Basic IPv6 Concepts

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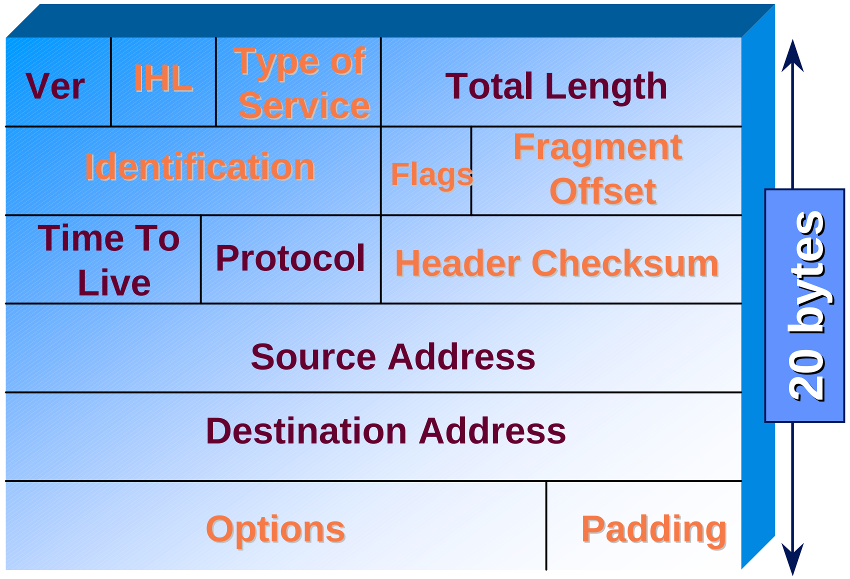
- Header Formats
- Autoconfiguration
- ICMPv6
- Neighbour Discovery

New IPv6 Features

- IPv6 is an evolution from IPv4 (not a revolution)
  - IPv6 = IPv4 redesigned incorporating more than 20 years of operational experience

Addressing:	**128 bits addresses hierarchically assigned**
Routing:	**Strongly Hierarchical (route aggregation)**
Performance:	**Simple datagram header aligned to 64 bits**
Extensibility:	**Improved support for extensions and options** **New flexible option headers format**
Multimedia:	**Better support for QoS (flow label)**
Multicast:	**Compulsory. Better scope control**
Security:	**Built-in security: authentication/encryption (IPSEC)**
Autoconfiguration:	**Stateless and stateful address configuration**
Mobility:	**Better support (efficiency and security)**

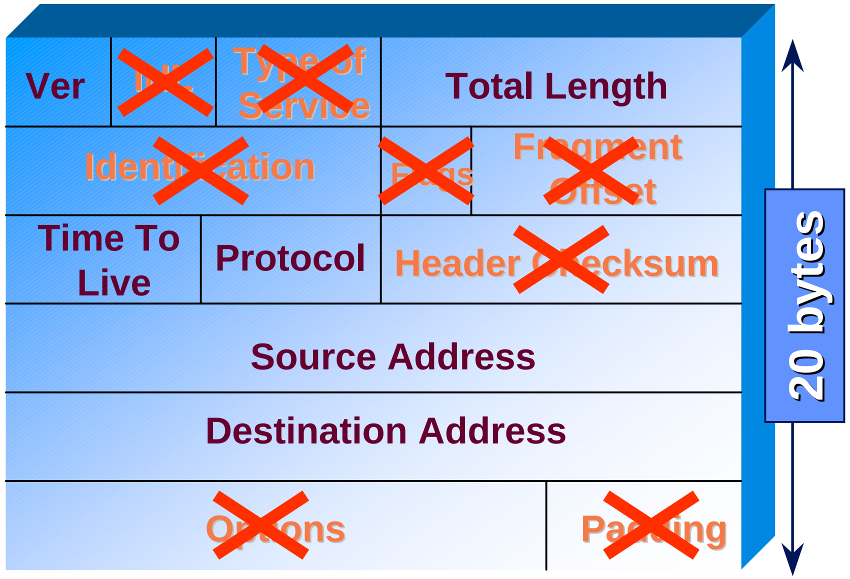
Header Format: IPv4 vs. IPv6



IPv4

- Some fields maintained
  - with some names changed
- Some fields disappear
- Some fields moved to optional headers

