IPv6 Configuration Know-How 2003
IPv6設定ノウハウ2003

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Today's Schedule

• Introduction to IPv6	5 min
• Concept of IPv6 network design	40 min
• Break	10 min
• Actual examples (1)	50 min
• Break (2)	10 min
• Actual examples (2)	45 min
• Q&A	20 min
• Total	3hours

Introduction to IPv6

Internet Protocol

- Now we're using Internet Protocol Version 4 :
  - which succeeds quite well beyond original expectations for DARPA Internet
  - which was designed more than 20 years ago
  - whose address space is going to be running out
  - whose functions are not enough
- "It's a victim of its great success"

Shortage of IPv4 address

- An observation of usage of IPv4 address space predicts that we'll use the entire IPv4 address space around 2010±5
- In this prediction, new types of usage like
  - Internet ready cellular phone
  - Internet ready cable TV
  - huge number of users in China, India ….
  - and so on
- Are NOT COUNTED.

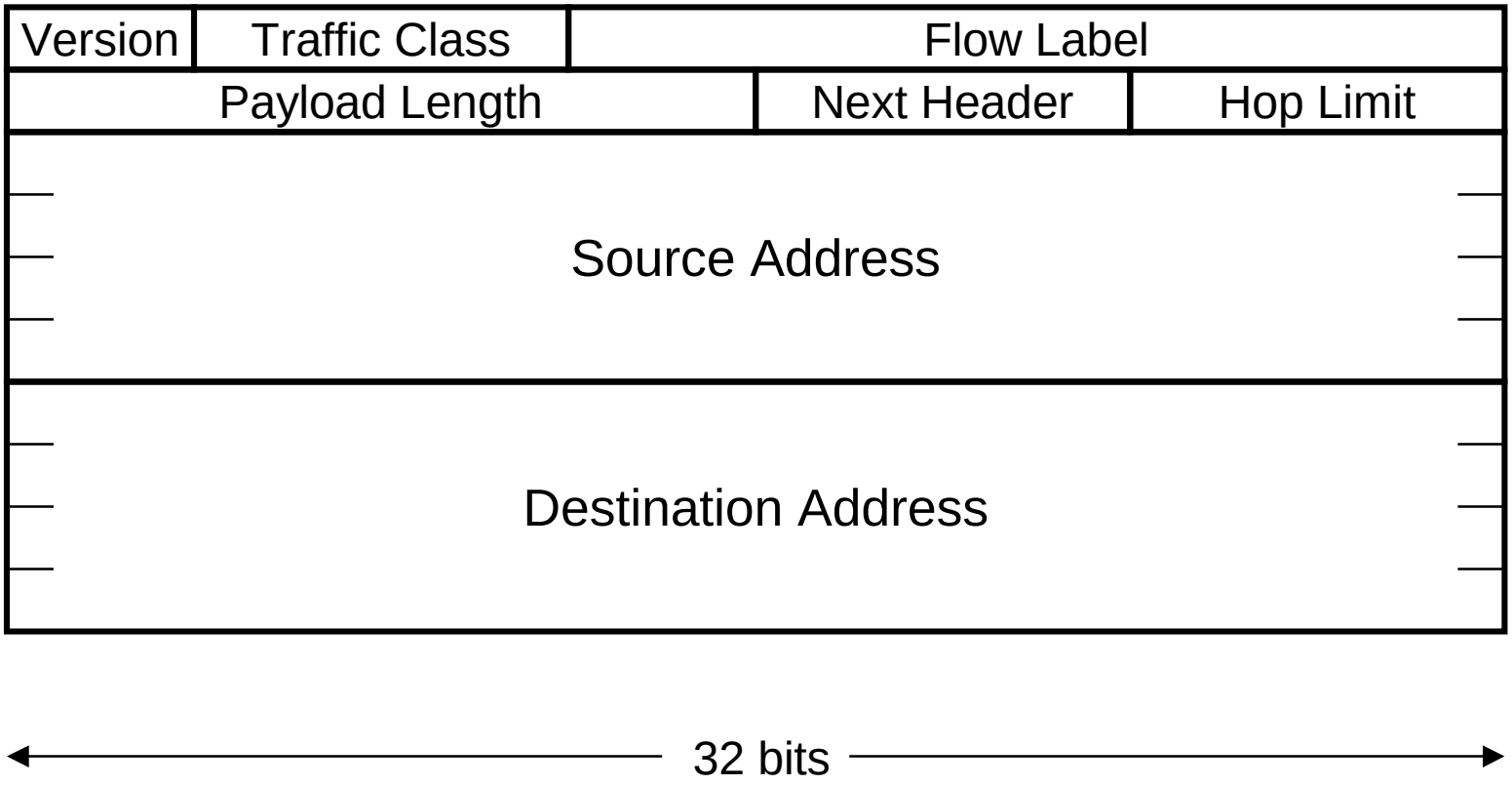
NAT

- Network Address Translation
  - is a technology which prolongs the life of IPv4.
  - Some people believe “IPv4ever” by this…..
- But, it actually
  - makes difficult to use IPsec, Mobile IP… many new protocols above IP
  - makes the management of the networks complicated
  - will become more expensive solution after the date of the IPv4 address running out

