Current Status of IPv6 Standardization

Arifumi Matsumoto
NTT Information Sharing Platform Laboratories

arifumi@nttv6.net

NTT

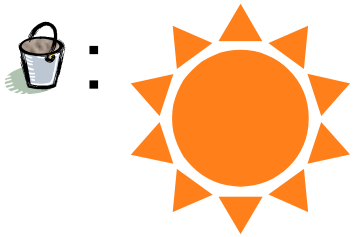
Self Introduction

- Arifumi Matsumoto
  - NTT Information Sharing Platform Laboratories
  - Labs are attached to Holding Company of NTT group companies
    - i.e. East/West/Data/DoCoMo/Com
- Work and Interests
  - Standardization of IPv6 address selection mechanism for 4-5 years at IETF
  - IPv6 home network technology
  - Internet Multihoming technology

Today's Contents

- What is IPv6
  - Very brief summary of IPv6
- Why IPv6 was born
  - The brief motivation and history of IPv6 standardization
- What is happening at IETF
  - Recent topics of IPv6 standardization at IETF
- What is happening at Registries
  - Recent topics at Internet Resource Management Communities
- Our activity on IPv6 standardization

IPv6 quick review



- Very large address space
  - IPv4:IPv6 = volume of [a bucket:the sun]
  - Route Aggregation to stop rapid increase in number of routing table entries
  - end-to-end communication will be easy
- Plug & Play
  - Address autoconfiguration by default
- IPsec is implemented on ALL IPv6 devices
- QoS/Multicast
- Mobility with routing optimization

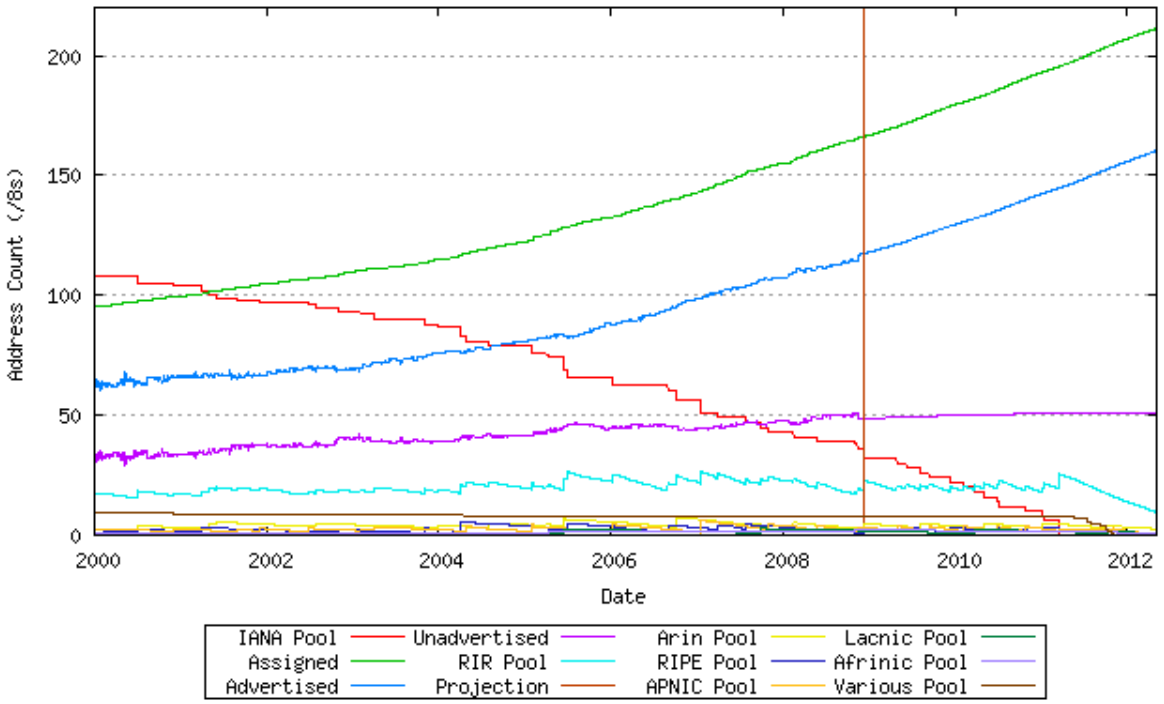
IPv6 Standardization
Motivation & History

Why was IPv6 born?

- Internet growth exposes IPv4's problems
  - Shortage of IP addresses
    - This leads to NAT prevalence, which breaks end-to-end principle.
    - This stops continuous development of the Internet.
  - Rapid increase in the number of global routing table entries
    - This leads to collapse of the Internet !?

Prediction by Geoff Huston

- Huston included idea equivalent to that of Tony Hain in his prediction model
  - http://www.potaroo.net/tools/ipv4/index.html



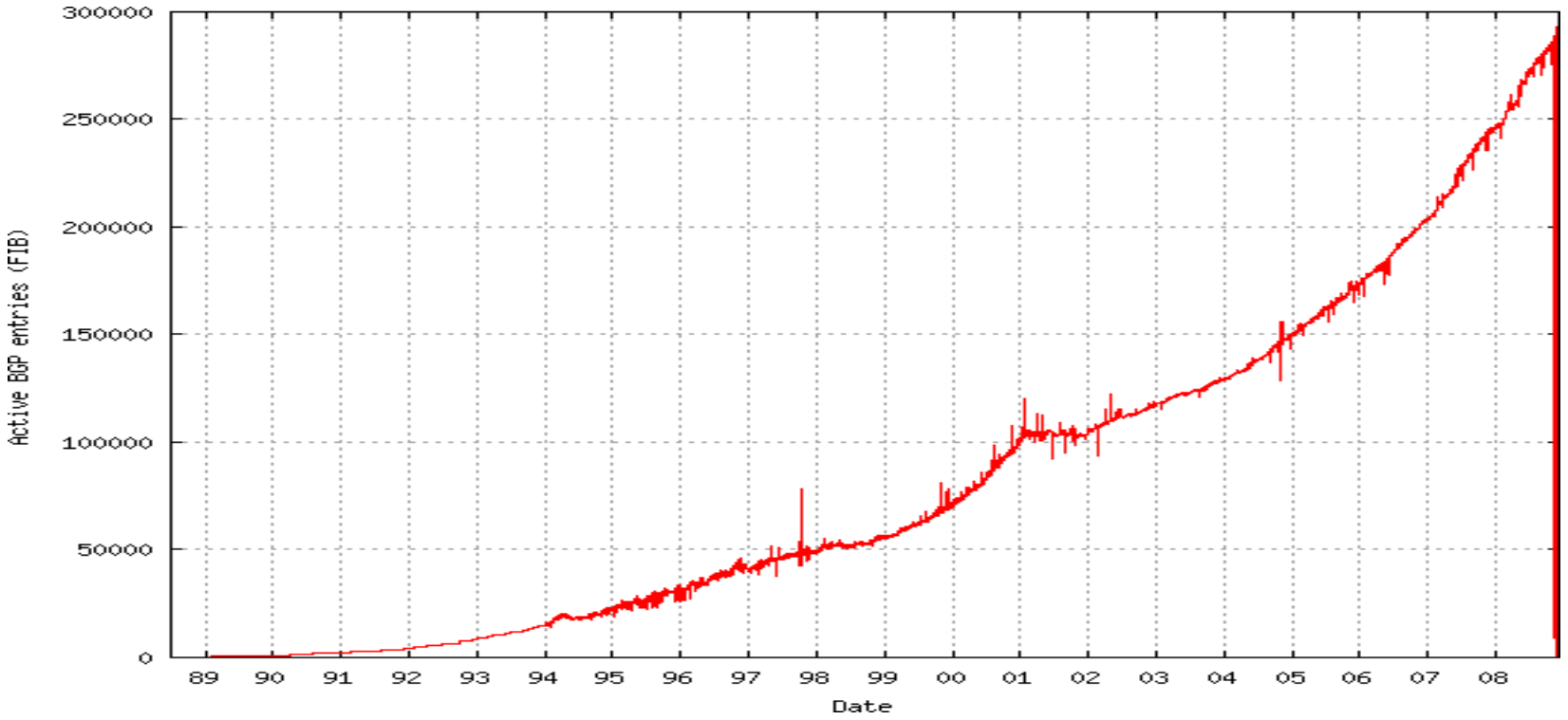
As of Nov. 2008,
IANA unallocated block depletion
28 Jan. 2011

RIR block depletion
28 Jul. 2012

NTT

Growth of global routing table

- Number of routing entries at cidr-report
  - In Dec. 2008, over 290,000 entries
  - In 10 years, entries increased 5-times



adapted from http://www.cidr-report.org/ , as of 2008.12.4

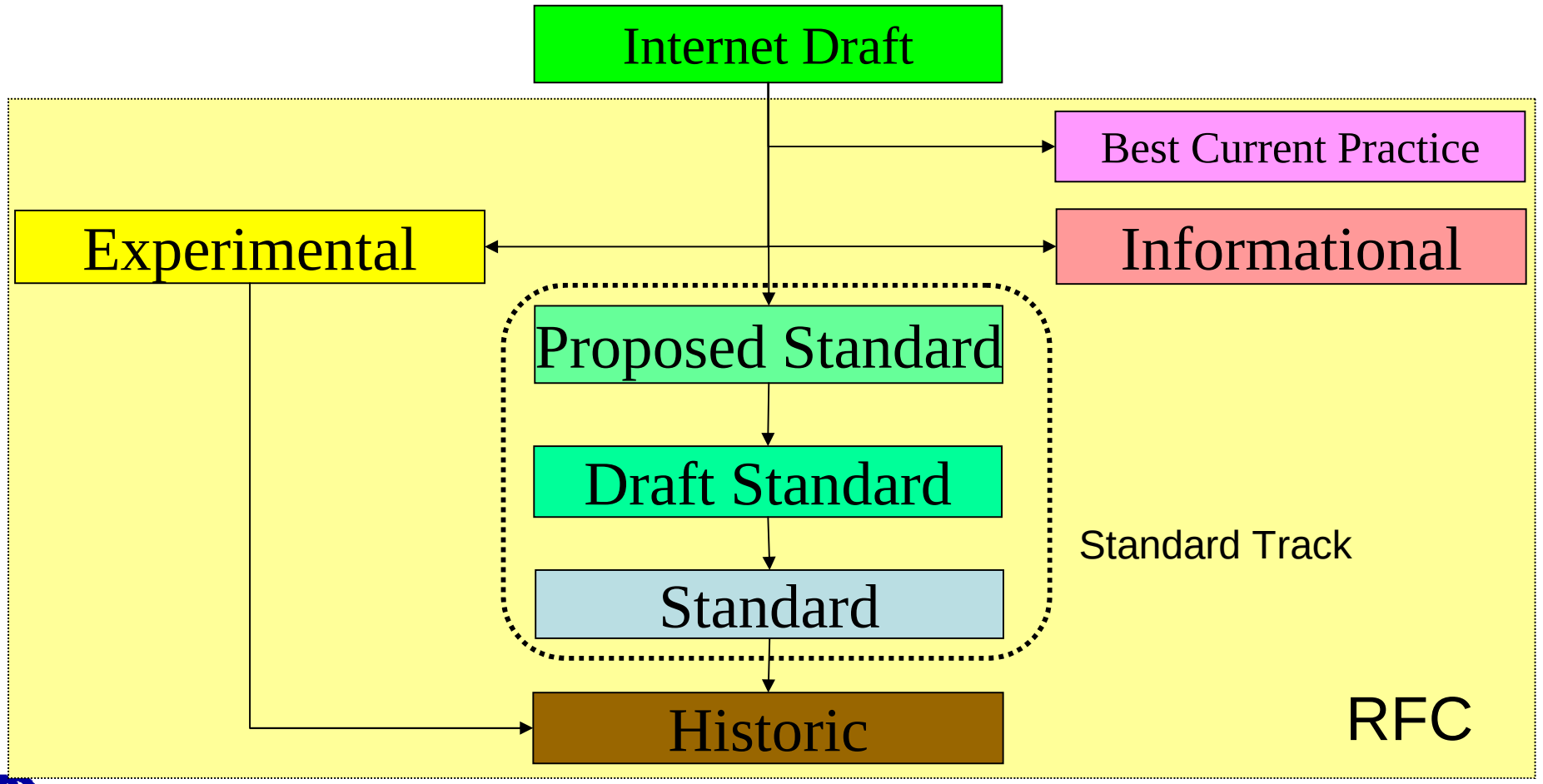
History of IPv6 Standardization

IPv6 was standardized at IETF

- IETF is …
  - Internet Engineering Task Force
  - an organization that standardizes technology for the Internet like TCP/IP.
  - Standardized technology specifications are published as RFCs (Request For Comments).

