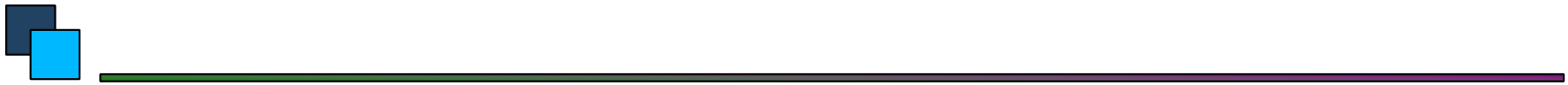
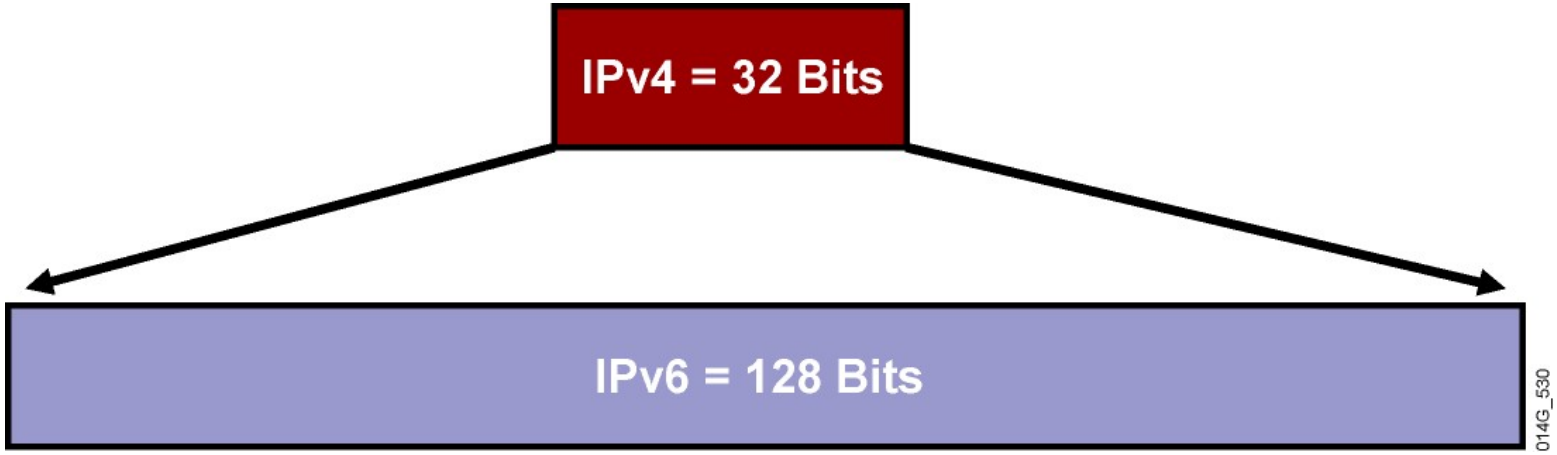


IPv6

Why IPv6?

- Shortage of IPv4 addresses
  - Internet is expanding very rapidly in developing countries like India, China
  - New devices like phones need IP address
- End-to-End Reachability is not possible without IPv6
- New Features like Autoconfiguration, better support for QoS, Mobility and Security, Route Aggregation, Jumbo Frames

IPv6 Address

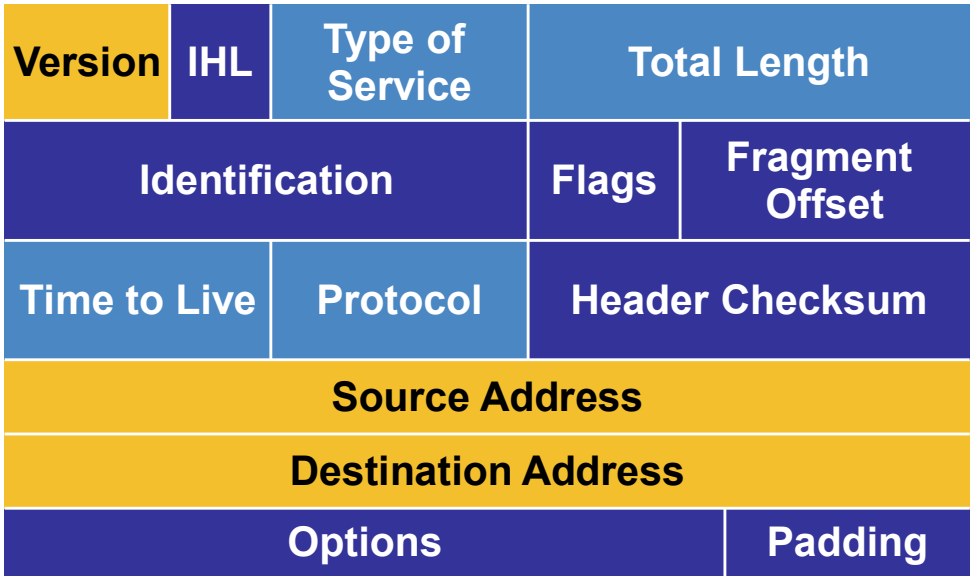


- IPv4: 32 bits or 4 bytes long
  - 4,200,000,000 possible addressable nodes
- IPv6: 128 bits or 16 bytes
  - $3.4 * 10^{38}$ possible addressable nodes
  - 340,282,366,920,938,463,374,607,432,768,211,456
  - $5 * 10^{28}$ addresses per person

