IPv6 : ICMPv6
Focus on ICMPv6

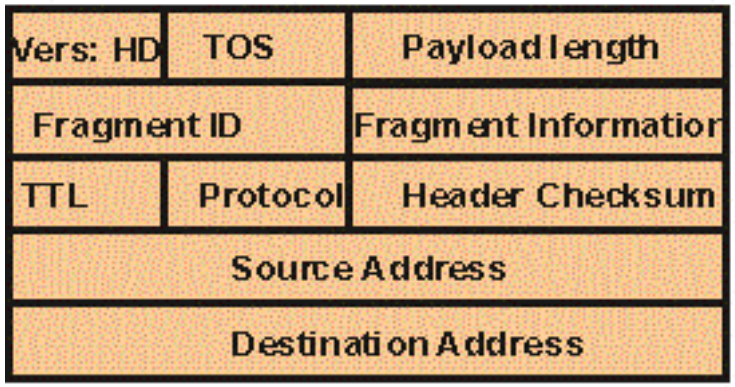
Laura Knapp
WW Business Consultant
Laurak@aesclever.com

What is IPv6

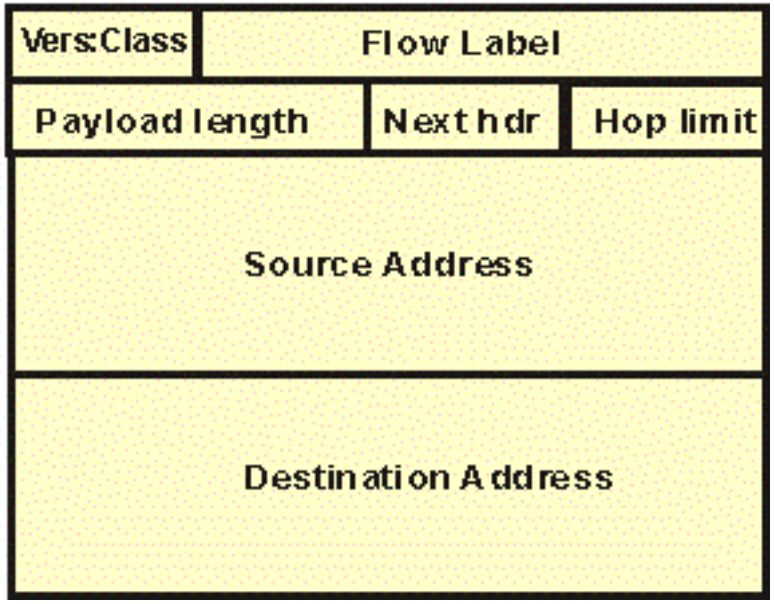
Addressing	**128 bits addresses hierarchically assigned**
Routing	**Strongly hierarchical (route aggregation)**
Performance	**Simple datagram**
Extensibility	**New flexible option header format**
	Improved support for extensions and options
Multimedia	**Better support for QoS**
Multicast	**Compulsory-better scope control**
Security	**Built in security (IPSEC)**
Auto-configuration	**Stateless and state-full address configuration**
Mobility	**Better efficiency and security**

IPv6 Header

IPv4 Header



IPv6 Header



IPv4 header is 20 bytes : IPv6 header is 40 bytes
Address increased from 32 to 128 bits
Fragmentation fields moved out of base header
Header checksum
Time to Live replaced with 'Hop Limit'
Protocol replaced with 'Next Header'
TOS replaced with 'Flow Label'
Alignment changed from 32 to 64 bits

Items to Be Discussed

IP Addressing

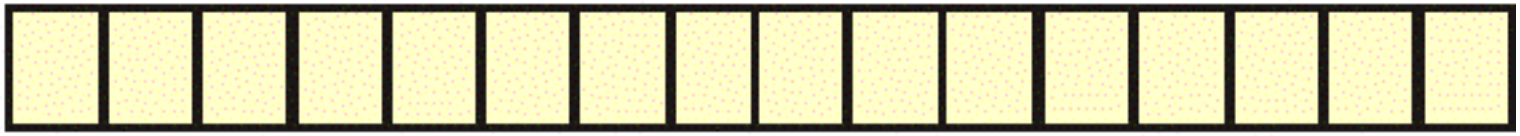
Autoconfiguration

SNMP MIBs

Addressing Format

1080:0002:4544:0000:8532:9A14:0648:417A

IPv6



Format Prefix are the high order bits with fixed values

Defined in RFC 3513
40,282,366,920,938,463,374,607,431,768,211,456 addresses
40 trillion trillion trillion addresses

Addresses are assigned to interfaces

Multiple address can be defined to a single interface

Address structure
Ipv6 address = Prefix + Interface id

Separation of 'who you are' from 'where you are connected'

Assignments by ARIN, APNIC, RIPE

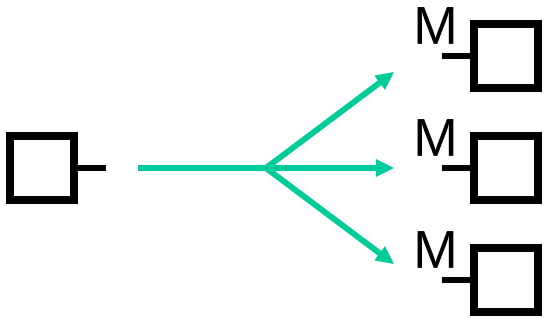
IPv6 Address Types

unicast:

for one-to-one communication

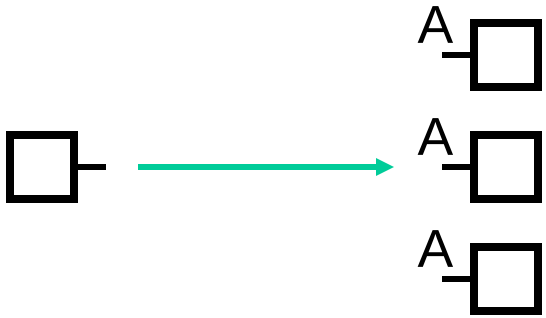
multicast:

for one-to-many communication



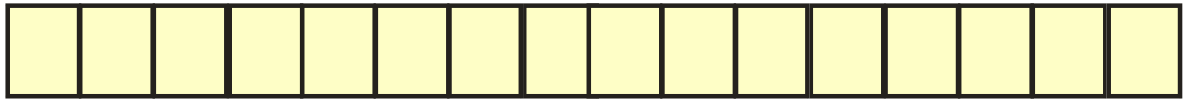
anycast:

for one-to-nearest communication



IPv6 Address: Site and Link

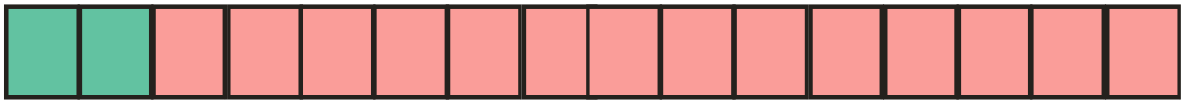
IPv6



2001:0DB8::15:219:D1FF:FE10:74EE/64

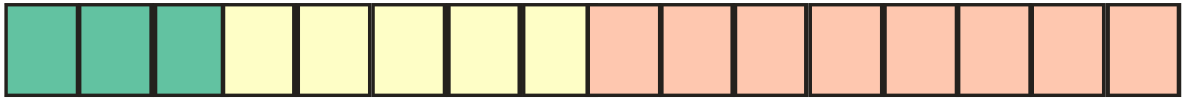
Multicast

Prefix=FF00::/8 112 bit group ID



Unicast

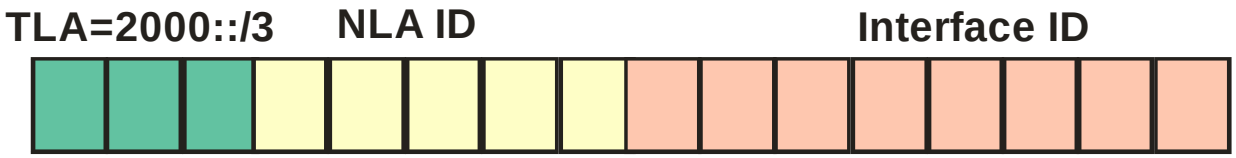
TLA=2000::/3 NLA ID Interface ID



2001:0408/32 ATT
2001:0506:0000/48 Verizon Business
2001:4840/32 Earthlink
2001:49C0/32 IBM
2001:0200--039F 12 ISPs in Korea

FC00::/7 Unique Local – Internet router will discard
FE80::/10 Link Local – Non-routeable

Global Unicast Address



TLA : Top Level Aggregation - 3 bytes (21 bits; First three bits of byte 1 are 001)
IANA allocates address blocks to the regional Internet registries
They allocate portions of their block to national registries or to ISPs

NLA : Next Level Aggregation - 5 bytes
High order part assigned to smaller or regional ISPs, large companies
Holders of an NLA block assign partsof their block to their customers
They assign middle chunks to locations
Low order numbers identify subnets

Interface ID : host interface (64 bits)
Assigned by the owning organization
IEEE has defined a 64 bit NIC address known as EUI-64
NIC driver for IPv6 will convert 48 bit NIC to 64 bit NIC

Structure greatly reduces the entries in the routing table....only one entry needed in a US router to define all the networks in a region or country

Address Type Prefixes

- Unspecified
  - used when there is no address
- Loopback
- Link Local Unicast
- Multicast
- Unicast + Anycast
  - hierarchical
  - /13 - /32 to LIR's (ISP's)
  - /48 or /56 to endusers / sites
  - "Site Local" used to exist (fec0::/10) but this has been deprecated in favor of ULA

http://www.iana.org/assignments/ipv6-address-space

0000 .... 0000 (::/128)

