Université Constantine 2
جامعة قسنطينة 2

Network Management

– Course 1 –

Chapter 6: Introduction to IPv6 Protocol (1/1)

Dr. Nadira Benlahrache

NTIC Faculty

email@univ-constantine2.dz

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Concerned Students :

Faculty	Department	Level	Speciality
NTIC	TLSI	License 3	G.L.

Objectives:

The objective of this course is to present IPv6 :

- its objectives,
- its notation and structure,
- its types.

Main Objectives of IPv6

- Solve the problem of IPv4 address exhaustion,
- Reduce the size of routing tables,
- Simplify the protocol (by simplifying the IP header) to improve router efficiency,
- Provide better security (authentication and confidentiality),
- Manage host mobility (auto-configuration),
- Allow for flexible coexistence with IPv4.

Presentation

IPv6 retains the principles that made IP a **success**; and corrects the "*weaknesses*" in IPv4. Thus, it uses:

- A **new** notation,
- An aggregated addressing plan,
- Each machine in IPv6 **has its own** IP address (directly visible on the Internet).
- An "**unclassified**" address.

IPv6 Address: Notation

An IPv6 address is defined on **128 bits** (16 bytes). Format:

X:X:X:X:X:X:X:X

where **X** is a **quadruplet of 4** hexadecimal digits.

Capacity between 1,564 and 3,911,873,538,269,506,102 addresses on the entire Earth.

Note: **no** more general broadcast addresses.

IPv6 Address: Notation

Address on **128 bits** for:

- Hierarchical, aggregated organization;
- Flexible enough for the future.

Reuse of CIDR principles:

Prefix / prefix_length

Example:

2001:660:111:2:*a*00:20*ff*:*fe*18:964*c*/64

IPv6 Address: Notation

- **Full address**:

  FEDC:0000:0000:0000:400:A987:6543:210F

- **Condensed notation**:

  Remove one or more blocks of consecutive **zeros**. Use "**::**" to indicate where the replacement occurred.

  FEDC :: 400:A987:6543:210F

  Note: Only one group of consecutive blocks can be removed.

- **Representation of a prefix**:

  3EDC:BA98:7654:3210::/64

- **Example**: The machine **a200:e8ff:fe65:df9a** on the network **fedc:6482:cafe:ba05** has the following IPv6 address:

  fedc:6482:cafe:ba05:a200:e8ff:fe65:df9a /64

IPv6 Address Types and Structure

IPv6 addressing is structured into **multiple levels** according to an "aggregated" model defined by the **IANA** (Internet Assigned Numbers Authority). This structure should allow for better **route aggregation** and a **reduction** in the size of **routing tables**.

Prefix (48 bits)				**Sub-Net**	**Interface**
3 bits	13 bits	8 bits	24 bits	16 bits	64 bits
001	**TLA**	Reserved	**NLA**	**SLA**	ID Interface

Aggregatable Global Unicast Address

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Aggregatable Global Unicast Address

