Plan d'adressage

Objectif:
Comprendre pourquoi une interface a plusieurs adresses

Adresse

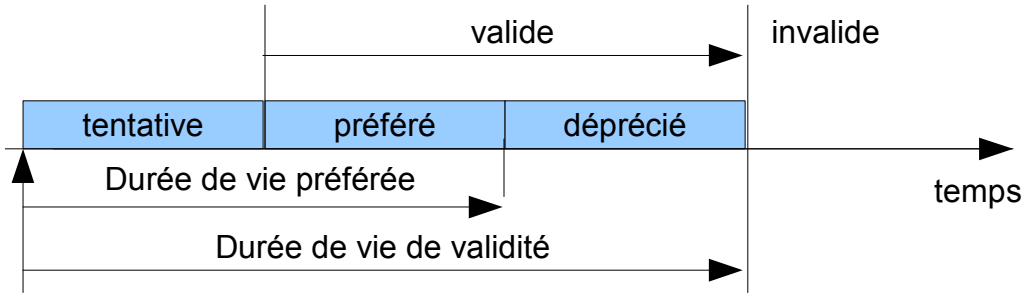
- Qu'est-ce qu'une adresse ?
- A quoi sert-elle ?
- Dans les réseaux d'ordinateurs l'adresse est associée a la machine (host) ou à l'interface ?
- Est-ce que une interface peut avoir plusieurs adresses ?
- Qui a une adresse IPv4 fixe ? Laquelle ?
- Qui a une adresse IPv6 fixe ? Laquelle ?

Adressage

- Qu'est-ce qu'une adresse ? A quoi sert-elle ?
  - Localisation
    - Pour trouver un intermédiaire qui saura livrer les paquets
    - Adresse globale et locale (identifiant de réseau et de machine)
    - Durée de vie longue
  - Identification
    - Pour reconnaître son interlocuteur
    - Durée de vie minimale: connexion TCP
- Structuration et Notation
- Portée et Durée de vie
- Types
  - Unicast, Multicast, Anycast

Durée de vie des adresses

- Les préfixes restent la propriété des opérateurs
- Les adresses sont prêtées



- Durée de 30 jours, mais peut être prolongée ou portée à l'infini
  - L'adresse lien-local a une durée illimitée
  - La renumérotation consiste à passer d'une adresse à l'autre
  - Mécanisme d'obsolescence pour invalider progressivement une adresse
    - Une adresse dépréciée peut être utilisée pour recevoir un paquet, mais pas pour initialiser une nouvelle connexion

Notation

- 128 bits, 8 mots de 16 bits séparés par :
- Hexadécimal
  - FEDC:BA98:7654:3210:EDBC:A987:6543:210F
- Simplification des zéros
  - FEDC:0:0:0:400:A987:6543:210F
  - FEDC::400:A987:6543:210F
- Préfixes par indication du numéros de bits concernés
  - 3EDC:BA98:7654:3210:0000:0000:0000:0000/64
  - 3EDC:BA98:7654:3210:0:0:0:0/64
  - 3EDC:BA98:7654:3210::/64

Adressage global : attribution des préfixes

INTERNET PROTOCOL VERSION 6 ADDRESS SPACE

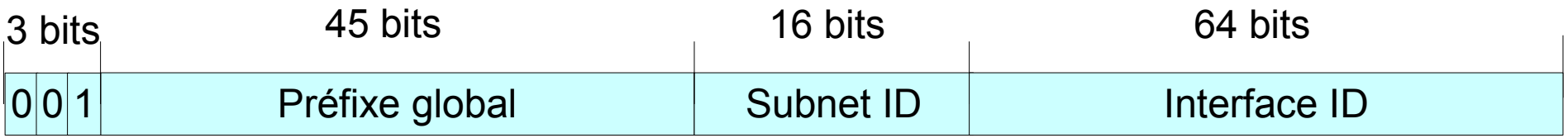
[last updated 27 February 2006]

IPv6 Prefix	Allocation	Reference	Note
0000::/8	Reserved by IETF	[RFC3513]	[1] [5]
0100::/8	Reserved by IETF	[RFC3513]	
0200::/7	Reserved by IETF	[RFC4048]	[2]
0400::/6	Reserved by IETF	[RFC3513]	
0800::/5	Reserved by IETF	[RFC3513]	
1000::/4	Reserved by IETF	[RFC3513]	
2000::/3	Global Unicast	[RFC3513]	[3]
4000::/3	Reserved by IETF	[RFC3513]	
6000::/3	Reserved by IETF	[RFC3513]	
8000::/3	Reserved by IETF	[RFC3513]	
A000::/3	Reserved by IETF	[RFC3513]	
C000::/3	Reserved by IETF	[RFC3513]	
E000::/4	Reserved by IETF	[RFC3513]	
F000::/5	Reserved by IETF	[RFC3513]	
F800::/6	Reserved by IETF	[RFC3513]	
FC00::/7	Unique Local Unicast	[RFC4193]	
FE00::/9	Reserved by IETF	[RFC3513]	
FE80::/10	Link Local Unicast	[RFC3513]	
FEC0::/10	Reserved by IETF	[RFC3879]	[4]
FF00::/8	Multicast	[RFC3513]	

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

Adresse unicast globale

- Topologie publique sur 48 bits
- Topologie privé sur 16 bits
- Identifiant d'interface sur 64 bits
- RFC 3587
  http://www.ietf.org/rfc/rfc3587.txt



Global Unicast Address Assignments

IPV6 GLOBAL UNICAST ADDRESS ASSIGNMENTS [0]

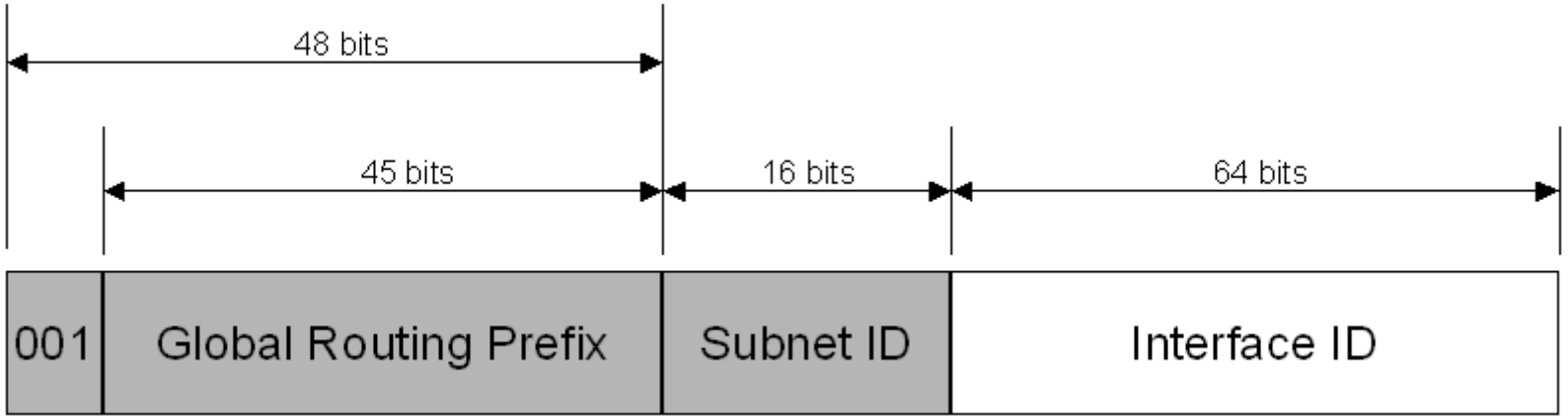
[last updated 14 Jun 2006]