Header Format: IPv4 vs. IPv6



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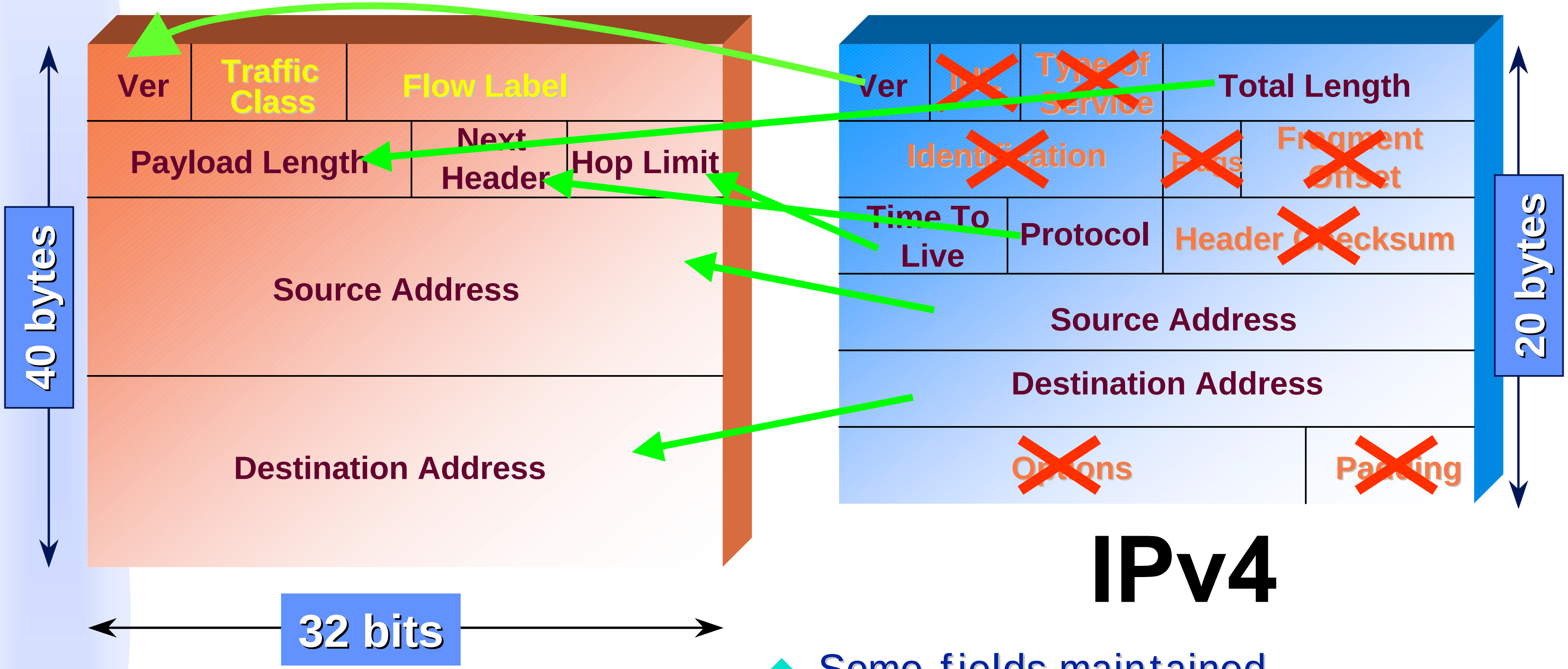

