IPv6 associated protocols

Address auto-configuration in IPv6

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Agenda

- Associated protocols in IPv6
- Neighbor Discovery Protocol
- Path MTU protocol
- Address auto-configuration in IPv6

New Protocols

- New features specified in IPv6 Protocol (RFC 2460 DS)
- Neighbor Discovery (ND) (RFC 2461 DS)
- Auto-configuration:
  - Stateless Address Auto-configuration (RFC 2462 DS)
  - DHCPv6:
    - Dynamic Host Configuration Protocol for IPv6 (RFC 3315 PS)
  - Path MTU discovery (pMTU) (RFC 1981 PS)

New Protocols (2)

- MLD (Multicast Listener Discovery) (RFC 2710 PS)
  - Multicast group management over an IPv6 link
  - Based on IGMPv2
  - MLDv2 (equivalent to IGMPv3 in IPv4)
- ICMPv6 (RFC 2463 DS) "Super" Protocol that :
  - Covers ICMP (v4) features (Error control, Administration, …)
  - Transports ND messages
  - Transports MLD messages (Queries, Reports, …)

Neighbor Discovery

IPv6 nodes which share the same physical medium (link) use Neighbor Discovery (NDP) to:

- discover their mutual presence
- determine link-layer addresses of their neighbors
- find routers
- maintain neighbors' reachability information (NUD)

➢ *not directly applicable to NBMA (Non Broadcast Multi Access) networks : ND uses multicast for certain services.*

Neighbor Discovery (2)

- Protocol features:
  - Router discovery
  - Prefix(es) discovery
  - Parameters discovery (link MTU, Max Hop Limit, ...)
  - Address auto-configuration
  - Address resolution
  - Next Hop determination
  - Neighbor Unreachability Detection
  - Duplicate Address Detection
  - Redirect

Neighbor Discovery (3): Comparison with IPv4

- It is the synthesis of:
  - ARP
  - R-Disc
  - ICMP redirect
  - ...

Neighbor Discovery (4)

- ND specifies 5 types of ICMP packets :
  - **Router Advertisement** (RA) :
    - periodic advertisement (of the availability of a router) which contains:
      - » list of prefixes used on the link (autoconf)
      - » a possible value for Max Hop Limit (TTL of IPv4)
      - » value of MTU
  - **Router Solicitation** (RS) :
    - the host needs RA immediately (at boot time)

Neighbor Discovery (5)

- **Neighbor Solicitation** (NS):
  - to determine the link-layer @ of a neighbor
  - or to check its impeachability
  - also used to detect duplicate addresses (DAD)
- **Neighbor Advertisement** (NA):
  - answer to a NS packet
  - to advertise the change of physical address
- **Redirect** :
  - Used by a router to inform a host of a better route to a given destination