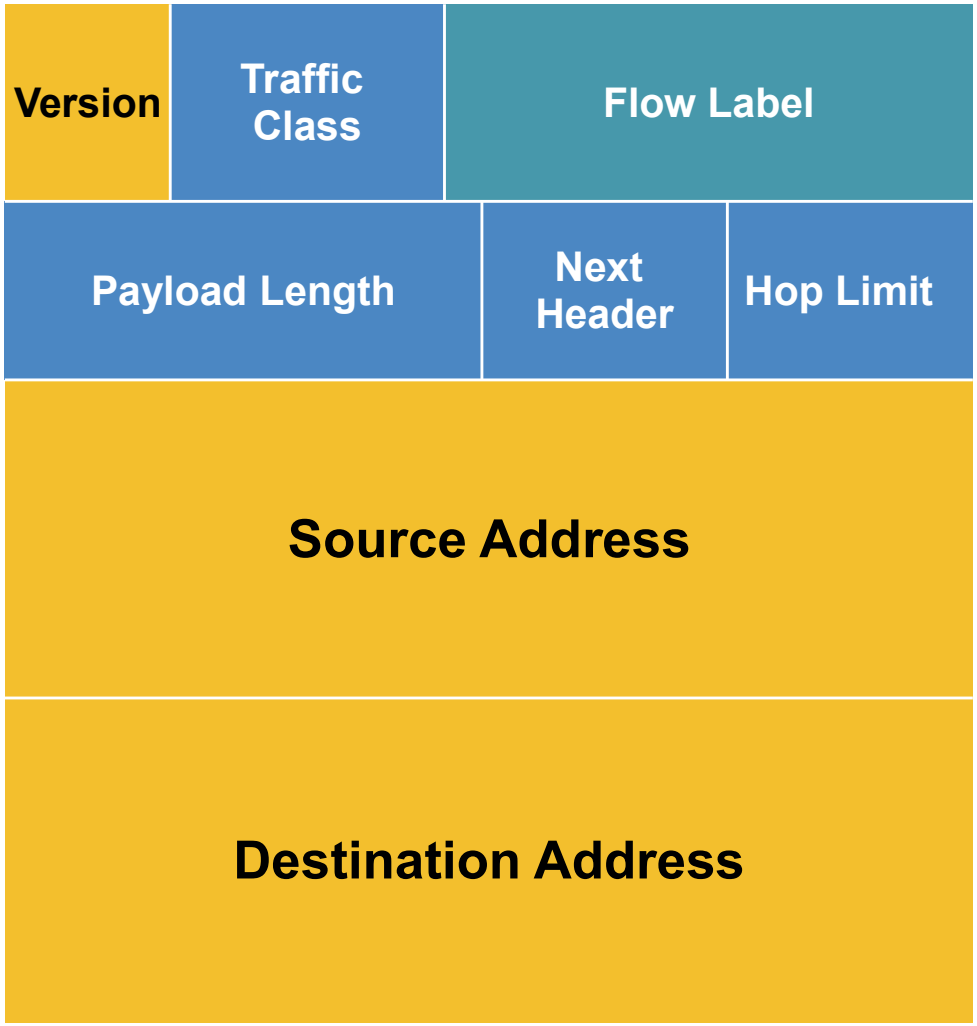
IPv6 Header Format

- IPv4: 20 Bytes + Options IPv6: 40 Bytes + Extension Header

IPv4 Header



IPv6 Header



IPv6 Address Types

- **Unicast**
  - Address is for a single interface.
  - IPv6 has several types (for example, global and IPv4 mapped).
- **Multicast**
  - One-to-many
  - Enables more efficient use of the network
  - Uses a larger address range
- **Anycast**
  - One-to-nearest (allocated from unicast address space).
  - Multiple devices share the same address.
  - All anycast nodes should provide uniform service.
  - Source devices send packets to anycast address.
  - Routers decide on closest device to reach that destination.
  - Suitable for load balancing and content delivery services.

IPv6 Address Scope

- **Link-local**: The scope is the local link (nodes on the same subnet)
- **Unique-local**: The scope is the organization (private site addressing)
- **Global**: The scope is global (IPv6 Internet addresses)

IPv6 Address Representation

- ***x*:*x*:*x*:*x*:*x*:*x*:*x*:*x*, where *x* is a 16-bit hexadecimal field**
- **Leading zeros in a field are optional:**
  - **2031:0:130F:0:0:9C0:876A:130B**
- **Successive fields of 0 can be represented as ::, but only once per address.**

Examples:

2031:0000:130F:0000:0000:09C0:876A:130B

2031:0:130f::9c0:876a:130b

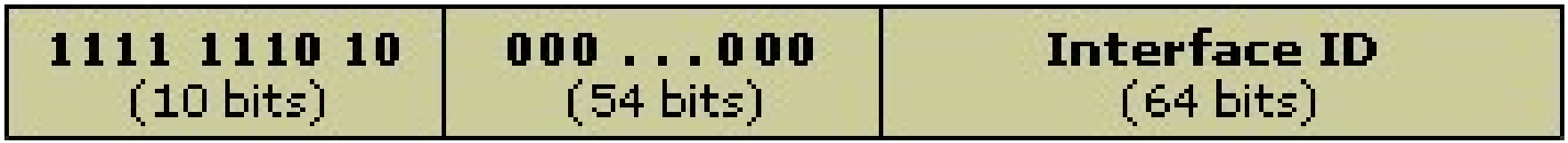
FF01:0:0:0:0:0:0:1 >>> FF01::1

0:0:0:0:0:0:0:1 >>> ::1

0:0:0:0:0:0:0:0 >>> ::

IPv6 Address Representation: Link Local

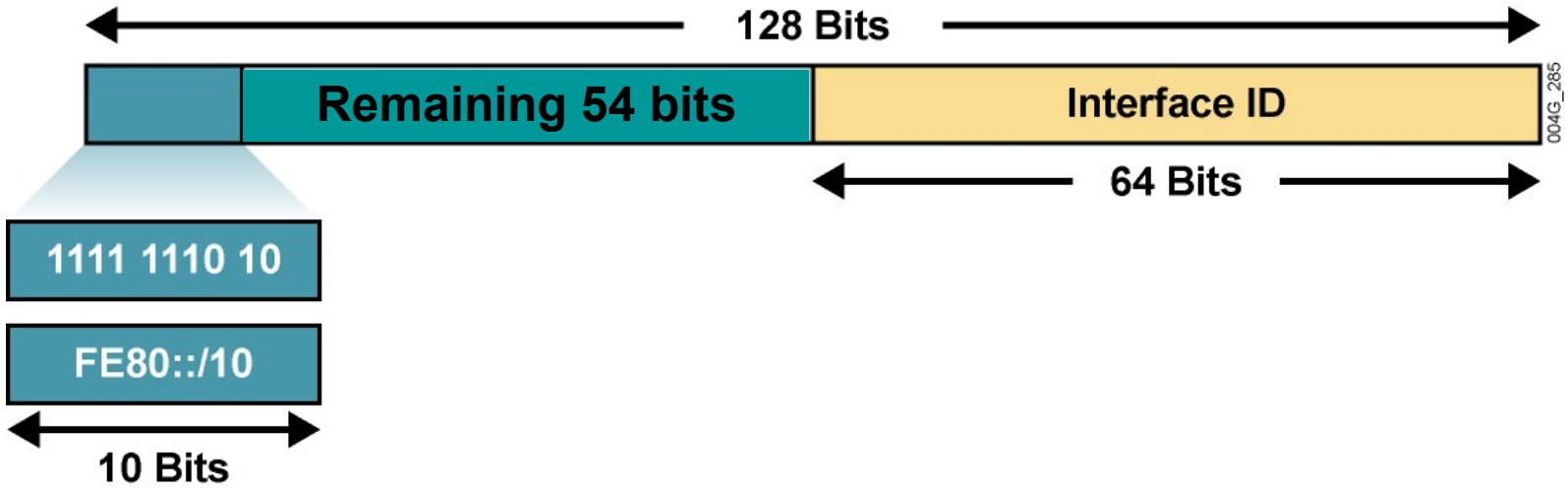
- Hosts on the same link (the same subnet) use these automatically configured addresses to communicate with each other.
- Neighbor Discovery provides address resolution.
- The prefix for link-local addresses is FE80::/64.
- The following illustration shows the structure of a link-local address.



