CHAPTER 9

# Internet Protocol

This chapter describes the level of support that Cisco ANA provides for IP, as follows:



# Technology Description

## IP

IP is a network layer (Layer 3) protocol that contains addressing information and some control information that enables packets to be routed. IP is documented in RFC 791 and is the primary network layer protocol in the Internet protocol suite. Along with TCP, IP represents the heart of the Internet protocols. IP has two primary responsibilities: providing connectionless, best-effort delivery of datagrams through an internetwork; and providing fragmentation and reassembly of datagrams to support data links with different maximum transmission unit (MTU) sizes.

## ARP

Address Resolution Protocol (ARP) is a protocol for mapping an IP address to a physical machine address (a MAC address) that is recognized in the local network. For example, in IP version 4 (IPv4), the most common level of IP in use today, an address is 32 bits long. In an Ethernet LAN, however, addresses for attached devices are 48 bits long. A table, usually called the ARP cache, is used to maintain a correlation between each MAC address and its corresponding IP address. ARP provides the protocol rules for making this correlation and providing address conversion in both directions.

# HSRP

Hot Standby Router Protocol (HSRP) is a routing protocol that provides automatic router backup by allowing host computers on the Internet to use multiple routers that act as a single virtual router, maintaining connectivity even if the first hop router fails, because other routers are on hot standby and ready to go. The protocol is fully compatible with Novell's Internetwork Packet Exchange (IPX), AppleTalk, and Banyan VINES, and (in some configurations) with Xerox Network Systems (XNS) and DECnet.

Developed by Cisco and specified in RFC 2281, HSRP ensures that only a single router (called the active router) is forwarding packets on behalf of the virtual router at any given time. A standby router is chosen to be ready to become the active router, in the event that the current active router fails. HSRP defines a mechanism used to determine active and standby routers by referring to their IP addresses. Once these are determined, the failure of an active router will not cause any significant interruption of connectivity.

On any given LAN, there may be multiple, possibly overlapping, hot standby groups, each with a single MAC address and IP address. The IP address should belong to the primary subnet, but must be different from any actual or virtual addresses allocated to any routers or hosts on the network.

# GRE

Generic Routing Encapsulation (GRE) is a tunneling protocol, originated by Cisco Systems and standardized in RFC 2784. It was designed to encapsulate a wide variety of network layer packets inside IP tunneling packets. The original packet is the payload for the final packet. The protocol is used on the Internet to secure VPNs.

# IPv6

IP version 6 (also known as IPv6, specified in RFC 2373, "IP Version 6 Addressing Architecture") is the successor to IPv4. The changes from IPv4 to IPv6 fall primarily into these categories:

- Expanded Addressing Capabilities—IPv6 increases the IP address size from 32 bits to 128 bits, supporting more levels of addressing hierarchy, a much greater number of addressable nodes, and simpler auto-configuration of addresses. It improves scalability of multicast routing by adding a scope field to multicast addresses. It also defines a new type of "anycast" address, used to send a packet to any one of a group of nodes.
- Header Format Simplification— Some IPv4 header fields have been dropped or made optional, to reduce the common-case processing cost of packet handling and to limit the bandwidth cost of the IPv6 header.
- Improved Support for Extensions and Options—Changes in the way IP header options are encoded allows for more efficient forwarding, less stringent limits on the length of options, and greater flexibility for introducing new options in the future.
- Flow Labeling Capability—This new capability enables the labeling of packets belonging to particular traffic flows for which the sender requests special handling, such as non default quality of service or real-time service.

Currently, Cisco ANA support for IPv6 has the following limitations:

- ANA does not support native IPv6 devices; this implies use of dual stack on all devices.
- ANA implementation of IPv6 is limited to discovery and display of IPv6-enabled interfaces and IPv6-enabled VPNs.
- Fault management of IPv6-enabled interfaces and VPN is limited to parsing and displaying the events reported for those interfaces and VPNs. ANA does not correlate or otherwise process these events.
- None of the routing protocols are supported for IPv6-enabled interfaces. To get topology links among IPv6-enabled interfaces, Cisco Discovery Protocol (CDP) must be enabled.

## 6VPE

IPv6 on VPN to Provider Edge (6VPE, RFC 2547) permits IPv6 domains to communicate with each other over an IPv4 core network, without explicit tunnel setup, requiring only one IPv4 address per IPv6 domain. 6VPE operates much like a normal IPv4 MPLS VPN provider edge, but with the addition of IPv6 support within VRF. It lets service providers support IPv6 over operational IPv4 MPLS backbones without requiring dual-stacking within the MPLS core, representing a large cost savings over core re-engineering. Only PE equipment must be dual-stack, to support awareness of both IPv4 and IPv6 access devices. 6VPE provides logically separate routing table entries for VPN member devices.