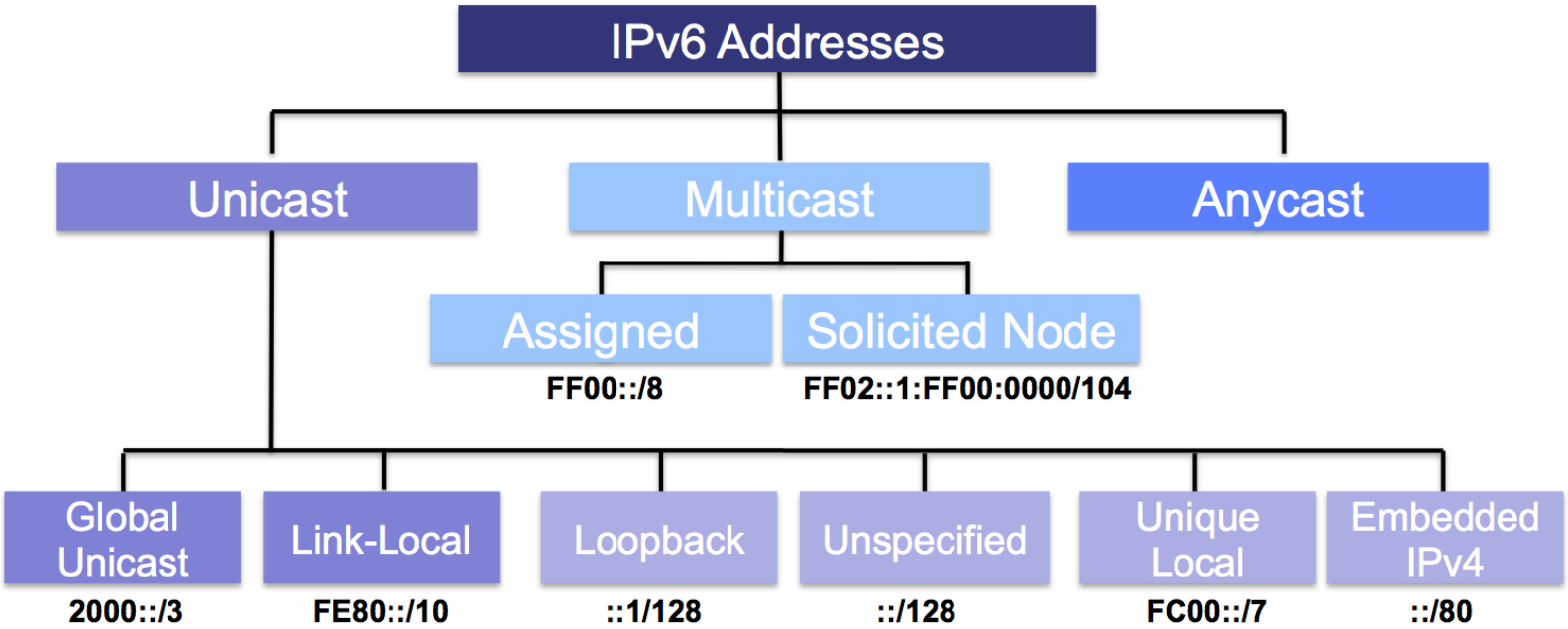
Top Level Aggregator (TLA): An entity that has received delegation directly from IANA, typically a first-level operator such as "AlgérieTélécom".
Network Level Aggregator (NLA): A network operator/ISP (Internet Service Provider) such as "Djezzy".
Site Level Aggregator (SLA): A local authority at a site, such as a Company network.

Site Level Aggregator

- A company has its own **SLA** identifier, or several (one per site);
- For example, when subscribing to an ISP, the ISP will assign the subscriber their own **SLA**.
- Through an **SLA**, an enterprise can configure *65536 networks* of 2^{64} machines each.

Types of addresses

A machine does not have **just one**, but **multiple** IPv6 addresses. Each IPv6 address can be used in a specific context:



Types of addresses

A machine does not have **just one**, but **multiple** IPv6 addresses.
Each address can be used in a specific context:

1. Unicast:
   - **Global Unicast** address, which is routable on the Internet,
   - **Link-Local** address obtained through automatic configuration,
   - **Unique Local** address, which is equivalent to a private network address,
   - **Loopback** address, which is equivalent to the IPv4 127.0.0.1 address,
   - **Mapped** or **Embedded** IPv4 address, which is used to communicate with IPv4 hosts,
   - **Reserved** IPv6 address.
2. Multicast,
3. Anycast.

Global Unicast Address

- A Unicast address defines a **specific host**.
- A packet sent to this destination address is delivered to only the machine having this IPv6 address.
- Starts at **2000::/3**
- **48** bits for the network: public prefix or topology
- **16** bits for subnet or site topology
- **64** bits for interface or host or interface topology.