IPv6 Address Representation: Unique Local

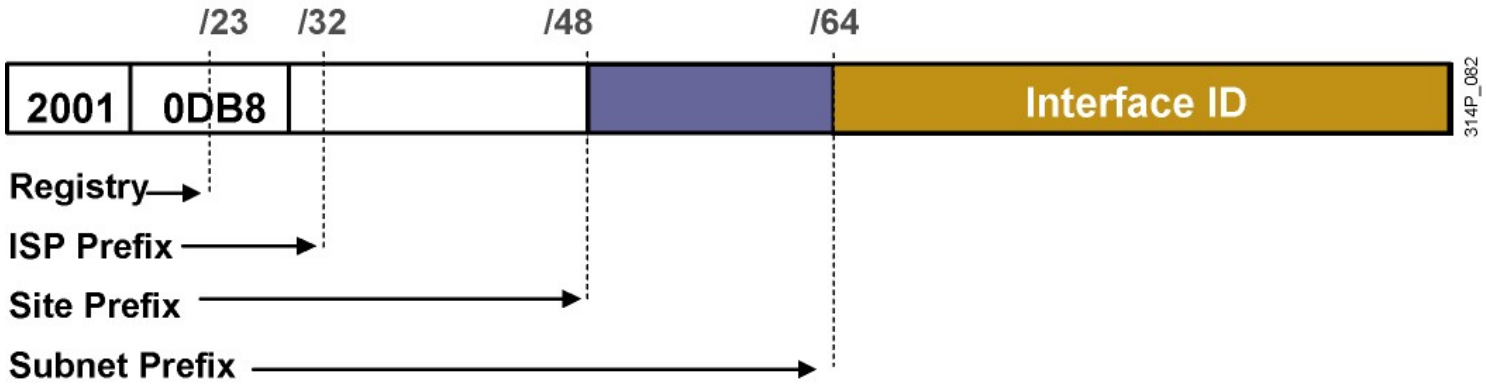
- IPv6 unicast unique-local addresses are similar to IPv4 private addresses.
- The scope of a unique-local address is the internetwork of an organization's site. (You can use both global addresses and unique-local addresses in your network)
- The prefix for unique-local addresses is FC00::/8.

IPv6 Address Representation: Link Local



- Mandatory address for communication between two IPv6 devices
- Automatically assigned by router as soon as IPv6 is enabled

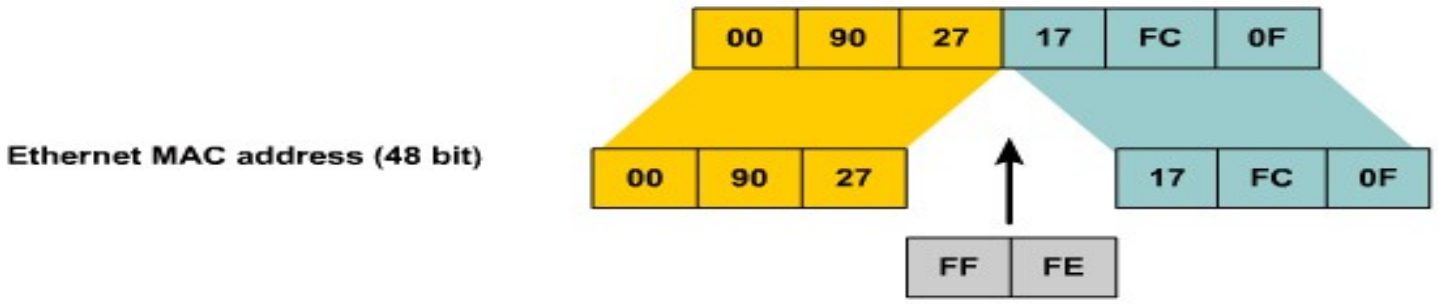
IPv6 Address Representation: Global Unicast



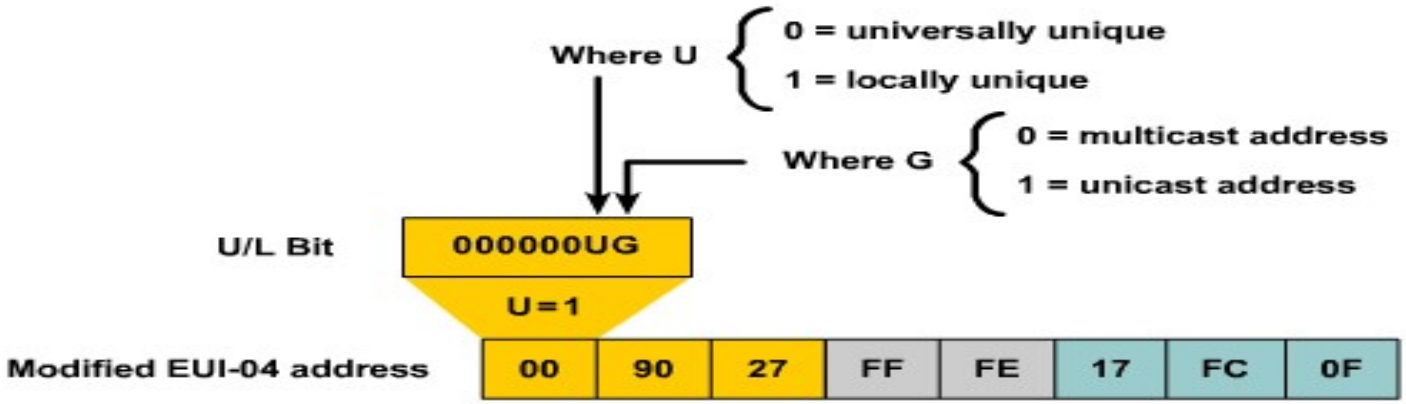
- Global unicast and anycast addresses are defined by a global routing prefix, a subnet ID, and an interface ID.

