6rd - Enabling IPv6 Customers on an IPv4-only Network

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This session will talk about

- What problem 6rd want to solve
- What is 6rd
- Latest development on 6rd
- Case study on 6rd deployment

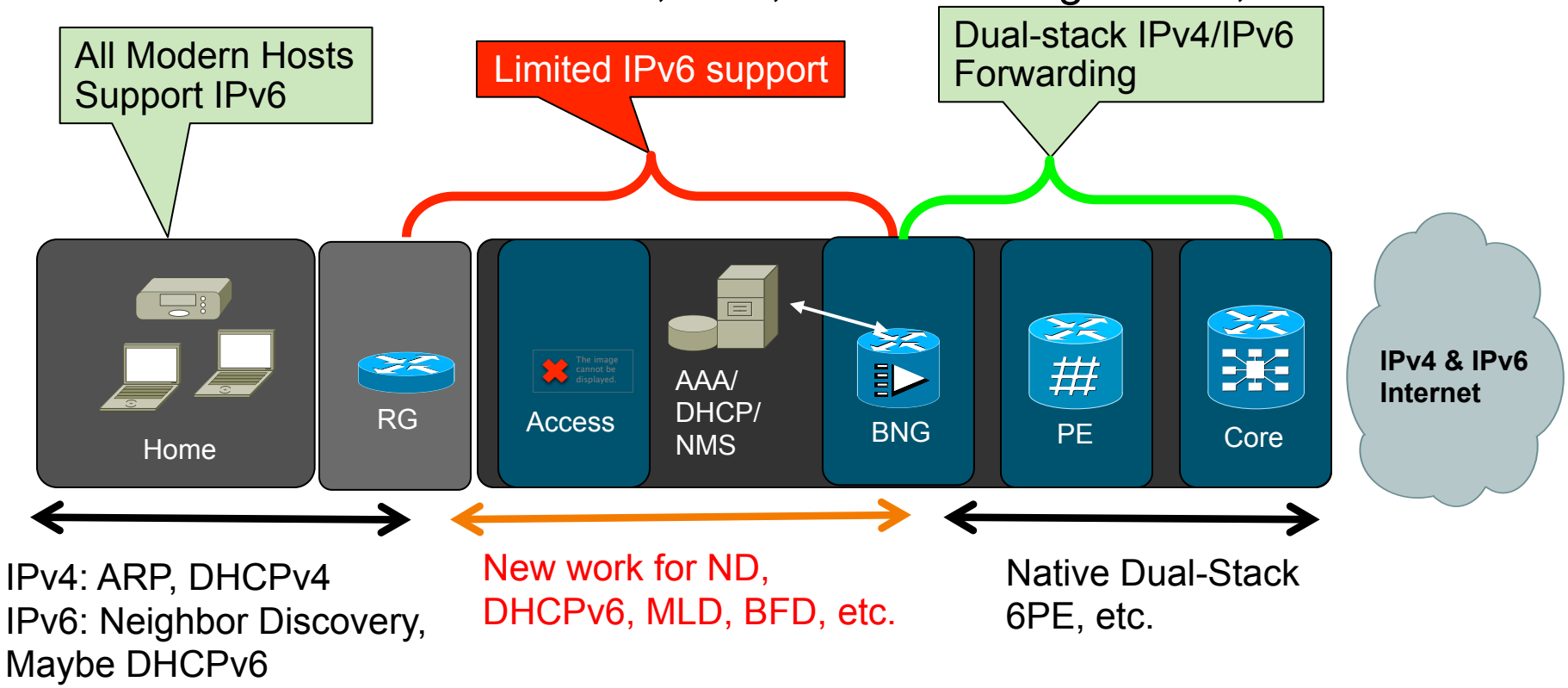
