Introduction to IPv6
Sep 3 2019

www.lacnic.net

Alejandro Acosta
alejandro@lacnic.net
@ITandNetworking

Let’s begin !

Firsts, just few basic things about IPv6

IPv6

- 1998 – Defined by RFC 2460 (now RFC 8200)
  - 128-bit addressing
  - Simplified packet header
  - Extension headers
  - Data flow identification (QoS)
  - Inclusion of IPSEC mechanisms in the protocol
  - Packet fragmentation and reassembly performed at the source and destination
  - Does not require the use of NAT: allows end-to-end connections
  - Mechanisms to simplify network configuration
  - ....

IPv6 addresses

- An IPv4 address is formed by 32 bits.

$2^{32} = 4.294.967.296$

- An IPv6 address is formed by 128 bits.

$2^{128} = 340.282.366.920.938.463.463.374.607.431.768.211.456$

~ $5,6 \times 10^{28}$ IP addresses for each human being.
~ $7,9 \times 10^{28}$ times the number of IPv4 addresses.

Addresses

The IPv6 addresses representation divides an address in 8 groups of 16 bits, separated by ":", represented by hexadecimal digits.

2001:0DB8:AD1F:25E2:CADE:CAFE:F0CA:84C1

2 bytes

When representing an IPv6 address it is allowed:

- To use lowercase or uppercase letters
- Omit leading zeros and ...
- Represent groups of contiguous zeros by "::".

Example: 2001:0DB8:0000:0000:130F:0000:0000:140B
2001:db8:0:0:130f::140b

Not valid format: 2001:db8::130f::140b (generates ambiguity)

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Addresses

- Prefix representation
- Like CIDR (IPv4)
  - “IPv6 address/prefix size”
  - Example:
    - Prefix 2001:db8:3003:2::/64
    - Global Prefix 2001:db8::/32
    - Subnet ID 3003:2
- URL
  - http://[2001:12ff:0:4::22]/index.html
  - http://[2001:12ff:0:4::22]:8080

Addresses

Three types of addresses have been defined for IPv6:

- *Unicast* ⟶ Individual Identification
- *Anycast* ⟶ Selective Identification
- *Multicast* ⟶ Group Identification
- Broadcast addresses don't exist anymore.

Nothing new here, just as in v4

Do you remember this one?
Well, here is identical to v4

IPv6 is power user
of anycast ☺

Please note this one !

Doing well?. Nice ☺

Now move on to the famous –and very important- IPv6 header

Doing well?. Nice ☺

Now move on to the famous –and very important- IPv6 header

Ok, not that fast !!

…. let’s recap the IPv4 header, good idea

IPv4 Header

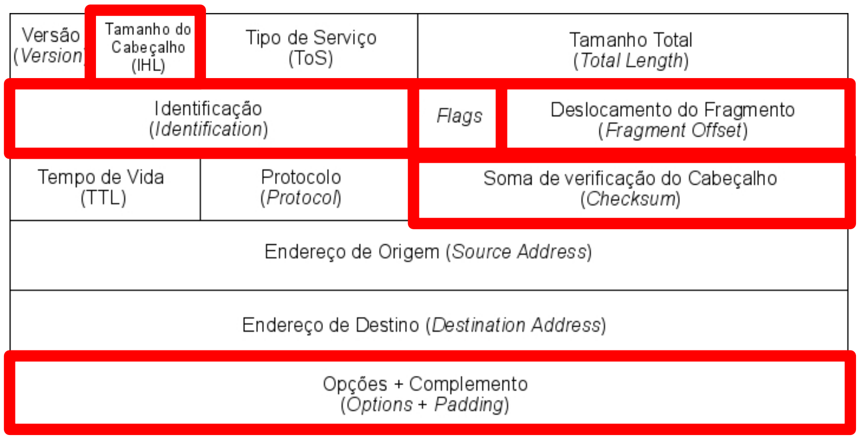
<table>
<tr><td>Versão
(Version)</td><td>Tamanho do
Cabeçalho
(IHL)</td><td>Tipo de Serviço
(ToS)</td><td colspan="2">Tamanho Total
(Total Length)</td></tr>
<tr><td colspan="3">Identificação
(Identification)</td><td>Flags</td><td>Deslocamento do Fragmento
(Fragment Offset)</td></tr>
<tr><td colspan="2">Tempo de Vida
(TTL)</td><td>Protocolo
(Protocol)</td><td colspan="2">Soma de verificação do Cabeçalho
(Checksum)</td></tr>
<tr><td colspan="5">Endereço de Origem (Source Address)</td></tr>
<tr><td colspan="5">Endereço de Destino (Destination Address)</td></tr>
<tr><td colspan="5">Opções + Complemento
(Options + Padding)</td></tr>
</table>