IPv6 Address Representation EUI 64

- IPv6 uses the extended universal identifier (EUI)-64 format to do stateless autoconfiguration.
- This format expands the 48-bit MAC address to 64 bits by inserting “FFFE” into the middle 16 bits.
- To make sure that the chosen address is from a unique Ethernet MAC address, the universal/local (U/L bit) is set to 1 for global scope (0 for local scope).



IPv6 Address Representation EUI 64

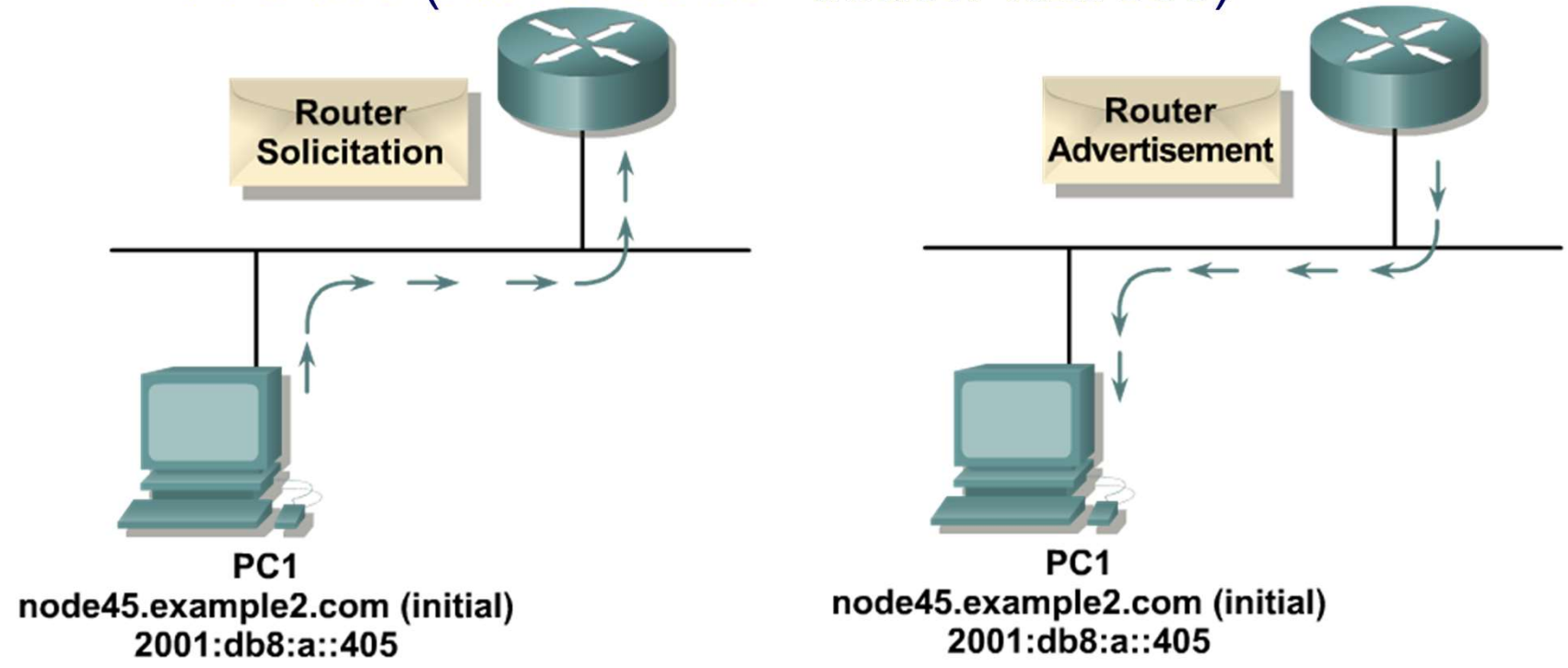


Stateless Autoconfiguration

- Stateless Address Configuration (IP Address, Default Router Address)
- Routers sends periodic Router Advertisement
- Node gets prefix information from the Router advertisement and generates the complete address using its MAC address
- Global Address=Link Prefix + EUI 64 Address
- Router Address is the Default Gateway

Stateless Autoconfiguration Example

- MAC address: 00:0E:0C:31:C8:1F
- EUI 64 Address: 20E:0CFF:FE31:C81F
- Router Solicitation is sent on FF01::2 (All Router Multicast Address) and Advertisement sent on FF01::1 (All Node Multicast Address)



IPv6 Address Example

```
[root@vsnlproxy ~]# ifconfig

eth0      Link encap:Ethernet  HWaddr 00:18:71:E5:47:82

inet addr:172.31.1.227  Bcast:172.31.255.255  Mask:255.255.0.0

inet6 addr: 2001:df0:92:0:218:71ff:fee5:4782/64 Scope:Global

inet6 addr: fe80::218:71ff:fee5:4782/64 Scope:Link
```

DHCPv6

- Stateful Configuration
- Provides not only IP address, also other configuration parameters like DNS

