IPv6 Addressing and Implementation

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IPv6 - Agenda

- Why IPv6?
  - No business case
  - Different drivers
- IPv6 main features
- IPv6 Transition
- IPv6 Status

IPv6

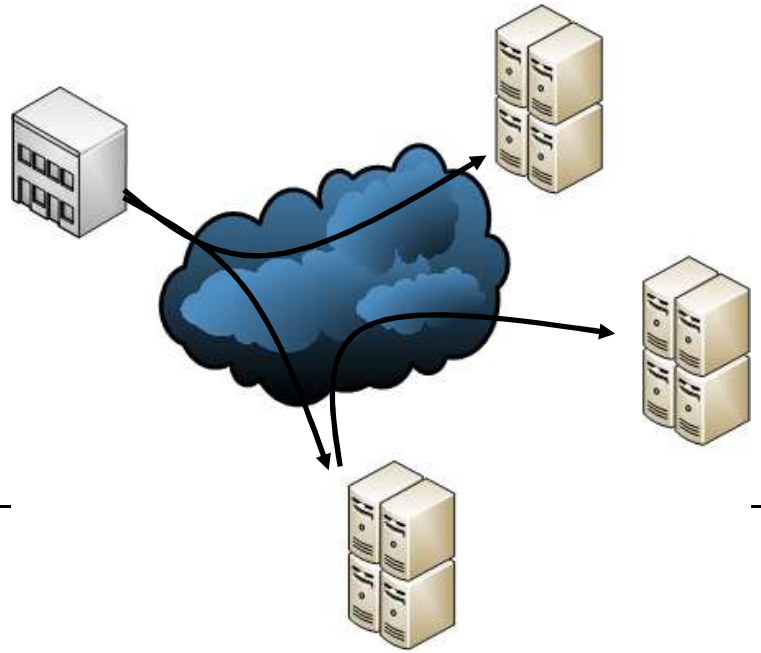
- IPv4 has been the Internet Protocol for almost 30 years
- In the early nineties, IPv4 address exhaustion became a concern
- A new IP protocol was devised and standardized by IETF in 1995: IPv6
- Since then it was always predicted IPv4 address depletion in the next 3 years
- However, it has not happened so far
- And the business case has been fading

The world is changing

- More people being connected to the Internet:
  - Growth of connected population in Asia, Latin America, Africa
- Internet and connectivity is not an entertainment but an essential need

New paradigms for servers

- SaaS (Salesforce.com)
- IaaS (EC2)
- Cloud Computing
- Mega-Datacenters (tens and hundreds of thousands of commodity low-end servers)



New paradigms for servers

- Virtualization
  - Migration (MIPv6), IPv6 address
- Autonomic Computing (Self-managed systems)
  - In the server segment and client segment
  - Autoconfiguration and neighbor discovery
  - EFIPSANS *www.**efipsans**.org*

Billions of mobile devices

- Embedded systems: digital home, digital health, automotive, military, wireless sensor networks
- Ubiquitous devices: cameras, smartphones
- New form factors: netbooks, MIDs
- Always-on data connection
- Different link technologies: 802.11, 802.15.x, 3G, 4G (WiMAX, LTE), 802.21 …
- PAN, Ad-hoc networks, Wifi Direct (My Wifi)
- P2P, paging, notifications

IPv6 - Main Features

- Address size is 16 Bytes.
- Extended address hierarchy.
- New header format: 1 Base Header + n Extension Headers.
- Different support for options (comparing to IPv4).
- Support for protocol extensions (e.g. Mobility support).

