




IPv6

What, Why, How

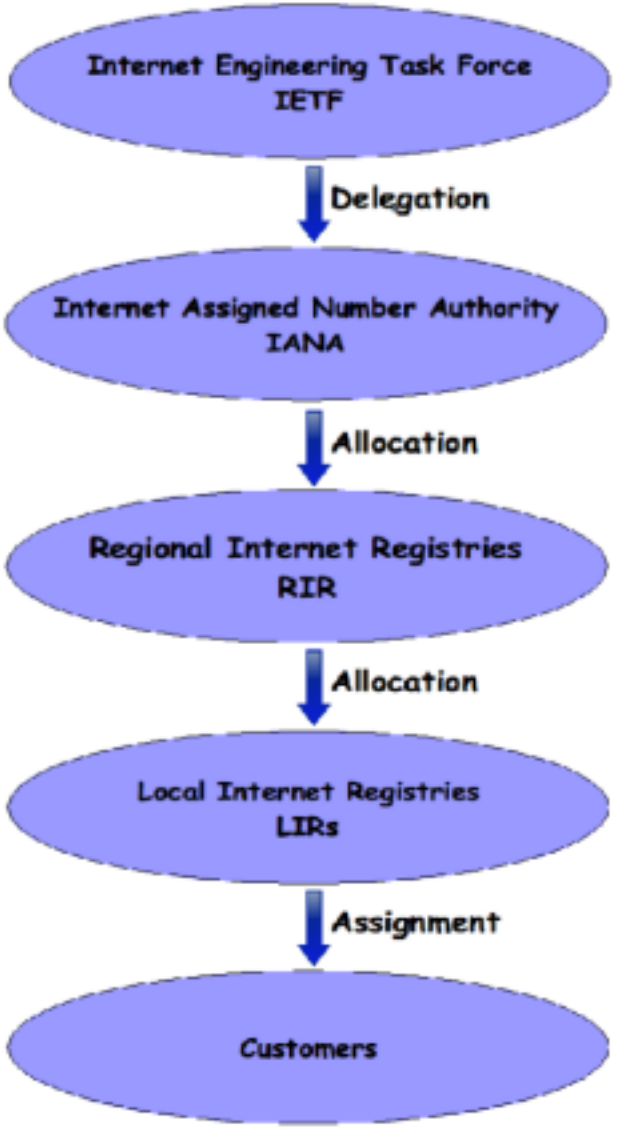
Jen Linkova aka Furry
furry – at -openwall.com
Openwall, Inc
http://www.openwall.com