Problems getting IPv6 to the Home

- DSLAMs with “IP-specific” features

  DHCP snooping for Line ID and other parameters

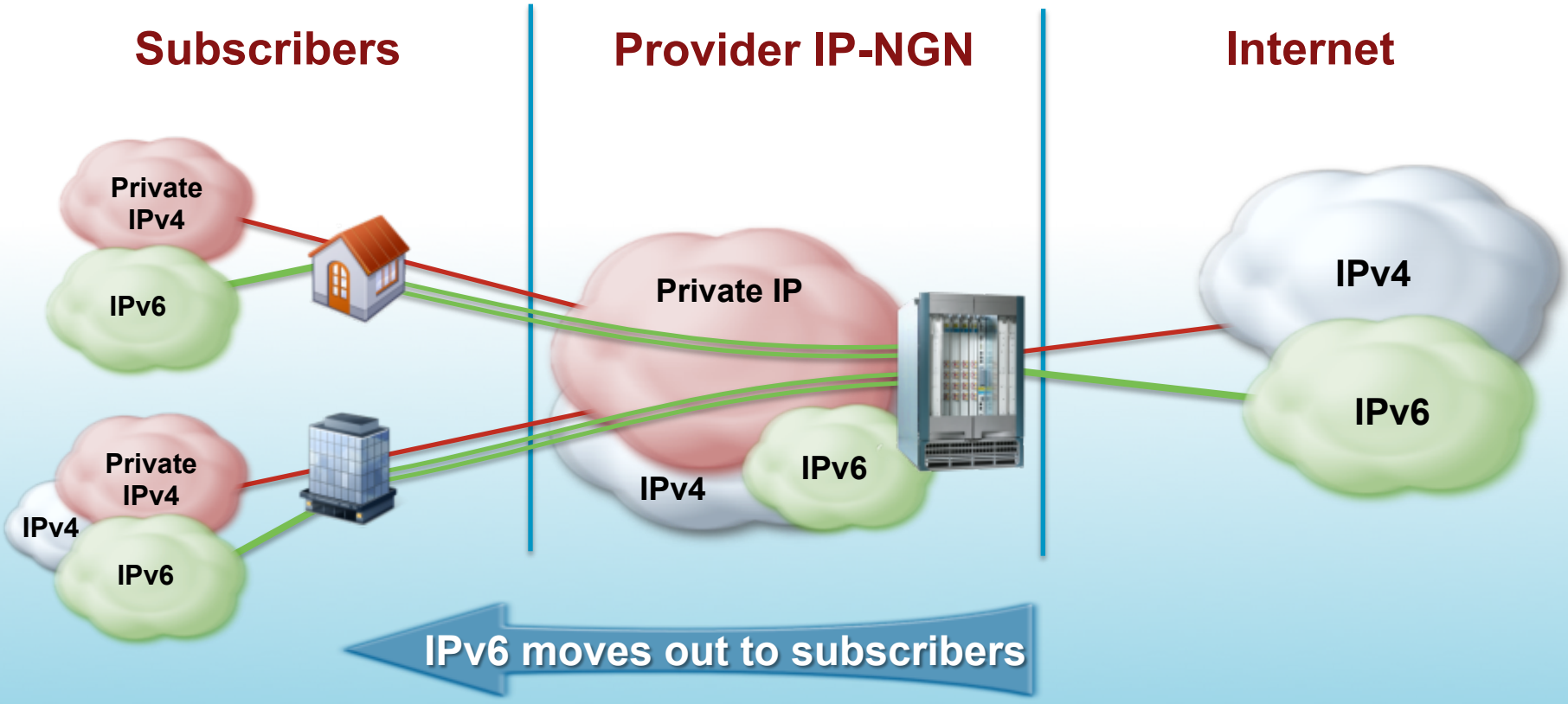
  IGMP snooping, MAC-Forced Forwarding, “MAC-NAT”, etc

- “IPv4 Sessions” at the BNG, AAA, Address Assignments, etc.