IPv6

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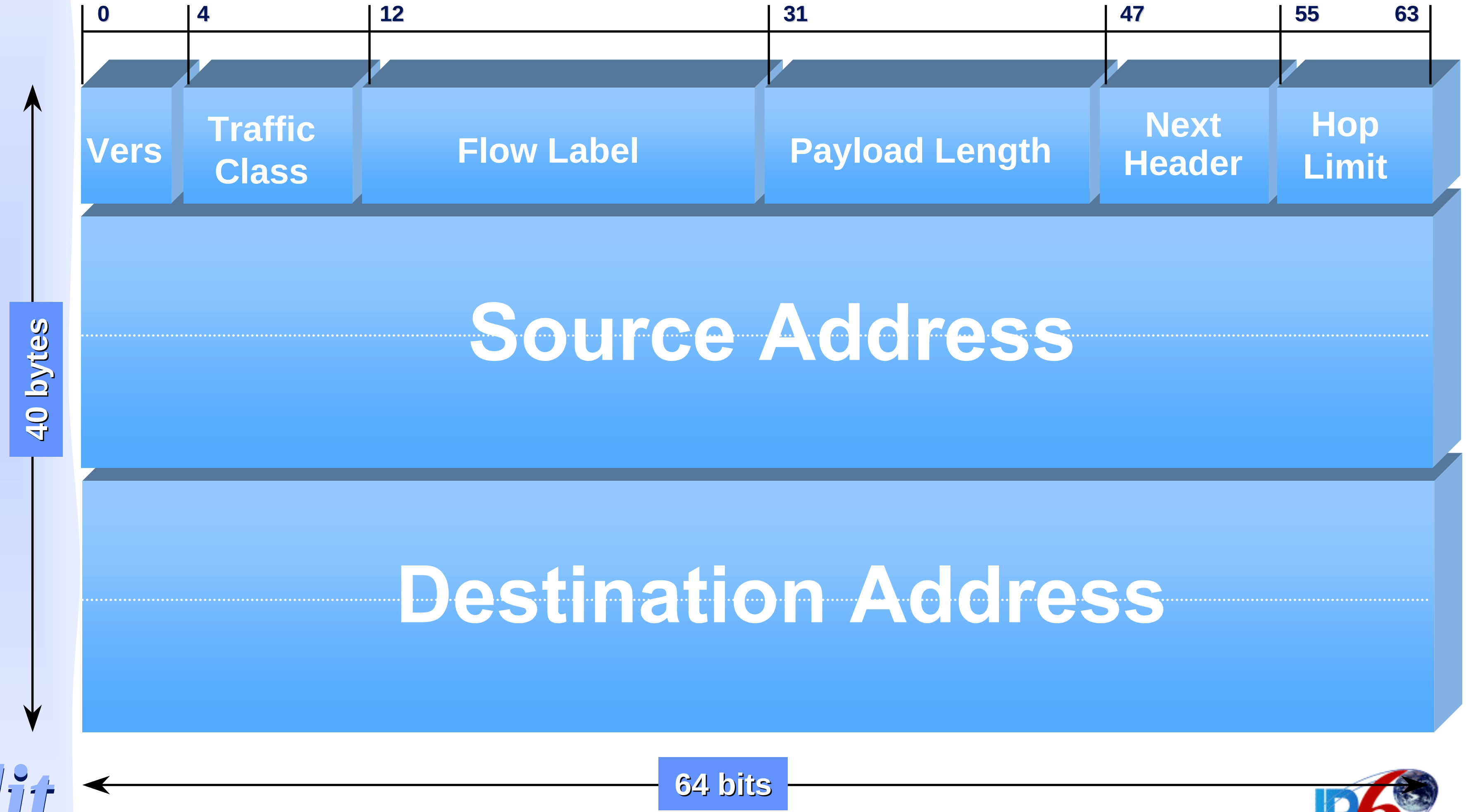
Basic IPv6 Header Format



Summary of Header Changes

- Address length increased to 128 bits
- Fragmentation and options fields removed from base header
- Header checksum removed
- Header length field removed (fixed length header)
- New flow label field
- Fields renamed:
  - ToS -> Traffic Class
  - Protocol -> Next header
  - Time To Live -> Hop Limit
- Alignment changed to 64 bits

IPv6 Extension Headers

- Option headers format and treatment greatly improved:

- Advantages:
  - Number and size of options not limited
  - Extension headers strictly ordered to simplify processing by routers
  - Definition of behavior for unknown options

