IPv6 Tutorial

Association G6

Contribution

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G6 group

- Group of IPv6 testers in France, Tunisia, Senegal,
- Academic & industrial partners
  - Renater, CNRS, ENST Bretagne, INRIA, Universities
  - AFNIC, 6Wind, Bull, ...
- Launched in 1995 by:
  - Alain Durand
  - Bernard Tuy
- Is today a legal association under French Law (1901)
  - Bernard Tuy, President
- For further information: http://www.g6.asso.fr

G6 charter

- Share experience gained from experimentations
- Spread IPv6 information
  - Book published (OReilly)
    - *IPv6, Théorie et pratique , 4th edition (November 2005)*
- Tutorials and trainings (ISPs, Engineers, netadmins,)
- Active in RIPE & IETF working groups
- Responsible for Renater IPv6 pilot service design

IPv6 Header: Simpler

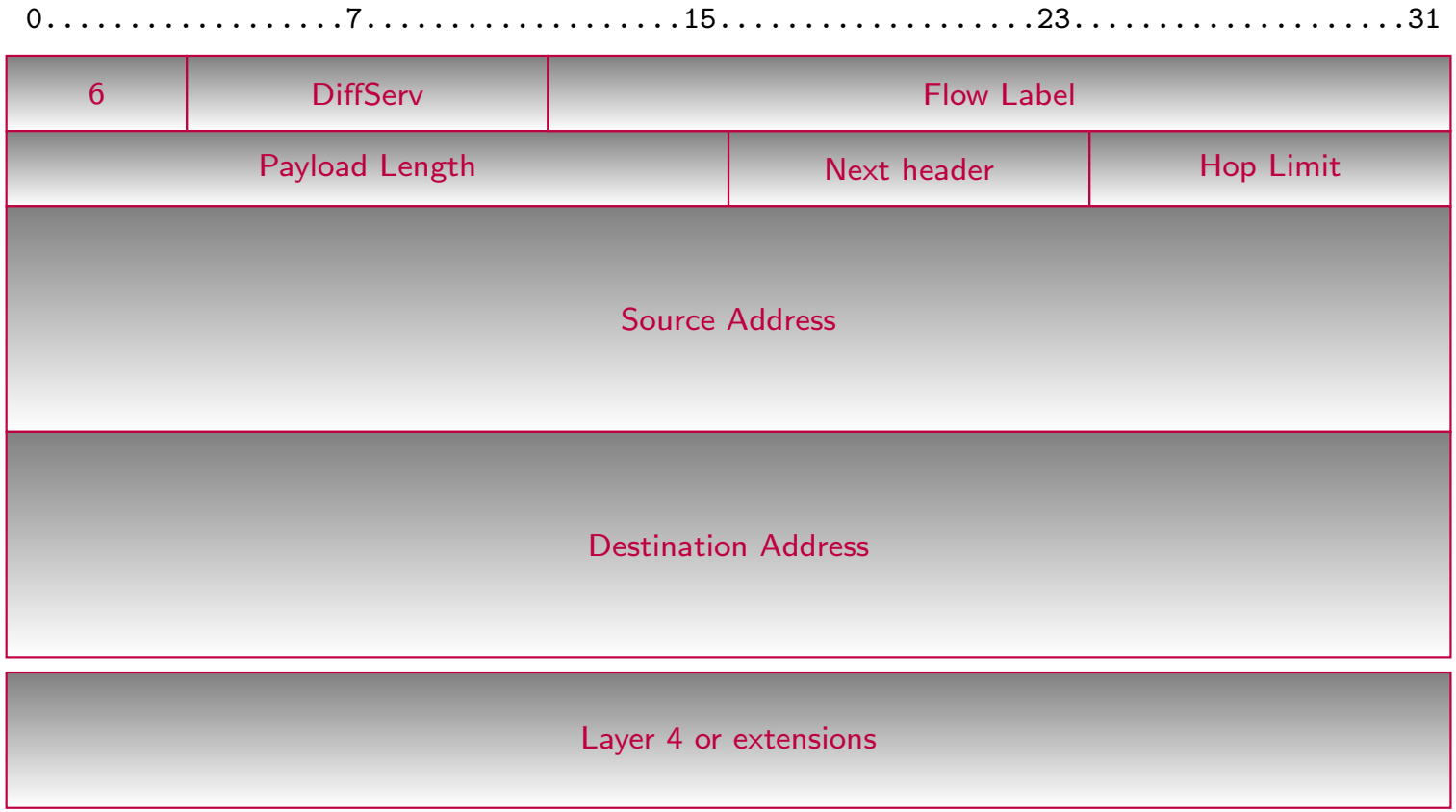
Definition

- IPv6 header follows the same IPv4 principle:
  - fix address size ... but 4 times larger
  - alignment on 64 bit words (instead of 32)
- Functionalities never used in IPv4 are supressed

Goal :

- Forward packet as fast as possible
- Less treatments in routers
- More functionalities at both ends

IPv4 Header



Is it enough for the future ?