0000 .... 0001 (::1/128)

1111 1110 1000 0000 .... (fe80::/16)

1111 1111 .... (ffxx::/8)

The rest, 2000::/3, which is 1/8th of total IPv6 space

2001::/16 = RIRs

2001::/32 = Teredo

2002::/16 = 6to4

3ffe::/16 = 6bone*

fd00::/8 = ULA

* = 6bone shut down on 6/6/6

Items to Be Discussed

IP Addressing

Autoconfiguration

SNMP MIBs

IPv6: Autoconfiguration

Combination

ARP : ICMP router discovery : ICMP redirect

Neighbor discovery

Multicast and unicast datagrams

Establishes MAC address on same network

ICMPv6 router solicitation

ICMPv6 router advertisement

ICMPv6 neighbor solicitation

ICMPv6 redirect

ICMPv6 includes IGMP protocol for Multicast IP

Reduces impact of finding hosts

Stateless: router configures a host with IPv6 address

Stateful: DHCP for IPv6

Link Local Address: IPv6 connectivity on isolated LANs

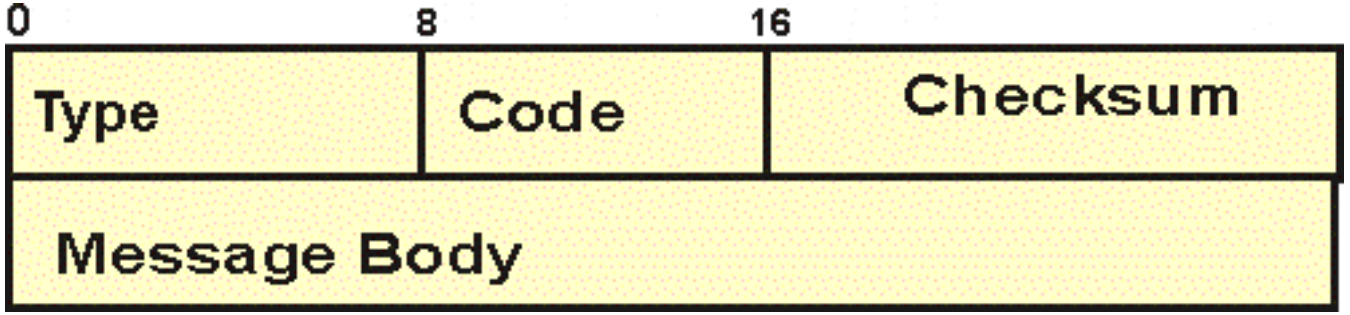
ICMPv6

ICMPv6 is used by IPv6 nodes to report errors encountered in processing packets, and to perform other internet-layer functions, such as diagnostics (ICMPv6 "ping")

ICMPv6 is an integral part of IPv6 and MUST be fully implemented by every IPv6 node

ICMPv6 messages are grouped into two classes:
error messages - Types 0-127
informational messages - Types 128-255

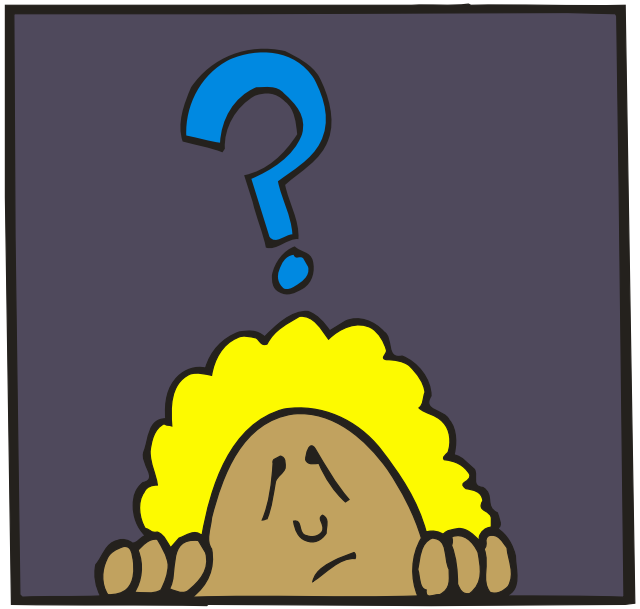
IPv6 next 'header' value for ICMP is 58



ICMPv6 Functions

Reports:

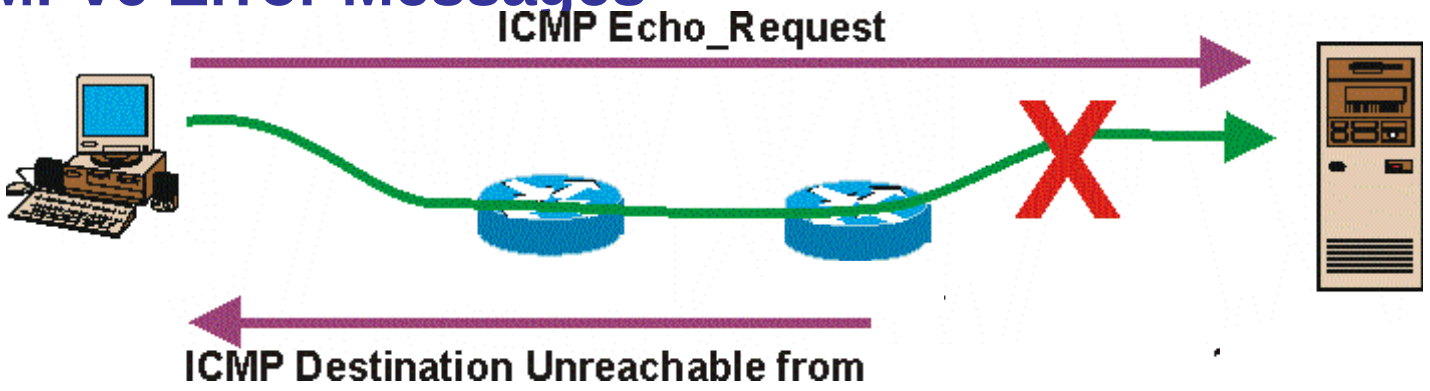
- **packet processing errors**
- **intranetwork communications path diagnosis**
- **multicast membership**



New functions:

- **Neighbor Discovery**
  - **allows nodes on the same link to discover each other**
  - **allows nodes to discover each other's addresses**
  - **finds routers for paths to other networks**
  - **determines fully qualified name of a node**
- **path MTU discovery determines the maximum path size along a path**

ICMPv6 Error Messages



ICMPv6 error messages:

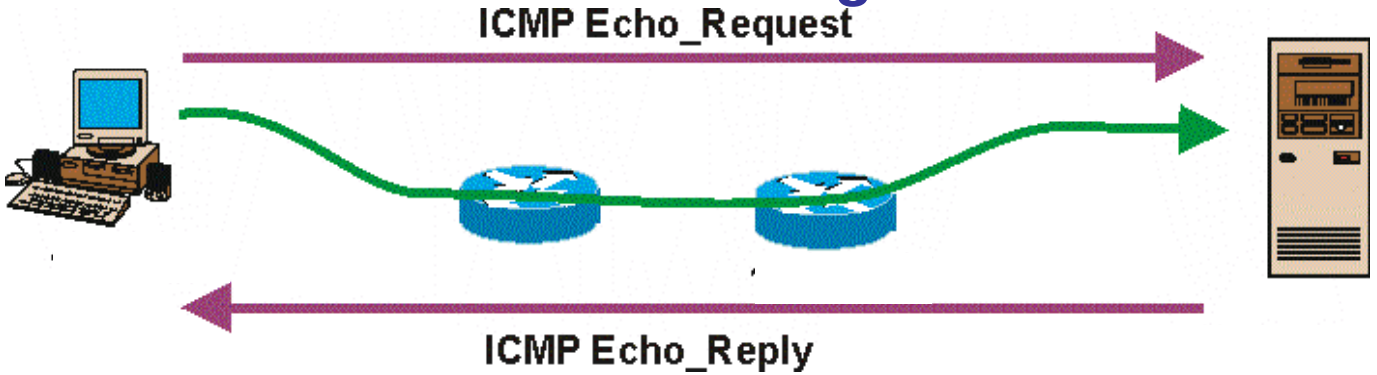
1 Destination unreachable
- **code=0 no route to destination**
- **code=1 communication with destination prohibited**
- **code=2 (not assigned)**
- **code=3 address unreachable**
- **code=4 port unreachable**

2 Packet too big
- **code=0 next byte contains the maximum transmission MTU of the next hop**

3 Time exceeded
- **code=0 hop limit exceeded in transit**
- **code=1 fragment reassembly time exceeded**

4 Parameter problem
- **code=0 erroneous header field encountered**
- **code=1 unrecognized next header type encountered**
- **code=2 unrecognized IPv6 option encountered**

ICMPv6 Informational Messages



ICMPv6 informational messages:

128 Echo request
code=0 and Identifier and sequence number carried
129 Echo reply
code=0 and identifier and sequence number carried
130 Multicast listener query
131 Multicast listener report
132 Multicast listener done
133 Router solicitation
134 Router advertisement
135 Neighbor solicitation
136 Neighbor advertisement
137 Redirect

ICMPv6 Multicast Listener (MLD)

Took pieces from IGMP (Internet Group Management Protocol) (RFC 1112 and RFC 2236) and merged into new protocol