IPv6 - Main Features

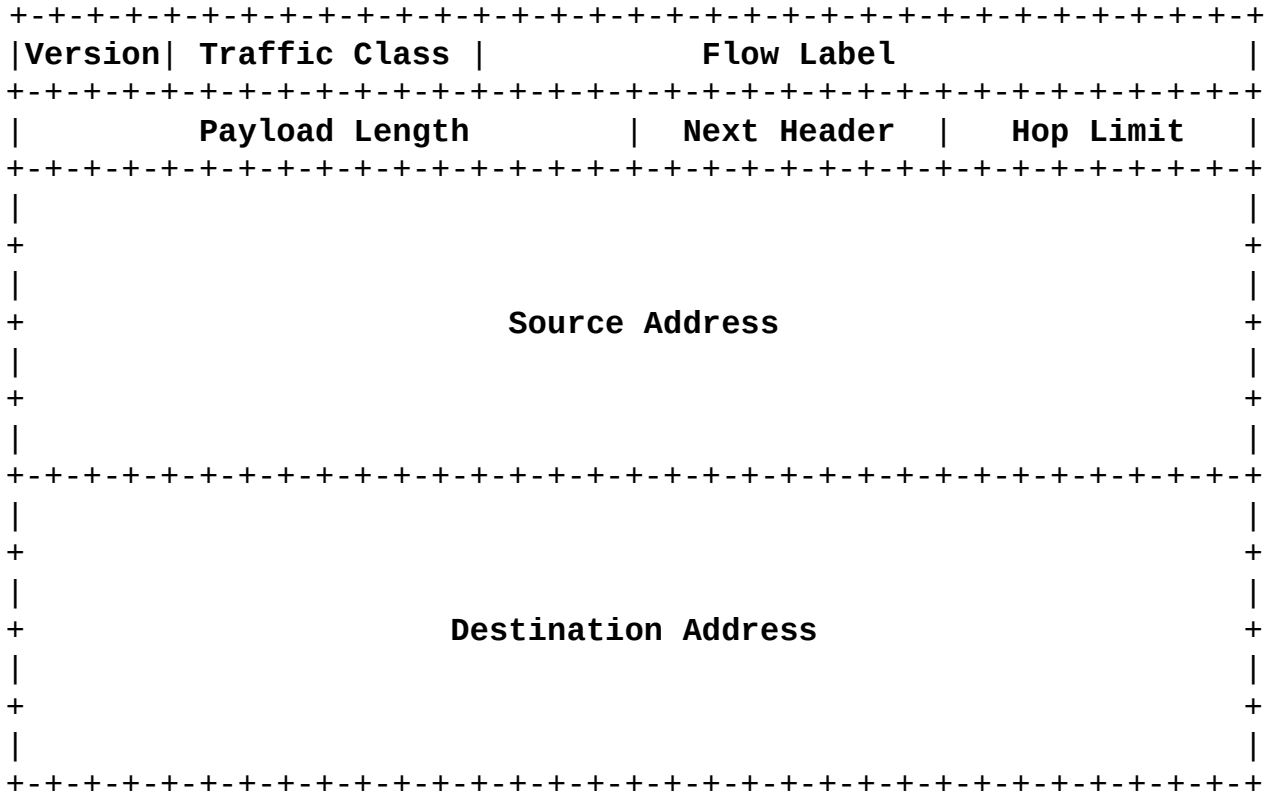
- Support for autoconfiguration and renumbering.
- Support for resource allocation: Flow label and service type.
- Support for authentication and privacy is specified: IPsec natively supported

IPv6 – Headers

- An IPv6 datagram has 40-octect Base Header and n Extension Headers.
- Advantages:
  - Improves performance on header processing.
  - The user can choose which extension headers to include and which to omit.
  - Flexibility for new options: more extension headers can be added.

