Routing Protocols and Concepts

Network Technology 1 – Routing protocol and concepts

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History

- 1974, the network prefix was determined by the first 8 bits of an IP address.
- September 1981 RCP 791 was published dividing the address space into three classes (Classful IP addressing)
  - Class A: first 8 bits.
  - Class B: first 16 bits.
  - Class C: first 24 bits.

Classful IP addressing

High Order Bits

Class	High Order Bits	Start	End
Class A	0	0.0.0.0	127.255.255.255
Class B	10	128.0.0.0	191.255.255.255
Class C	110	192.0.0.0	223.255.255.255
Multicast	1110	224.0.0.0	239.255.255.255
Experimental	1111	240.0.0.0	255.255.255.255

[2]

Figure : Classful address ranges

Subnet Mask based on Class

	1st Octet	2st Octet	3st Octet	4st Octet	Subnet Mask
Class A	Network	Host	Host	Host	255.0.0.0 or /8
Class B	Network	Network	Host	Host	255.255.0.0 or /16
Class C	Network	Network	Network	Host	255.255.255.0 or /24

Number of Networks and Hosts per Network for Each Class

Address class	First Octet Range	Number of Possible Networks	Number of Host per Networks
Class A	0 to 127	128 (2 are reserved)	16,777,214
Class B	128 to 191	16,348	65,534
Class C	192 to 223	2,097,152	254

- Classes solved one problem.
- Still a shortage of addresses.

Prolonging the inevitable

- VLSM and CIDR (RFC 1519) - 1993
- Native Address Translation (RFC 1631) - 1994
- Private addresses (RFC 1918) - 1996

Classless Inter-domain Routing and VLSM

- Role of the subnet mask?
- Variable Length Subnet Mask (VLSM)
  - Allows us to subnet a classful address.
  - Or even subnet an already sub-netted classful address.
- Classless Inter-domain Routing
  - Allows us to aggregate multiple routes into a single route
  - Prefix aggregation or Route summarization.
  - Decrease the size of the routing tables.
- Concept of classes is no longer needed.