Defined in RFC 2710

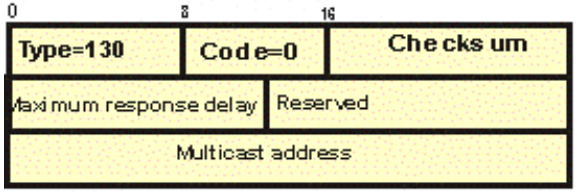
MLD is a sub-protocol of ICMPv6

Allows routers to discover nodes that wish to receive multicast packets on all the routers links

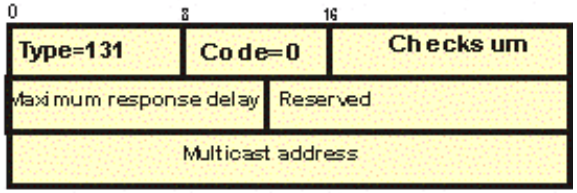
Query can be general or specific
- Tell me all nodes with multicast address x
- Tell me all nodes and their multicast addresses

Maximum response delay only is used with the Query message

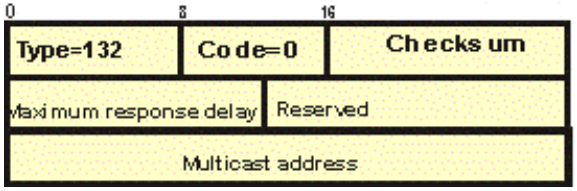
MLD Query Message



MLD Listener Report



MLD Listener Done



ICMPv6 Neighbor Discovery

Defined in RFC 2461

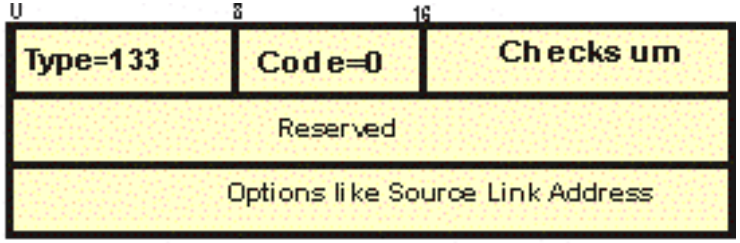
- **Combines prior IPV4 functions**
  - **ARP (RFC 826)**
  - **Router Discovery (RFC 1256)**
  - **Redirect Message (RFC 792)**

Mechanisms to:

- **Discover routers**
- **Prefix discovery for on-link**
- **Parameter discovery (i.e link MTU)**
- **Address autoconfiguration**
- **Address resolution**
- **Next hop determination**
- **Neighbor unreachable**
- **Duplicate address**
- **Redirect**

ICMPv6 Router Solicitation/Advertisement

Router Solicitation
Host to router to prompt the router to generate a Router Advertisement message quickly



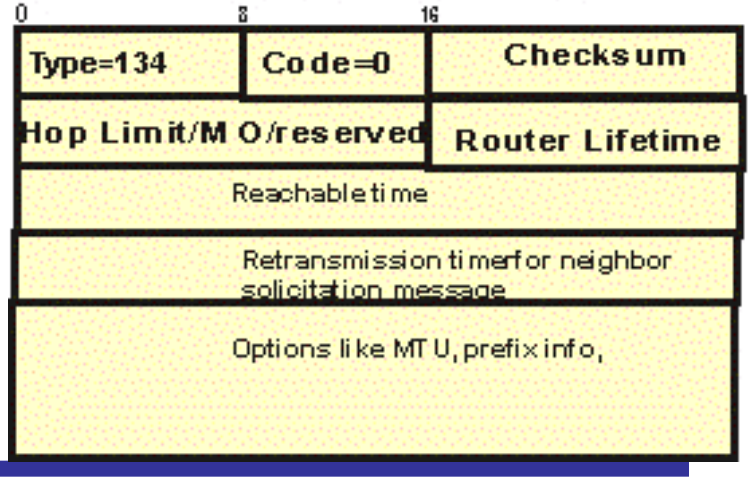
Router Advertisement

Sent on periodic basis from router to the 'all nodes address'

Hop limit should be 255

Could include security header

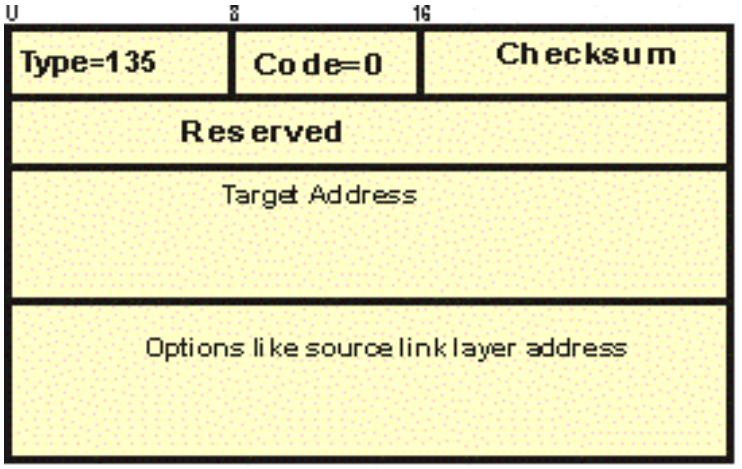
M=1 use DHCP for address configuration
O=1 use stateful protocol for address configuration



ICMPv6 Neighbor Messages

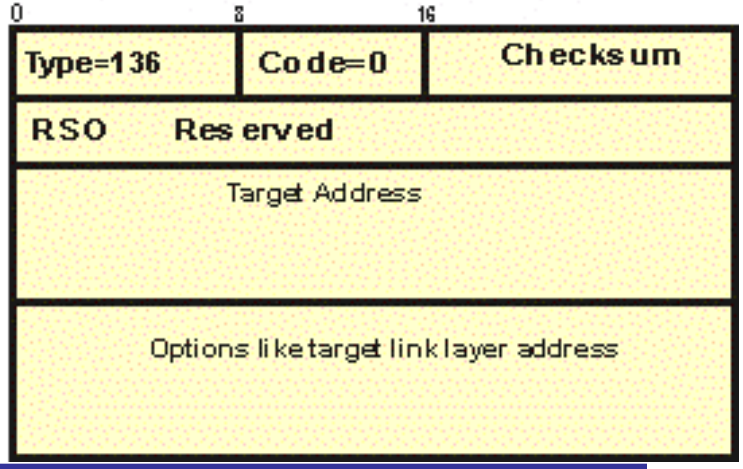
Neighbor Solicitation

- Nodes ask for link layer address of a target while providing their own link layer address to the target
- Multicast to resolve an address
- Unicast to verify the reachability of a neighbor



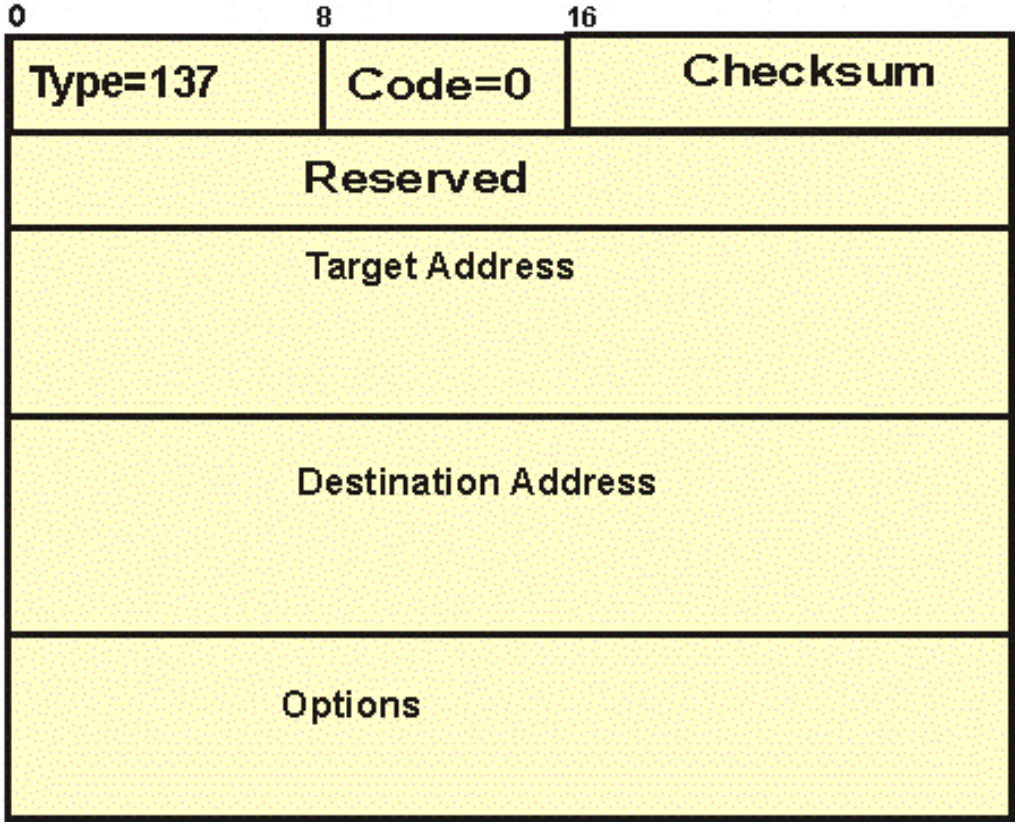
Neighbor Advertisement

- Sent by nodes in response to Neighbor solicitation messages
- Can be sent unsolicited to quickly ask for information
- Identify sender as router (r), destination address (s) response, or should over-ride existing cache (o)