- Address length
  - Between 1 564 and 3 911 873 538 269 506 102 addresses by m^2
  - 60 000 trillion trillion addresses per inhabitant of the earth
  - Addresses for every grain of sands in the world
- Justification of a fix address length

Warning:

- An address for everything on the network and not an address for everything
- No addresses for whole life:
  - Depend of your position on the network
  - ISP Renumbering may be possible

Notation

- Base format (a 16 byte Global IPv6 Address):
  - `2001:0660:3003:0001:0000:0000:6543:210F`
- Compact Format:

2001:0660:3003:0001:0000:0000:6543:210F

1. remove 0 on the left of each word
2. substitute one sequence of zeros by `::`

- an IPv4 address may also appear : `::FFFF:123.12.34.56`

Warning:

`2001:660:3::/40` is in fact `2001:660:0003::/40` and not `2001:660:0300::/40`

Notation

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2001:660:3003:1:0:0:6543:210F

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Addressing scheme

- RFC 4291 defines current IPv6 addresses
  - loopback (`::1`)
  - `link local (FE80::/10)`
  - `global unicast (2000::/3)`
  - `multicast (FF00::/8)`
- Use CIDR principles:
  - Prefix / prefix length notation
  - `2001:660:3003::/48`
  - `2001:660:3003:2:a00:20ff:fe18:964c/64`
- Interfaces have several IPv6 addresses
  - at least a link local and a global unicast addresses

Addressing Space Utilization

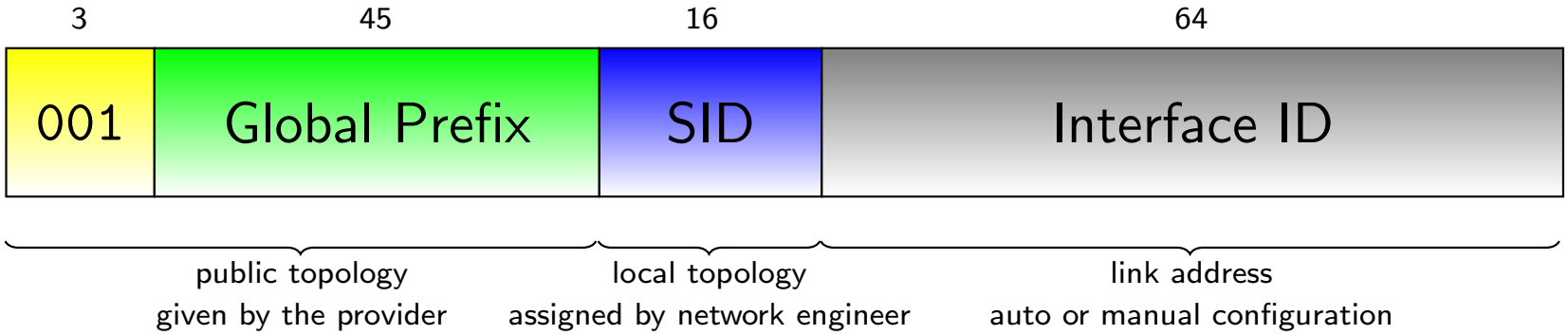

```
0000::/8 Reserved by IETF [RFC4291]
0100::/8 Reserved by IETF [RFC4291]
0200::/7 Reserved by IETF [RFC4048]
0400::/6 Reserved by IETF [RFC4291]
0800::/5 Reserved by IETF [RFC4291]
1000::/4 Reserved by IETF [RFC4291]
2000::/3 Global Unicast [RFC4291]
4000::/3 Reserved by IETF [RFC4291]
6000::/3 Reserved by IETF [RFC4291]
8000::/3 Reserved by IETF [RFC4291]
A000::/3 Reserved by IETF [RFC4291]
C000::/3 Reserved by IETF [RFC4291]
E000::/4 Reserved by IETF [RFC4291]
F000::/5 Reserved by IETF [RFC4291]
F800::/6 Reserved by IETF [RFC4291]
FC00::/7 Unique Local Unicast [RFC4193]
FE00::/9 Reserved by IETF [RFC4291]
FE80::/10 Link Local Unicast [RFC4291]
FEC0::/10 Reserved by IETF [RFC3879]
FF00::/8 Multicast [RFC4291]
```

Source:

