SWINBURNE UNIVERSITY OF TECHNOLOGY

TNE20002 / TNE70003

Topic 11 IPV6 V1.0

Why We Need More Address Space

- The **IPv4** address space provides approximately 4,294,967,296 unique addresses.
  - Only 3.7 billion addresses are assignable.
    - Separates the addresses into classes.
    - Reserves addresses for multicasting, testing, and other specific uses.
  - Despite the large number, IPv4 address space has run out.

Why is IPv4 Address Space Shrinking?

- Population Growth:
  - The Internet population is growing.
    - Users stay on longer.
    - Reserve IP addresses for longer periods.
    - Contacting more and more peers daily.

- Mobile Users:
    - Mobile idevices need an iP address – itablets, ipads, ilaptops, iphones

Why is IPv4 Address Space Shrinking?

Transportation:

- More than one billion automobiles
- Newer models are IP-enabled to allow remote monitoring.

Consumer Electronics:

- The newest home appliances allow remote monitoring using IP technology.

Reasons for Using IPv6

- The ability to scale networks for future demands requires a limitless ? supply of IP addresses.
- IPv6 satisfies the increasingly complex requirements of hierarchical addressing that IPv4 does not provide.

IPv4: 4 octets
11000000.10101000.00001010.01100101
192.168.10.101
4,294,467,295 (2^32) IP addresses

IPv6: 16 octets
11010001.11011100.11001001.01110001.11011100. 11001100.01110001.11010001.11011100.11001001. 11010001.11011100.11001001.01110001.00000010.11011110
A524:72D3:2C80:DD02:0029:EC7A:002B:EA73
3.4 x 10^38 IP addresses

Reasons for Using IPv6

- Address Availability:
  - IPv4: 4 octets - 32 bits
    - 2^32 or 4,294,467,295 IP Addresses.
  - IPv6: 16 octets - 128 bits (32 hexadecimal)
    - 3.4 x 10^38 or

340,282,366,920,938,463,463,374,607,431,768,211,456

(340 undecillion) IP Addresses.

- *Every atom of every person on Earth could be assigned 7 unique addresses with some to spare (assuming 7×10^{27} atoms per human x 7 Billion humans).*