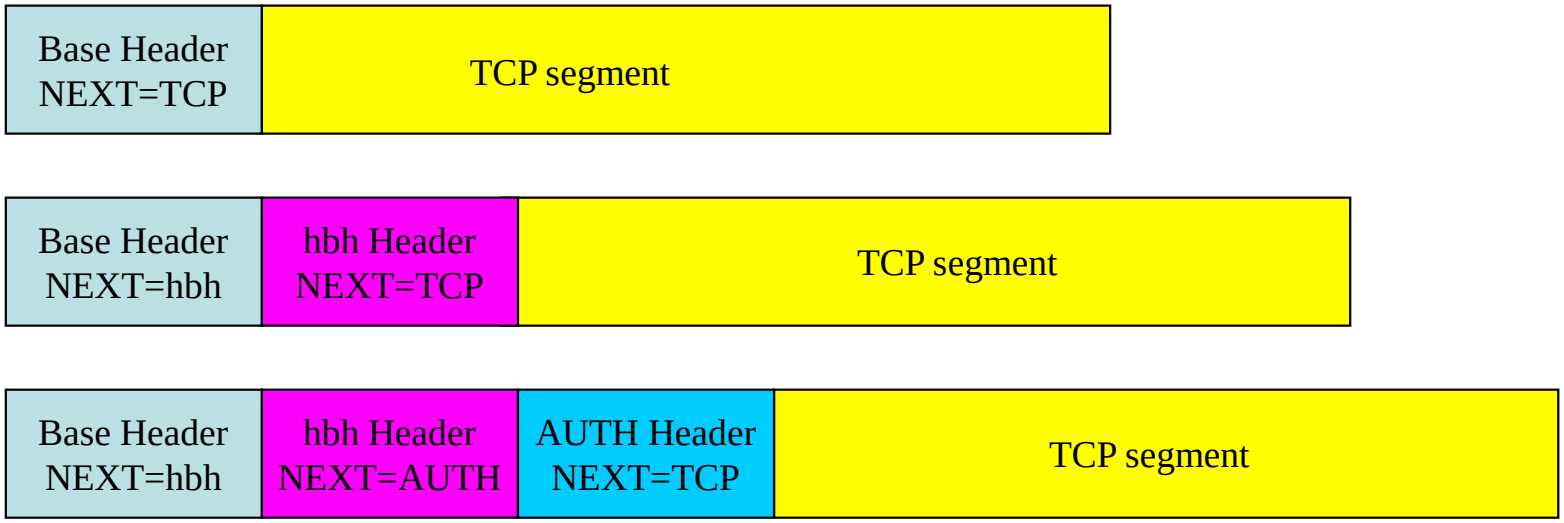
IPv6 – Base Header

- An IPv6 datagram has 40-octect Base Header and n Extension Headers.



IPv6 – Headers

- In order to Extract any header information from an IPv6 datagram a sequential search from the base header is required. Every header has a “next header” field.
- Different possibilities for datagrams with base header and n extension headers:



IPv6 – Extension Headers

- Recommended order:
  - Base header
  - Hop-by-Hop options header
  - Destination options header-1
  - Source Routing header (Type 0)
  - Type 2 routing header (for mobility)
  - Fragment header
  - Authentication header (AH).
  - Encapsulating Security Payload (ESP) header
  - Destination Options header-2
  - Upper-layer header

IPv6 – Text Representation of Addresses

- RFC 4291
- 16 Bytes: 128 bits.
- Text representation: Colon Hexadecimal Notation.

  2004:FFED:01:0:0:0:0CC:A1BC

  2004:FFED:1::0CC:A1BC

  0:0:0:0:128:FA:1234:5678

  ::128:F0A:1234:5678

  ::192.168.0.5 (x:x:x:x:x:x:d.d.d.d for embeddedIPv4 addresses)

  Note: Zero compression can be applied only once.

IPv6 - Addresses
Address types

- Unicast: specifies a single interface (a single node).
- Anycast: specifies a set of interfaces (typically belonging to different nodes). They are unicast addresses assigned to different interfaces. The pkt is delivered to exactly one of them, the nearest one.
- Multicast: specifies a set of interfaces (typically belonging to different nodes). The pkt is delivered to all of them.

Note: broadcast is handled with multicast addresses.

IPv6 - Addresses

Types and Scopes

Address Type	Binary Prefix	IPv6 Notation
Unspecified	**00…0**	**::/128**
Loopback	**00…1**	**::1/128**
Multicast Addresses	**1111 1111**	**FF00::/8**
Link-Local Unicast Addresses	**1111 1110 10**	**FE80::/10**
Unique Local IPv6 Unicast Addresses (RFC 4193)	**1111 1100**	**FC00::/7**
Global Unicast Addresses (Aggregatable)	**everything else**	