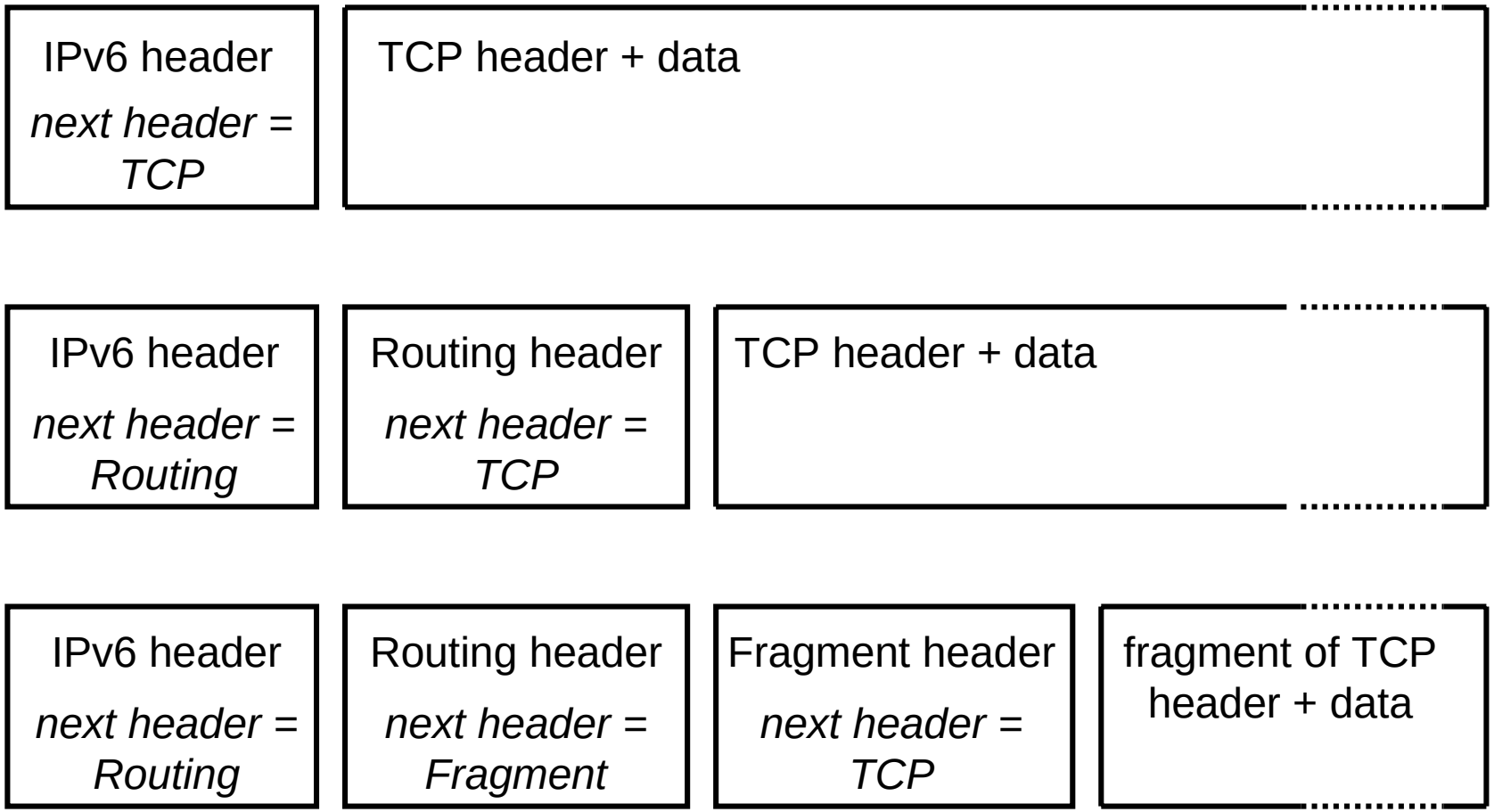
IPv6

- Wider address space: from 32bits to 128bits
  - (it's not 4 times larger but 2^{96} times) : NAT Free !
- Plug and Play
  - a host does not need to be manually configured
- Not a single complicated header but multiple simple headers
  - more functions but still faster processing
- and more….

The IPv6 Header



Extension Headers



Address Types

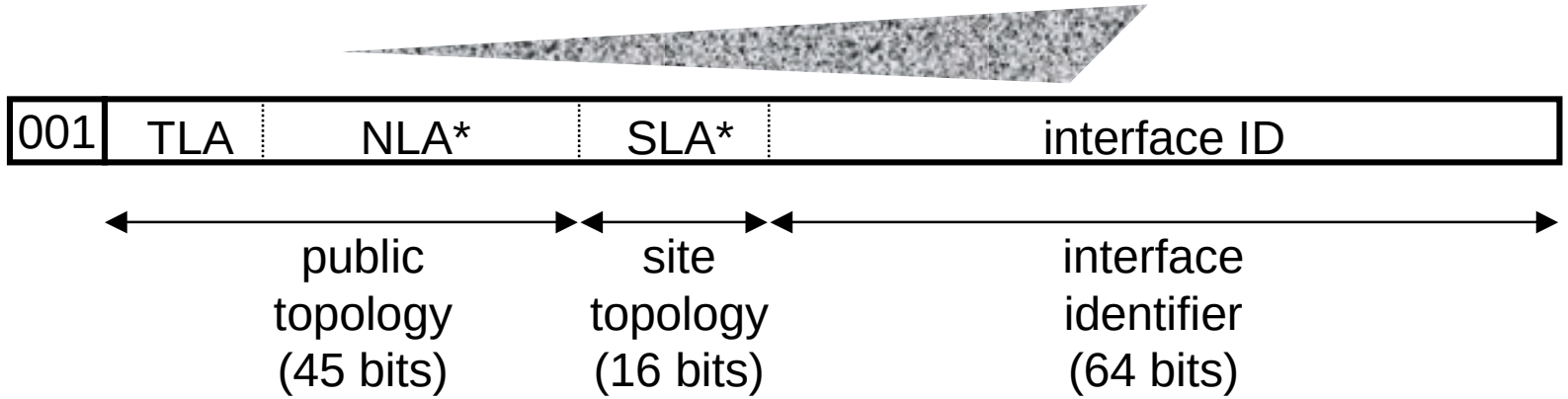
- unicast (one-to-one)
  - global
  - link-local
  - site-local [controversial]
  - compatible (IPv4, IPX, NSAP)[now not so important]
- multicast (one-to-many)
- anycast (one-to-one-of-many) [merged to unicast]
- reserved
- NO BROADCAST (one-to-ALL)

Address Type Prefixes

address type	binary prefix
IPv4-compatible	0000...0 (96 zero bits)
global unicast	001
link-local unicast	1111 1110 10
site-local unicast	1111 1110 11
multicast	1111 1111

- all other prefixes reserved (approx. 7/8ths of total)
- anycast addresses allocated from unicast prefixes

Global Unicast Addresses



- TLA = Top-Level Aggregator
  NLA* = Next-Level Aggregator(s)
  SLA* = Site-Level Aggregator(s)
- all subfields variable-length, non-self-encoding (like CIDR)
  - although /64 is going to be the standard subnet prefix
- TLAs may be assigned to providers or exchanges

TLA Assignment

- Now there are two kinds of TLA
  - pTLA (pseudo TLA) : for 6BONE experiment
    - easy to get, but for experiment purpose only (originally)
  - sTLA (Sub TLA) : for production
    - IANA and its affiliate RIRs (ARIN for America and sub-Saharan Africa, RIPE-NCC for Europe, middle East and a part of Africa, APNIC for Asia-Pacific) have authorities just like IPv4
    - not easy to get, there is a strict rule (still controversial…)
    - no (standalone) TLA has not been assigned yet