In

each

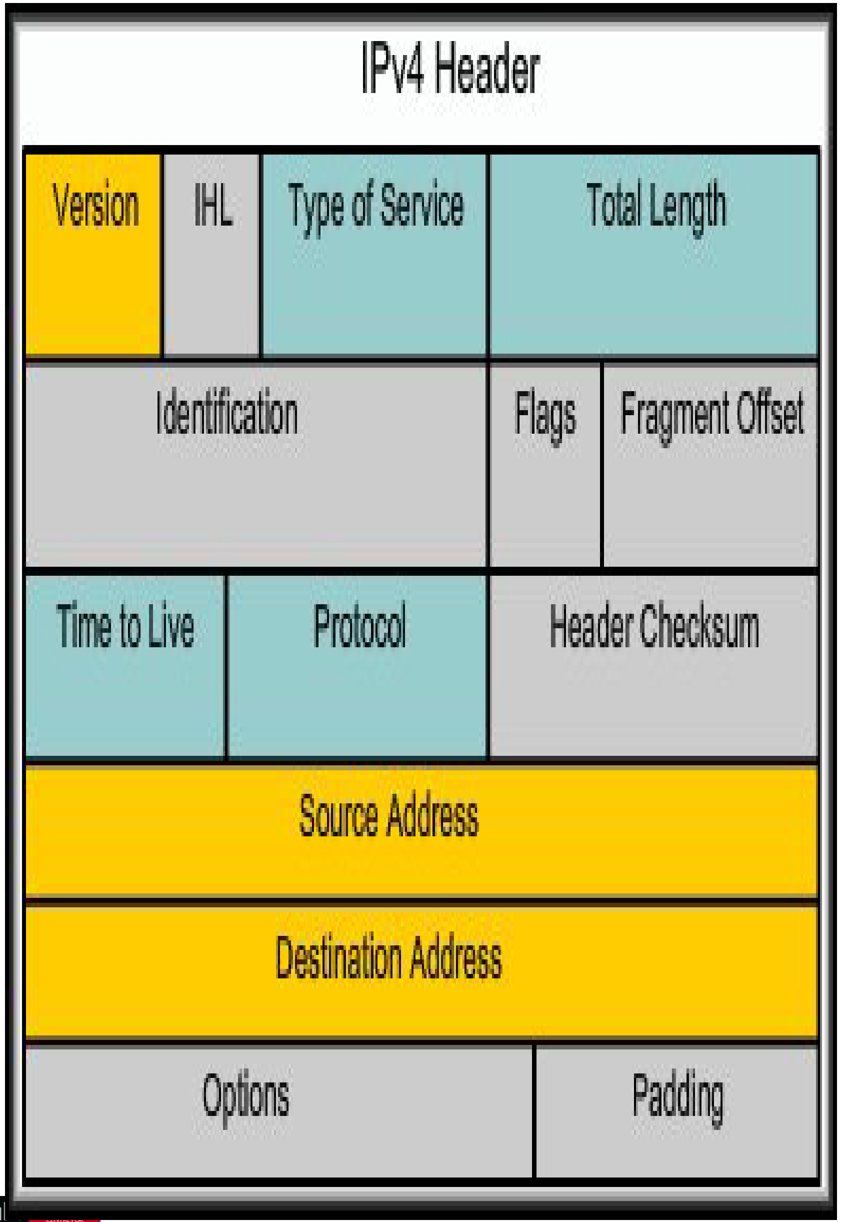
square metre of the planet

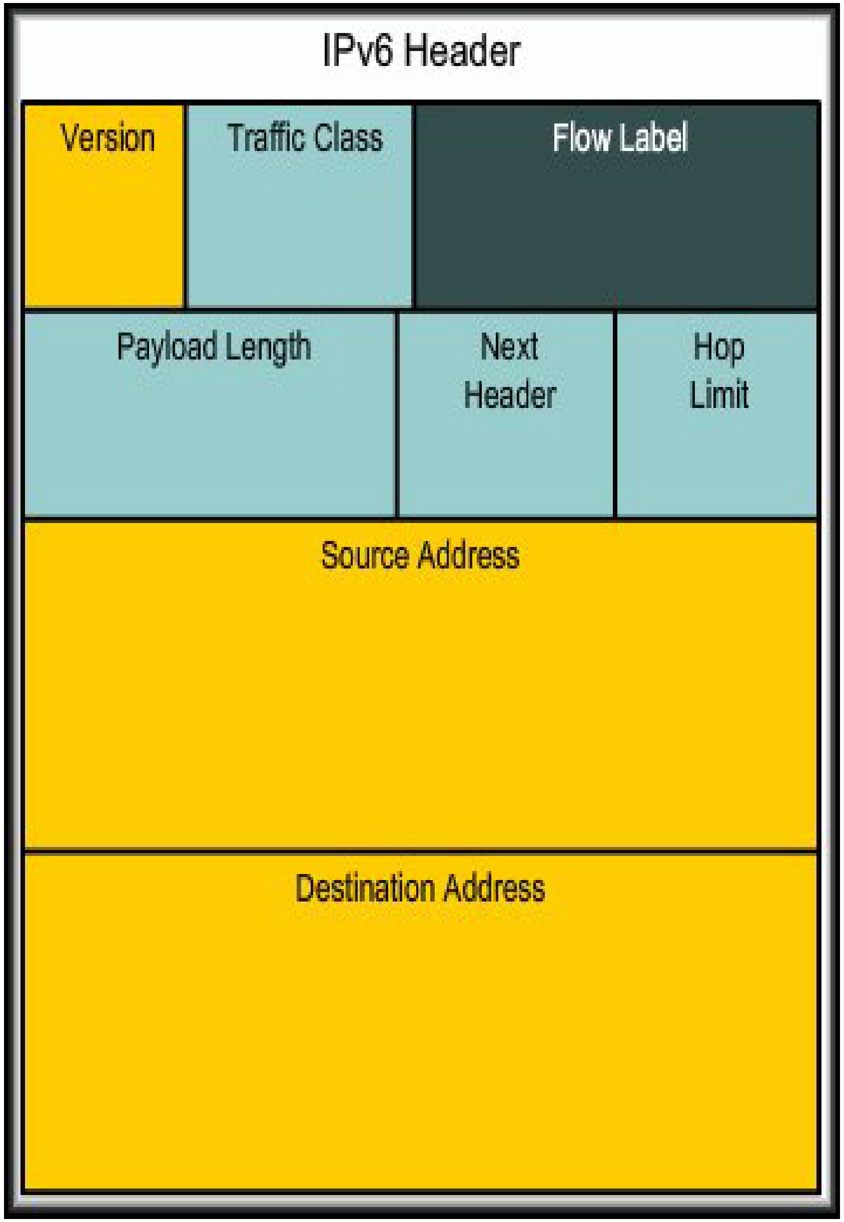
we can allocate

665,570,793,348,866,943,898,599

IPv6 addresses

IPv6 vs IPv4 Header





IPv6 vs IPv4 Packet Header

- Deleted Fields
  - IHL, Identification, Flags, Fragment Offset, Header Checksum (will this affect performance ?)
- Renamed Fields
  - Type of Service -> Traffic Class (8 bit)
  - Total Length -> Payload Length (16 bit)
  - Protocol -> Next Header (8 bit)
  - Time to Live -> Hop Limit (8 bit)