ICMPv6 Redirect

Redirect messages are sent by routers to tell a host of a better first-hop node



ICMPv6 Neighbor Discovery Options

Five options

type=1 Source link layer option used by
- **Neighbor Solicitation**
- **Router Solicitation**
- **Router Advertisement**

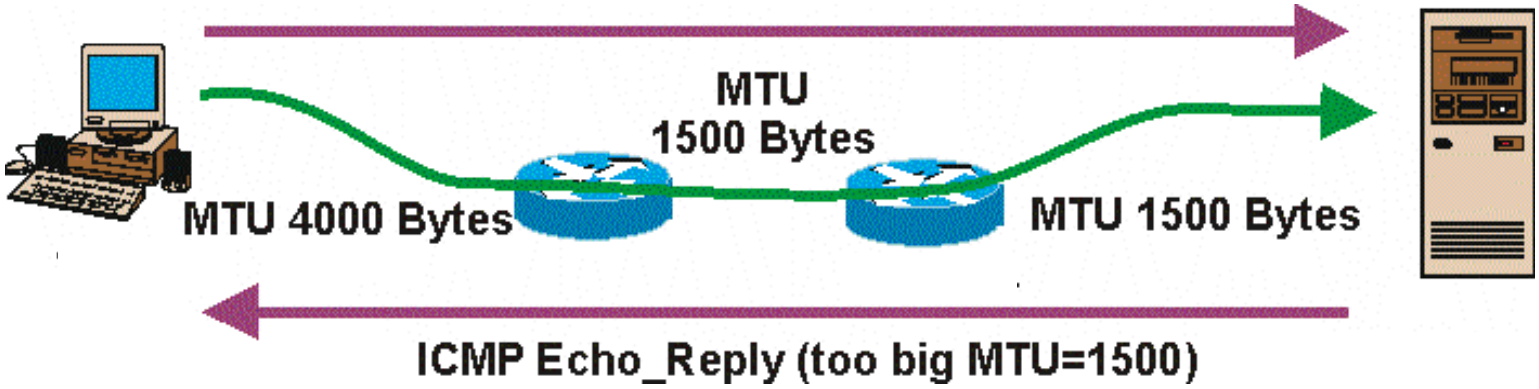
type=2 Target link layer option used by
- **Neighbor Advertisement**
- **Redirect messages**

type=3 Prefix information
- **How many bits in prefix are valid**

type=4 Redirected header used by
- **Redirect messages**
- **Makes sure the message does not exceed 1280 octets**

type=5 Recommended MTU used by
- **Router Advertisement**
- **All nodes use same MTU**

ICMPv6 Path MTU Discovery



RFC 1981

Since fragmentation is a host function the host most have an idea of the route topology

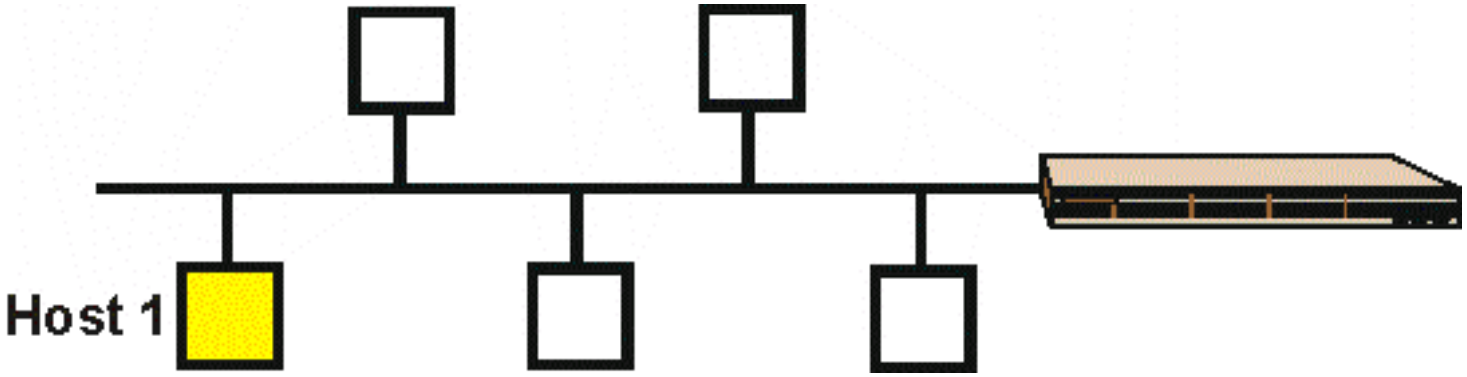
Assume that the MTU of the path is the same as your local link

Source node transmits a packet and sees if ICMPv6 ‘packet too big’ is returned

If ICMPv6 ‘packet too big’ is returned reset PMTU is reduced

Repeat the test

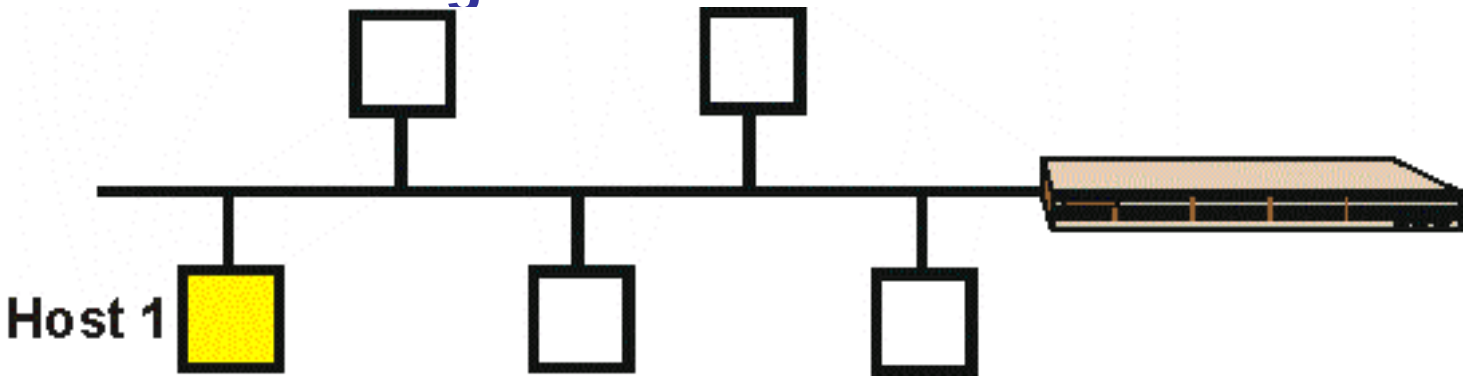
ICMPv6 Model Host



Each host is to maintain the following:

- **Neighbor Cache**
- **Destination Cache**
- **Prefix List**
- **Default Router List**
- **LinkMTU**
- **CurHopLimit**
- **BaseReachable Time**
- **Reachable Time**
- **Retransmit Timer**

IPv6 Auto-configuration



Host 1 comes on line and generates a link local address

Host 1 sends out a query called neighbor discovery to the same address to verify uniqueness. If there is a positive response a random number generator is used to generate a new address

Host 1 multicasts a router solicitation message to all routers

Routers respond with a router advertisement that contains an aggregatable global address (AGA) prefix and other information

Host 1 automatically configures its global address by appending its interface

ID to the AGA

Host 1 can now communicate

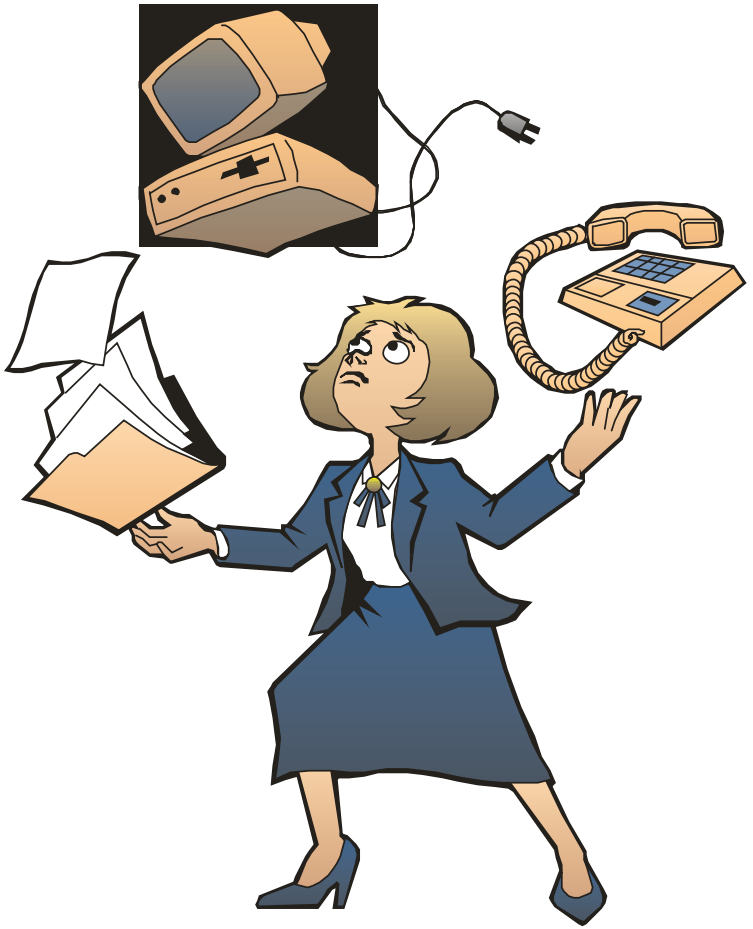
Changes Needed to Implement IPv6

Hosts
- Implement IPv6 code in operating system
- TCP/UDP aware of IPv6
- Sockets/Winsock library updates for IPv6
- Domain Name Server updates for IPv6