Examples

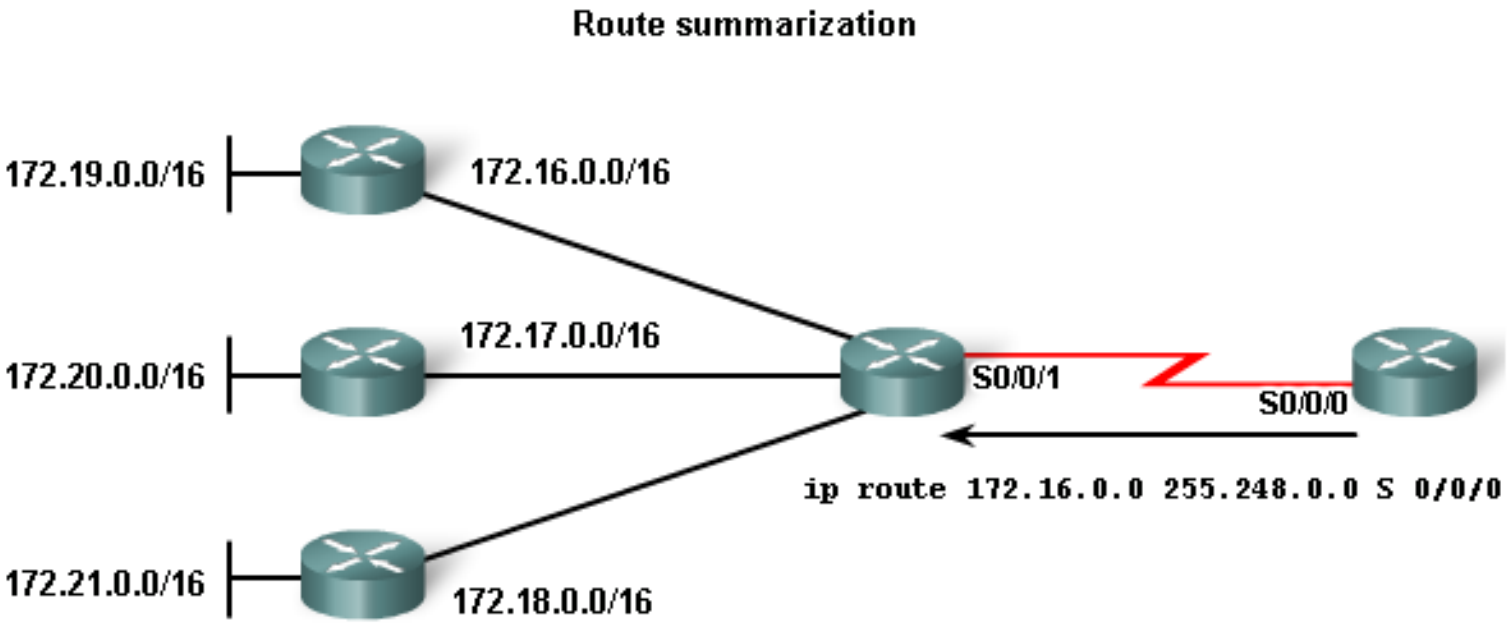
Variable Length Subnet Mask

- `193.45.68.0/24`
  - 8 subnets

When subnetting we always try to keep as large of address ranges available as possible.

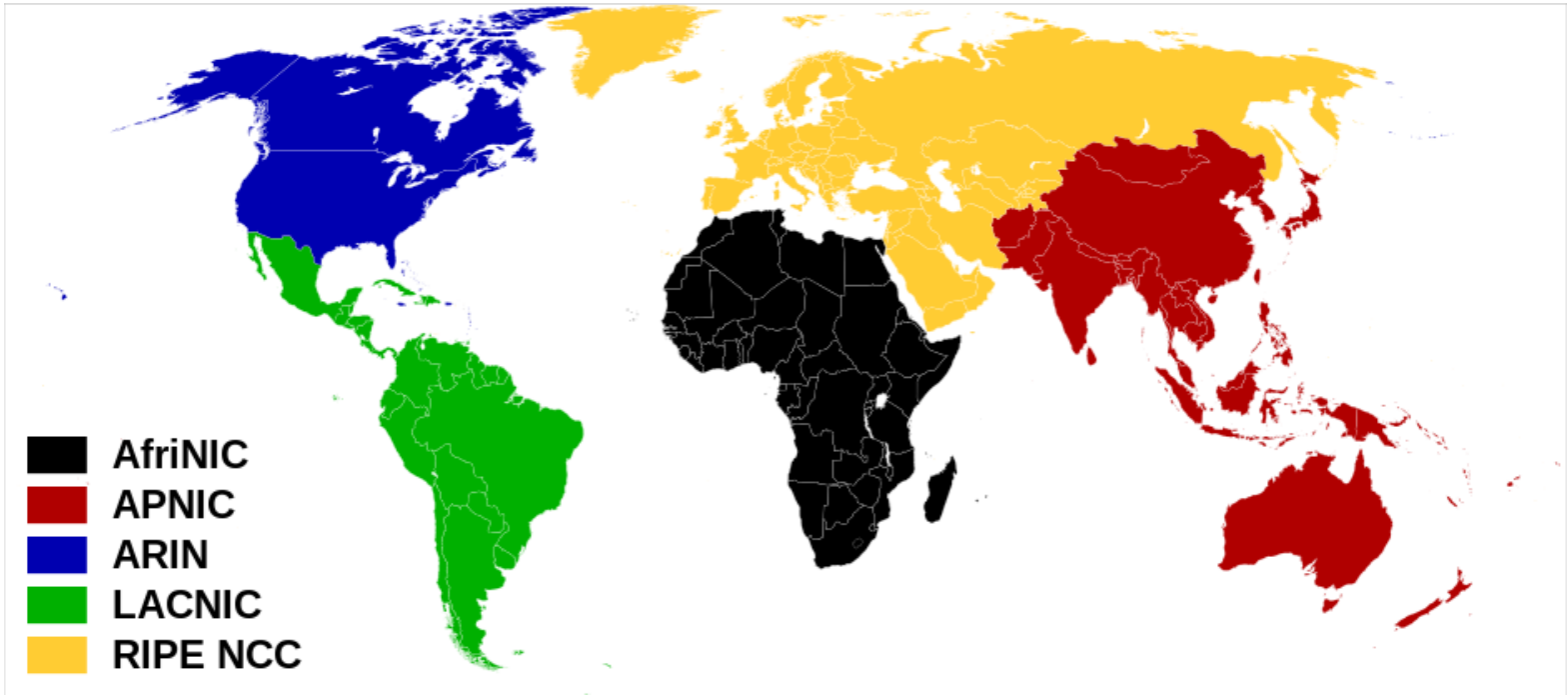
- 174.15.0.0/16
  - 1 network should support 500 hosts
  - 2 networks should support 120 hosts
  - 7 networks should support 1000 hosts
  - 5 WAN-link networks (2 hosts)
  - 3 networks should support 16 000 hosts