IPv4-Mapped IPv6 Address: **::FFF:d.d.d.d (used in dual-stack nodes)**

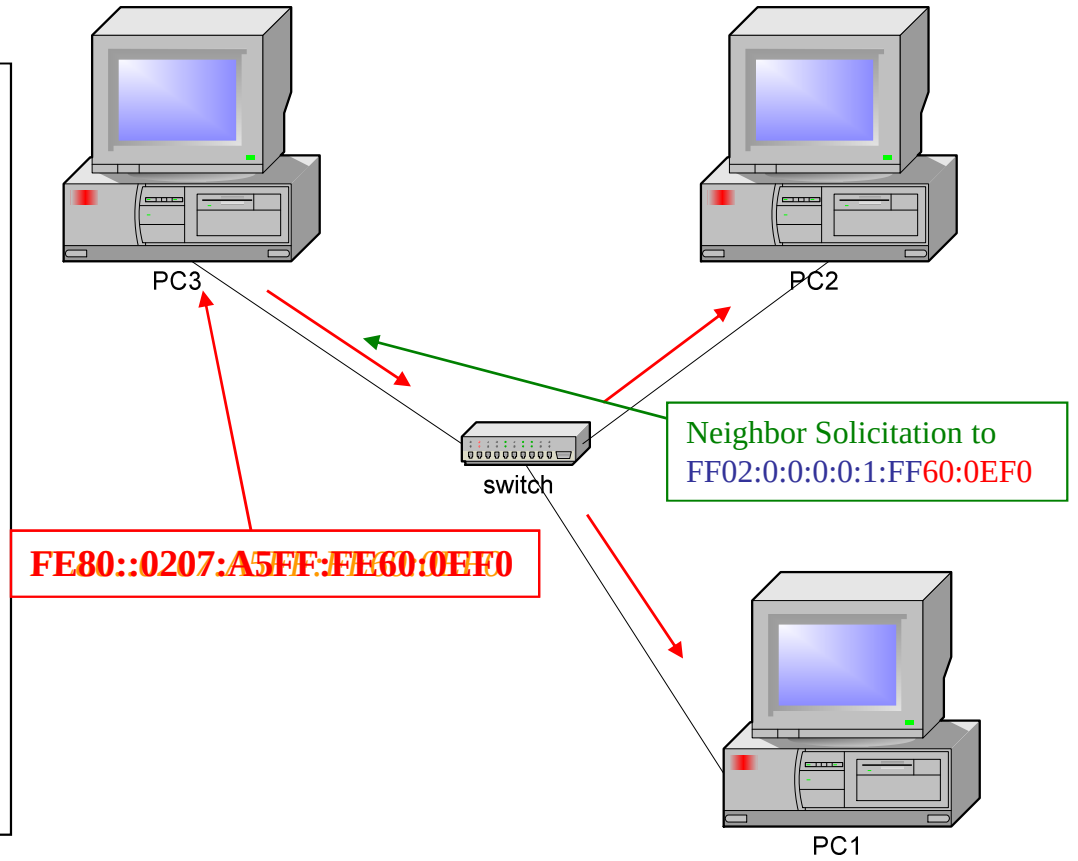
IPv6 – Address Autoconfiguration

- The procedure a host follows to create its interface addresses without manual assistance.
- Autoconfiguration is performed on a per-interface basis on multicast-capable links in multicast-capable interfaces. Begins when the interface becomes enabled.
- It uses Neighbor Discovery Protocol messages.
- Address Autoconfiguration can be:
  - Stateless: without assistance of stateful servers.
  - Stateful: with assistance of a stateful server; for example DHCPv6.
- Both Stateless and Stateful are complementary.