Tunneling IPv6 to Subscribers

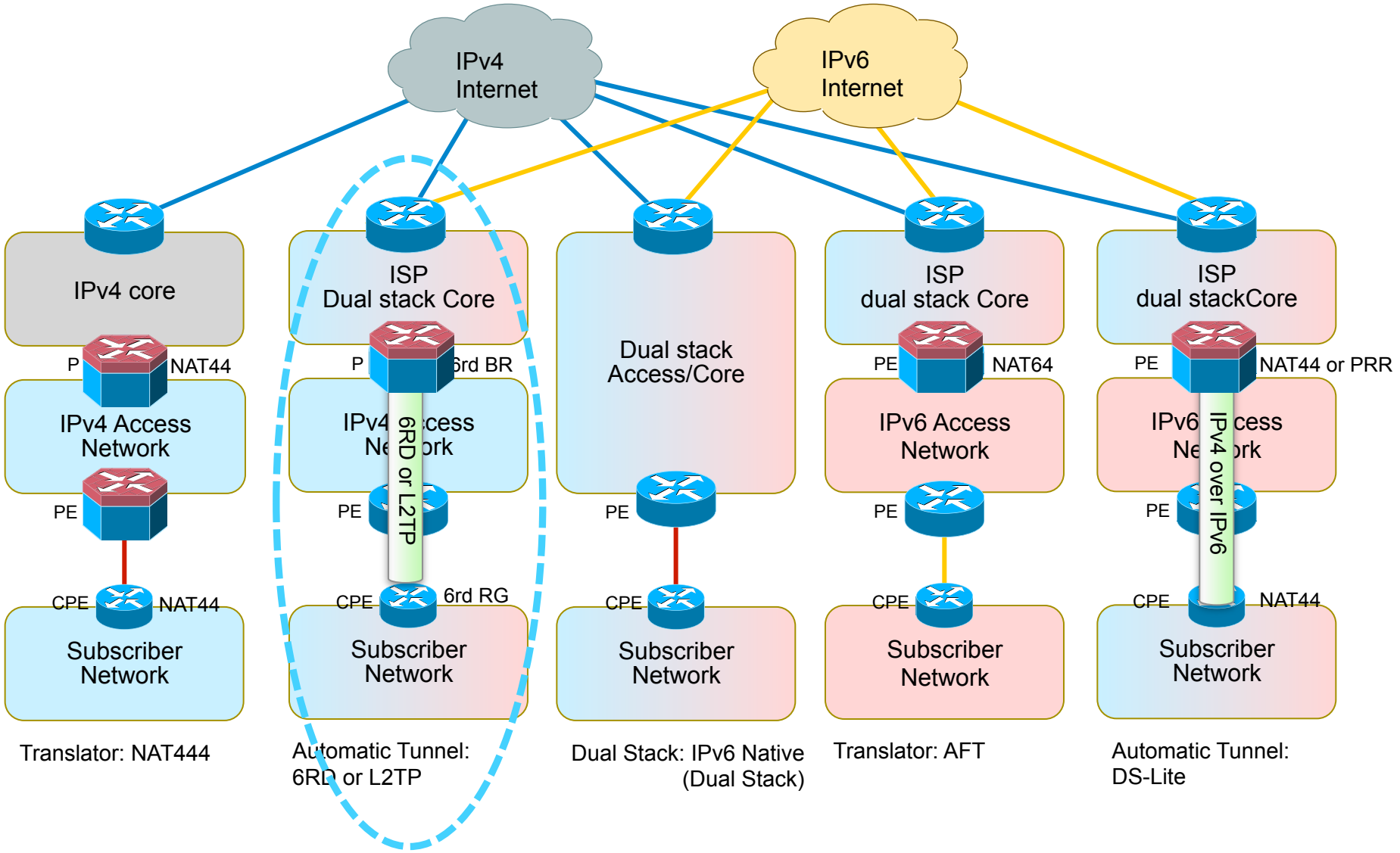
6PE, L2TP (softwires), 6rd



Comparing IPv6 Tunneling Technologies

Technologies	Based Transport	Prefix From	Topology	RG IPv6 Prefix
6PE/6VPE	MPLS	ISP	Multipoint	Provisioned
6rd	IPv4	ISP	Multipoint	From IPv4
6to4	IPv4	2002::/16	Multipoint	From IPv4
DS lite	IPv6	ISP	Pt-to-Pt	Provisioned
GRE	IPv4 or IPv6	ISP	Pt-to-Pt	Provisioned