Standardization at IETF

RFC standardization process at IETF

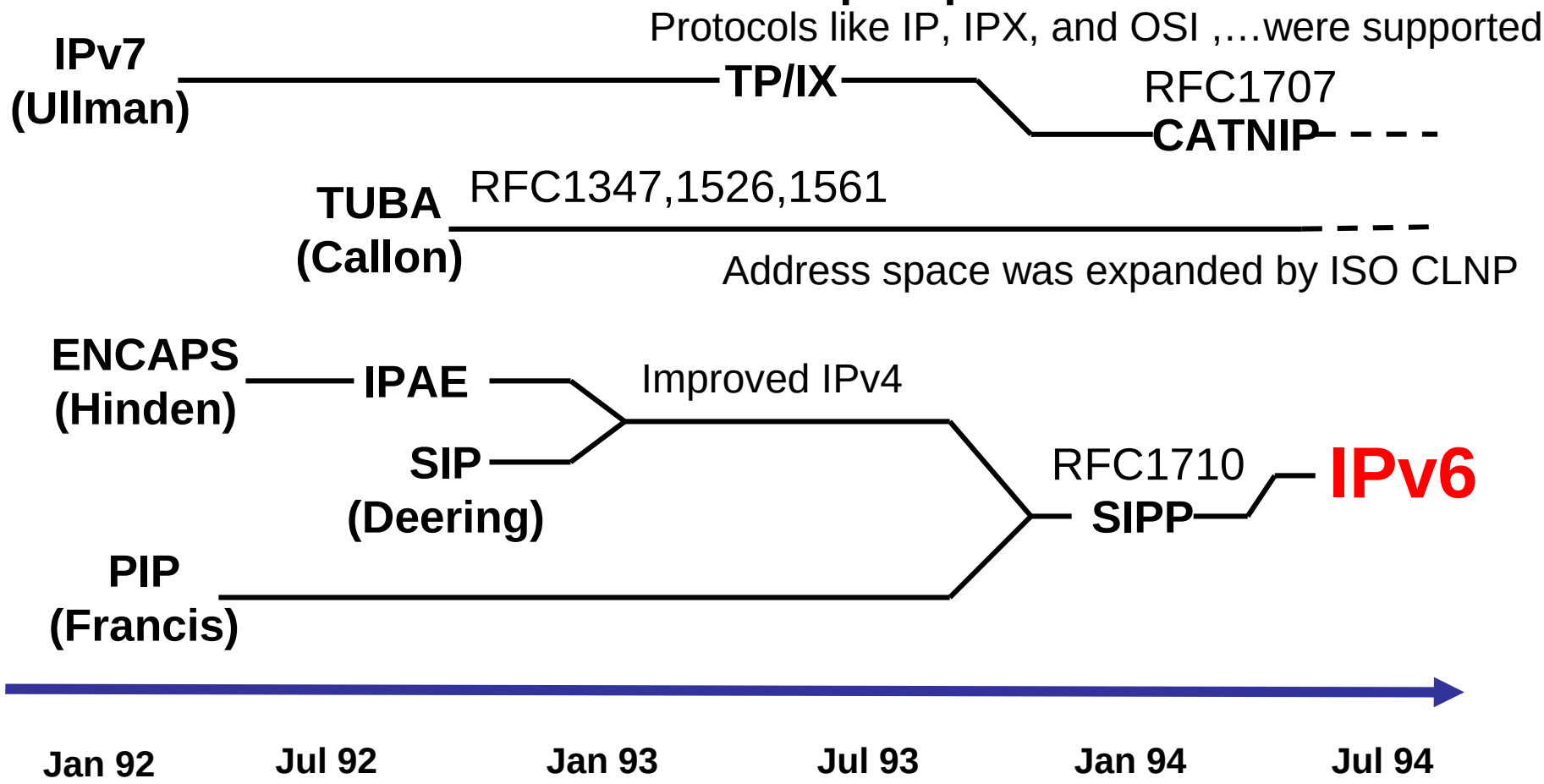


IPv6 standardization history

- 1991.7
  - survey begun at IETF triggered by IPv4 address depletion report
- 1992.11
  - Survey results were documented in RFC1380, “IESG Deliberations on Routing and Addressing”
  - Internet Protocol next generation (IPng) study begun
- 1993.12
  - RFC1550, “IP: Next Generation (IPng) White Paper Solicitation” summarized requirements
- …1994
  - Various protocols were proposed, dismissed, and merged
- 1995.1
  - In RFC1752, “The Recommendation for the IP Next Generation Protocol,” IPng was renamed to IPv6

IPng candidates (RFC1752)

- Four series of candidate proposal



IP version 6

- Internet protocol number `6' was assigned for IPng standardization

Decimal	Keyword	Version
0		Reserved
1-3		Unassigned
4	IP	Internet Protocol
5	ST	ST Datagram Mode
6	**IPv6**	**Internet Protocol version 6**
7	TP/IX	TP/IX: the next Internet
8	PIP	the P Internet Protocol
9	TUBA	TUBA
10-14		Unassigned
15		Reserved

iana
Internet Assigned Numbers Authority

http://www.iana.org/assignments/version-numbers

IPv6 base spec revision status

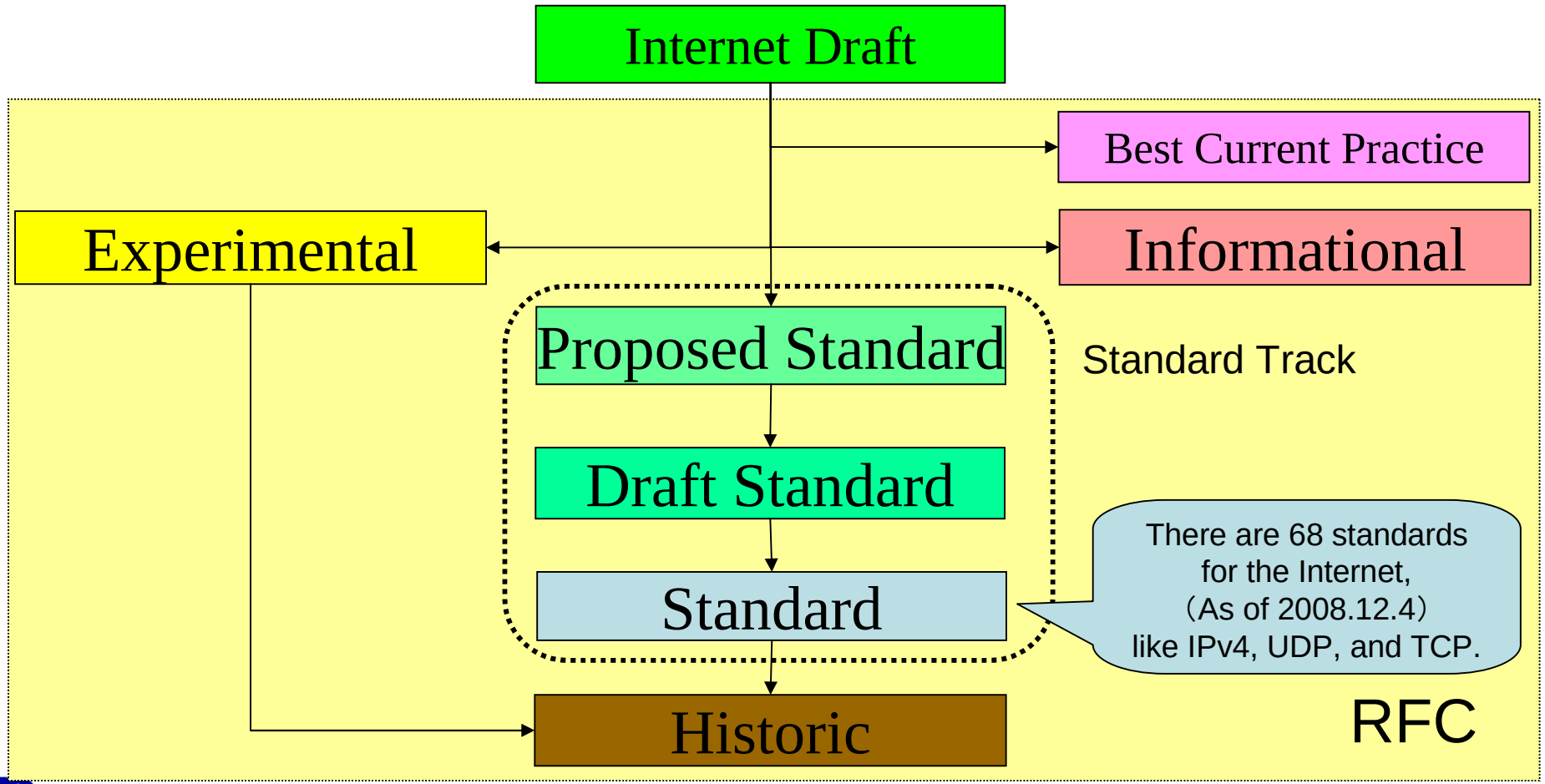
- 1995.12 …1996.8, base-specs became Proposed Standard (PS)
  - RFC1883 IPv6 Protocol Specification
  - RFC1885 ICMPv6
  - RFC1970 Neighbor Discovery
  - RFC1971 Stateless Address Autoconfiguration

- 1998.12 base specs became Draft Standard (DS)
  - RFC2460 IPv6 Protocol Specification
  - RFC2461 Neighbor Discovery
  - RFC2462 Stateless Address Autoconfiguration
  - RFC2463 ICMPv6

- 2007-2008 minor updates became Draft Standard(DS)
  - RFC4443 ICMPv6
  - RFC4861 Neighbor Discovery
  - RFC4862 Stateless Address Autoconfiguration
  - RFC5095 Deprecates Routing Header Type 0 (RFC 2460 update)

