CHAPTER 4

IP Mobility

This chapter provides the following major sections to describe the Cisco Mobile Ad-hoc Network (MANET):

Introduction to the Cisco Mobile Ad-hoc Network

The Cisco solution for MANETs provides the following capabilities:

- Optimal route selection based on Layer 2 feedback from the radio network
- Faster convergence when nodes join and leave the network
- Efficient integration of point-to-point, directional radio topologies with multi-hop routing
- Flow-controlled communications between each radio and its partner router
- OSPFv3 MANET features
  - OSPFv3 MANET Per Node Overlapping Relays
  - OSPFv3 MANET Selective Peering
- OSPFv3 Address Families
- VMI NBMA-Mode Multicast
- Dynamic Link Exchange Protocol (DLEP)—DLEP is a Radio Aware Routing (RAR) protocol providing efficient routing over Radio Frequencies (RF). DLEP functionality includes the following features:
  - IP Multicast support across Broadcast Multi-Access (BMA)
  - DLEP server interaction with an existing MANET infrastructure
  - DLEP server interaction with an existing Virtual Multipoint Interface (VMI)
  - Supported interaction between DLEP (and/or the underlying MANET infrastructure) and capabilities such as Address Resolution Protocol (ARP) and Cisco IOS Timer Services (Chapter 6, "Understanding and Configuring DLEP.")

- Mobile Ad-hoc Network (MANET)—Cisco MANETs for router-to-radio communications address the challenges faced when merging IP routing with mobile radio communications. For more information, see Chapter 5, "Introduction to Radio Aware Routing and MANET."
- Virtual Multipoint Interfaces (VMI)—VMI provides services that map outgoing packets to the appropriate Point-to-Point Protocol over Ethernet (PPPoE) sessions. The VMI also provides a broadcast service that emulates a set of point-to-point connections as a point-to-multipoint interface with broadcast ability. For more information, see Chapter 8, "Configuring PPPoE" and Chapter 5, "Introduction to Radio Aware Routing and MANET."
- Enhanced Interior Gateway Routing Protocol (EIGRP)—EIGRP integrates the capabilities of link-state protocols into distance-vector protocols. In addition to providing fast convergence, EIGRP is distinguished from other routing protocols by supporting variable-length subnet masks, partial updates, and multiple network layer protocols. For more information, see Chapter 11, "Configuring EIGRP in a MANET."

Effective Networking in a MANET

The following are benefits of effective networking in a MANET environment:

- Routers and radios can interoperate efficiently, and without impacting operation of the radio network
- Radio point-to-point and router point-to-multipoint paradigms can be rationalized
- Radios can report status to routers for each link and each neighbor
- Routers can use this information to optimize routing decisions

Routing Challenges for MANETs

MANETs enable users deployed in areas with no fixed communications infrastructure to access critical voice, video, and data services. For example, soldiers in the field can employ unified communications, multimedia applications, and real-time information dissemination to improve situational awareness and respond quickly to changing battlefield conditions. Disaster managers can use video conferences, database access, and collaborative tools to coordinate multi-agency responses within an Incident Command System (ICS) framework. For event planners and trade show managers, MANETs represent a cost-effective way to accommodate mobile end users on a short-term basis. MANETs set the stage for more timely information sharing and faster, more effective decision-making.

Highly Dynamic Routing Topologies

In a Cisco MANET environment, highly mobile nodes communicate with each other across bandwidth-constrained radio links. An individual node includes both a radio and a network router, with the two devices interconnected over an Ethernet. Since these nodes can rapidly join or leave the network, MANET routing topologies are highly dynamic. Fast convergence in a MANET is challenging because the state of a node can change well before the event is detected by the normal timing mechanisms of the routing protocol.

Radio link quality in MANETs can vary dramatically because it can be affected by a variety of factors such as noise, fading, interference, and power fluctuation. As a result, avoiding congestion and determining optimal routing paths also pose significant challenges for the router network.