DHCPv6

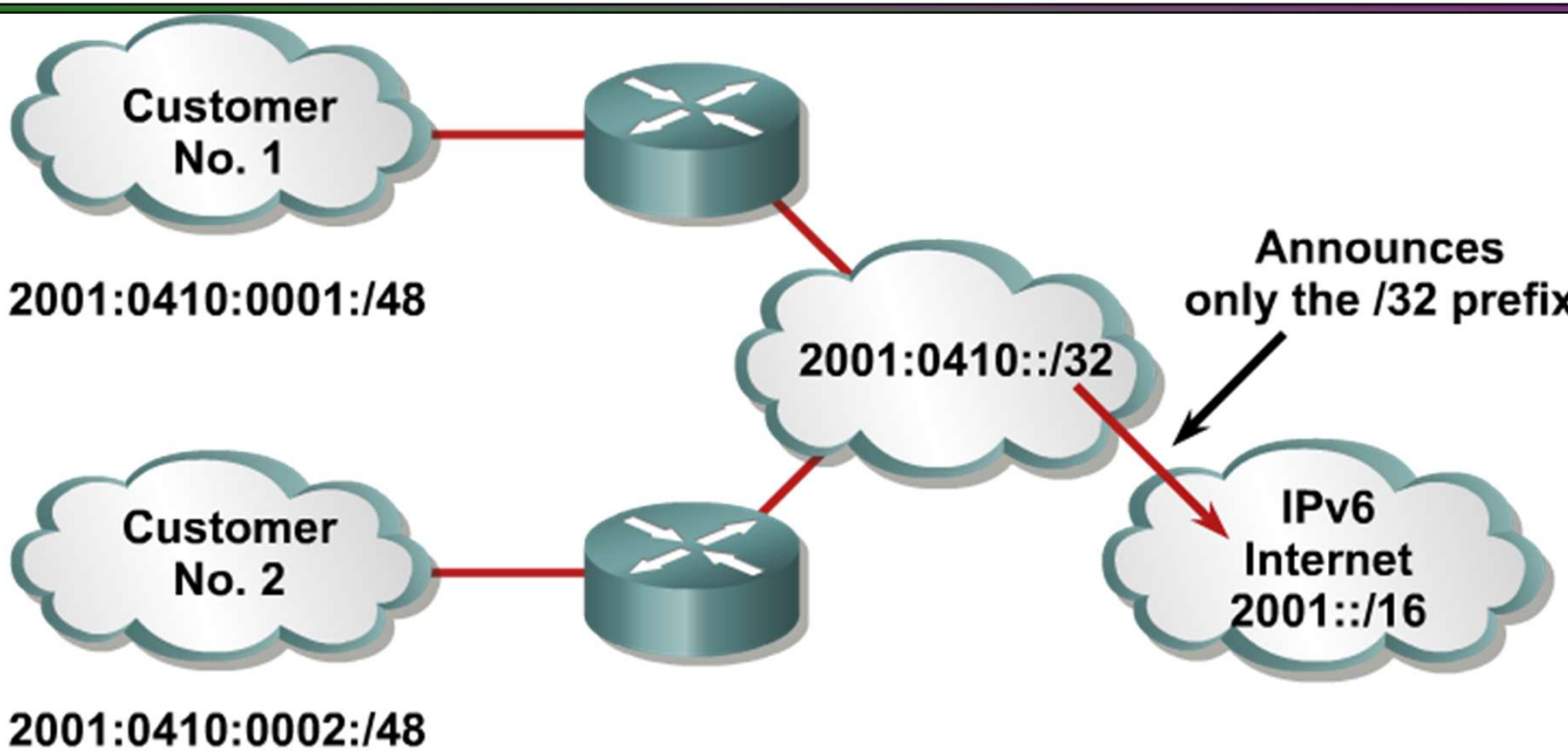
- **Client**
  - Initiates requests on a link to obtain configuration parameters
  - use its link local address to connect the server
  - Send requests to FF02::1:2 multicast address (All_DHCP_Relay_Agents_and_Servers)
- Relay Agent/ DHCPv6 Server
  - node that acts as an intermediary to deliver DHCP messages
  - between clients and servers
  - is on the same link as the client
  - Is listening on multicast addresses: All_DHCP_Relay_Agents_and_Servers (FF02::1:2)

Routing in IPv6

- Same Protocols as in IPv4
  - Static
  - RIPng
  - OSPFv3
  - MP-BGP4

- Use ping6 and traceroute6 commands to check reachability and route

Routing in IPv6



- Aggregation of prefixes announced in the global routing table
- Efficient and scalable routing

Neighbor Discovery

- IPv6 nodes which share the same physical medium (link) use Neighbor Discovery (NDP) to:
  - Discover their mutual presence
  - Determine link-layer addresses of their neighbors (equivalent to ARP)
  - Find routers
  - Maintain neighbors' reachability information
- Uses Multicast Address

Neighbor Discovery

Protocol features:

- Router discovery
- Prefix(es) discovery
- Parameters discovery (link MTU, Max Hop Limit, ...)
- Address auto-configuration
- Address resolution
- Next Hop determination
- Neighbor Unreachability Detection
- Duplicate Address Detection
- Redirect

Neighbor Discovery

It provides the functionality of:

- ARP
- ICMP redirect

Neighbor Discovery

ND specifies 5 types of ICMP packets:

- **Router Advertisement (RA) :**

  Periodic advertisement (of the availability of a router) which contains:

  »list of prefixes used on the link (autoconf)

  »a possible value for Max Hop Limit (TTL of IPv4)

  »value of MTU

- **Router Solicitation (RS) :**

  The host needs RA immediately (at boot time)