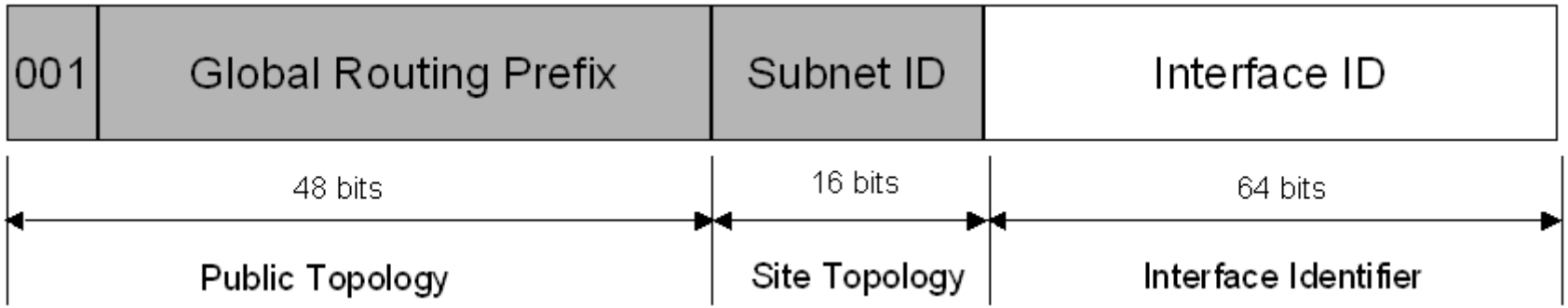
Global Unicast Prefix	Assignment	Date	Note
2001:0000::/23	IANA	01 Jul 99	[1] [6]
2001:0200::/23	APNIC	01 Jul 99	
2001:0400::/23	ARIN	01 Jul 99	
2001:0600::/23	RIPE NCC	01 Jul 99	
2001:0800::/23	RIPE NCC	01 May 02	
2001:0A00::/23	RIPE NCC	02 Nov 02	
2001:0C00::/23	APNIC	01 May 02	[2]
2001:0E00::/23	APNIC	01 Jan 03	
2001:1200::/23	LACNIC	01 Nov 02	
2001:1400::/23	RIPE NCC	01 Feb 03	
2001:1600::/23	RIPE NCC	01 Jul 03	
2001:1800::/23	ARIN	01 Apr 03	
2001:1A00::/23	RIPE NCC	01 Jan 04	
2001:1C00::/22	RIPE NCC	01 May 04	
2001:2000::/20	RIPE NCC	01 May 04	
2001:3000::/21	RIPE NCC	01 May 04	
2001:3800::/22	RIPE NCC	01 May 04	
2001:3C00::/22	RESERVED	11 Jun 04	[3]
2001:4000::/23	RIPE NCC	11 Jun 04	
2001:4200::/23	AfriNIC	01 Jun 04	
2001:4400::/23	APNIC	11 Jun 04	
2001:4600::/23	RIPE NCC	17 Aug 04	
2001:4800::/23	ARIN	24 Aug 04	
2001:4A00::/23	RIPE NCC	15 Oct 04	
2001:4C00::/23	RIPE NCC	17 Dec 04	
2001:5000::/20	RIPE NCC	10 Sep 04	
2001:8000::/19	APNIC	30 Nov 04	
2001:A000::/20	APNIC	30 Nov 04	
2001:B000::/20	APNIC	08 Mar 06	
2002:0000::/16	6to4	01 Feb 01	[4]
2003:0000::/18	RIPE NCC	12 Jan 05	
2400:0000::/19	APNIC	20 May 05	
2400:2000::/19	APNIC	08 Jul 05	
2400:4000::/21	APNIC	08 Aug 05	
2404:0000::/23	APNIC	19 Jan 06	
2600:0000::/22	ARIN	19 Apr 05	
2604:0000::/22	ARIN	19 Apr 05	
2608:0000::/22	ARIN	19 Apr 05	
260C:0000::/22	ARIN	19 Apr 05	
2610:0000::/23	ARIN	17 Nov 05	
2800:0000::/23	LACNIC	17 Nov 05	
2A00:0000::/21	RIPE NCC	19 Apr 05	
2A01:0000::/16	RIPE NCC	15 Dec 05	[5]

- Regional Internet Registry
  - RIPE NCC, Europe
    - Réseaux IP Européens
  - APNIC, Asia Pacific
  - ARIN, American Registry
  - LACNIC, Latin America
  - AfriNIC, Africa
- 6to4
  - Mécanisme de transition