- New Field - Flow Label (20 bit)
  - Source can tag the packet as being part of a specific flow, allowing routers to handle traffic on a per-flow basis rather than per-packet

IPv6 Addressing

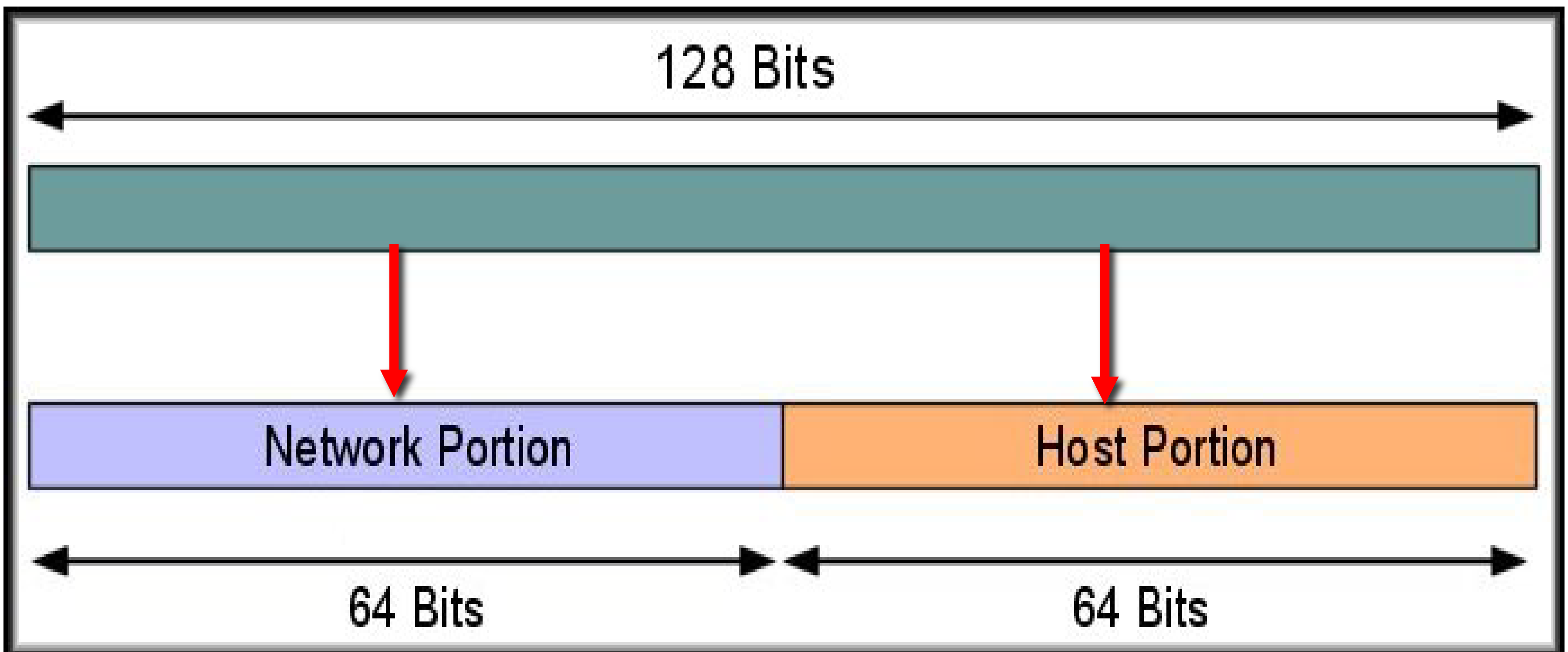
IPv6 Global Unicast Address

equivalent to

IPv4 public address

IPv6 Global Unicast Addressing

- A unicast address is an address that identifies a single device.
- A global unicast address is a unicast address that is globally unique.
  - Can be routed globally with no modification.



