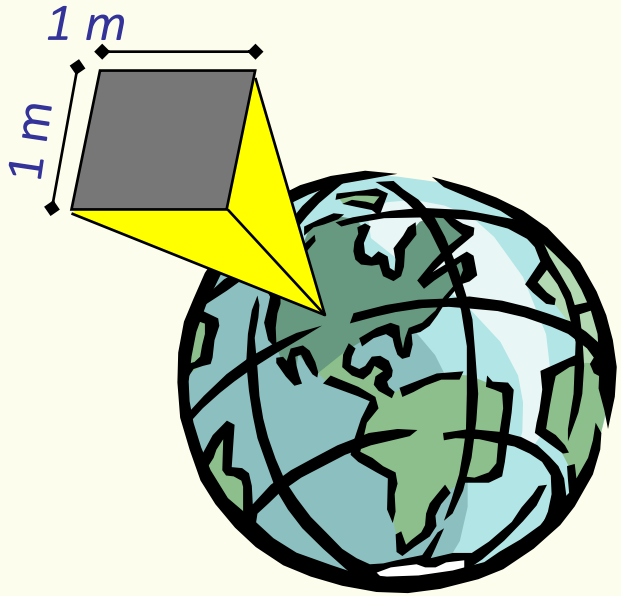
IPv6

Addressing

Motivation for IPv6

- IPv6 address space
  - 2^{128} = 340.282.366.920.938.463.463.374.607.431.768.211.456
  - 340 trillion trillion trillion (i.e. ~ 340 x 10^{36})

- About 6.65*10^{23} addresses per square meter on earth (including waters)



Address categories

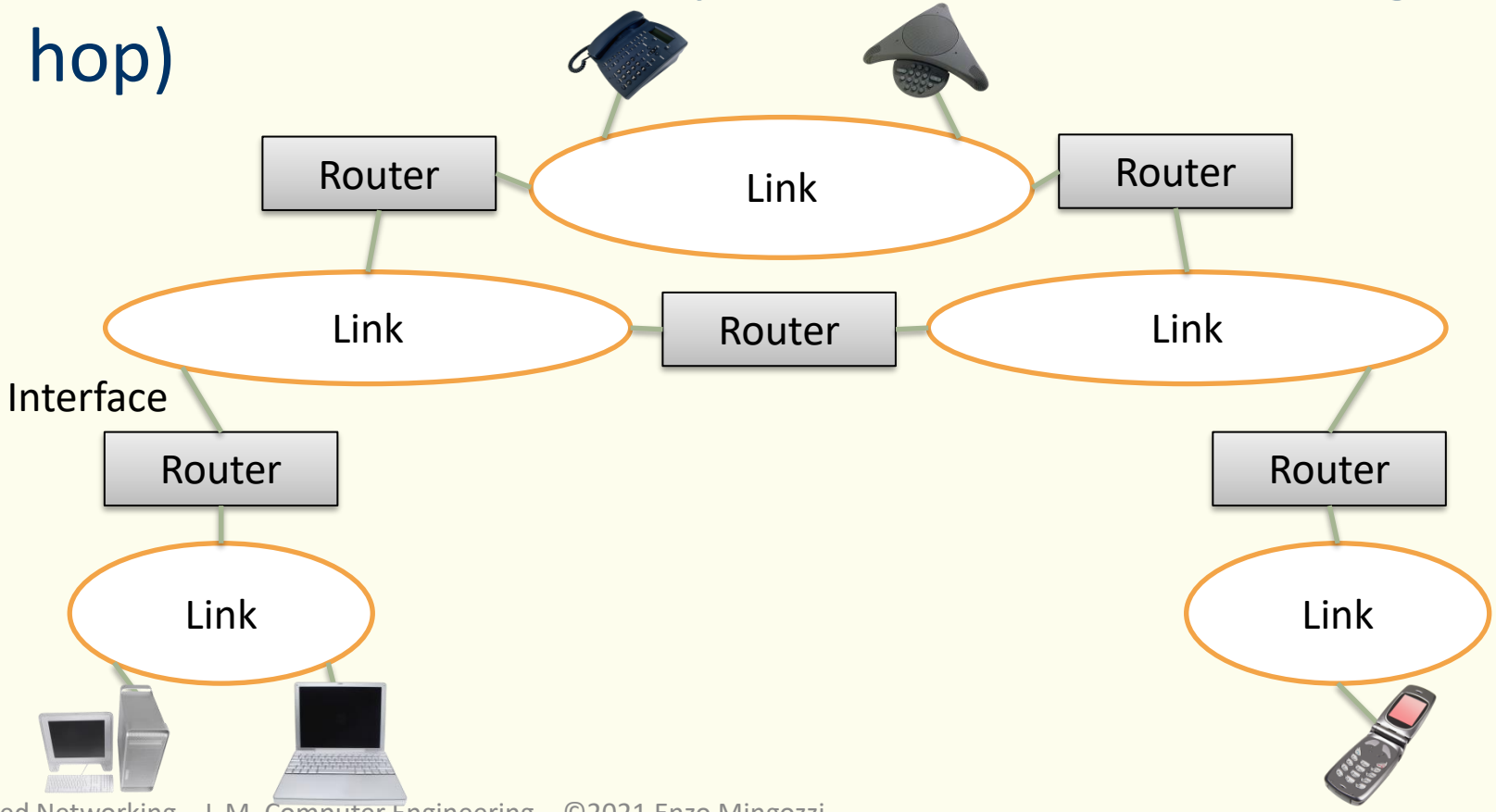
- *Unicast*
  - A ***unicast*** address uniquely identifies an interface of an IPv6 node. A packet sent to a unicast address is delivered to the interface identified by that address
- *Multicast*
  - A ***multicast*** address identifies a group of IPv6 interfaces. A packet sent to a multicast address is processed by all members of the multicast group
- *Anycast*
  - An ***anycast*** address is assigned to multiple interfaces (usually on multiple nodes). A packet sent to an anycast address is delivered to only one of these interfaces (usually the nearest one)