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

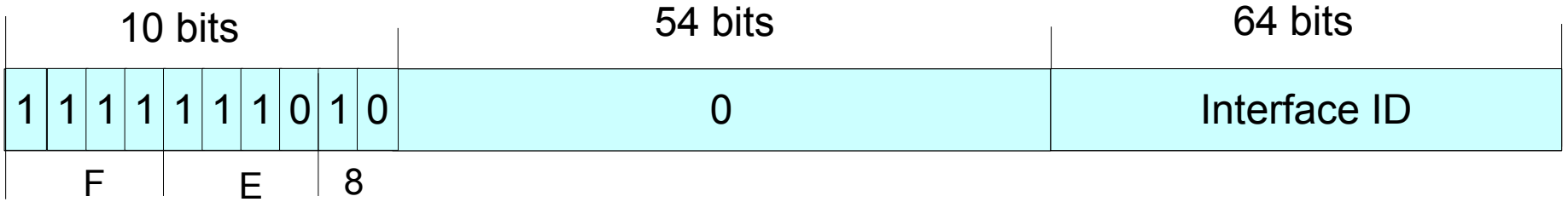
Global Unicast Address



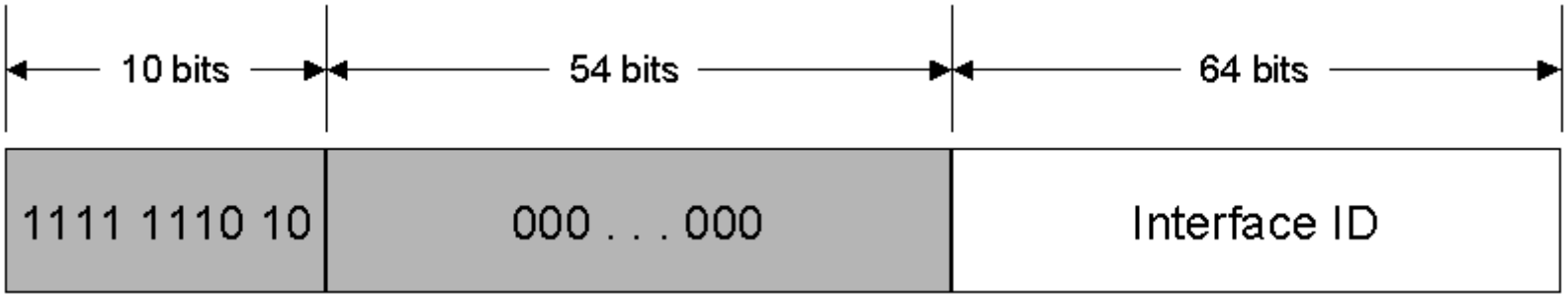


Les adresses lien-local

- Validité: lien local
  - Ethernet
  - Liaison Point à Point
  - Extrémité d'un tunnel
- Configurées automatiquement
  - Concaténation
    - Préfixe + Interface ID
- Uniques à l'intérieur du lien
  - Protocole de détection d'adresse dupliquée
- Routeur ne doit jamais retransmettre un paquet avec ces adresses
- Portée de l'adresse (scoped address)
  - Interface de sortie désignée en concatenant %nom-interface (ou index) à l'adresse de destination

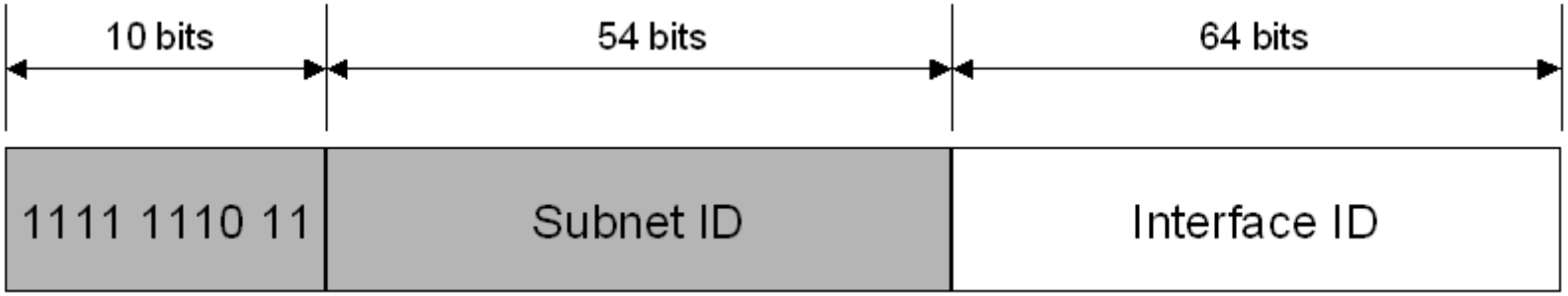


Link-Local Address



- IPv6 link-local addresses are equivalent to IPv4 link-local addresses defined in RFC 3927 that use the 169.254.0.0/16 prefix.
- IPv4 link-local addresses are known as Automatic Private IP Addressing (APIPA) addresses for computers running current Microsoft Windows operating systems.
- The scope of a link-local address is the local link.

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).
- For example, 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

Zone IDs for Local-Use Addresses

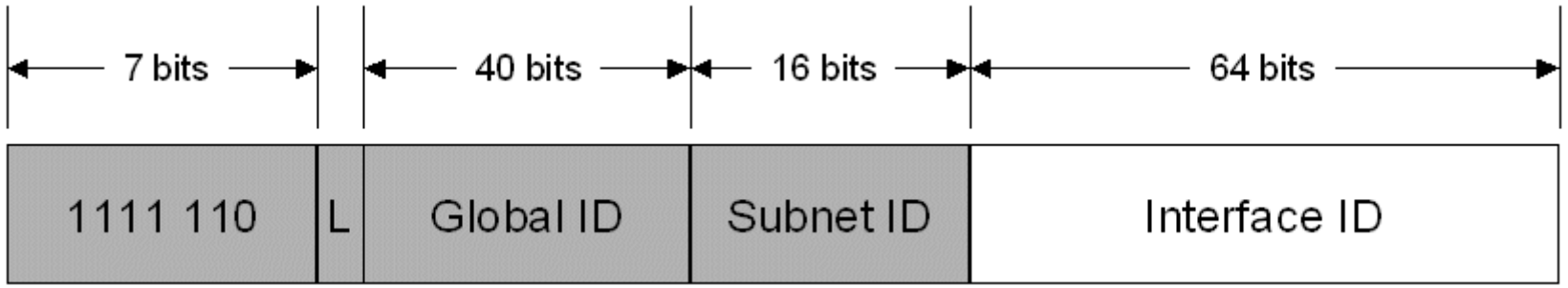
- Unlike global addresses, local-use addresses can be reused.
  - Link-local addresses are reused on each link.
  - Site-local addresses can be reused within each site of an organization.
- Because of this address reuse capability, link-local and site-local addresses are ambiguous.
  - To specify which link on which an address is assigned or located or within which site an address is assigned or located, an additional identifier is needed.
    - This additional identifier is a zone identifier (ID), also known as a scope ID, which identifies a connected portion of a network that has a specified scope.
- The syntax specified in RFC 4007 for identifying the zone associated with a local-use address is the following:
  - *Address%zone_ID*

Zone IDs for Windows IPv6 Hosts

- For Windows-based IPv6 hosts, the zone IDs for link-local and site-local addresses are defined as follows:
  - For link-local addresses, the zone ID is typically the interface index of the interface either assigned the address or to be used as the sending interface for a link-local destination.
    - The interface index is an integer starting at 1 that is assigned to IPv6 interfaces, which include a loopback and one or multiple tunnel or LAN interfaces.
  - To view the list of interface indexes use **netsh interface ipv6 show interface** command.
  - For site-local addresses, the zone ID is the site ID, an integer assigned to the site of an organization.
    - For organizations that do not reuse the site-local address prefix, the site ID is set to 1 by default and does not need to be specified.
  - To view the site ID use **netsh interface ipv6 show address level=verbose** command.