# Information Model Objects (IMOs)

This section describes the following IMOs:

- IP Interface (IIPInterface)
- IP Multiplexer Entry (IIPMuxEntry)
- IP Interface Address (IIPInterfaceAddress)
- IP Subnetwork (IPSubnet)
- Routing Entity (IRoutingEntity)
- Equivalent Routing Entry (IRoutingEntries)
- Routing Entry (IRoutingEntry)
- ARP Entity (IARPEntity)
- ARP Entry (IARPEntry)
- IP Address Pool (IIPPool)
- IP Range-Based Address Pool Entry (IIPRangeBasedIPPoolEntry)
- IP Subnet-Based Address Pool Entry (IIPSubnetBasedIPPoolEntry)
- Hot Standby Router Protocol (HSRP) Group Entry (IHSRPGroupEntry)
- Generic Routing Encapsulation (GRE) Tunnel Interface (ITunnelGRE)

# IP Interface

The network layer IP Interface IMO represents the IP-level functionality of an interface configuration in a network element. Its Containing Termination Points attribute is its primary binding to a data link layer interface object. It is accessed primarily by a Routing Entity.

***Table 9-1 IP Interface (IIPInterface)***

| Attribute Name | Attribute Description | Scheme | Polling Interval |
|---|---|---|---|
| IP Address | IP addresses (including IPv6) | Product | Configuration |
| Subnetwork Mask | IP subnetwork masks (including IPv6) | Product | Configuration |
| IP Interface Addresses Array | Array of all IP Interface Addresses (including IPv6) | Product | Configuration |
| Interface Name | Interface name | Product | Configuration |
| Interface Description | Interface description | Product | Configuration |
| IP Interface State | IP interface state (*Unknown, Up, Down*) | Product | Configuration |
| OSPF Interface Cost | $2x10^9$/<interface speed in BPS> | Any | Configuration |
| Broadcast Address | The broadcast address of the subnetwork | Any | Configuration |
| MTU | Maximum transmit units | Any | Configuration |
| Lookup Method | Lookup method (*Route Table First*, *Host Table First*) | Any | Configuration |
| Address Resolution Type | Address resolution type | Any | Configuration |
| ARP Timeout | ARP table entry aging timeout | Any | Configuration |
| Secured ARP | Secured ARP settings (*Enable*, *Disable*) | Any | Configuration |
| ICMP Mask Reply | Control message mask reply | Any | Configuration |
| IGMP Proxy | Group management proxy | Any | Configuration |
| HSRP Groups | Arrays of Hot Standby Router Protocol (HSRP) Group Entry (valid only for Cisco routers that implement HSRP) | Any | Configuration |
| IP Multiplexing Table | Array of IP Multiplexing Entries | Any | Configuration |
| IANA Type | Internet Assigned Numbers Authority (IANA) type of the sublayer | N/A | N/A |
| Containing Termination Points | Underlying termination points (connection or physical) | Any | N/A |
| Contained Connection Termination Points | Bound connection termination points | Any | N/A |

# IP Multiplexer Entry

The IP Multiplexer Entry IMO represents an entry in the IP Multiplexing Table of an IP Interface object. It is used when an IP Interface is bound to multiple virtual connection-based data link layer interfaces (such as ATM Interface and Frame Relay Interface) in order to map a destination IP subnet to a specific virtual connection.

*Table 9-2 IP Multiplexer Entry (IIPMuxEntry)*

| Attribute Name | Attribute Description | Scheme | Polling Interval |
|---|---|---|---|
| Termination Point | Virtual data link layer encapsulation | Any | Configuration |
| Destination IP Subnet | Destination IP subnet | Any | Configuration |

# IP Interface Address

The IP Interface Address IMO represents one of several possible IP addresses and their subnetwork masks that can be assigned to an IP Interface using an IP Subnetwork IMO. It indicates whether it is the primary or a secondary address.

*Table 9-3 IP Interface Address (IIPInterfaceAddress)*

| Attribute Name | Attribute Description | Scheme | Polling Interval |
|---|---|---|---|
| Type | IP address type (for IPv4: *Primary*, *Secondary*; for IPv6, *IPv6 Link-local*, *IPv6 Unicast*, *IPv6 Anycast*, *IPv6 Multicast*) | Any | Configuration |
| IP Subnet | IP subnetwork (supports IPv6) | Any | Configuration |

# IP Subnetwork

The IP Subnetwork type (it is not an IMO) describes either an IP Subnetwork Address (with the host part zeroed) or, alternatively, a host IP address along with the IP subnetwork mask.