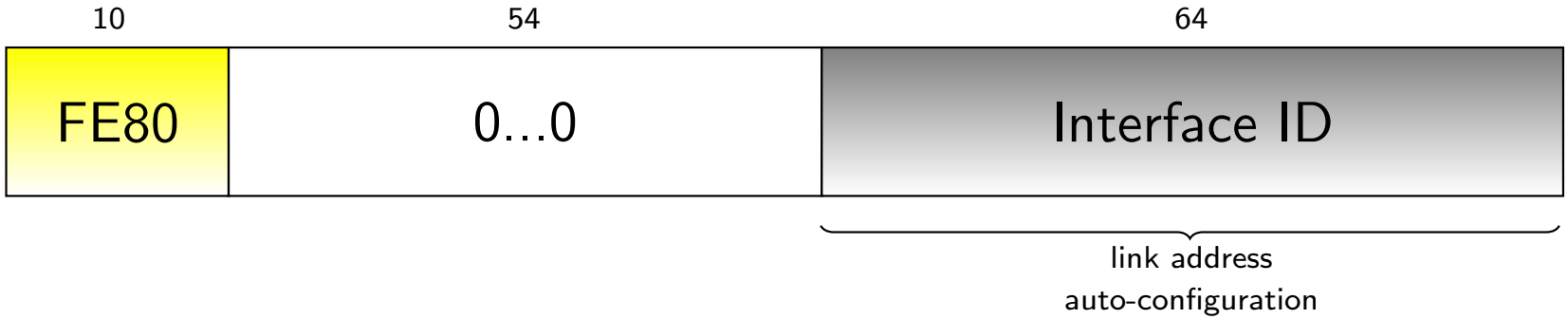
http://www.iana.org/assignments/ipv6-address-space

Address Format

Global Unicast Address:



Link-Local Address:



Link Local Scoped Addresses

- Global Address, the prefix designates the exit interface
- Link-Local address, the prefix is always fe80::/10
  - The exiting interface is not defined
  - A %iface, can be added at the end of the address to avoid ambiguity.
- Example:

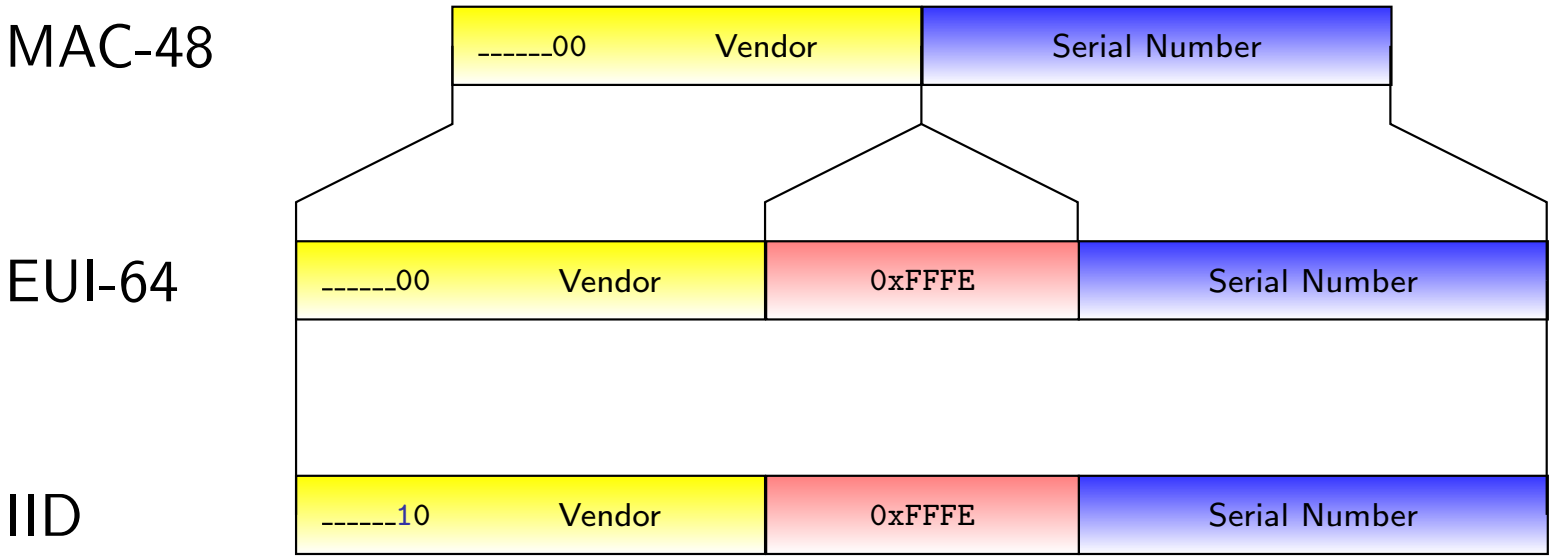
```
Routing tables

Internet6:
Destination                       Gateway                       Flags      Netif Expire

default                           fe80::213:c4ff:fe69:5f49%en0  UGSc        en0
```

How to Construct an IID from MAC Address

- 64 bits is compatible with EUI-64 (i.e. IEEE 1394 FireWire, ...)
- IEEE propose a way to transform a MAC-48 to an EUI-64
- U/L changed for numbering purpose



