جامعة المنارة
كلية الهندسة
الهندسة المعلوماتية

أساسيات الشبكات الحاسوبية

مدرس المقرر
أ.د. مثنى علي القبيلي

الفصل الدراسي الثاني

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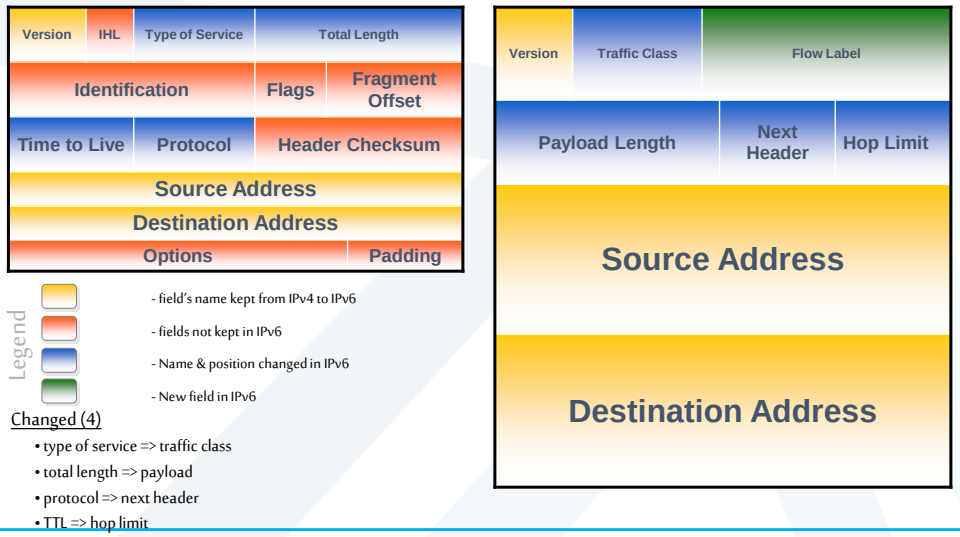
Explosion of New Internet Appliances

IPv4 & IPv6 Header Comparison



Changed (4)

- type of service => traffic class
- total length => payload
- protocol => next header
- TTL => hop limit

Major Improvements of IPv6 Header

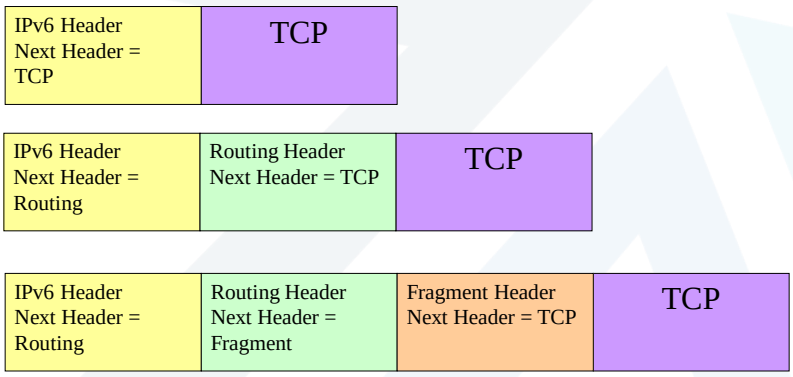
- No option field: Replaced by extension header. Result in a fixed length, 40-byte IP header.
- No header checksum: Result in fast processing.
- No fragmentation at intermediate nodes: Result in fast IP forwarding.