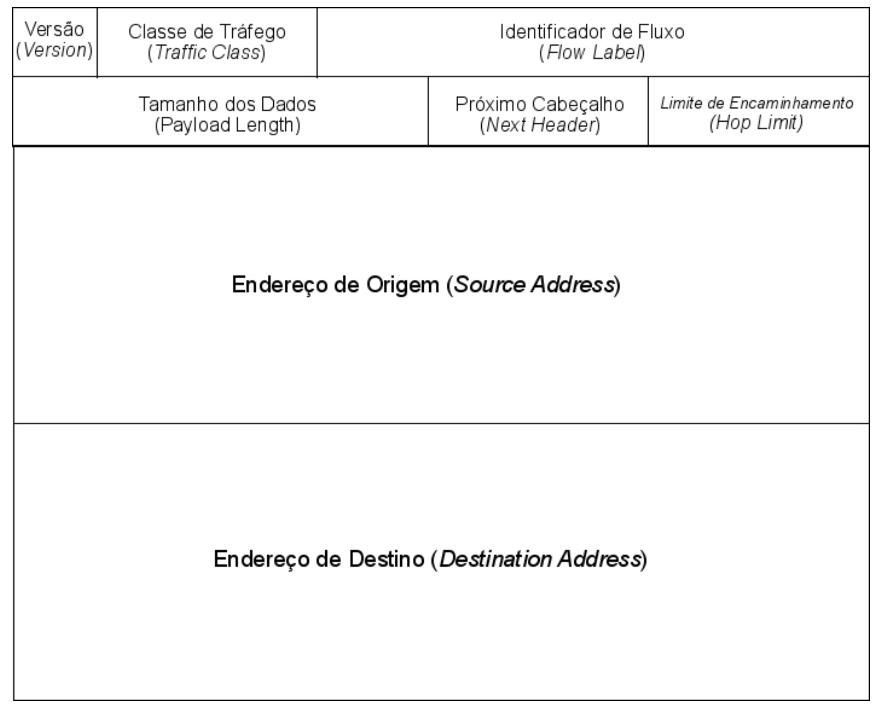
It’s integrated by 12 fixed fields. It may contain options or not, therefore it’s size can vary from 20 to 60 Bytes.

IPv6 Header

- Simpler
  - 40 Bytes (fixed size)
  - Only twice bigger than the older version
  -
- More flexible
  - Extensions through additional headers
  -
- More efficient
  - Header overhead is minimized
  - Packet processing cost is reduced