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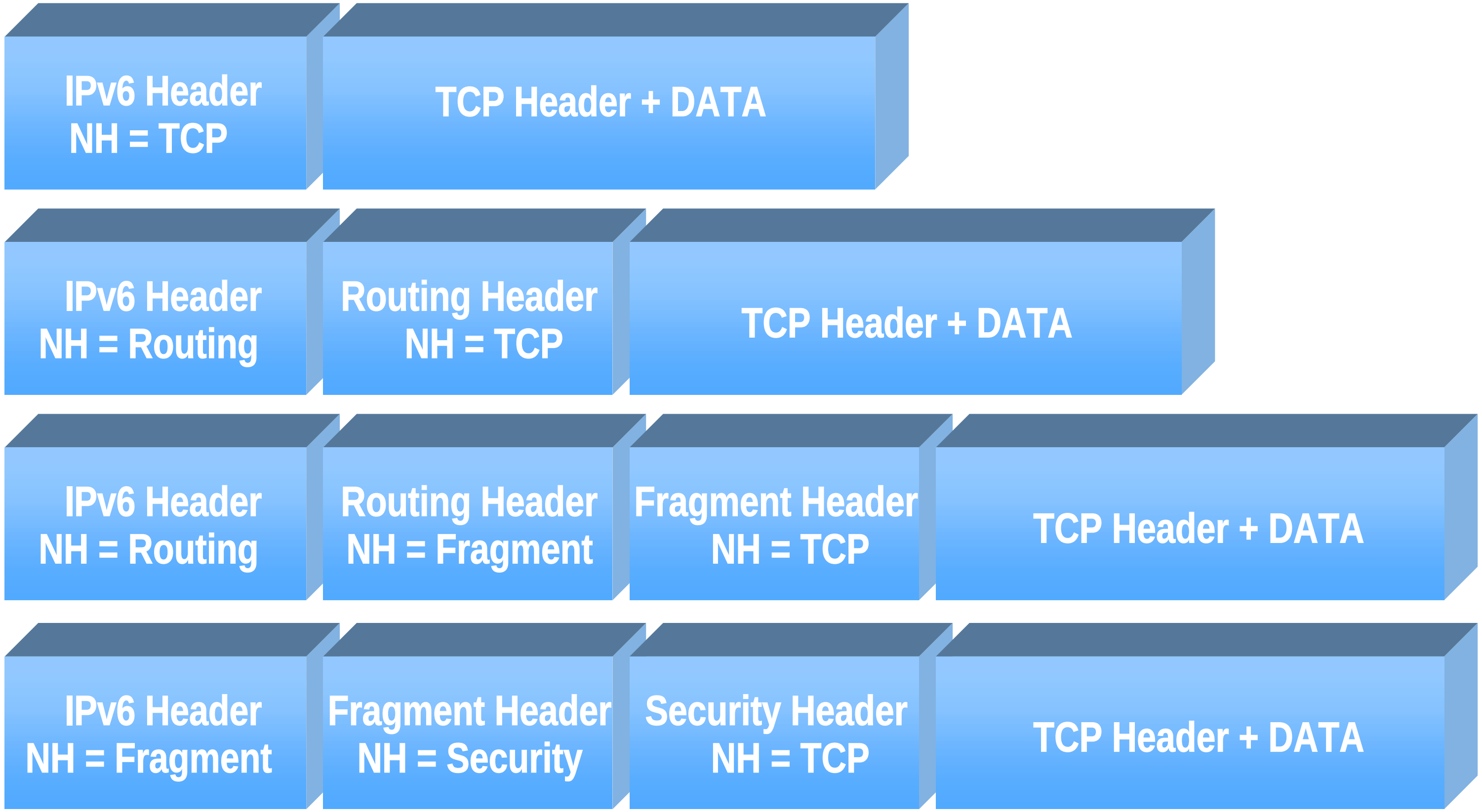
Examples of IPv6 Packets



Extension Headers Currently Defined

- *Hop-by-Hop Options:*
  - Information to be processed by every node

    Exs: Jumbogram (RFC 2675): packets up to 4 GB!!

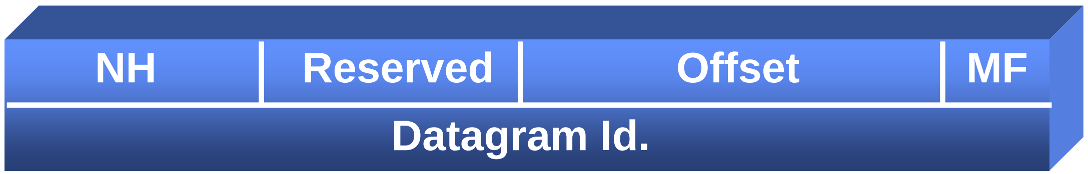
    Router Alert (RFC 2711)
- *Routing:*
  - similar to IPv4 Source Route option
- *Fragment:*
  - Fragmentation and reassembly
- *Authentication:*
  - Digital Signatures
- *Encapsulating Security Payload :*
  - Encryption Information
- *Destination Options:*
  - Information to be processed by destination

Fragmentation in IPv6 (I)

- End-to-end fragmentation:
  - Only the source can fragment
  - Routers DO NOT fragment
- Path MTU Discovery (RFC 1981) used to discover MTU for each destination
  - Used at present in most IPv4 implementations
- Simple technique: trial and error
  - Send packets using link MTU
  - If a router discards a packet due to MTU:
    - Sends an ICMPv6 Packet Too Big message to the source informing about the MTU causing the discarding
  - Source adapts PMTU for that destination (PMTU cache)

Fragmentation in IPv6 (II)

- Fragment header:



- Link layer must support a 1280-byte MTU
  - Otherwise, link layer must use a transparent fragmentation and reassembly scheme
- For configurable MTU link layers, MTU size of at least 1500 bytes
  - Example: Maximum Receive Unit (MRU) of a Point-to-Point Protocol (PPP) link

QoS Support in IPv6 Header

- Two fields related with QoS:

Traffic Class (8 bits)	Flow Label (20 bits)