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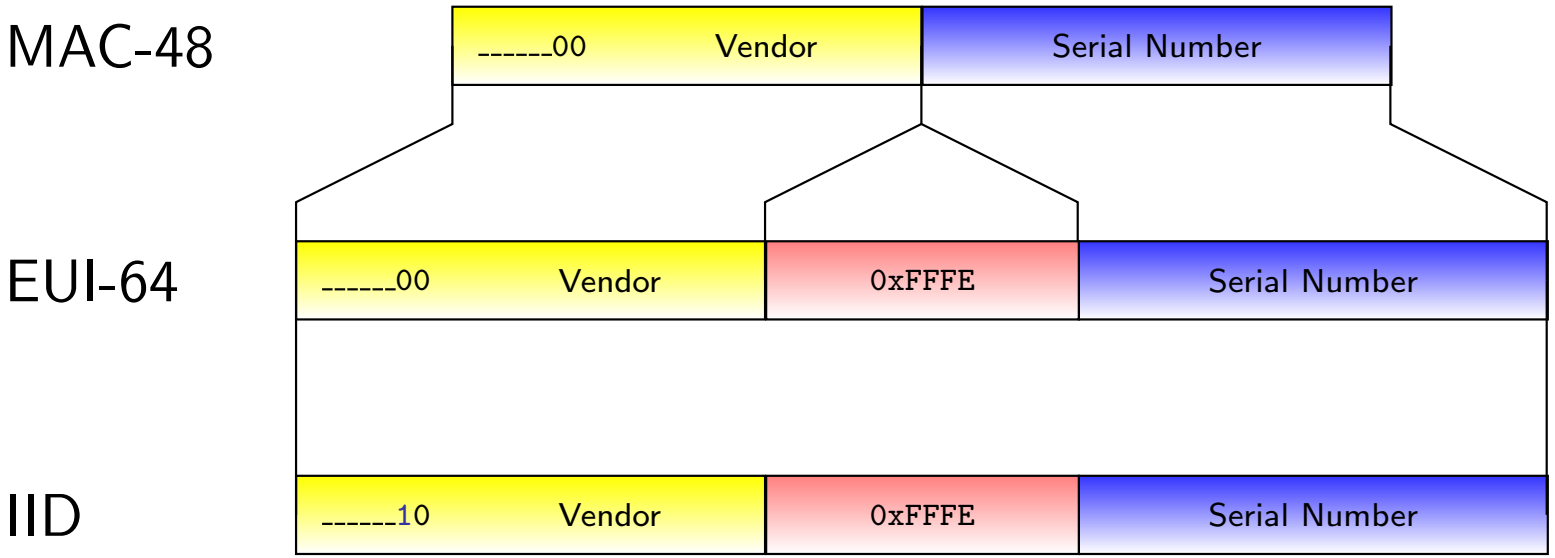

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Other kind of addresses: Multicast

Generic Format:

- T (Transient) 0: well known address - 1: temporary address
- P (Prefix) 1 : assigned from a network prefix (T must be set to 1)
- R (Rendez Vous Point) 1: contains the RP address (P and T set to 1)
- Scope :
  - 1 - node-local
  - 2 - link-local
  - 3 - subnet-local
  - 4 - admin-local
  - 5 - site-local
  - 8 - organisation-local
  - E - global

Some Well Known Multicast Addresses


```
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
FF02:0:0:0:0:0:0:6 OSPFIGP Designated Routers
FF02:0:0:0:0:0:0:9 RIP Routers
FF02:0:0:0:0:0:0:FB mDNSv6
FF02:0:0:0:0:0:1:2 All-dhcp-agents
FF02:0:0:0:0:1:FFXX:XXXX Solicited-Node Address
FF05:0:0:0:0:0:1:3 All-dhcp-servers
```

Web:

see : `http://www.iana.org/assignments/ipv6-multicast-addresses` for all multicast addresses

ICMPv6

- ICMPv6 is different from ICMP for IPv4
- Functionalities are extended and organized better
- Two functions :
  - Error occurs during forwarding ($value < 128$)
    - 1 Destination Unreachable (0 - no route to destination, 1 - communication with destination administratively prohibited, 3 - address unreachable, 4 - port unreachable)
    - 2 Packet Too Big
    - 3 Time Exceeded (0 - hop limit exceeded in transit, 1 - fragment reassembly time exceeded)
    - 4 Parameter Problem (0 - erroneous header field encountered, 1 - unrecognized Next Header type encountered, 2 - unrecognized IPv6 option encountered)
  - Management Applications ($value > 128$) :
    - ping6, traceroute6, neighbor discovery, multicast listener discovery,...