Route Summarization



Address allocation

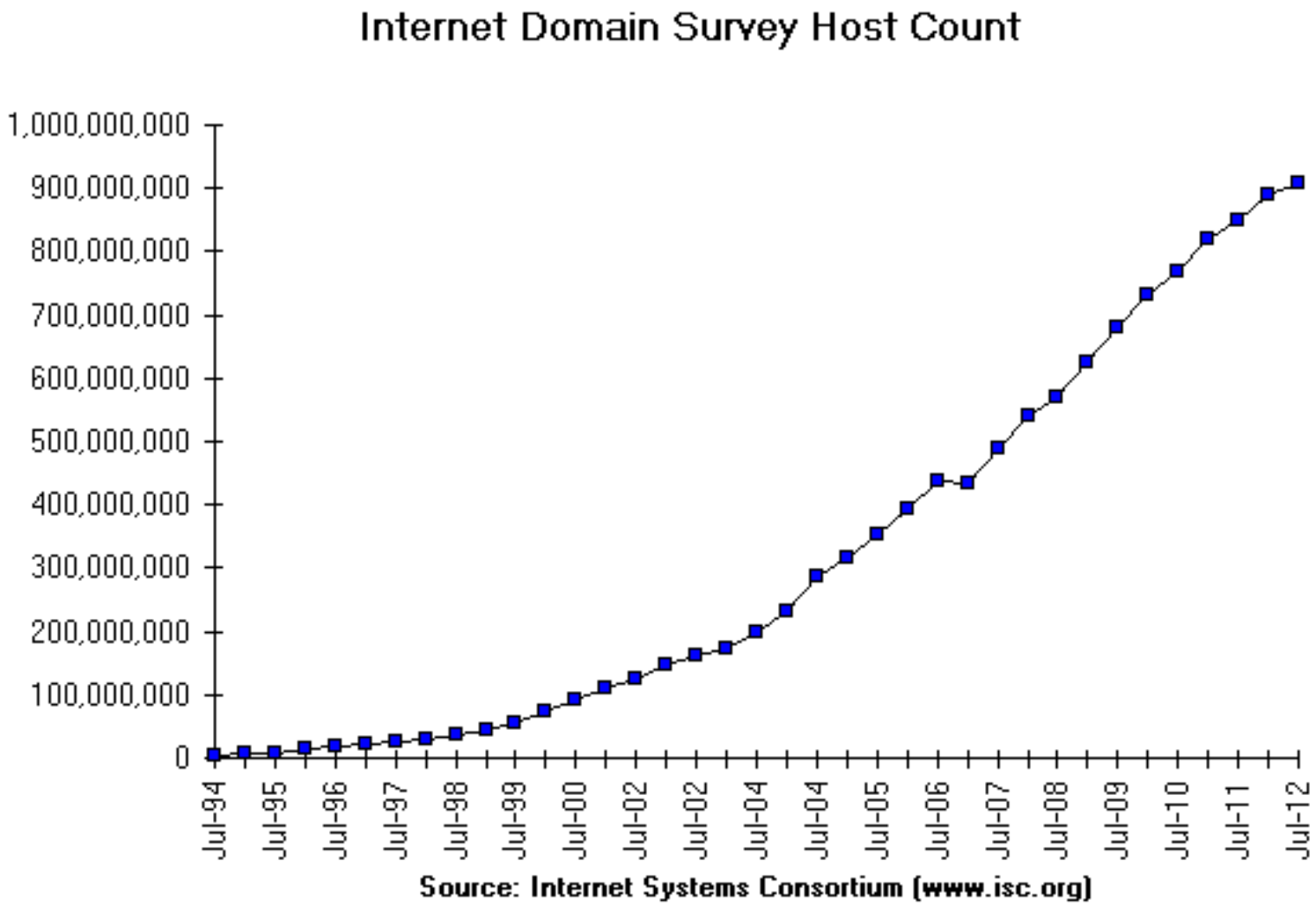
- IANA (Internet Assigned Numbers Authority)
- IP addresses and Autonomous System numbers
- Allocates to Regional Internet Registries
  - APNIC (Asia-Pacific Network Information Centre)
  - AfriNIC (African Network Information Centre)
  - ARIN (American Registry for Internet Numbers)
  - LACNIC (Latin-America and Caribbean Network Information Centre)
  - RIPE (Réseaux IP Européens, European IP Networks)