Unique Local Unicast Address

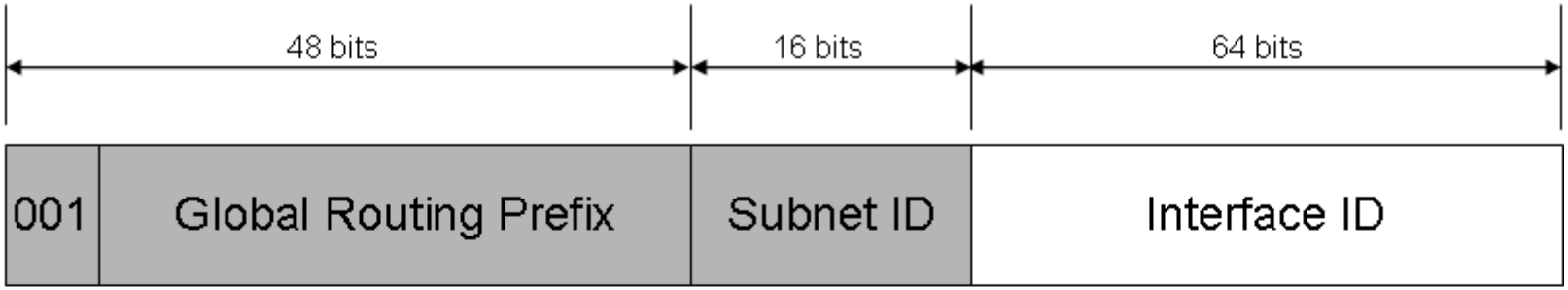
- The ambiguity of site-local addresses in an organization adds complexity and difficulty for applications, routers, and network managers.
- To replace site-local addresses with a new type of address that is private to an organization, yet unique across all of the sites of the organization, RFC 4193 defines unique local IPv6 unicast addresses.

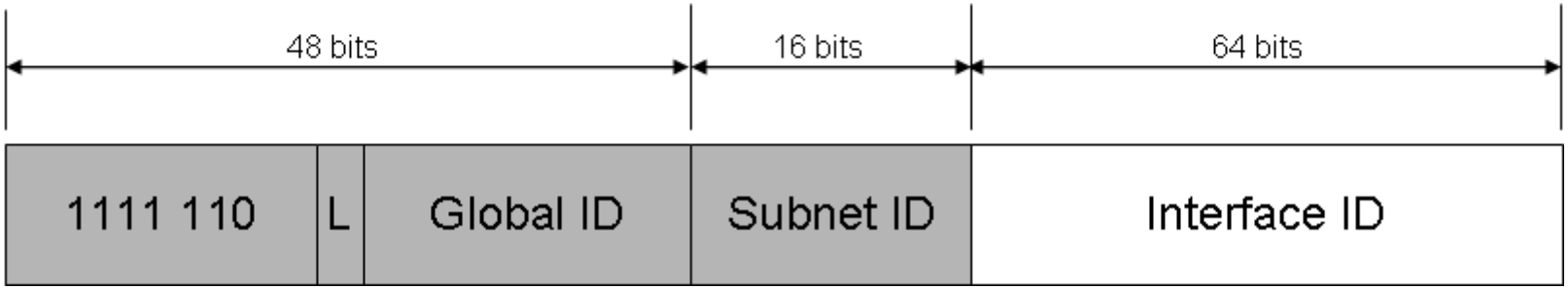


Unique Local Address

- All unique local addresses have the address prefix FC00::/7.
  - The Local (L) flag is set 1 to indicate a local address.
  - The L flag value set to 0 has not yet been defined.
  - Therefore, unique local addresses with the L flag set to 1 have the address prefix of FD00::/8.
  - The Global ID identifies a specific site within an organization and is set to a randomly derived 40-bit value.
    - By deriving a random value for the Global ID, an organization can have statistically unique 48-bit prefixes assigned to the sites of their organizations.
    - Additionally, two organizations that use unique local addresses that merge have a low probability of duplicating a 48-bit unique local address prefix, minimizing site renumbering.
  - Unlike the Global Routing Prefix in global addresses, you should not assign Global IDs in unique local address prefixes so that they can be summarized.

Global and Unique Local Addresses





Global and Unique Local Addresses (2)

- In global addresses, the Subnet ID field identifies the subnet within an organization.
- For unique local addresses, the Subnet ID field can perform the same function.
- Therefore, you can create a subnet numbering scheme that can be used for both local and global unicast addresses.
- Unique local addresses have a global scope but their reachability is defined by routing topology.
- Organizations will not advertise their unique local address prefixes outside of their organizations or create DNS AAAA entries with unique local addresses in the Internet DNS.

Special IPv6 Addresses

- Unspecified address
  - The unspecified address (0:0:0:0:0:0:0:0 or ::) is only used to indicate the absence of an address. It is equivalent to the IPv4 unspecified address of 0.0.0.0.
  - The unspecified address is typically used as a source address for packets attempting to verify the uniqueness of a tentative address.
    - The unspecified address is never assigned to an interface or used as a destination address.
- Loopback address
  - The loopback address (0:0:0:0:0:0:0:1 or ::1) is used to identify a loopback interface, enabling a node to send packets to itself.
  - It is equivalent to the IPv4 loopback address of 127.0.0.1.
    - Packets addressed to the loopback address must never be sent on a link or forwarded by an IPv6 router.

Compatibility Addresses

- IPv4-compatible address
  - The IPv4-compatible address, 0:0:0:0:0:0:*w.x.y.z* or ::*w.x.y.z* (where *w.x.y.z* is the dotted decimal representation of an IPv4 address), is used by IPv6/IPv4 nodes that are communicating using Ipv6.
  - When the IPv4-compatible address is used as an IPv6 destination, the IPv6 traffic is automatically encapsulated with an IPv4 header and sent to the destination using the IPv4 infrastructure.
- IPv4-mapped address
  - The IPv4-mapped address, 0:0:0:0:0:FFFF:*w.x.y.z* or ::FFFF:*w.x.y.z*, is used to represent an IPv4-only node to an IPv6 node.
  - It is used only for internal representation.
  - The IPv4-mapped address is never used as a source or destination address of an IPv6 packet.

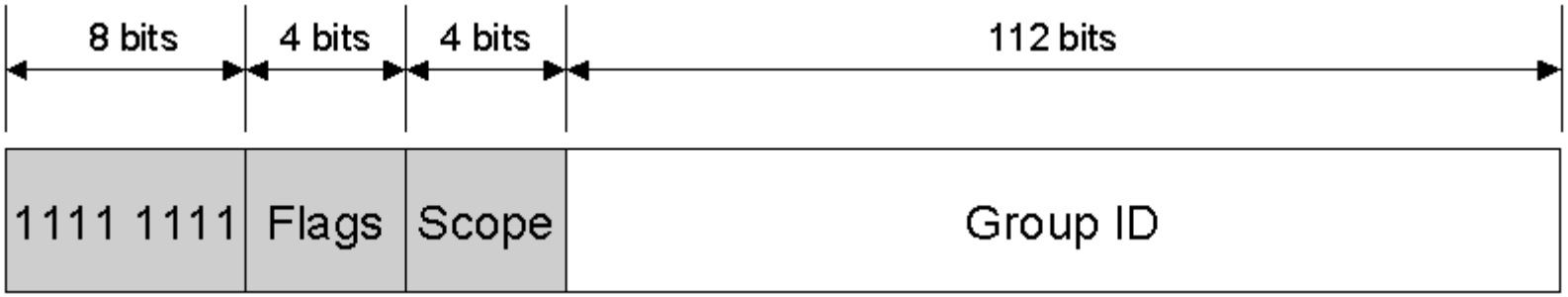
6to4 Addresses

- 6to4 address
  - The 6to4 address is used for communicating between two nodes running both IPv4 and IPv6 over an IPv4 routing infrastructure.
  - The 6to4 address is formed by combining the prefix 2002::/16 with the 32 bits of a public IPv4 address, forming a 48-bit prefix.
  - 6to4 is a tunneling technique described in RFC 3056.