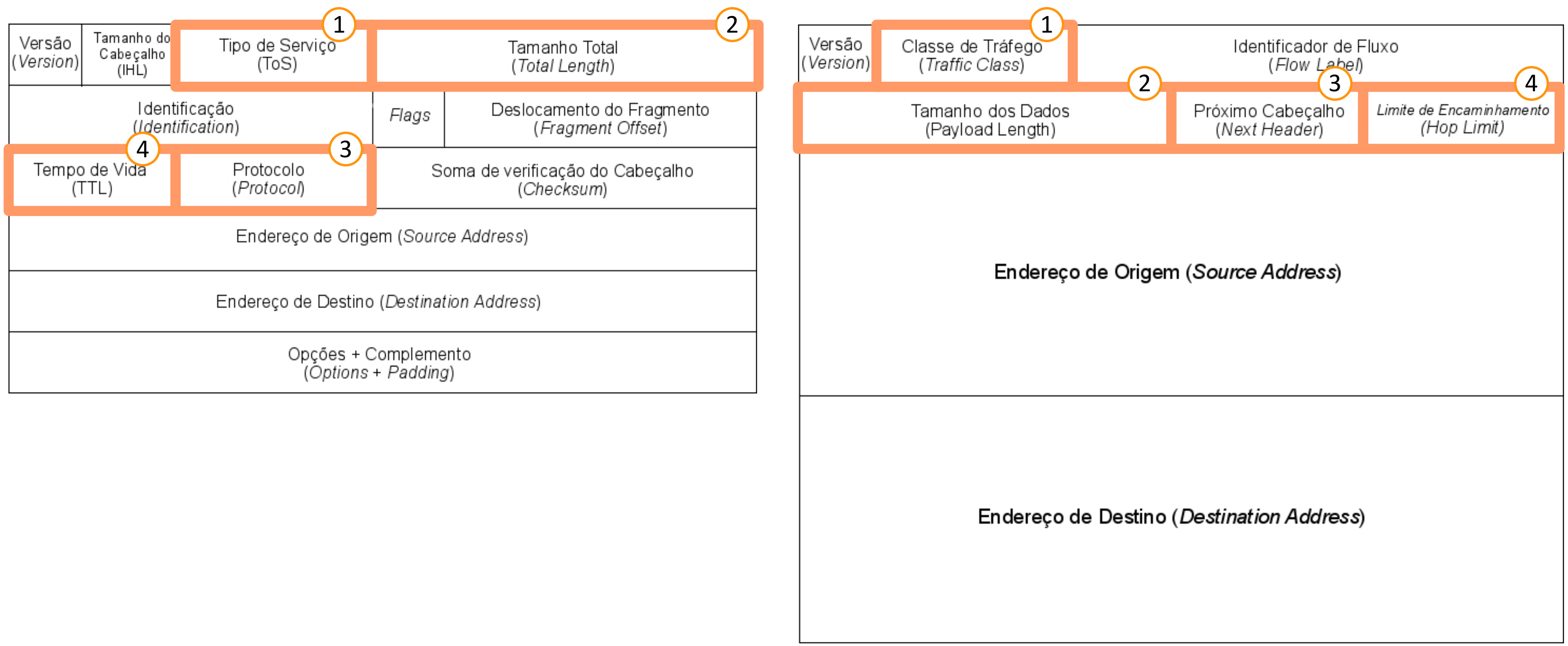
IPv6 Header





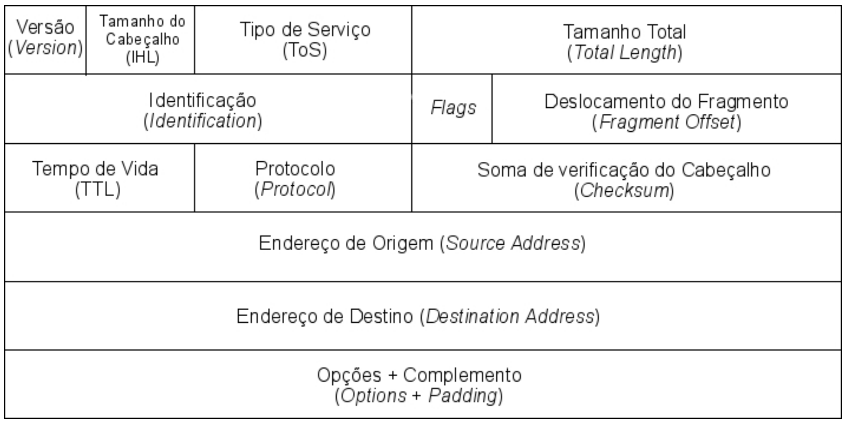
- Six fields from the IPv4 header were removed