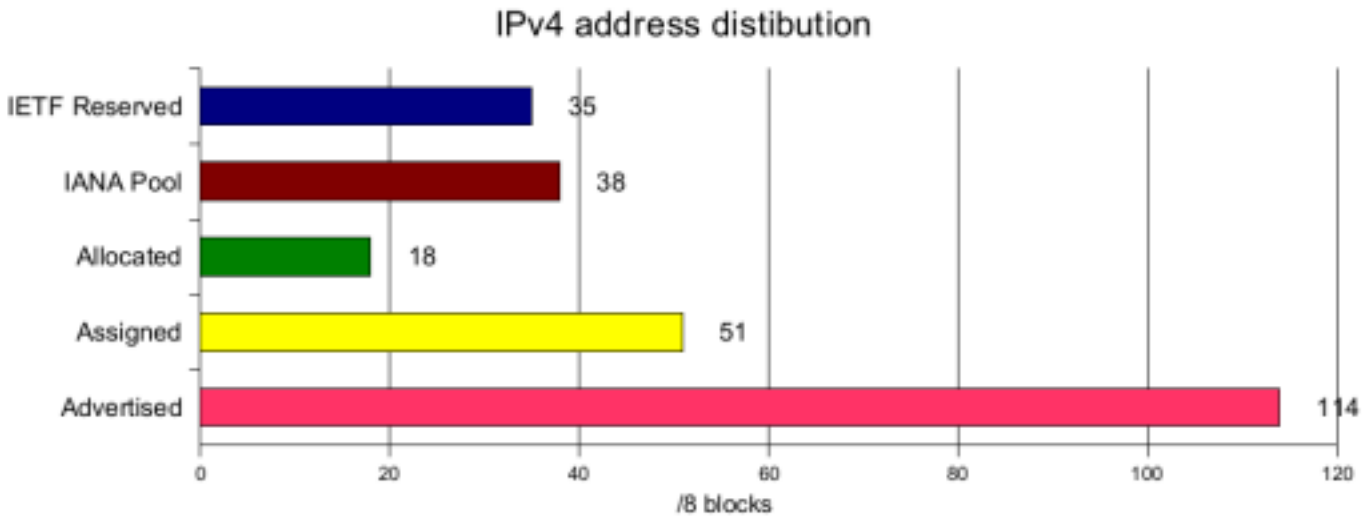



Revision 1.0

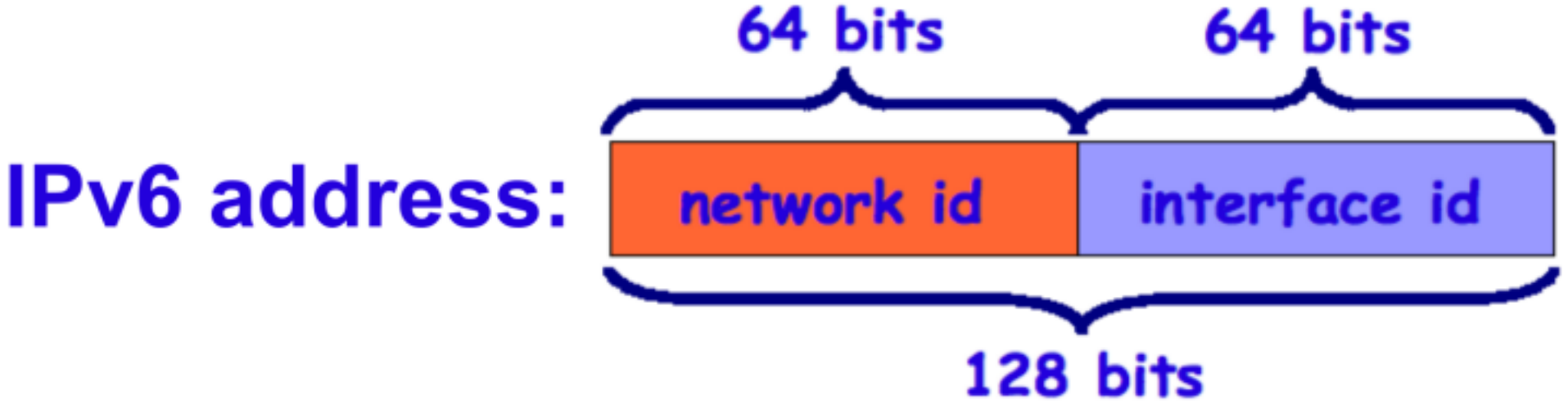
IPv4 Address Distibution



- 32-bit number
- 4 294 967 296 addresses
- 256 /8 network blocks

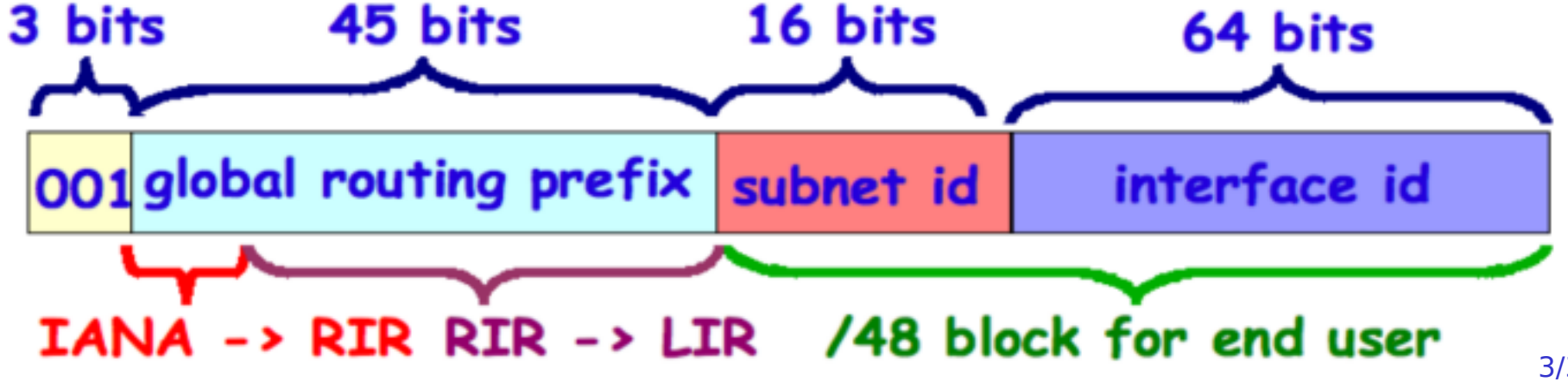


...or earn more! ;-)



- *340 282 366 920 938 463 463 374 607 431 768 211 456* total addresses
- 2^64 nodes per subnet
- fixed subnet size

http://docente.ifsc.edu.br/odilson/RED29004/enderec-v6.pdf



IPv6 Address Format

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

where X = 0000 ... FFFF (hex)

- 2001:0DB8:0000:0000:0008:8000:0000:417A
- 2001:DB8:0:0:8:8000:0:417A
- 2001:DB8::8:8000:0:417A
- 2001:DB8:0:0:8:8000::417A

Examples

- loopback address

  0:0:0:0:0:0:0:1 or ::1

- unspecified address

  0:0:0:0:0:0:0:0 or ::