*Table 9-4 IP Subnetwork (IPSubnet)*

| Attribute Name | Attribute Description | Scheme | Polling Interval |
|---|---|---|---|
| IP Address | IP address (supports IPv6) | Any | Configuration |
| Subnetwork Mask | IP subnetwork mask (supports IPv6) | Any | Configuration |

# Address Family

The Address Family IMO represents the VRF route targets associated with IPv4 and IPv6 address family configurations.

*Table 9-5 Address Family (IAddressFamily)*

| Attribute Name | Attribute Description | Scheme | Polling Interval |
|---|---|---|---|
| Address family type | Address family type (*IPv4 address family*, *IPv6 address family*) | Any | Configuration |
| Export route targets | List of export route targets | Any | Configuration |
| Import route targets | List of import route targets | Any | Configuration |

# Routing Entity

The Routing Entity IMO represents the routing and address resolution protocol-independent forwarding component of an IP router. It is bound by its Logical Sons attribute to all the network-layer IP Interface IMOs among which this Routing Entity is routing IP packets.

*Table 9-6 Routing Entity (IRoutingEntity)*

| Attribute Name | Attribute Description | Scheme | Polling Interval |
|---|---|---|---|
| Routing Table | Array of Equivalent (Shared Destination) Routing Entries | Product | Configuration |
| ARP Entity | Address resolution entity (ARP Entity) | Product | Configuration |
| Routing Table Changes | Routing table changes count | Any | Configuration |
| Name | Routing entity name | Any | Configuration |
| Logical Sons | Array of all IP Interfaces which IP packets are being routed between, by this Routing Entity | Any | N/A |

# Equivalent Routing Entry

The Equivalent Routing Entry and Routing Entry IMOs together describe a routing table's entries. Each routing table entry is an array of entries sharing a single IP Subnetwork destination. Based on their protocol type, some of a device's routing table entries which are not relevant to the Cisco ANA Information Model may be omitted from this table structure.

*Table 9-7 Equivalent Routing Entry (IRoutingEntries)*

| Attribute Name | Attribute Description | Scheme | Polling Interval |
|---|---|---|---|
| Routing Entries | Array of Routing Entries (sharing a single destination) | Any | Configuration |

# Routing Entry

See the description for Equivalent Routing Entry.

*Table 9-8 Routing Entry (IRoutingEntry)*

| Attribute Name | Attribute Description | Scheme | Polling Interval |
|---|---|---|---|
| Destination IP Subnet | Final destination IP subnet | Product | Configuration |
| Next Hop IP Address | Next hop IP address | Product | Configuration |
| Type | Routing entry type (*Null*, *Other*, *Invalid*, *Direct*, *Indirect*, *Static*) | Product | Configuration |
| Routing Protocol Type | Routing protocol type (*Null, Other, Local, Network Managed, ICMP, EGP, GGP, Hello, RIP, IS-IS, ES-IS, Cisco IGRP, BBN SPF IGP, OSPF, BGP, EIGRP*) | Product | Configuration |
| Outgoing Interface Name | Outgoing IP interface name | Product | Configuration |
| Prefix Length | The number of bits set in the subnet mask (the shorthand way of expressing the subnet mask). | Product | Configuration |

# ARP Entity

The ARP Entity IMO describes a domain-wide IP address to MAC Address Resolution Protocol (ARP) entity.

*Table 9-9 ARP Entity (IARPEntity)*

| Attribute Name | Attribute Description | Scheme | Polling Interval |
|---|---|---|---|
| ARP Table | Array of ARP Entries | Product | Configuration |

# ARP Entry

The ARP Entry IMO describes a domain-wide IP address to MAC Address Resolution Protocol (ARP) table entry.

*Table 9-10 ARP Entry (IARPEntry)*

| Attribute Name | Attribute Description | Scheme | Polling Interval |
|---|---|---|---|
| IP Address | IP address | Product | Configuration |
| MAC Address | MAC address | Product | Configuration |
| Port | Data link layer (MAC) interface | Product | Configuration |
| Entry Type | ARP entry type (*Null, Other, Invalid, Dynamic, Static*) | Product | Configuration |

# IP Address Pool

The IP Address Pool IMO, with its associated IP Range-Based Address Pool Entry and IP Subnet-Based Address Pool Entry IMOs, describes an IP address pool of a gateway or router device. Protocols such as Dynamic Host Configuration Protocol (DHCP) and IP Control Protocol (IPCP) use these pools to distribute IP assignments to local and remote parties.

*Table 9-11 IP Address Pool (IIPPool)*

| Attribute Name | Attribute Description | Scheme | Polling Interval |
|---|---|---|---|
| IP Address Pool Entries | Array of IP Range Based Address Pool Entries or IP Subnet Based Address Pool Entries | Any | Configuration |
| Name | IP addresses pool name | Any | Configuration |
| Index | IP addresses pool index | Any | Configuration |

# IP Range-Based Address Pool Entry

See the description for IP Address Pool.