Link-Local & Site-Local Unicast Addresses

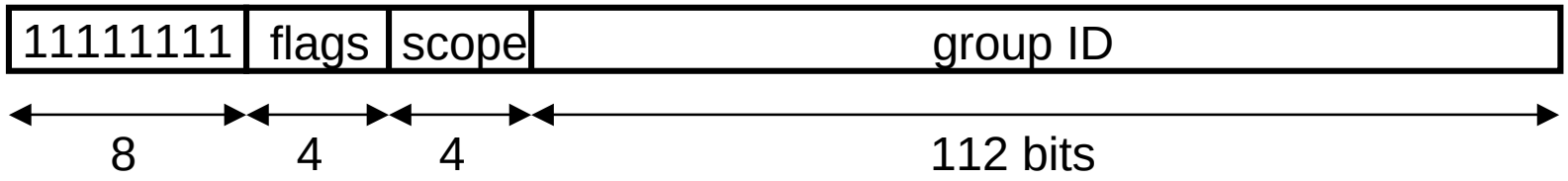
Link-local addresses:

- auto negotiation
- EBGP peering (controversial)
- maintenance purpose
- ...

Site-local addresses:

- independent use from ISPs (controversial)
- IBGP peering (controversial)
- will be deprecated soon
- ...

Multicast Addresses



- low-order flag indicates permanent / transient group; three other flags reserved
- scope field:
  1 - node local
  2 - link-local
  5 - site-local
  8 - organization-local
  B - community-local
  E - global

  (all other values reserved)

Routing

- uses same “longest-prefix match” routing as IPv4 CIDR
- straightforward changes to existing IPv4 routing protocols to handle bigger addresses

  unicast: OSPF(aka OSPFv3), RIP-II (aka RIPng), IS-IS, BGP4+, …

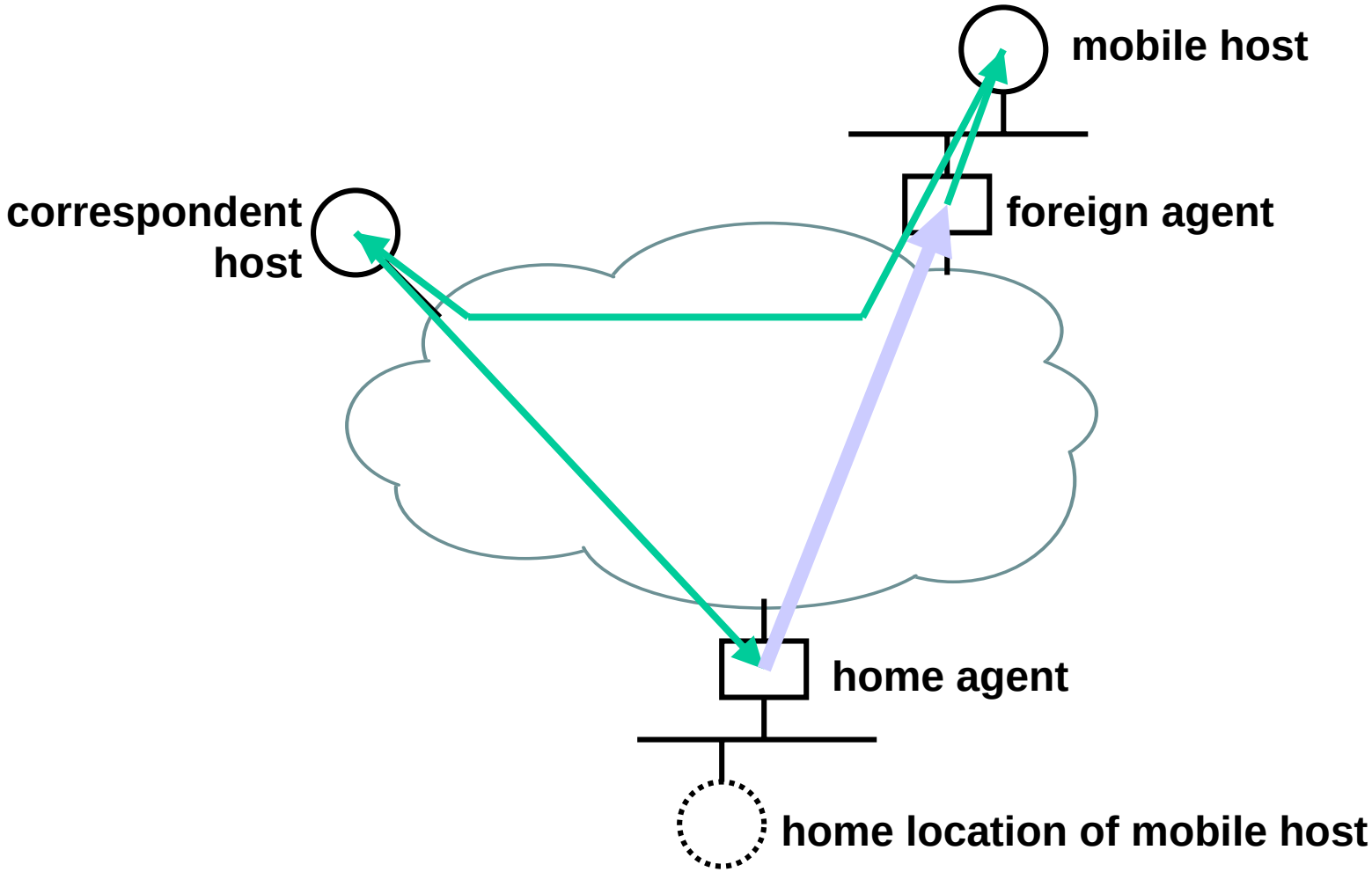
  multicast: MOSPF, PIM, …
- can use Routing header with anycast addresses to route packets through particular regions (not tested yet)

  e.g., for provider selection, policy, performance, etc.