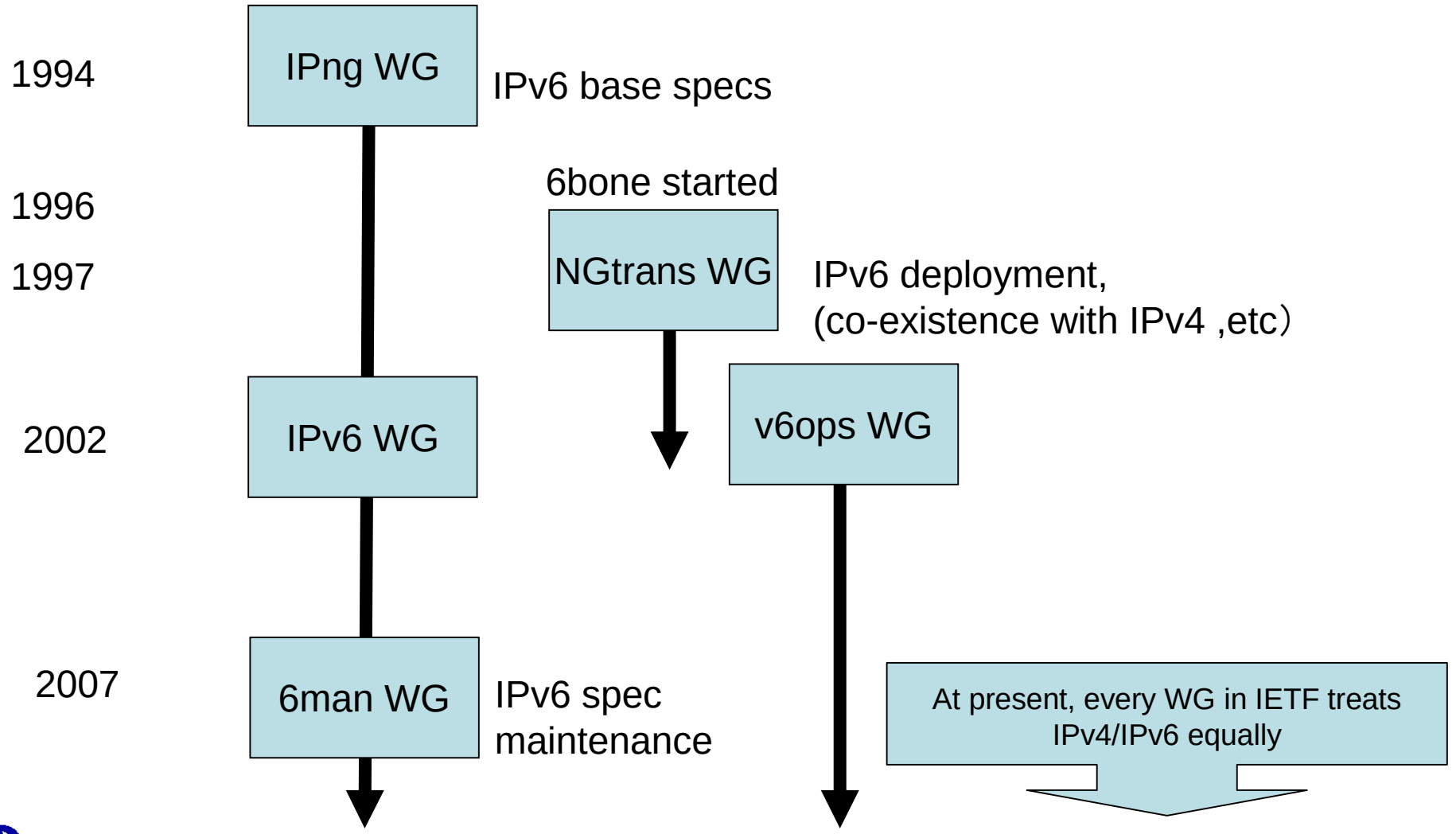
Standardization at IETF

RFC Standardization Process at IETF



Recent topics in IPv6 standardization

Transition of IPv6-related WGs

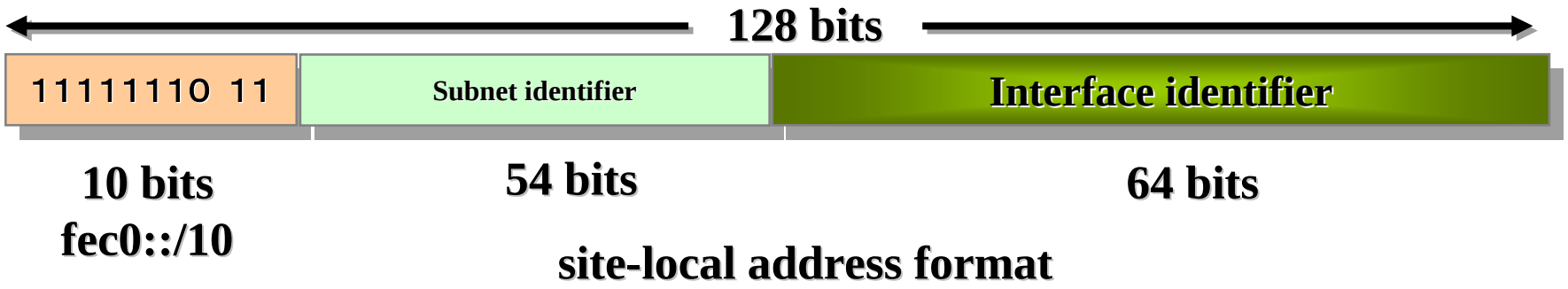


Recent topics in IPv6 standardization

Site-local address was deprecated, and unique local unicast address was defined

Site-local address definition

- Site-local address was…
  - unicast address for local use, just like IPv4 Private Address (RFC1918),
  - defined in RFC 3513 “IPv6 Addressing Architecture”
  - One type of IPv6 “scoped” address
    - More widely available than link-local addresses, but less widely available than global address



Problems with site-local address

- Possibility of address duplication.
  - e.g., both networks to be merged are using fec0::/48
- Difficulties at site-border router
  - For vendors, operators, and standardization
- Security Issues
  - What happens when a mobile host visits two networks with the same address?
- Address leak
  - Site-local address could leak out to the global Internet due to misconfiguration, for example.

The same problems with IPv4 private address (RFC1918) apply to site-local address.

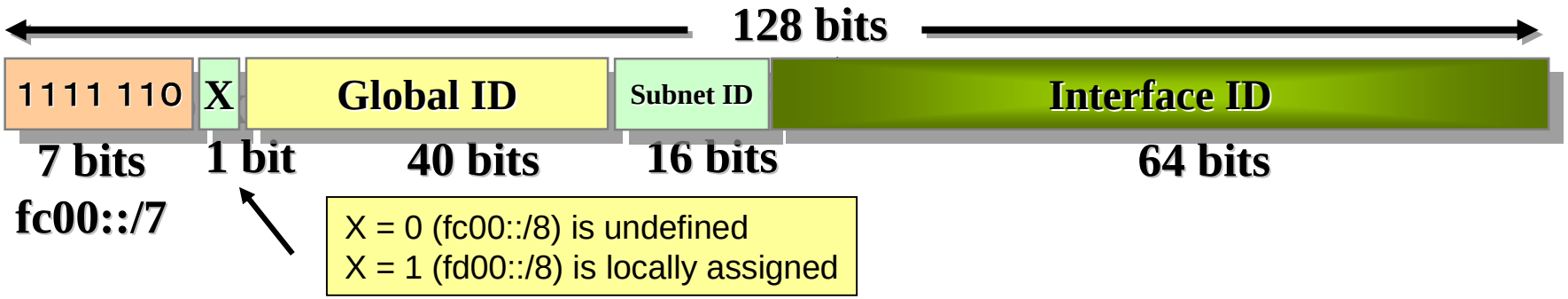
New local-use address

- Uniqueness is important
  - Many problems are caused by addresses that are not unique

- RFC4193:Unique Local IPv6 Unicast Address
  - Sufficient guarantee of uniqueness
    - Initially, two address assignment methods were supported
      1. Centrally managed, unique guaranteed addresses
      2. Not perfect but most likely unique addresses
  - Routing in the Internet is not guaranteed.

RFC4193: “Unique Local IPv6 Unicast Addresses” (ULA),

Format of Unique Local IPv6 Unicast Address



- Locally assigned
  - Generated randomly. Generation algorithm specified decreases possibility of duplication
  - Anybody can use this address anytime for free (focused on convenience rather than perfect uniqueness)
- Undefined space was initially supposed to be used for centrally assigned address
  - Managed by an organization to ensure unique assignment
  - To be revisited dependent on popularity of locally assigned address

Recent topics of IPv6 Standardization

IPv6 Multihoming
-Plan, reality and yet another plan-

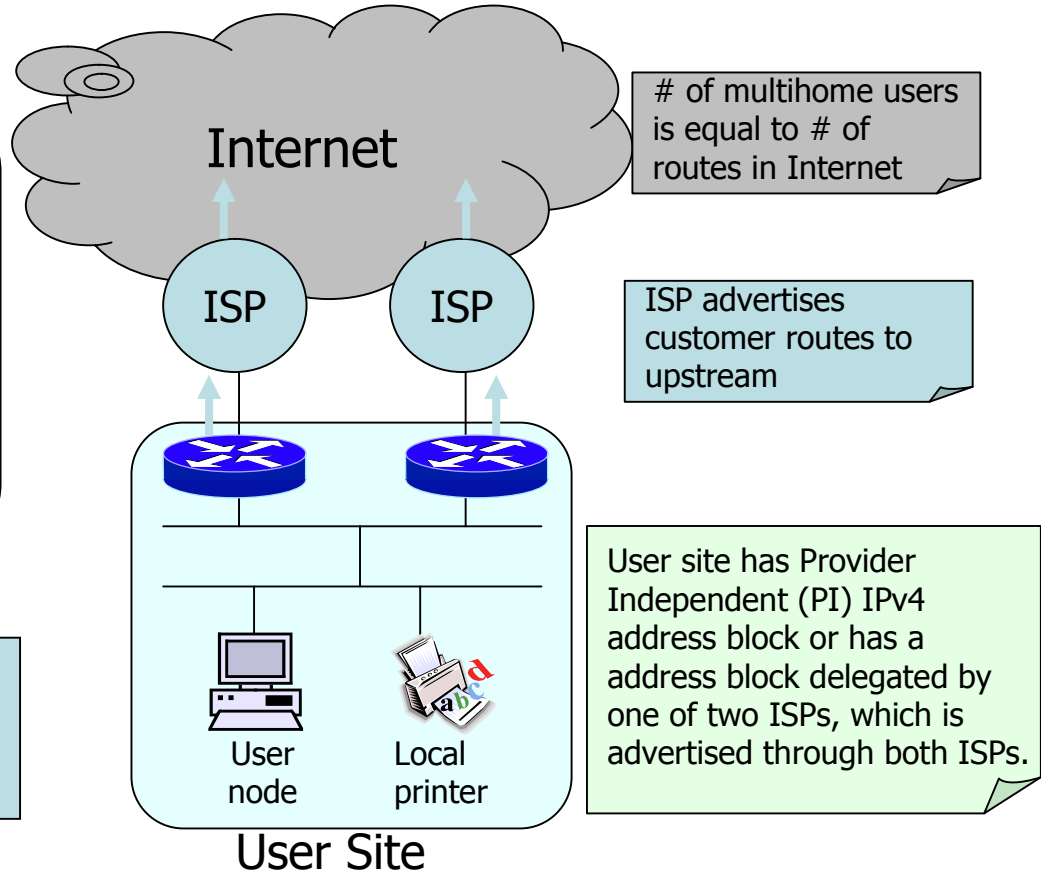
What is multihoming

- To maintain and operate multiple ISP connectivities for redundancy and/or load-balancing.
  - Common style of IPv4 Multihoming

Purpose of Multihoming

- Redundancy of Internet connectivity (in and out)
- Load balance(in and out)
- Better network performance achieved by better routing
- Policy-based traffic control
- Less dependency on upstream ISP