Topology Databases

Finally, directional radios that operate on a narrow beam tend to model the network as a series of physical point-to-point connections with neighbor nodes. This point-to-point model does not translate gracefully to multi-hop, multipoint router environments, as it increases the size of each router's topology database and reduces routing efficiency.

Router-to-Radio Links

Through the router-to-radio link, a radio can inform the router immediately when a node joins or leaves, and this enables the router to recognize topology changes more quickly than if it had to rely on timers. The link-status notification from the radio enables the router to respond faster to network topology changes. The radio passes metric information regarding the quality of a link to the router, enabling the router to more intelligently decide on which link to use.

Link-status Signaling

With link-status signaling provided by the router-to-radio link, applications such as voice and video work better because outages caused by topology changes are reduced or eliminated. Sessions are more stable.

Link-Quality Reporting

The quality of a radio link has a direct impact on throughput. The Cisco IOS software implements DLEP, RFC5578, OSFPv3, and EIGRP such that the route cost to a neighbor is updated dynamically based on radio-reported metrics, thus allowing the best route to be selected within a given set of radio links.

Link-Quality Metrics

Each routing protocol receives raw, radio-link data and computes a composite quality metric per link. In computing these metrics, the router may consider the following factors:

- Maximum Data Rate (MDR) — theoretical MDR of radio link, in scaled bits per second (bps)
- Current Data Rate (CDR)—CDR achieved on the link, in scaled bps
- Latency—encountered transmission-delay packets, in milliseconds
- Resources—a percentage (0-100) indicating remaining resource availability (such as battery power)
- Relative Link Quality (RLQ)—a numeric value (0-100) representing relative quality, where 100 indicates the highest quality

Router metrics can be weighted during the configuration process to emphasize or de-emphasize particular characteristics. For example, if throughput is a particular concern, you can weight the *throughput* metric so that it is factored more heavily into the composite route cost. Similarly, a metric of no concern can be omitted from the composite calculation.

Dynamic Reporting

Link metrics change rapidly, which can result in a flood of trivial routing updates. In a worst-case scenario, the network churns while reacting to relentless, minor variations. To prevent such churn, the Cisco IOS software provides a tunable dampening mechanism, thereby allowing you to configure thresholds. Any change in metrics below a configured threshold is ignored.

When the routing protocol is OSPFv3 or EIGRP, the connection quality for a neighbor session is determined by characteristics of that interface. The routing protocol receives dynamic, raw, radio link characteristics and computes a composite metric that is used to reduce the effect of frequent routing changes.

Tunable Hysteresis

A tunable hysteresis mechanism allows you to adjust the threshold to the routing changes that occur when the router receives a signal that a new peer has been discovered, or that an existing peer is unreachable. The tunable metric is weighted and adjusted dynamically to account for the following characteristics:

- Current and Maximum Bandwidth
- Latency
- Resources
- Relative Link Quality (RLQ)

Individual weights can be deconfigured and all weights can be cleared so that the cost returns to the default value per interface type. Based on the routing changes, cost can be determined by the application of these metrics.

Neighbor Up/Down Signaling

MANETs are highly dynamic environments. Neighbors enter and exit radio range rapidly. Each time a node joins or leaves the network, routers must reconstruct the topology logically. Routing protocols typically track topology changes with the use of timer-driven “hello” messages or neighbor timeouts. MANETs, however, cannot rely on such mechanisms given unacceptably slow convergence.