Multicast

- In IPv6, multicast traffic operates in the same way that it does in IPv4.
- Arbitrarily located IPv6 nodes can listen for multicast traffic on an arbitrary IPv6 multicast address.
- IPv6 nodes can listen to multiple multicast addresses at the same time.
- Nodes can join or leave a multicast group at any time.

Multicast IPv6 Addresses



Flags

- The first low-order bit is the Transient (T) flag.
  - When set to 0, the T flag indicates that the multicast address is a permanently assigned (well-known) multicast address allocated by IANA.
  - When set to 1, the T flag indicates that the multicast address is a transient (non-permanently-assigned) multicast address.
- The second low-order bit is for the Prefix (P) flag, which indicates whether the multicast address is based on a unicast address prefix.
  - RFC 3306 describes the P flag.
- The third low-order bit is for the Rendezvous Point Address (R) flag, which indicates whether the multicast address contains an embedded rendezvous point address.
  - RFC 3956 describes the R flag.

Scope

- Indicates the scope of the IPv6 internetwork for which the multicast traffic is intended.
- In addition to information provided by multicast routing protocols, routers use the multicast scope to determine whether multicast traffic can be forwarded.
- The most prevalent values for the Scope field are
  - 1 (interface-local scope),
  - 2 (link-local scope), and
  - 5 (site-local scope).
- For example, traffic with the multicast address of FF02::2 has a link-local scope.
  - An IPv6 router never forwards this traffic beyond the local link.

Group ID

- Identifies the multicast group and is unique within the scope.
- The size of this field is 112 bits.
- Permanently assigned group IDs are independent of the scope.
- Transient group IDs are only relevant to a specific scope.
- Multicast addresses from FF01:: through FF0F:: are reserved, well-known addresses.
- List of permanently assigned IPv6 multicast addresses:

  http://www.iana.org/assignments/ipv6-multicast-addresses

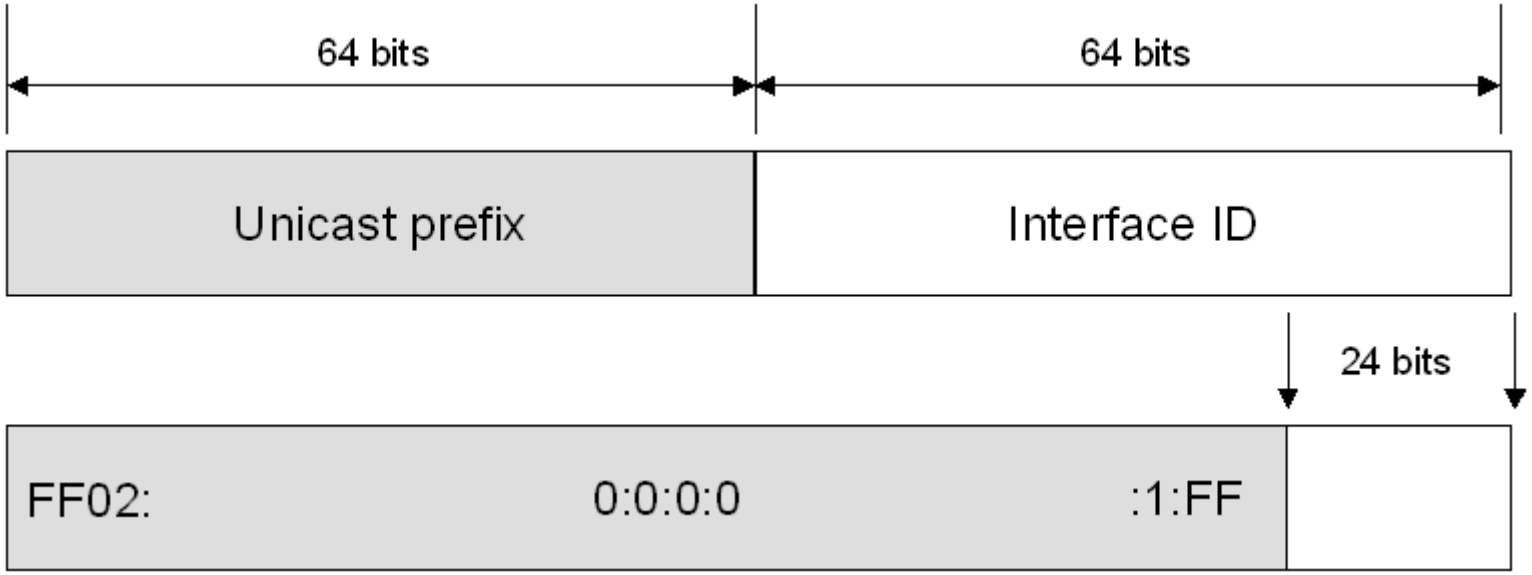
All-Nodes and All-Routers

- To identify all nodes for the interface-local and link-local scopes, the following addresses are defined:
  - FF01::1 (interface-local scope all-nodes multicast address)
  - FF02::1 (link-local scope all-nodes multicast address)
- To identify all routers for the interface-local, link-local, and site-local scopes, the following addresses are defined:
  - FF01::2 (interface-local scope all-routers multicast address)
  - FF02::2 (link-local scope all-routers multicast address)
  - FF05::2 (site-local scope all-routers multicast address)

Solicited-Node

- The solicited-node address facilitates the efficient querying of network nodes during address resolution
  - In IPv4, the ARP Request frame is sent to the MAC-level broadcast, disturbing all nodes on the network segment, including those that are not running IPv4
- IPv6 uses the Neighbor Solicitation message to perform address resolution
  - However, instead of using the local-link scope all-nodes multicast address as the Neighbor Solicitation message destination, which would disturb all IPv6 nodes on the local link, the solicited-node multicast address is used

Solicited-Node Address



- FF02:0:0:0:0:1:FF00::/104
- FF02::1:FF00:0/104

Example

- Node A is assigned the link-local address of FE80::2AA:FF:FE28:9C5A and is also listening on the corresponding solicited-node multicast address of FF02::1:FF28:9C5A (the underline highlights the correspondence of the last six hexadecimal digits).
- Node B on the local link must resolve Node A's link-local address FE80::2AA:FF:FE28:9C5A to its corresponding link-layer address.
- Node B sends a Neighbor Solicitation message to the solicited node multicast address of FF02::1:FF28:9C5A.
- Because Node A is listening on this multicast address, it processes the Neighbor Solicitation message and sends a unicast Neighbor Advertisement message in reply.