- special exception: IPv4-mapped

  0:0:0:0:0:FFFF:192.0.2.1

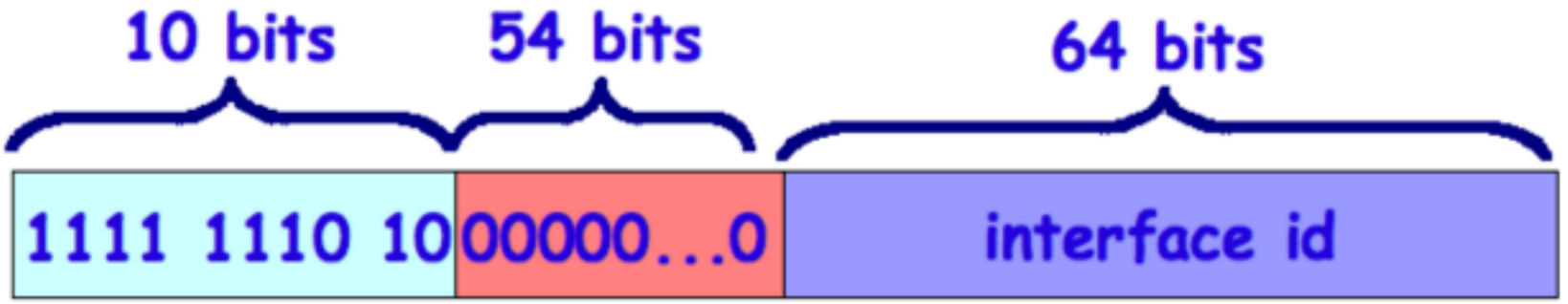
  ::FFFF:192.0.2.1

Executar:
ipv6calc --showinfo -i -m 2804:1454:1004:200:2247:47ff:fefd:7c24/64

IPv6 Address Types

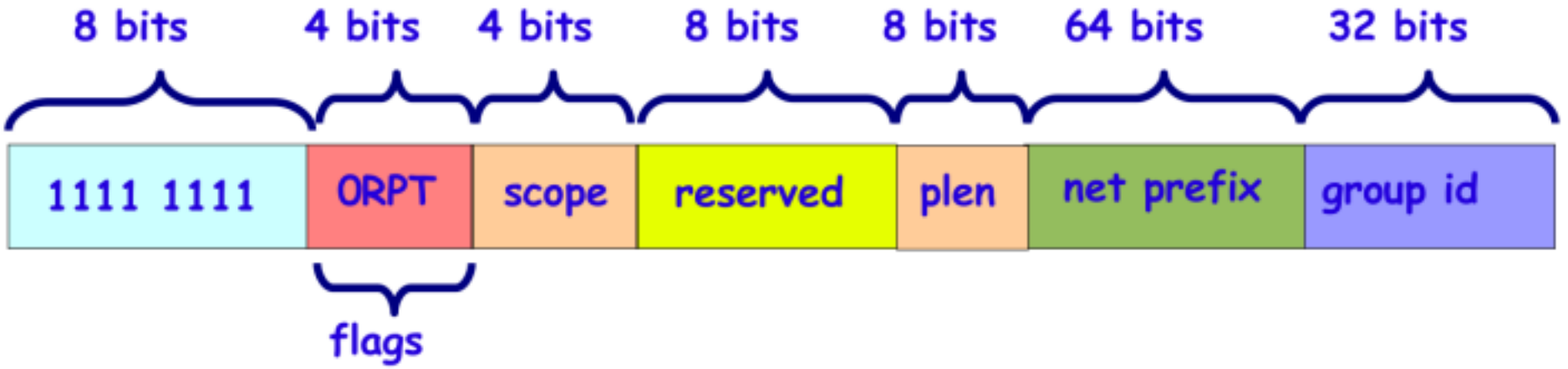
Address Type	Binary Prefix	Prefix
unspecified	000…0 (128 bits)	::/128
loopback	0000…01 (128 bits)	::1/128
link-local unicast	1111 1110 10	FE80::/10
multicast	1111 1111	FF00::/8
Global unicast	all other addresses	

Link-local Addresses



- FE80::/10 prefix
- Analogous to IPv4 169.254.0.0/16
- Automatically assigned to an interface
- Valid in the scope of the given link! Not to be routed!
- To be used for
  - auto-address configuration
  - neighbour discovery

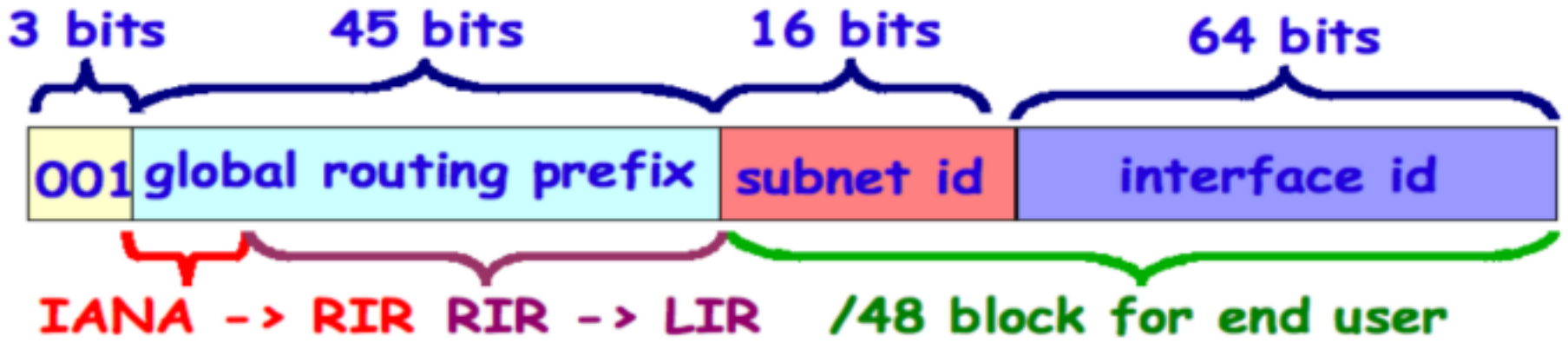
Multicast Addresses



- T=0 – permanently-assigned ("well-known") address, T=1 – non-permanently-assigned ("transient")
- Scope
  - 1 – node-local
  - 2 – link-local
  - 5 – site-local
  - 14 – global (Internet)
- Group ID identifiifes the mulicast group within the given scope. For example:
  - 1 – all nodes (scope = 1,2)
  - 2 – all routers (scope = 1,2,5)
  - 101 – all NTP servers
- Examples:
  - FF02::101 – all NTP-servers on the same link as a sender
  - FF02::2 – all routers on the same link as a sender
  - FF05::101 – all NTP-servers on the same site as a sender