General rules

- An IPv6 address is assigned to an interface
  - At least one unicast address per interface of a node
  - A single interface can be assigned multiple IPv6 addresses of any type
- IPv6 addresses have a scope (encoded as part of the address)
  - The scope is **a topological span** within which the address may be used as a unique identifier
  - Global and non-global (e.g., link-local) scopes

IPv6 links

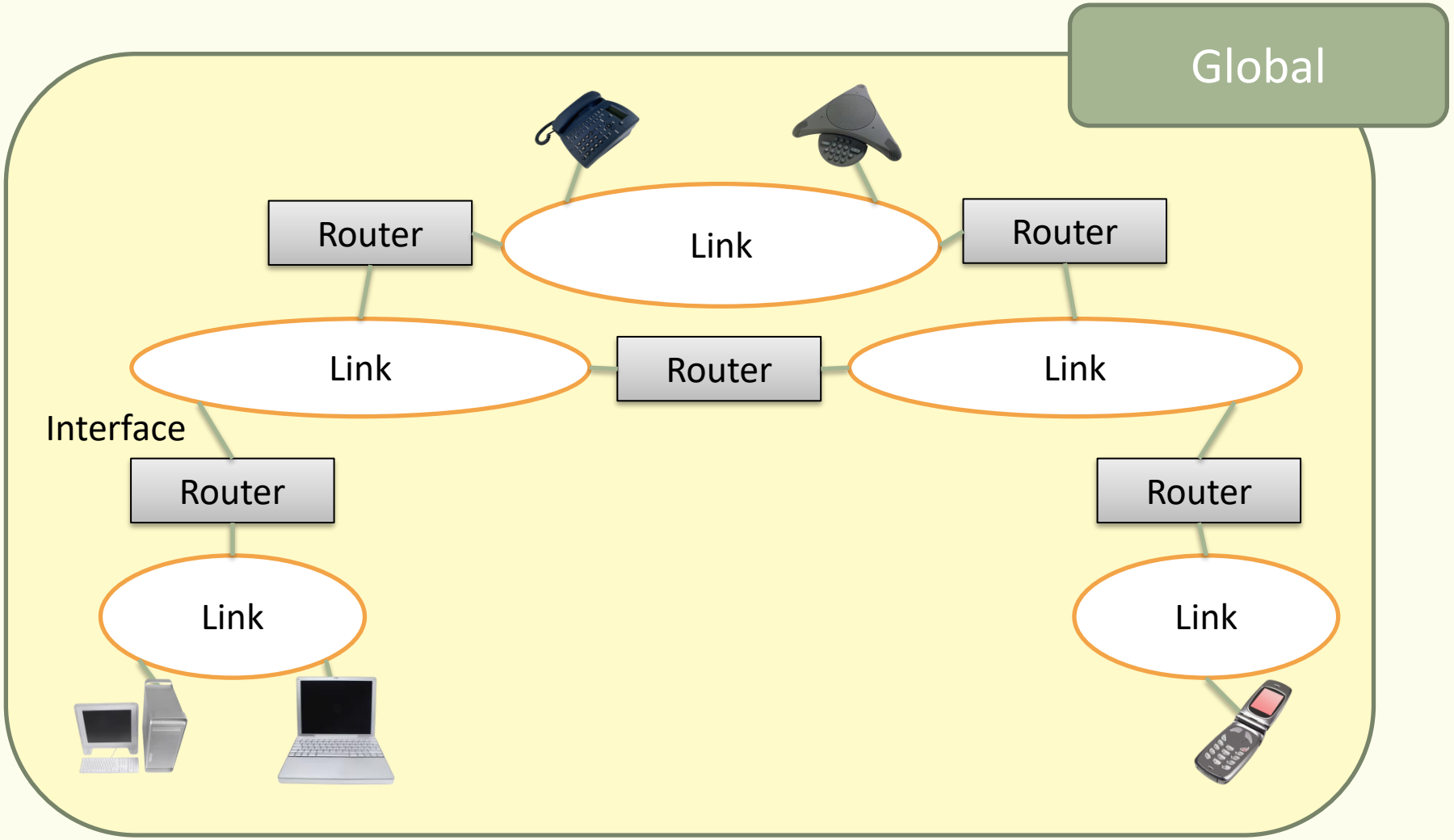
- Identified by a set of interfaces which can communicate directly with each other (single hop)