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3 bits	13 bits	8 bits	24 bits	16 bits	64 bits
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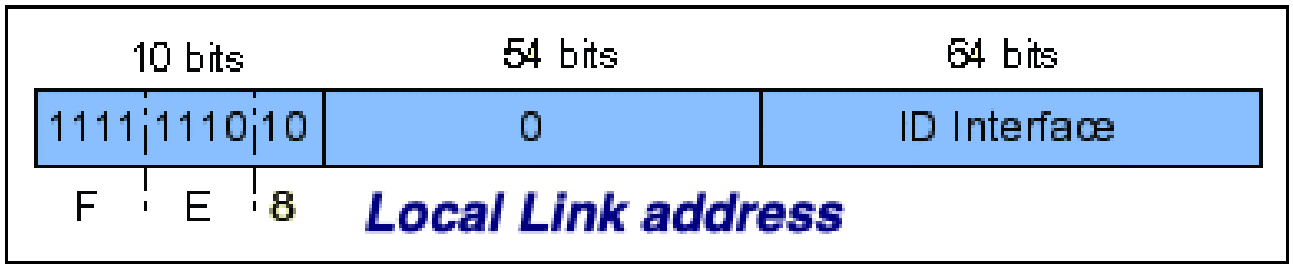
Aggregatable Global Unicast Address

Global Unicast Address

1. Public Topology (48 bits)
   - **3** bits identify the aggregated addressing plan,
   - **13** bits identify the Top-Level Aggregation (TLA),
   - **8** bits reserved for addressing evolution. To be allocated to TLA or NLA $\rightarrow$ Needs difficult to quantify.
   - **24** bits identify the Next-Level Aggregation (NLA).
2. `Site` Topology (SLA): can be hierarchized by the manager and define its own subnets within this range.
   In summary, the 48 + 16=64 bits identify the network portion of the IPv6 address.
3. Site interface Topology (64 bits): these bits identify the interface where the host is on the network.

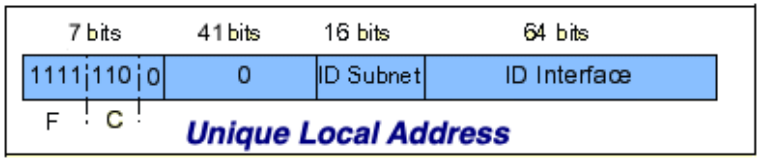
Link-local address

- This link-local address is obtained through automatic configuration and is only valid within the same link space without any intermediate router.
- The interconnection through a hub or Mac-level switch represents this link space.
- The prefix of a link-local address is **fe80::/10**.
- It starts from **FE8** to **FEB** (generally FE80).
- Has a "**plug and play**" effect.



Unique local address

- These addresses are used for local communications and are routable only within sites that choose to use them.
- They are equivalent to **private** address ranges.
- **fc00::/7**
- The 8th bit must currently be set to 1 (setting it to 0 is not yet defined), which gives the prefix for locally assigned addresses as **fd00::/8**.
- The address includes a pseudo-random 40-bit prefix to avoid conflicts when interconnecting private networks.



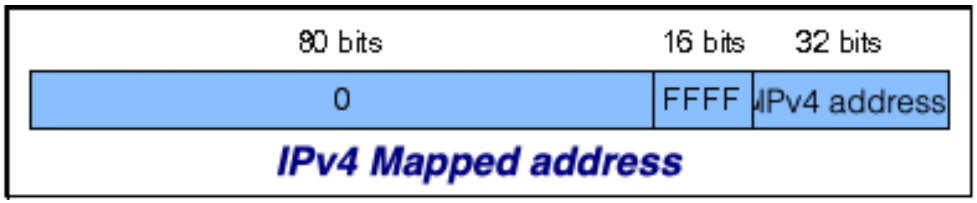
Reserved addresses

- These are the addresses **::/8** (constituting 1/256 of the total space),
- **::/128** : unspecified address usable as a source address in the IPv6 address acquisition phase,
- **::1/128** : loopback address identical to 127.0.0.1 in IPv4,
- **::ffff:0:0/96** : used by programs, not visible on the network, to encode IPv4 addresses in a structure intended for IPv6.

