IPv6 Transition Technologies

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Agenda

1. Current status of IPv4 / IPv6 internet
2. IPv4 continuity
3. IPv4 continuity over IPv6 network
4. IPv6 rapid deployment
6. Wider IPv6 deployment
6. Solution comparison

Appendix. Multi-ServiceProvider Issuue in IPv6

1 Current status of IPv4 / IPv6 internet

IANA IPv4 address pool has been sold out !!

http://www.icann.org/en/news/releases/release-03feb11-en.pdf

FOR IMMEDIATE RELEASE
February 3, 2011

Available Pool of Unallocated IPv4 Internet Addresses Now Completely Emptied

The Future Rests with IPv6

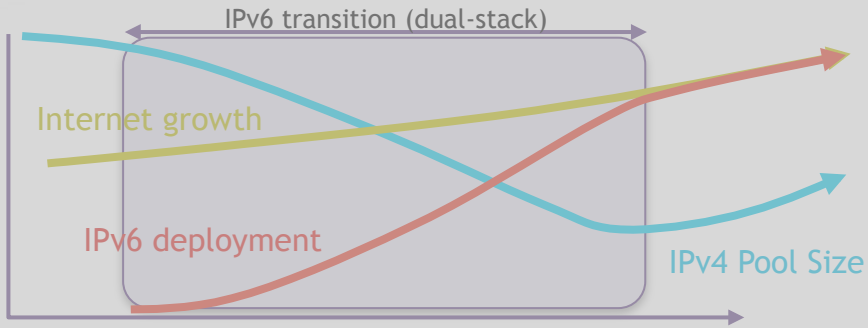
A critical point in the history of the Internet was reached today with the allocation of the last remaining IPv4 (Internet Protocol version 4) Internet addresses from a central pool. It means the future expansion of the Internet is now dependant on the successful global deployment of the next generation of Internet protocol, called IPv6.

The announcement was made by four international non-profit groups, which collaboratively work to coordinate the world's Internet addressing system and its technical standards.

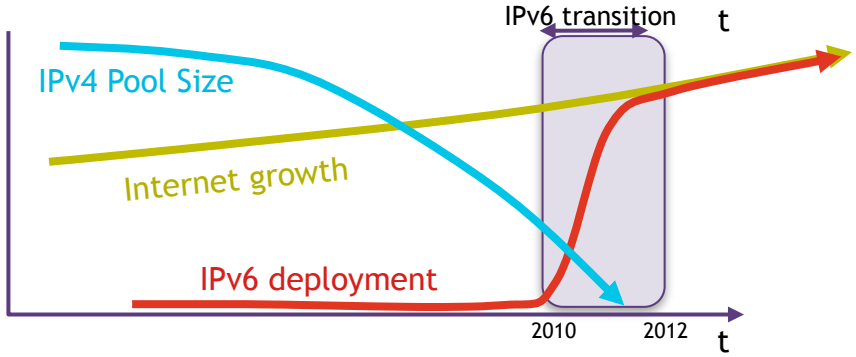
At a news conference in Miami, Florida, the Internet Corporation for Assigned Names and Numbers (ICANN) joined the Number Resources Organization (NRO), the Internet Architecture Board (IAB) and the Internet Society in announcing that the pool of first generation Internet addresses has now been completely emptied.

IPv4 address exhaustion has become REAL.. People needs go to IPv6 anyway..

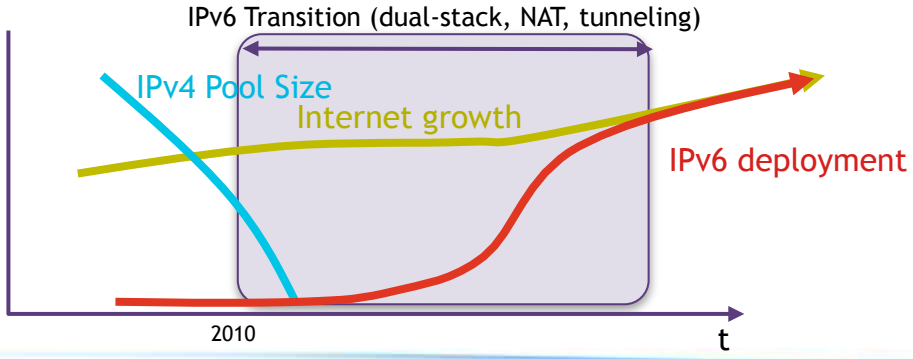
IPv4 Address Exhaust and IPv6 Deployment



Original Expectation



Rapid migration to IPv6



IPv4 continuity until IPv6 migration

Geoff Huston
http://www.potaroo.net/ispcol/2009-09/v6trans.html

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Transition to IPv6 : Two Approaches we need to consider..

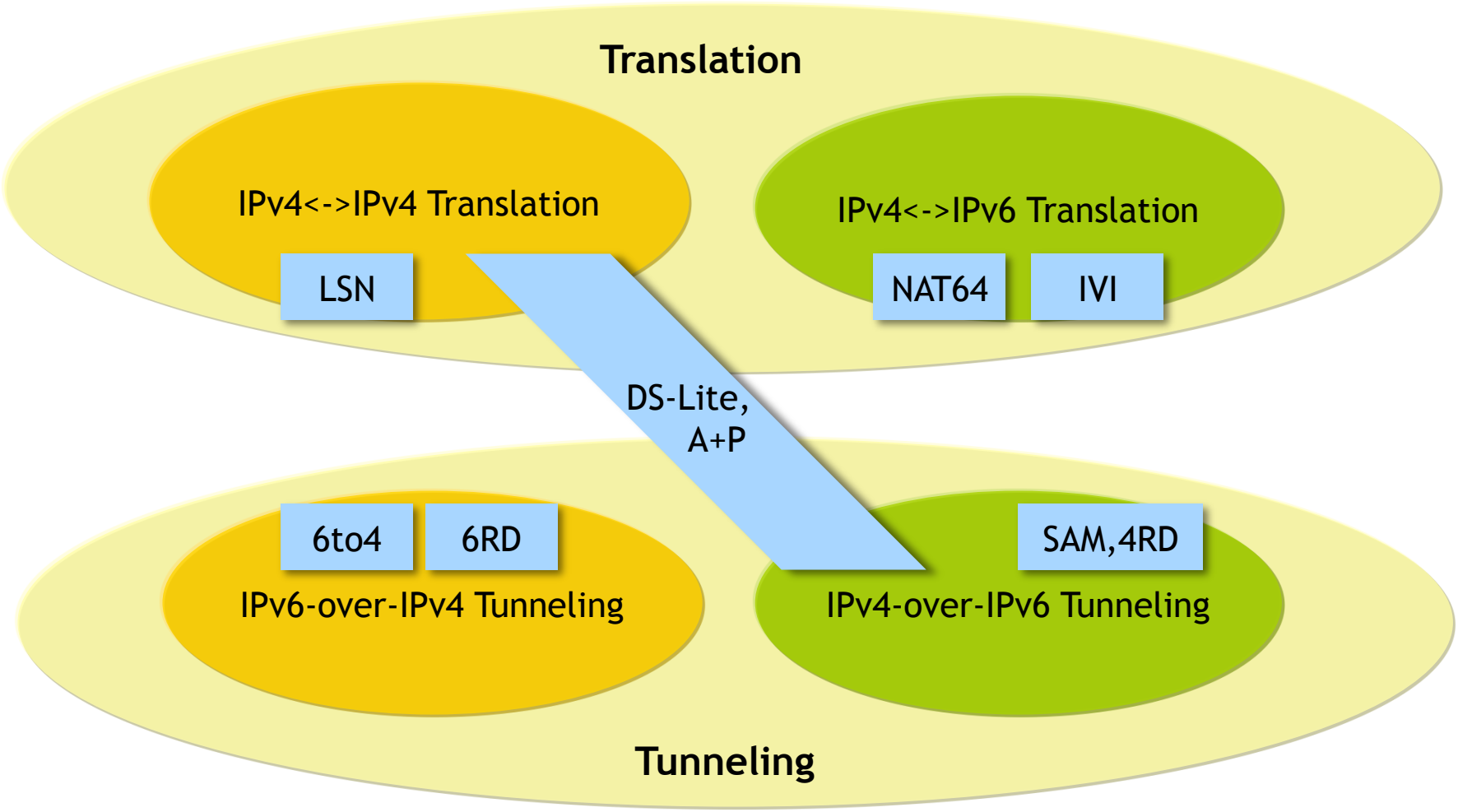
1. IPv4 continuity/Address sharing

- Extend the life of IPv4 until all the internet become IPv6
- Global address sharing between the users, with using NAPT
- IPv6 connectivity can be provided by dual-stack, some tunneling technologies, or protocol translation.

2. IPv6 migration focus

- Rapid/Gradual introduction of IPv6 capabilities (CPE, Access, BNG)
- Progressive steps to native IPv6 service
- IPv4 connectivity through dual-stack or protocol translation or tunneling

Transition to IPv6 : applicable technologies

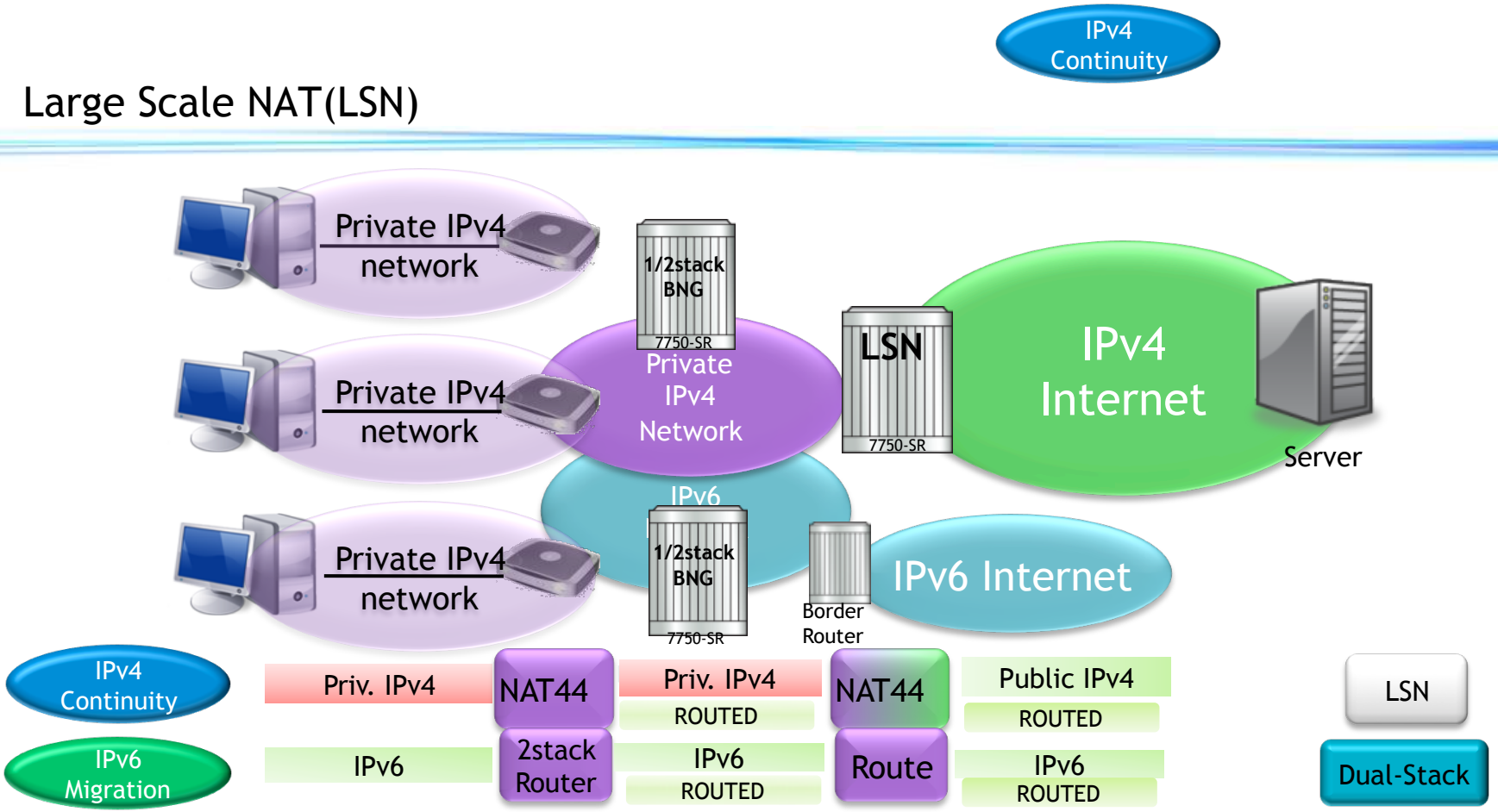


Methods

Home device	Access network	Destination	Solutions
IPv4	IPv4	IPv4 Internet	Large Scale NAT
IPv4	IPv6	IPv4 Internet	Dual-Stack Lite SAM, 4RD
IPv6	IPv6	IPv4 Internet	NAT64 Stateful NAT64 Stateless IVI
IPv6	IPv4	IPv6 Internet	6to4 6RD
IPv6	IPv6	IPv6 Internet	Dual-Stack