Neighbor Discovery

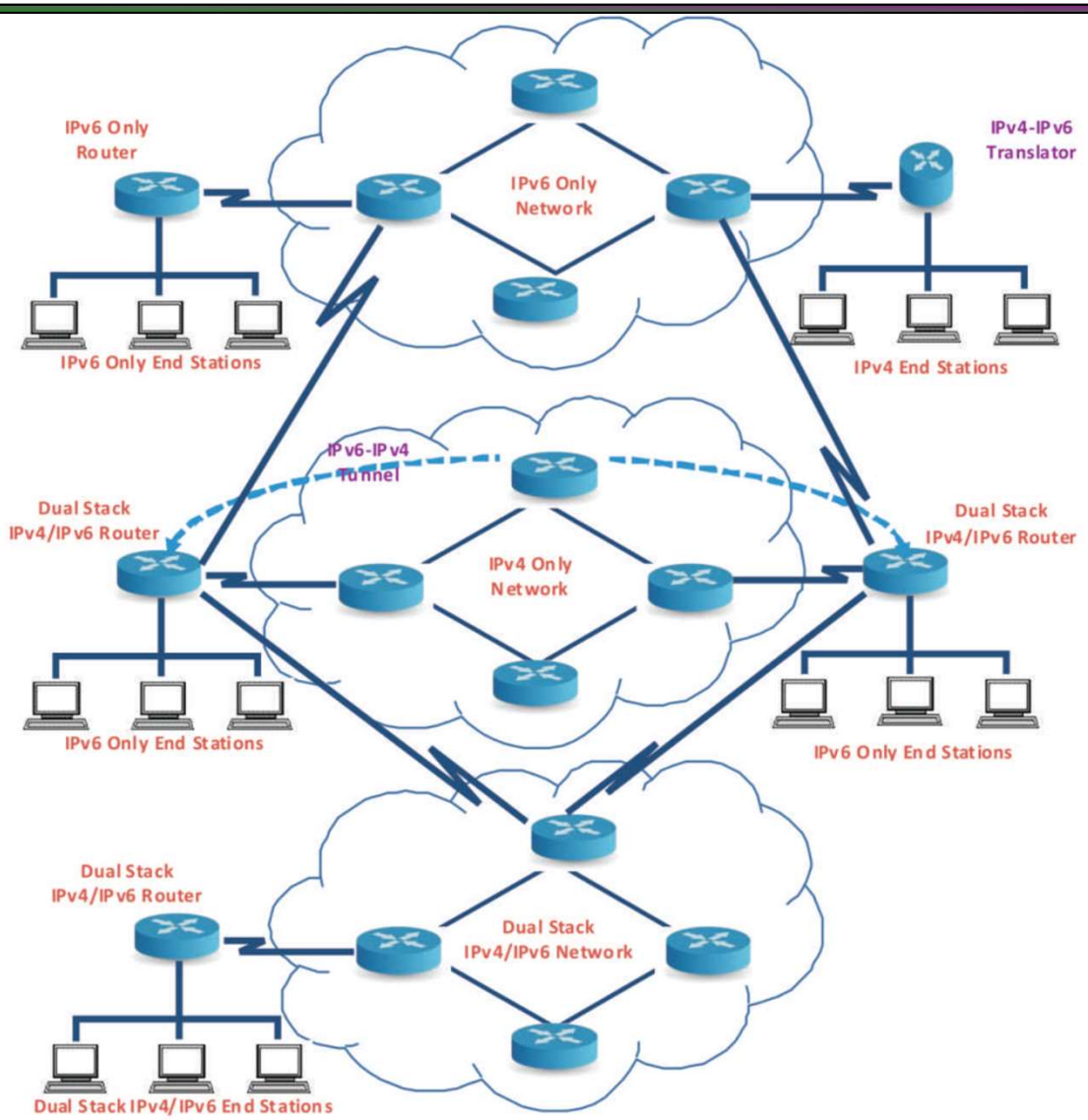
- **Neighbor Solicitation (NS):**
  - »to determine the link-layer address of a neighbor
  - »or to check its reachability
  - »also used to detect duplicate addresses (DAD)
- **Neighbor Advertisement (NA):**
  - »answer to a NS packet
  - »to advertise the change of physical address
- **Redirect:**
  - »Used by a router to inform a host of a better route to a given destination

Transition to IPv6

Transition Mechanism

- No fixed day to convert; no need to convert all at once.
- Transition Options:
  - Dual Stack
  - IPv6-IPv4 Tunnel
  - IPv6-IPv4 Translation

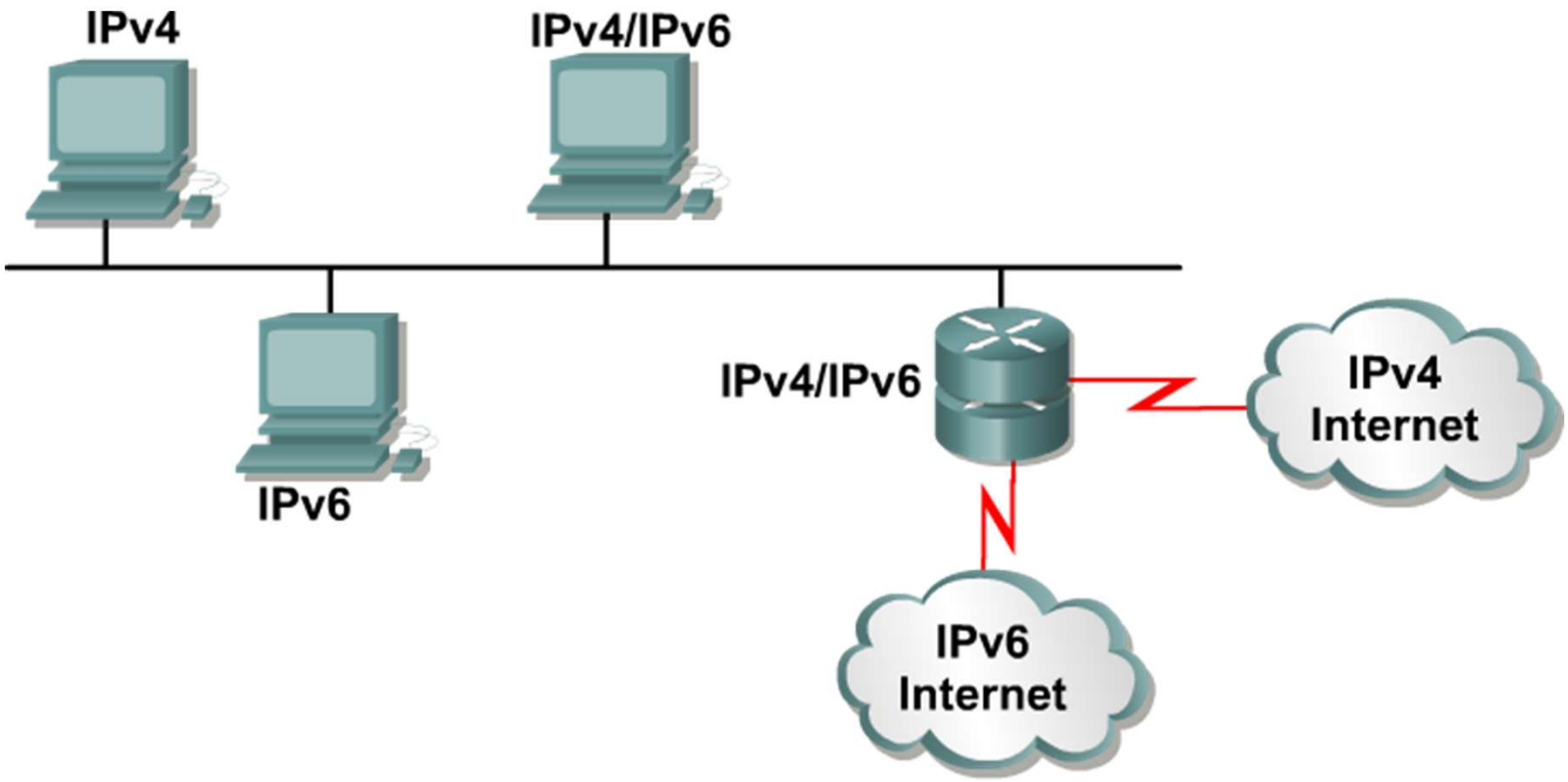
Transition Mechanism



6/4 Dual Stack Hosts and Network

- This allows all the end hosts and intermediate network devices (like routers, switches, modems etc.) to have both IPv4 and IPv6 addresses and protocol stack.
- If both the end stations support IPv6, they can communicate using IPv6; otherwise they will communicate using IPv4.
- This will allow both IPv4 and IPv6 to coexist and slow transition from IPv4 to IPv6 can happen.