Global Unicast

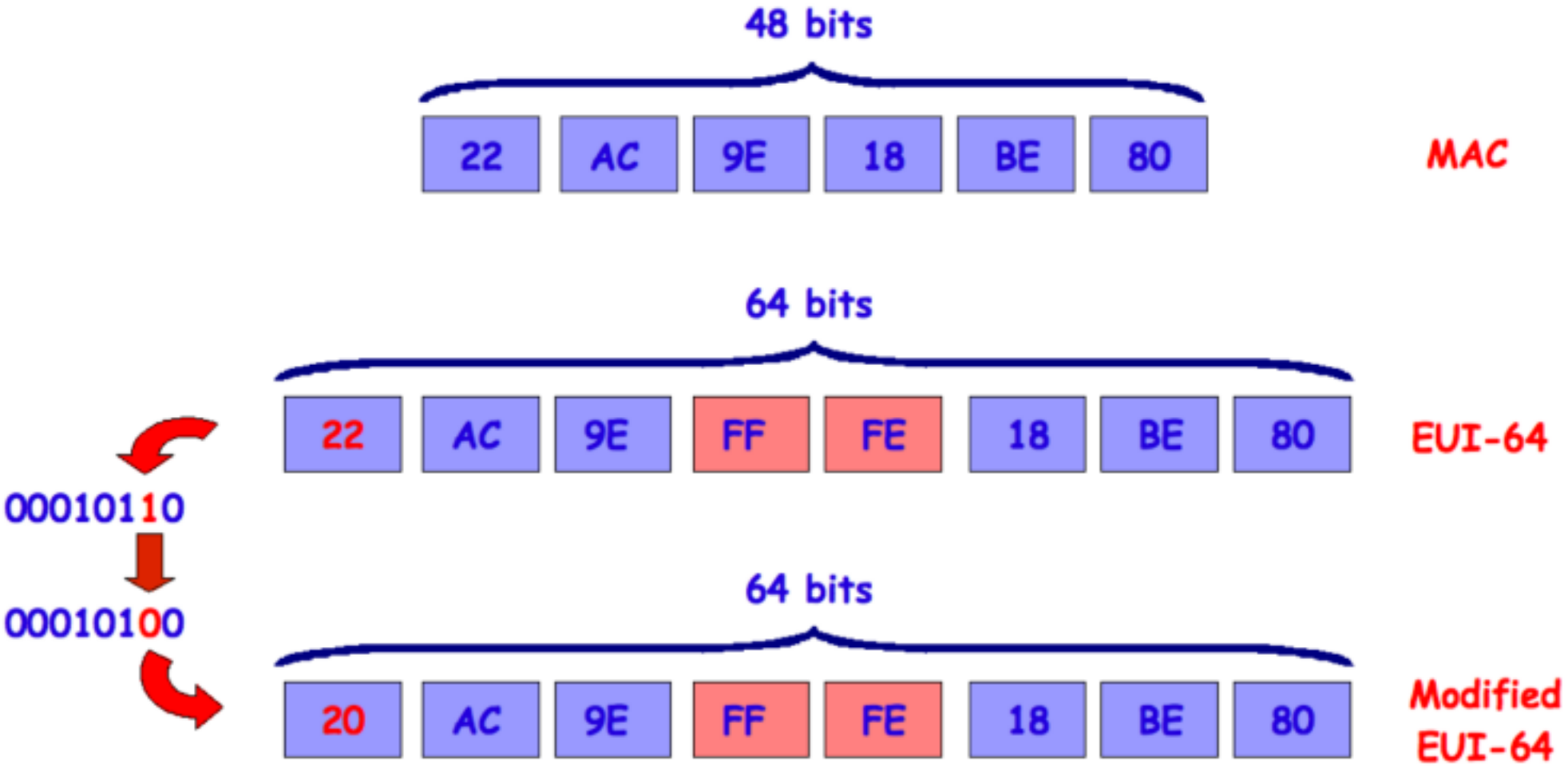
Address Type	Binary prefix	Prefix
unspecified	000...0 (128 bits)	::/128
loopback	0000...01 (128 bits)	::1/128
Ipv4-mapped	000...01111111111111111(96 bits)	::FFFF/96
ULA	1111 110	FC00::/7
Assigned to RIRs	001	2000::/3
Global unicast	all other addresses	



Interface Identifier
How to configure

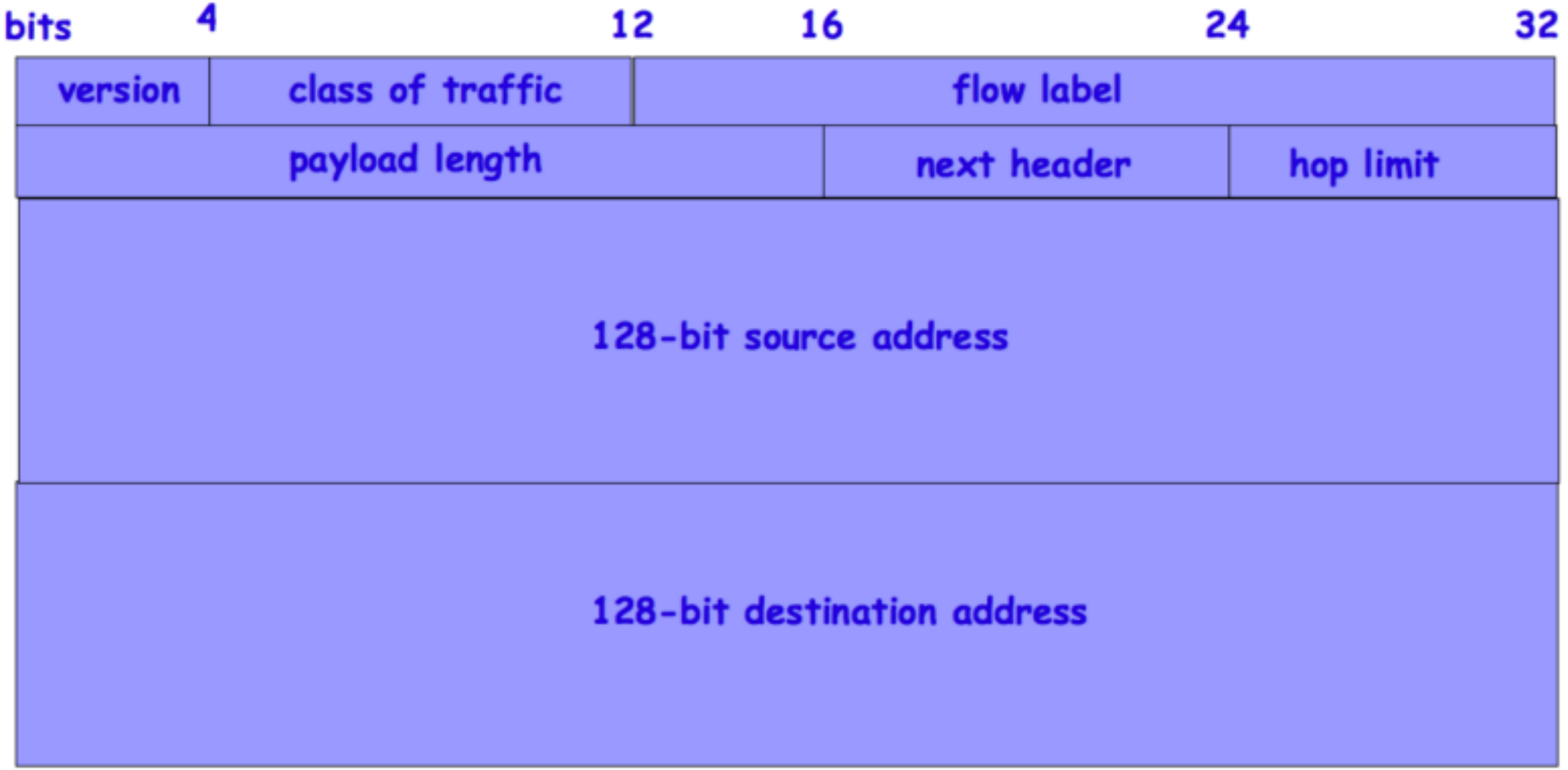
- Manual configuration
- Autoconfiguration (EUI-64-based interface ID)
- DHCPv6
- Pseudo-random interface ID
- Cryptographically generated ID