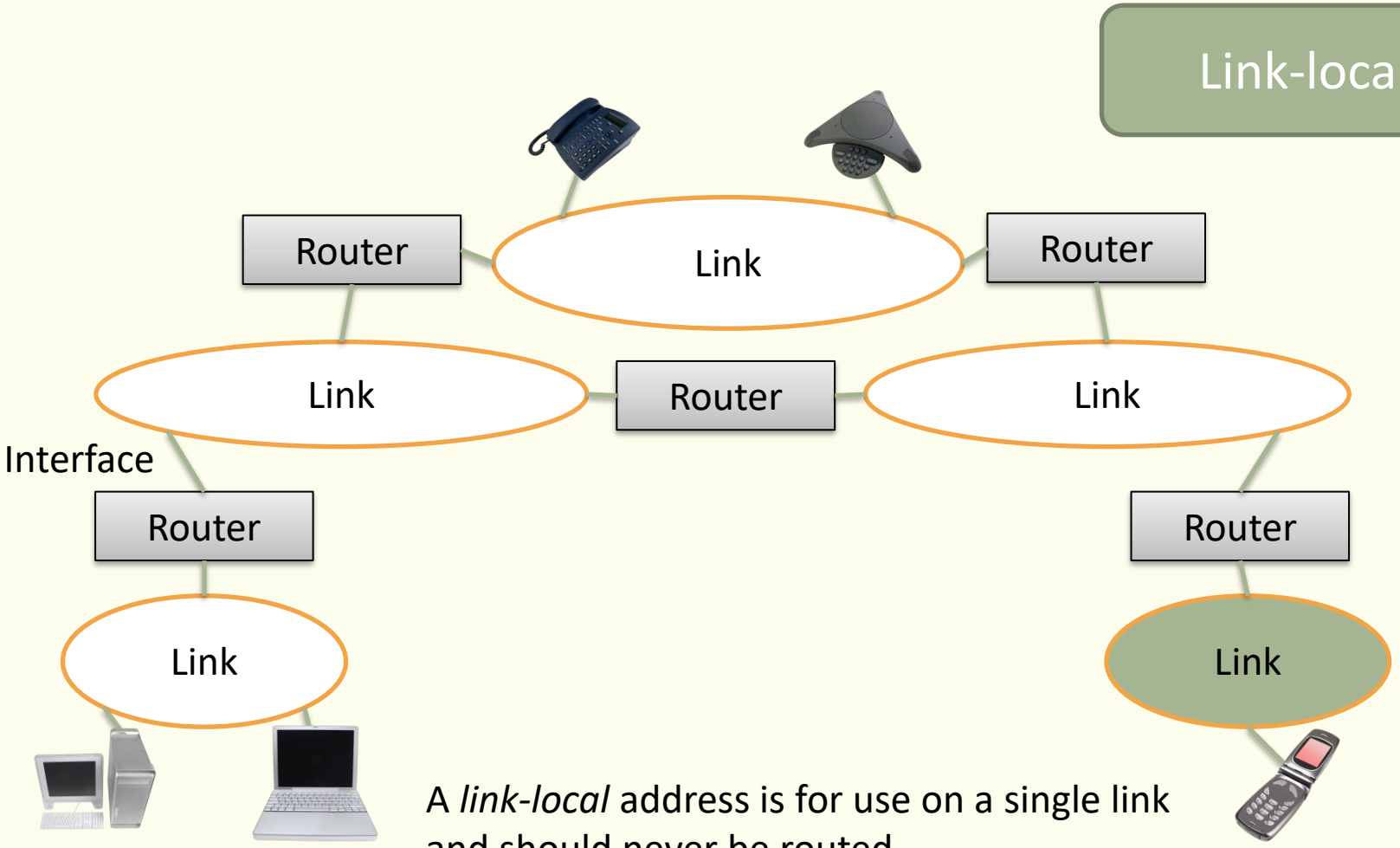
IPv6 links

- Typical assumptions about a link (e.g., Ethernet or point-to-point)
  - Stable (over time)
  - Single link-layer broadcast domain
  - Transitive (if A→B and B→C, then A→C)
- Implications
  - Network prefixes can be used to determine if an interface is attached to a given link
  - Duplicate address detection can be simply addressed