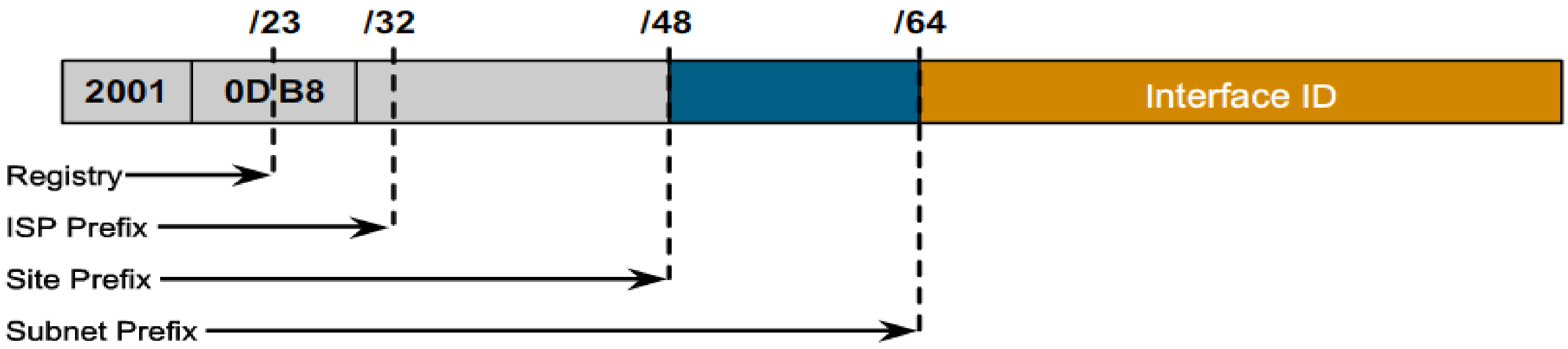
IPv6 Global Unicast Addressing

- IPv6 has an address format that enables aggregation upward eventually to the ISP.
- Global unicast addresses consists of a 48-bit global routing prefix and a 16-bit subnet ID.
- Individual organizations can use a 16-bit subnet field to create their own **local** addressing hierarchy.

IPv6 Addresses

IANA - Internet Assigned Numbers Authority

Global Routing Prefix /48



IANA - Internet Assigned Numbers Authority

- The global unicast addresses are assigned by the IANA using a range of addresses

- Currently the Range 2001::/16 to 2FFF::/16 is allocated to the five Regional Internet Registries (RIRs)

- 4096 blocks (16x16x16)

IPv6 Addressing - RIRs

Regional Internet Registries

AfriNIC	**Africa region**
APNIC	**Asia and Pacific region**
ARIN	**Canada, many Caribbean and North Atlantic islands, and the United States**
LACNIC	**Latin America and parts of the Caribbean**
RIPE NCC	**Europe, Parts of Asia and the Middle East**