Extended Unique Identifier EUI-64



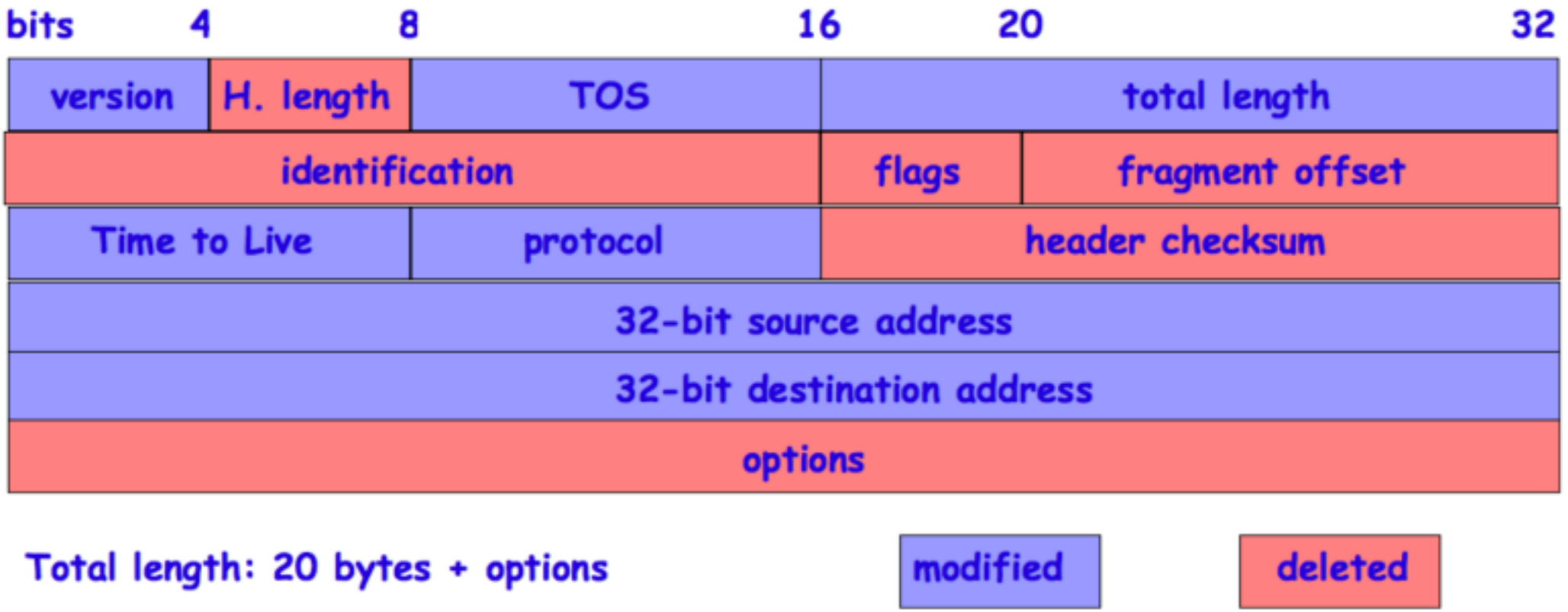
Therefore: ::1 – globally assigned EUI-64, but locally assigned MEUI-64