6/4 Dual Stack Hosts and Network



6/4 Dual Stack Hosts and Network

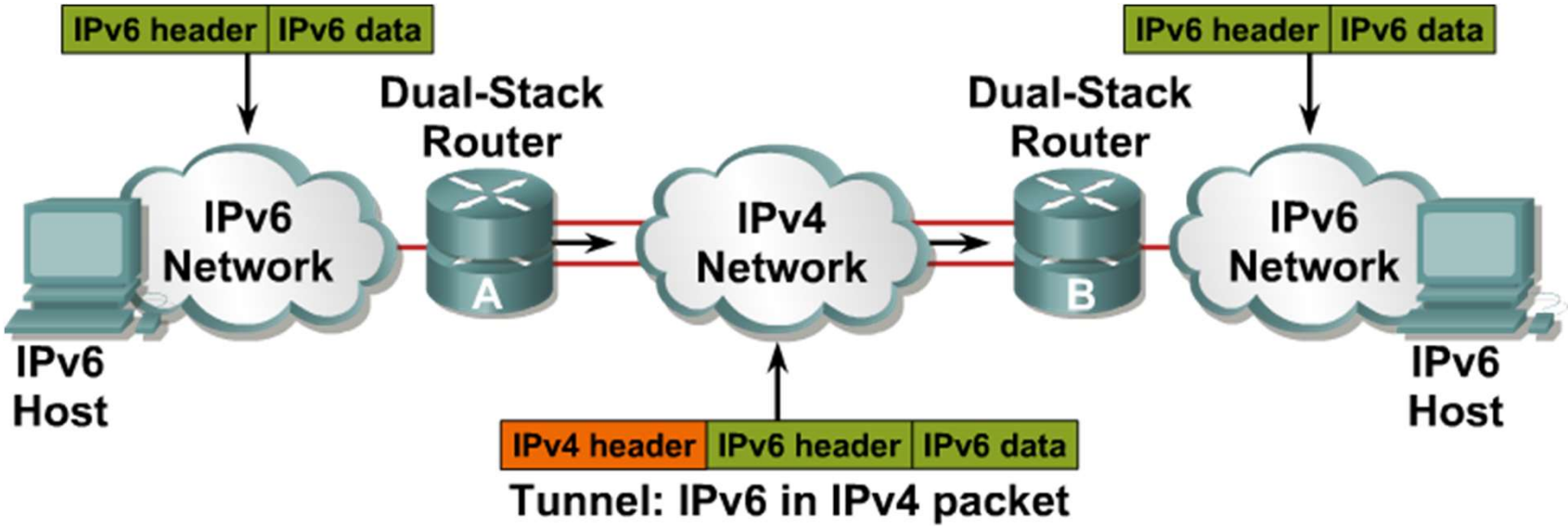
```
IITK_KNPR_CMTR_DIA#sh run
Building configuration...

interface GigabitEthernet0/1
 description Connected to IITK
 ip address 203.197.196.18 255.
 ipv6 address 2001:DF0:92::1/64
 ipv6 enable
!

interface GigabitEthernet0/2
 description Airtel IPv6 Connectivity
 ip address 59.144.72.85 255.255.255.2
 ipv6 address 2404:A800:2:D::2/64
 ipv6 enable
!
```

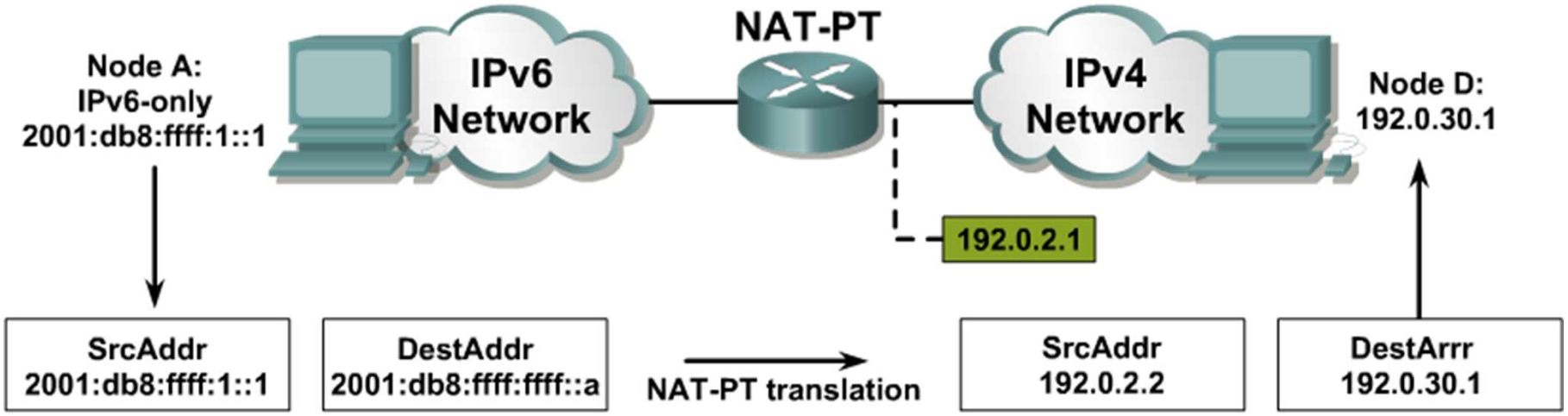
Tunneling IP6 via IP4

- This allows encapsulating IPv6 packets in IPv4 packets for transport over IPv4 only network.
- This will allow IPv6 only end stations to communicate over IPv4 only networks.