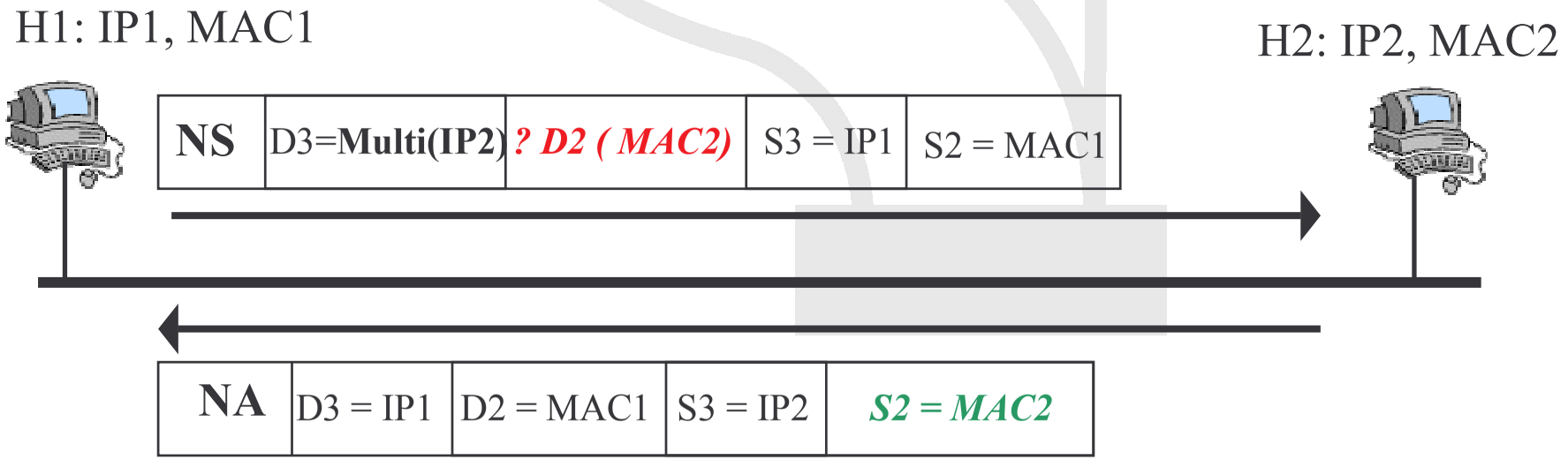
Address Resolution

- Find the mapping: Dst IP @ ➔ Link-Layer (MAC) @
- Recalling IPv4 & ARP
  - ARP Request is broadcasted
    - e.g. `ethernet @: FF-FF-FF-FF-FF-FF`
    - Btw, it contains the Src's LL @
  - ARP Reply is sent in unicast to the Src
    - It contains the Dst's LL @

Address Resolution (2)
IPv6 with Neighbor Discovery

At boot time, every IPv6 node has to join 2 special multicast groups for each network interface:

- All-nodes multicast group: `ff02::1`
- Solicited-node multicast group: `ff02:1:ffxx:xxxx` (derived from the lower 24 bits of the node's address)



Address Resolution (3)
Solicited Multicast Address

- **Concatenation** of the prefix `FF02::1:FF00:0/104` with the last 24 bits of the IPv6 address

Example:

- **Dst IPv6 @:** `2001:0660:010a:4002:4421:21FF:FE24:87c1`

- **Sol. Mcast @:** `FF02:0000:0000:0000:0000:0001:FF24:87c1`

- **ethernet:** `33-33-FF-24-87-c1`

Path MTU discovery (RFC 1981)

- Derived from RFC 1191, (IPv4 version of the protocol)
- **Path** : set of links followed by an IPv6 packet between source and destination
- **link MTU** : maximum packet length (bytes) that can be transmitted on a given link without fragmentation
- **Path MTU** (or pMTU) = min { link MTUs } for a given path
- Path MTU Discovery = automatic pMTU discovery for a given path

Path MTU discovery (2)

- Protocol operation
  - makes assumption that pMTU = link MTU to reach a neighbor (first hop)
  - if there is an intermediate router such that link MTU < pMTU ➔ it sends an ICMPv6 message: "Packet size Too Large"
  - source reduces pMTU by using information found in the ICMPv6 message

  => Intermediate network element aren't allowed to perform packet fragmentation

IPv6 Address autoconfiguration

Stateless and Stateful

Contributions

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Prerequisites

- You must have followed previously the modules:
  - 010-IPv6 Introduction
  - 020-IPv6 Protocol
  - 030-IPv6 Addressing
  - 040-IPv6 Associated Protocols

Agenda

- Stateless Autoconfiguration
- Stateful Autoconfiguration (DHCPv6)
- Conclusions

Stateless Autoconfiguration

- Hosts should be plug & play
- Uses some of the Neighbor Discovery ICMPv6 messages
- When booting, the host asks for network parameters:
  - IPv6 prefix(es)
  - default router address(es)
  - hop limit
  - (link local) MTU

Stateless Autoconfiguration

- Only routers have to be manually configured
  - but work on prefix delegation is in progress

    (http://www.ietf.org/rfc/rfc3633.txt)

- Hosts can get automatically an IPv6 address
  - BUT it isn't automatically registered in the DNS