IPv6 Header Format



Total length: 40 bytes

IPv4 Header Format



Total length: 20 bytes + options

modified

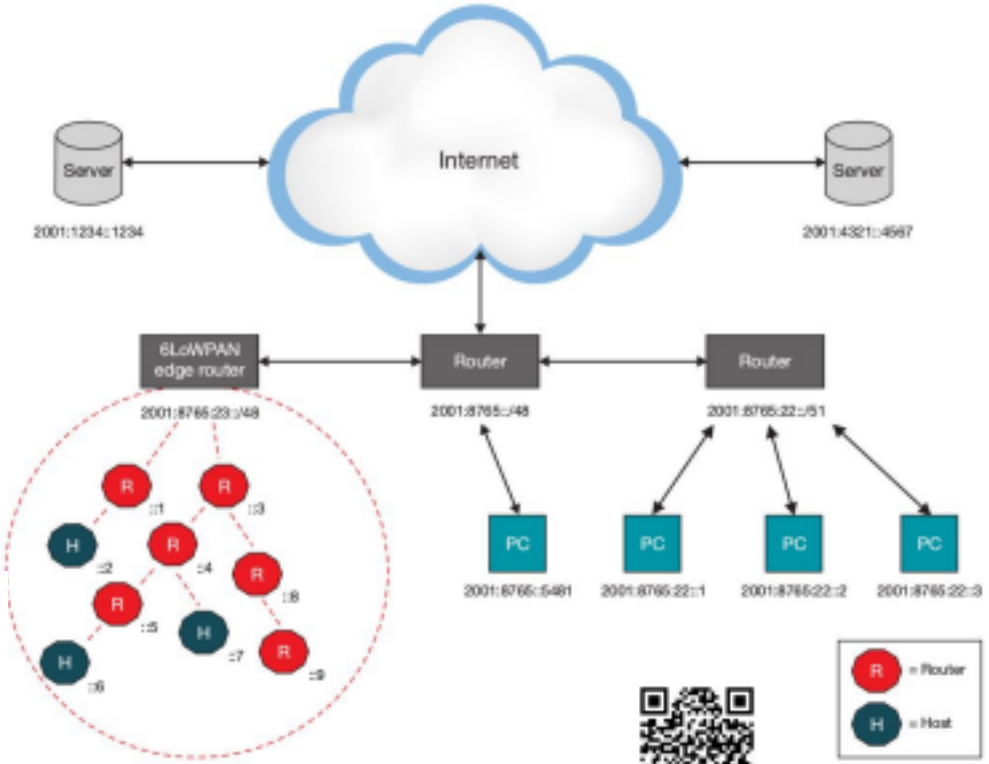
deleted

IPv6 Header

- Fixed length
- All optional/additional info is encoded in **Extension Header(s)**
- Is not protected by checksum
- **Payload** Length instead of **Total** Length
- “Time To Live” field is replaced by “Hop Limit” one to better reflect its functions

6LoWPAN

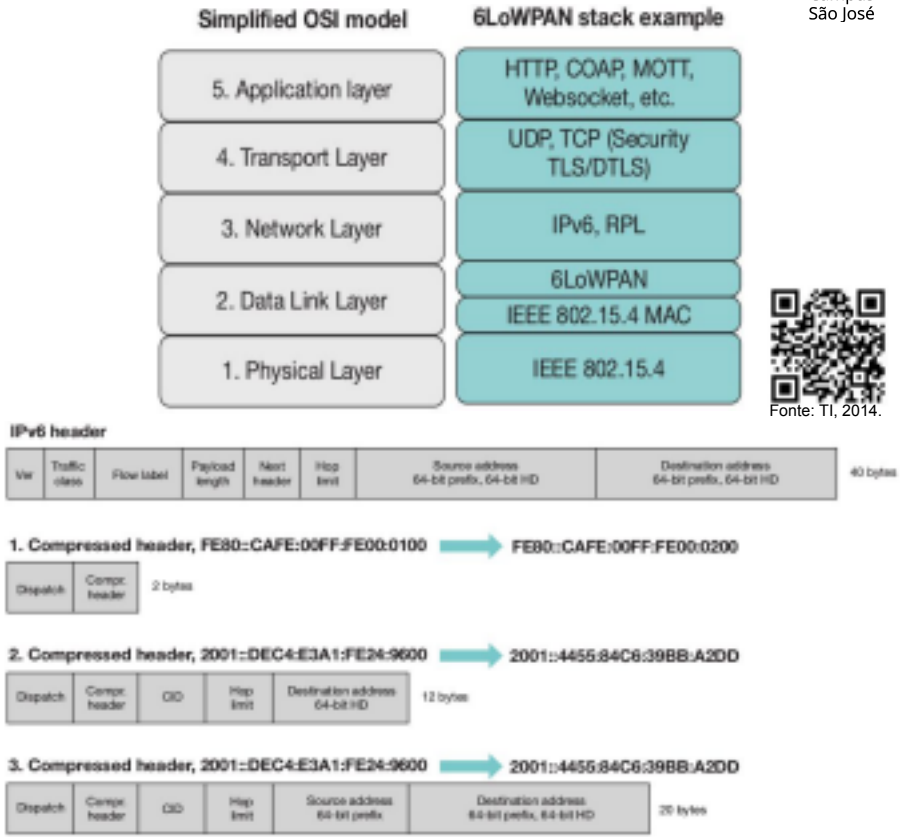
- IPv6 over Low power WPAN
  - IPv6 - 128 bits
  - Sobre IEEE 802.15.4
  - IP500
  - IPSO Alliance
- IPv6 em plataformas restritas
  - Baixo uso de memória
  - Baixa demanda de CPU
  - Baixo consumo de energia
- Fique de olho em
  - Thread
  - OpenThread



Fonte: TI, 2014.

6LoWPAN cont.

- Protocol Data Unit (PDU)
  - Ethernet: 1500 bytes
  - IEEE 802.15.4: 127 bytes
- Cabeçalhos
  - IPv6: 40 bytes
  - UDP: 8 bytes
  - TCP: 20 bytes
- Camada de adaptação
  - Compressão de cabeçalhos
    - Endereços IPv6 usam MAC
    - Compressão de TCP não faz parte da norma!
  - Fragmentação/remontagem
  - Stateless autoconf



Fonte: TI, 2014.