Stateless Auto-configuration: Basic Principles

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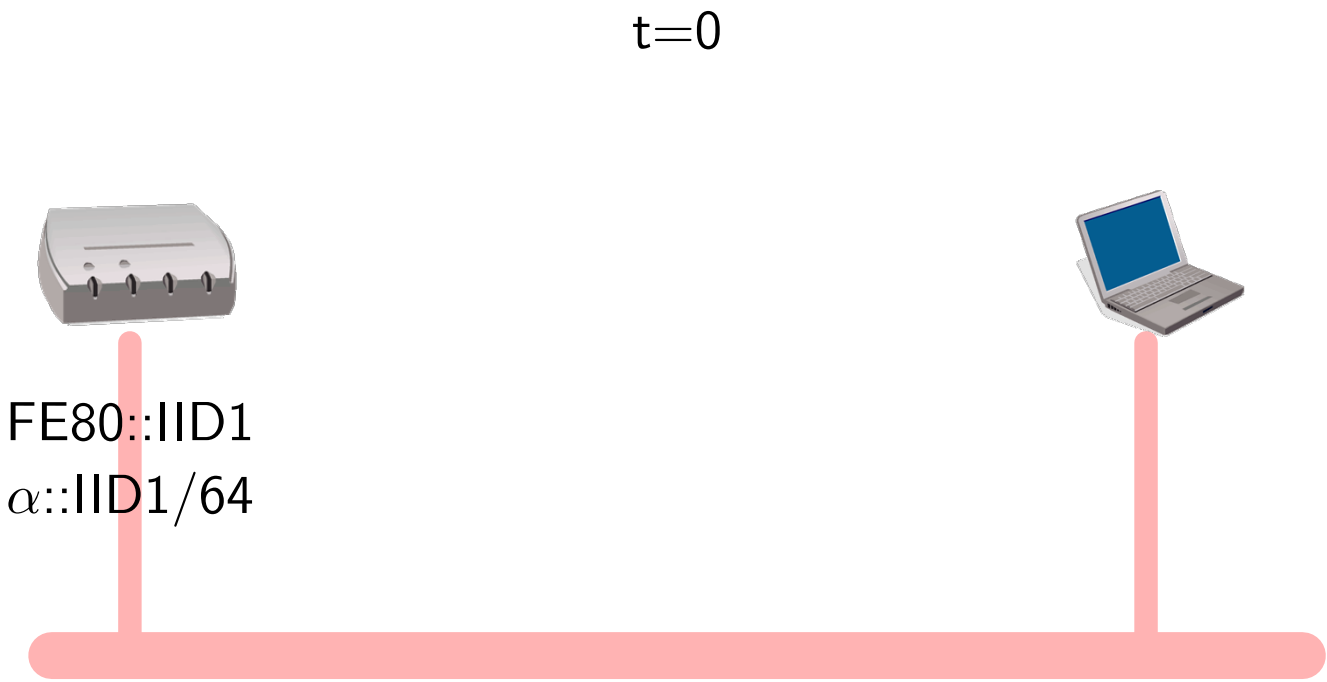


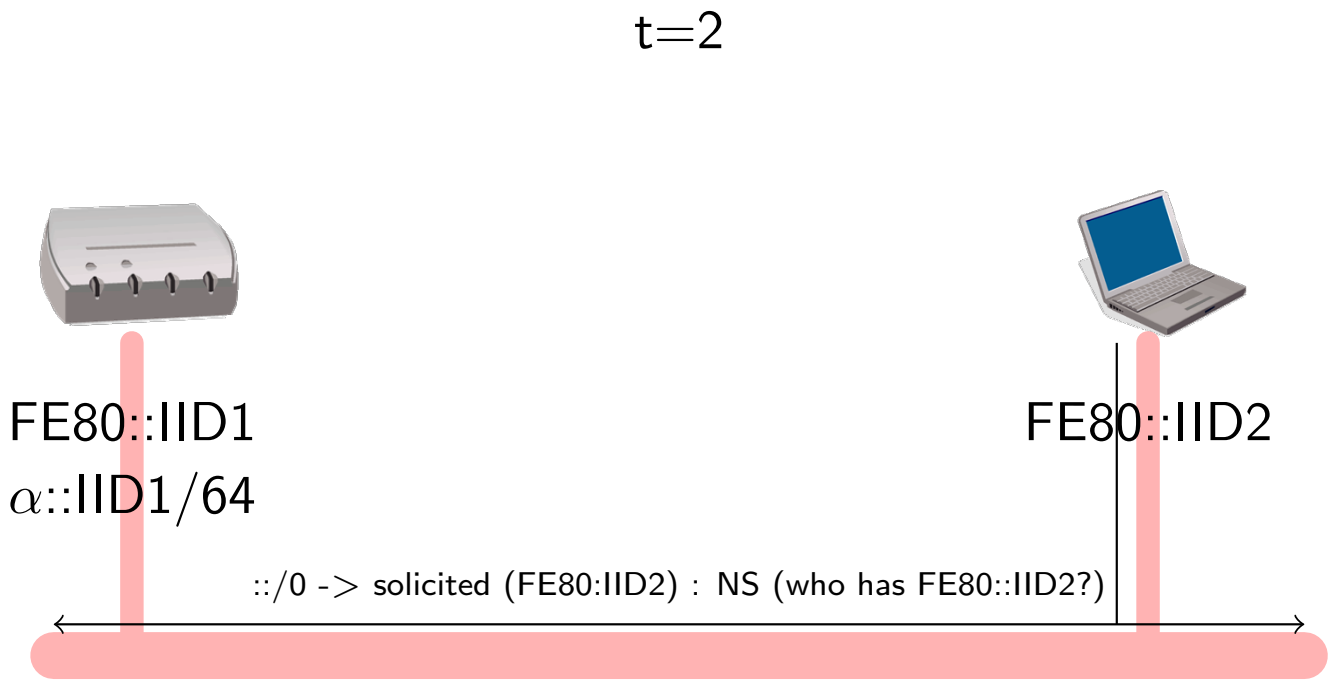
Time t=0: Router is configured with a link-local address and manually configured with a global address (α::/64 is given by the network manager)