Address scope

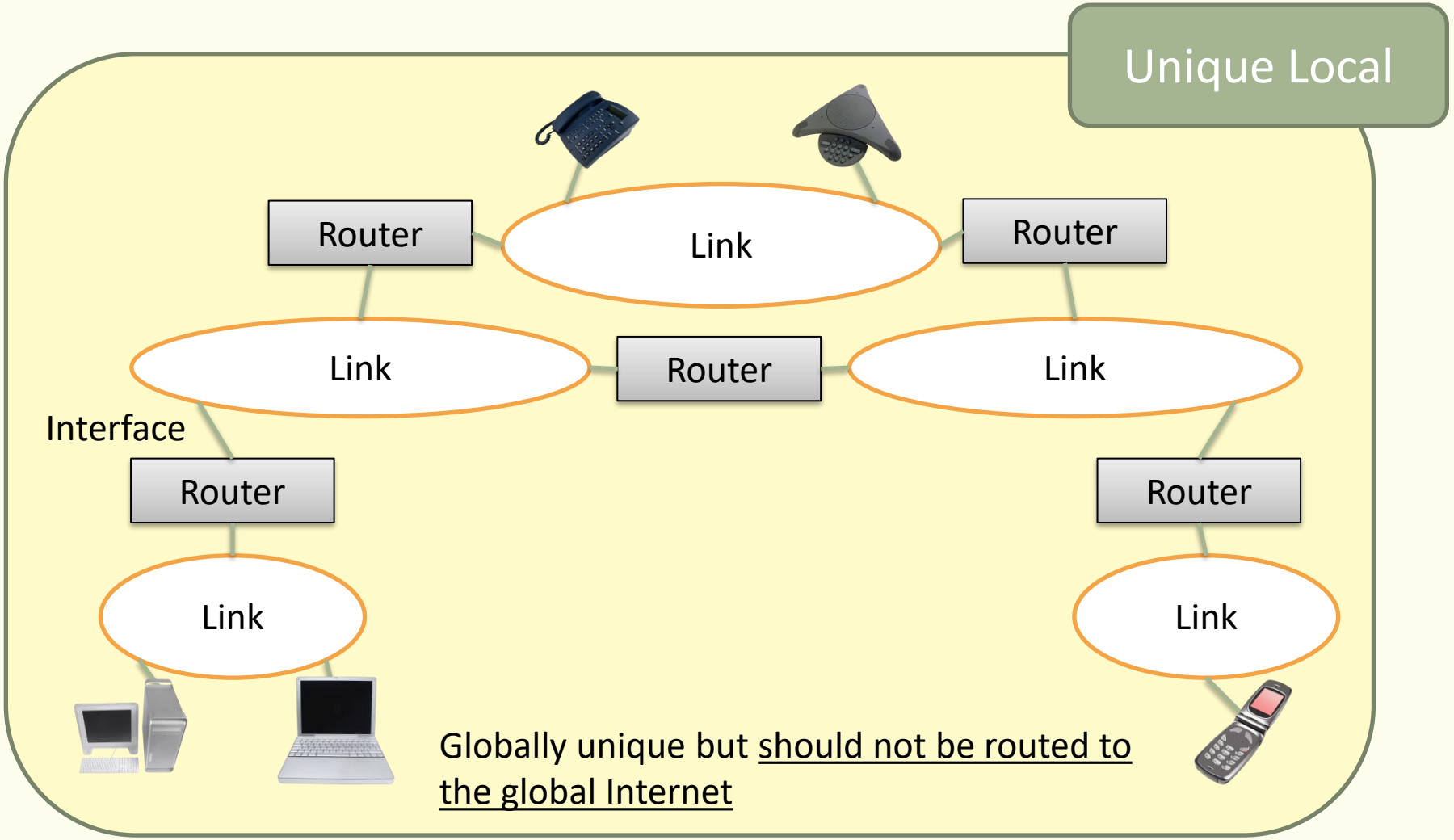


Address scope



A *link-local* address is for use on a single link and should never be routed

Address scope



Address notation

- Format: **x:x:x:x:x:x:x:x**
  - **x** is a 16-bit block represented with four hex digits
- Abbreviation rules
  - Leading zeros can be skipped
    - 09C0 = 9C0
    - 0000 = 0
    - 2031:**000**0:130F:**000**0:**000**0:**0**9C0:876A:130B = 2031:0:130F:0:0:9C0:876A:130B
  - Consecutive zeros can be replaced by '::'
    - 2031:0:130F:**0000**:**0000**:9C0:876A:130B = 2031:0:130F::9C0:876A:130B
    - This rule can be applied **only once!**

Address notation

- FF01:0000:0000:0000:0000:0000:0000:0001 → FF01:0:0:0:0:0:0:1 → **FF01::1**
- E3D7:0000:0000:0000:51F4:00C8:C0A8:6420 → **E3D7::51F4:C8:C0A8:6420**
- 3FFE:0501:0008:0000:0260:97FF:FE40:EFAB → 3FFE:501:8:0:260:97FF:FE40:EFAB → **3FFE:501:8::260:97FF:FE40:EFAB**
- 0:0:0:0:0:0:0:0 → **::** (unspecified address)
- 0:0:0:0:0:0:0:1 → **::1** (loopback address)