IPv6 – Address Autoconfiguration

Address Autoconfiguration Steps – Link-Local Address

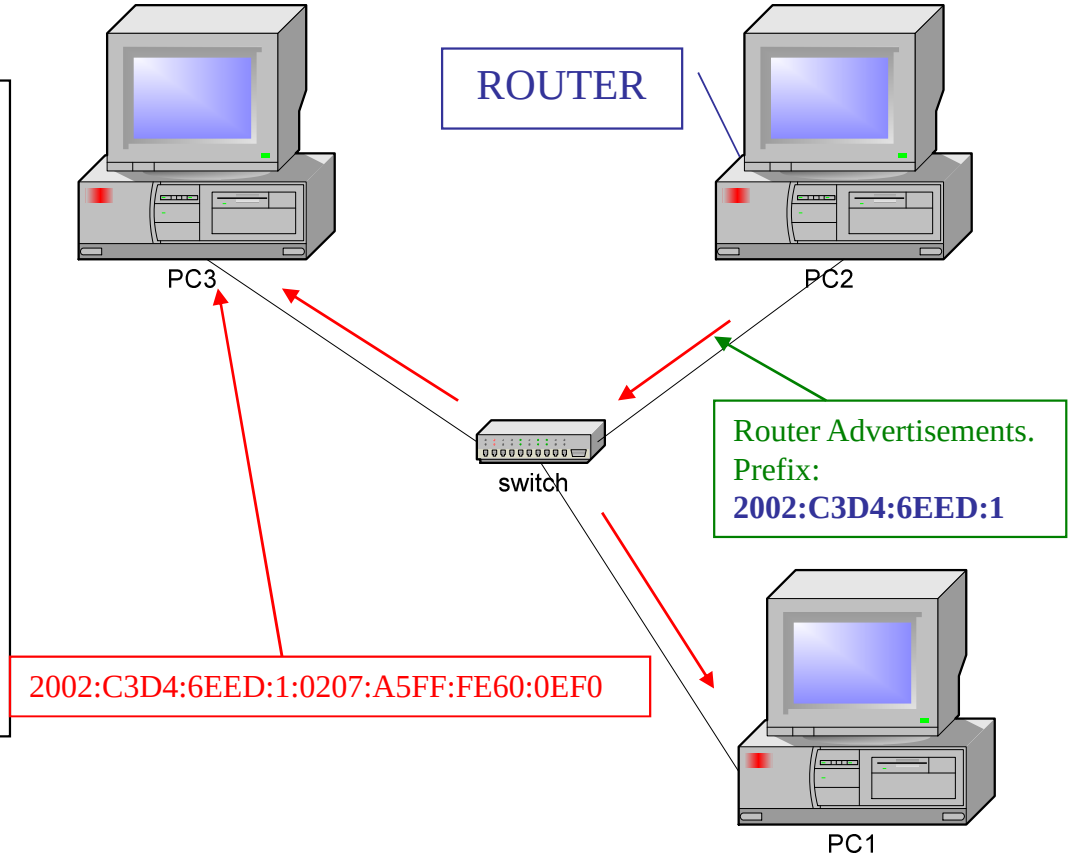
1. Interface is enabled.
2. "Tentative" link-local address is formed.
3. Duplicate Address Detection is performed: A Neighbor Solicitation is sent to Solicited-Node Multicast Address of the Target Address
4. If the node ascertains the link-local address is unique, it is assigned to the interface.
5. The node has only link connectivity.



IPv6 – Address Autoconfiguration

Stateless Address Autoconfiguration - Next Steps

1. Routers periodically send out Router Advertisements with Prefix Information Options.
2. If a prefix published in the Prefix Information Option has the appropriate flag set, it can be used to form a Global Address or a Local Unicast Address.
3. The node has Site or Internet-wide connectivity.