Stateless Auto-configuration: Basic Principles

t=1 : Node Attachment

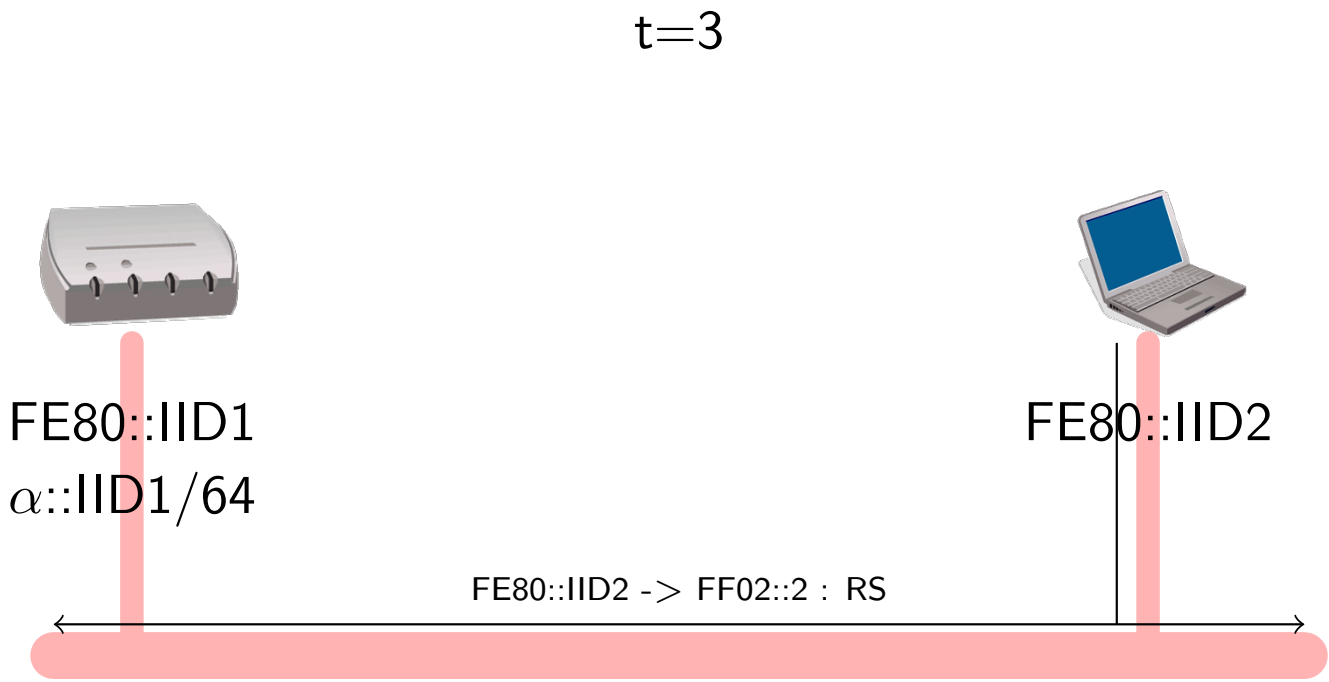
Host constructs its link-local address based on the interface MAC address