Extension Headers

- Routing – Extended routing, like IPv4 loose list of routers to visit
- Fragmentation – Fragmentation and reassembly
- Authentication – Integrity and authentication, security
- Encapsulation – Confidentiality
- Hop-by-Hop Option – Special options that require hop-by-hop processing
- Destination Options – Optional information to be examined by the destination node

IPv6

- IPv6 Packet



Extension Headers

Base Header	Extension Header 1	…	Extension Header N	Data

1. Hop-by-Hop (e.g. MLD)
2. Dest Opts header (intermediate nodes)
3. Routing Header
4. Fragment Header
5. Authentication Header (AH) (~deprecated)
6. Encapsulating Security Payload (ESP) header
7. Destination Opts header (final destination)
8. Mobility Header

128-bit IPv6 Address

3FFE:085B:1F1F:0000:0000:0000:00A9:1234

8 groups of 16-bit hexadecimal numbers separated by ":"

Leading zeros can be removed

3FFE:85B:1F1F::A9:1234

:: = all zeros in one or more group of 16-bit hexadecimal numbers

IPSAA → IPv6 addr. Separated into 2 parts: Network and Interface id.

IPv6 Zero Suppression

❖**To determine the number of 0 bits represented by the "::"**

1. count the number of blocks in the compressed address
2. (-) subtract this number from 8
3. (*) multiply the result by 16.

❖**For example**

1. FF02::2
2. two blocks - "FF02" block and "2" block.
3. The number of bits expressed by the "::" is 96 (96 = (8 – 2)×16).

❖**Zero compression can only be used once in a given address.**

- Otherwise, you could not determine the number of 0 bits represented by each instance of "::".

IPv6 Address Notation: Example

128.91.45.157.220.40.0.0.0.252.87.212.200.31.255

Binary	10000000010110110010110110011101110111000010100000000000000000 00000000000000001111110001010111110101001100100000011111111111111														
Dotted Decimal	128	91	45	157	220	40	0	0	0	0	252	87	212	200	31	255

Hexadecimal	0		32		64		96	128
Straight Hex	805B	2D9D	DC28	0000	0000	FC57	D4C8	1FFF
Leading-Zero Suppressed	805B	2D9D	DC28	0	0	FC57	D4C8	1FFF
Zero-Compressed	805B	2D9D	DC28	::		FC57	D4C8	1FFF

IPv6 - Addressing Model

Addresses are assigned to interfaces

change from IPv4 model :

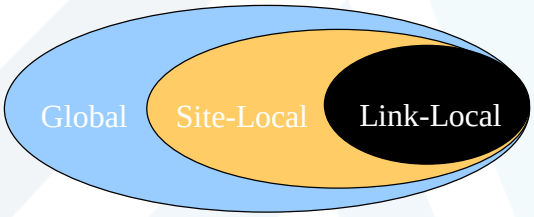
Interface 'expected' to have multiple addresses

Addresses have scope

Link Local

Site Local

Global



Addresses have lifetime

Valid and Preferred lifetime

Types of IPv6 Addresses

❖ **Unicast**

- One address on a single interface
- Delivery to single interface

❖ **Multicast**

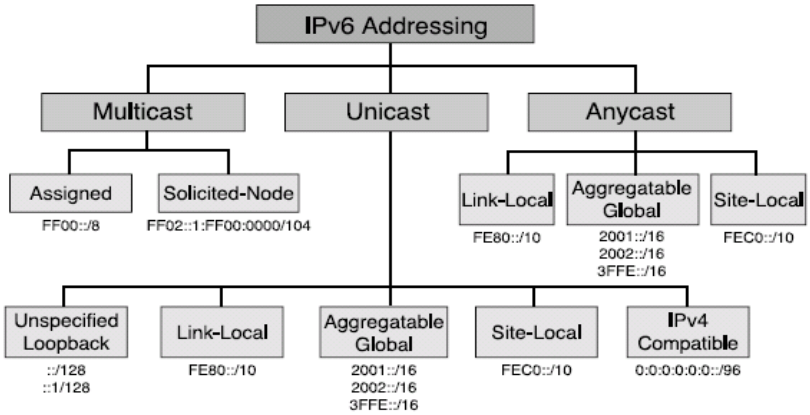
- Address of a set of interfaces
- Delivery to all interfaces in the set

❖ **Anycast**

- Address of a set of interfaces
- Delivery to a single interface in the set, typical utilization: DNS