2 IPv4 continuity

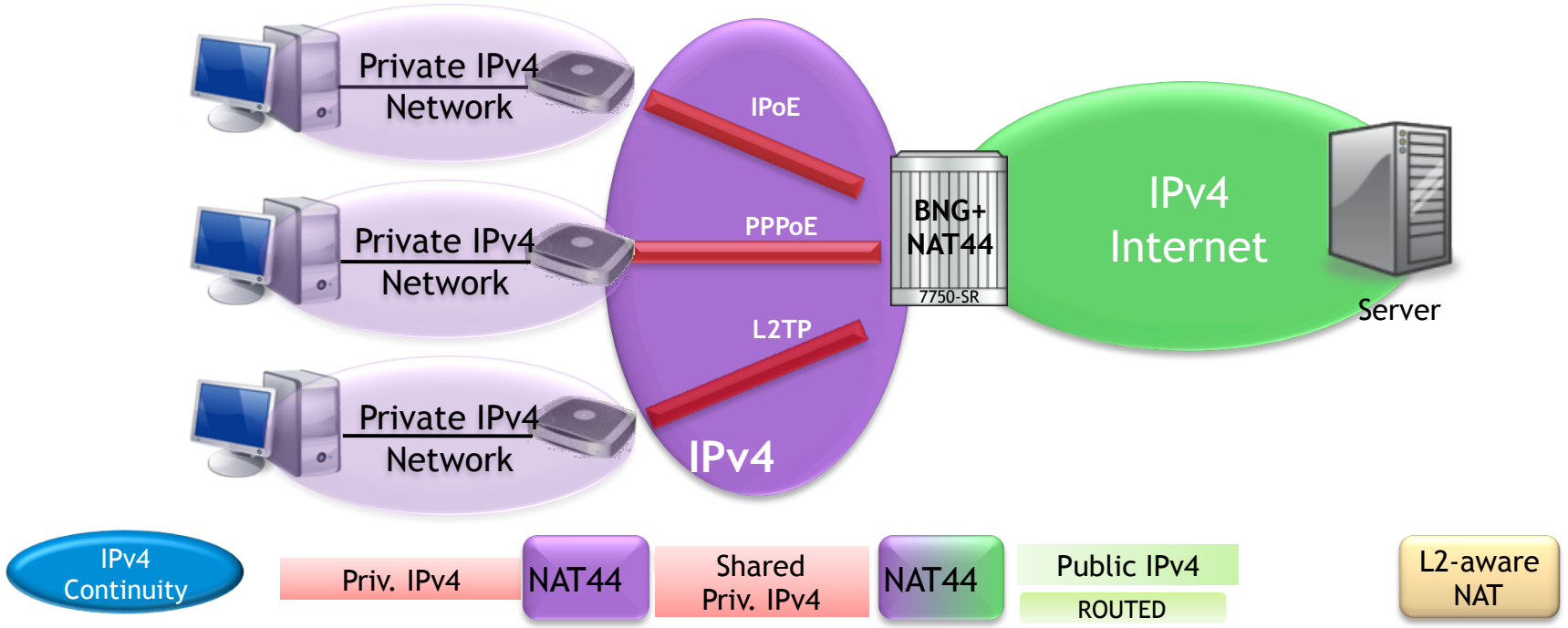
Large Scale NAT(LSN)



- CGN (aka. large scale NAT or NAT444) is the most traditional approach to IPv4 continuity
- Use of RFC1918 may collide with the addresses used within the subscriber LAN
- IPv6 services can be offered in parallel to the NATed IPv4 service through dual-stack BNGs.
- No new feature required on CPE.

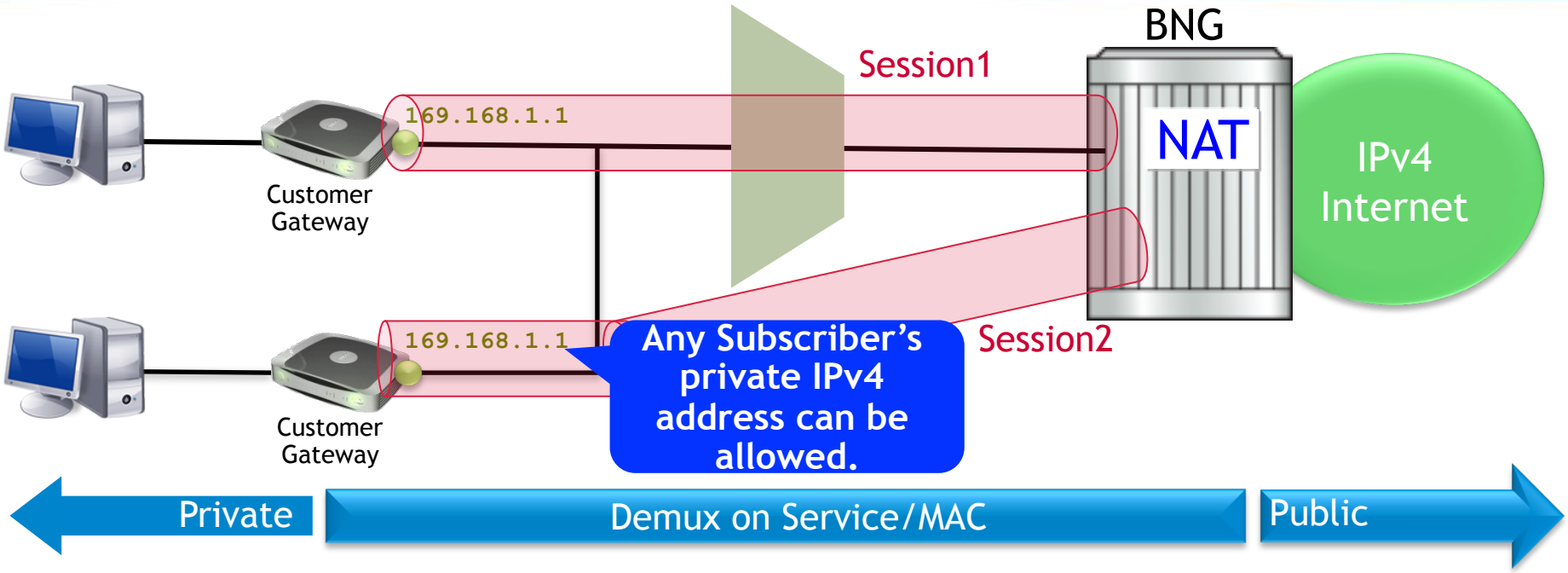
IPv4 Continuity

L2-aware NAT



- L2-aware NAT offers subscriber-aware NAT by using L2 delimiter information (S-/C-VLAN, PPPoE, MAC, DHCP Option82, etc.)
- Based on the Radius user record, subscriber traffic is subject to NAT on the BNG
- Unique subscriber-id is used to create NAT mapping to allow duplicate inside-IP addresses
- No new feature required on CPE

L2-aware NAT (cont'd)



NAT Function

UDP | TCP | TCP | UDP

IP

Ethernet

Ethernet

RFC 2684

ATM

DSL

Subscriber is identified by "Session".

IPoE

PPP

L2TP

NAT Function

UDP | TCP | TCP | UDP

IP

802.1ad

Ethernet

802.3 PHY

Minor change in BNG

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3 IPv4 continuity over IPv6 Network

DS-Lite (Dual stack Lite)

draft-ietf-softwire-dual-stack-lite

Dual-Stack Lite Broadband Deployments Following IPv4 Exhaustion

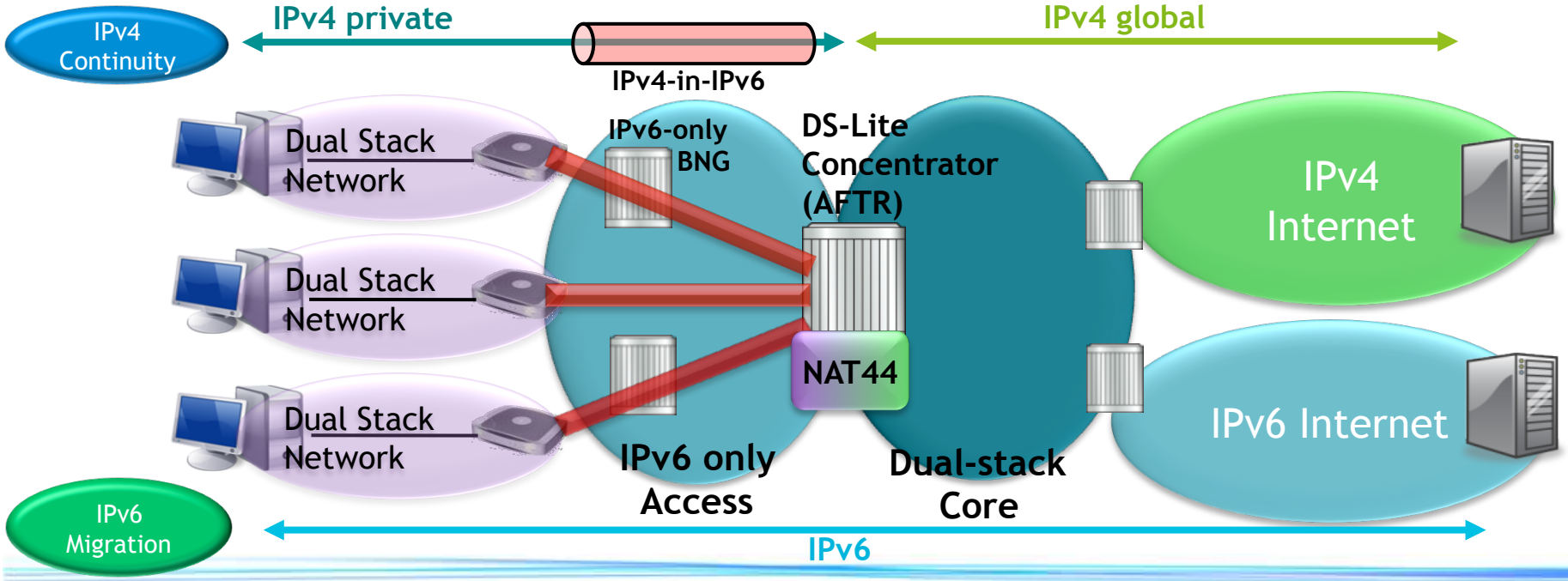
- Carry IPv4 packet over IPv6 tunnel(IPv4-in-IPv6), on “IPv6 ONLY” Access Network