Domain Name Server (DNS)
- Many products already support 128 bit addresses
- Uses ‘AAAA’ records for IPv6
- IP6.INT (in_addr_arpa in IPv4)

Routers
- IPv6 forwarding protocols
- Routing protocols updated to support IPv6
- Management needs to support ICMPv6
- Implement transition mechanisms

IPv6 Protocol Status
- RIPv6 - Same as RIPv2
- OSPFv6 - Updated for IPv6
- EIGRP - Extensions implemented
- IDRP - Recommended for exterior protocol over BGP4
- BGP4+ - Preferred implementation in IPv6 today



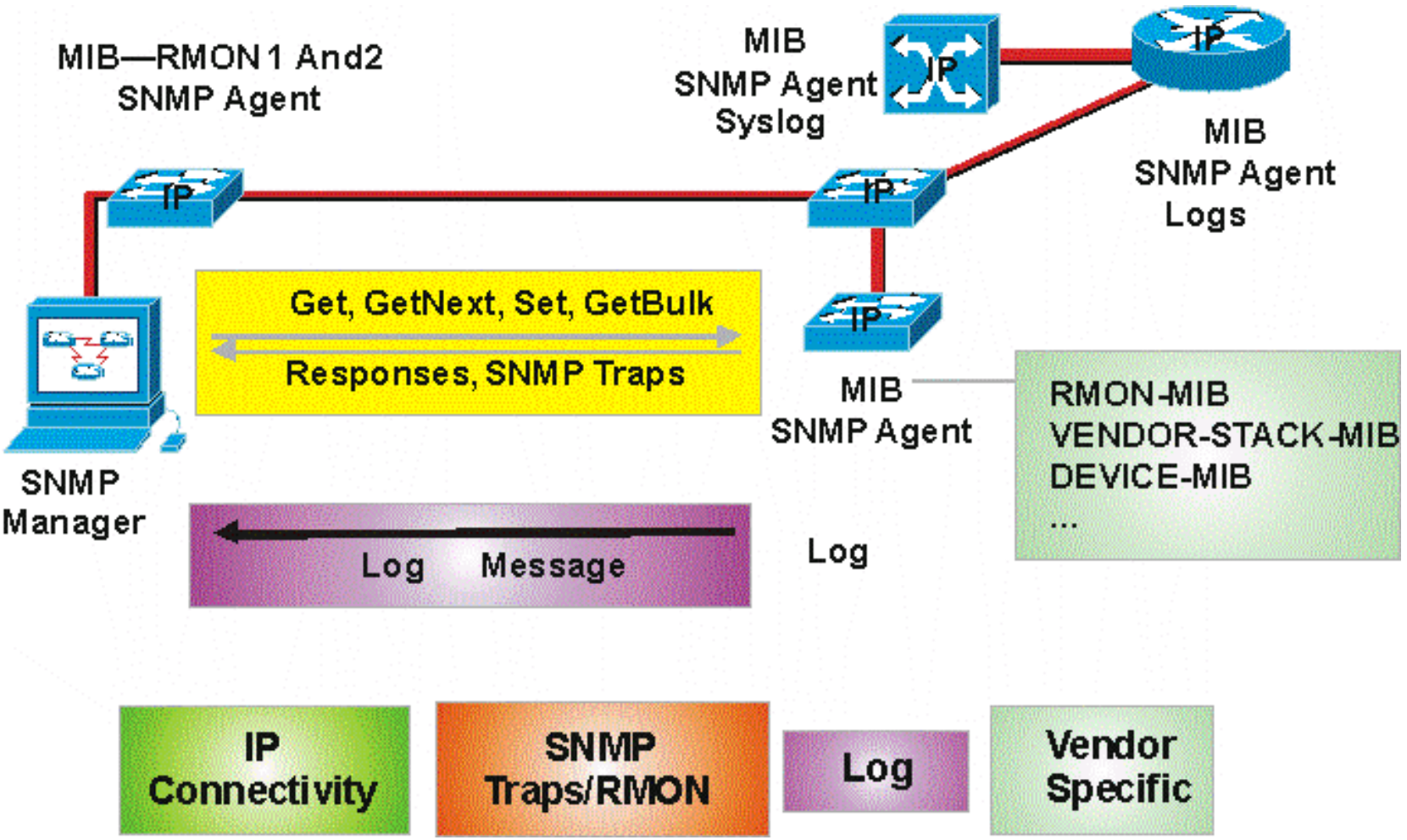
Items to Be Discussed

IP Addressing

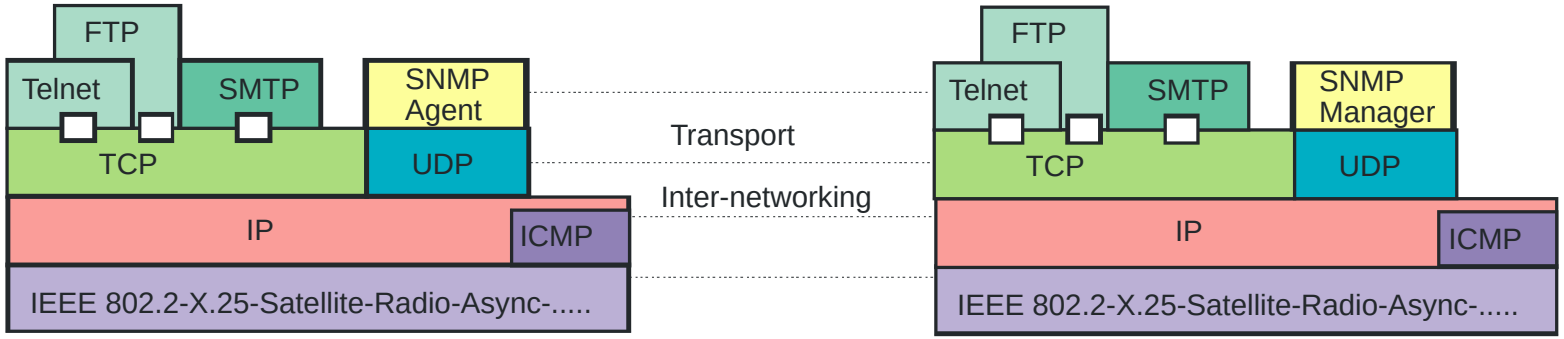
Autoconfiguration

SNMP MIBs

SNMP Technology Base



SNMP Deficiencies



SNMP version 1 and 2

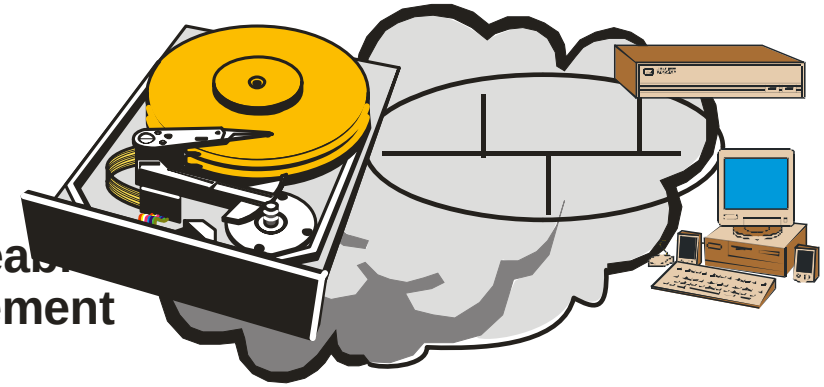
- Version 1 showing age
- Large counters
- Limited security
- Poor WAN protocol
- No bulk data retrieval

SNMP version 3

- User Security Module (USM)
- Authenticates users
- Multiple administrative levels
- Multiple user levels
- Encrypts PDUs
- Distributes management
- Confirmed notifications
- 64 bit counters
- Bulk data retrieval

Management Information Base - MIB

How do the agents keep the information ?