No broadcast addresses

Types of IPv6 Addresses



Types of IPv6 Addresses

Loopback :	::1
Link Local :	FE80:
Site Local (private address) :	FEC0:
Multicast :	FF::
Undetermined address :	0.0.0.0.0.0.0.0 ou ::

Adresse Globale :

- Production network 2001 à 3FFF:
- Specific integration IPv4 / IPv6 2002:

Types of IPv6 Addresses

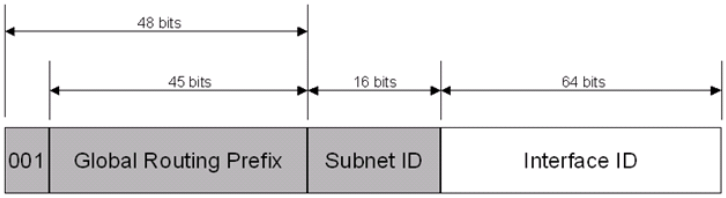
- For example:
  - **link-local address**
    - FE80:0:0:0:2AA:FF:FE9A:4CA2 → FE80::2AA:FF:FE9A:4CA2.
  - **multicast address**
    - FF02:0:0:0:0:0:0:2 → FF02::2
  - **loopback address**
    - 0:0:0:0:0:0:0:1 → ::1

Unicast IPv6 Addresses

- The following types of addresses are unicast IPv6 addresses:
  - Global unicast addresses
  - Link-local addresses
  - Site-local addresses
  - Unique local IPv6 unicast addresses
  - Special addresses

Global Unicast Addresses

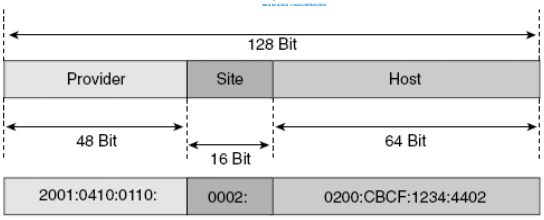
- Equivalent to public IPv4 addresses.
- Globally routable and reachable on the IPv6 portion of the Internet.
- Unlike the current IPv4-based Internet, which is a mixture of both flat and hierarchical routing, the IPv6-based Internet has been designed from its foundation to support efficient, hierarchical addressing and routing.
- The scope, the portion of the IPv6 internetwork over which the address is unique, of a global unicast address is the entire IPv6 Internet.
- Global scoped communication are identified by high-level 3 bits set to 001 (2000::/3)



Global Unicast Addresses

- Each aggregatable global unicast IPv6 address has three parts:
- Fixed portion set to 001 – The three high-order bits are set to 001. The address prefix for currently assigned global addresses is 2000::/3.
- **Global Routing Prefix – Site Prefix**
  - Site prefix assigned to an organization (leaf site) by a provider should be at least a /48 prefix = 45 + high-order bits (001).
  - /48 prefix represents the high-order 48-bit of the network prefix.
  - prefix assigned to the organization is part of the provider's prefix.
- **Subnet-id - Site**
  - With one /48 prefix allocated to an organization by a provider, it is possible for that organization to enable up to 65,535 subnets (assignment of 64-bit's prefix to subnets).
  - The organization can use bits 49 to 64 (16-bit) of the prefix received for subnetting.
- **Interface-id – Host**
  - The host part uses each node's interface identifier.
  - This part of the IPv6 address, which represents the address's low-order 64-bit, is called the *interface ID*.