Mapped or Embedded IPv4 Address

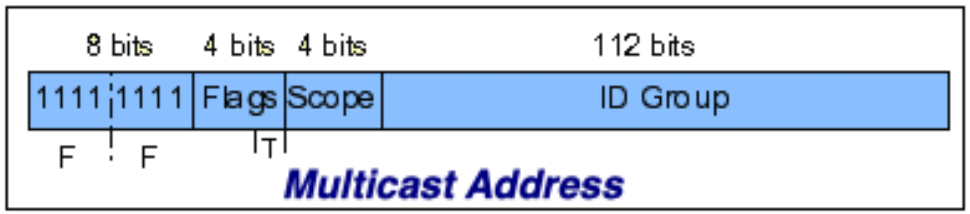
- An IPv6 machine can communicate with both an IPv4 machine and an IPv6 machine
- It uses **@IPv4-mapped** addresses to communicate with IPv4 machines and uses IPv6 addresses to communicate with IPv6 machines.
- The machine then has both stacks.
- These addresses are in the form:

  ::ffff:a.b.c.d
- For example, **::ffff:147.30.20.10** .



Multicast Address

- The **Multicast Address** concerns a group of hosts belonging to the same broadcast group.
- Equivalent to **224** in IPv4 or **Class D**.
- A packet sent to this destination address is delivered to all machines concerned by this address.
- The prefix of a multicast address is **ff00::/8**.



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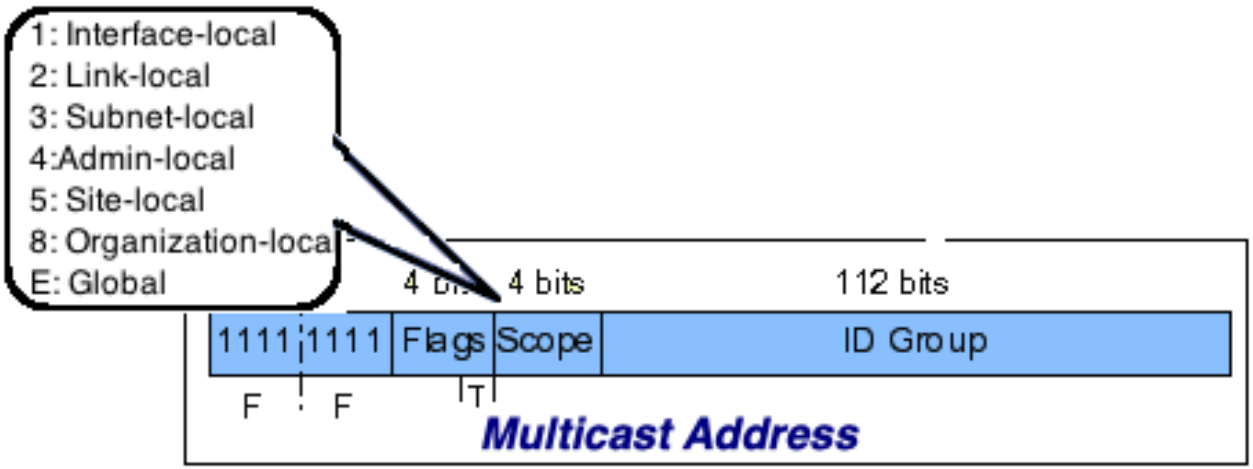