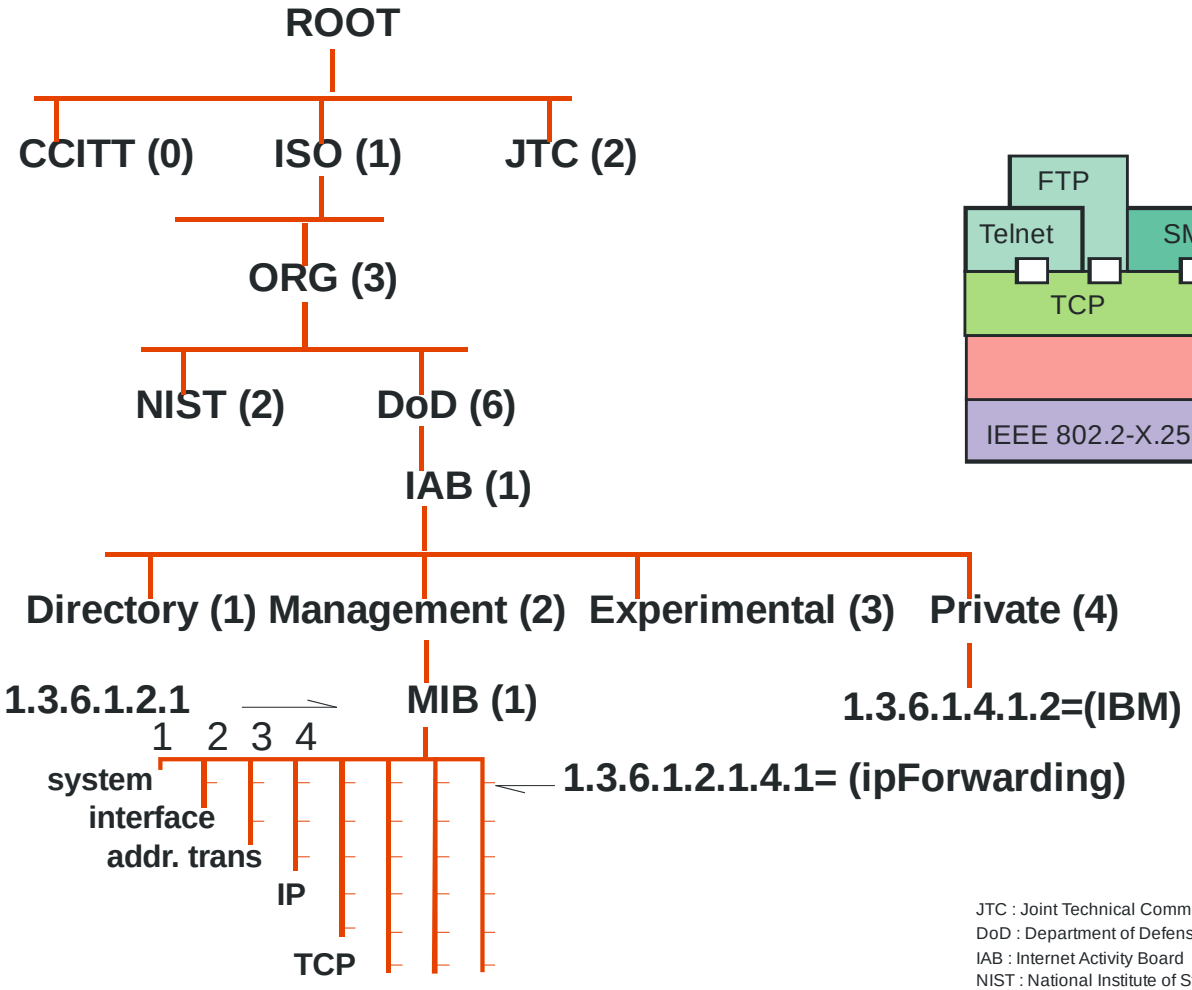
Universe of network manageable objects is called the Management Information Base (MIB).

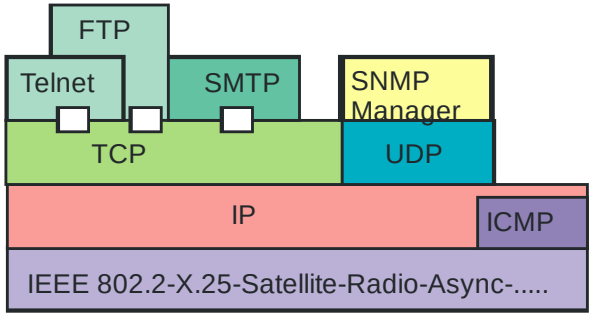
Items within the network elements which are manageable are called managed objects

Objects within the MIB are organized into the following groups:

MIB ....(114)	MIB-2 ....(171)
1) System	1) System
2) Interface	2) Interface
3) Address Translation	3) Address Translation
4) IP	4) IP
5) ICMP	5) ICMP
6) TCP	6) TCP
7) UDP	7) UDP
8) EGP	8) EGP
	9) CMOT
	10) Transmission
	11) SNMP I

Object Registration Hierarchy





JTC : Joint Technical Committee
DoD : Department of Defense (U.S.)
IAB : Internet Activity Board
NIST : National Institute of Standards and Technology (U.S.)

ICMPv6 MIB Modules

IPv6 General Group
- **RFC 2465**
- **ipv6ifTable - interface information**
- **ipv6IfStatsTable - traffic statistics on interfaces**
- **ipv6AddrPrefixTable - Address prefixes associated with interfaces**
- **ipv6AddrTable - Addressing information on interfaces**
- **ipv6RouteTable - Table for all valid unicast routes**
- **ipv6NetToMediaTable - Address translation**

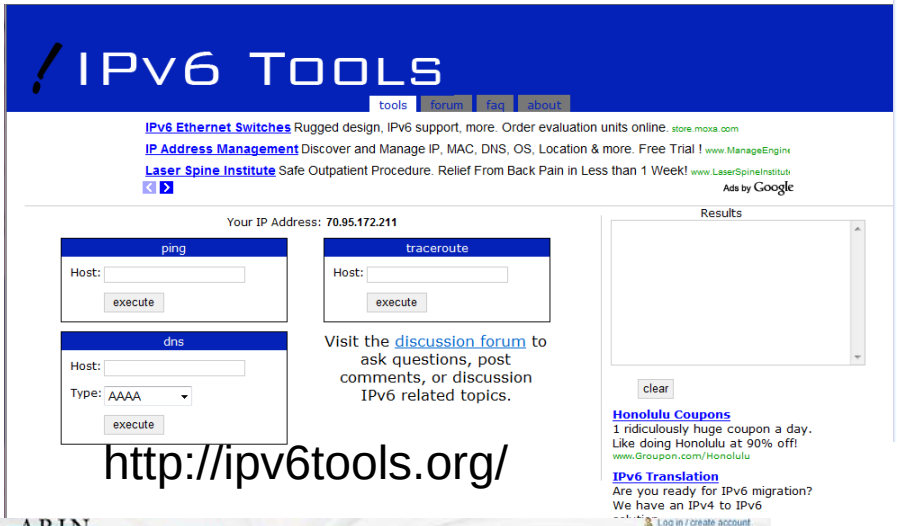
IPv6 ICMPv6 Group
- **RFC 2466**
- **ipv6IcmpTable - Statistics on both incoming and outgoing messages on a per interface basis**

IPv6 Multicast Listener MIB
- **RFC 3019**

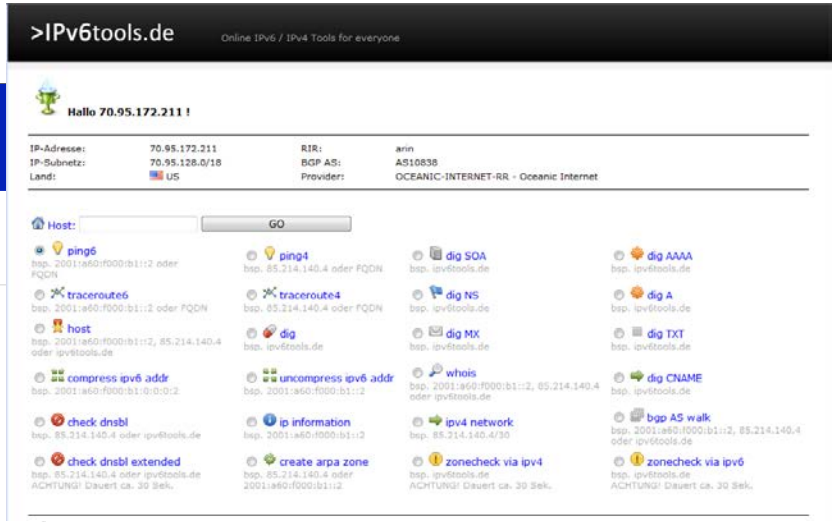
IPv6 UDP Group
- **RFC 2454 and RFC 2013**
- **ipv6UdpTable - UDP listeners using IPv6**
- **ipv6UdpMIB - Work in progress**

IPv6 TCP Group
- **RFC 2452**
- **ipv6TcpConnTable - TCP connections between IPv6 endpoints**
- **ipv6TcpMIB - Work in progress**

Adhoc Tools



http://ipv6tools.org/



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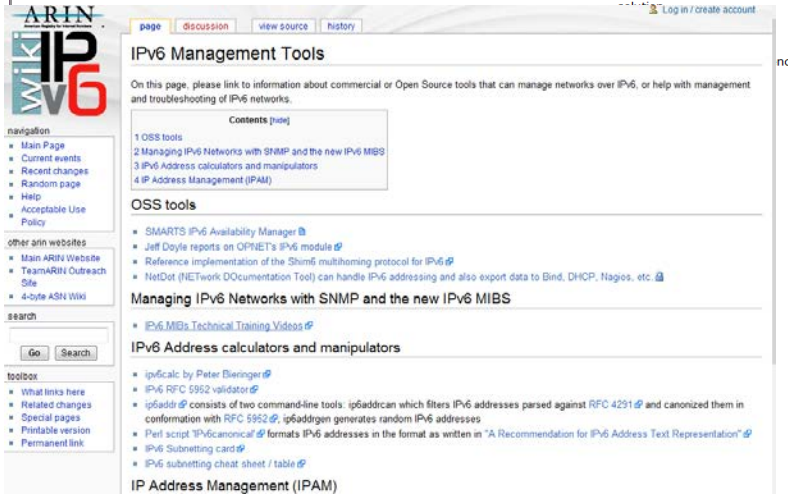