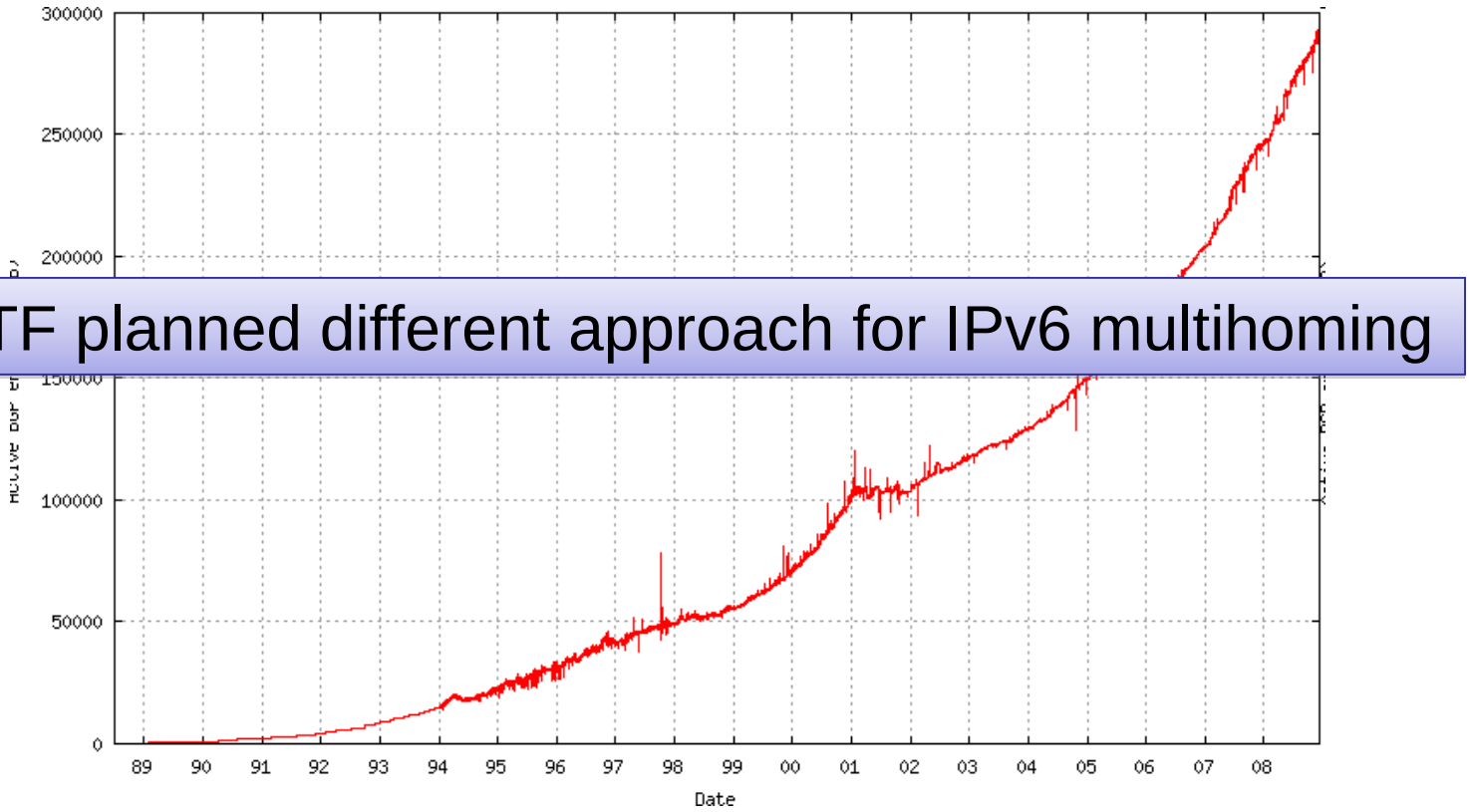
Multi-homing is popular for relatively large scale enterprises.



NTT

Multihoming Effects on Routing Table

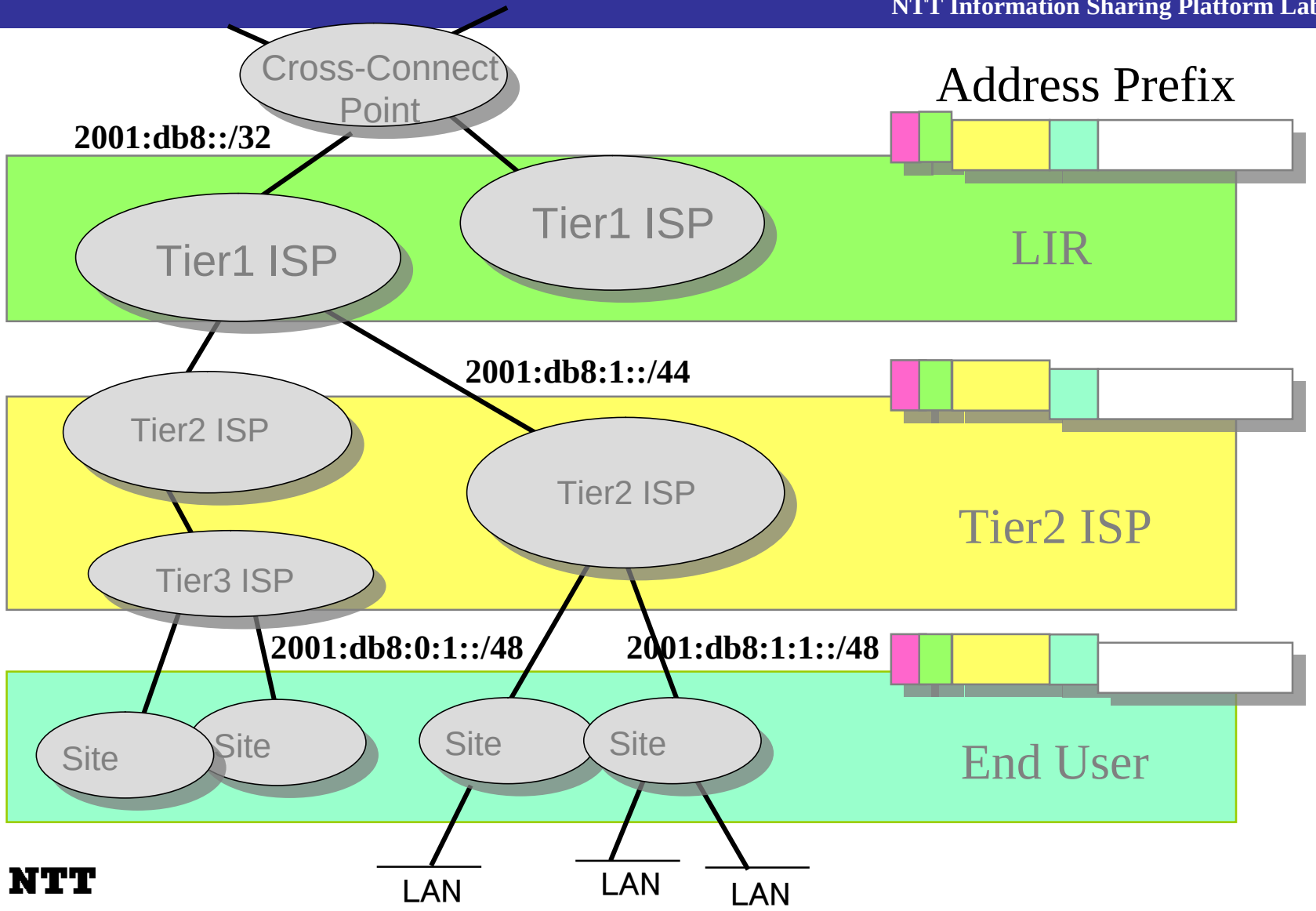
- One reason for IPv4 rapid increase in number of routing table entries is multihoming performed by small sites.



IETF planned different approach for IPv6 multihoming

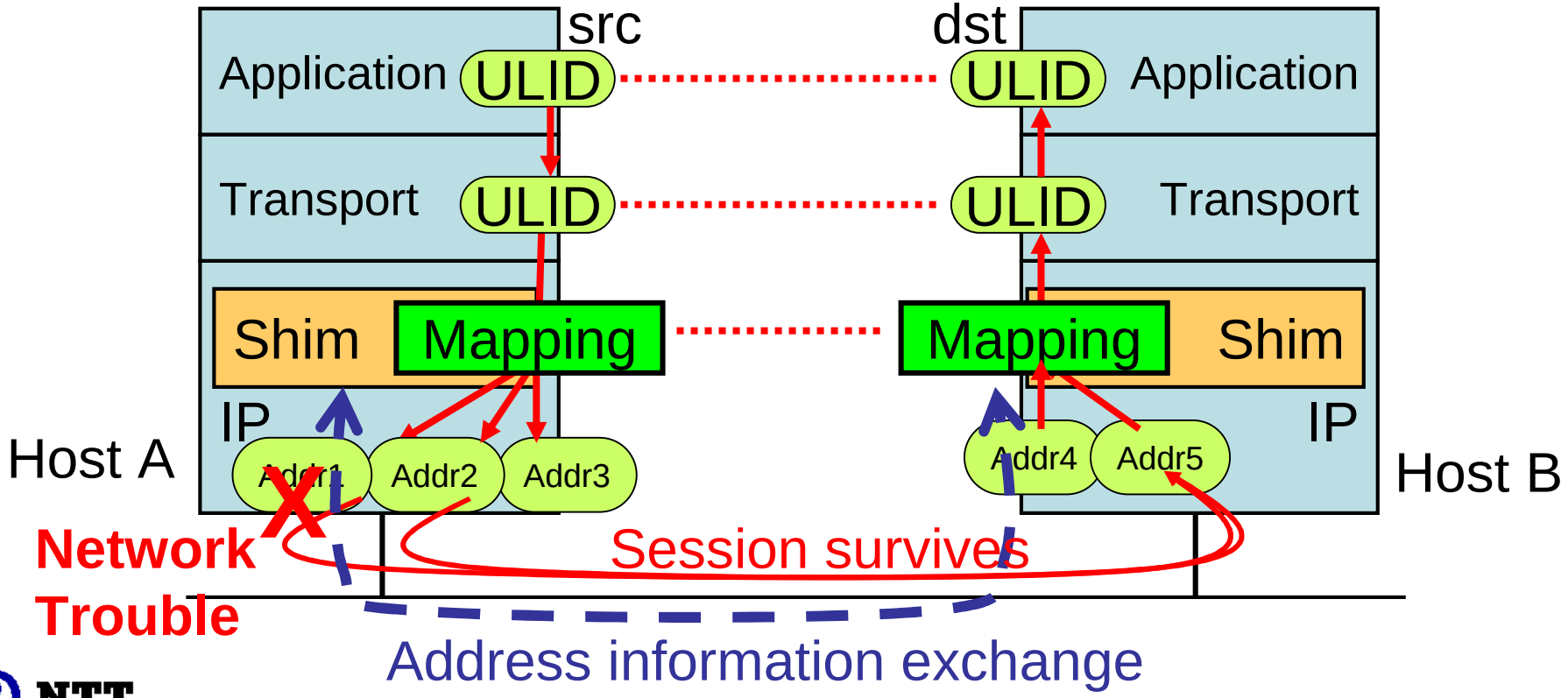
http://bgp.potaroo.net/as2.0/bgp-active.html

IPv6 Design: Hierarchical Address Assignment



SHIM: Multihoming technique assuming hierarchical address assignment

- A site is assigned multiple PA addresses, and a host uses them for multi-homing