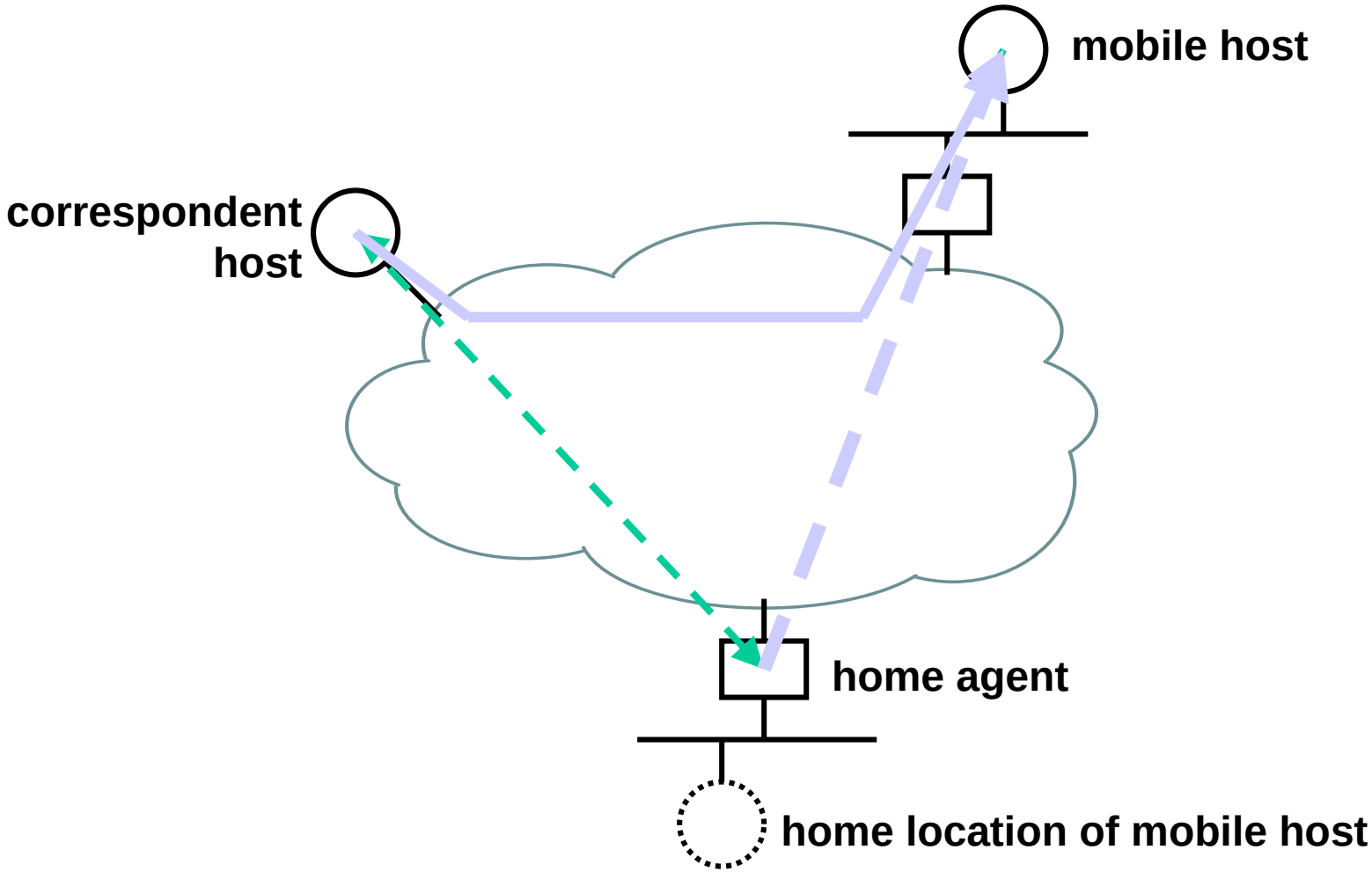
Serverless Autoconfiguration ("Plug-n-Play")

- hosts can construct their own addresses:
  - subnet prefix(es) learned from periodic multicast advertisements from neighboring router(s)
  - interface IDs generated locally, e.g., using MAC addresses
- other IP-layer parameters also learned from router adverts (e.g., router addresses, recommended hop limit, etc.)
- higher-layer info (e.g., DNS server and NTP server addresses) discovered by multicast / anycast-based service-location protocol [details still to be decided]
- DHCP also available for those who want more control

Mobile IP (v4 version)



Mobile IP (v6 version)



Concept of IPv6 Network Design

Networking Design Concept

- Basic Principles of networking design
  - IPv4/v6 dual stack
    - Pure IPv6 networking is not realistic for now
  - Plenty numbers of IPv6 address but few IPv4 addresses
    - NAT free, but filter firewall for IPv6
    - NAT full for IPv4, global IPv4 is only for DMZ as usual
  - Dual Stack server operation
    - No translator is needed (!)

Equipment choice

- Servers for IPv4/v6
  - NetBSD, FreeBSD, OpenBSD is default selection
    - As IPv6 server, *BSD is ultimate
    - Especially DNS, mail system
  - Linux is also good selection especially for applications
  - HP-UX, AIX, Solaris support IPv6
- Client for IPv4/v6
  - Windows XP (SP1) is good !
    - CE.NET is also good
  - Of course, FreeBSD and Linux works well

Equipment choice (2)

- Routers
  - (Again) *BSD is ultimate
    - With zebra routing daemon
  - We can not recommend Linux as router but firewall
  - Cisco, Juniper, Hitachi (GR, AG), NEC(IX) (and others) are available for IPv6 operations
  - Yamaha, Allied Telesys and others for SOHO
- Firewalls
  - Coming soon
    - Netscreen
    - Firewall-1
- NAT for IPv6 ?
  - What are you talking about ?

Equipment choice (3)

- Switches
  - Layer 2 switch
    - Just another layer 3 protocol
    - MLD (Multicast Listener Discovery) snooping was implemented
  - Tagged VLAN and Protocol VLAN is quite important to handle dual stack environment
  - Just FYI, 802.11 station is layer 3 independent which means IPv6 is just ok for wireless LAN