6rd role in IPv6 Implementation Phases



Translator: NAT444

Automatic Tunnel:
6RD or L2TP

Dual Stack: IPv6 Native
(Dual Stack)

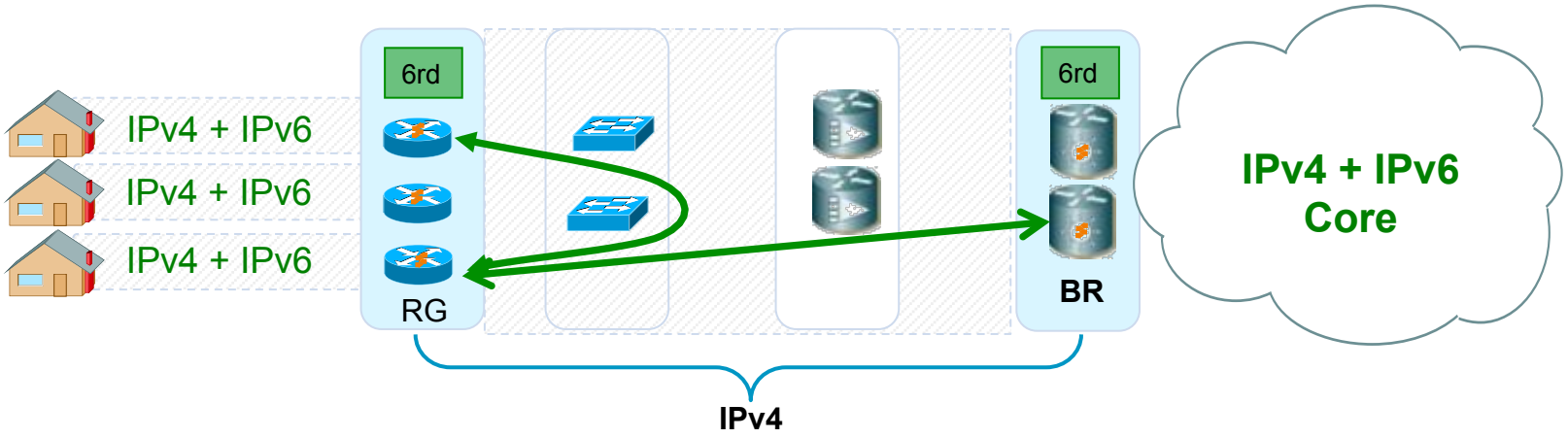
Translator: AFT

Automatic Tunnel:
DS-Lite

What is 6rd?

- 6rd = IPv6 Rapid Deployment (RFC 5969)
- Incremental method for deploying IPv6
- Service to subscriber is production-quality
  - Native IPv6 + IPv4 dual-stack
- Reuses IPv4 in the SP
- No IPv6 support needed in Access and Aggregation
- No DHCPv6 servers, no IPv6 Neighbor Discovery, etc.
- Similar to 6PE as it provides a native dual-stack service to a subscriber site by using existing infrastructure, operations, etc.

6rd in one slide



- RG=Residential Gateway, BR=Border Router
- Native dual-stack IPv4/IPv6 in the home or office
- Simple, stateless, automatic IPv6-in-IPv4 encap and decap functions
- IPv6 traffic automatically follows IPv4 Routing between CPE and BR
- BRs placed at IPv6 edge, addressed via anycast for load-balancing and resiliency
- Standardized in RFC 5969

Residential Gateway Implementation

LAN-Side:
Production Native IPv6 Service +
Global or Natted IPv4

WAN-Side:
Global or Natted IPv4

IPv6 Internet Access delivered to home, subscriber IPv6 prefix **derived from WAN IPv4 address**