[1]

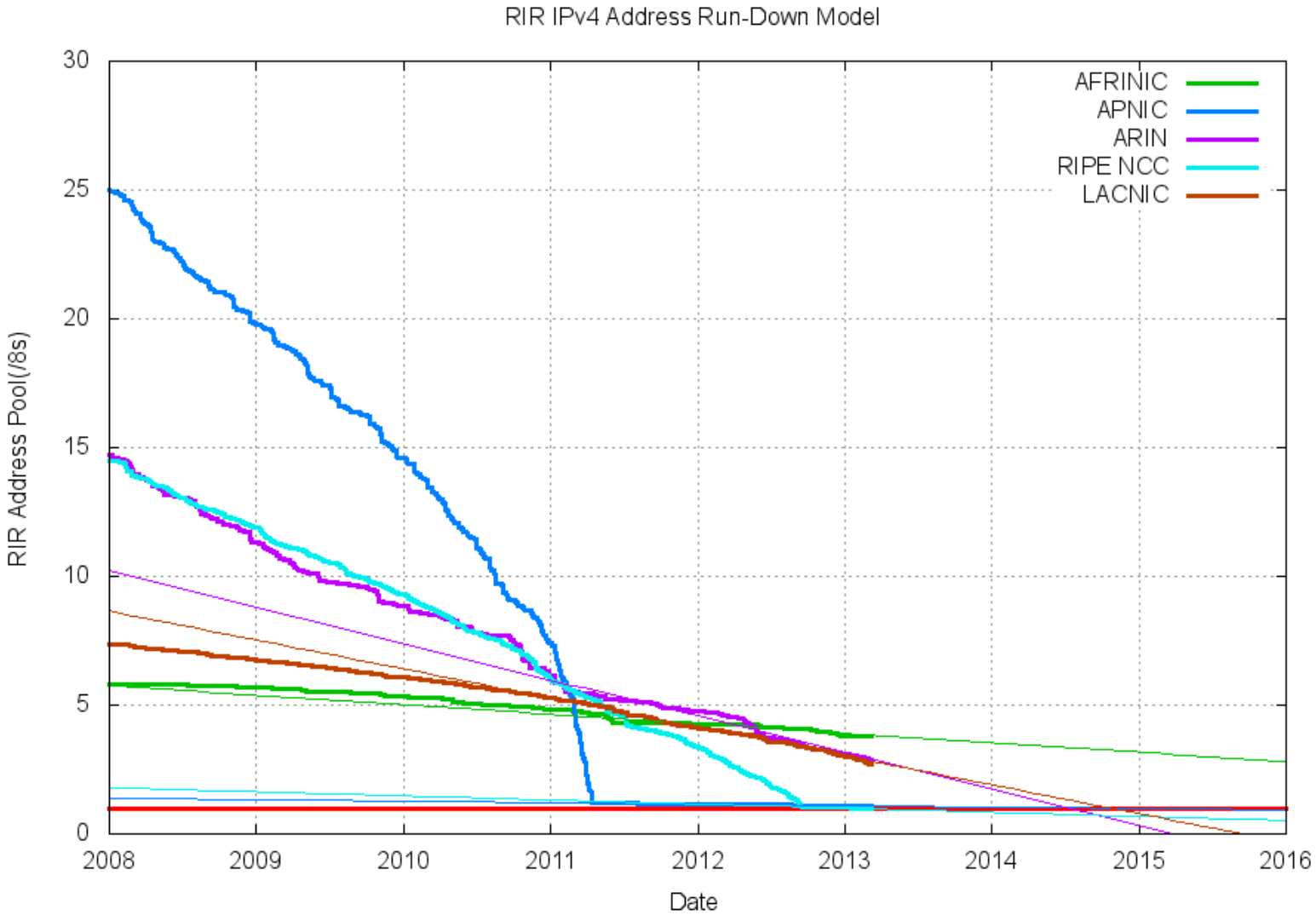
Figure : Regional Internet Registries

Internet Systems Consortium Domain Survey



[2]

Figure : Internet growth



[?]

Figure : Projection of consumption of Remaining RIR Address Pools

Internet Protocol Version 6

IPv6

- IETF started working on a solution to this problem 1990
- Major goals
  - Support billions of hosts.
  - Reduce the size of routing tables
  - Simplify the protocol
  - Provide better security
  - Better support for ToS, QoS
  - Allow roaming
  - space to evolve
  - backwards compatible with IPv4

IPv6 development process

- RFC 1550 - A call for proposal, dec 1993 [5]
- 21 proposals received, 7 serious proposals
- RFC 1710 - Simple Internet Protocol Plus White paper, oct 1994 [8]
- RCF 1883 - Internet Protocol, Version 6 Specification, dec 1995 [6]
- RFC 4291 - IP Version 6 Addressing Architecture, dec 1995 [9]

IPv6 header

40 byte header:

- Version
- Traffic class
- Flow label
- Payload length
- Next header
- hop limit

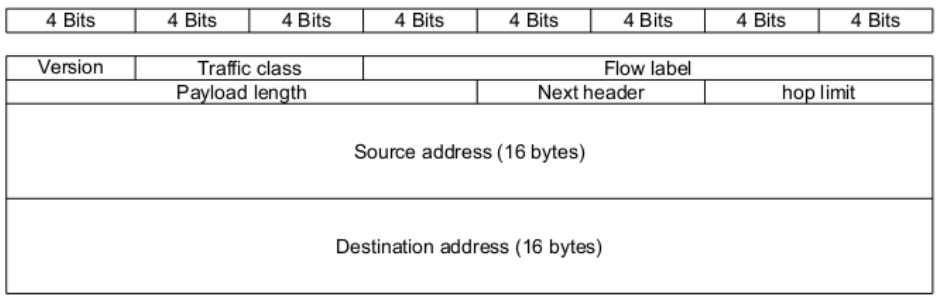


Figure : IPv6 fixed header[7]

Extension headers

Allows the simple format for IPv6 header, defined in `rfc2460`[7]. There are currently six extension headers:

- Hop-by-hop options
- Destination options
- Routing
- Fragmentation
- Authentication
- Encrypted security payload (ESP)

With one exception, extension headers are not examined or processed by intermediary devices.

