23.23 Summary

IPv4 uses the Address Resolution Protocol, ARP, to bind a next-hop IPv4 address to an equivalent MAC address. ARP defines the format of messages that computers exchange to resolve an address, the encapsulation, and the rules for handling ARP messages. Because hardware addressing differs among networks, ARP only specifies a general pattern for message format, and allows the details to be determined by the MAC addressing scheme. ARP specifies that a computer should broadcast a request message, but that a response should be directed. Furthermore, ARP uses caching to avoid sending a request for each packet. IPv6 uses an alternative address resolution mechanism known as IPv6 Neighbor Discovery, IPv6-ND.

Both IPv4 and IPv6 define a companion error reporting mechanism known as the Internet Control Message Protocol (ICMP). Routers use ICMP when a datagram arrives with incorrect values in header fields or when a datagram cannot be delivered. ICMP messages are always sent back to the original source of a datagram, never to intermediate routers. In addition to messages that report errors, ICMP includes informational messages such as the Echo Request and Echo Reply messages used by the *ping* application. Each type of ICMP message has a unique format; a type field in the header allows a receiver to divide a given message into appropriate fields. An ICMP message is encapsulated in an IP datagram for transmission.

Originally, separate protocols were used to obtain each of the configuration parameters needed at startup. The Dynamic Host Configuration Protocol (DHCP), which extends the Bootstrapping Protocol (BOOTP), allows a host to obtain all necessary information with a single request. A DHCP response can provide an IPv4 address, the address of a default router, and the address of a name server. When it allocates an IP address automatically, DHCP offers the host a lease during which the address can be used. Once a lease expires, the host must extend the lease, or stop using the address. When IPv6 was created, designers chose an autoconfiguration mechanism that allows a host to generate a unique IPv6 address; however, DHCPv6 has been created to permit administrators to use DHCP to assign IPv6 addresses.

A NAT mechanism allows a site to have multiple computers using the Internet through a single IPv4 address. NAT rewrites header fields in each datagram that passes out to the Internet or into the site. For client applications, NAT translations can be established automatically when the NAT device finds the first outgoing packet of the communication. Several variations of NAT exist. The most popular form, NAPT, operates on transport-layer headers, and translates protocol port numbers as well as IPv4 addresses. NAPT allows an arbitrary number of applications running on arbitrary computers within a site to communicate with arbitrary destinations on the Internet simultaneously.