- Traffic Class:
  - Differentiated Services Field (RFC 2474)
  - Aligned with IPv4 TOS field
- Flow label:
  - Enables efficient IPv6 flow classification based only on IPv6 main header fields in fixed positions
  - Work in progress: draft-ietf-ipv6-flow-label-07.txt

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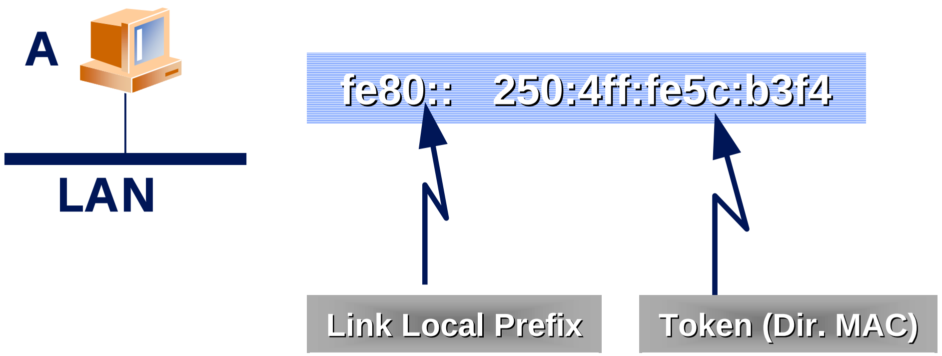
Autoconfiguration in IPv6

- Key feature of IPv6
- Main autoconfiguration goals:
  - Designed for hosts
  - Plug & play
  - Avoid manual configuration of addresses
  - Isolated networks
  - Graceful renumbering
- Three autoconfiguration types defined :
  - Stateless (Router Advertisement)
  - Stateful (DHCPv6)
  - Both
- Besides, link-local addresses for communication between nodes attached to the same link

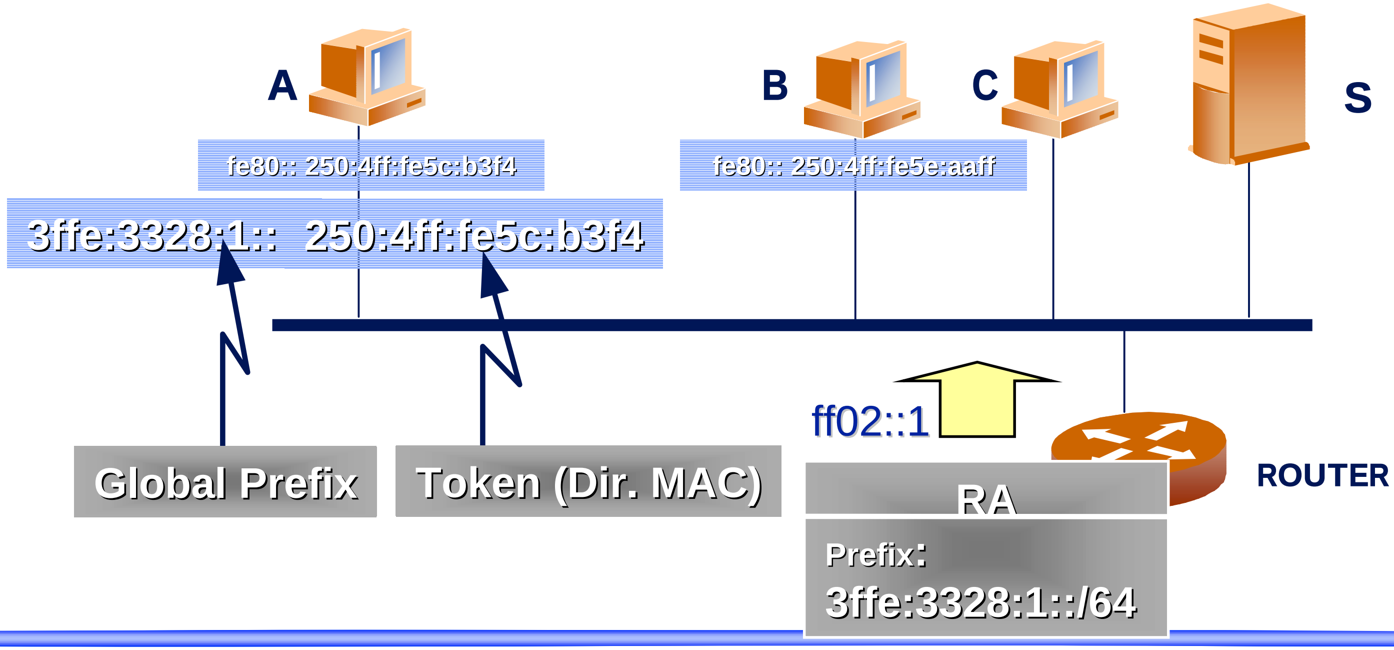
Link-Local Address

- A node forms a link-local address whenever an interface becomes enabled
- Formed by:
  - Fixed 64-bit address prefix (FE80::/64)
  - Unique interface identifier (typically a EUI-64 identifier build from the MAC addr)
- Duplicate Address Detection (DAD) mechanism guaranties uniqueness
- Example: link-local addresses on 802 LANs