  => Reduce Management/Operational cost

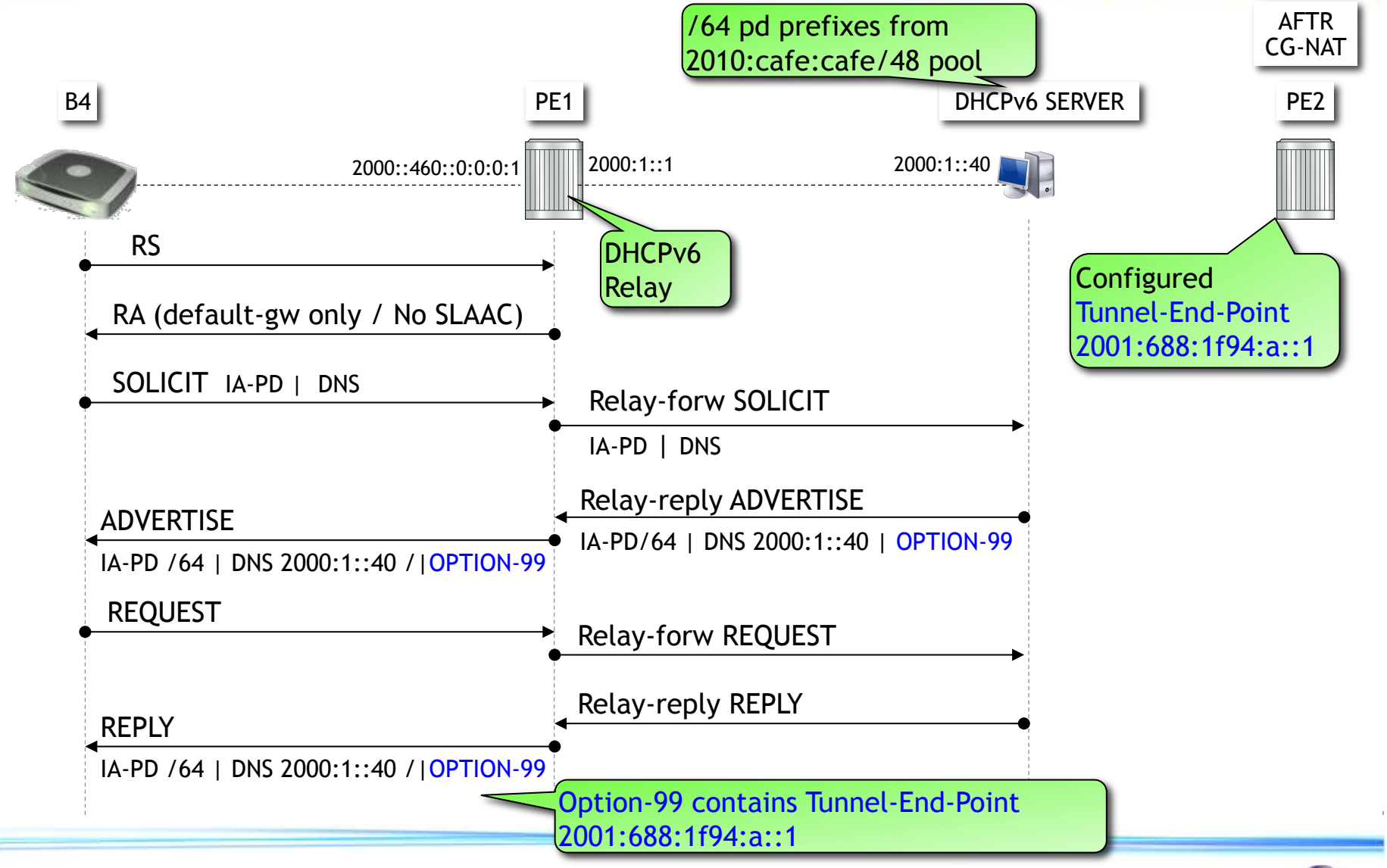
- Provide IPv4-to-IPv4 NAPT on AFTR(Concentrator)

  => Global IPv4 address saving by sharing the address in multiple users.

- CPE needs update for feature adding



DS-Lite Control plane sequence example



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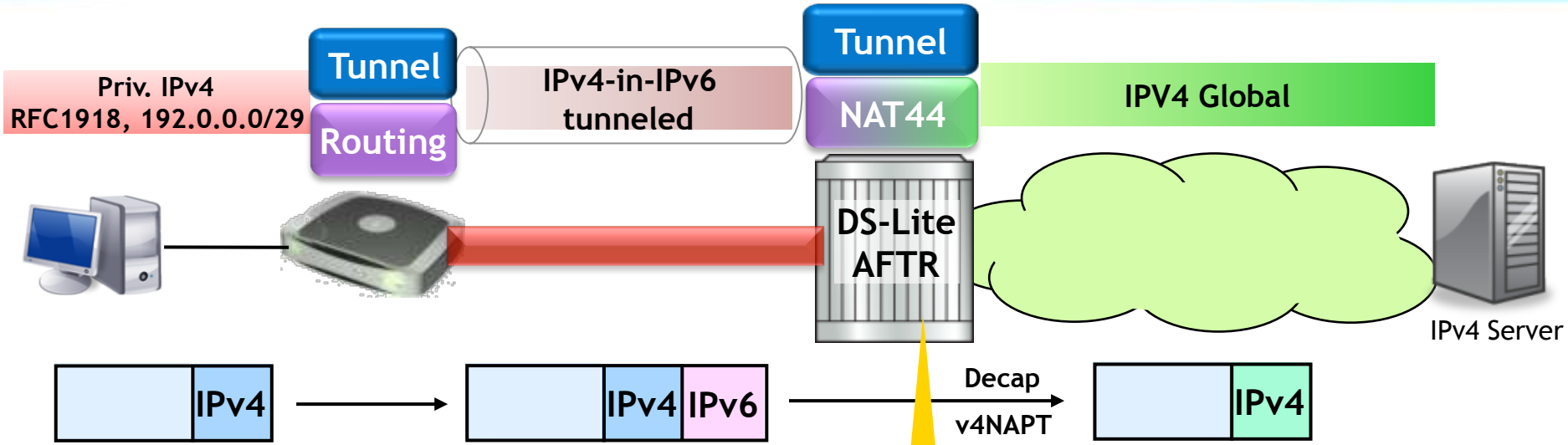
DS-Lite Packet Flow




```
Dst-IPv4=198.51.100.1
Src-IPv4=192.168.0.2
Dst-port=80
Src-port=10000
```

```
Dst-IPv6=2001:db8:20::2
Src-IPv6=2001:db8:10::2
Dst-IPv4=198.51.100.0
Src-IPv4=192.168.0.2
Dst-port=80
Src-port=10000
```

```
Dst-IPv4=198.51.100.0
Src-IPv4=192.0.2.1
Dst-port=80
Src-port=20000
```

Softwire-ID	Inside IP	Prot	Inside Src Port	Outside IP	Prot	Outside SrcPort
2001:db8:10::2	192.168.0.2	TCP	10000	192.0.2.1	TCP	20000