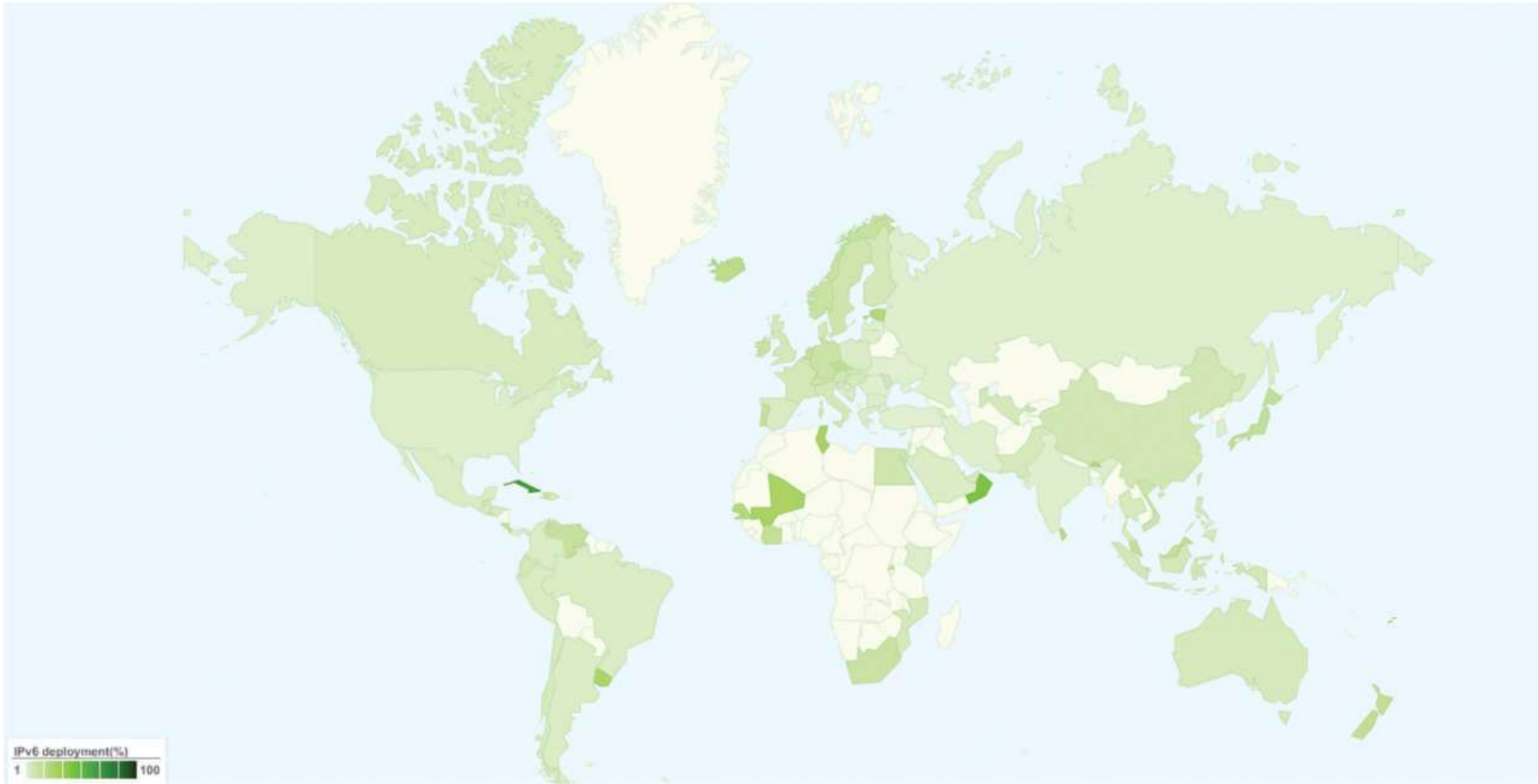
IP6-IP4 Translation

- This allows communication between IPv4 only and IPv6 only end stations.



- The job of the translator is to translate IPv6 packets into IPv4 packets by doing address and port translation and vice versa.

Current Status of IPv6 Deployment



What, When and How to Migrate

- All the major Operating Systems support IPv6.
- Most of the new network equipment supports IPv6 either by default or is available as an upgrade.
- Countries like US, France, Canada, Japan, China, and South Korea etc. have taken a lead in IPv6 deployment. The government in these countries have strongly promoted the use of IPv6 and also mandated the support of IPv6 by all equipment manufacturers and suppliers and service providers.
- China has launched China Next Generation Internet (CNGI) which is based on IPv6. China also showcased IPv6 readiness in the Beijing 2008 Olympics.

- IT IS TIME FOR INDIA TO ACT

Migration Steps

1. Check IPv6 compliance:

- Study the existing network and verify that all the equipment installed supports IPv6.
- Recommend upgrade of the equipment which does not support software upgrade or hardware upgrade/replacement.
- All future equipment purchase must ensure that the equipment is IPv6 compatible.

Migration Steps

2. Plan IPv6 addressing:

- Take IPv6 addresses from the Regional Internet Registry (APNIC in case of India) or upstream Internet provider.
- Make IPv6 Address allocation policy and plan IPv6 addressing for the entire network.

Migration Steps

3. Enable IPv6 Routing:

- Enable IPv6 routing in the entire network.
- For organization LANs, this would require IPv6 address configuration in all Layer 3 switches and routers and enable static/ dynamic routing.
- In case of Service provider networks, this would require configuring Provider Edge (PE) Routers as 6PE to support IPv6 over MPLS (Multi Protocol Label Switching) backbone, enabling IPv6 routing in the Customer Edge (CE) Router or Customer Premise Equipment (CPE) to connect the customer network over IPv6 and enabling BGP (Border Gateway Protocol) routing over IPv6 with the upstream providers to provide Internet access over IPv6.
- The IPv6 routes to customer networks may be static or BGP

Migration Steps

4. Setup IPv6 Application Servers:

- Upgrade the Domain Name servers to support IPv6 address resolution.
- Other servers like Web servers, Mail servers, Network Management servers, Authentication/ AAA servers etc. can also be upgraded to support IPv6.

Migration Steps

5. Enable IPv6 Peering:

- Enable IPv6 peering with upstream Internet providers.
- Service Providers need to enable IPv6 peering with other ISPs (Internet Service Providers) also through Internet Exchange (NIXI in case of India).

Migration Steps

6. Migrate Services on IPv6:

- Test various services like Internet access, Email, VoIP, IPTv etc. on IPv6 and migrate the services to support both IPv6 and IPv4.

- Service Providers should test and migrate their services like Internet Leased Line, VPN, Broadband, Multiplay, and Mobile etc. to support both IPv6 and IPv4.