Anycast Address

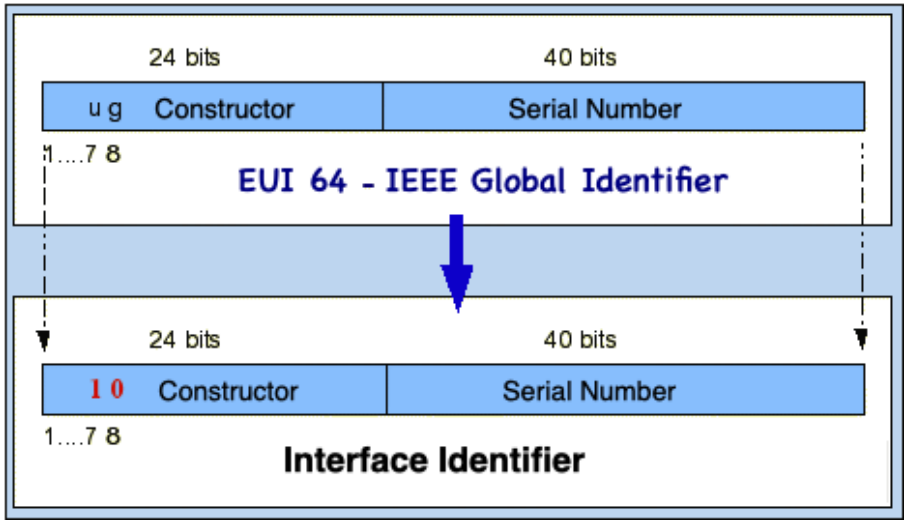
- With an **Anycast** address, a packet sent will be delivered to only one member of the group.
- Used to reach the closest host when multiple hosts share the same **anycast** address,
- All nodes with the same **anycast** address provide the same service (e.g., routers)
- Useful for **load balancing** across multiple servers,
- An **anycast** address is indistinguishable from a global unicast address and cannot be used as a source address.

Recap

Address Type	Range	Application
Aggregateable Global Unicast	2000::/3	Host-to-Host communication
Link-local Unicast	FE80::/10	Connected-link communication
Multicast	FF00::/8	One-to-many communication
Anycast	Same as Unicast	Application-based, including load balancing & redundancy

Interface Identifier

- The **interface identifier** allows to build the IPv6 address and guarantee its global uniqueness.
- The mechanism used consists of taking the **Mac address** of the network interface (network card) and placing it in the last 64 bits of the IPv6 address.



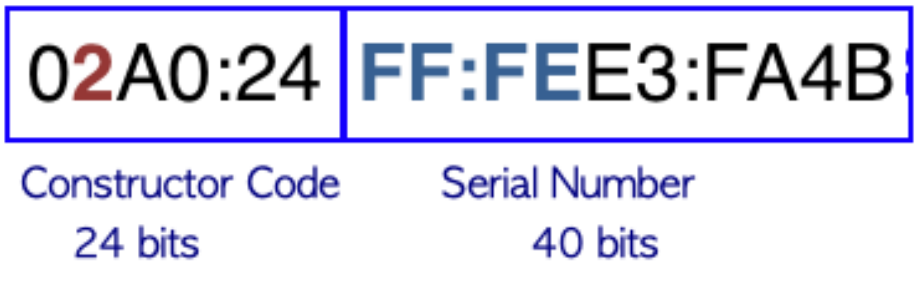
Example:

Let's take a **MAC address** = **00:A0:24:E3:FA:4B** (48 bits)