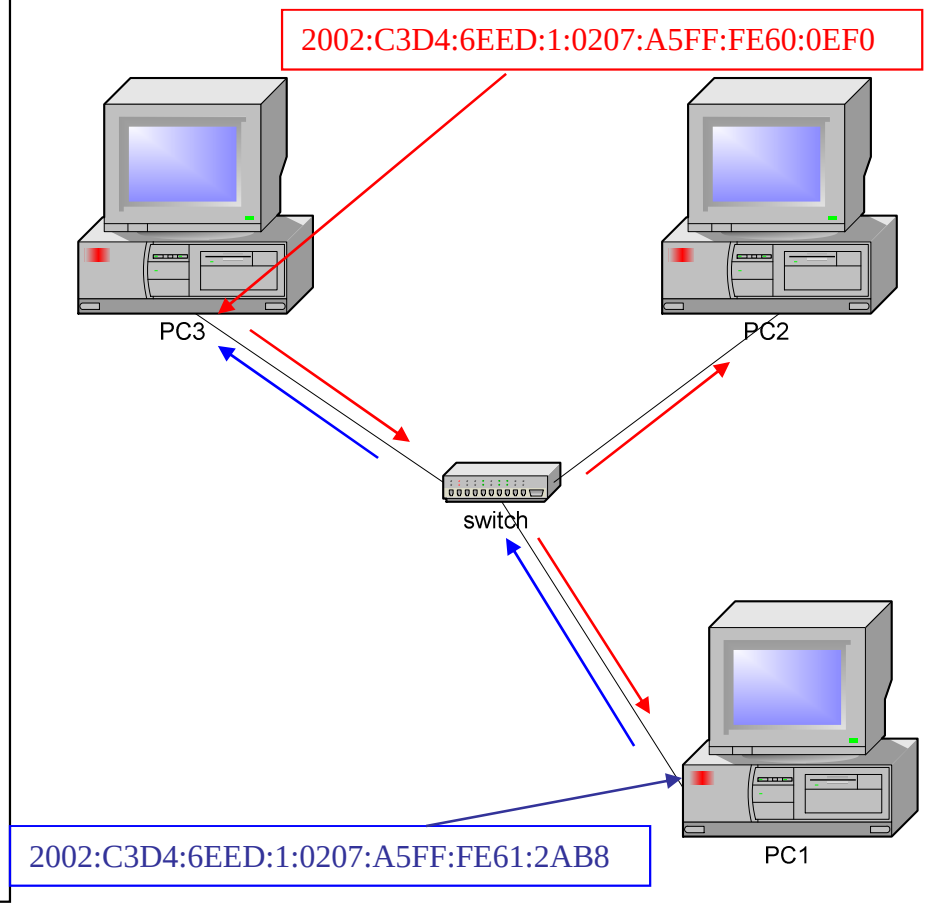


Neighbor Discovery Protocol for IPv6

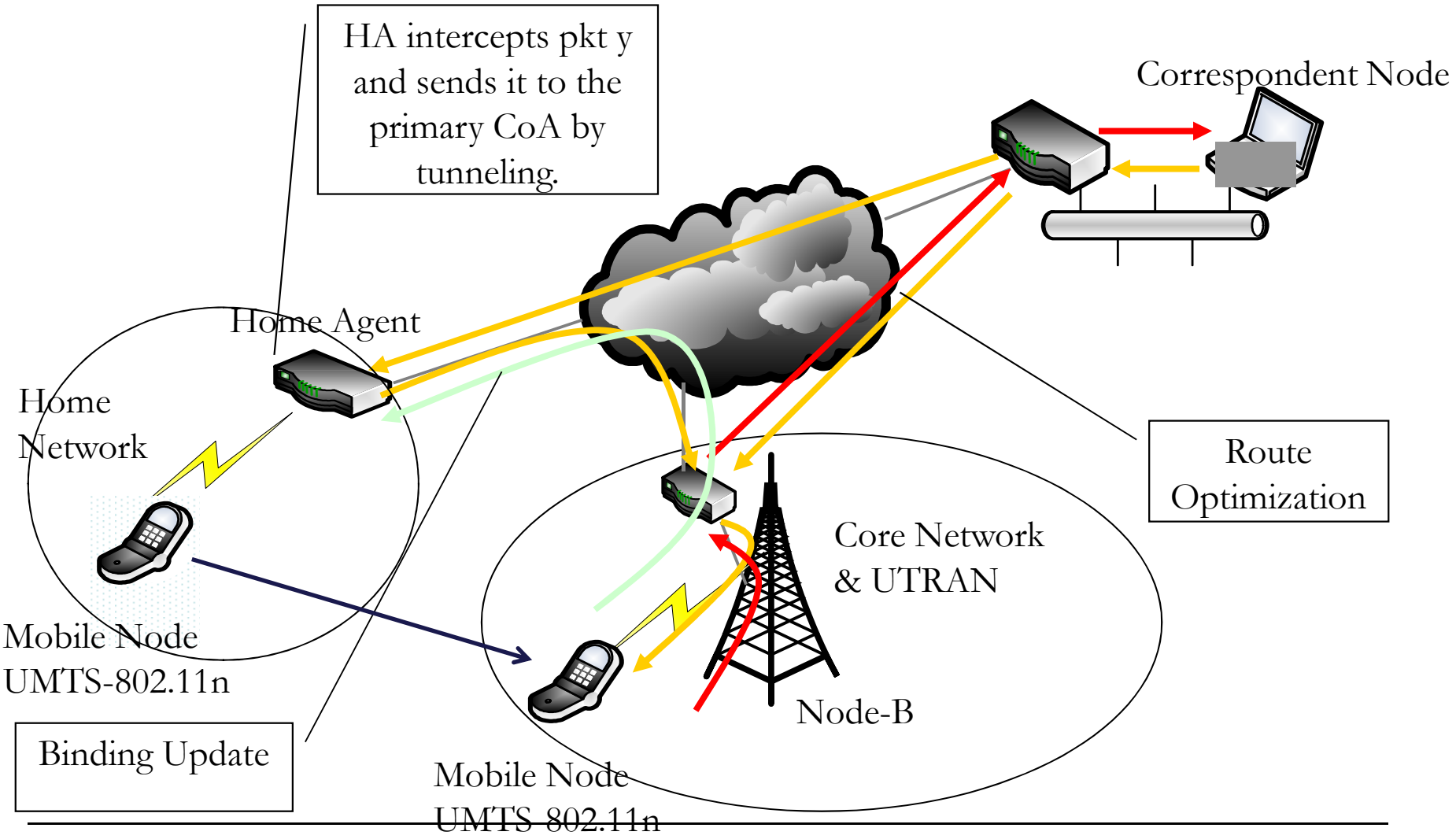
- This protocol is used in IPv6 to:
  - Determine neighbor's link-layer address, i.e. address resolution (NO ARP).
  - Determine neighbor bidirectional reachability: Neighbor Unreachability Detection.
  - Discover neighboring routers.
  - Learning link specific parameters: network prefixes, MTU, etc.
  - Next-Hop determination and Redirect.
  - Duplicate Address Detection in Address Autoconfiguration.
  - Proxy support.
- Messages used in ND Protocol are part of ICMPv6.