Stateless Auto-configuration: Basic Principles



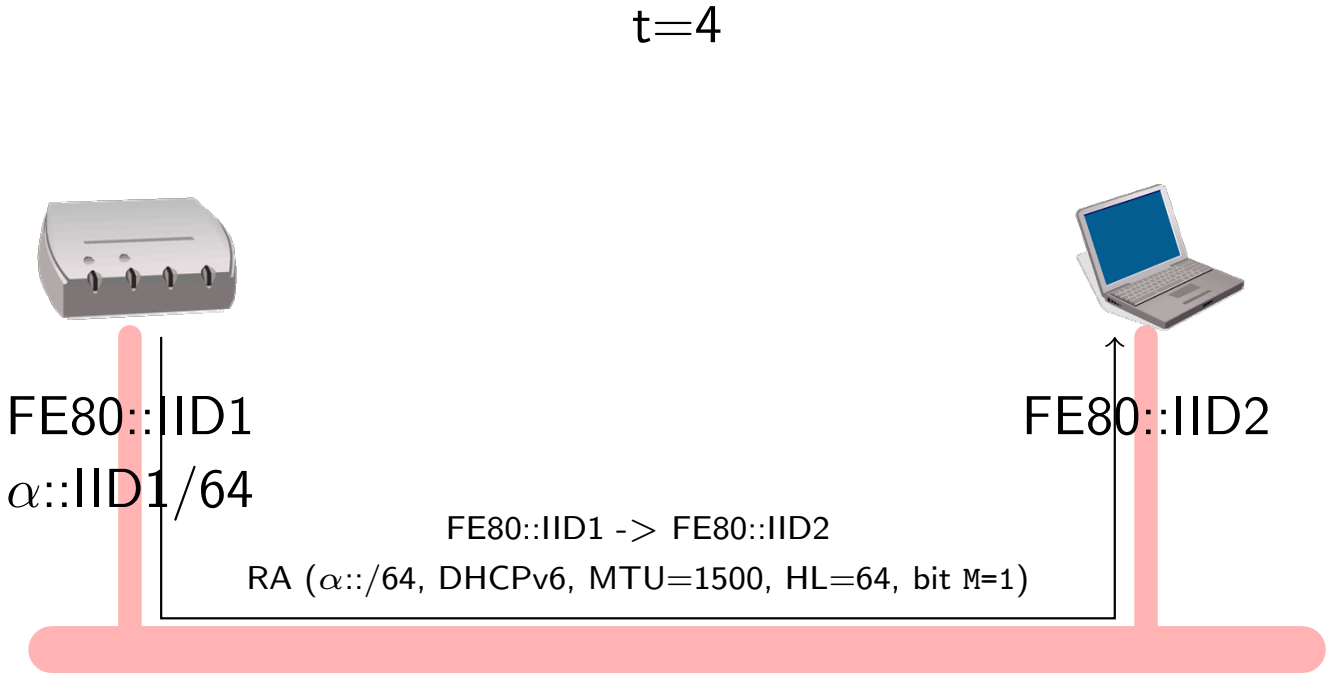
Host does a DAD (i.e. sends a Neighbor Solicitation to query resolution of its own address: no answers means no other host as this value).

Stateless Auto-configuration: Basic Principles



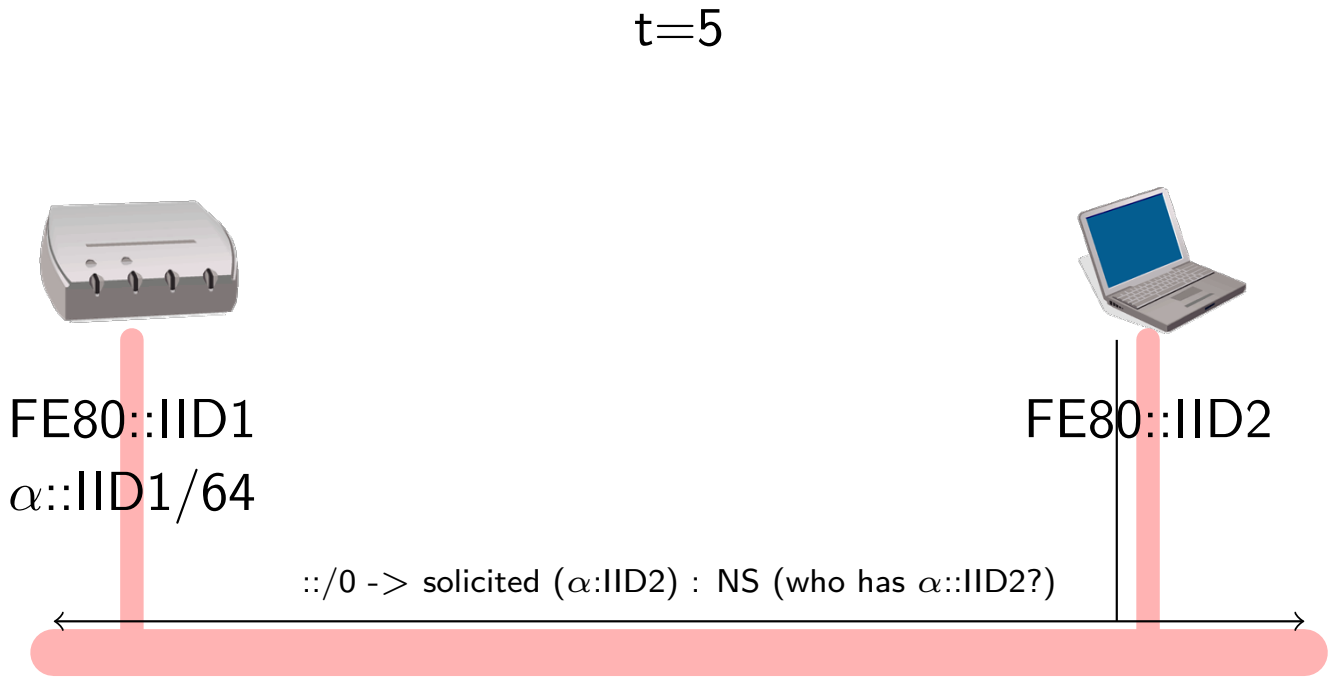
Host sends a Router Solicitation to the All Router Multicast group using the newly link-local configured address.