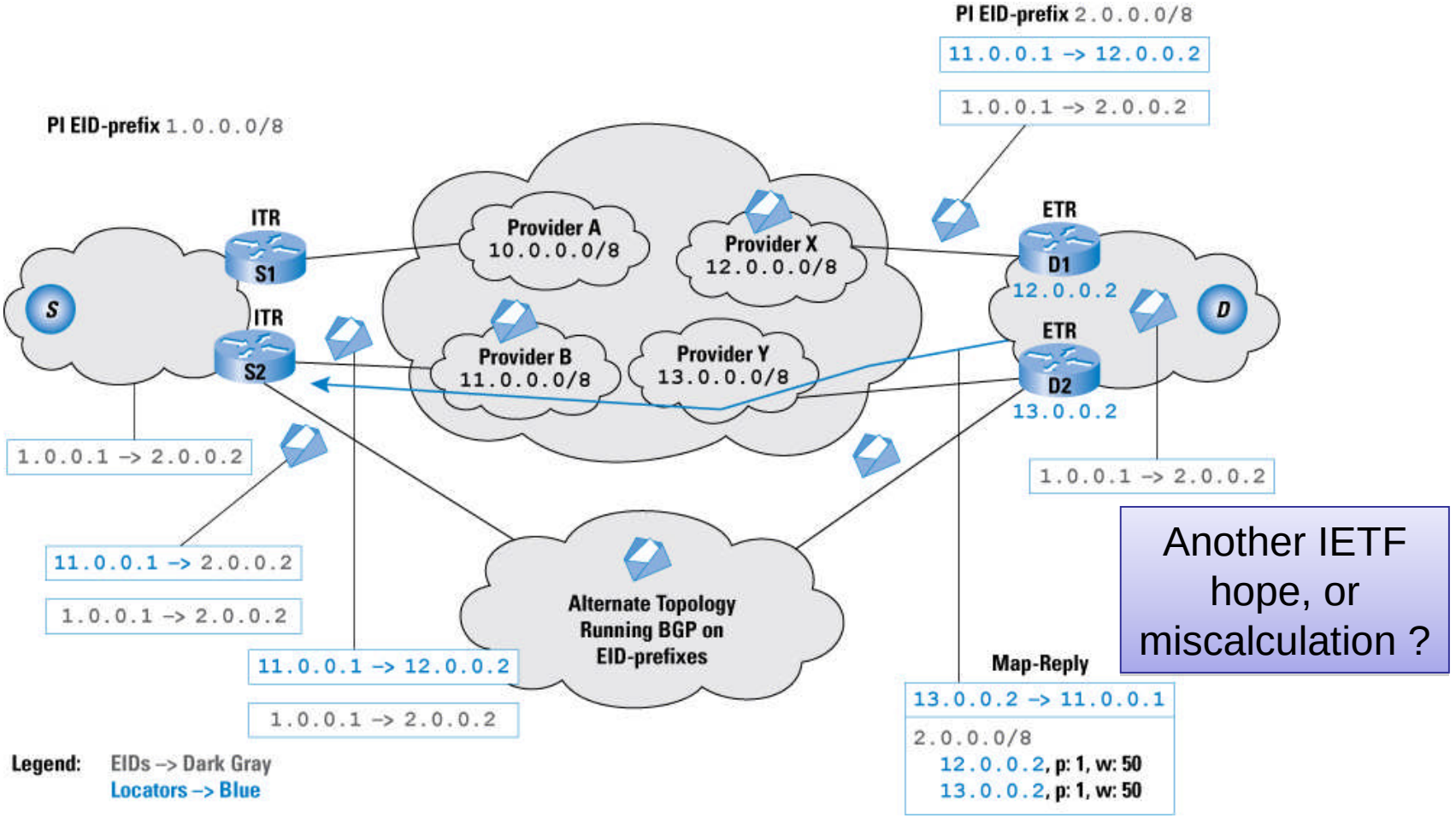


Multi-homing Issue Update

- IETF Miscalculation
  - Hierarchical address assignment is invalidated, now that IPv6 PI (Provider Independent) Address is created.
    - The situation is same as IPv4, however, IPv6 routing table explosion can be more serious than IPv4.
  - Shim6 technique is disliked by operators
    - Host based approach is hard to deploy at servers, and hard to reflect operation policy.
- Then, IETF started another approach called LISP around Mar. 2007

LISP(Locator Identifier Separation Protocol)

LISP Tunnels IPv4/IPv6 packets between border routers



Another IETF hope, or miscalculation ?

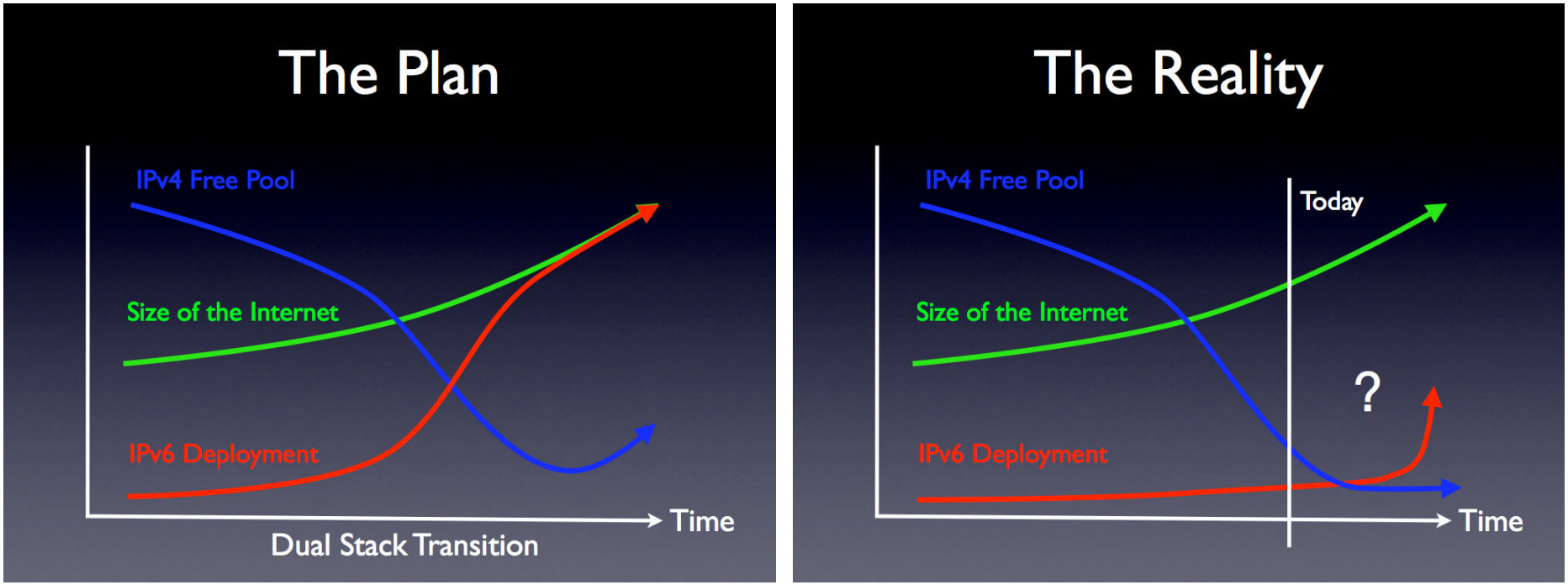
http://www.cisco.com/web/about/ac123/ac147/archived_issues/ipj_11-1/111_lisp.html

Recent topics of IPv6 standardization

IPv4 to IPv6 Transition Technology

Transition Plan and Reality

- IETF faced the reality:



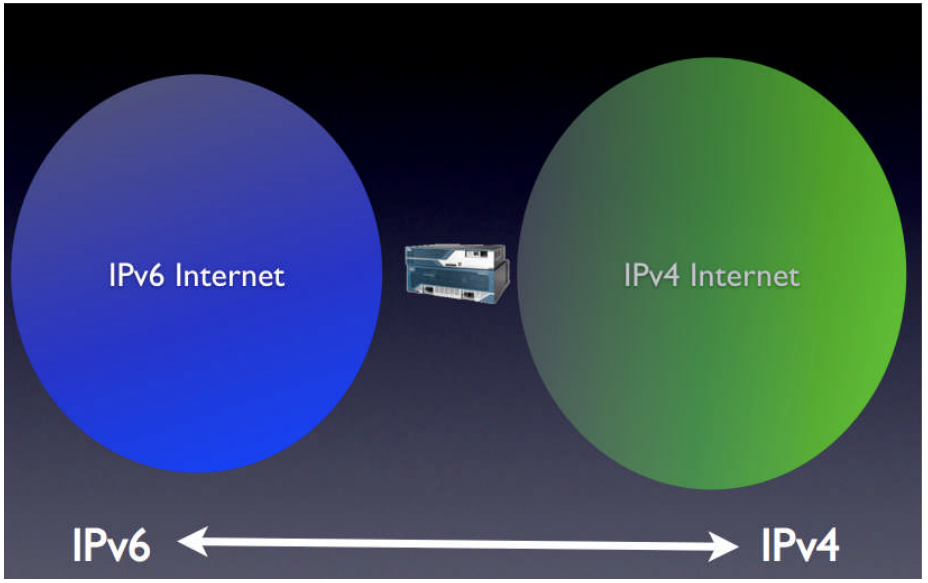
- Then, started to re-design IPv4-IPv6 transition/co-existence scenarios.

Transition Approach

- Standardize less-harmful IPv4-IPv6 Translation technique
  - There was IPv4-IPv6 translation technique called NAT-PT (RFC 2766), but it was invalidated because of some defects. (RFC 4966)
  - IETF is seeking to produce another translation technique
- Make IPv4-IPv6 dual-stack easier to deploy.
  - Dual-stack is best way for transition, but hard to deploy in some cases.
  - IETF is seeking yet another technique to implement dual-stack environment.

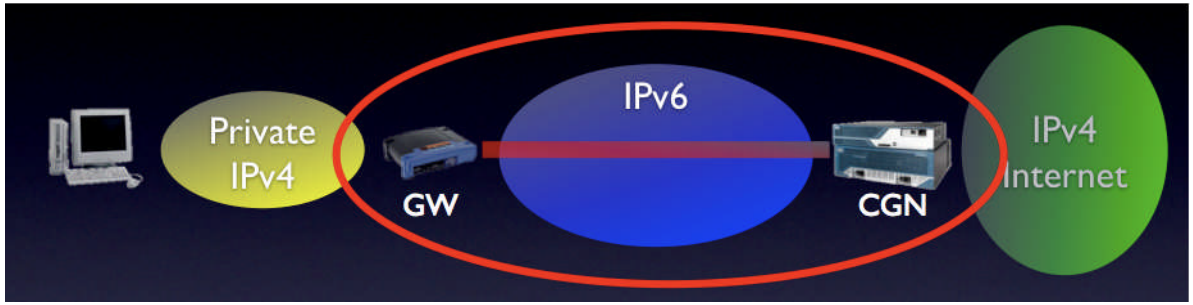
Translation Approach

- Some techniques are proposed, but...
  - similar to NAT-PT and/or restricted form of NAT-PT.
  - It is not sure whether these are enough harmless or not.
  - Any kind of trans. approach effects on applications, so ALG is needed.



Dual-Stack Approach

- Dual-Stack Lite by Alain Durand, Comcast
  - Provides IPv4 connectivity through IPv6 network with two NAT boxes.
    - User has private IPv4 address, GW performs 4-to-6 NAT, and CGN (Carrier Grade NAT) 6-to-4 NAT.
  - Makes dual-stack easier and saves IPv4 address.



- A+P approach by Rundy Bush, IIJ
  - Mainly for saving IPv4 address

Transition Plan Ahead

- IETF is working hard on transition work
  - They meet more often than usual, i.e. at interim meeting.
- However, the market needs don't necessarily drive IETF standardization
  - They don't want to make a BAD technique, however people want it. e.g. NAT.
- IETF needs more time to decide which new technique to adopt.

Recent topics of IPv6 standardization

IPv6 NAT

Excuse me ? IPv6 what ?

- IPv6 is designed to be end-to-end transparent and to eliminate evil NAT
  - but,
- IPv6 NAT is on the table of IETF.
  - some people claims that NAT is necessary for several reasons, like topology hiding.
  - even if RFC does not exist, some people can implement IPv6 NAT just like IPv4 NAT.