Service Provider selection

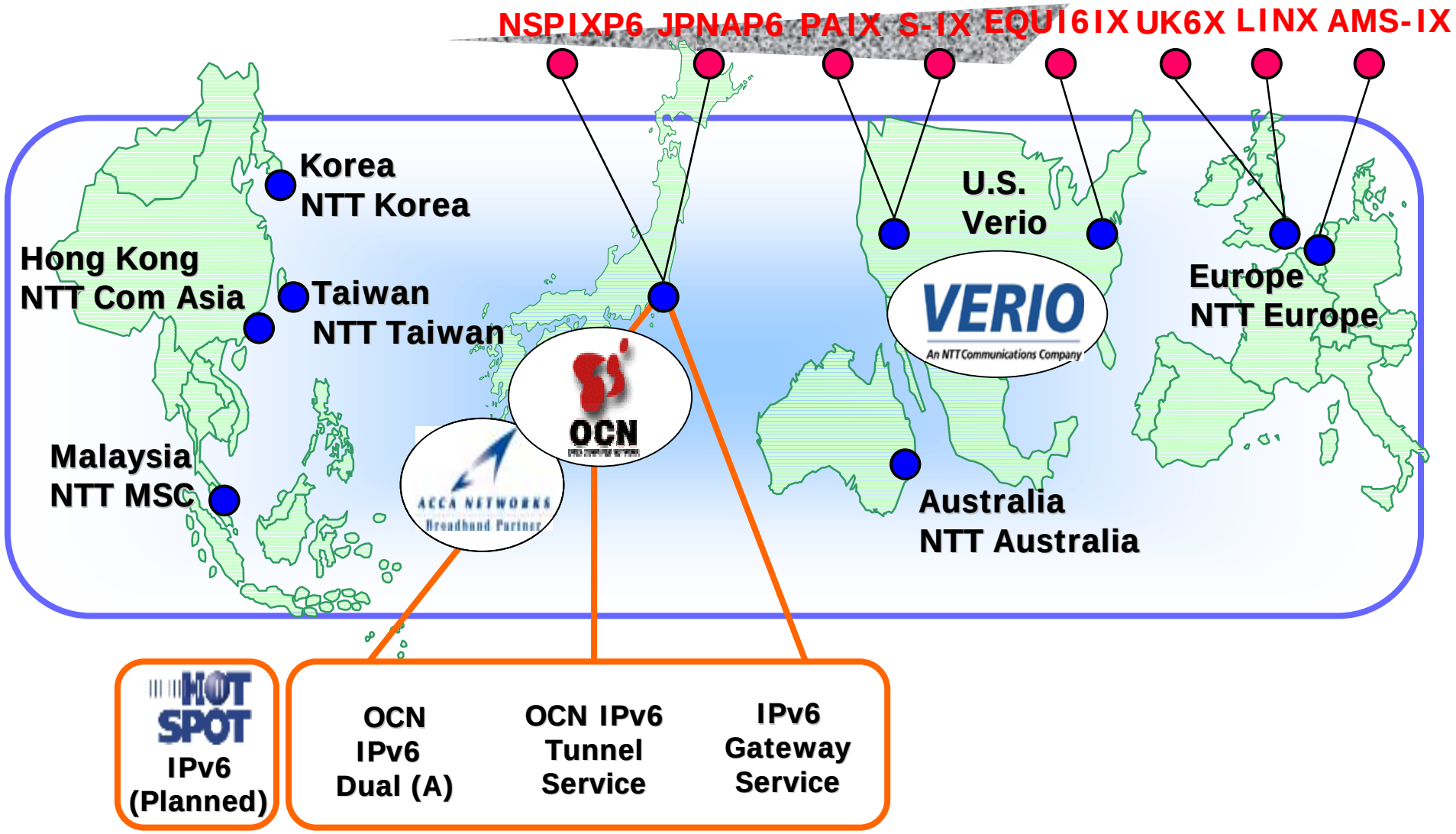
- Today, several IPv6 ISPs are available
- Let us use our own (NTT/VERIO) service menu…
  - For fairness,
    - IIJ, JT, POWEREDCOM,KDDI etc. have also commercial services
    - Other ISPs have experimental services too
  - List of available services in Japan
    http://www.ipv6style.jp/jp/statistics/services/index.shtml

What we can use (in Japan)

- Leased Line Service
  - Usual IP network configuration
- Native link in Data Center
  - Some people prefers this
- ADSL
  - For SOHO
- MPLS
  - IP-VPN
- Also there is tunneling service

NTT/VERIO Global IPv6 Operation

2003年7月時点



Japan NTT Communications

NTT/Verio IPv6 operation / activities

- Global
  - Global scale service based on the Tier 1 Backbone from Asia through North America to Europe
    - Probably, world one and only IPv6 commercial provider who has both trans-Pacific and trans-Atlantic link

- Commercial Grade IPv6 operation
  - 24 X 365 operation by Two Global NOC in Tokyo and Dallas, Texas
  - Native Peering with many other ASes on the world Internet Exchanges

NTT/Verio IPv6 operation / activities (cont')

- Rich service line-up
  - International transit service "IPv6 Gateway Service" for ISP/iDC
  - "OCN IPv6 tunnel connection service" for initial trial of enterprises and research organization
  - "OCN Dual ADSL (A)" for advanced individuals / SOHO / branch office
  - "Hotspot™" Wireless LAN service (Planned)
  - Commercial IX "JPNAP6 (in Japan)", "S-IX (in San Jose, California)"
  - Solution providing

Addresses which we can get

- Typically,
  - ISP allocates /48 for one single “site”
    - “site” is defined as “contractor”
    - A personal subscriber could be “site”
    - One site has 2^16 subnets
      - If we assume /24 in IPv4 is equivalent /64 in IPv6, it’s class A !
  - APNIC guide line
    - http://ftp.apnic.net/apnic/docs/ipv6-address-policy
- For IPv4,
  - 1? 8? 16?
  - Static (we hope), but sometime Dynamic
  - Use NAT, especially 10.X.Y.Z. we do not recommend 192.168.A.B.

Addressing Plan

- Principles
  - Use /64 for any subnets
    - Even for P-P link !
      - We admit to say that this is controversial
      - Some people said /126
  - Think Global, Don’t trust site-local
    - Use it for limited purpose
      - Again, this is also controversial
    - Site-local will be deprecated
  - You can make any subnet un-reachable from outside using filter and/or routing
  - Make it aggregable as much as possible, but this is not so strong recommendation

Some tips

- Use
  - <your-prefix>::<service port> as servers' interface ID
  - So that you can remember them easier
- For example
  - 2001:218::25 for SMTP
  - 2001:218::80 for HTTP
  - 2001:218::53 for DNS

  - Some people said they should be ::19, ::50, ::35
  - Why ? It's hexadecimal

Routing Protocol issues

- Most important rule: DO IT SEPARETELY
  - Use IPv4 transport for IPv4 routing information
  - Use IPv6 transport for IPv6 routing information
  - Do not mix them each other
    - Even a routing protocol is multi protocol capable, use two of them separately
    - Maybe IS-IS is only exception from this rule.. But..
  - Sometime, you do need to use two different AS numbers for each stack

Routing Protocols

	IPv4	IPv6
Unicast IGP	RIPv2	RIPng
	OSPFv2 →	OSPFv3
	ISIS	ISIS
Unicast EGP	BGP4 →	BGP4+
Multicast	PIM	PIM