6rd lives here

IPv4-only SP Access Network

Most RG can support 6rd thru open source, e.g. DD-WRT and OpenWrt

Both D-Link and Linksys will have official 6rd support in 2011

6rd RG Configuration

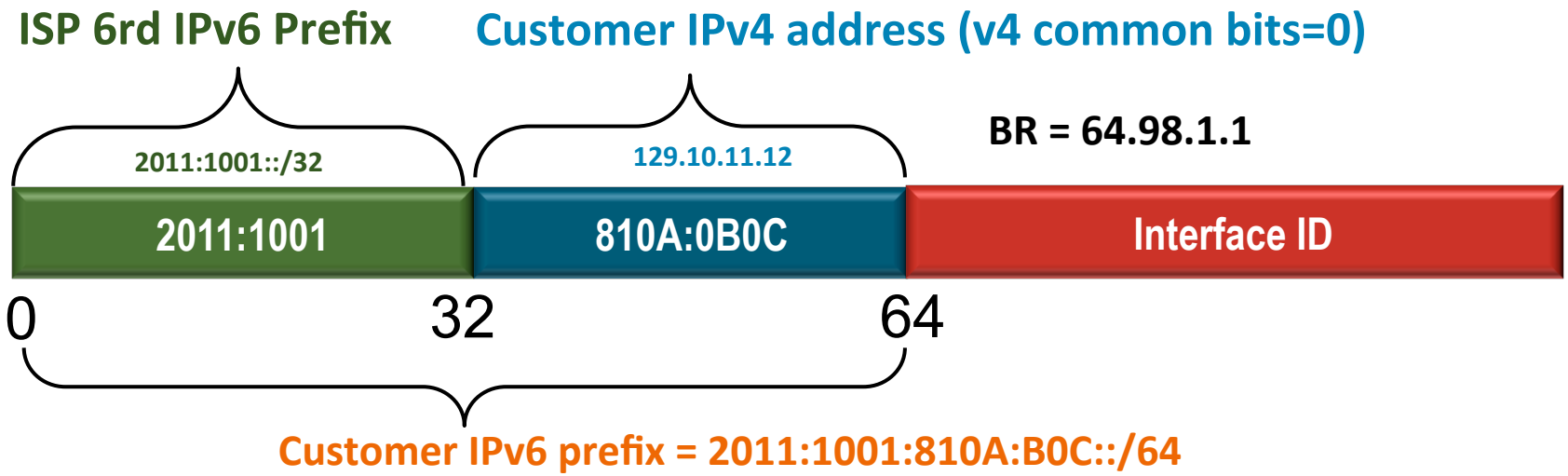
- 6rd RG configuration, 3 main parameters
  1. ISP 6rd IPv6 Prefix and length
  2. IPv4 common bits
  3. 6rd Border Relay IPv4 address
- All these parameters need to be defined by SP. One set of such configurations is considered as one 6rd domain.
- Configuration can be pushed via

  TR-69

  DHCP option 212

  PPP IPCP option

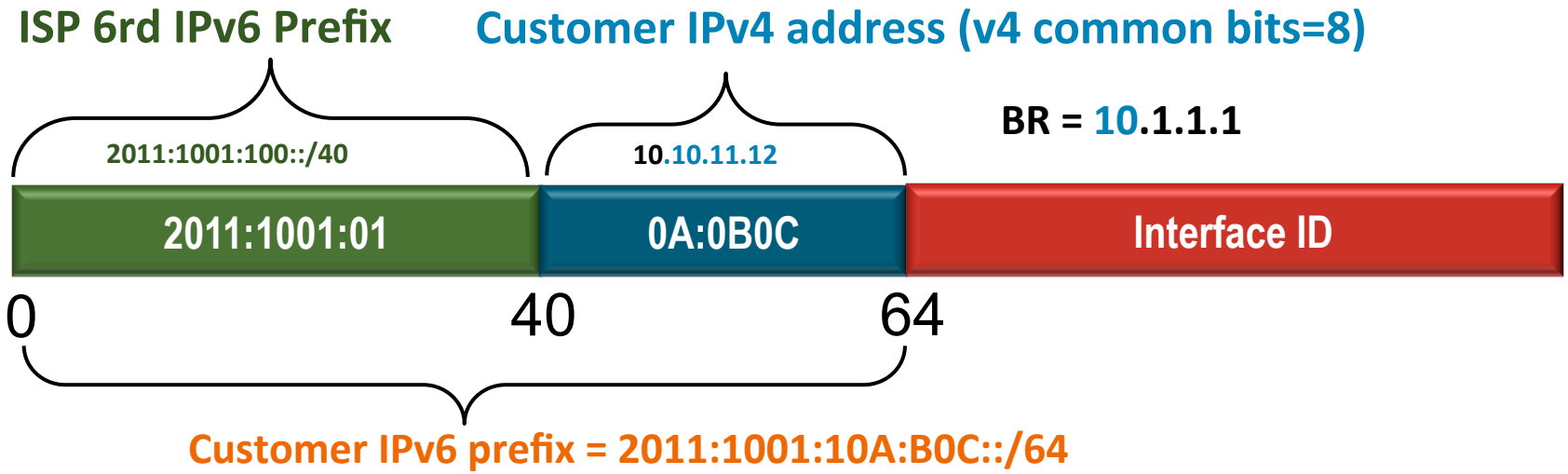
6rd RG IPv6 Prefix derived from IPv4 address