Control Protocol(s)

- IPv4 Control Protocols:
  - ARP (for Ethernet)
  - ICMP
  - IGMP
- IPv6 Control Protocol:

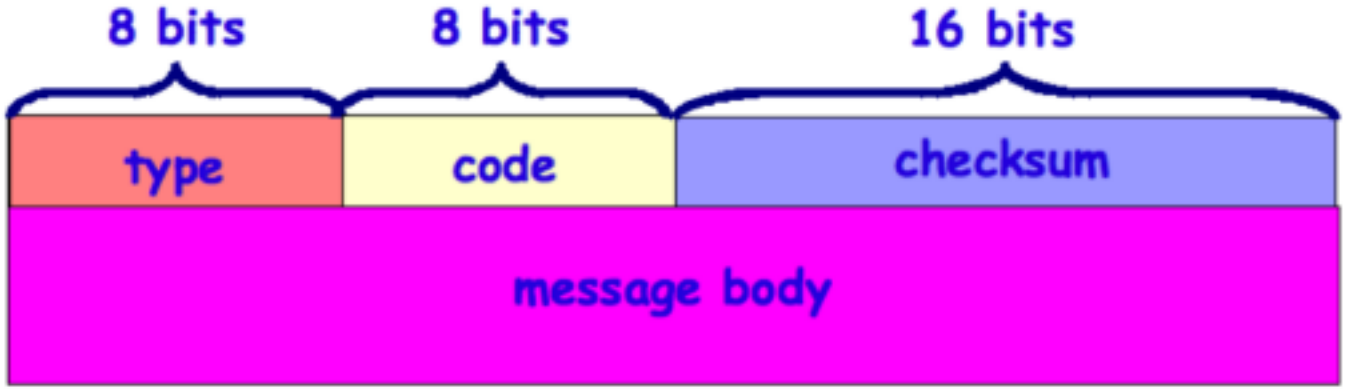
ICMPv6

(IPv6 Next Header value = 58)

Must be fully implemented & supported!

ICMPv6

- Type field:
  - 0 – 127: error messages
  - 128 – 255: informational messages
- Body includes the the start of the invoking packet!
- Must not be fragmented!
- Must not be originated in response to
  - ICMPv6 error or redirect messages
  - multicast/broadcast packets addresses (with some exceptions)



MULTIfunctions of MULTIcast

- IPv6 node **MUST** support multicast!
- Broadcast == «all nodes on this link» multicast group
  - *don't forget to enable IGMP snooping/GMRP on switches*
- All nodes with *"similar"* addresses share the same *solicited-node multicast address*
- Solicited-node multicast address format:
  - Globally-assigned prefix **FF02**::1:FF00:0:/104
  - low-order 24 bits of a node address

Example: a node 2001:db8::1:20cd:f345:5432:51d8 joins the multicast group FF02::1:FF00:0:32:51d8

ARP is Dead, Long Live ND!

- Much more than ARP (see Router Discovery and redirects)
- Reducing network load (multicast vs broadcast)
- Improving robustness of packet delivery
  - Neighbor unreachability detection (incl. half-link failures detection)
  - Notification from/to upper-layer!

Anycast

.

- The same “anycast” address is assigned to a group of interfaces (nodes)
- A packet sent to an anycast address is delivered to the “nearest” interface (node) having this address
- Allow to increase the service reliability
- Allocated from the unicast address space

IPv6 Node Configuration

- IPv6 address configuration:
  - Interface ID
    - manual
    - auto (stateful or stateless)
  - Network ID
    - manual
    - auto (stateful or stateless)
    - **pre-defined well-known prefix (link-local, FE80::/10)**
  - additional parameters (routes, e.g.)

Interface Autoconfiguration

- Modified EUI-64 constructed from MAC
  - *see next slides for some alternatives*
- What about collisions?
  - duplicate MAC addresses
  - duplicate interface ID (manual configuration, e.g.)
- Neighbor Discovery locates the owner of given IP address
- **Duplicate Address Detection (DAD)** based on ND

StateLess Address Auto Configuration (SLAAC)

- Link-local address is already here:
  - *well-know network ID*
  - *modified EUI-64 as interface ID*
  - *DAD to ensure uniqueness*
- **Ready to communicate with neighbors!**
- What's next?
  - other IPv6 network IDs (global, e.g.)
  - default gateway(s)
  - routing table
- **Routers have this info already!**

Your Router Is Your Neighbor!

- Neighbor Discovery (RFC4861)
- Routers join the “all routers” multicast group FF02::2
- Cliens send a «Router Solicitation» query (RS)
- Routers send out «Router Advertisiment» messages (RA)
  - periodically
  - in response to the RS query

Fragmentation

"Fragmentation considered harmful"

- Inefficient use of resources of hosts, routers and bandwidth
- Degraded performance due to loss of fragments
- Reassembly is difficult

Why fragmentation?

- MTU mismatch along the packet path (!tunnels!)
- TCP/IP implementations

Blocking PMTUD leads to packets disappearing into "black hole"

IPv6 & DNS

New Resource Record introduced: AAAA

furry:~ furry$ dig www.kame.net aaaa

www.kame.net. IN AAAA 2001:200::8002:203:47ff:fea5:3085

Reverse Delegation:

- the pseudo-domain ipv6.arpa
- Each label is a *nibble* (4 bits, one hex number)

Example:

PTR RR for an IPv6 address **2001:db8::20:219f:bd8c:17af**

f.a.7.1.c.8.d.b.f.9.2.1.0.2.0.0.0.0.0.0.0.0.0.0.8.b.d.0.1.0.0.2.ipv6.arpa. PTR

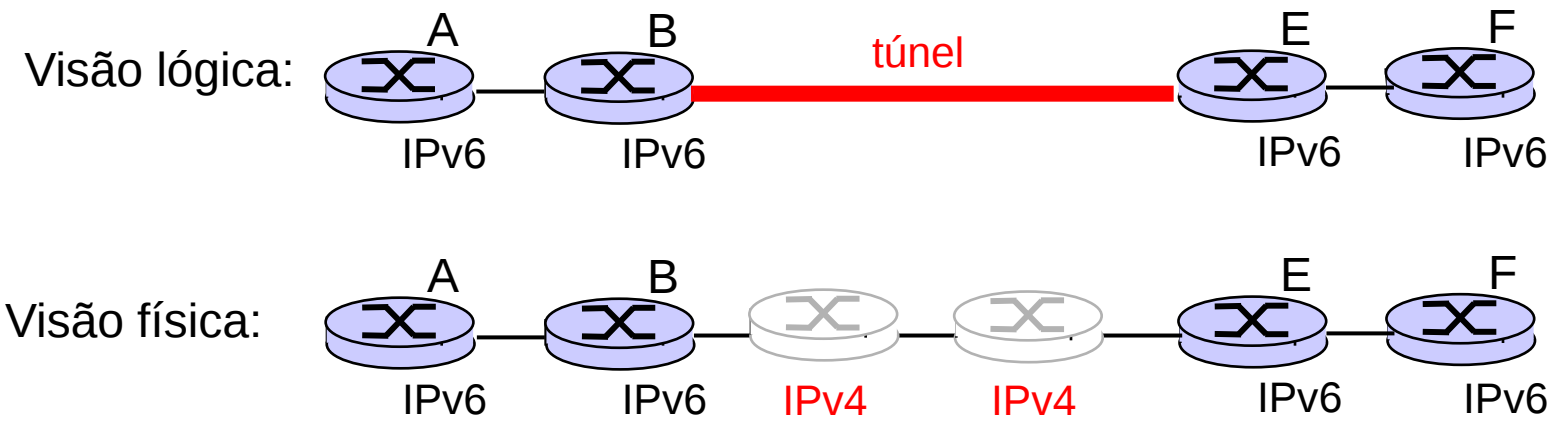
Don't forget to use $ORIGIN to simplify your DNS zone file!

Transição de IPv4 para IPv6

- Nem todos os roteadores podem ser atualizados simultaneamente
  - sem “dia de conversão”
  - como a rede operará com roteadores IPv4 e IPv6 misturados?
- *Pilha dupla:* IPv4 e IPv6 convivendo na mesma interface
- *Implantação de túnel:* IPv6 transportado como carga útil no datagrama IPv4 entre roteadores IPv4

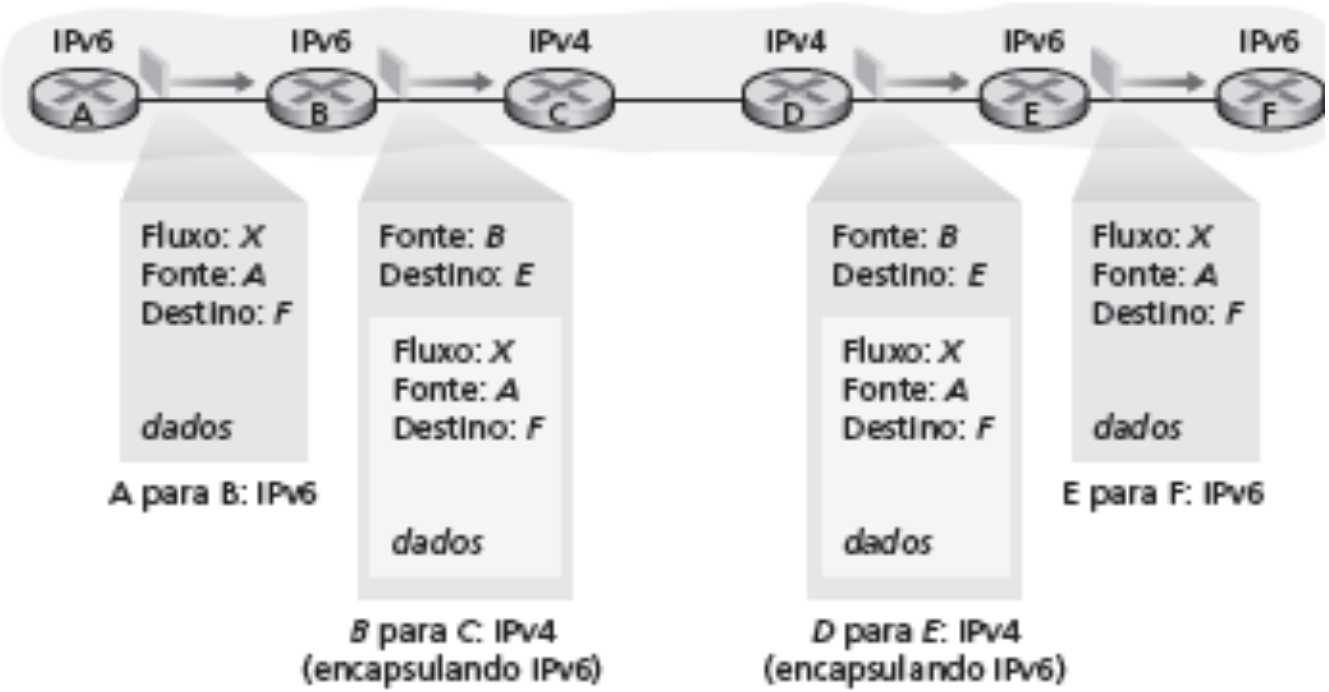
- http://ipv6.br/

Implantação de túnel



Visão lógica:

Visão física:



IPv6 Advantages

- More efficient address space allocation
- End-to-end addressing; no NAT anymore!
- Fragmentation only by the source host
- Routers do not calculate header checksum (speedup!)
- Multicasting instead of broadcasting
- Built-in security mechanisms
- Single control protocol (ICMPv6)
- Auto-configuration
- Modular headers structure

Outras mudanças do IPv4

- *Fragmentação/remontagem:* NÃO
- *soma de verificação*: removida inteiramente para reduzir tempo de processamento em cada salto
- *opões:* permitidas, mas fora do cabeçalho, indicadas pelo campo de “Próximo Cabeçalho”
- *ICMPv6:* nova versão do ICMP
  - tipos de mensagem adicionais, p. e. “Pacote Muito Grande”
  - funções de gerenciamento de grupo multicast

"Tudo" sobre IPv6:
http://ipv6.br/media/arquivo/ipv6/file/48/IPv6-apostila.pdf