Prefix notation

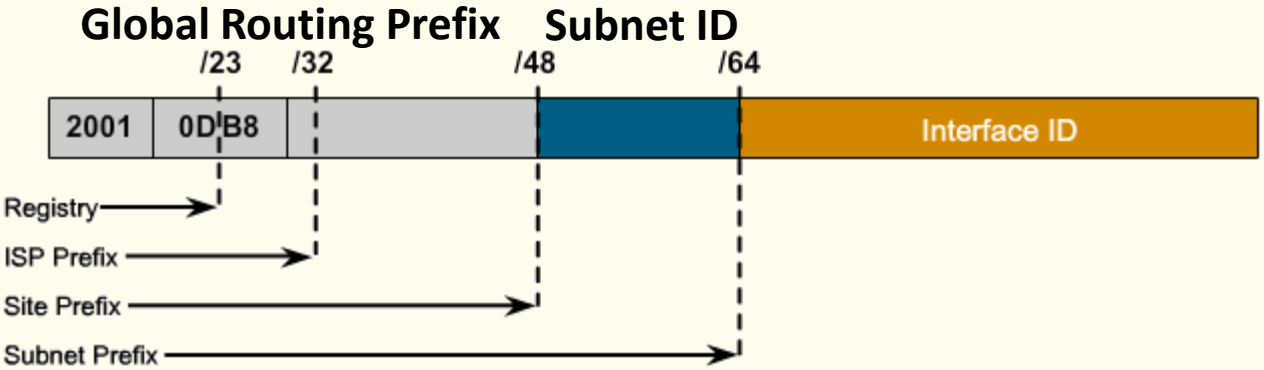
- Similar to IPv4 with CIDR
  - [IPv6 address]/[prefix length]
- Identifies a set of addresses (e.g., belonging to the same subnet)
- Examples
  - 2E78:DA53:1200::/40
  - 2001:DB8:0:56::/64

Prefix allocation

Allocation	Prefix binary	Prefix hex	Fraction of address space
Unassigned	**0000 0000**	**::0/8**	**1/256**
Reserved	0000 001		1/128
Global unicast	**001**	**2000::/3**	**1/8**
Link-local unicast	**1111 1110 10**	**FE80::/10**	**1/1024**
Reserved (formerly Site-local unicast)	1111 1110 11	FEC0::/10* * deprecated	1/1024
Unique-local	**1111 110**	**FC00::/7**	
Private administration	1111 1101	FD00::/8	
Multicast	**1111 1111**	**FF00::/8**	**1/256**

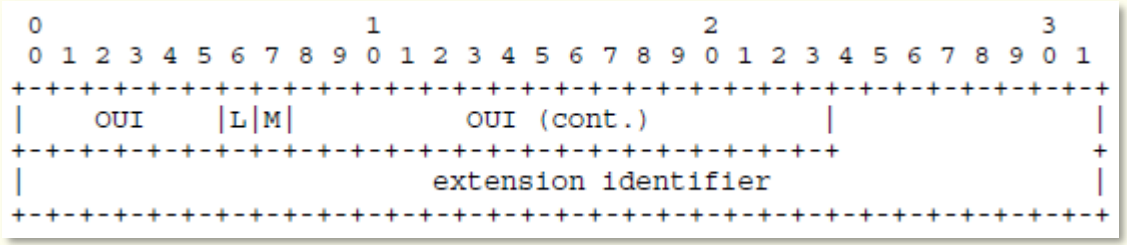
Global unicast address

- The *global routing prefix* identifies the address range allocated **to a site**



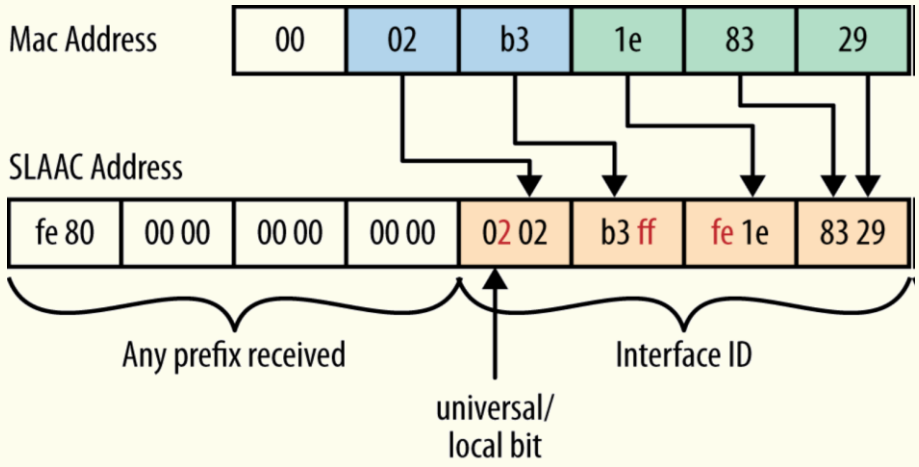
- Current allocations
  - *http://www.iana.org/assignments/ipv6-unicast-address-assignments*

