to save energy through which we can overcome propagation delay.

Optimal Routing Algorithm
The idea behind the optimal routing algorithm is the optimum route (OR) is that route between a source node and a destination, providing the following specifications:

- It is the only route, if the source and the destination are one hop neighbours.
- It is the shortest route between the source and destination.
- Doesn’t cross with any other route through any one of the source’s neighbours to the same destination, unless the joint node is one of the Destination’s neighbours. (No joint node (JN) or joint link (JK)).

A. Optimal route algorithm’s (ORA) messages:
- Hello message, every 1 sec, sends by each an old node to confirm that, it is still in the network, and the replay should be Hello as well from each node receives it.
- Hello message, no specific time, sends by each new node joined the network, and the replay should be a welcome message in this case, to differentiate between a new node joined the network and an old node still in the network.
- Welcome message, is a replay message from each node recognises there is a new node joined the network where the metric R=1 or R=2.

• **New node** message, it is a forward announcement message between the neighbours to identify there is a new node joined the network. If the metric associated with this message R<2 no replay needed, but if R=1 or 2 a welcome message should be send back to the new node through the neighbour who send the New node message.

• **Route request**, it is a message from a node to its neighbours, when requests a route to a node out of its zone where metric R>2, any node knows the required node should replay, unless the node required is replayed itself.

• **Route replay**, it is a replay message for a route request, when a required node is found by any other node or by itself.

• **NT request**, it is a message from a new node to its closest one hop neighbour where R=1, to send its whole Network table (NT), to create its own NT for future on demand route request to any node outside of its zone where R<2.

• **Route Error RERR**, this is a forward message, generates by any node discovers a link break, to all its neighbours. Each node receives this message should deletes any related nodes from its NT or any related route in its ORT or NORT.

• **Route Update**, is a forward message from the node discovered the broken link to the source node which still using the node caused the break as an intermediate node and doesn’t know that node is moved.

**Implementation**

In this wireless mesh topology we use optimal routing algorithm we provide fixed bandwidth and fixed timed to each node. Fixed bandwidth and fixed time can be achieved by constant bit rate allocation. Constant bit rate (CBR) is a term used in telecommunications, relating to the quality of service. CBR is an ATM bandwidth-allocation service that requires the user to determine a fixed bandwidth requirement at the time the connection is set up so that the data can be sent in a steady stream. CBR service is often used when transmitting fixed-rate uncompressed video. With limited bandwidth available, the recommended mode is normally CBR (constant bit rate) as this mode generates a constant bit rate that can be predefined by a user [12]. Energy will be saved in the process because of constant bit rate allocation for small data. Due to its efficiency the energy is saved. Thus we have overcome the propagation delay due to energy saving.

**References**


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