Anycast

- An anycast address is assigned to multiple interfaces.
  - Packets addressed to an anycast address are forwarded by the routing infrastructure to the nearest interface to which the anycast address is assigned.
  - In order to facilitate delivery, the routing infrastructure must be aware of the interfaces assigned anycast addresses and their “distance” in terms of routing metrics.
- At present, anycast addresses are only used as destination addresses and are only assigned to routers.
  - Anycast addresses are assigned out of the unicast address space and the scope of an anycast address is the scope of the type of unicast address from which the anycast address is assigned.

Subnet-Router Anycast Address

- The Subnet-Router anycast address is predefined and required.
- It is created from the subnet prefix for a given interface.
- To construct the Subnet-Router anycast address, the bits in the subnet prefix are fixed at their appropriate values and the remaining bits are set to 0.
- All router interfaces attached to a subnet are assigned the Subnet-Router anycast address for that subnet.
- The Subnet-Router anycast address is used for communication with one of multiple routers attached to a remote subnet.

IPv6 Addresses for a Host

- An IPv4 host with a single network adapter typically has a single IPv4 address assigned to that adapter.
- An IPv6 host, however, usually has multiple IPv6 addresses—even with a single interface.
- An IPv6 host is assigned the following unicast addresses:
  - A link-local address for each interface
  - Unicast addresses for each interface (which could be a site-local address and one or multiple global unicast addresses)
  - The loopback address (::1) for the loopback interface

Multihome

- Typical IPv6 hosts are logically multihomed because they have at least two addresses with which they can receive packets—
  - a link-local address for local link traffic and
  - a routable site-local or global address.

Multicast

- Additionally, each host is listening for traffic on the following multicast addresses:
- The interface-local scope all-nodes multicast address (FF01::1)
- The link-local scope all-nodes multicast address (FF02::1)
- The solicited-node address for each unicast address on each interface
- The multicast addresses of joined groups on each interface

IPv6 Addresses for a Router

- An IPv6 router is assigned the following unicast addresses:
- A link-local address for each interface
- Unicast addresses for each interface (which could be a site-local address and one or multiple global unicast addresses)
- A Subnet-Router anycast address
- Additional anycast addresses (optional)
- The loopback address (::1) for the loopback interface

Multicast

- Additionally, each router is listening for traffic on the following multicast addresses:
- The interface-local scope all-nodes multicast address (FF01::1)
- The interface-local scope all-routers multicast address (FF01::2)
- The link-local scope all-nodes multicast address (FF02::1)
- The link-local scope all-routers multicast address (FF02::2)
- The site-local scope all-routers multicast address (FF05::2)
- The solicited-node address for each unicast address on each interface
- The multicast addresses of joined groups on each interface

Identifiant d'interface

- Différent types
  - EUI-64
  - Valeur aléatoire
    - Anonymat
    - Périodiquement l'adresse est mise dans l'état déprécié
      - http://www.ietf.org/rfc/rfc3041.txt
  - Manuel
    - De préférence pour les serveurs
    - Adresse ne change pas en cas de changement de la carte d'interface
  - Cryptographique
    - A partir de la clé publique
    - Cryptographic Generated Addresses (CGA)
      - http://www.ietf.org/rfc/rfc3972.txt

IPv6 Interface Identifiers

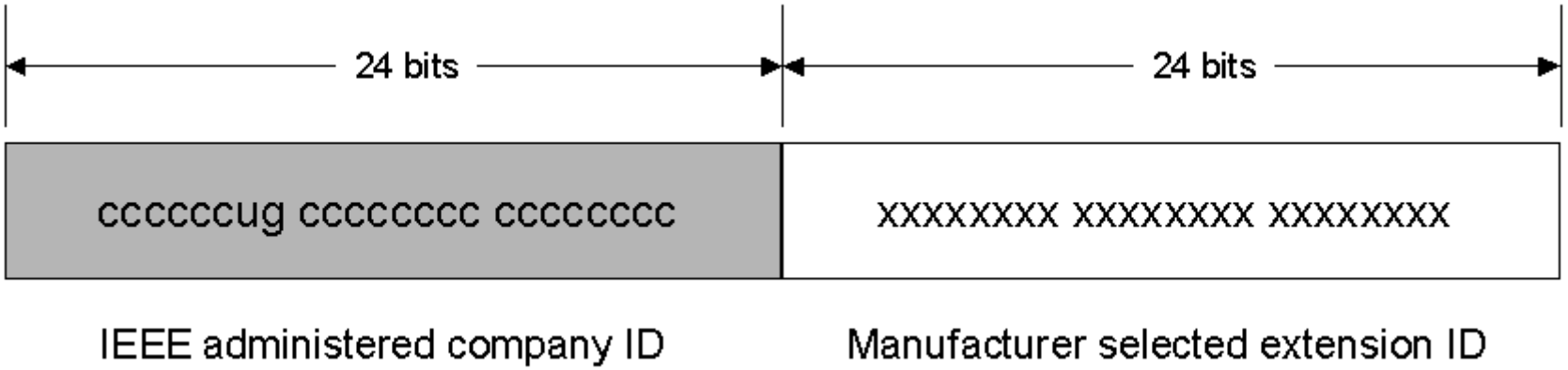
- The last 64 bits of an IPv6 address are the interface identifier that is unique to the 64-bit prefix of the IPv6 address.
- The following are the ways in which an IPv6 interface identifier is determined:
  - A 64-bit interface identifier that is derived from the Extended Unique Identifier (EUI)-64 address.
    - The 64-bit EUI-64 address is defined by the Institute of Electrical and Electronic Engineers (IEEE).
  - EUI-64 addresses are either assigned to a network adapter or derived from IEEE 802 addresses.
    - This is the default behavior for IPv6 in Windows XP and Windows Server 2003.

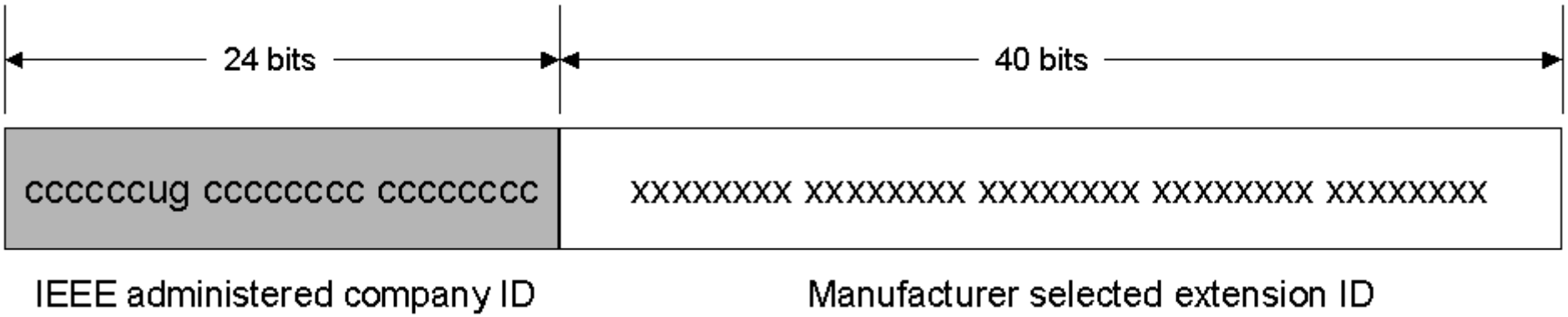
IPv6 Interface Identifiers (2)