NAT66 Discussion at IETF73

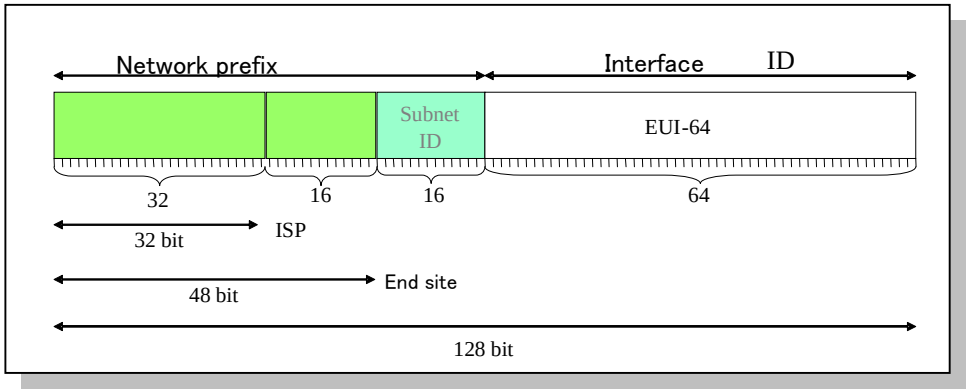
- Proposed Mechainism draft-mrw-behave-nat66
  - No per-host, per-session state required
  - Translate to an IPv6 address, so that L4 checksum needs not be changed
  - Two-way translation method is defined to be MUST, which demands /48 prefixes.
  - In topology hiding mode, subnet part of prefix is cleared to be zero.
  - Inside NAT box, ULA is recommended to use.
  - Do not rewrite port numbers of L4 headers.
- Conclusion at IETF73
  - Agreed to continue discussion based on this proposal.

Recent topics of IPv6 standardization

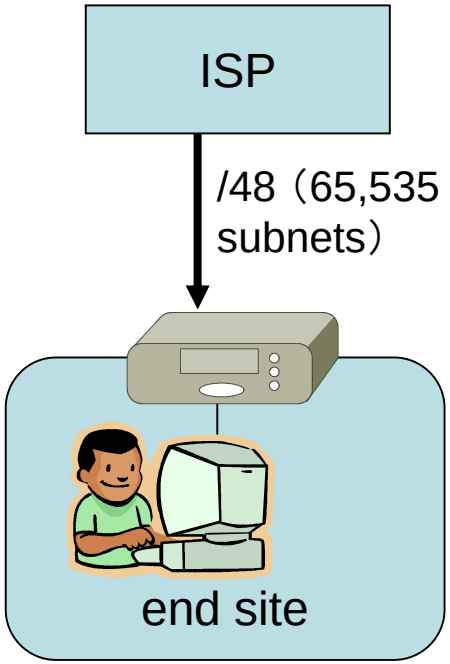
Modification of IPv6 address size assigned to end sites

IPv6 address size assigned to end sites

- RFC3177 defines address size for end sites
  - /48 in the general case, except for very large subscribers.
  - /64 when it is known that one and only one subnet is needed by design.
  - /128 when it is absolutely known that one and only one device is connecting.



IPv6 addressing architecture



Discussion to modify IPv6 address size assigned to end sites

- There was a discussion of IPv6 address exhaustion in IP address registries.
  - Allocate smaller address block to ISPs
  - Modification of IPv6 address assignment size to end sites
- Current documents of registries refer to RFC3177, and modification of this RFC was proposed
  - draft-narten-ipv6-3177bis-48boundary
  - Remove assignment size details from this document
    - IETF should treat only technical issues, and assignment size should be discussed and defined in IP address registries
- RFC3177 will be updated accordingly
- Now, RIRs recommend /56 assignment for an end site.

Recent topics of IPv6 standardization

IPv6 Network Operation

V6ops recent topics

- As the IPv6 deployment proceeds, operational or security problems come out
  - RA Security, such as rogue RA.
    - draft-chown-v6ops-rogue-ra
    - draft-ietf-v6ops-ra-guard
  - How to implement security at CPE
    - draft-ietf-v6ops-cpe-simple-security
  - Teredo security issues
    - draft-thaler-v6ops-teredo-extensions
  - Security concerns related to tunnel
    - draft-ietf-v6ops-tunnel-security-concerns

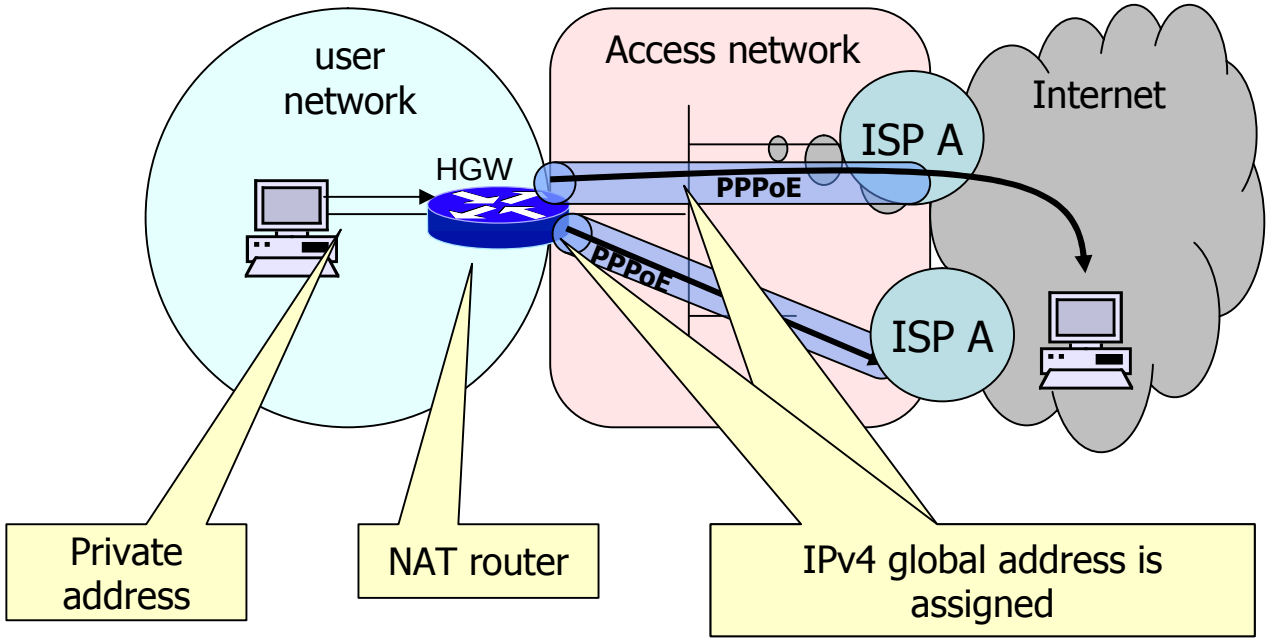
IPv6 standardization activities in NTT Labs

Proposal of IPv6 address selection mechanism

Multihoming in residential network

In IPv4, NAT can be used to connect multiple upstream networks

- In Japan, NAT-based IPv4 multihoming is widely used

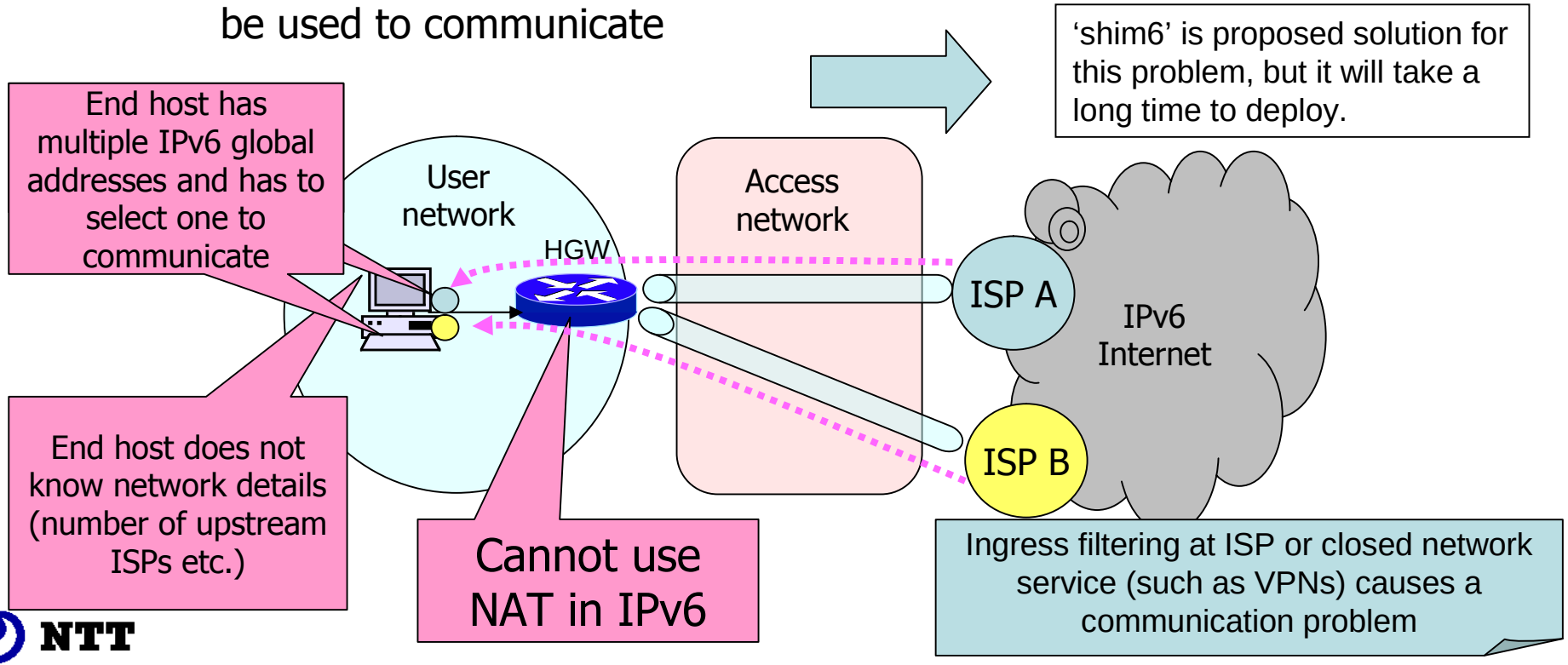


- NAT router selects suitable upstream provider and its IPv4 address

IPv6 residential multihoming

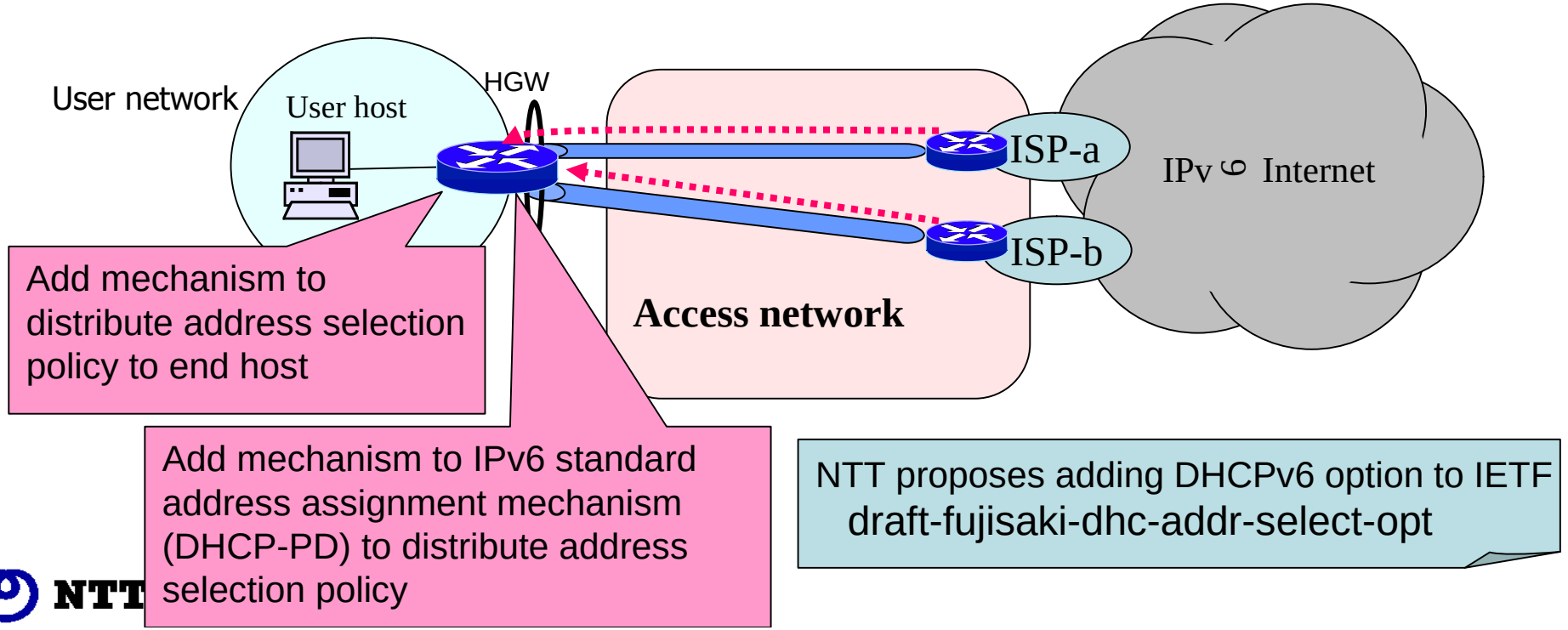
In IPv6 network, IPv4 technique cannot be used because:

- There is no NAT in IPv6
- Global IPv6 addresses are assigned to end host, and end host will have multiple IPv6 addresses
- End host does not care (cannot control) which upstream provider will be used to communicate



Solution for IPv6 residential multihoming proposed by NTT

- Distributing address selection policy defined in RFC3484
  - Propose mechanism to distribute source address selection policy to end host
    - End host selects proper IPv6 address corresponding to destination address with this policy



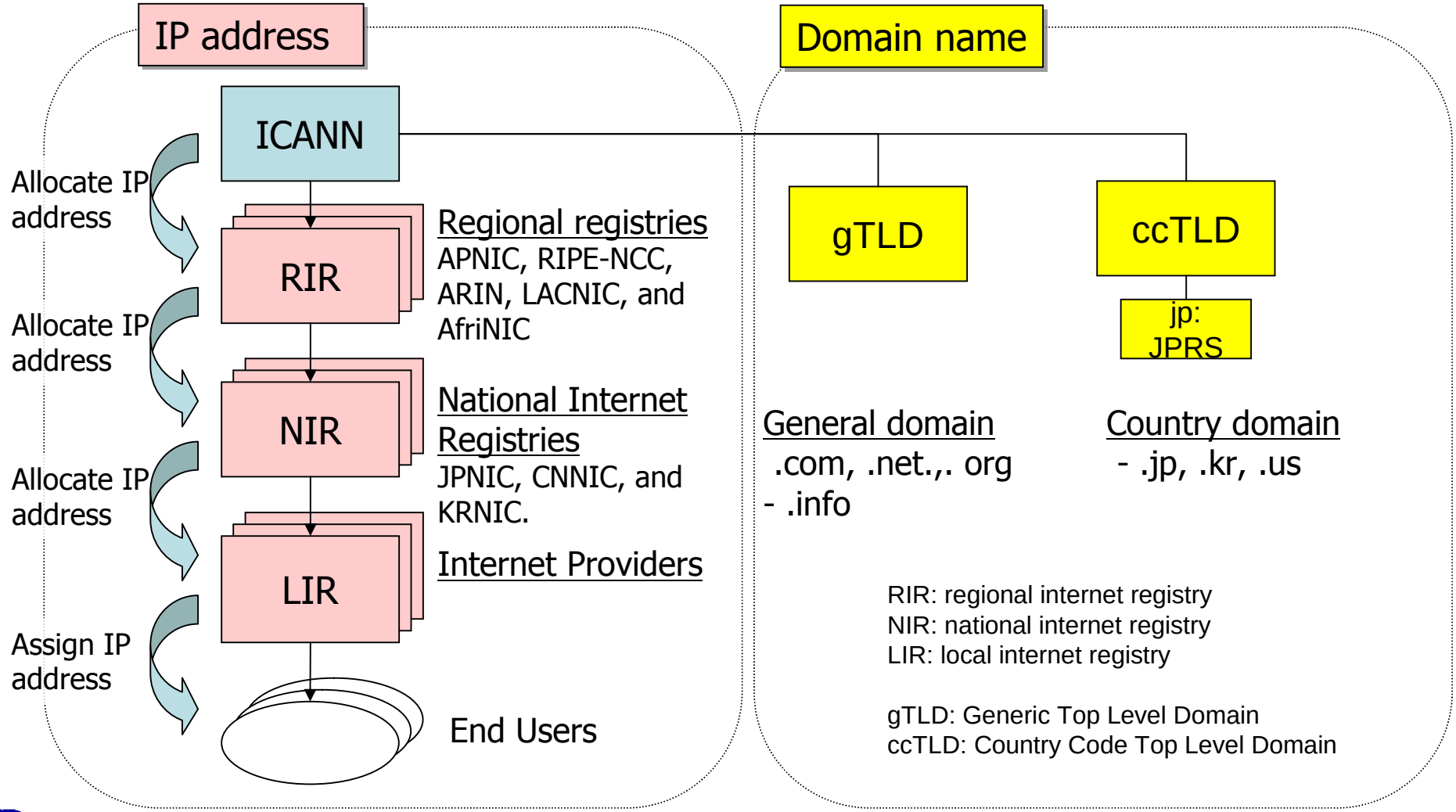
Recent topics of IPv6 Standardization

IPv6-Related Activities of Internet Resource Management Communities (Registries) ～ mainly on APNIC～

What is APNIC?

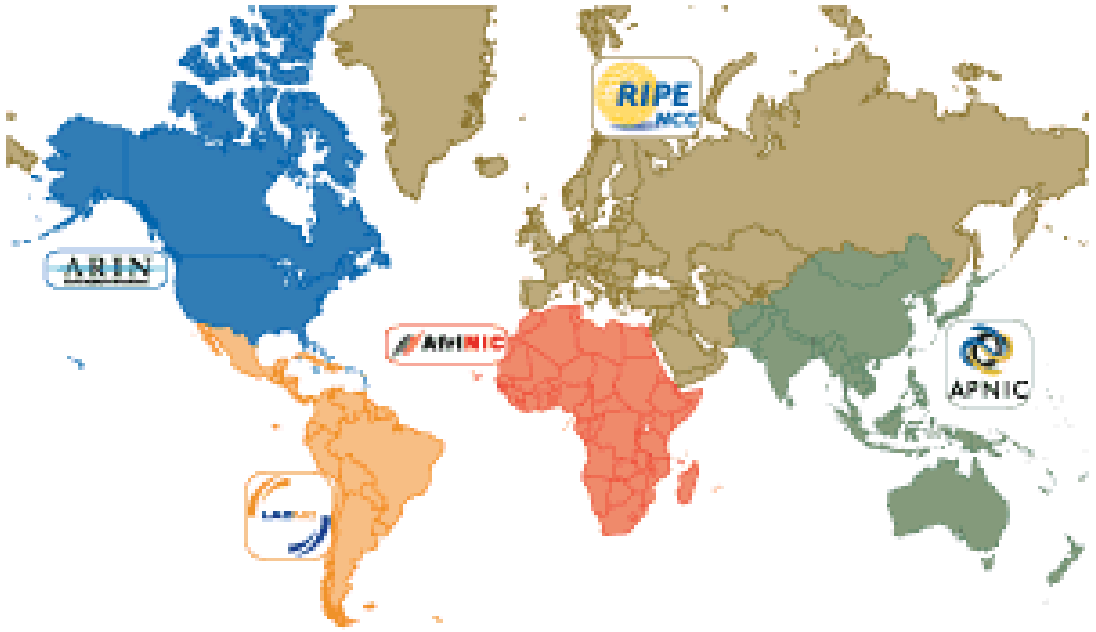
- APNIC (Asia Pacific Network Information Centre)
  - An organization that manages Internet resources (e.g., IP address, AS numbers) in Asia Pacific region. APNIC is one of five RIRs (RIR : Regional Internet Registry) in the world.

Hierarchies of Internet resource management

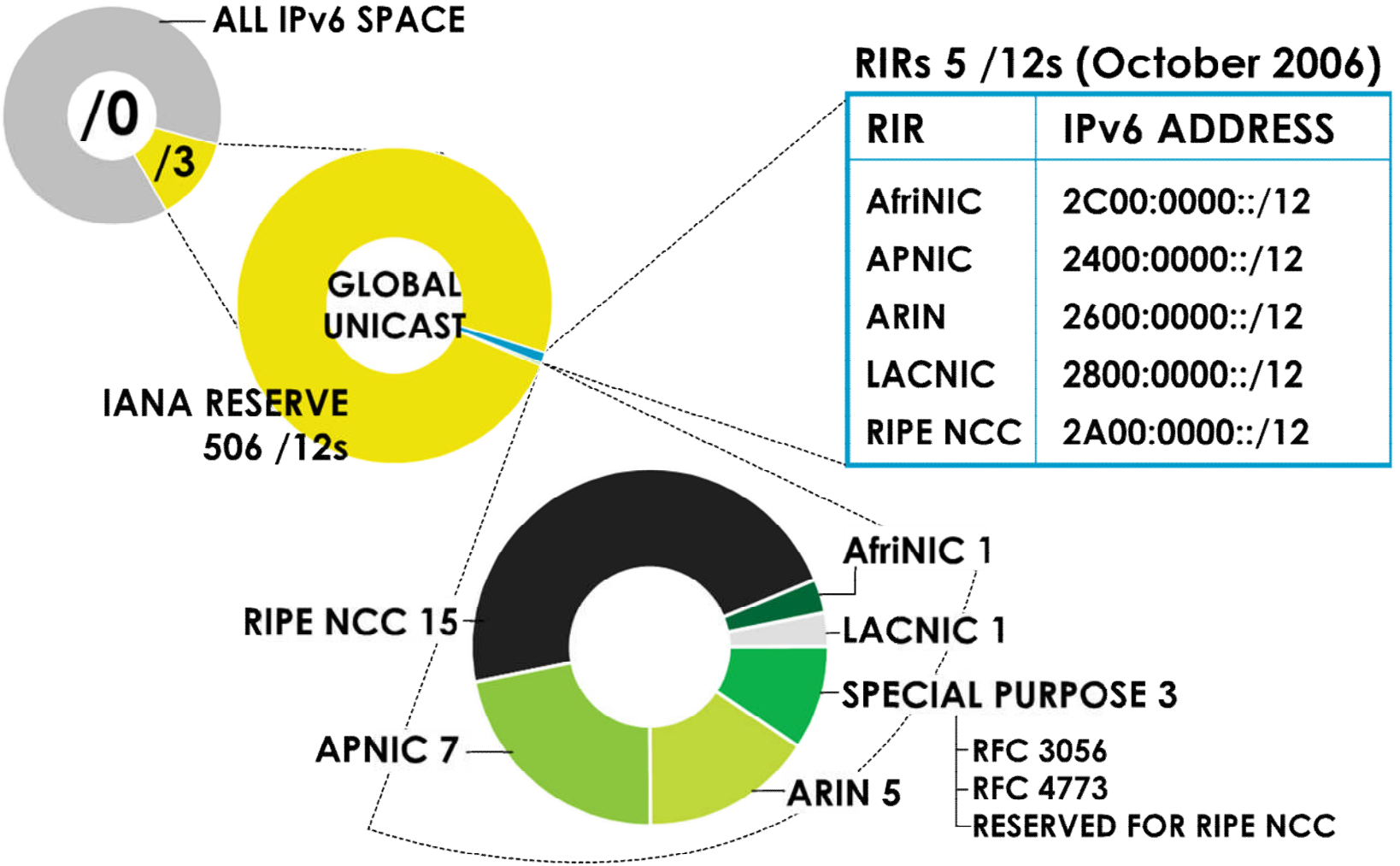


RIRs

- RIR (Regional Internet Registries)
  - There are five RIRs
    - ARIN, RIPE-NCC, APNIC, LACNIC, and AfriNIC