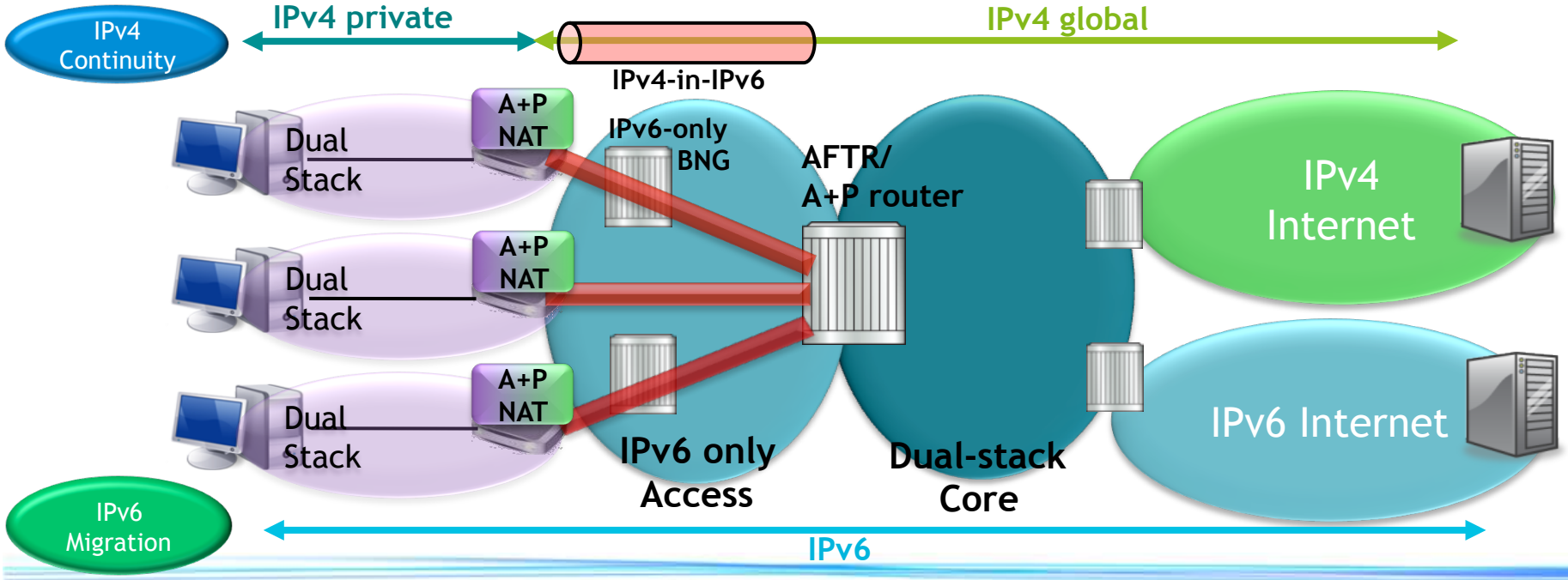
DS-Lite + A+P

draft-ietf-softwire-dual-stack-lite

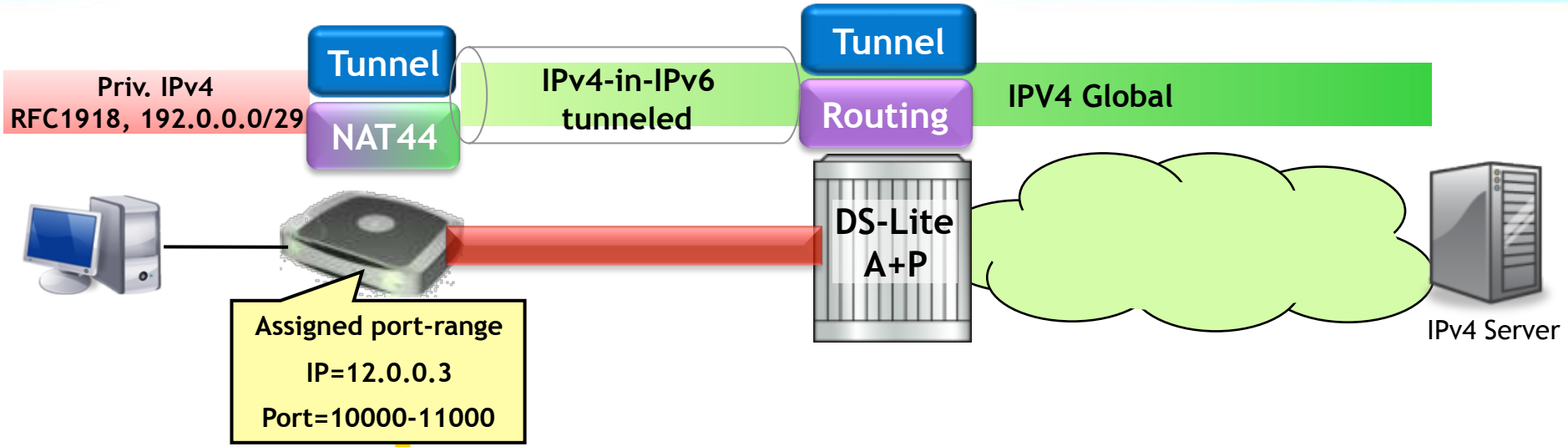
draft-ymbk-aplusp

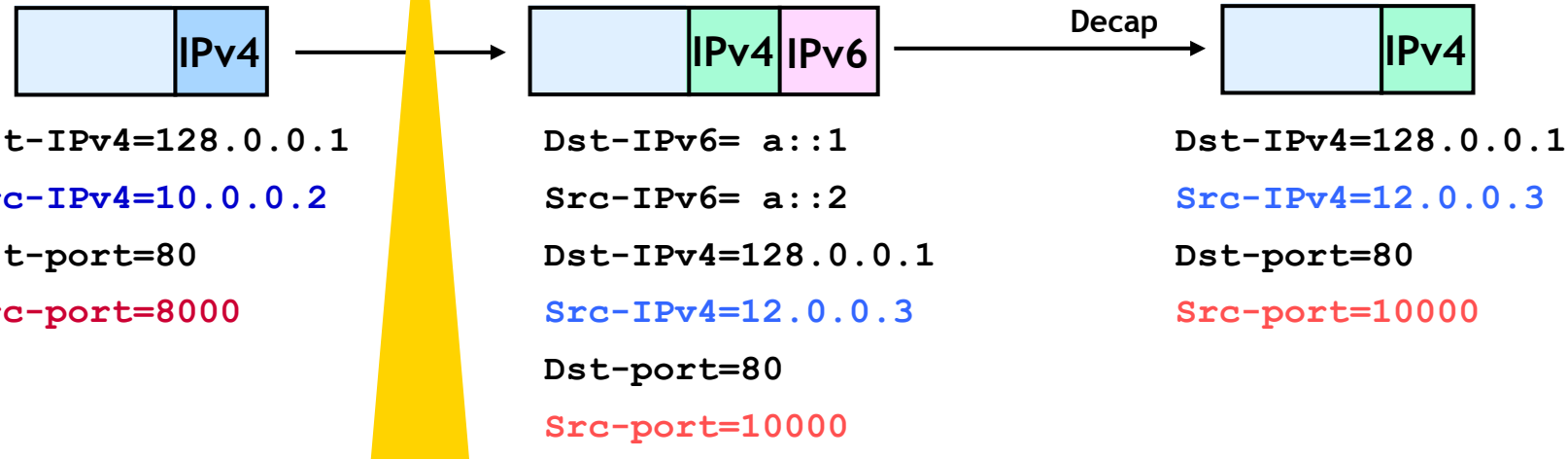
The A+P Approach to the IPv4 Address Shortage

- Carry IPv4 packet over IPv6 tunnel(IPv4-in-IPv6), on "IPv6 ONLY" Access Network
- CPE learns Global address/port-range, and CPE perform IPv4-IPv4 NAPT.
- NAPT function can be distributed to CPE side, more scalable than DS-Lite. Minimal state core.
- More Flexible, more close to End-to-End transparency (but still limited)



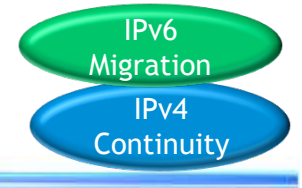
DS-Lite + A+P Packet Flow



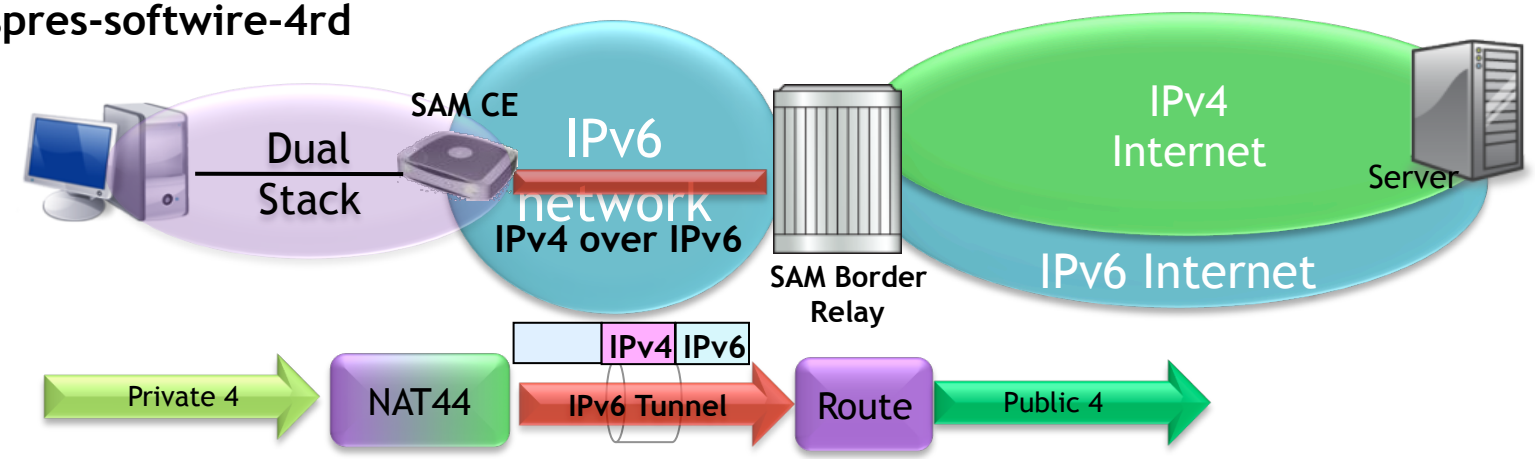


Inside IP	Prot	Inside Src Port	Outside IP	Prot	Outside SrcPort
10.0.0.2	TCP	8000	12.0.0.3	TCP	10000

Stateless Address Mapping (SAM) - Mesh Softwires without e-BGP
IPv4 Residual Deployment across IPv6-Service networks (4rd)

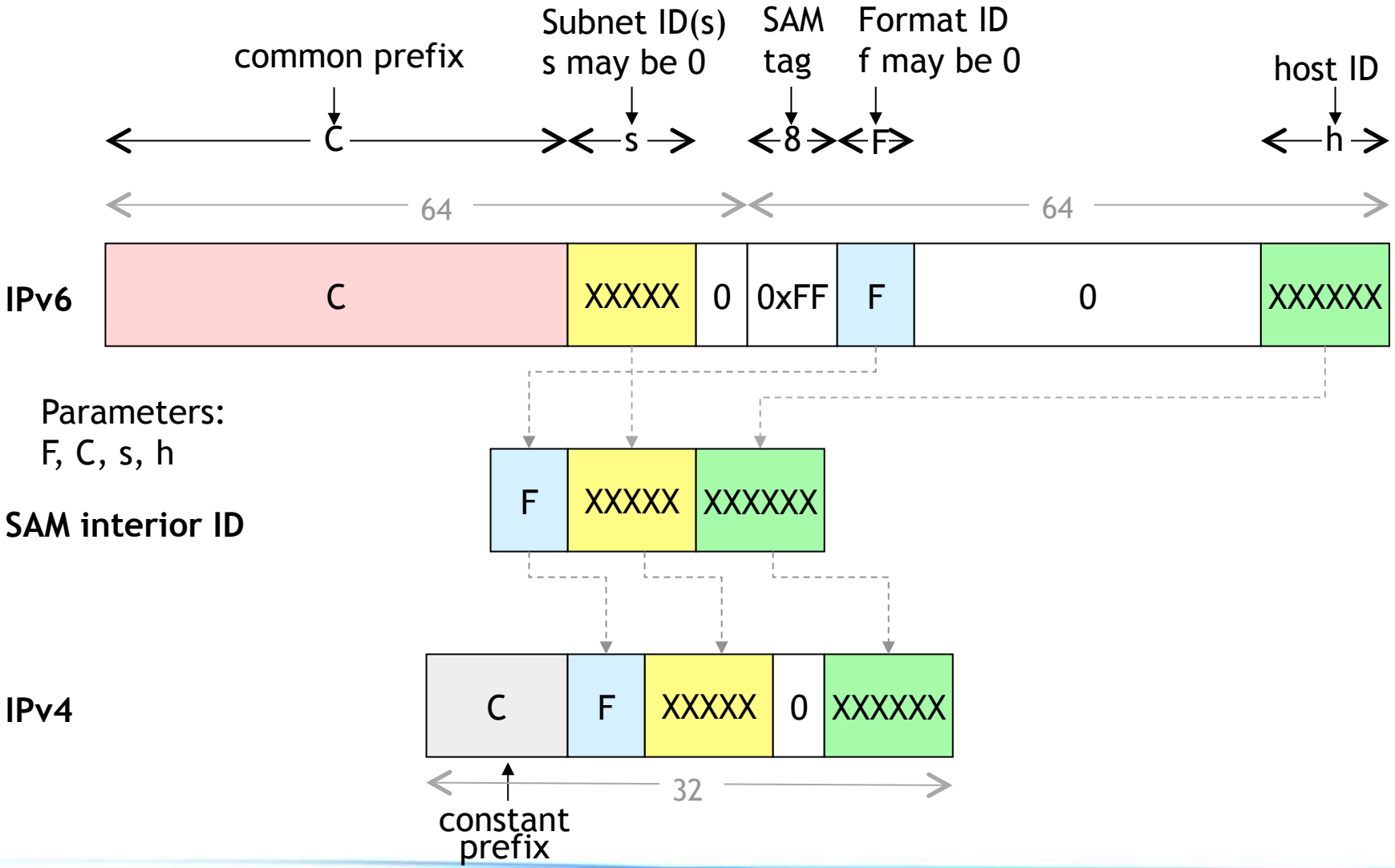


draft-despres-softwire-mesh-sam-01
draft-despres-softwire-4rd



- Addresses IPv4 continuity and IPv6 deployment in stateless tunneling by using address sharing model.
- Use Stateless IPv6 address to IPv4 address/port mapping to reduce complexity.
- IPv4 address/port-range is embedded into IPv6 address. CPE can know allocated IPv4 Global Address and port-range from allocated IPv6 address, and other SAM related parameters.
- CPE can perform NAPT based on leaned IPv4 GA/port-range, and also perform IPv4 over IPv6 tunneling.
- 4RD extends applicability to IPvX o/ IPvY, and NAT less solution.