- RG need to get an IPv4 address first, from SP assignment
- RG will generate IPv6 prefix from 6rd prefix and ipv4 address
- RG configured exactly as for any native IPv6 connectivity to LAN side

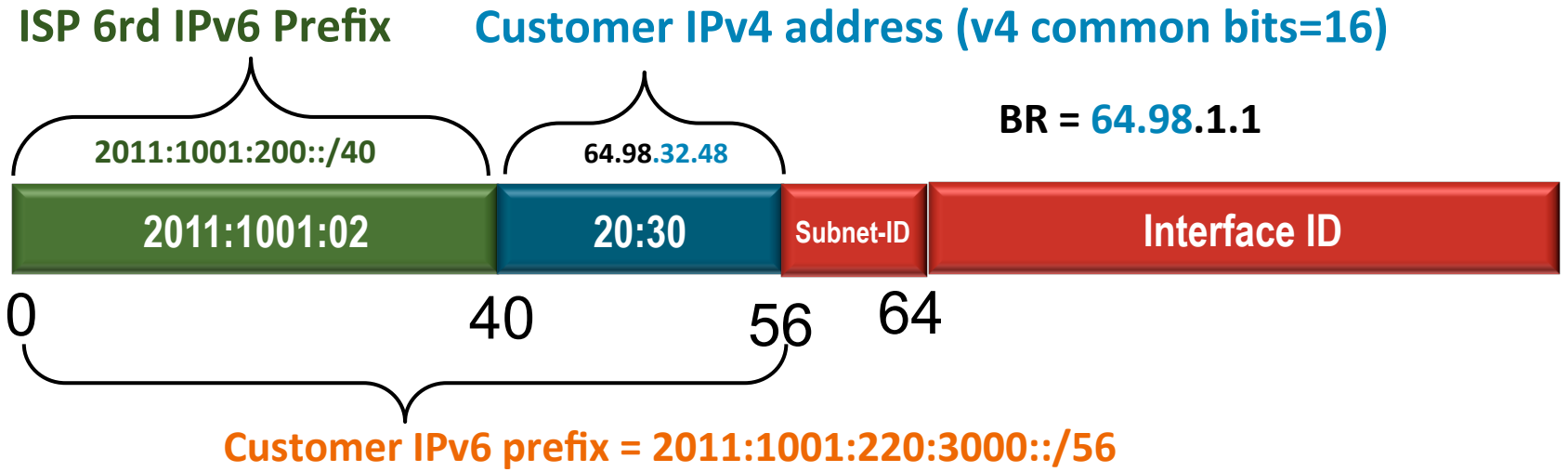
  SLACC or DHCPv6
- LAN station use ipv6 prefix to generate ipv6 address.
- Most browsers will prefer to use ipv6 if they can get AAAA record.