*Table 9-12 IP Range-Based Address Pool Entry (IIPRangeBasedIPPoolEntry)*

| Attribute Name | Attribute Description | Scheme | Polling Interval |
|---|---|---|---|
| Start IP Address | Start IP address of the IP address pool | Any | Configuration |
| End IP Address | End IP address of the IP address pool | Any | Configuration |
| Unused Addresses | Unused addresses count | Any | Configuration |
| Used Addresses | Used addresses count | Any | Configuration |
| Reserved Addresses | Reserved addresses count | Any | Configuration |

# IP Subnet-Based Address Pool Entry

See the description for IP Address Pool.

*Table 9-13 IP Subnet-Based Address Pool Entry (IIPSubnetBasedIPPoolEntry)*

| Attribute Name | Attribute Description | Scheme | Polling Interval |
|---|---|---|---|
| IP Subnet | IP Subnetwork of the IP address pool | Any | Configuration |
| Unused Addresses | Unused addresses count | Any | Configuration |
| Used Addresses | Used addresses count | Any | Configuration |
| Reserved Addresses | Reserved addresses count | Any | Configuration |

# Hot Standby Router Protocol (HSRP) Group Entry

The Hot Standby Router Protocol (HSRP) Group Entry IMO represents both the configuration and the result of running HSRP within a group of routers connected to the same segment of an Ethernet network. HSRP provides backup for router failures by presenting the group of routers to the LAN as a single virtual router with a single set of IP and MAC addresses.

*Table 9-14 Hot Standby Router Protocol (HSRP) Group Entry (IHSRPGroupEntry)*

| Attribute Name | Attribute Description | Scheme | Polling Interval |
|---|---|---|---|
| Group Number | Group number | Product | Configuration |
| Port Description | Port description | Product | Configuration |
| Priority | Priority from *0* (*Lowest*) to *255* (*Highest*) used for active router selection | Product | Configuration |
| Coupled Router | Coupled active or standby router IP address (as the grouping is implemented using only two routers) | Product | Configuration |
| State | Protocol state (*Disabled, Initial, Learn, Listen, Speak, Standby, Active*) | Product | Configuration |
| Virtual IP Address | Virtual IP address used by this group | Product | Configuration |
| Virtual MAC Address | Virtual MAC address used by this group | Product | Configuration |

# Generic Routing Encapsulation (GRE) Tunnel Interface

The network-layer Generic Routing Encapsulation (GRE) Tunnel Interface IMO represents a GRE tunnel interface configuration in a network element. It is accessed primarily by an IP Interface bound by its Contained Connection Termination Points attribute.

*Table 9-15 Generic Routing Encapsulation (GRE) Tunnel Interface (ITunnelGRE)*

| Attribute Name | Attribute Description | Scheme | Polling Interval |
|---|---|---|---|
| Name | Tunnel name | Product | Configuration |
| Tunnel Destination and Source | Tunnel destination and source IP addresses | Product | Configuration |
| IP Address | Primary IP address | Product | Configuration |
| IP Interface State | IP interface state (*Unknown, Up, Down*) | Any | Configuration |
| IANA Type | Internet Assigned Numbers Authority (IANA) type of the sublayer | N/A | N/A |
| Containing Connection Termination Points | Underlying termination points (connection or physical) | Any | N/A |
| Contained Connection Termination Points | Bound connection termination points | Any | N/A |
| Keep Alive State | Indicates whether the GRE keep alive is *set* or *not set* | Any | N/A |
| Keep Alive Time | The interval at which GRE will try to send keepalive packets | Any | N/A |
| Keep Alive Retry | Number of times the GRE will try to send keepalive packets without a response before bringing down the interface or tunnel protocol | Any | N/A |

# Network Topology

Discovery of the IP network layer is unsupported. However, IP addresses and subnets are used in signature and test of the underlying MPLS, PPP, and HDLC topology discovery when searching for the local IP address in any one-hop-away remote side's routing table. In particular, the local and remote IP addresses of IP Interface found under the same subnet are compared.

For more information, see Chapter 14, "Multiprotocol Label Switching," Chapter 21, "Point-to-Point Protocol," and Chapter 22, "High-Level Data Link Control."

# Service Alarms

The following alarms are supported for this technology:

- All IP Interfaces Down/IP Interface Up
- GRE Tunnel Down/GRE Tunnel Up
- IP Interface Down/IP Interface Up
- HSRP Group Member Not Active/HSRP Group Member Active

For detailed information about alarms and correlation, see the *Cisco Active Network Abstraction 3.6.7 User Guide.*