Stateless Autoconfiguration

- Based on ICMPv6 Router Advertisements (RA) sent by routers
- Formed by:
  - Address prefix exported in RA
  - Unique interface identifier (same as in link-local)



Router Advertisement

Time (ms) that node assumes a neighbor is reachable
0 = unspecified

Time (ms) between neighbor solicitations

Complete configuration with DHCP
M = obtain more addresses
O = Servers addresses

Default router lifetime
- 0 = no default router
- few seconds
- 18.2 hours

Router Advertisement

Source
Router address

Destination
link-local multicast
or
node link-local

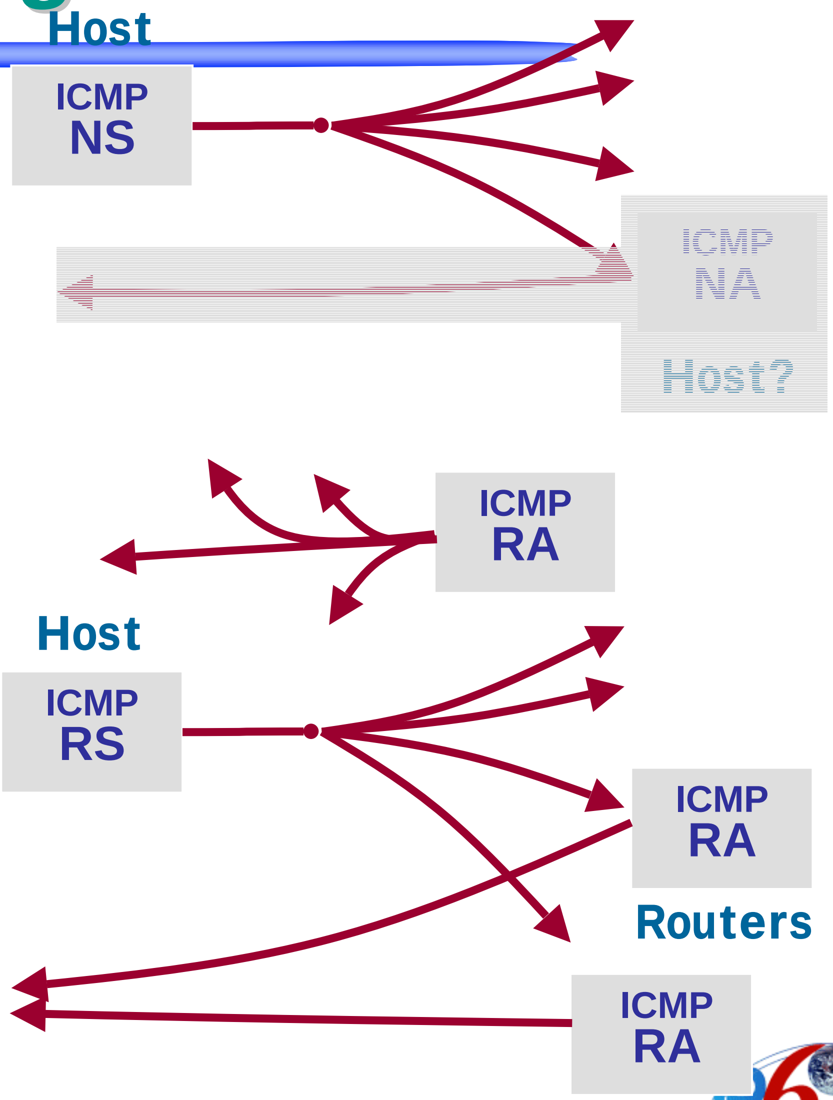
Type = 13	Code			Checksum
Cur Hop Limit	M	O	Reserved	Router Lifetime
Reachable Time				
Retrans Timer				
Options				

Prefix Information options
- Subnet number and mask
- Node Subnets addresses

Link MTU definition

Stateless Autoconfiguration Process

a. Assign link-local address
   - Duplicate detection
b. IF fails THEN
   Autoconfiguration stops
c. Find routers
   - Wait periodic RA
     (from few seconds
     to 30 minutes)
   - Send RS
d. IF no receive any RA THEN
   Isolated network
e. Finish autoconfiguration



Privacy Issues in Autoconfiguration

- RFC 3041: Privacy Extensions for Stateless Address Autoconfiguration in IPv6
- Proposes extensions to generate global-scope addresses from interface identifiers that change over time
- Objective:
  - difficult eavesdroppers and other information collectors to identify when different addresses used in different transactions actually correspond to the same node.