IPv6 address allocation

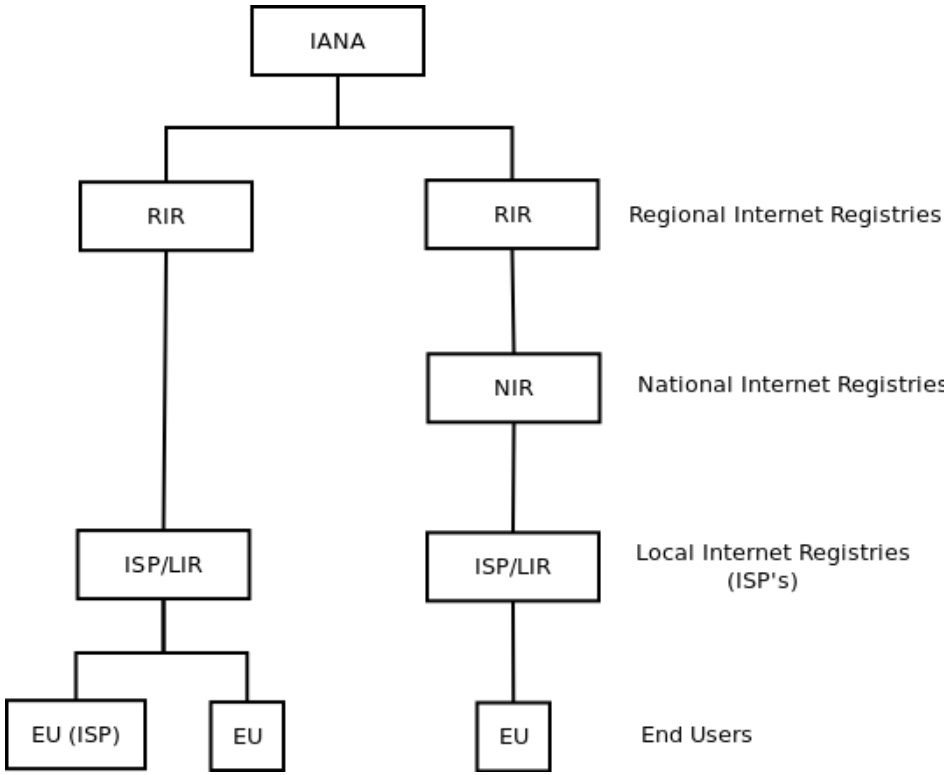


Figure : Internet Registries Hierarchy[4]

Address format

- 128 bit address (16 bytes)
- Represented as a number of 16 bit fields written in hexadecimal.
- Each field is separated by a :
- `2001:0db8:0000:71F5:35A1:0000:0000:0001`
- Still use CIDR notation for network prefix size

Network Prefix

- Divided into RIR subnet, ISP subnet, Site subnet.
- End users are given a /64 subnet
- 64 bits are needed for Interface Identifiers.

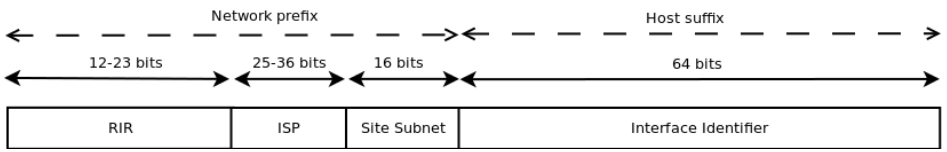


Figure : IPv6 address example

Host suffix

64 bits are used to identify the NIC.[9]