Global Unicast Address: Example



2001:0410:0110::/48 is assigned by a provider

2001:0410:0110:0002::/64 network subnet within the organization

2001:0410:0110:0002:0200:CBCF:1234:4402 – node address within the subnet

Representation	Values
Range	2xxx:xxxx:xxxx:xxxx:xxxx:xxxx:xxxx:xxxx/3
First address of the range	2000:0000:0000:0000:0000:0000:0000:0000
Last address of the range	3FFF:FFFF:FFFF:FFFF:FFFF:FFFF:FFFF:FFFF
Binary format	High-order 3-bit is set to 001

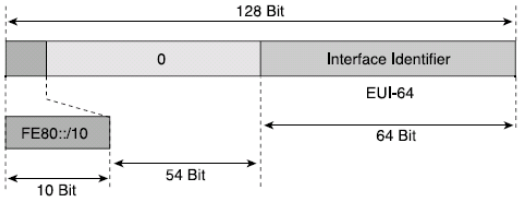
Local-Use Unicast Addresses

- There are two types of local-use unicast addresses:

1. **Link-local addresses**
   - used between on-link neighbors and for Neighbor Discovery Processes.
2. **Site-local addresses**
   - used between nodes communicating with other nodes in the same site.

Link-local Unicast Address

- Used only between nodes connected on the same local link.
- When an IPv6 stack is enabled on a node, one link-local address is automatically assigned to each interface of the node at boot time.
- IPv6 **link-local prefix FE80::/10** is used and the **interface identifier in Extended Unique Identifier 64 (EUI-64)** format is appended as the address's low-order 64-bit.
- Bits 11 through 64 are set to 0 (54-bit).
- Link-local addresses are only for local-link scope and must never be routed between subnets within a site.



Link-local unicast address

Representation	Value
Preferred format	FE80:0000:0000:0000:0000:0000:0000:0000/10
Compressed format[1]	FE80:0:0:0:0:0:0:0/10
Compressed format	FE80::/10
Binary format	High-order 10-bit is set to 1111 1110 10

- Because the low-order 64-bit of the link-local address is the interface identifier itself, the length of the link-local prefix is based on a 64-bit length (/64).
- In IPv6, a node having an aggregatable global unicast address on a local link uses the link-local address of its default IPv6 router rather than the router's aggregatable global unicast address.
- If network renumbering must occur, meaning that the unicast aggregatable global prefix is changed to a new one, the default router can always be reached using the link-local address.
- Link-local addresses of nodes and routers do not change during network renumbering.

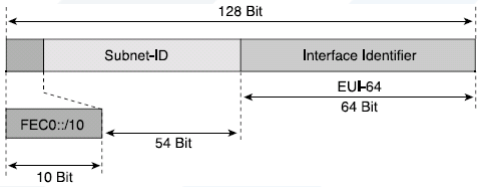
Site-Local Address

- Site-local addresses are equivalent to the IPv4 private address space (10.0.0.0/8, 172.16.0.0/12, and 192.168.0.0/16).
- Private intranets that do not have a direct, routed connection to the IPv6 Internet can use site-local addresses without conflicting with global unicast addresses.
- Site-local addresses are not reachable from other sites, and routers must not forward site-local traffic outside the site.
- Site-local addresses can be used in addition to global unicast addresses.
- The scope of a site-local address is the site.
- A site is an organization network or portion of an organization's network that has a defined geographical location (such as an office, an office complex, or a campus).

Site-Local Address

- Unlike link-local addresses, site-local addresses are not automatically configured and must be assigned either through stateless or stateful address configuration processes.
- May be assigned to any nodes and routers within a site.

Representation	Value
Preferred format	FEC0:0000:0000:0000:0000:0000:0000:0000/10
Compressed format[1]	FEC0:0:0:0:0:0:0:0/10
Compressed format	FEC0::/10
Binary format	High-order 10-bit is set to 1111 1110 11



Primary Address Types

- Global
- Link-local (FE80::/10)
  - Routers do not forward beyond link
- Site-local (FEC0::/10) (deprecated)
  - Routers do not forward beyond site
- Multicast (FF00::/8)
  - no broadcast in IPv6
  - FF02::1 (Link-local all-nodes address)
  - FF02::2 (Link-local all-routers address)
- Null = :: (:: = string of zero hextets)
- Loopback = ::1