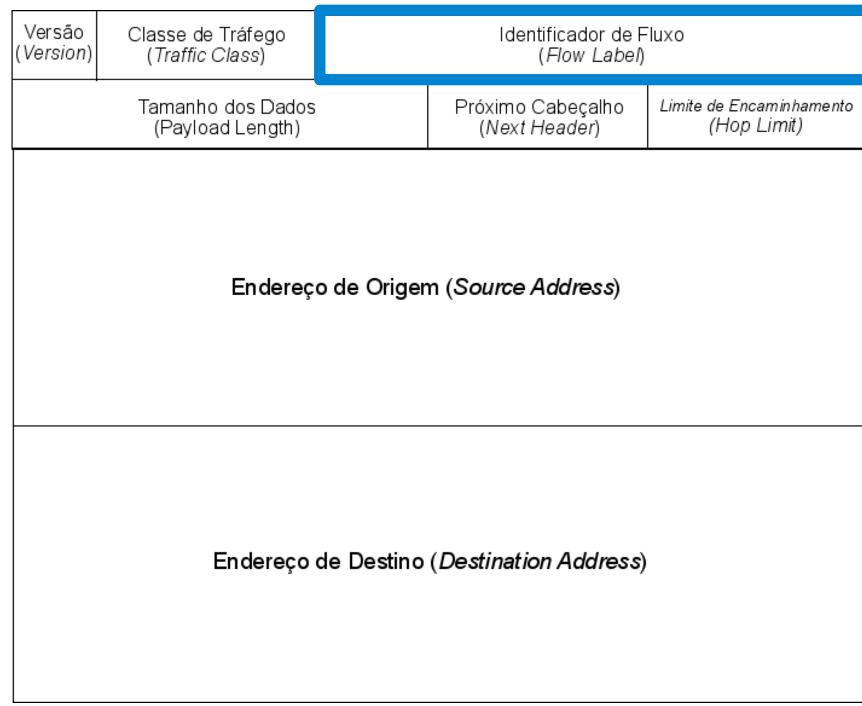
IPv6 Header



- Six fields from the IPv4 header were removed
- Four fields had it's name and it's location changed

IPv6 Header





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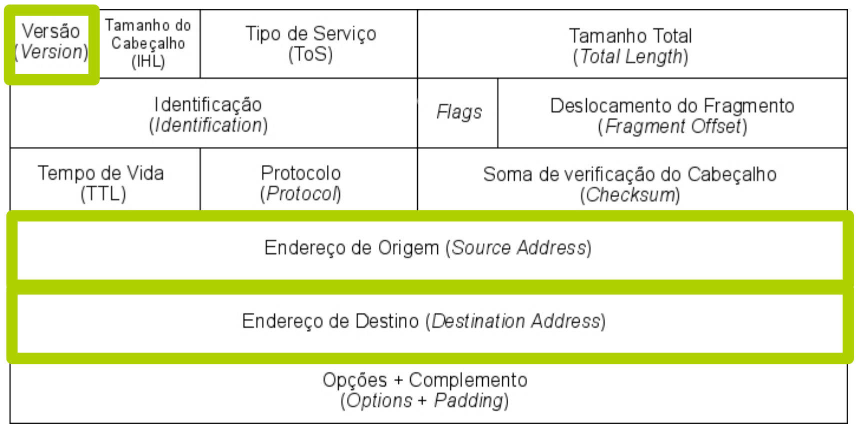
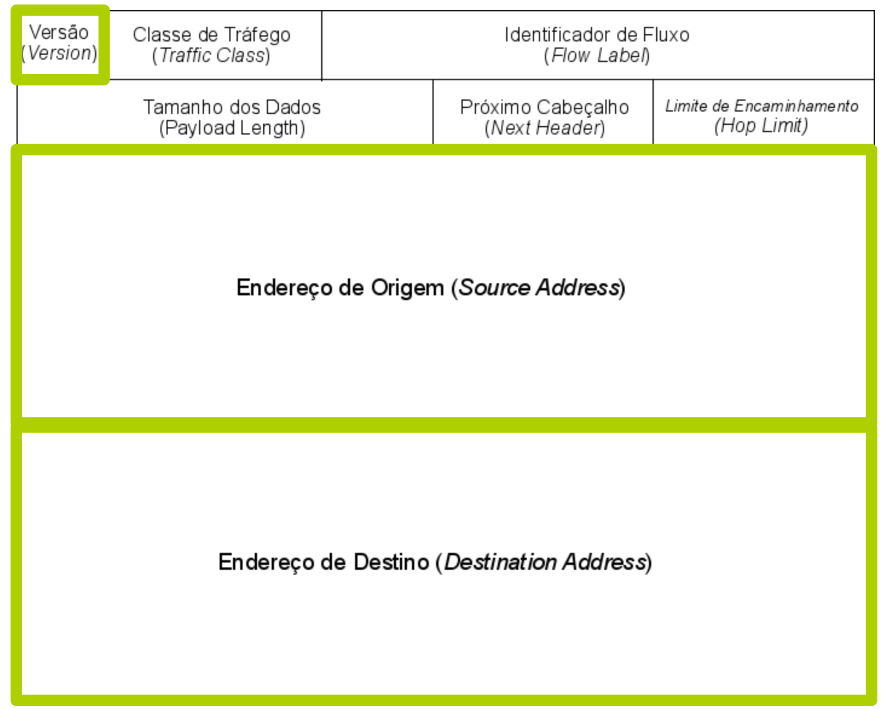
- Four fields had it's name and it's location changed
- The Flow Label field was enlarged