6rd domains example (1)



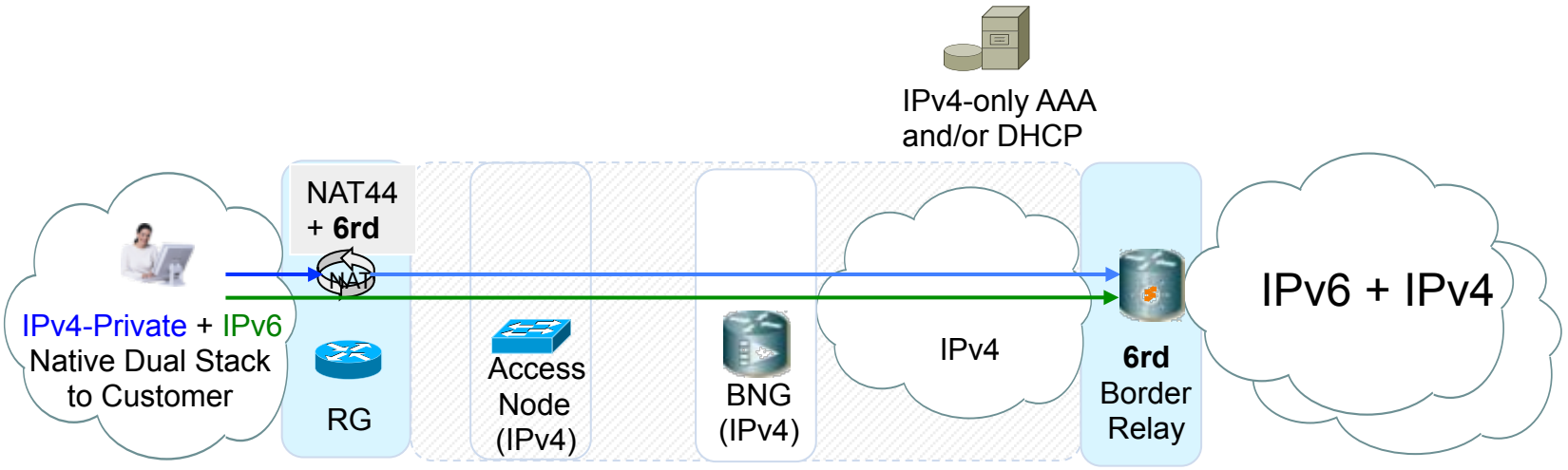
- Without domain, we have to carry all 32 bits ipv4 address in ipv6 prefix.
- SP owns only part of ipv4 address space, and normally can summarized as multiple /16-24
- Domain can be used to define longer ipv4 common bits, so we can carry less ipv4 bits in ipv6 prefix

6rd domains example (2)



- By carrying less ipv4 bits in ipv6 prefix, SP can have more room to assign shorter prefix to customer.
- Each domain will have a mapping of 6rd prefix and ipv4 address block, defined by BR address and common bits.
- Configuration for each domain is different, SP may have operation overhead to due with the complexity

6rd BR Setup and Provisioning



1. BR must have IPv6 reachability (Native, 6PE, GRE Tunnel, etc).
2. An access-network-facing IPv4 address (BR address configured in RG)
3. ISP 6rd IPv6 Prefix and Length