Hierarchical Addressing

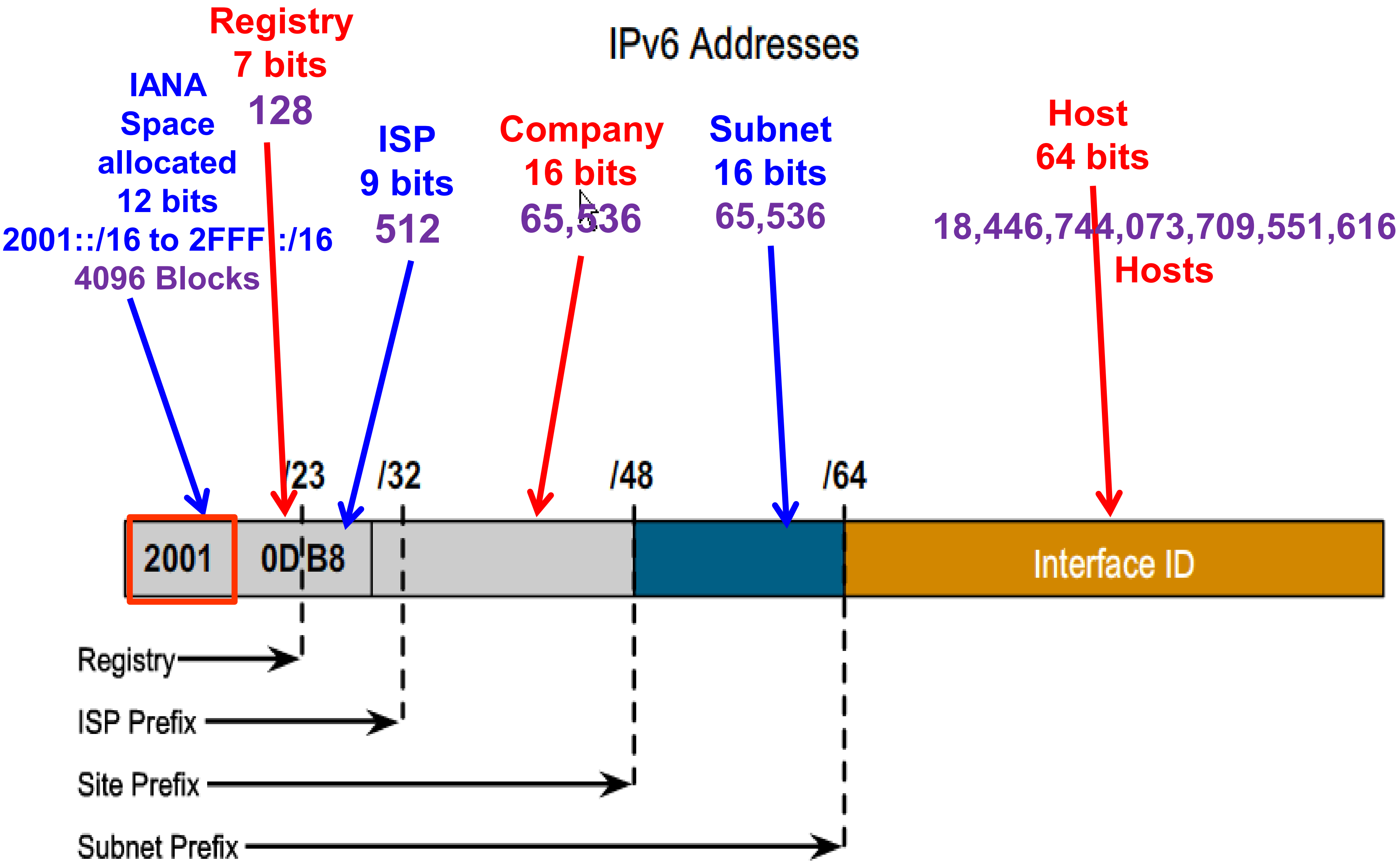
IPv4 – Address Hierarchy

- External to Company 2 Levels
  - Class A N.H.H.H
  - Class B N.N.H.H
  - Class C N.N.N.H

- Internal using VLSM Subnetting can have ? Levels
  - Class A N.S.S.SH
  - Class B N.N.S.SH
  - Class C N.N.N.SH

The END of VLSM ?

IPv6 Global Unicast Addressing – 6 Levels



IANA - Internet Assigned Numbers Authority

IANA Address Space Current – EUI 64

- Currently allocated 2001 to 2FFF, 2**12 = 4096 blocks
- Block 2001 alone provides:
  - 128 * 512 * 65536 = 4,294,967,296 **company** addresses
  - Each **company** can have 65356 subnets
  - **Each subnet in the company can have 18,446,744,073,709,551,616 hosts**

IPv6 vs IPv4 Addressing Representation

Characteristic	IPv4	IPv6
Format	x.x.x.x 4, 8-bit fields Separated by dots	x:x:x:x:x:x:x:x 8, 16-bit fields Separated by colons
Field Representation	Decimal Format	Groups of 4 hexadecimal digits, *non case sensitive* for A, B, C, D, E and F.
Leading Zeroes	Omitted	Optional
Successive Zero Fields	Must be included	Can be represented by "::" *once* in an address.