Interface ID



- Interface ID: should follow the IEEE EUI-64 format
  - http://standards.ieee.org/regauth/oui/tutorials/EUI64.html

Esempio

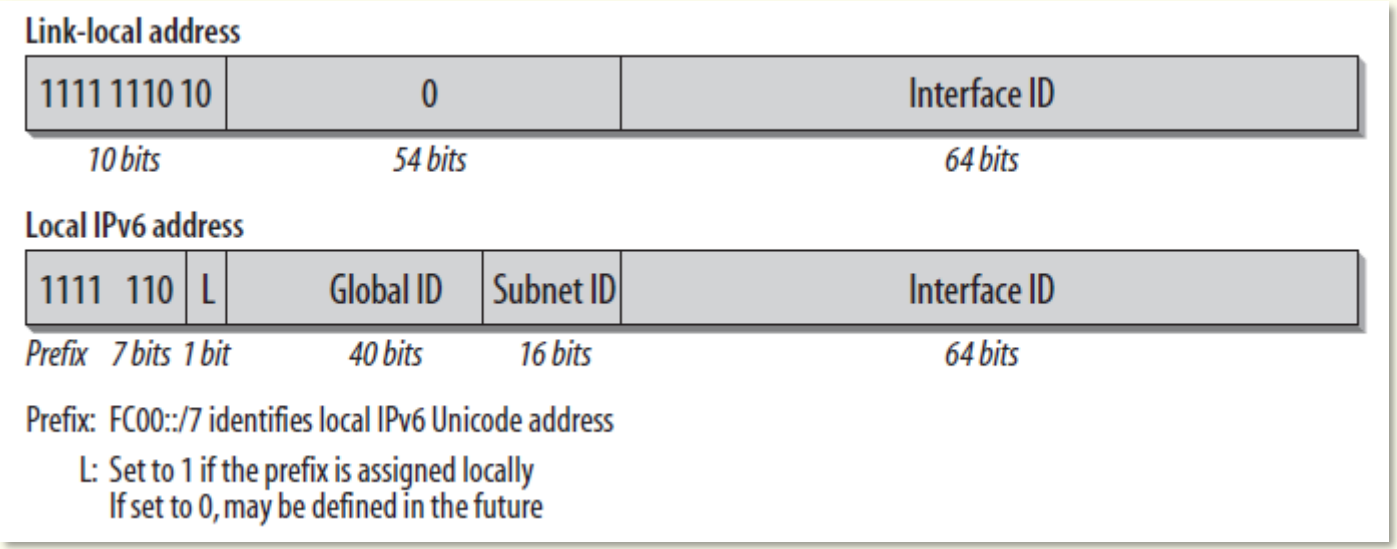


Interface ID

- **Privacy issue**
  - Internet access could be traced even across networks, because the identifier is unique to the interface
- Stable vs. *temporary transient* [RFC 4941] addresses
  - Assigned using a random number that changes in regular intervals
- Stable privacy addresses [RFC 7217]
  - not based on any hardware identifier
  - stable within a subnet, but change when the host moves from one network to another

Link-local and local addresses

- Link-local addresses are assigned by default through auto-configuration
- The Global ID of local IPv6 addresses is generated randomly