IPv6 – ND Protocol Address Resolution

1. PC3 is to send a packet to 2002:C3D4:6EED:1:0207:A5FF:FE61:2AB8 but first it needs to know the corresponding HW address.
2. PC3 sends a Neighbor Solicitation asking for the owner of the destination address: it is sent to the solicited-node multicast address for the target addr.
3. PC1 reads the Neighbor Solicitation and responds with a Neighbor Advertisement telling its link-layer address.
4. PC3 can physically send the packet to the HW (link-layer) address of PC1.



Mobile IPv6

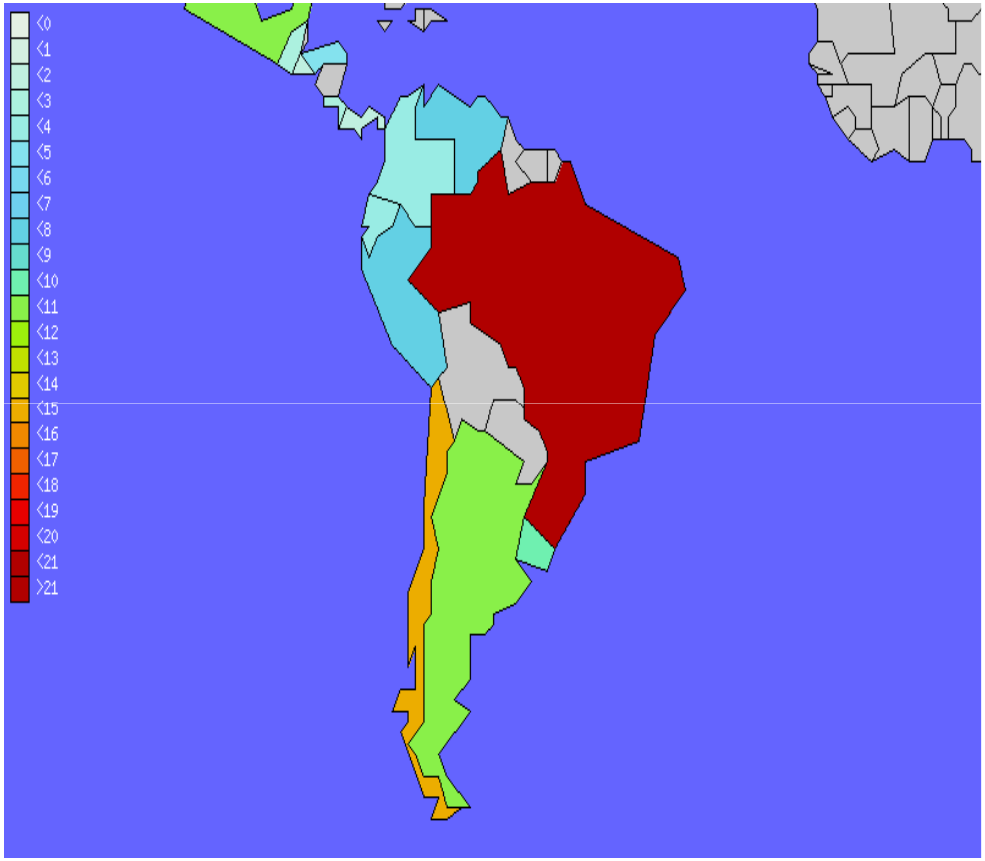

HA intercepts pkt y and sends it to the primary CoA by tunneling.
Correspondent Node
Home Agent
Home Network
Route Optimization
Core Network & UTRAN
Node-B
Mobile Node UMTS-802.11n
Binding Update
Mobile Node UMTS-802.11n

Transition and co-existence

- Slow Transition:
  - IPv4 and IPv6 will co-exist for more than 10 years
- Application must be protocol agnostic
  - Use URL instead of IP address
  - Rely on dual-stack
  - Abstract from protocol-specific
- Technology transition:
  - Teredo
  - 6to4
  - ISATAP
  - Dual-stack