➢ Servers should be manually configured

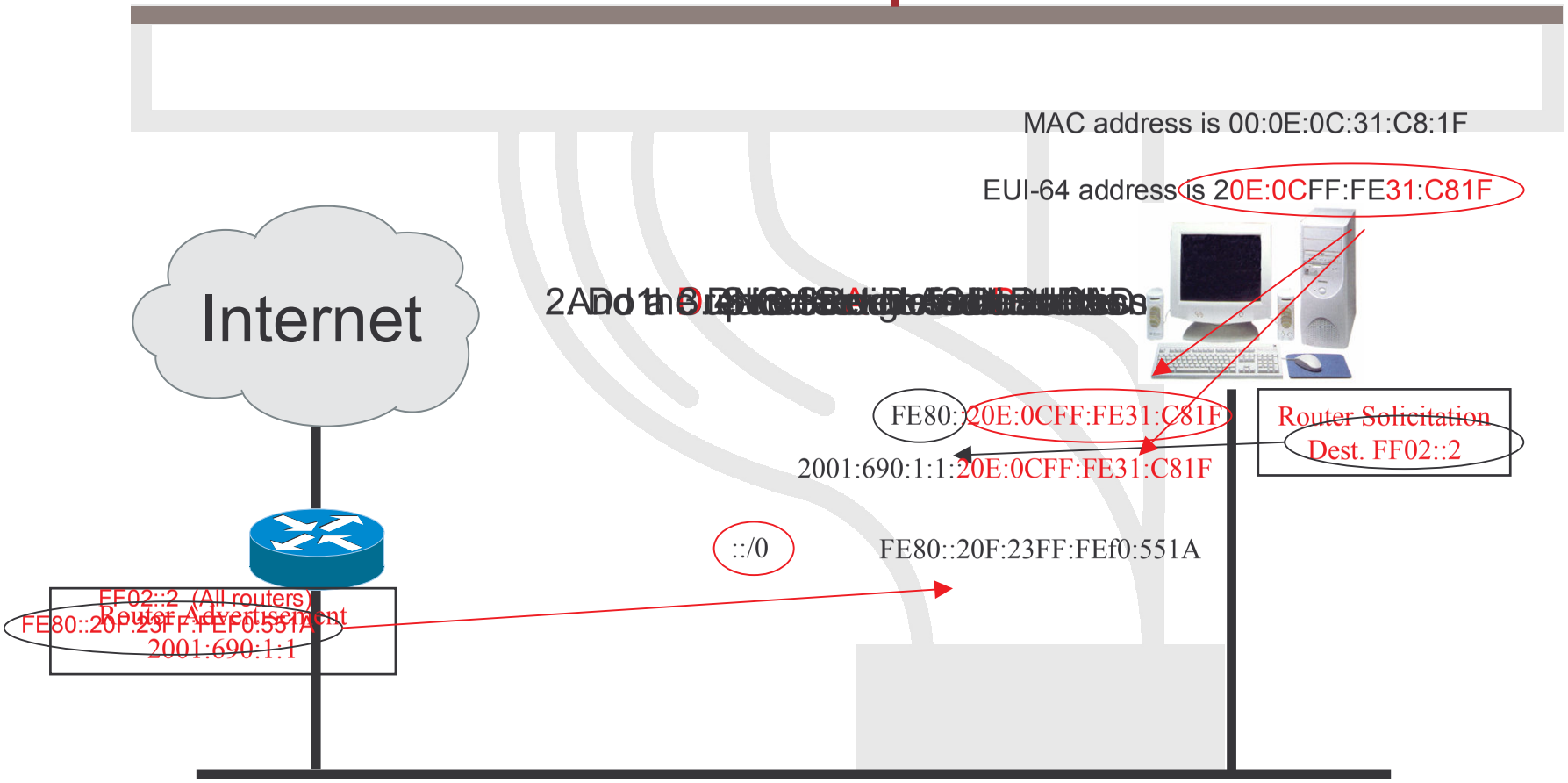
Stateless Autoconfiguration

- IPv6 Stateless Address Autoconfiguration is described in RFC 2462
- Hosts are listening for Router Advertisements (RA) messages, periodically transmited by routers
- RA messages coming from the router(s) on the link identify the subnet
- Allows a host to create a global IPv6 address from:
  - Its interface identifier (EUI-64 address)
  - Link Prefix (obtained via Router Advertisement)
- Global Address = combine *Link Prefix* with *EUI-64 address*

Stateless Autoconfiguration

- Usually, the router sending the RA messages is used, by hosts, as the default router
- If the RA doesn't carry any prefix
  - The hosts don't configure (automatically) any global IPv6 address (but may configure the default gateway address)
- RA messages contain two flags indicating what type of stateful autoconfiguration (if any) should be performed
- *It's impossible to automatically send DNS server addresses*
- IPv6 addresses depends on NIC card

Stateless Autoconfiguration example



Stateful autoconfiguration (DHCPv6)

- Dynamic Host Configuration Protocol for IPv6
  - RFC 3315
  - stateful counterpart to IPv6 Stateless Address Autoconfiguration.
- According to RFC 3315 DHCPv6 is used when:
  - no router is found
  - Or if Router Advertisement message enables use of DHCP