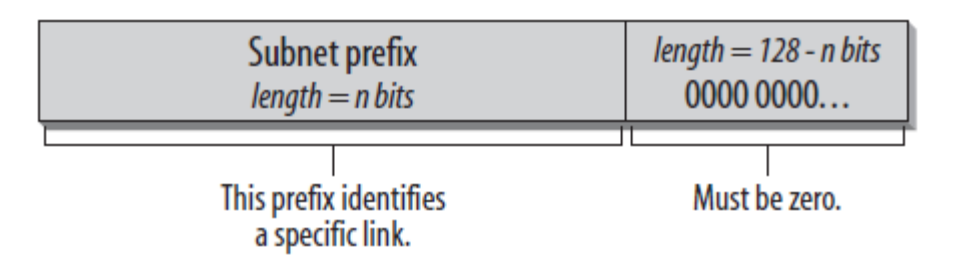


Anycast address

- An **anycast** address is assigned to multiple interfaces (usually on multiple nodes). A packet sent to an anycast address is delivered to only one of these interfaces (usually the nearest one)
- Designed to provide redundancy and load-balancing when the same service is provided by multiple hosts/routers
  - Multiple HTTP or DNS servers
  - Multiple routers of the same ISP
- Implemented by the routing functionality
- The sender has **no control** over which interface the packet will be delivered

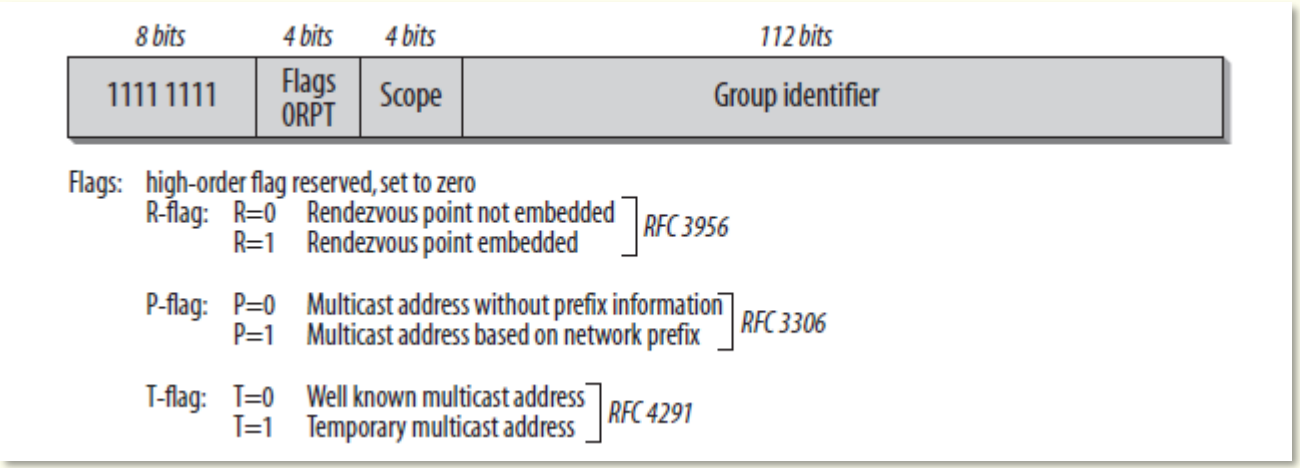
Anycast address

- The *subnet-router anycast address* is a required anycast address



Multicast addresses

- When a packet is sent to a multicast address, all members of the multicast group process the packet
  - A node can belong to more than one multicast group



Value	Description
1	Interface-local scope
2	Link-local scope
E	Global scope
…	…

Multicast addresses

- Well-known link-local scope multicast addresses

Address	Description
FF02:0:0:0:0:0:0:1	All-nodes address
FF02:0:0:0:0:0:0:2	All-routers address
FF02:0:0:0:0:0:0:5	OSPFIGP
FF02:0:0:0:0:0:0:9	RIP routers
FF02:0:0:0:0:0:0:A	EIGRP routers
FF02:0:0:0:0:0:0:B	Mobile agents
FF02:0:0:0:0:0:1:2	All DHCP agents
FF02:0:0:0:0:0:1:4	DTCP Announcement
FF02:0:0:0:0:1:FFXX:XXXX	Solicited-node address
…	…

References

- RFC 4291, “IPv6 Addressing Architecture,” 2006