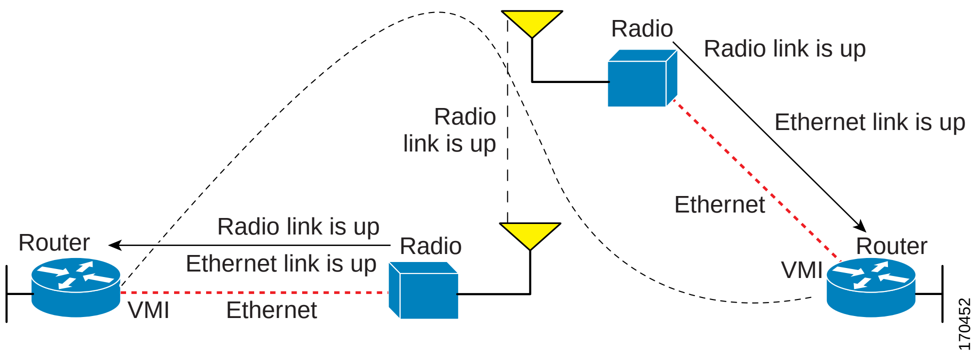
Neighbor Sessions

Each radio-router pair is a roaming client (or potential neighbor), constantly seeking new neighbors while checking for the continued existence of those already established. Neighbor discovery occurs when one radio discovers another. Each time a radio-to-radio link is established (between one neighbor and another), the radio initiates a neighbor session with its local router. When this neighbor session is successfully created and becomes active at both ends, router-to-router communication ensues—thereby completing the successful formation of a new neighbor session.

The neighbor up/down signaling capability in the Cisco IOS software provides faster network convergence by using link-status signals received from the local radio. The local radio notifies the router each time a link to a neighbor is established (up) or terminated (down), as depicted in Figure 4-1.

This change in link status occurs each time DLEP or RFC5578 creates or terminates a neighbor session.

Figure 4-1 Up and Down Signaling Sequence



OSPFv3 or EIGRP

The Cisco IOS routing protocol (OSPFv3 or EIGRP) responds immediately to each link-status signal by expediting a new adjacency (up—for a new neighbor) or tearing down an adjacency (down—for a neighbor suddenly lost). For example, if a vehicle drives behind a building and loses its connection, the router immediately senses the loss and establishes a new route to the vehicle through neighbors that are not blocked. This high-speed network convergence is essential for minimizing dropped voice calls and video disruptions.

When using VMI with RAR protocol and the link status changes (indicating a new or lost neighbor), the radio informs the router immediately of the topology change. Immediately upon receiving the link-status signal, the router declares the change and updates the routing tables.

Increased Performance

Link-status signaling provides the following benefits:

- Reduced routing delays
- Prevention of application time-outs
- Reliable and quick delivery of network-based applications and information over directional radio links
- Fast convergence and optimal route selection—preventing disruption of delay-sensitive traffic such as voice and video
- Reduced impact on radio equipment by minimizing the need for internal queuing/buffering
- Consistent Quality of Service (QoS) for multiple-radio networks
- Messaging enables dynamic rerouting to avoid disruptions and interference such as radio-link noise, fading, congestion, and power fade.

Dynamic Radio Capacities

The carrying capacity of each radio link may vary due to location changes or environmental conditions, and many radio-transmission systems have limited buffering capabilities. To minimize the need for packet queuing in the radio, the Cisco IOS software implements PPPoE with capabilities to control traffic buffering when congested.

Implementing flow-control also allows the use of fair queuing.

Credit-based Flow Control

The flow-control solution implements a credit-based mechanism documented in RFC 5578. When the PPPoE session is established, the radio can request a flow-controlled session. If the router acknowledges the request, all subsequent traffic must be flow-controlled. If a flow-control session has been requested and cannot be supported by the router, the session is terminated. Typically, both radio and router grant credits during session discovery. Once a device exhausts its credits, it must stop sending until additional credits have been granted. Credits can be added incrementally over the course of a session.

Metrics Scaling

High-performance radios use *metrics scaling* to meet high-speed link requirements. The radio can express the maximum and Current Data Rates (CDRs) with varying scalar values. Credit scaling allows a radio to change the default credit grant (or scaling factor) from 64 bytes to its default value.

You can use the **show vmi neighbor detail** command to display scalar values and maximum and current data rates (MDRs and CDRs).