Stateful Autoconfiguration

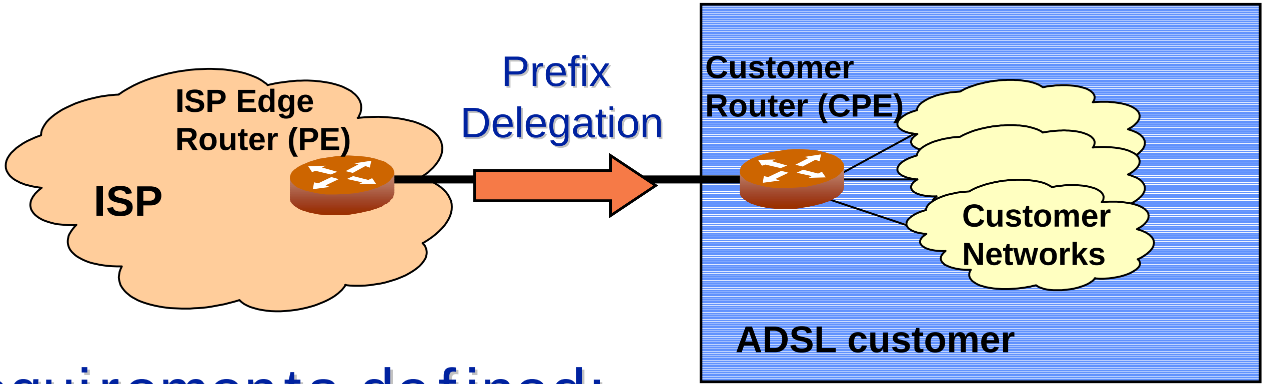
- Standard DHCP based autoconfiguration
  - Dynamic Host Configuration Protocol for IPv6 (DHCPv6): draft-ietf-dhc-dhcpv6-28.txt
  - Not integrated with Pv4 (independent autoconfiguration)
  - New packet design (no BOOTP legacy)
  - Clients may obtain many addresses
- Clients use link-local addresses to speak with DHCP server/relays
  - No more 255.255.255.255's !!

Stateless or Stateful?

- Decision made by the network or site administrator:
  - *Managed Address Configuration* bit in RA
    - 0 = Do Stateless configuration.
    - 1 = Do not do Stateless configuration
- Stateless and Stateful can Coexist. For example:
  - *Other stateful configuration* bit in RA
    - Addresses could come from Stateless
    - Additional Configuration Information could be provided by DHCPv6

More Autoconfiguration in IPv6

- Proposals to automate the delegation of address prefixes to customer sites:



- Requirements defined:
  - "Requirements for IPv6 prefix delegation". draft-ietf-ipv6-prefix-delegation-requirement-01.txt
- Several proposals:
  - Extensions to DHCP
  - New ICMP Prefix Delegation messages
  - Router renumbering (RFC2894)

ICMP in IPv6

- A new version of Internet Control Message Protocol (ICMPv6) has been defined
- Apart from ICMP original functionalities (error messages and diagnostic) it provides the framework for:
  - Autoconfiguration
  - Address resolution (Neighbor Discovery)
  - Path MTU Discovery
  - Multicast Group Management (Multicast Listener Discovery – MLD)
  - Duplicate Address Detection (DAD)
  - IPv6 mobility

Neighbor Discovery Overview

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- Defined in RFC2461

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- Used by IPv6 nodes on the same link:
  - to discover each other's presence,
  - to determine each other's link-layer addresses,
  - to find routers, and
  - to maintain reachability information about the paths to active neighbors.