- will be based on the EUI-64 or MAC-address
- inverting the Universal/Local bit

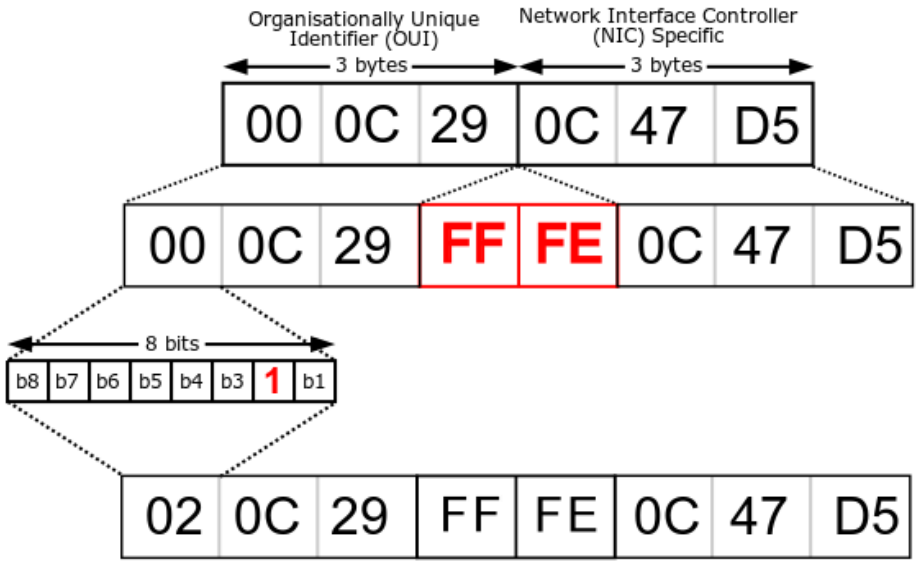


Figure : MAC address expansion[3]

IPv6 address text representation

Difficult and bothersome to write the IPv6 addresses.
RFC-5952[10] addresses this issue.
Multiple ways of represent the same address:

- `2001:0db8:0000:0000:1:0000:0000:0001`
- `2001:db8:0:0:1:0:0:1` - Remove leading 0's
- `2001:0db8:0:0:1:0:0:1` - Leave leading 0's if not all 16 bits are 0's
- `2001:db8::1:0:0:1` - Shortens fields of 0's with ::
- `2001:db8:0:0:1::1`
- `2001:DB8:0:0:1::1` - Uppercase

[10]

Problems with this system

This flexibility causes some problems:

- Search, parse and modify
- Quickly see the difference between `2001:db8::1:0:1` and `2001:db8:1::0:1`
- difficult to parse the addresses.

[10]

Guidelines to follow

Example address: `2001:0db8:0000:0000:1:0000:0000:0001`

- Maximize :: Do not use to shorten just one 16 bit fields of consecutive zeroes.
- If there are multiple 16 bit fields with consecutive zeroes, use the first
- When specifying a socket address, put IPv6 address within [] followed by : port

[10]

Questions?

References I

[1] Regional internet registries world map. URL http://commons.wikimedia.org/wiki/File:Regional_Internet_Registries_world_map.svg. Published under CC BY-SA 3.0.

[2] Ipv4 address report. URL http://www.potaroo.net/tools/ipv4/index.html.

[3] Modified-eui-64, 2012. URL http://en.wikipedia.org/wiki/File:Modified-EUI-64.svg.

[4] Ipv6 address allocation and assignment policy. ripe-552, May 2012. URL http://www.ripe.net/ripe/docs/ripe-552.

[5] S. Bradner and A. Mankin. IP: Next Generation (IPng) White Paper Solicitation. RFC 1550 (Informational), December 1993. URL http://www.ietf.org/rfc/rfc1550.txt.

References II

[6] S. Deering and R. Hinden. Internet Protocol, Version 6 (IPv6) Specification. RFC 1883 (Proposed Standard), December 1995. URL http://www.ietf.org/rfc/rfc1883.txt. Obsoleted by RFC 2460.

[7] S. Deering and R. Hinden. Internet Protocol, Version 6 (IPv6) Specification. RFC 2460 (Draft Standard), December 1998. URL http://www.ietf.org/rfc/rfc2460.txt. Updated by RFCs 5095, 5722, 5871, 6437, 6564.

[8] R. Hinden. Simple Internet Protocol Plus White Paper. RFC 1710 (Informational), October 1994. URL http://www.ietf.org/rfc/rfc1710.txt.

[9] R. Hinden and S. Deering. IP Version 6 Addressing Architecture. RFC 4291 (Draft Standard), February 2006. URL http://www.ietf.org/rfc/rfc4291.txt. Updated by RFCs 5952, 6052.

References III

[10] S. Kawamura and M. Kawashima. A Recommendation for IPv6 Address Text Representation. RFC 5952 (Proposed Standard), August 2010. URL http://www.ietf.org/rfc/rfc5952.txt.