Today's first choice

Routing protocol choice

- Usually, static routing for upstream is enough
- BGP if you would like to be a sTLA
  - Connecting JPNAP6 or NSPIXP6
  - Be careful, some router can not handle two AS numbers (one for IPv4, one for IPv6) in the same single box
- For IGP,
  - Again, use static !
  - OSPFv3 is ready to go
    - Partial introduction works well
  - RIPng could be OK
  - Some router vendors are pushing IS-IS but…
    - X day to enable IPv6 all over the IS-IS routing area, because topology is determined not by IPv6, but by IS-IS

Server issues

- Be careful about
  - /etc/inetd.conf or equivalent
  - Do not trust IPv4 mapped address
    - You should prohibit by kernel and/or API
  - Single daemon for both sockets (recommended!) or Two daemons for each service
- DNS is most critical and difficult to treat
  - At the same time, tricks with DNS solves a lot of problems

DNS issues

- The problem is around recursive query
  - DNS cache must have both transport
  - All the hosts must refer dual-stack DNS cache
    - Typical /etc/resolv.conf could be
      - domainname yourdomain.jp
      - nameserver 2001:380::53
      - nameserver 2001:380:0:1::53
    - If no other choice…
- Zone transfer over IPv6 transport works fine but be careful about source address selection
- Query by IPv6 is also just OK

DNS Issues (2)

- For reverse lookup
  - Both ip6.int and ip6.arpa are important
- Just for your information
  - Good job! > JPRS
  - We can register AAAA address on .JP by WEB

Mail server

- Also, Mail system must be configured very carefully
  - Use global v4 and v6 for MX servers
  - One IPv4 only MX might help wrongly implemented dual stack mail server
  - Current version of sendmail is dual stack
  - We have patches for qmail and postfix and testing those now

Printers

- LPR is just fine, but not printers are accepting IPv6 protocol for now
  - Only demonstration units has been presented

File Sharing

- NFS is just fine
- NetBIOS !
  - We hope it coming soon
- WebDAV works fine

SSH

- Today not so many applications are IPv6 compatible natively but…
- SSH port forwarding makes almost any applications IPv6 compatible
  - TeraTERM PRO + IPv6 extension and other SSH client on Windows is quite important

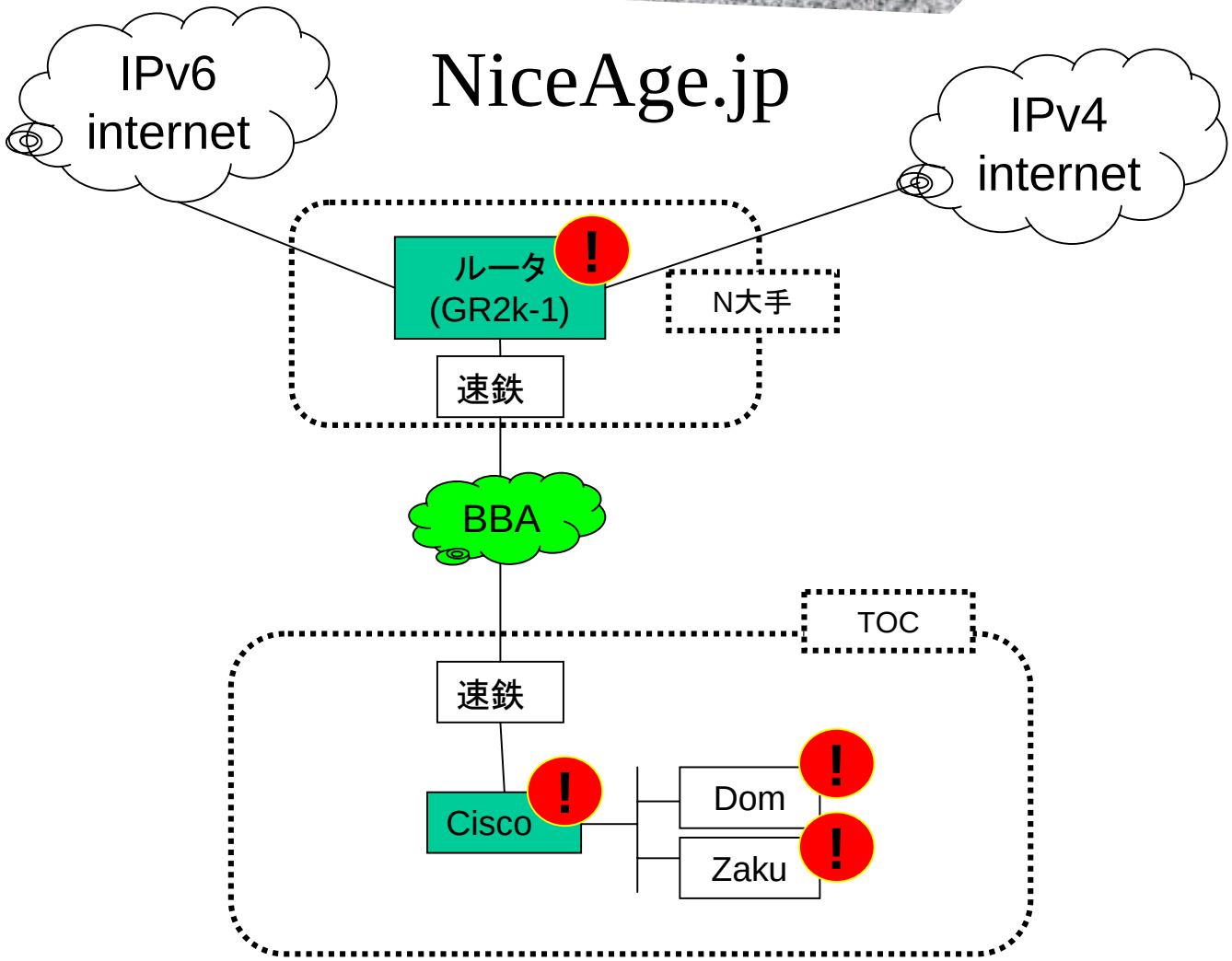
Seeing is Believing

- We will show you actual examples of…
  - Filter, DMZ, NAT
    - ip6fw, ipfw + natd
  - Router settings
    - zebra
    - Cisco and others
  - DNS
  - Mail
  - SSH
  - WWW
    - WebDAV
  - Monitoring tools
  - And others…

Setting Up Routers & Servers

- Routers
  - RA
  - Routing
    - IGP
    - EGP
  - Filter
- Servers
  - Fundamental setup
  - Domain Name servers
  - Mail system
  - Web system