IPv6 Status – BGP mon http://bgpmon.net/blog/?p=166

Position	Country	Score (Ipv6/IPv4)
1	Holy See (Vatican City State) (VA)	100% (1/1)
2	Cuba (CU)	60% (3/5)
3	Fiji (FJ)	50% (1/2)
4	**Uruguay (UY)**	**35% (9 / 26)**
5	Tunisia (TN)	33% (1/3)
5	Senegal (SN)	33% (1/3)
5	Monaco (MC)	33% (1/3)
5	Mali (ML)	33% (1/3)
6	**Estonia (EE)**	**28% (10/36)**
7	Isle of Man (IM)	25% (1/4)
8	**European Region (EU)**	**22% (22/99)**
9	Madagascar (MG)	20% (1/5)
9	Bhutan (BT)	20% (1/5)
10	**Luxembourg (LU)**	**19% (8/42)**
10	**Czech Republic (CZ)**	**19% (30 /159)**
11	**New Zealand (NZ)**	**18% (31 / 173)**
11	**Costa Rica (CR)**	**18% (2/11)**
12	Cote D'Ivoire (CI)	17% (1/6)
12	Virgin Islands, U.s. (VI)	17% (1/6)
12	Qatar (QA)	17% (1/6)
13	**Japan (JP)**	**15% (82 / 537)**
13	**Viet Nam (VN)**	**15% (5/34)**
13	**Taiwan, Province of China (TW)**	**15% (17 / 112)**
14	**Portugal (PT)**	**14% (10 / 70)**
14	**Netherlands (NL)**	**14% (66 / 484)**
14	**Malaysia (MY)**	**14% (9 / 64)**
14	Mauritius (MU)	14% (1/7)
15	**Liechtenstein (LI)**	**13% (2/16)**
16	**Egypt (EG)**	**11% (5/45)**
16	**Norway (NO)**	**11% (12 /111)**
16	**South Africa (ZA)**	**11% (10/ 88)**
16	Trinidad and Tobago (TT)	11% (1/9)



IPv6 Status

- Most OS's: Windows Vista/7, Linux, Chrome OS
- Products: Microsoft's DirectAccess
- Google since 2008 (http://www.google.com/intl/en/ipv6)
  - Plans to add IPv6 to YouTube
  - http://www.networkworld.com/news/2009/032509-google-ipv6-easy.html?page=2
- Devices connecting to Verizon's LTE network (2010) must support IPv6
- US Government agencies are IPv6 ready since 2008
- Comcast is offering IPv6 transit services and has plans for residential IPv6 trials (2010)
- Hurricane Electric, Global Crossing, NTT America
- IPv6 at Olympics

Conclusions and Call To Action

- IPv6 is silently gaining adoption
- It is not a matter of migration but co-existence of IPv4 and IPv6
- New IPv4 addresses could be unavailable in 2011
- IPv6 is not only about more IP addresses
  - Opportunity for innovation
- Plan for IPv6 training and pilots in 2010
- IPv6 Task Force?
- GoGo6: http://www.gogo6.com

Questions
And
Answers?

Link References

- IST IPv6 Portal: http://www.ist-ipv6.org
- IPv6 Forum: http://www.ipv6forum.org
- Argentina IPv6 Task Force: http://www.ar.ipv6tf.org (?)
- NTIA comments on IPv6: http://www.ntia.doc.gov/ntiahome/ntiageneral/ipv6
- North American IPv6 Task Force: http://www.nav6tf.org/
- IPv6 and Broadband: www.ist-ipv6.org/pdf/ISTClusterbooklet2005.pdf
- IPv6 Forum Roadmap & Vision: http://www.6journal.org/archive/00000261/02/WWC_IPv6_Forum_Roadmap__Vision_2010_v6.pdf
- IETF: www.ietf.org
- HP IPv6 tutorial: http://h10026.www1.hp.com/netipv6/IPv6_seminar_Oct2004.pdf
- IPv4-IPv6Transition:
  - http://www.6journal.org/archive/00000046/01/trans_ipv6_v014.pdf
  - http://usipv6.unixprogram.com/North_American_IPv6_Summit_2004/IPv6_Tutorial/marc_blanchet_tutorial_ipv6_transition.pdf