IPv6 Addressing – Unicast Hierarchy

2001:0DB8:0001:0001:0290:27FF:FE3A:9E9A

Current IANA Allocated Space for Registries: 2001::/16 but 12 bits allocated

Registry Space Address Id/Prefix: 2001:0D00::/23 7 bits allocated for Registers

ISP Address Id/Prefix: 2001:0DB8::/32 9 bits allocated for ISPs

Site (eg Company) Address Id/Prefix: 2001:0DB8:0001::/48 16 bits allocated for Sites

Subnet Address Id/Prefix: 2001:0DB8:0001:0001::/64 16 bits allocated for Subnets

Host Address Id/Prefix:

2001:0DB8:0001:0001:0290:27FF:FE3A:9E9A/64 64 bits allocated for Hosts

IPv6 Addressing

Representation

Rules

IPv6 Addressing Representation Rules

Rule 1:

- *The leading 0s in a field are optional.*

Rule 2A:

- *Successive fields of 0 can be represented as two colons* **::**

Rule 2B:

- *Rule 2A can only be applied once in an address*

IPv6 Addressing Representation Rules

2001:0000:130F:0000:0000:09C0:876A:130B

Rule 1:

- *The leading 0s in a field are optional.*

2001:0000:130F:0000:0000:09C0:876A:130B

- *0000 fields equal 0, 09C0 field equals 9C0*

2001:0:130F:0:0:9C0:876A:130B

SWIN BUR NE CENTRE FOR ADVANCED INTERNET ARCHITECTURES

IPv6 Addressing Representation Rules

Rule 2A:

- *Successive fields of 0 can be represented as two colons* **::**

2001:0:130F:0:0:9C0:876A:130B

$\boxed{\textit{2001:0:130F::9C0:876A:130B}}$

IPv6 Addressing Representation Rules

Rule 2B:

- *Rule 2A can only be applied once in an address*

Example: **2001::FA01::BC31**

Ambiguity ?

2001:0000:0000:FA01::BC31

OR

2001::FA01:0000:0000:BC31

IPv6 Addressing - Applying the Rules

2001:0000:0000:0000:01F4:00C8:C0A8:0420

2001:0501:0008:0000:0260:07FF:FE40:EFAB

2001:00F0:0000:0000:0145:0000:0000:00AB

IPv6 Addressing – Unicast Hierarchy

Given the IPV6 Address:

`2001:B00:C18:2:1F:AAEQ:1:2`

1. Fully expand the Address

2. What is the subnet (LAN) address Id/Prefix?

3. What is the company (Site) address Id/Prefix?

4. What is the Registry Space address Id/Prefix?

IPv6 Addressing

- Unspecified Addresses (::/128):

  - In IPv4, an IP address of all zeroes (0.0.0.0):
    - It is used by a device in request to a DHCP server to have its IPv4 address configured

  - In IPv6, an IP address of all-zeroes address (0000:0000:0000:0000:0000:0000:0000:0000):
    - It is used by a device in request to a DHCP server to have its IPv6 address configured

IPv6 Addressing

Loopback Address (::1/128):

- Just as in IPv4 (127.0.0.1), a provision has been made for a special loopback IPv6 address for testing local IPv6 stack

- Packets sent to this address "loop back" to the sending device.

- In IPv6 there is just one address, not a whole block, for this function.

Addresses

the

First

16 bits

0000 to FFFF

IPv6 Address Space

Address Type	High Order Bits (Binary)	High-Order Bits (Hex)
Unspecified	00…0	::/128
Loopback	00…1	::1/128
Multicast	11111111…	FF00::/8
Link Local Unicast	1111111010	FE80::/10
Global Unicast	0010 or 0011	
Reserved (Future Global unicast)	Everything Else	

IPv6 Addressing – FE80::/10

Link Local Address FE80::/10 to FEB0::/10

- Have a first octet value FE then third hexadecimal digit 8 to B
- FE8, FE9, FEA, FEB
- These addresses refer only to a particular physical link.
- Routers do not forward packets using link-local addresses.
- They are only for local communication on a particular physical network segment (LAN).
- Dynamically created on all IPv6 interfaces
- They are used for link communications
    - Automatic address configuration.
    - Neighbor discovery.
    - Router discovery.
    - IPv6 Routing Protocols.

IPv6 Addressing

Multicast Address FF00::/8

- A multicast address identifies a multicast group (set of devices).
- A packet being sent to a multicast group is originated by a single device.
  - A multicast packet normally has a unicast address as its source address and a multicast address as its destination address.
- A multicast address never appears in a packet as a source address.
- There is no reserved broadcast address like IPv4.