Example Network



RA

- Cisco
  - Only Configuring IPv6 address on interfaces is enough
  - Use “ipv6 nd suppress-ra” if you don’t need RA
- GR2k
  - Use “ra”
- *BSD
  - rtadvd
- Shorter lifetime and Shorter advertisement period allow us to use RA as “routing protocol”

IGP

- Cisco
  - ipv6 route ::/0 2001:218::1
  - ipv6 router rip
  - ipv6 router ospf 3949
- GR2k
  - static ::/0 gateway fe80::1234%fa-1-1
  - ripng yes
  - ospf6 yes

EGP

- Cisco, Zebra
  - “router bgp XXXX
    address-family ipv6”
- GR2k
  - “bgp4+ yes”

Example Configuration (Cisco)

```
ipv6 unicast-routing
!
interface FastEthernet1/0
 ip address 210.248.164.228 255.255.255.248
 ipv6 enable
 ipv6 address 2001:218:1:1045::228/64
 ipv6 ospf 3949 area 0
!
interface FastEthernet1/1
 ip address 210.163.36.9 255.255.255.248
 ipv6 enable
 ipv6 address 2001:218:1:10C3::1/64
!
router ospf 65037
 network 210.163.36.8 0.0.0.7 area 0
 network 210.248.164.224 0.0.0.7 area 0
```

```
!
router bgp 3949
 bgp log-neighbor-changes
 neighbor 2001:218:1:1045::1 remote-as 3949
 address-family ipv4
 no neighbor 2001:218:1:1045::1 activate
 exit-address-family
 !
 address-family ipv6
 neighbor 2001:218:1:1045::1 activate
 exit-address-family
!
ip classless
!
ipv6 route ::/0 2001:218:1f01:f000::/56 Null0
ipv6 router ospf 3949
  redistribute static
```

Example Configuration (Cisco) cont’

```
access-list 99 permit 210.163.36.8 0.0.0.7
!
ipv6 access-list acl99
 permit ipv6 2001:218:1f01:f010::/64 any
 permit ipv6 host 2001:218:1:1040::4 any
 deny ipv6 any any
!
line vty 0 4
 access-class 99 in
 ipv6 access-class acl99 in
```

Example Configuration (GR2k)

```
line fa-0-0 ethernet 0/0;
line fa-0-1 ethernet 0/1;
line fa-0-2 ethernet 0/2;
line fa-1-1 ethernet 1/1;
ip fa-0-0 {
        2001:218:0:4f:0:1400:0:1e/126;
};
ip fa-0-1 {
        2001:218:1f01::1/64;
        210.254.137.105/30;
};
ip fa-0-2 {
        210.163.36.1/29;
        2001:218:1:1040::1/64;
};
ip fa-1-1 {
        fe80::2914:9;
        2001:200:0:1800::2914:9;
};
ra yes {
        interface fa-0-2;
};
```

```
autonomoussystem 3949;
routerid 210.163.36.1;
ospf6 yes {
        area 0 {
                interface fa-0-3 cost 1;
        };
};
bgp4+ yes {
        group type routing peeras 3949 {
                peer 2001:218:1:1045::228 description "musai";
        };
};
static {
        default gateway 210.190.177.5;
        210.163.36.8/29 gateway 210.254.137.110;
         ip6-default gateway  2001:218:0:4f:0:1400:0:1d;
};
```

Multicast Routing

- GR2k
  - “pim6 yes sparse”
- KAME
  - Use pim6sd (PIM-SM for IPv6 daemon)
  - Specify interfaces with phyint

PIM Example Configuration

GR2000

```
pim6 yes {
        sparse {
                interface fa-0-3;
                interface fa-0-1;
                interface fa-1-1;
        };
};
```

KAME pim6sd.conf

```
phyint fxp0 disable;
phyint fxp1 disable;
phyint fxp2;
phyint fxp3 disable;
phyint fxp4 disable;
phyint fxp5;
phyint xl0;
```

Packet Filter

- ip6fw
  - Apply same rule IPv4 first
  - Close IPv6 non-capable application ports
  - Don’t filter out link-local packets
  - Don’t filter out ICMPv6 packet

```
add 200 pass ipv6-icmp from any to any
add 210 pass all from fe80::/64 to ff02::/16
add 220 pass all from fe80::/64 to fe80::/64

add 310 pass tcp from any to 2001:218:1:10c2::2 smtp,domain setup
add 320 reset tcp from any to 2001:218:1:10c2::2 auth setup
```

SOHO Router (ex. ADSL)

- Automatic configuration
  - PPP IPCP for IPv4
  - PPP IPV6CP for IPv6 link-local address
  - DHCPv6 based Prefix Delegation (PD) mechanism for Prefix and DNS configuration
- User ID and Password with Web configuration

Server IP Address

- Configure interface ID by hand
  - ifconfig fxp0 inet6 fe80::10
- RA + configured interface ID -> global address
  - inet6 fe80::10 + RA (2001:218::/64)
  - > 2001:218::10/64
- 2 routers with same prefix option in RA
  - *BSD: backup router
  - HP-UX: load balance

inetd

- /etc/inetd.conf

```
ftp    stream  tcp6    nowait  root    /usr/libexec/ftpd       ftpd -l
```

Domain Name system

- IPv6 capability for RR
  - AAAA
- IPv6 transport support

bind9

- Configure script detects IPv6 capability automatically
- Use –enable-ipv6 flag for configure script to enforce
- Use bind-9.2.3 or later

named.conf

```
options {
            listen-on-v6 { any; };
# any or none before bind-9.3.0
      transfer-source-v6 2001:218:1f01:f010::10;
# specify some source IPv6 address especially you have multiple global address on the interfaces
      notify-source-v6 2001:218:1f01:f010::10;
};
#  share zone file with ip6.int and ip6.arpa
      zone “0.1.0.f.1.0.f.1.8.1.2.0.1.0.0.2.ip6.int" {
            type master; allow-transfer { slaves; };
            file "0.1.0.f.1.0.f.1.8.1.2.0.1.0.0.2.ip6";
      };

      zone "0.1.0.f.1.0.f.1.8.1.2.0.1.0.0.2.ip6.arpa" {
            type master; allow-transfer { slaves; };
            file "0.1.0.f.1.0.f.1.8.1.2.0.1.0.0.2.ip6";
      };
```

Zone file

- You don’t need to use A6
- Use AAAA

```
$TTL 86400
zaku    IN A    210.163.36.10
        IN AAAA 2001:218:1f01:f010::10
dom     IN A    210.163.36.11
        IN AAAA 2001:218:1f01:f010::11
musai   IN A    210.163.36.9
        IN AAAA 2001:218:1f01:f010::1
```