Stateless Auto-configuration: Basic Principles



Router answer directly to the host using Link-local addresses. The answer may contain a/several prefix(es). Router can also mandate hosts to use DHCPv6 to obtain prefixes (state full auto-configuration) and/or other parameters (DNS servers,...): Bit $\texttt{M} = 1$.

Stateless Auto-configuration: Basic Principles



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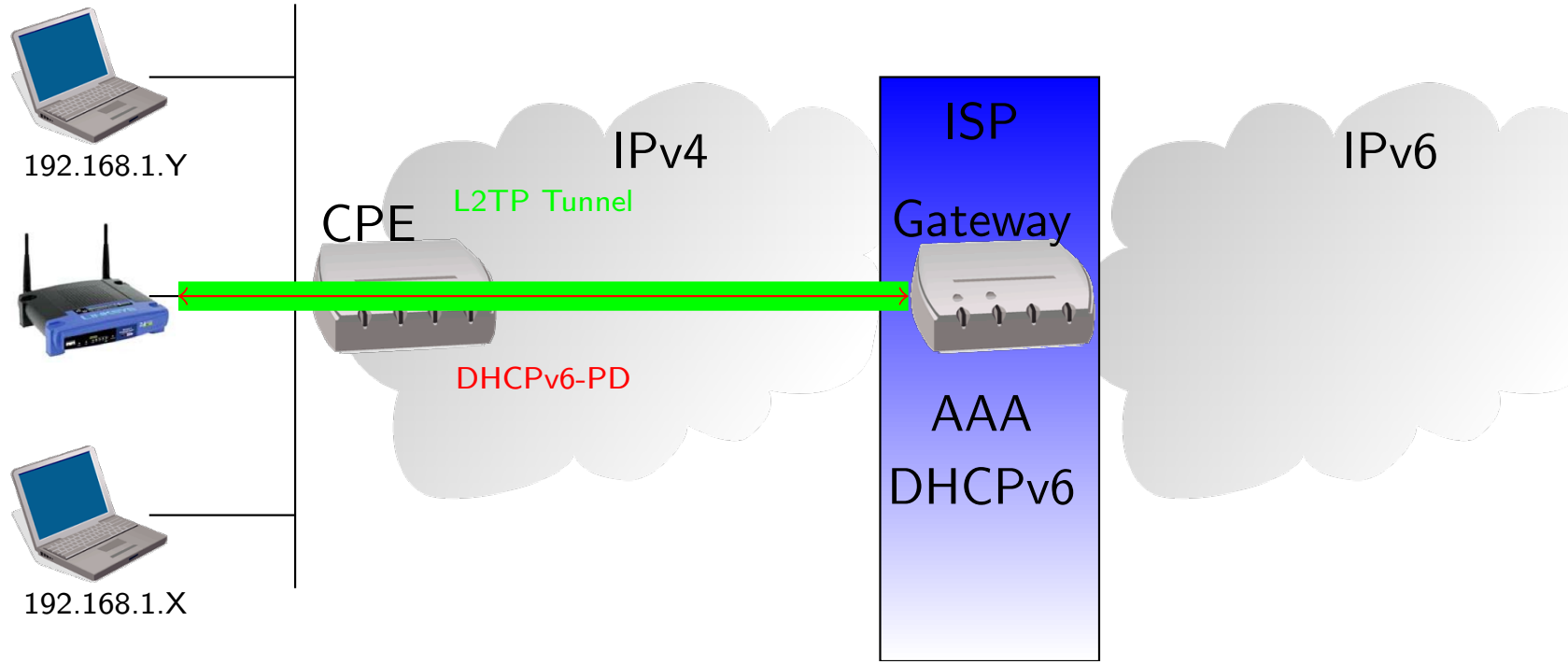
Softwires: H&S Architecture



IPv6 prefix for Home Network provided by DHCPv6

- Standard prefix delegation
- Link with AAA for prefix management