http://www.getipv6.info/index.php/IPv6_Management_Tools

IPv6 Migration Plans

Define topology and functions on hosts, routers, and service machines

Upgrade DNS, DHCP, ARP servers to handle IPv6 addresses

Introduce dual stack systems that support IPv4 and IPv6

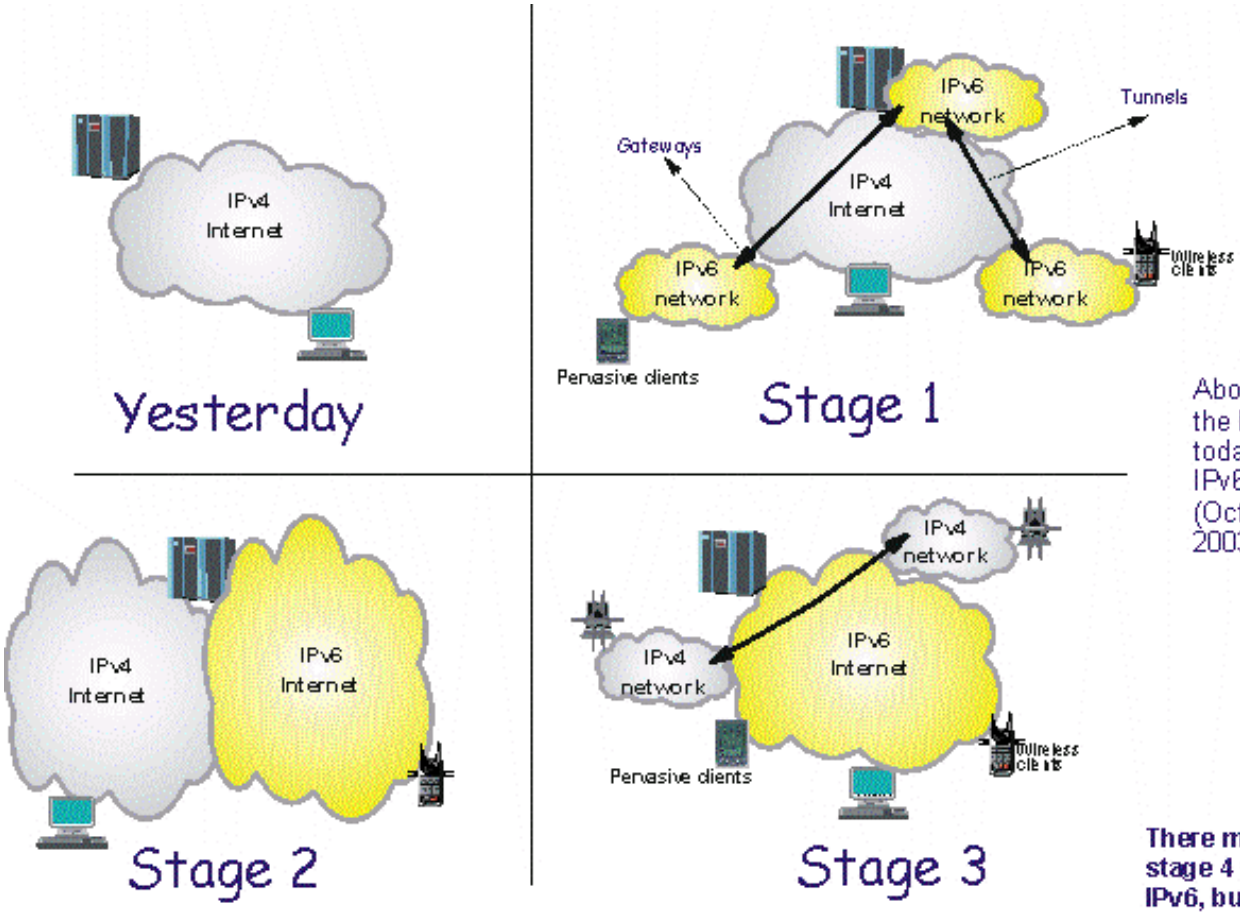
Configure to Internet using IPv6

Rely on tunnels to connect IPv6 islands separated by IPv4 networks

Gradually remove IPv4 from systems

Work closely with ISP for connections to the Internet

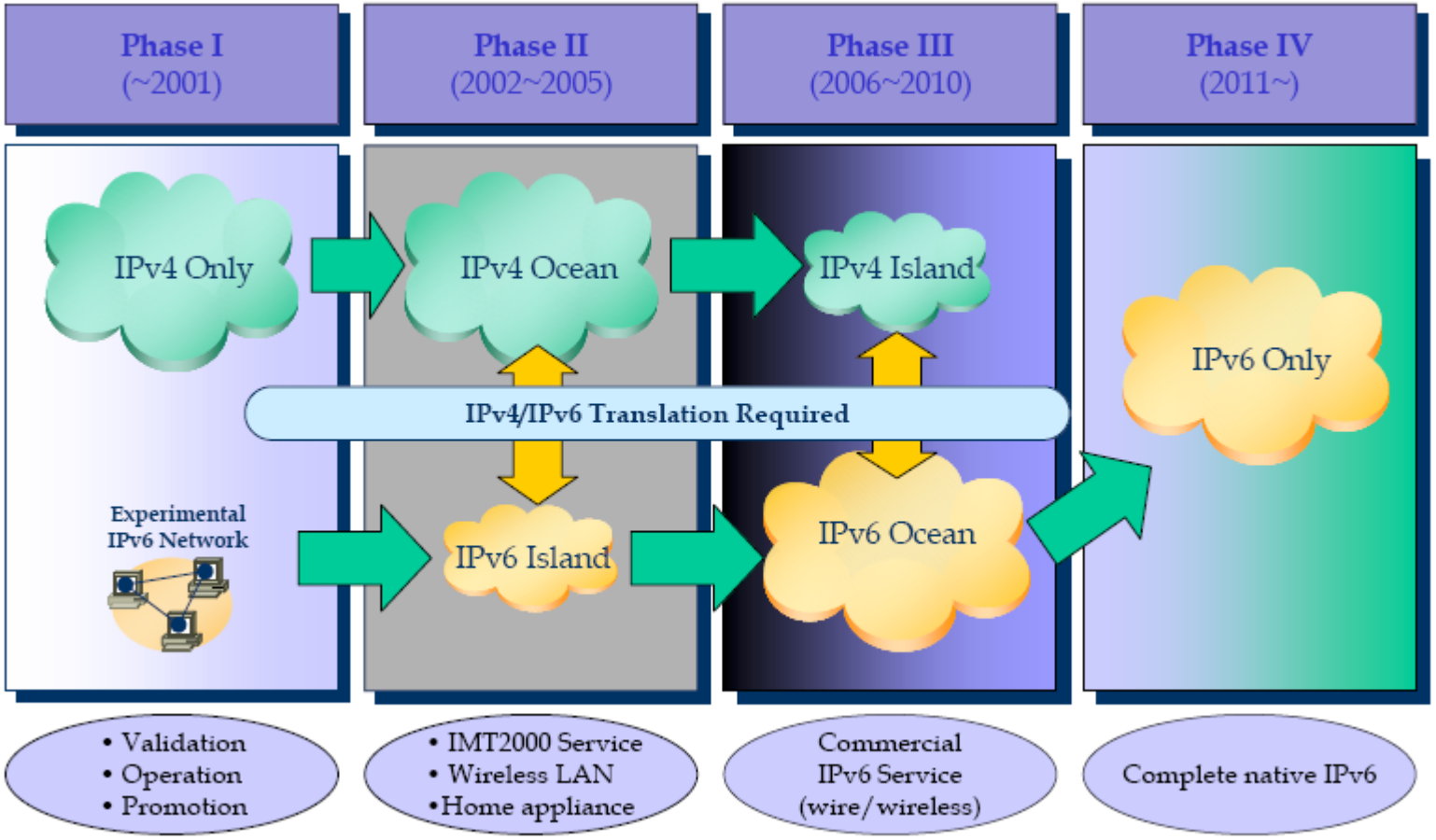
IPv6 Transition Paths



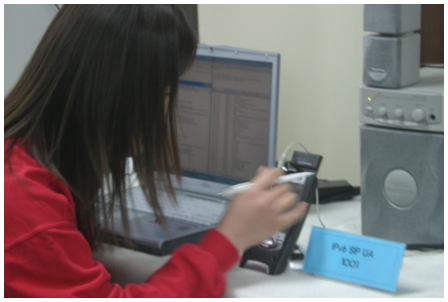
About 2% of the Internet is today IPv6-based (October 2003)

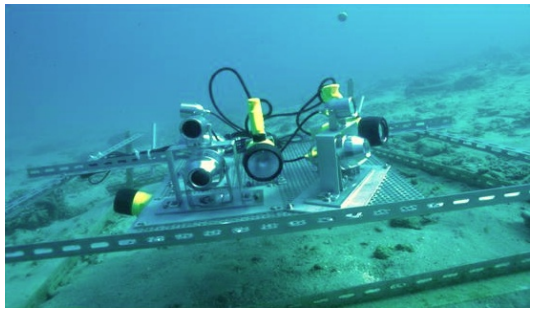
There may be a stage 4 with only IPv6, but it will take some years to get there.