- As defined in RFC 2472, an interface identifier can be based on link-layer addresses or serial numbers, or randomly generated when configuring a Point-to-Point Protocol (PPP) interface and an EUI-64 address is not available.
- It is assigned during manual address configuration.
- As defined in RFC 3041, it might have a temporarily assigned, randomly generated interface identifier to provide a level of anonymity when acting as a client.
- It is a permanent interface identifier that is randomly generated to mitigate address scans of unicast IPv6 addresses on a subnet.
  - This is the default behavior for IPv6 in Windows Vista and Windows Server "Longhorn."
  - You can disable this behavior with the

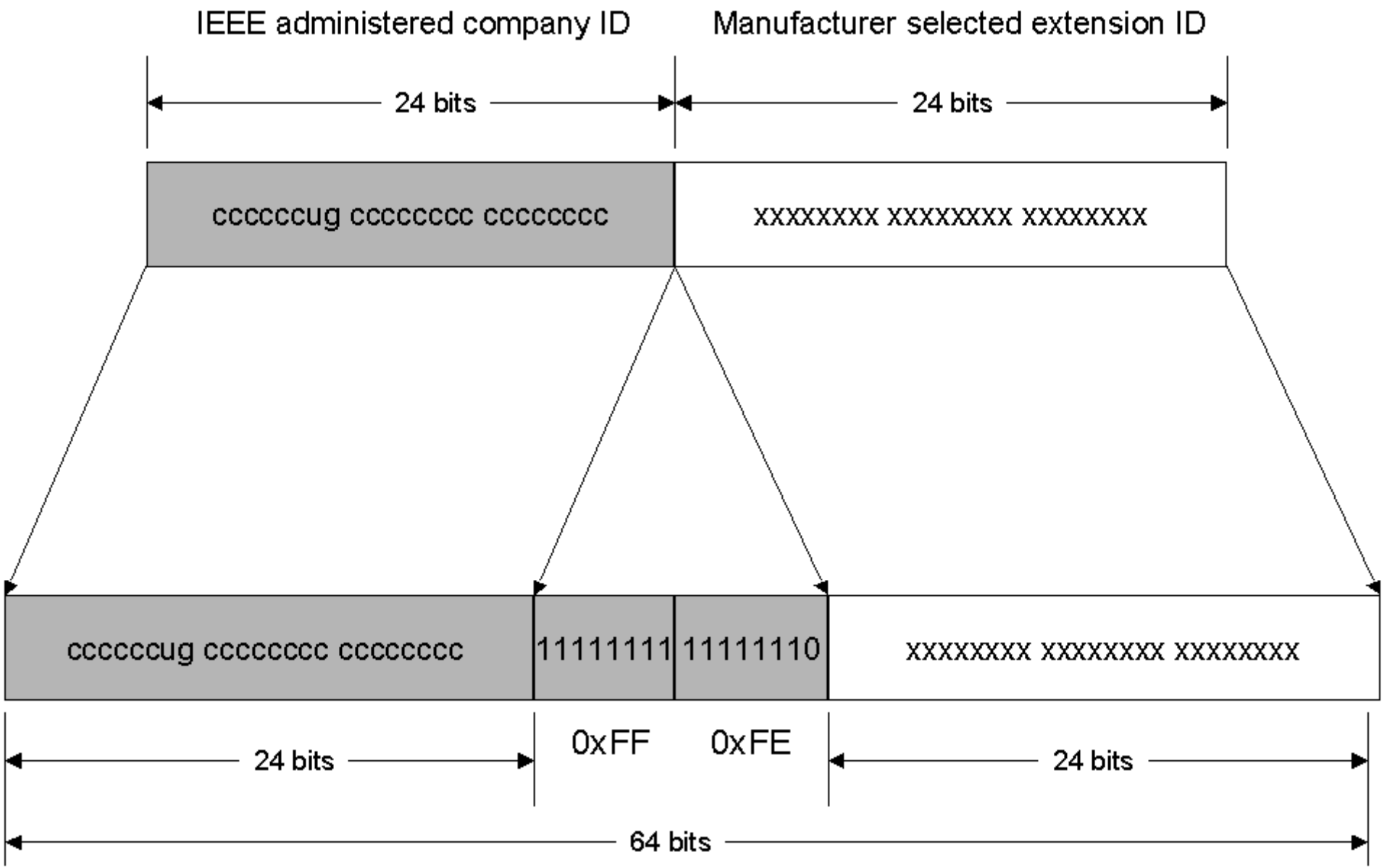
    netsh interface ipv6 set global randomizeidentifiers=disabled command.