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- Replaces ARP, ICMPv4 Router Discovery, and ICMPv4 Redirect
- Eliminates the use of broadcast for address resolution (intelligent use of multicast)

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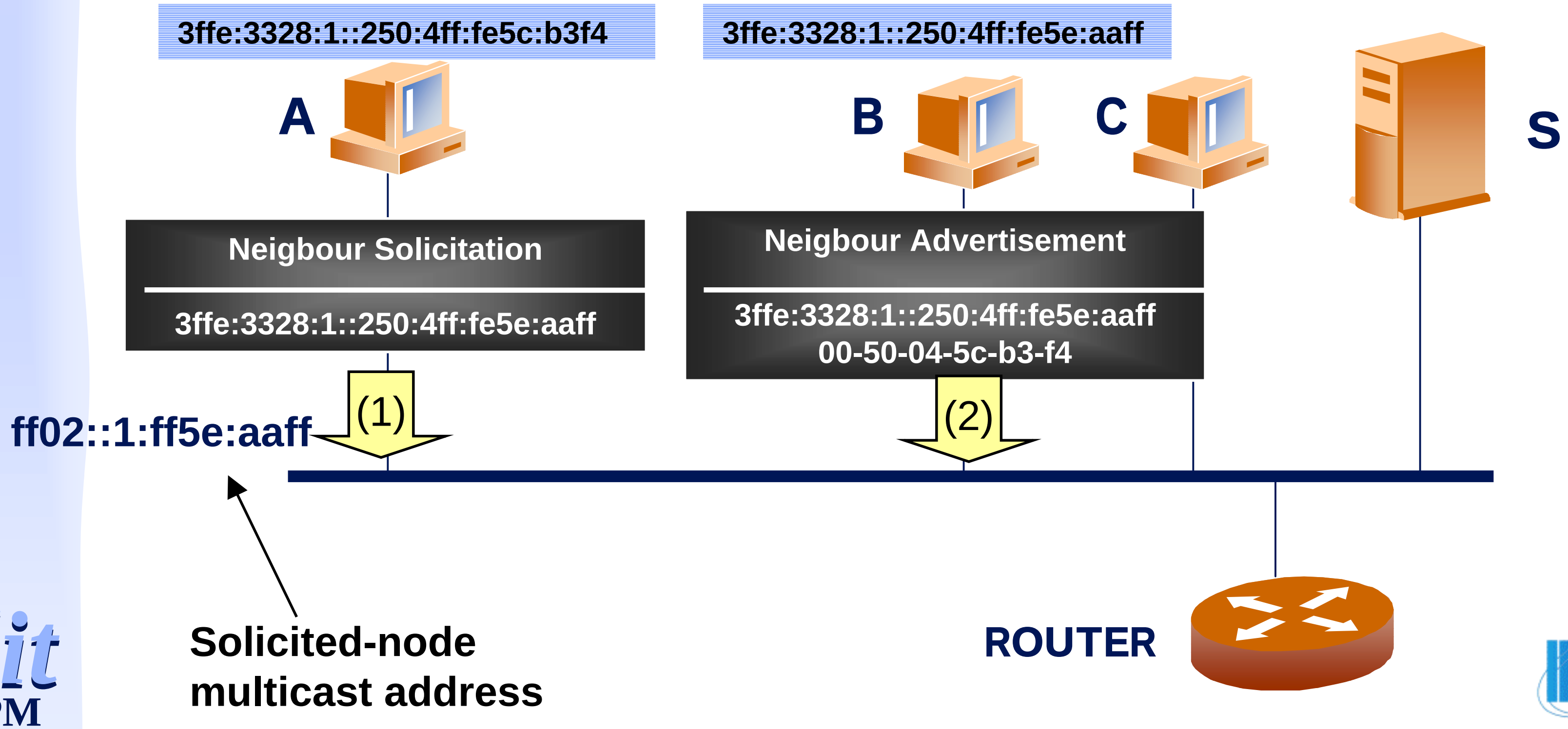
Address Resolution

- Requests sent to "Solicited-node multicast address"
  - Most probably only the node queried will receive the Neighbor Solicitation message



Neighbor Discovery Overview (II)

- ND is used by nodes:
  - For address resolution
  - To determine link-layer address changes
  - To determine neighbor reachability
- ND is used by hosts:
  - To discover neighboring routers
  - Autoconfigure addresses, address prefixes, and other configuration parameters
- ND is used by routers:
  - To advertise their presence, host configuration parameters, and on-link prefixes
  - To inform hosts of a better next-hop address to forward packets for a specific destination

Neighbor Discovery Processes & Messages

ND Processes

- Router discovery
- Prefix discovery
- Parameter discovery
- Address autoconfiguration
- Address resolution
- Next-hop determination
- Neighbor unreachability detection
- Duplicate address detection
- Redirect function

Messages

- Router Solicitation
- Router Advertisement
- Neighbor Solicitation
- Neighbor Advertisement
- Redirect

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