IPv6 Addressing

Multicast Address(FF00::/8):

- Examples of well-known IPv6 Multicast Addresses
- FF02 – 1111111100000010::A in reserved range FF00::/16 to FF0F::/16

Address	Multicast Group
FF02::1	**All Nodes**
FF02::2	All Routers
FF02::5	**OSPFv3 Routers**
FF02::6	OSPFv3 Designated Routers
FF02::9	RIPng Routers
FF02::A	**EIGRP Routers**
FF02::B	Mobile Agents
FF02:C	**DHCP Servers** / Relay Agents
FF02::D	All PIM Routers

IPv6 Address Management

- Four methods of address assignment:
  - Static assignment to an interface
  - Manual assignment using an EUI-64
  - Dynamic Stateless Autoconfiguration.
  - Dynamic DHCP for IPv6 (DHCPv6)

IPv6 Address Management

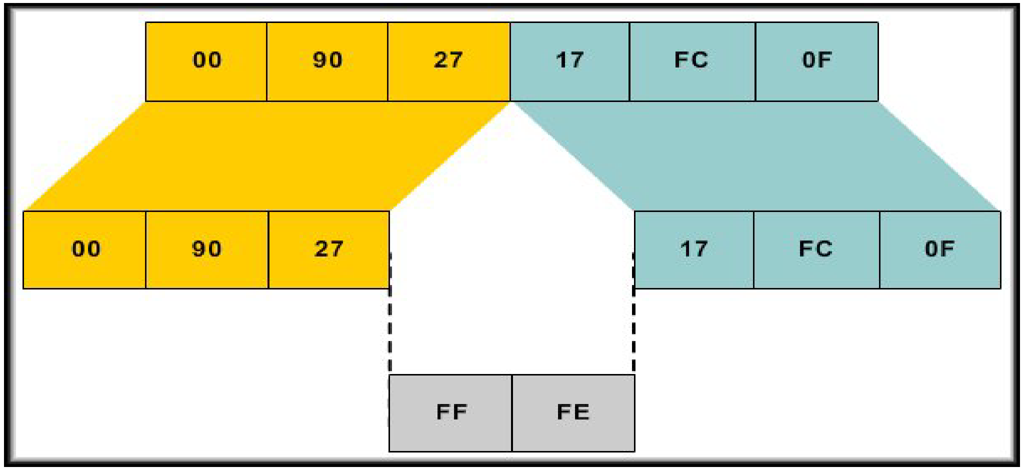
- Static assignment to an interface

- To configure an IPv6 address on a Cisco router interface, use the **`ipv6 address`** command in interface configuration mode.

```
interface G0/0/1
 ipv6 address 2001:DB8:2222:7272::72/64
```