IPv6 Header





- Six fields from the IPv4 header were removed
- Four fields had it's name and it's location changed
- The Flow Label field was enlarged
- Three fields were unchanged

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IPv6 Header

<table>
<tr><td>Versão
(Version)</td><td>Classe de Tráfego
(Traffic Class)</td><td colspan="3">Identificador de Fluxo
(Flow Label)</td></tr>
<tr><td colspan="3">Tamanho dos Dados
(Payload Length)</td><td>Próximo Cabeçalho
(Next Header)</td><td>Limite de Encaminhamento
(Hop Limit)</td></tr>
<tr><td colspan="5">Endereço de Origem (Source Address)</td></tr>
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</table>

Ok, move on and now talk about the **core** of IPv6

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If you don't understand the following there is no chance you can deploy & troubleshoot IPv6

Neighbor Discovery

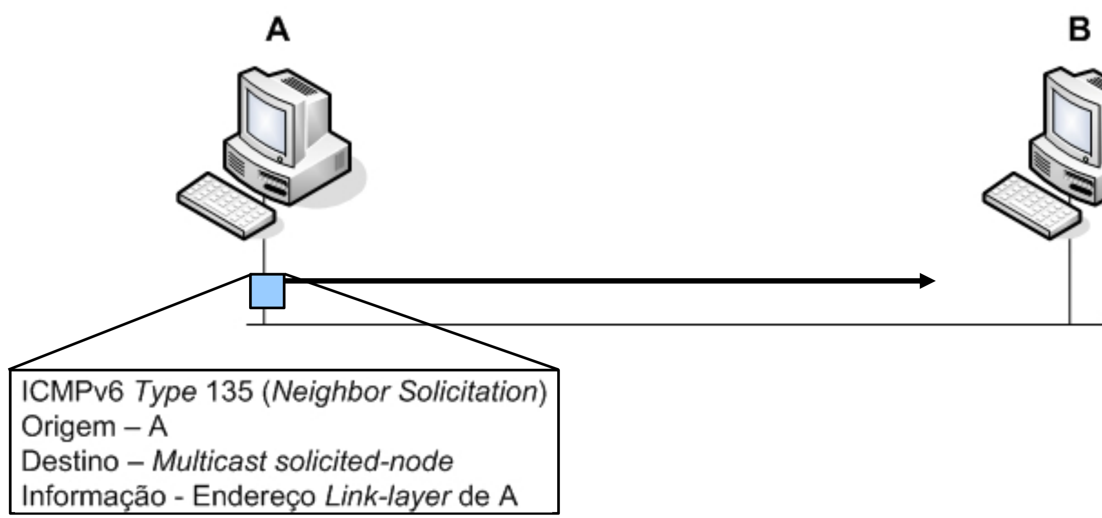
- Neighbor Discovery – Defined in RFC 4861.
- It assumes IPv4 functionalities such as ARP, ICMP Router Discovery and ICMP.
- It adds new methods and mechanisms that didn't exist in IPv4
- Optimize some of the processes for network configuration:
- Determining MAC addresses of hosts in the network
- Finding neighboring routers.
- Determining prefixes and other information for network configuration.
- Detecting overlapping addressing.
- Determining routers accessibility.
- Address autoconfiguration