SAM Address mapping format



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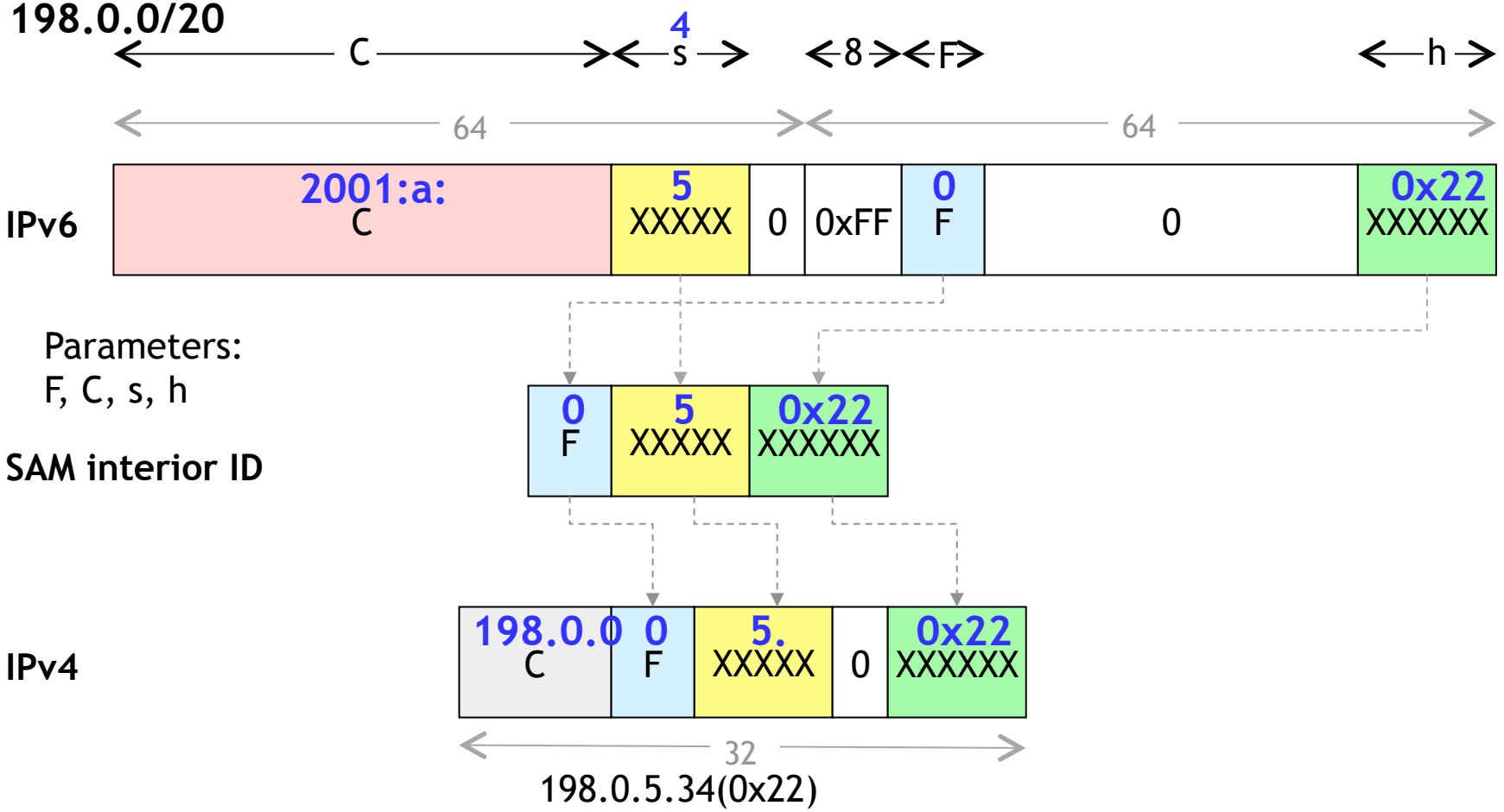
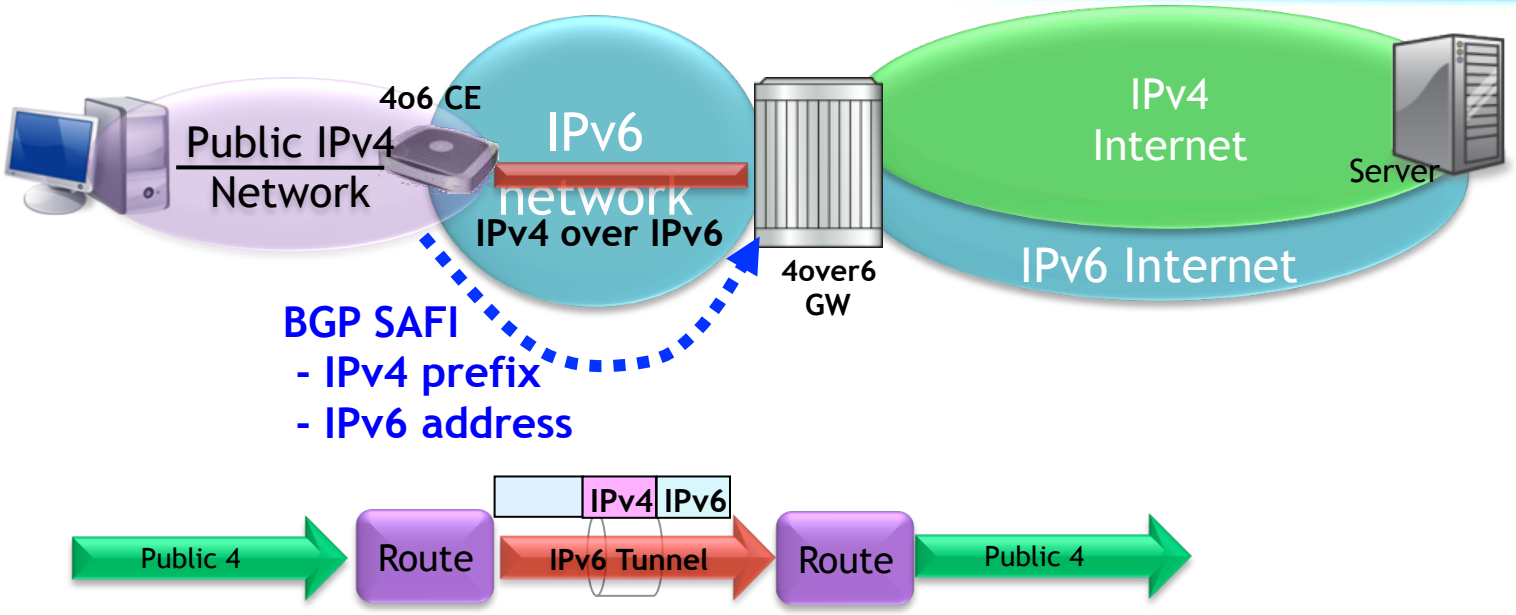
SAM Address mapping format example

2001:a:5000:0:ff00:0:0:22
2001:a::/32 | s=4, h=8
198.0.0/20



RFC 5747

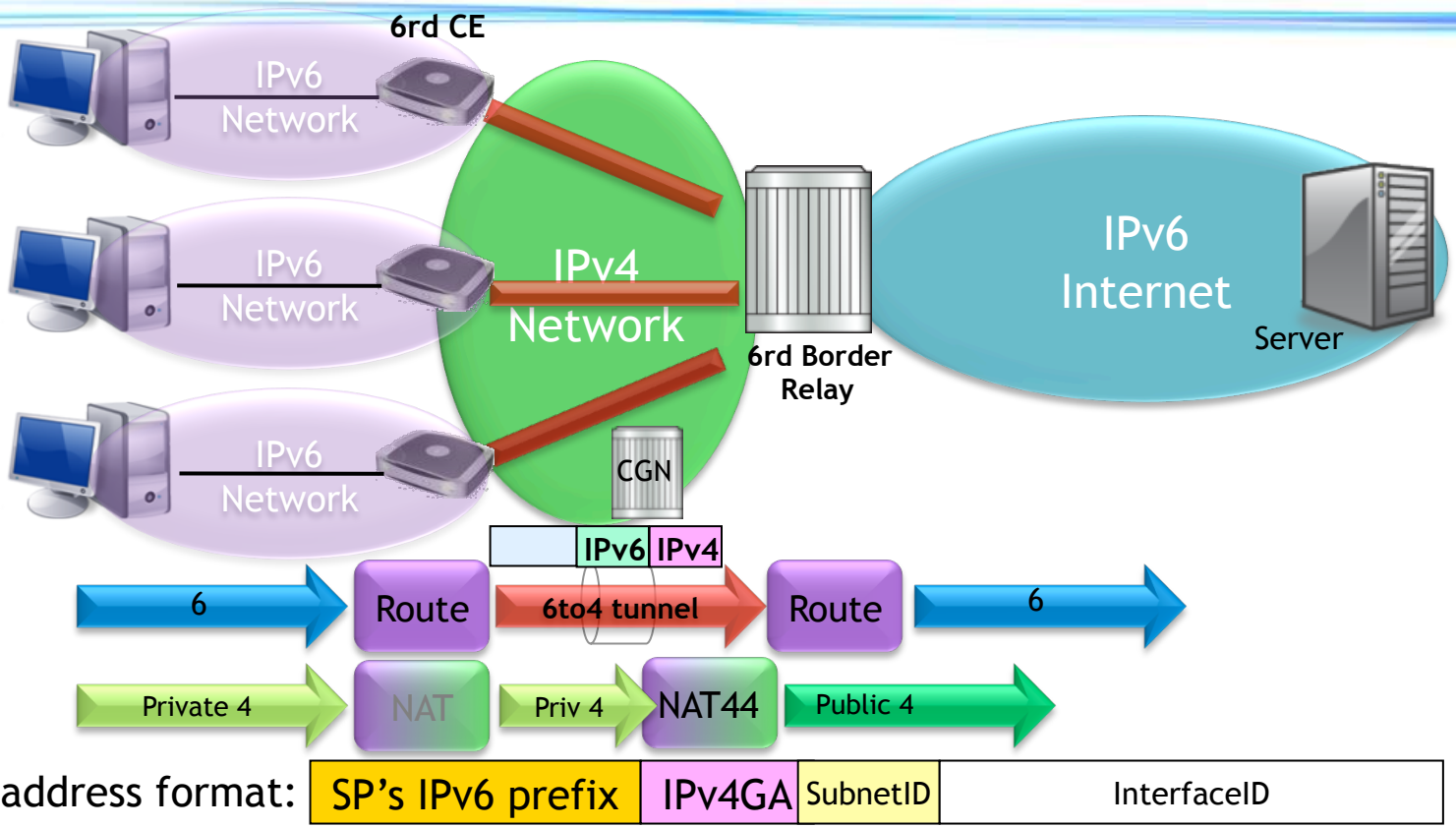
4over6 Transit Solution Using IP Encapsulation and MP-BGP Extensions



- Not Addressing IPv4 continuity. Just for IPv6 deployment in stateless tunnelling
- User's IPv4 prefix and IPv6 address(tunnel destination address for that IPv4 prefix) information are advertised via BGP as newly defined SAFI.
- 4over6 GW router must cache IPv4-prefix=IPv6-address mapping, and IPv4 traffic is encapsulated by IPv6 header.
- IPv4:IPv6 mapping advertiser(BGP speaker) can be another BGP router/server, not CPE.