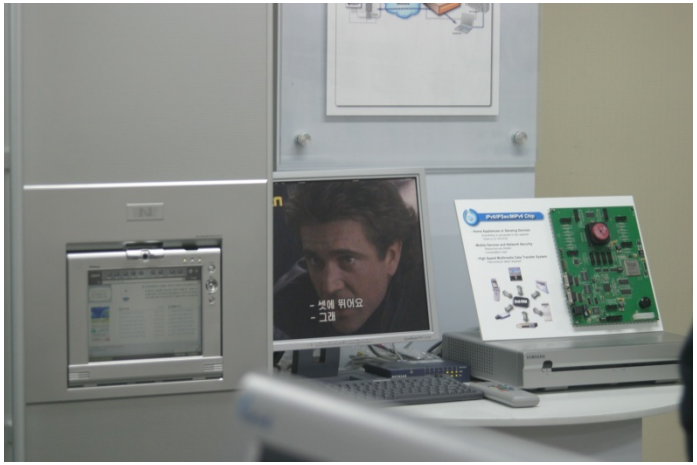
IPv6 Transition Roadmap – Leading Korean ISP



IPv6 Toys: Home automation, fridges, sensors, etc







For more:

google(IPv6 toys)

google(IPv6 cool)

AES Sessions at Share

Mar 12, 2012: 1:30-2:30 10715: Keeping Your Network at Peak Performance as You Virtualize the Data Center
Mar 14, 2012: 8:00-9:00 10397: IPv6 Basics
Mar 14 2012: 1:30-2:30 10395: IPv6 Tunneling Technologies
Mar 14, 2011: 1:30-2:30 10720: **Network Problem Diagnosis with OSA Examples**
Mar 15, 2012: 3:00-4:00 10401: IPv6 Transitioning
Mar 16, 2012 9:30-10:30 10393: CSI Maui: The Case of the Compromised Server
Mar 16 2012 11:00-12:00 10414 IPv6 Deep Dive

Questions?
Session 8191

laurak@aesclever.com
www.aesclever.com
650-617-2400

Our other presentations:

Tuesday, 9:30 am – 10:30 am: Performance Management 101
Tuesday, 3:00 pm - 4:00 pm: Performance Management in a Virtualized Environment
Wednesday 3:00 pm – 4:00 pm: Management Changes in IPv6 – Focus on ICMPv6
Thursday 9:30 am – 10:30 am: Hot Topics in Networking and Security
Thursday 1:30 pm – 2:30 pm: Network Problem Diagnosis with OSA Examples
Thursday 3:00 pm – 4:00 pm: TCP/IP Forensics
Friday 8:00 am – 9:00 pm: Keeping Your Network at Peak Performance as you Virtualize the Data Center
Friday 9:30 am – 10:30 am: Virtualization: New Technologies and Methods to Assure the Health of the Infrastructure

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IPNG Internet Protocol Next Generation - ISBN-0-201-63395-7
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1809 Using the flow label in IPv6
1825 Security Architecture
1826 IPv6 Authentication
1827 IPv6 Encapsulating Security Payload
1881 IPv6 Address allocation Management
1883 IPv6 Specifications
1885 ICMPv6
1886 DNS extensions to support
1887 An architecture for IPv6 Unicast
1888 OSI NSAPs and IPv6
1981 Path MTU discovery
1897 IPv6 Testing Address Allocations
1924 A Compact Representation
1933 Transition Mechanism for IPv6 Hosts
2147 TCP and UDP over IPv6
2292 Advanced Sockets API
2373 IPv6 Addressing
2374 IPv6 Aggregate able Address
2375 IPv6 Multicast Address
2450 TLA and NLA Assignment Rules
2452 IPv6 MIB for TCP
2454 IPv6 MIB for UDP
2460 IPv6 Specification
2461 Neighbor Discovery
2462 IPv6 Stateless Address
2463 ICMPv6
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2466 MIB for ICMPv6
2467 IPv6 over FDDI
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2497 IPv6 over Arcnet
2507 IP Header Compression
2526 Reserved IPv6 Anycast
2529 explicit Tunnels
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2675 IPv6 Jumbograms
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2874 DNS Ext. to Support Addr. Aggr. and Renum.
2894 Router Renumbering
2928 IPv6 TLA Assignments
3019 MIB for Multicast Listener Discovery
3041 Privacy Extensions
3056 Connection of IPv6 Domains via IPv4 Clouds
3122 Ext. to IPv6 Neighbor Disc. for Inv. Disc.
3142 An IPv4-IPv6 Transport Relay Translator
3146 Transmission of IPv6 Packets over IEEE 1394 networks
3162 Radius and Ipv6
3175 Aggregation of RSVP for IPv4 and IPv6 Reservations
3178 IPv6 Multihoming Support at Site Exit Routers
3226 DNNSSEC and IPv6 A6 aware server/resolver messages
3266 Support for IPv6 in Session Description Protocol
3306 Unicast-Prefix-based IPv6 Multicast Address
3307 Allocation Guidelines for IPv6 Multicast Addresses
3314 IPv6 in third generation Partnerships
3315 DHCPfor IPv6
3316 IPv6 for some second and third gen Cellular hosts
3319 DHCP for IPv6 and SIP
3456 DHCP configuration of IPsec tunnel Mode
3457 Requirements for IPsec Remote Access
3484 Default Address Selection for IPv6
3513 IPv6 Address Architecture
3572 IPv6 over MPOS
3582 Goals for IPv6 Site-Multihoming Architectures
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3596 DNS extensions to support IPv6
3633 IPv6 Prefix Options for DHCP
3646 DNS Configuration options for DHCP
3681 Delegation of E.F.F.3.IP6.ARPA
3697 IPv6 Flow Label Specification
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3776 IPSec to support mobile IPv6
3831 Support of IPv6 over Fiber Channel
3849 IPv6 Address Space reserved for documentation
3901 DNS IPv6 Operational Transport Guidelines
3904 Evaluation of IPv6 Transition Mechanisms for unmanaged networks
3964 Security Considerations for 6to4
4007 IPv6 Scoped Address Architecture
4025 A Method for Storing IPsec Keying Material in DNS
4029 Scenarios and Analysis for Introducing IPv6 into ISP Networks
4057 IPv6 Enterprise Network Scenarios
4068 Fast Handovers for Mobile IPv6
4135 Goals of detecting network attachment in IPv6
4140 Hierarchical Mobile IPv6 Mobility Management
4147 Proposed Changes to the format of the IANA IPv6 Registry
4177 Architectural Approaches to Multi-Homing for IPv6
4192 Procedures for Renumbering n IPv6 Network
4214 Intra-site Automatic Tunnel Addressing
4215 Analysis on IPv6 Transition in third generation partnership
4218 Threats Relating to IPv6 Multihoming Solutions
4219 Things Multihoming in IPv6
4225 Mobile IPv6 Route Optimization Security
4241 Model of IPv6/IPv4 Dual Stack Internet Access Service
4260 Mobile IPv6 Handovers for 802.11 Networks
4291 IPv6 Addressing Architecture
4294 IPv6 Node Requirements
4295 Mobile IPv6 Management Information base
4311 IPv6 Host-Router Load Sharing
4330 SNTP for IPv6
4338 Transmission of IPv6 over Fiber Channel
4339 IPv6 Host Configuration of DNS Server Info
4489 A Method for Generating Link-scoped IPv6 Multicast addresses
4584 Extension to Sockets API for Mobile IPv6

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4622 IPv6 Node Information Queries
4640 Problem Statement for Bootstrapping Mobile IPv6
4668 RADIUS Client MIB for IPv6
4669 RADIUS Server MIB for IPv6
4670 RADIUS Accounting Client MIB for IPv6
4671 RADIUS Accounting Server MIB for IPv6
4672 RADIUS Dynamic authorization client MIB for IPv6
4673 RADIUS Dynamic Authorization server MIB for IPv6
4676 DHCP option for Civic Addresses
4727 Experimental Value in IPv6 headers
4779 ISP IPv6 Deployment Scenarios in Broadband access Networks
4798 Connecting IPv6 islands over IPv4 MPLS using IPv6 Provider Edge Routers
4843 An IPv6 Prefix for ORCHID
4852 IPv6 Enterprise Network Analysis
4861 Neighbor Discovery for IPv6
4862 IPv6 Stateless Address Autoconfiguration
4877 Mobile IPv6 Operation with IKEv2
4882 IP Address Location Privacy nd Mobile IPv6
4891 Using IPsec to secure IPv6-in-IPv4 tunnels
4919 IPv6 over Low-Power Wireless PON
4941 Privacy Extensions for Stateless Address Autoconfiguration in IPv6
4942 IPv6 Transition/co-existence security considerations
4943 IPv6 Neighbor Discovery on-link assumption
4944 Transmission of IPv6 Packets over 802.15.4 Networks
4968 Analysis of IPv6 Link Models for 802.16 Networks
4994 DHCPv6 Relay agent Echo Request
5006 IPv6 Router Advertisement Option for DNS Configuration
5007 DHCPOv6 Leasequery
5014 IPv6 Socket API for Source Address Selection
5026 Mobile IPv6 Bootstrapping in Split Scenrio
5072 IPv6 over PPP
5075 IPv6 Router Advertisement Flags Option
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5096 MIPv6 Experimental Messages

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5121 Transmission of IPv6 via IPv6 Convergence Sublayer over IEEE 802.16
5156 Special use IPv6 Addresses
5157 IPv6 Implications for Network Scanning
5158 6to4 Reverse DNS Delegation Specification
5172 Negotiation of IPv6 Datagram Compression using IPv6 Control Protocol
5175 IPv6 Router Advertisement Flags Options
5180 IPv6 Benchmarking Methodology for Network Interconnect Devices
5181 IPv6 Deployment Scenarios in 802.16 Networks
5213 Proxy MIPv6
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5269 Distributing a Symmetric Fast MIPv6 Handover Key using SEND
5270 MIPv6 Fast Handovers over IEEE 802.16e Networks
5271 MIPv6 Fast Handovers for 3G CDM
5308 Routing IPv6 with IS_IS
5340 OSPF for IPv6

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5453 Reserved IPv6 Interface Identifiers
5454 Dual Stack MIPv6
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