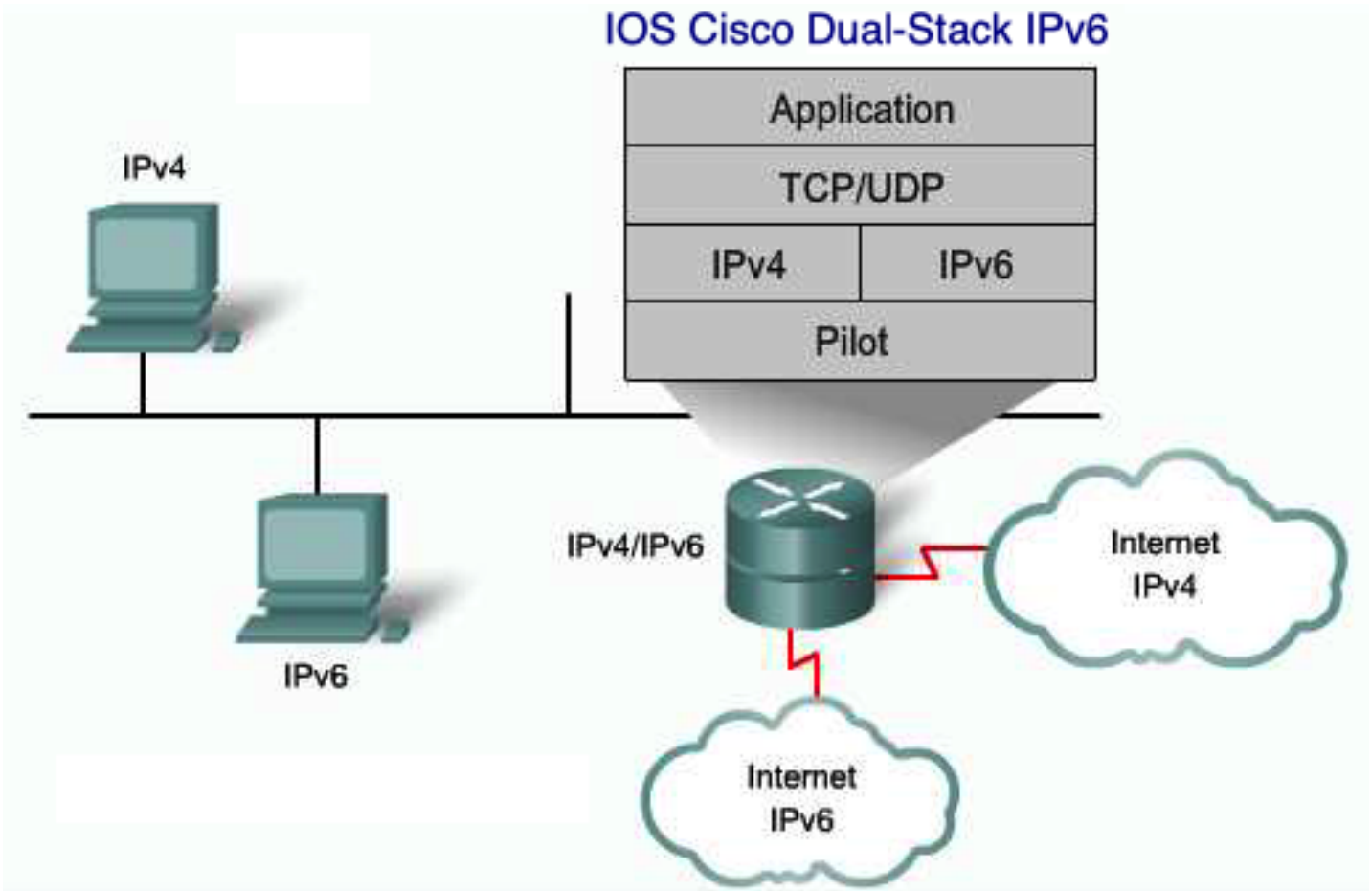
Interface Identifier or **EUI-64** =

02 A0:24 FF:FE E3:FA4B (48+16 bits)

Where the **seventh bit** is inverted to **1** and **FF:FE** is added in the middle of the interface address:



IPv4 - IPv6 Transition



New protocols

- **Neighbor Discovery** (ND),
- **Path MTU Discovery**,
- **IPv6 Auto-configuration**; stateless or stateful using DHCPv6,
- **Multicast Listener Discovery** (MLD), [RFC2710];
- **ICMPv6**, covers the functionality of ICMP in IPv4 and encapsulates ND and MLD messages.

IPv6 Routing

- **CIDR Routing:** the longest prefix (most specific) is used,
- Routing protocols are **extensions** of IPv4 protocols:
  RIPng
  OSPF-v3
- Routing operations (currently) are less efficient than in IPv4.

Conclusion

- This course aimed to introduce the basic concepts of IPv6 addressing such as notation, address types, and protocols dedicated to this type of addressing.

Some useful Links

- http://www.iplogos.fr/ipv6-les-differentes-adresses
- http://www.e-campus.uvsq.fr
- http://sesame-mips.unice.fr/~lips/cours/reseaux/cours/10-IPv6.pdf
- http://www.linux-france.org/
- http://wildcat.espix.org/ipv6/i01_principe_ip_v1b.pdf