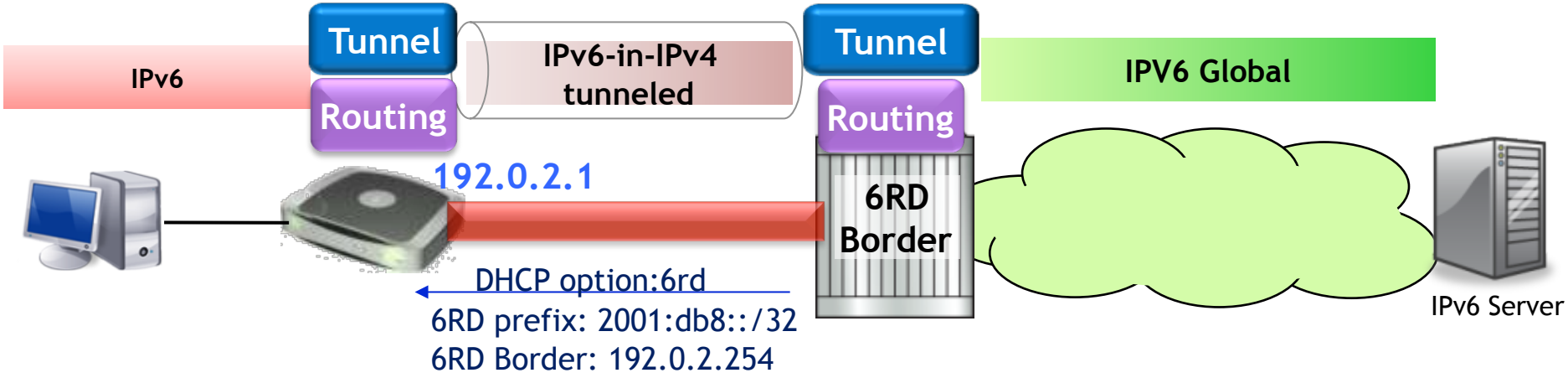
4 Rapid IPv6 deployment

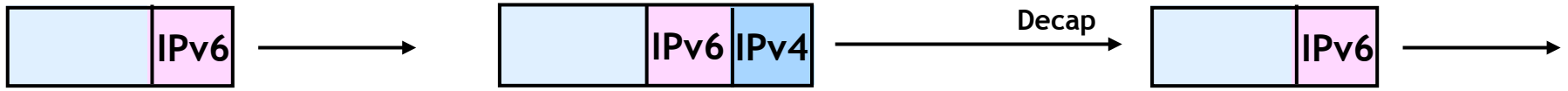
RFC 5969 - IPv6 Rapid Deployment on IPv4 Infrastructures (6rd)



- Addresses operators who want to quickly offer an IPv6 service over a non-IPv6 capable network
- Use 6to4 tunnel technique with specifying ISP's IPv6 prefix. Stateless Tunneling
- 6rd border relay decapsulates IPv6 packet and routes in natively towards IPv6 Internet
- 6rd prefix and BR address can be obtained by DHCP option
- IPv4 address required for 6to4 tunnel, CGN is optional.

6RD Packet Flow example





`Dst-IPv6=v6Globalx`
`Src-IPv6=`
`2001:db8:c000:0201::xxxx`

`Dst-IPv4=192.0.2.254`
`Src-IPv6=192.0.2.1`
`Dst-IPv6=v6Global`
`Src-IPv6=`
`2001:db8:c000:0201::xxxx`

`Dst-IPv6=v6Globalx`
`Src-IPv6=`
`2001:db8:c000:0201::xxxx`

6RD Border can know destination IPv4 address for the packet from IPv6 internet to user, by IPv6 destination address of the packet because user's IPv4 address is embedded into it.

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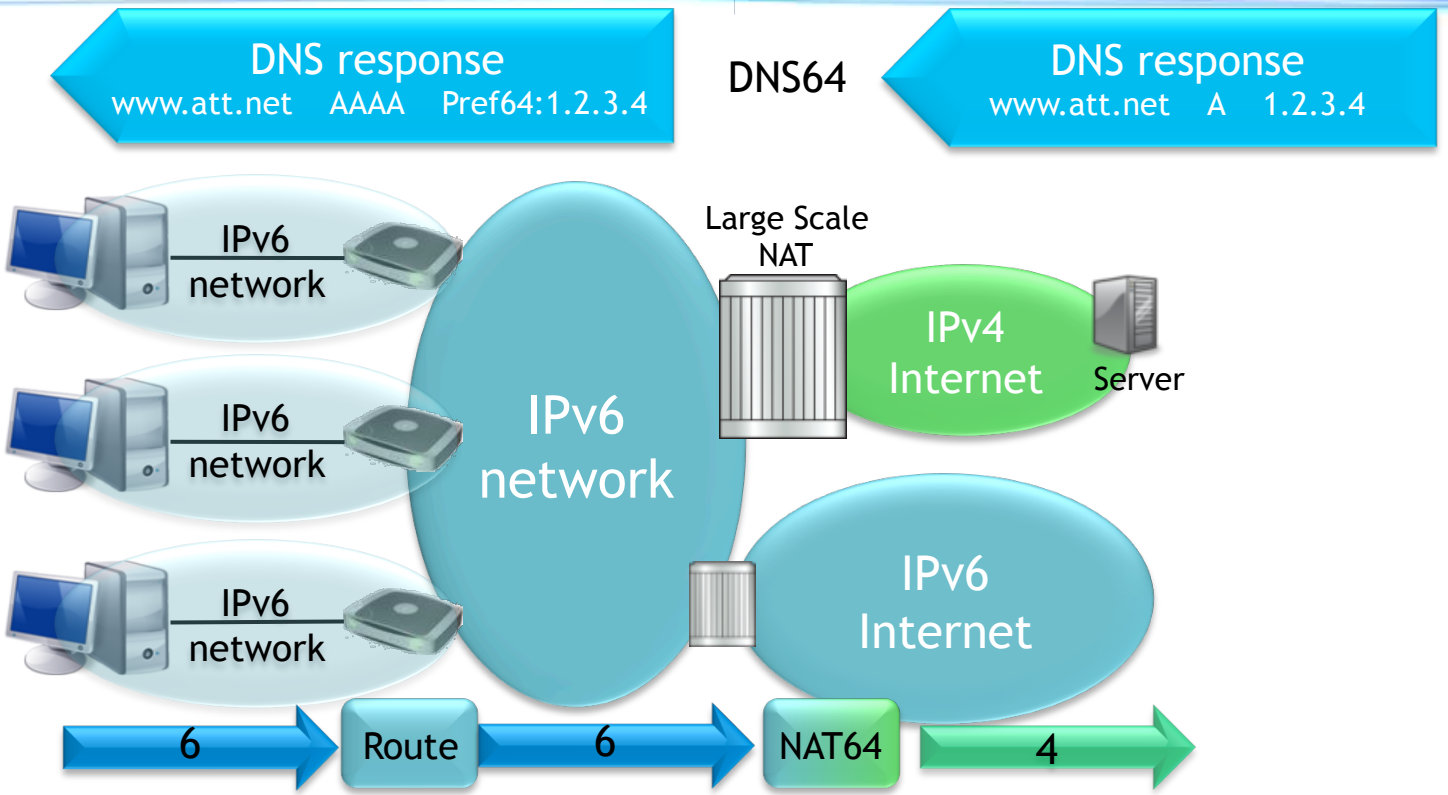
5 Wider IPv6 deployment

NAT64 (+ DNS64)

IPv6 Migration

(draft-ietf-behave-v6v4-xlate-stateful/RFC6146)



- Addresses IPv6-only hosts communicating with IPv4-only servers
- Does not support IPv4-only hosts (e.g., Windows 98/XP, or non-enabled IPv6 hosts)
- Requires a complementary DNS function (DNS64); see draft-ietf-behave-dns64(RFC6147)
- Not suited for IPv4 continuity (connections must be v6-initiated to create state in NAT64)
- Will be required to provide interworking between IPv6-only hosts and IPv4-only servers

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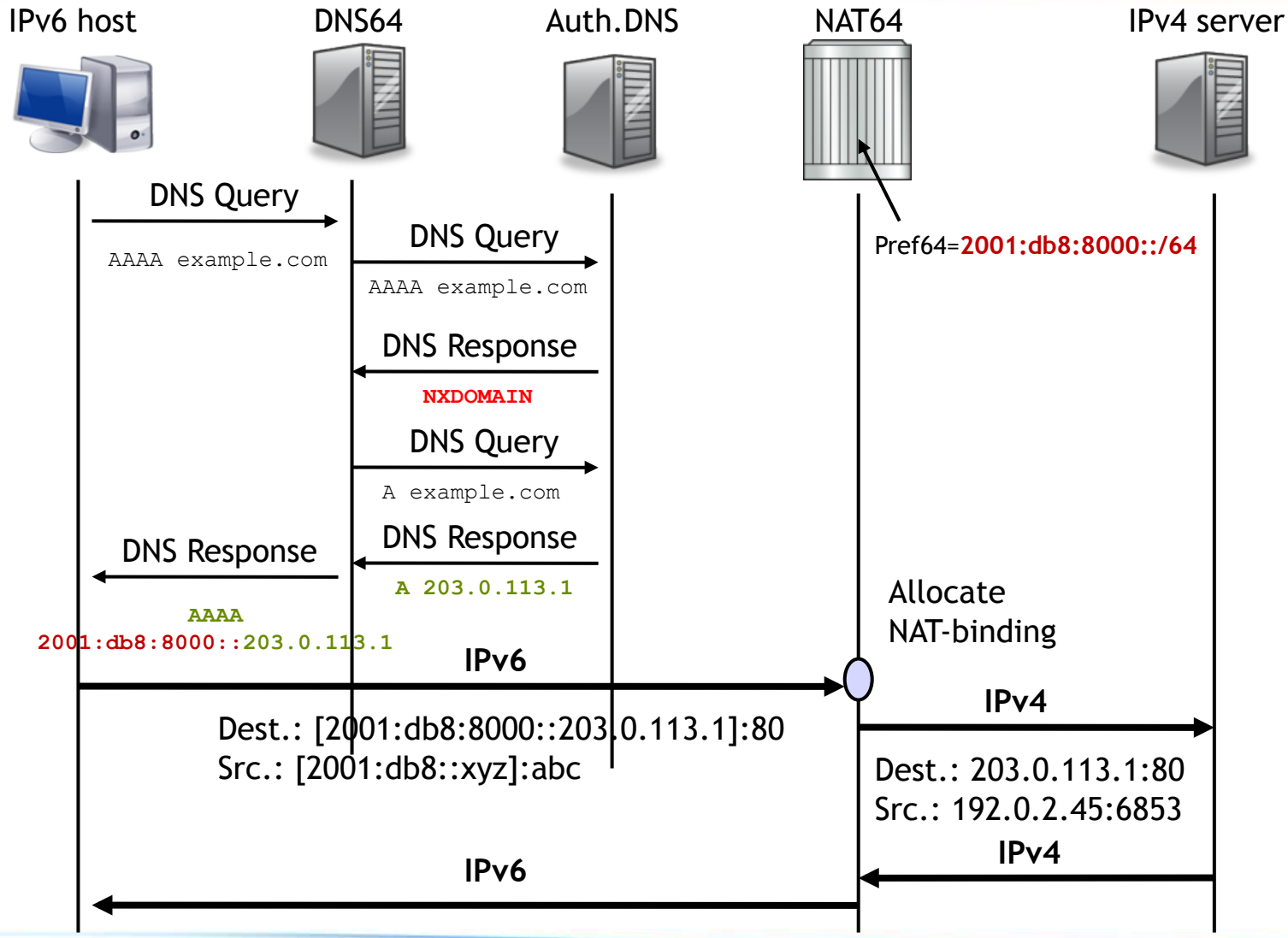
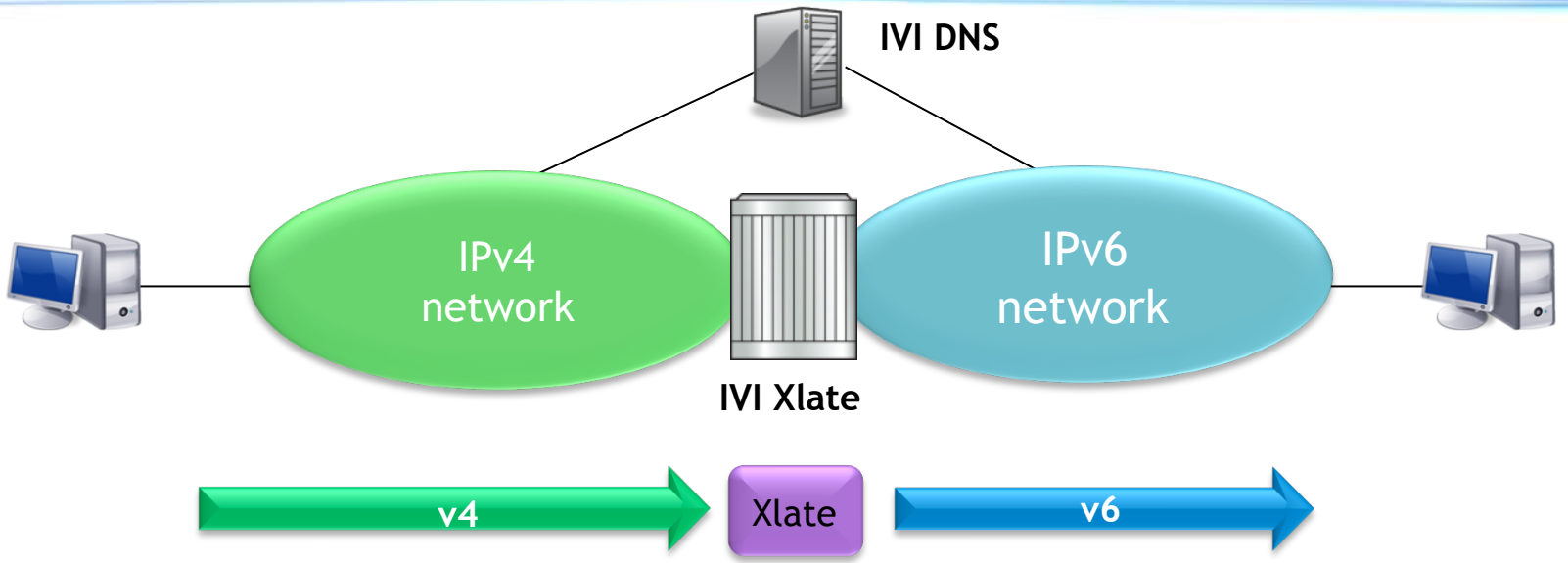
NAT64 (+ DNS64)
(draft-ietf-behave-v6v4-xlate-stateful)