Neighbor Discovery → ND → NDP

- It uses five types of ICMPv6 messages:
  - Router Solicitation (RS) – ICMPv6 type 133;
  - Router Advertisement (RA) – ICMPv6 type 134;
  - Neighbor Solicitation (NS) – ICMPv6 135;
  - Neighbor Advertisement (NA) – ICMPv6 type 136;
  - Redirect – ICMPv6 Type 137
- A value of 255 is set to the Hop Limit field.
- It can contain options:
  - Source link-layer address.
  - Target link-layer address.
  - Prefix Information.
  - Redirected header.
  - MTU

Neighbor Discovery

- *Link layer address discovering*
  - *It determines the link layer addressing of neighbors on the same link.*
  - *Replaces the ARP protocol.*
  - *It uses multicast address "solicited-node" instead of broadcast.*
  - *The host sends a NS message informing his MAC address and requests that of the neighbor.*



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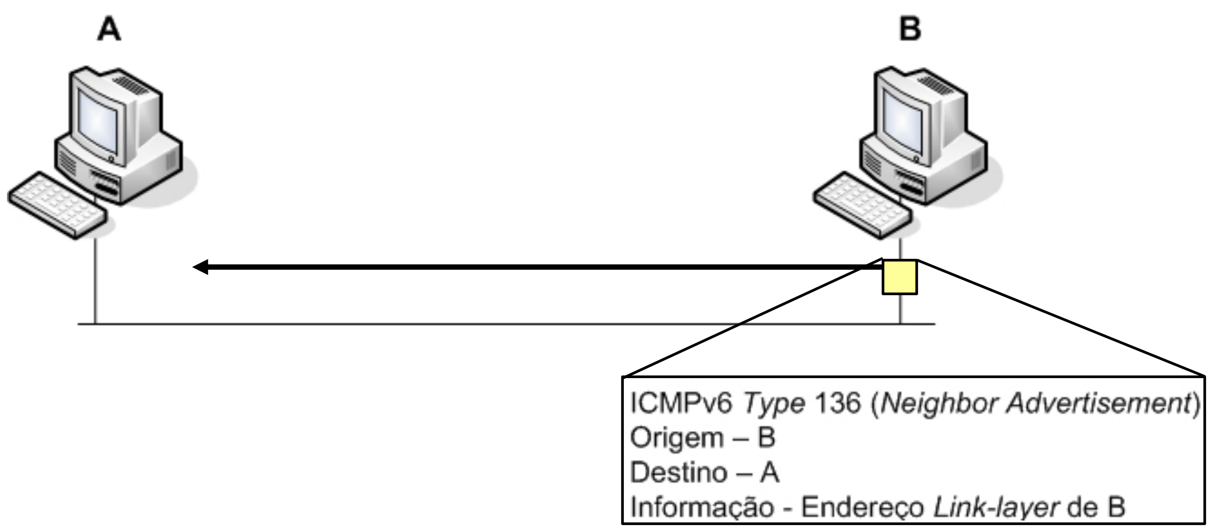
    - *The host sends a NS message informing his MAC address and requests that of the neighbor.*
    - *The neighbor answers by sending a NA message informing his MAC address.*