MAC and EUI-64 Addresses

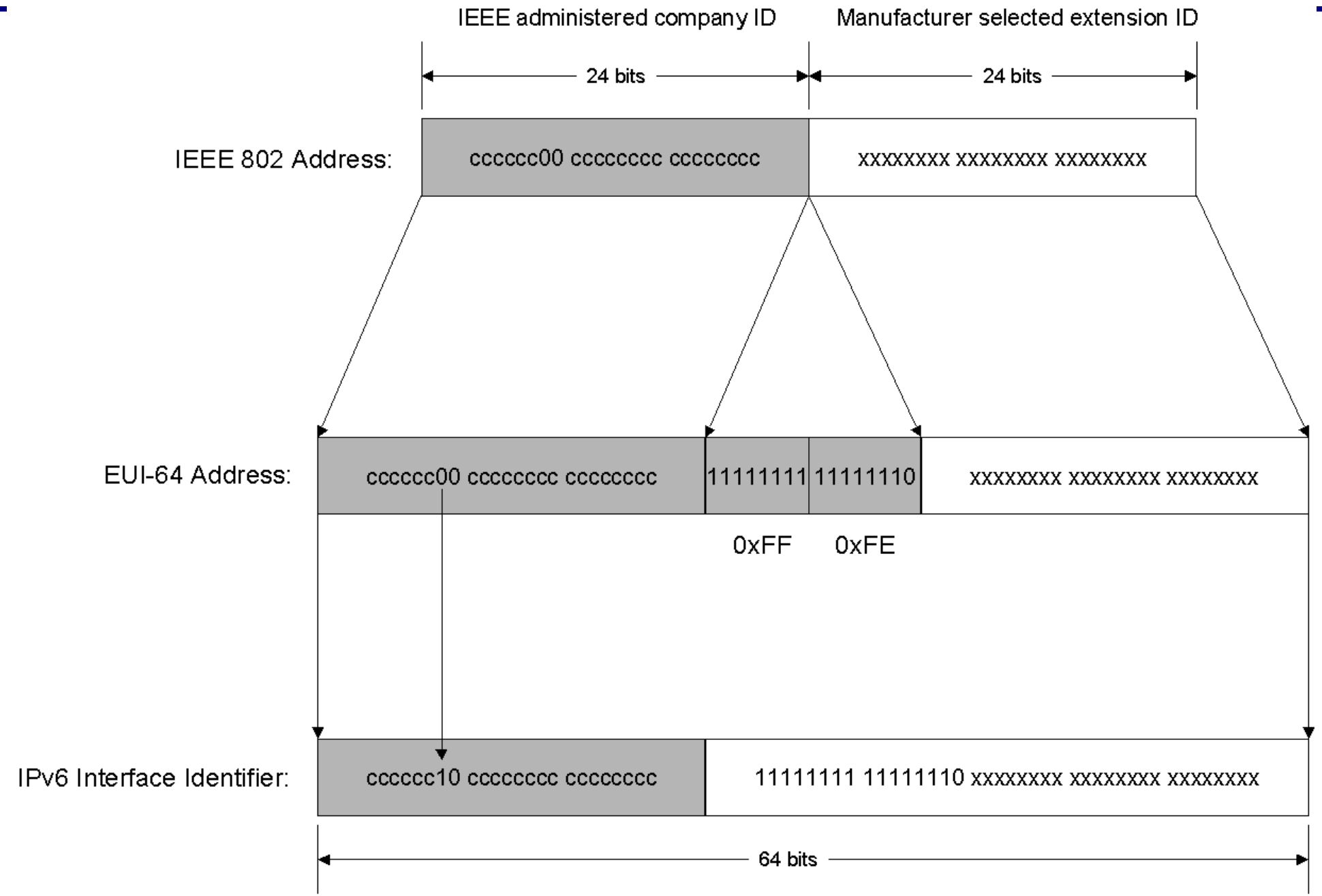




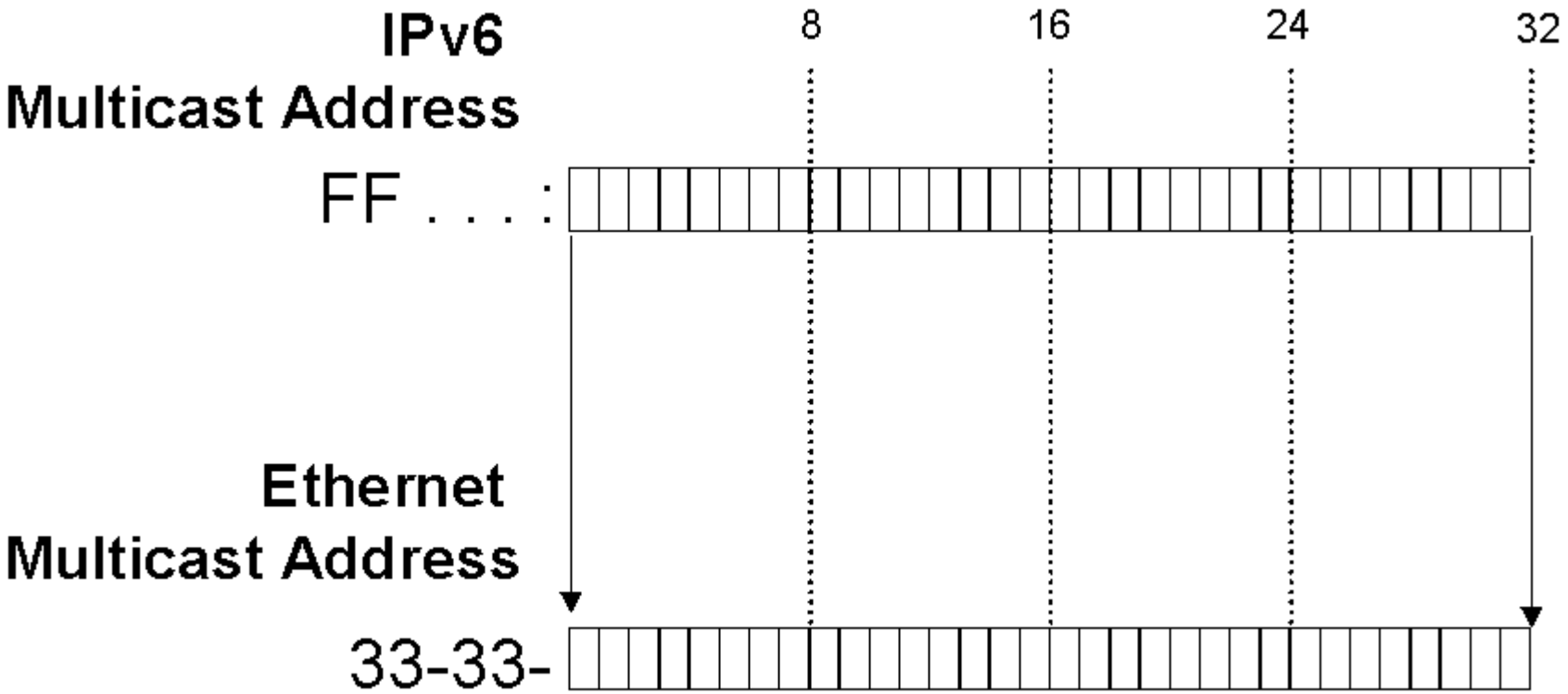
Mapping IEEE 802 to EUI-64



Mapping to IPv6 Interface Identifier



Mapping IPv6 Multicast Addresses to Ethernet @



Address Comparison

IPv4 Address	IPv6 Address
Internet address classes	Not applicable in IPv6
Multicast addresses (224.0.0.0/4)	IPv6 multicast addresses (FF00::/8)
Broadcast addresses	Not applicable in IPv6
Unspecified address is 0.0.0.0	Unspecified address is ::
Loopback address is 127.0.0.1	Loopback address is ::1
Public IP addresses	Global unicast addresses
Private IP addresses (10.0.0.0/8, 172.16.0.0/12, and 192.168.0.0/16)	Site-local addresses (FEC0::/10)
Autoconfigured addresses (169.254.0.0/16)	Link-local addresses (FE80::/64)
Text representation: Dotted decimal notation	Text representation: Colon hexadecimal format with suppression of leading zeros and zero compression. IPv4-compatible addresses are expressed in dotted decimal notation.
Network bits representation: Subnet mask in dotted decimal notation or prefix length	Network bits representation: Prefix length notation only
DNS name resolution: IPv4 host address (A) resource record	DNS name resolution: IPv6 host address (AAAA) resource record
DNS reverse resolution: IN-ADDR.ARPA domain	DNS reverse resolution: IP6.ARPA domain

Questions

- 1 -
- 2 -
- 3 -
- Vos questions
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Références

- CIDR
  http://www.cidr-report.org
- IANA/ICANN
  http://www.iana.org
- IPv6 Théorie et Pratique
  http://livre.point6.net/index.php/Les_extensions
- Microsoft, Introduction to IPv6
  http://technet.microsoft.com/library/bb726944.aspx