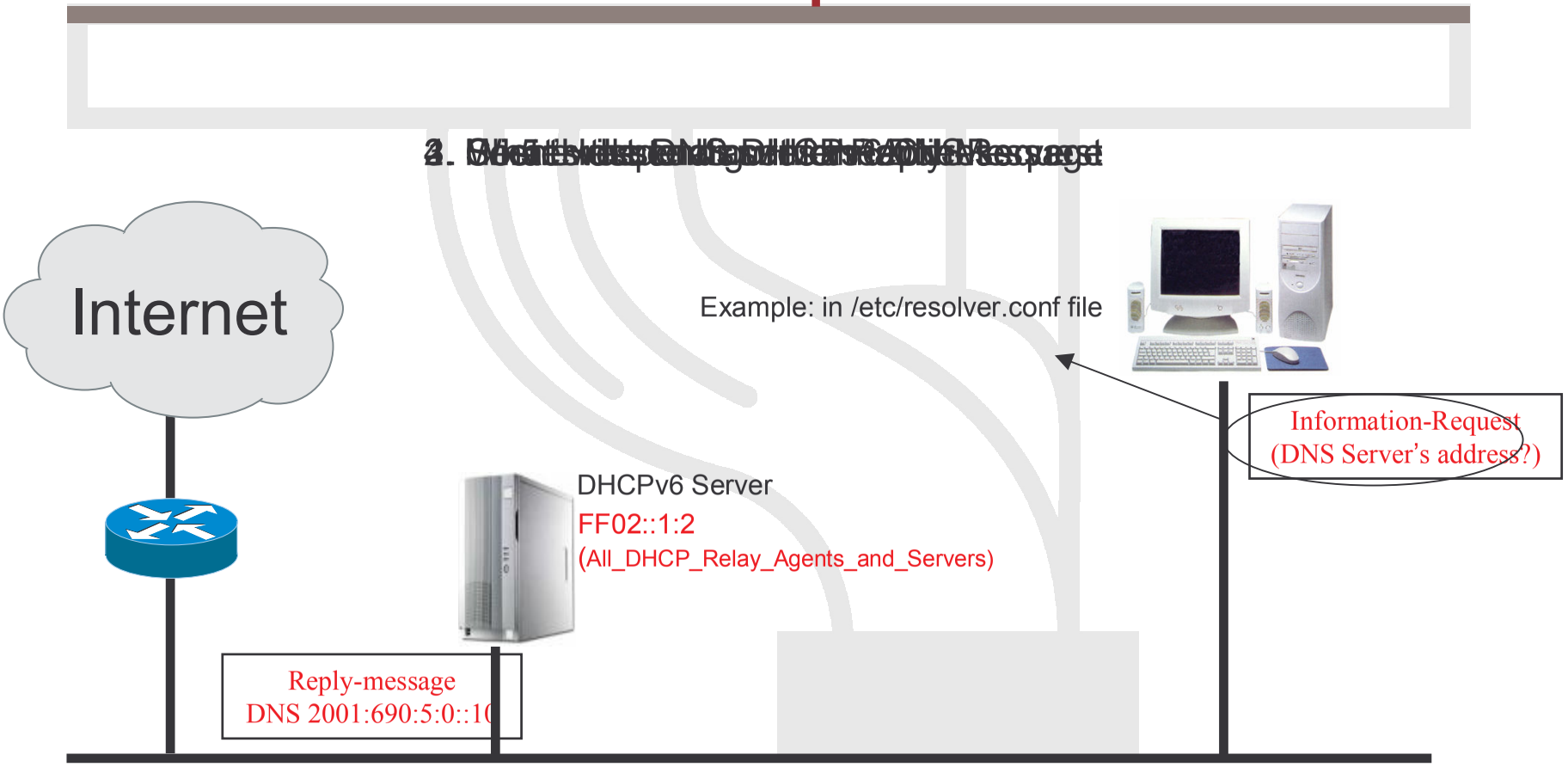
Stateful autoconfiguration (DHCPv6)

- DHCPv6 works in a client / server model
  - Server
    - Responds to requests from clients
    - Optionally provides the client with:
      - IPv6 addresses
      - Other configuration parameters (DNS servers…)
    - Is listening on multicast addresses:
      - All_DHCP_Relay_Agents_and_Servers (FF02::1:2)
      - All_DHCP_Servers (FF05::1:3)
    - Memorizes client's state
    - Provides means for securing access control to network resources

Stateful autoconfiguration (DHCPv6)

- Client
  - initiates requests on a link to obtain configuration parameters
  - uses its link local address to connect the server
  - Sends requests to FF02::1:2 multicast address (All_DHCP_Relay_Agents_and_Servers)
- Relay agent
  - node that acts as an intermediary to deliver DHCP messages between clients and servers
  - is on the same link as the client
  - Is listening on multicast addresses:
    - All_DHCP_Relay_Agents_and_Servers (FF02::1:2)

Stateful Autoconfiguration example



Conclusions

- The two types of configuration complement each other
  - Example: we can obtain the address from stateless autoconfiguration and the DNS server address from DHCPv6
- In dual-stack networks we can obtain DNS server addresses from **DHCPv4**
- DHCPv6 clients aren't still available natively in Operating Systems.
  - So, we still need to install manually a client
  - No transparent to users

Questions?