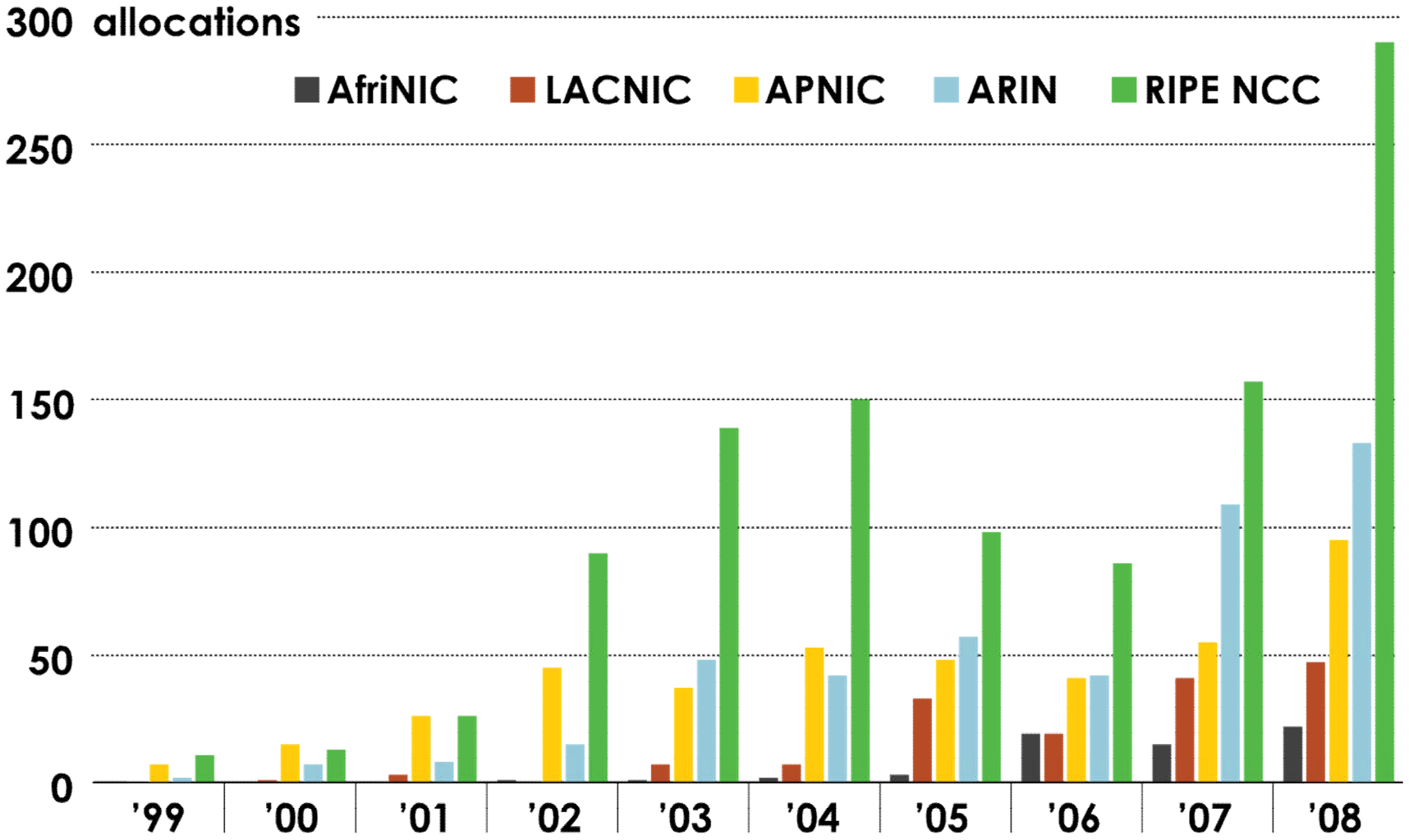


Current Status of IPv6 Address Allocation



http://www.nro.net/documents/presentations/jointstats.sept08.pdf

Transition of IPv6 Address Allocation



http://www.nro.net/documents/presentations/jointstats.sept08.pdf

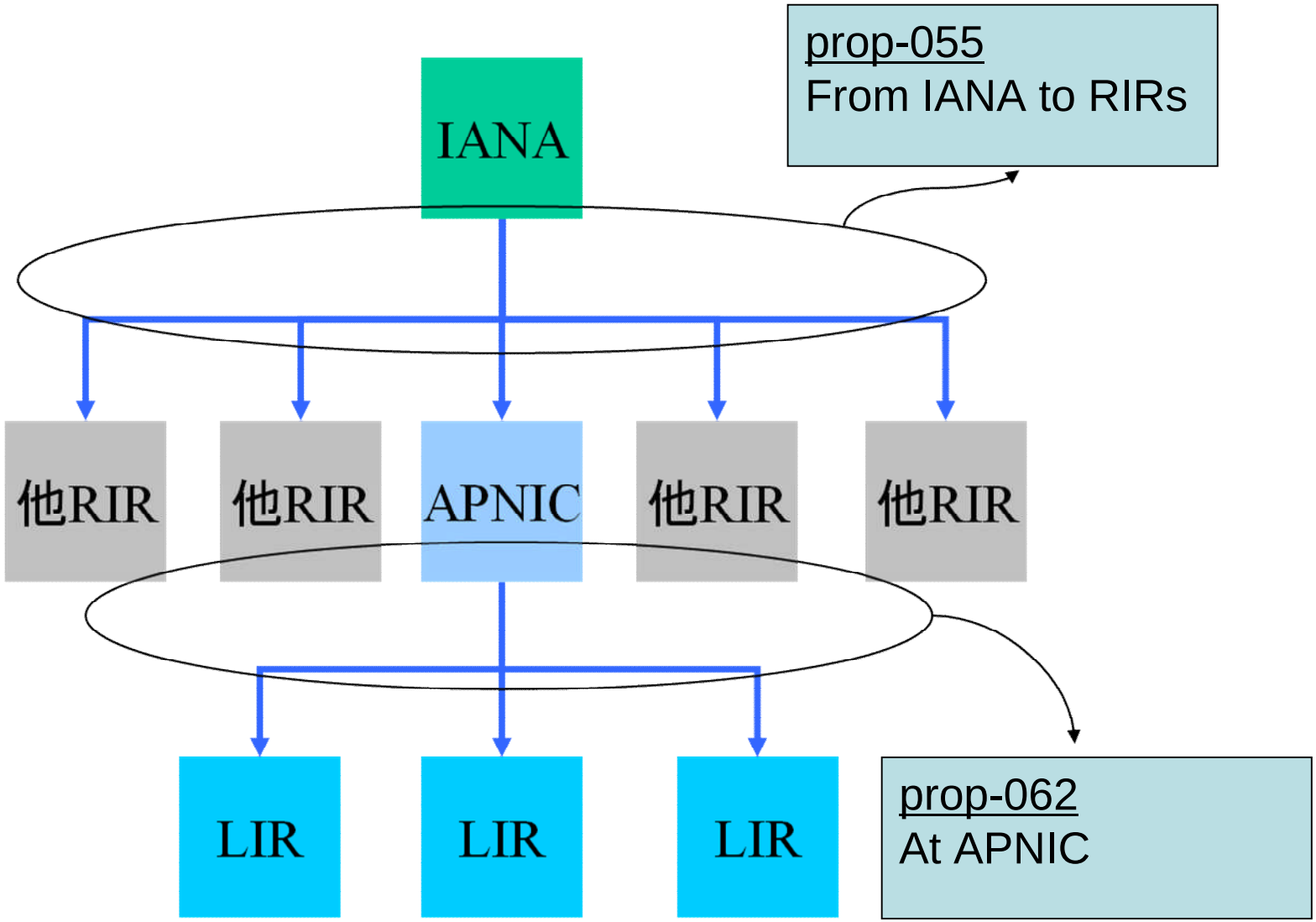
APNIC open policy meeting

- Internet resource management policy is decided in bottom-up process at each RIR.
  - Each RIR holds open policy meeting.
- APNIC Open Policy Meeting:
  - Everyone can attend and propose new policies
  - Held twice a year (February and September)
  - Workshops, tutorials, and SIGs
  - APNIC member meeting is held at the same time.

Recent Topics Regarding Address Policy

- Many proposals related to IPv4 address depletion and 4-byte AS introduction
  - The last IPv4 address allocation from IANA to RIR > adopted
  - 4-byte AS description > adopted
  - The last IPv4 /8 allocaiton at APNIC > adopted
  - A change of 4-byte AS number assignment policy > adopted
  - A change of 4-byte AS number description > adopted
  - Efficient use of Historical IPv4 PI address > adopted
  - Transfer of IPv4 Address > to be discuss
  - A change of standards for NIR creation > to be discuss
  - Making approval period shorter for IPv4 assignment > to be discuss

Proposal for the Last IPv4 address allocation



prop-055:
the Last IPv4 address assignment from IANA to RIRs

- Proposal : Reserve 5 /8s at IANA, and /8 to each RIR lastly
- Status: From 2007, globally proposed to each RIR
  - Sep. 2008, all RIRs reached concensus
  - ARIN @ARINXXI(Apr. 2008)
  - LACNIC @LACNICXI(May 2008)
  - AfriNIC @AfriNIC-8(Jun. 2008)
  - APNIC @APNIC26(Aug. 2008)
  - RIPE @ML after RIPE56 (Sep. 2008)
- Impact on address consumption
  - As this is a assignment policy from IANA, no direct impact on IPv4 depletion.
  - It was ensured that APNIC can have one /8 at last.
- Future step: If ICANN approved it, IANA will reserve 5 /8.

prop-062:
The last /8 assignment at APNIC

- Proposal
  - APNIC should limit the size of assignment to /22 per one organization.
  - APNIC should reserve /16 for unexpected situation.
- Status
  - APNIC Executive Committee approved this proposal, and decided to adopt.

IPv6 policy proposing activities in NTT

- We proposed IPv6-related address policy and reported IPv6 network deployment status in Japan.
  - IPv6 portable assignment for multihoming
    - http://www.apnic.net/docs/policy/proposals/prop-035-v002.html
  - Proposal on IPv6 IRR service at APNIC
    - http://www.apnic.net/docs/policy/proposals/prop-025-v001.html
    - Proposal to contract IPv6 routing database which contribute IPv6 internet stability
  - Expansion of initial allocation space for existing IPv6 address space holders
    - http://www.apnic.net/docs/policy/proposals/prop-021-v001.html
  - IPv6 address assignment size for end users
    - http://www.apnic.net/meetings/18/programme/sigs/policy.html
  - Source address selection policy distribution for multihoming

    http://www.apnic.net/meetings/19/programme/sigs/ipv6.html

Last, but not least

- IPv6 is very probably the only way to go.
  - Japan, and especially NTT is pursuing a better approach to the way.
- IETF and many other standardization organization needs more inputs.
  - especially they are missing inputs from the countries other than western countries.
- IPv4 is near ending and IPv6 is just in the beginning.
  - Now is the time for big change. Please make sure to catch up what does/will happen about IPv4 and IPv6.
  - Especially, countries with less IPv4 addresses will face difficulty sooner.