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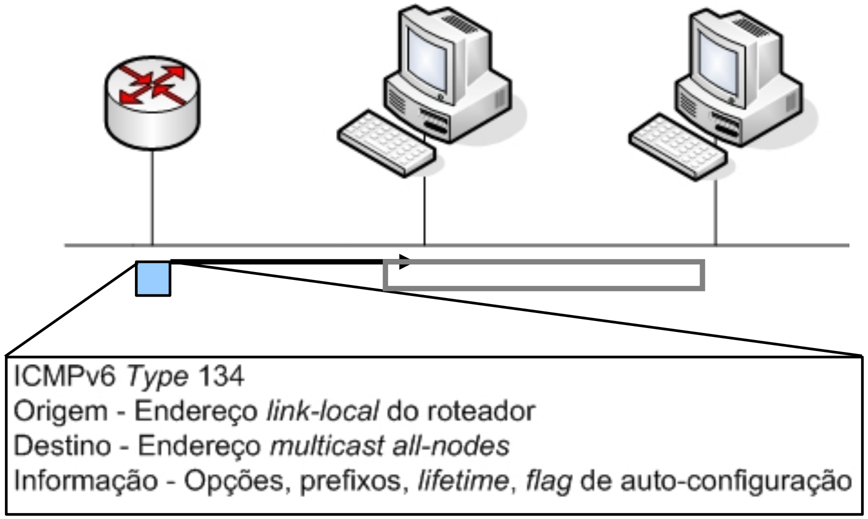
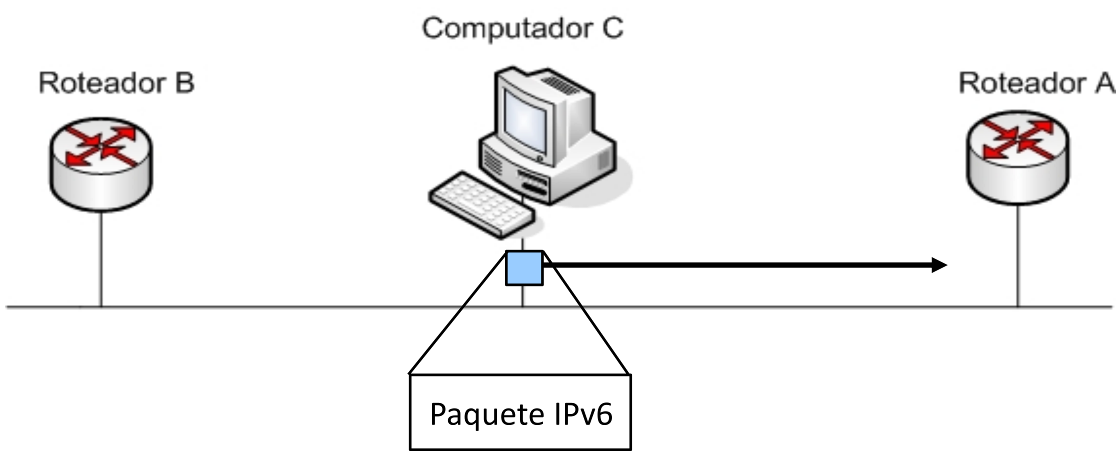
Neighbor Discovery

- ***Router and neighbor discovering***
  - ***Finds neighboring routers on the same link.***
  - ***Determines prefixes and parameters related to the address auto configuration.***
  - ***In IPv4, this function is held by the ARP request.***
  - ***Routers send RA messages to the multicast address "all-nodes"***



Neighbor Discovery

- Redirect
  - It sends Redirect messages.
  - It redirects a host to a more appropriate first hop router.
  - It informs the originator host that the destination is on the same link.
  - This mechanism is the same as the existing one in IPv4.



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Neighbor Discovery

- Overlapping addressing detection (Duplicate Address Detection)
  - Verifies that the address on the link is unique.
  - This mechanism should be held before assigning a Unicast address to an interface.
  - It consists in sending a NS message on behalf of the host with its own address on the "Target address" field. If it gets a NA as an answer, this means that the address is currently in used.

Questions?
Comment?

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lacnic
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