IVI Translation
draft-xli-behave-ivi-07



IVI address format:

SP's IPv6 prefix	FF	IPV4 address	Suffix

- More focusing on single-stack IPv6 network, with keeping connectivity to existing IPv4 network.
- IVI translator provides IPv4 to IPv6/IPv6 to IPv4 translation to interconnect v4/v6 network.
- IPv4 address is embedded into IPv6 address.
- Working with IVI DNS, and stateless translation on IVI translator, it provides more seamless translation between IPv4 and IPv6.

5 Solution Comparison

Summary of IPv4 continuation/IPv6 transition technologies

	LSN L2-NAT	DS-Lite	DS-Lite + A+P	SAM, 4RD	4over6	6RD	NAT64	IVI
CPE	No CPE change	CPE change required	CPE change required	CPE change required	CPE change required	CPE change required	Only IPv6 hosts	-
IPv4 continuity	○	○	○	○ Address Sharing	×	LSN Optional	-	-
IPv6 transition	IPv6 can be deployed in parallel	○	○	Still requires IPv4 address.	○	Still requires IPv4 address.	○	○
Access NW	IPv4/v6	IPv6	IPv6	IPv6	IPv6	IPv4	IPv6	IPv6
Stateful / Stateless	Stateful	Stateful	Stateful	Stateless	Stateless	Stateless	Stateful	Stateless
transparency	Limited	Limited	Limited	Not Limited in 1:1 map	Not Limited	Not Limited	Limited	Not Limited

Consideration for technology implementation

- What is your focus ?
  Rapid IPv6 deployment, or IPv4 address exhaustion ? Access network is IPv6 only or IPv4 only, or can be dual-stack ?
- Does it requires CPE change/feature adding ?
- How can you define NAT policy ?
  - How can you define port-range allocation policy ?
    - Max # of ports per user
    - Allocation algorithm: Fixed, Random
    - Port-block allocation, or session based allocation
  - How can you define logging policy for abuse traceability?
    - Session based logging(large amout of log), or port-block based logging

Consideration for technology implementation

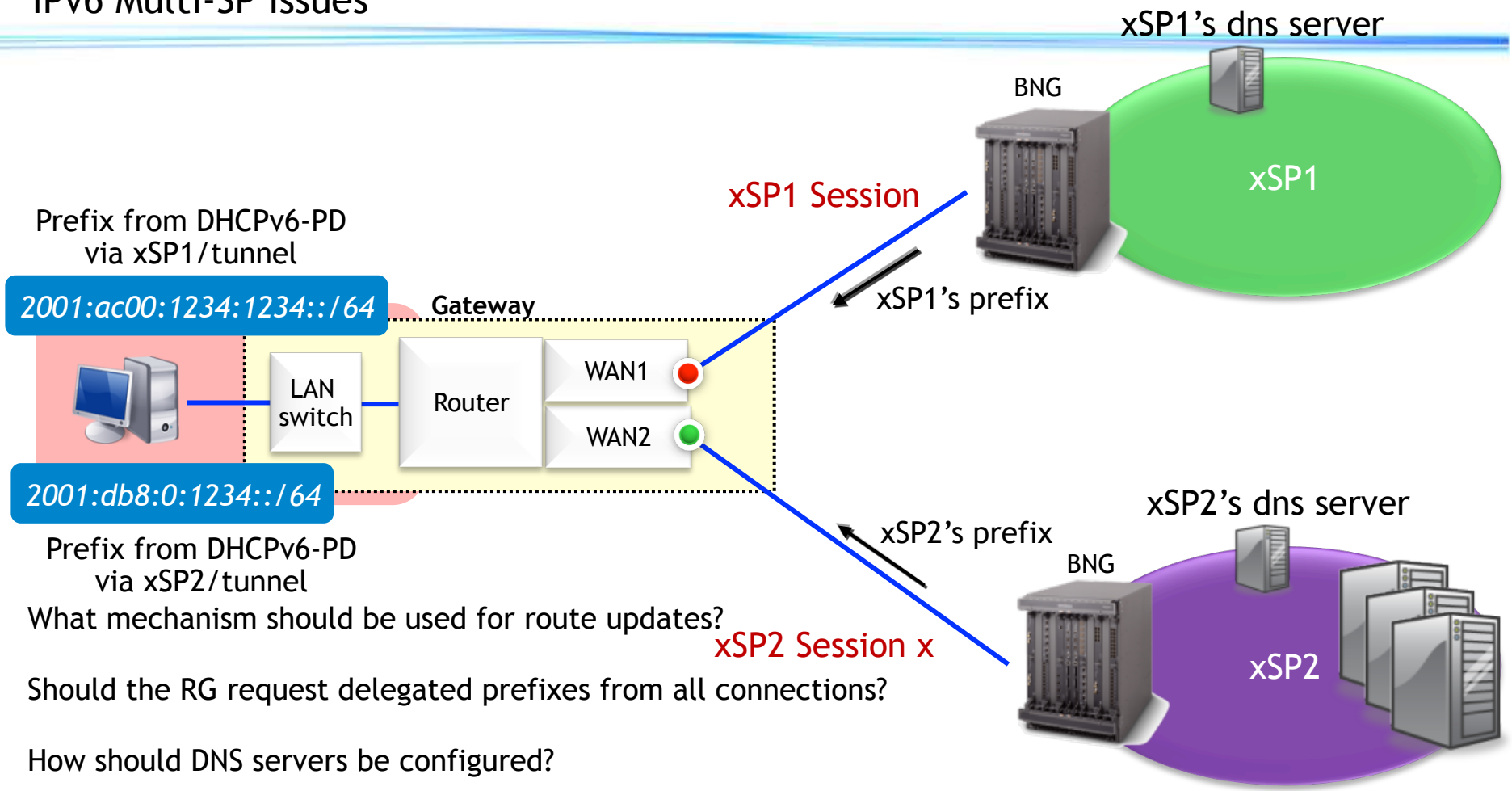
How can you perform per-sub control ?

- **How much you provide end-end transparency ?**
  - **UpNP treatment**

    draft-bpw-softwire-upnp-pcp-interworking
- **Where you put GW/Concentrator/NAT function ?**
  - **Distributed to edge ? Or Centralized to core ?**
- **Stateless or Stateful mapping/translation ?**
- **How you can define scalability parameters ?**
  - **# of tunnels, # of NAT session, performance, etc**
- **How much you need HA function ? (vs Cost)**

Appendix:
Multi-ServiceProvider Issue in IPv6

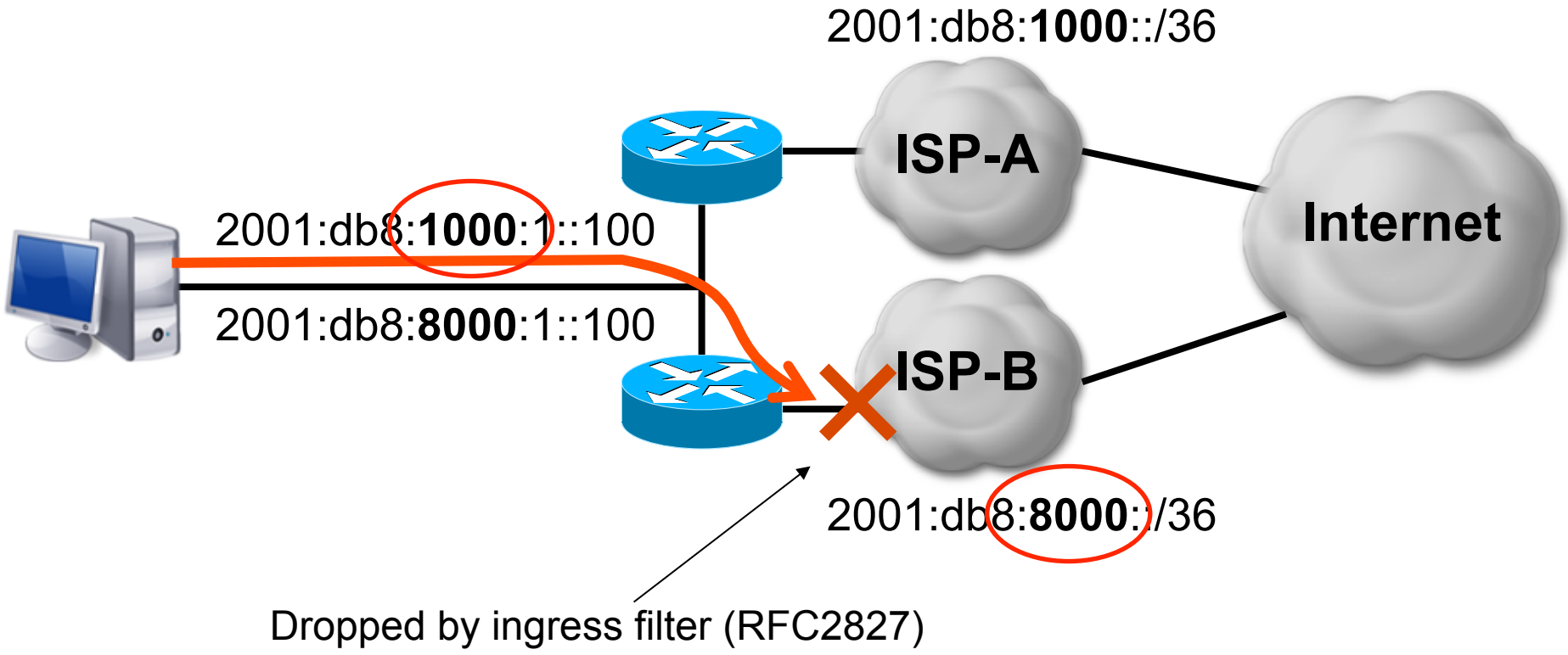
IPv6 Multi-SP Issues



- What mechanism should be used for route updates?
- Should the RG request delegated prefixes from all connections?
- How should DNS servers be configured?
- What about host source address selection?