IPv6 Address Management

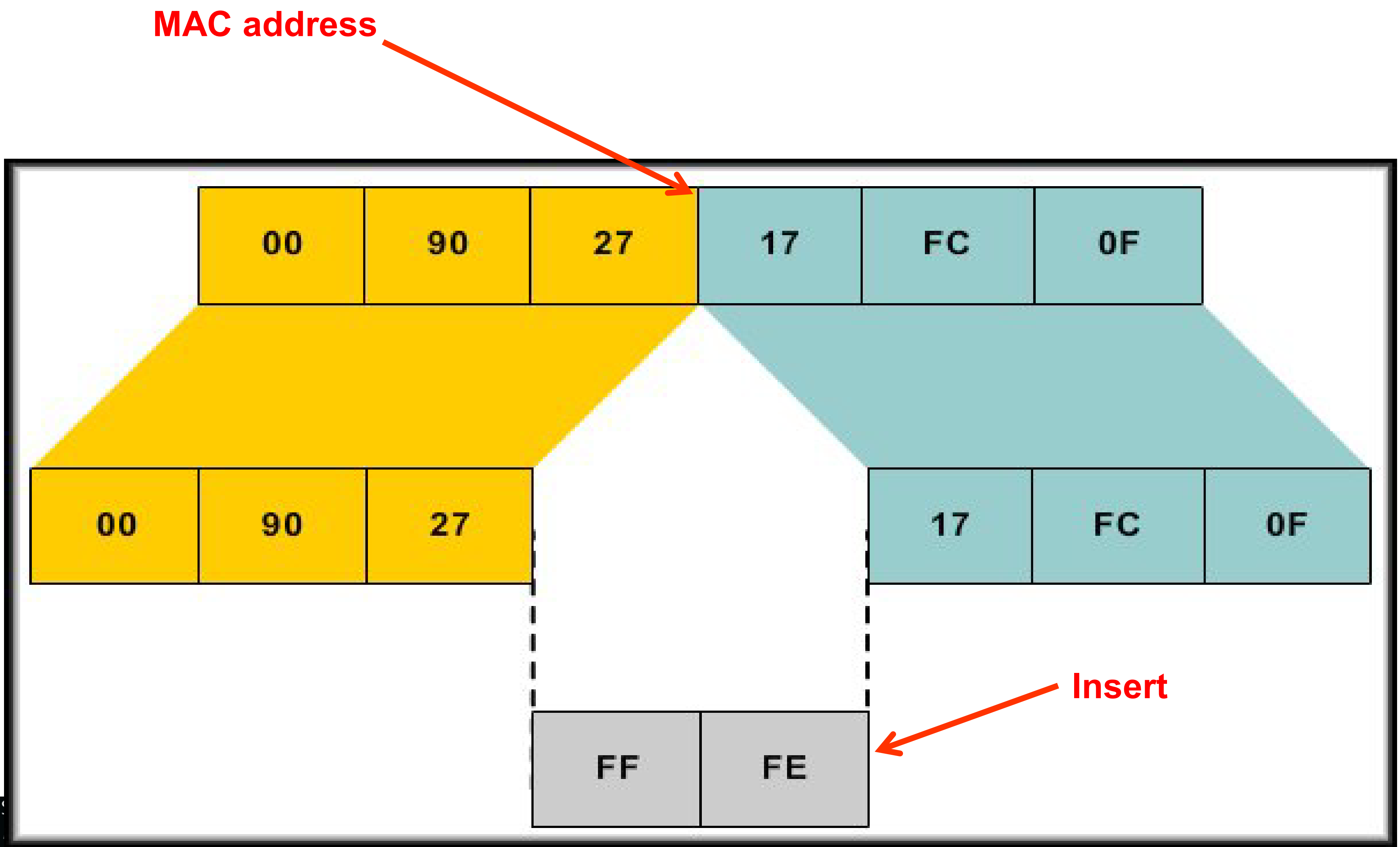
- Manual assignment using an EUI-64 interface ID.
  - The EUI-64 standard explains how to stretch IEEE 802 MAC addresses from 48 to 64 bits by inserting the 16-bit 0xFFFE in the middle at the 24th bit of the MAC address to create a 64-bit, unique interface identifier.




```
interface G0/0/1
  ipv6 address 2001:DB8:2222:7272::/64 eui-64
```

IPv6 Address Management

- Manual assignment using an EUI-64 interface ID.



Creating EUI-64 Interface ID

Ethernet Mac 48 bits	0260:3E47:1530
Split into 24 bits parts	0260:3E 47:1530
Insert 16 bit	FFFE
	0260:3EFF FE47:1530
EUI-64 Interface ID	0260:3EFF:FE47:1530

IPv6 Address Management

- Dynamic Stateless Autoconfiguration using an EUI-64
  1. The router interface has been configured with an IPv6 address.
  2. A device in the network will query the router for its address using ICMPv6 to exchange Neighbor Discovery Protocol (NDP) messages.
  3. The router will respond with its address and the device will use:
     - The Global Routing Prefix (64 bits) from the router address.
     - EUI-64 to add the device's MAC address.

IPv6 Address Management

- Dynamic Stateless Autoconfiguration:
  - Autoconfiguration automatically configures the IPv6 address.
  - The autoconfiguration mechanism was introduced to enable plug-and-play networking of these devices to help reduce administration overhead.
  - Uses IPv6 NDP (Neighbor Discovery Protocol) router solicitation and router advertisement messages to obtain the information.

IPv6 Address Management

- Dynamic DHCPv6 for IPv6:
  - Similar DHCP for IPv4.
    - Host sends a multicast packet searching for the DHCP server.
    - DHCP server replies.
    - DHCP client sends a message asking for a lease of an IP address.
    - DHCP server replies, listing an IPv6 address, prefix length, default router, and DNS IP addresses.
  - DHCPv4 and DHCPv6 actually differ in detail, but the basic process remains the same.

THE END