Zone file (rev)

- Prepare nibble format reverse lookup for both ip6.int and ip6.arpa (for backward compatibility)
- Don’t use $ORIGIN

```
$TTL 86400
;       |       |       |       *
0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0 PTR    niceage.jp.
1.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0 PTR    musai.niceage.jp.
0.1.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0 PTR    zaku.niceage.jp.
1.1.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0 PTR    dom.niceage.jp.
```

IPv6 global + IPv4 private

Private zone file

```
$INCLUDE global.zone

host1 IN A 192.168.0.123
```

Global zone file

```
@ IN SOA  dom.niceage.jp. root.niceage.jp.  (
                        2002121703      ; Serial
                        7200    ; Refresh
                        1800    ; Retry
                        604800  ; Expire
                        3600 )  ; Minimum
        IN NS   dom.niceage.jp.
        IN NS   zaku.niceage.jp.

host1 IN AAAA     2001:218::1234:5678
```

Mail system

- Right value of MX record should have AAAA record in DNS
- If you don’t have IPv6 network access, disable IPv6

sendmail

- DaemonPortOptions for both IPv6 and IPv4

O DaemonPortOptions=Name=IPv4, Family=inet

O DaemonPortOptions=Name=IPv6, Family=inet6

Postfix

- IPv6 patch is still needed
  - http://www.ipnet6.org/postfix/download/pv6-1.18a-pf-2.0.16.patch.gz
- postfix/mynetworks

210.248.164.224/28

[::1]/128

[2001:218:1f01:f010::]/64

POP3 and IMAP

- Courier-IMAP
  - Configure script detects IPv6 function automatically
- Cyrus
  - Patch is needed
  - http://www.imasy.or.jp/~ume/ipv6/cyrus-imapd-2.1.15-ipv6-20030819.diff.gz

Apache

- Apache 1.3.x needs IPv6 patch
  - http://motoyuki.bsdclub.org/data/IPv6/apache-1.3.27-v6-20021004.diff.gz
- Apache2 supports IPv6 natively
  - No patch is needed
  - It’s stable enough

IIS

- IIS 6.0 with Windows Server 2003
  - Add Microsoft TCP/IP version 6
  - Some part works with only IPv4 yet

httpd.conf

- Treat IPv6 addess as one of IP Virtual Host, if you want IPv6 special page

<VirtualHost [2001:218:1f01:f010::11]:80>
ServerAdmin ops@nttv6.jp
DirectoryIndex index6.html index.html
•
•
</VirtualHost>

WebDAV

- No special handling
- Acl works with IPv6 addresses

```
<Location "/share">
    DAV On
    AllowOverride AuthConfig
    Options MultiViews Indexes
    DirectoryIndex index.html
    Order allow,deny
    Allow from 2001:218:1f01:f010::/64 2001:218:1f01:f010:1::2687/128
http://dom.niceage.jp/
```

Monitoring

- MRTG
- hp OpenView NNM extended topology

Conclusions

conclusions

- You can create IPv6/v4 dual stack environment with not so much additional costs
- Many applications are available for IPv6
  - Even using port forwarding technique ssh
  - You can convert IPv4 only applications to address family independent applications
    - MAY THE SOURCE BE WITH YOU !

APPENDIX

Information Sources

- Magazine
  - IPv6マガジン（インプレス）
  - UNIXマガジン、BSDマガジン　（アスキー）
- Books
  - Christian Huitema, IPv6:The New Internet Protocol, Prentice Hall
  - IPv6-新世代インターネットプロトコル　ピアソンエデュケーション
  - Mark Miller「IPv6入門」　翔泳社
  - 増田など 「使って学ぶIPv6」　アスキー
  - 江崎浩　監修「IPv6教科書」　IDGジャパン
  - 宮本&齊藤「IPv6実践ガイド」　翔泳社
- Service
  - NTTコミュニケーションズ　IPv6プロジェクトトップ　http://www.v6.ntt.net/
- IETF　http://www.ietf.org/
  - IPv6　WG、V6OPS　WG （、NGTRANS WG)
  - DHCP、IPSEC、DNS、MobileIP、Zerouter、Send
- 団体など
  - IPv6普及・高度化推進協議会　http://www.v6pc.jp/
    - ショールーム　ガレリアV6　新丸の内ビル1F　月ー金11:00-19:00
  - IPv6 FORUM　http://www.ipv6form.com/
  - http://www.ipv6.org/　英語
  - http://www.v6style.jp/　日本語

IP version 6 at WIDE Project

- KAME/TAHI/USAGI for referenced implementation
  - KAME for *BSD* (http://www.kame.net)
  - USAGI for Linux (http://www.linux-ipv6.org)
  - TAHI for test and evaluation (http://www.tahi.org)
- NSPIXP
  - NSPIXP6 is for research (http://www.wide.ad.jp/nspixp6/)
  - NSPIXP is for commercial operation (http://nspixp.sfc.wide.ad.jp/)
- Root DNS servers with IPv6 Working with USC-ISI
- bind9 with ISC
- DVTS (http://www.sfc.wide.ad.jp/DVTS/)

Special projects on IPv6 in WIDE

- KAME IPv6/IPsec for BSD 亀(Turtle)
  - http://www.kame.net/
  - FreeBSD, NetBSD, OpenBSD and BSD/OS's IPv6 code are now KAME.
- USAGI IPv6/IPsec for LINUX 兎(Rabbit)
  - http://www.linux-ipv6.org/
  - patch-kit, not yet integrated to the original code
  - but more updated specification
  - closely working with Linux Society
  - collaborating with IBM@USA
- TAHI IPv6 Test & Evaluation Software 鯛(Snapper)
  - conformance test suites
  - http://www.tahi.org/
- DNS and BIND
  - WIDE project has worked on bind source code
  - with USC-ISI、ISC

Functional Integration into KAME

- Routing Protocol
  - Multicast：PIM-SM & PIM-DM
  - Unicast : OPSF for IPv6
    as a Zebra routing daemon sub-process
    Zebra has BGP4, RIP and more already
- QoS/CoS Control
  - Diff-Serv Integration with ALTQ(Sony-CSL)
  - BB(Bandwidth Broker) with COPS
- Mobile IP
- IPv6/v4 Internetworking
  - NAPT-PT (Hitachi, KAME)
  - SOCKS (Fujitsu, NEC, KAME)
- Label Switch (MPLS)
  - Integrate IPv6, PIM, Diff-Serve and BB
    (AYAME Project)

菖蒲 (Iris)