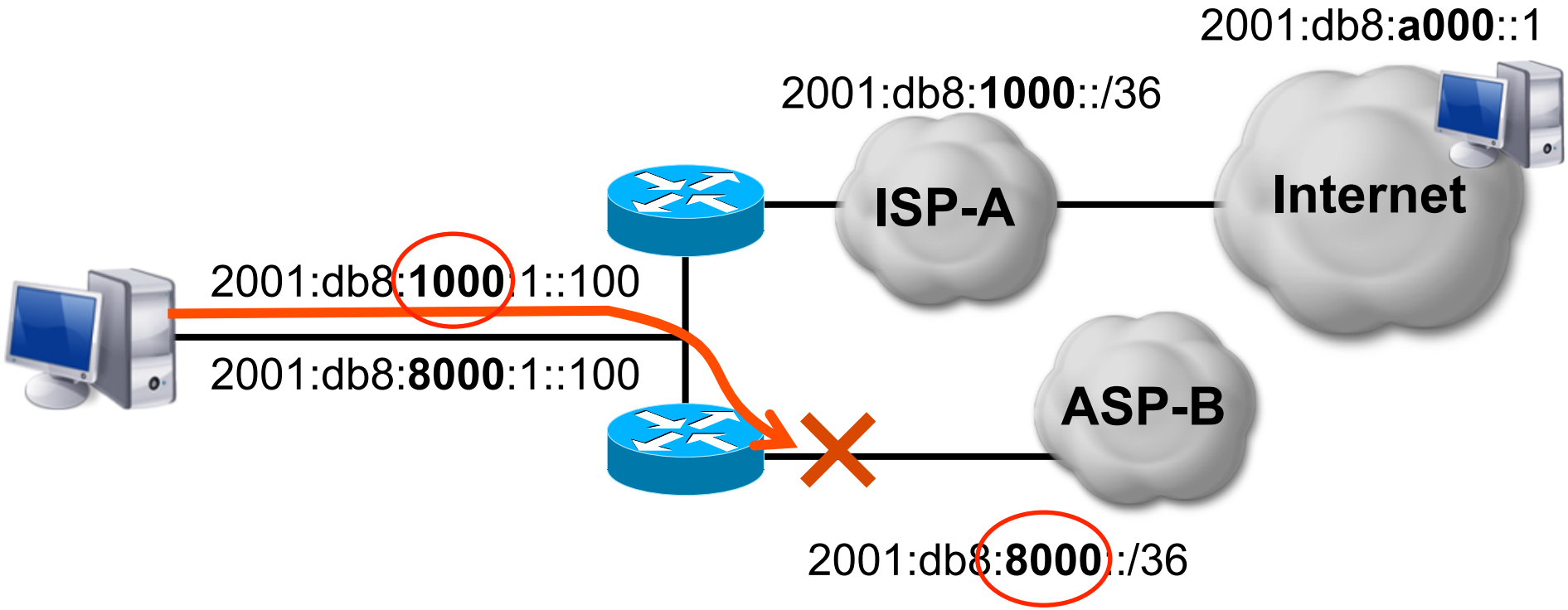
Problem: Source Address Selection

- Multiple prefixes on one physical interface
- Wrong ISP

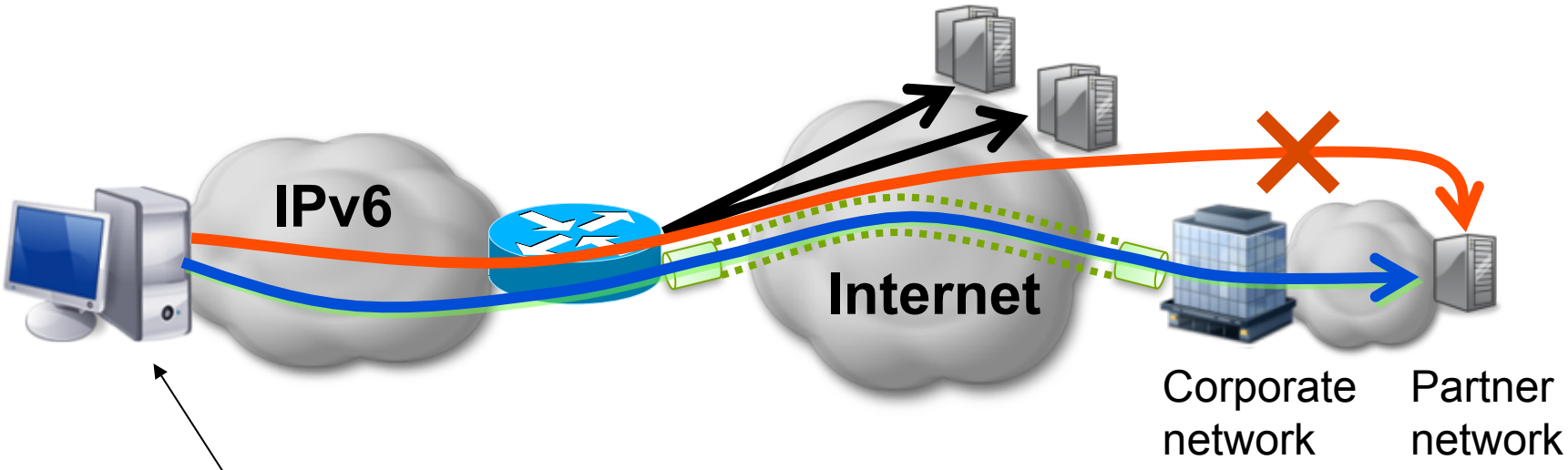


Problem: Source Address Selection

- Multiple prefixes on one physical interface
- Disconnected network



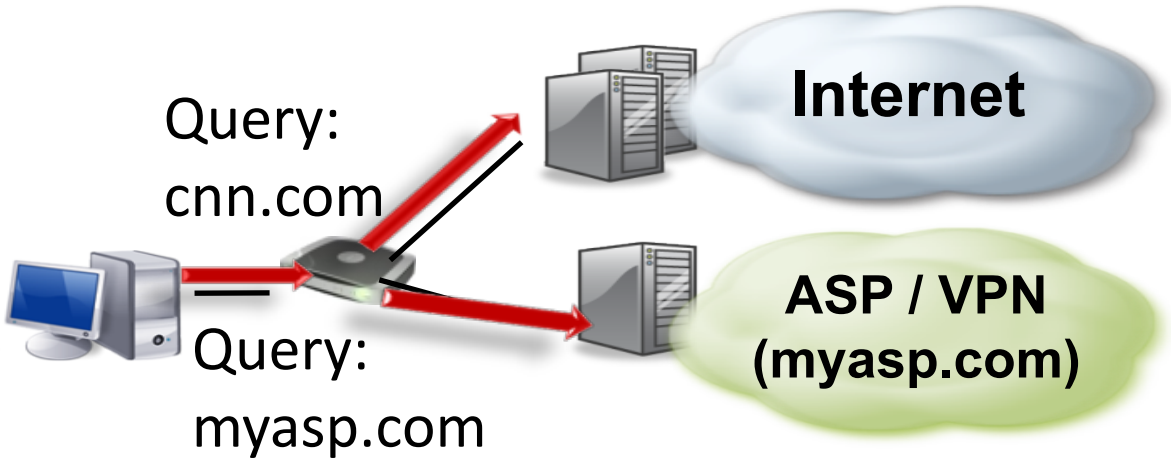
Problem: Next-Hop Route Selection



Provide host with routing information of Partner network – so that Address Selection (RFC3484) can choose correct source address. **RFC4191 does that** (but there is a problem..)

Problem: DNS Server Selection

- Different Answers
  - Public DNS returns empty answer
  - Private DNS returns IP address
- Solution: host queries proper DNS server
- long-existing industry practice



IETF Related I-Ds

<IETF>

- Source address selection policy
  - **draft-ietf-6man-addr-select-opt**
    Distributing Address Selection Policy using DHCPv6
- Route selection policy
  - **draft-ietf-mif-dhcpv6-route-option**
    DHCPv6 Route Option
- DNS selection policy
  - ***draft-ietf-mif-dns-server-selection***
  - ***DNS Server Selection on Multi-Homed Hosts***
- IPv6 Multi-NSP solution draft including above I-Ds
  - ***draft-troan-ipv6-multihoming-without-ipv6nat***
  - ***IPv6 Multi-homing without Network Address Translation***

Source address selection/Route information/DNS selection distribution
RG/Host Behaviour

Host

RG

xSP1

xSP2

DHCPv6 SOLICIT
IA_PD, OPTION_ROUTE,
DNS_SERVER_SELECT,
OPTION_DASP

DHCPv6 ADVERTISE
IA_PD: 2001:1:0:1::/64
OPTION_ROUTE: 2001:1::/32 -> xSP1
DNS_SERVER_SELECT: 2001:1::10 xSP1.com
OPTION_DASP: 2001:1::/32, Label 1, Prec 30

DHCPv6 SOLICIT
IA_PD, OPTION_ROUTE,
DNS_SERVER_SELECT,
OPTION_DASP

DHCPv6 ADVERTISE
IA_PD: 2001:2:0:1::/64
OPTION_ROUTE: 2001:2::/32 -> xSP2
DNS_SERVER_SELECT: 2001:2::10 xSP2.com
OPTION_DASP: 2001:2::/32, Label 2, Prec 10

OPTION_ROUTE: 2001:1::/32 -> xSP1
2001:2::/32 -> xSP2
DNS_SERVER_SELECT: 2001:1::10 xSP1.com
2001:2::10 xSP2.com
OPTION_DASP: 2001:1::/32, Label 1, Prec 30
2001:2::/32, Label 2, Prec 10

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Source address selection/Route information/DNS selection distribution
RG/Host Behaviour

Host

RG

xSP1

xSP2

RA PIO:
2001:1:0:1::/64 Autonomous
2001:2:0:1::/64 Autonomous

Construct
IP address

DHCPv6 SOLICIT
OPTION_DASP

DHCPv6 ADVERTISE
OPTION_DASP: 2001:1::/32, Label 1, Prec 30
OPTION_DASP: 2001:2::/32, Label 2, Prec 10

DHCPv6 SOLICIT
OPTION_DASP

DHCPv6 ADVERTISE
OPTION_DASP: 2001:1::/32, Label 1, Prec 30
OPTION_DASP: 2001:2::/32, Label 2, Prec 10

OPTION_DASP: 2001:1::/32, Label 1, Prec 30
2001:2::/32, Label 2, Prec 10

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THANK YOU