*One BR may serve one or more 6rd domains

More 6rd domains means more efficiency of

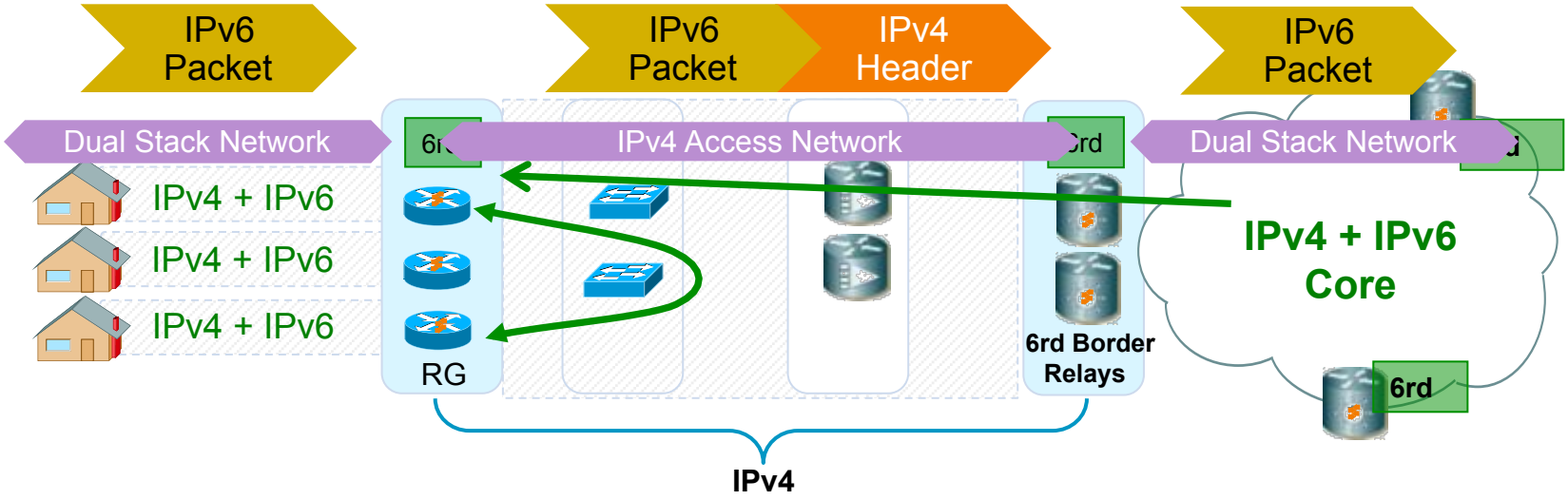
6rd BR Sample Configuration

```
interface Loopback0
 ip address 10.1.1.1 255.255.255.0
!
interface Tunnel0
 tunnel source Loopback0
 tunnel mode ipv6ip 6rd
 tunnel 6rd ipv4 prefix-len 8
 tunnel 6rd prefix 2011:1001:100:/40
 ipv6 address 2011:1001:101:101::/128 anycast
!
ipv6 route 2011:1001:100::/40 Tunnel0
ipv6 route 2011:1001:101:101::/64 Null0
```

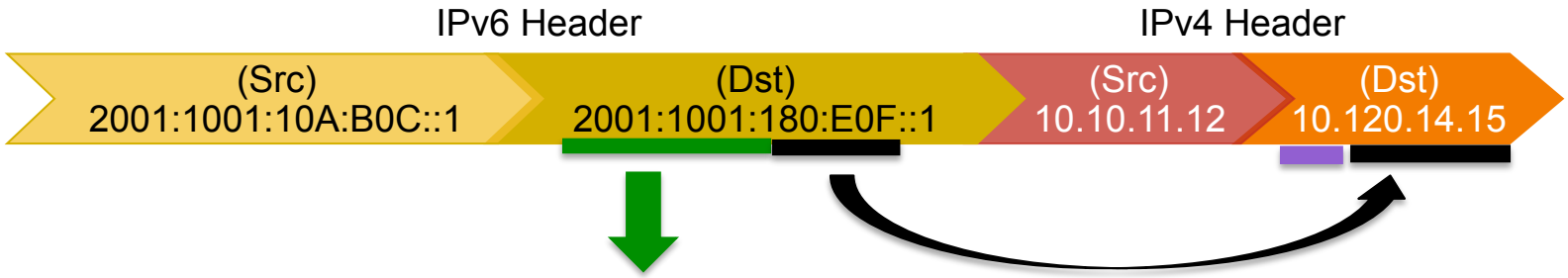
Simple and Easy to setup!

```
#show tunnel 6rd
Interface Tunnel0:
  Tunnel Source: 10.1.1.1
  6RD: Operational, V6 Prefix: 2011:1001:100:/40
       V4 Prefix, Length: 8, Value: 10.0.0.0
       V4 Suffix, Length: 0, Value: 0.0.0.0
  General Prefix: 2011:1001:101:101::/64
```

6rd Packet Encapsulation within domain

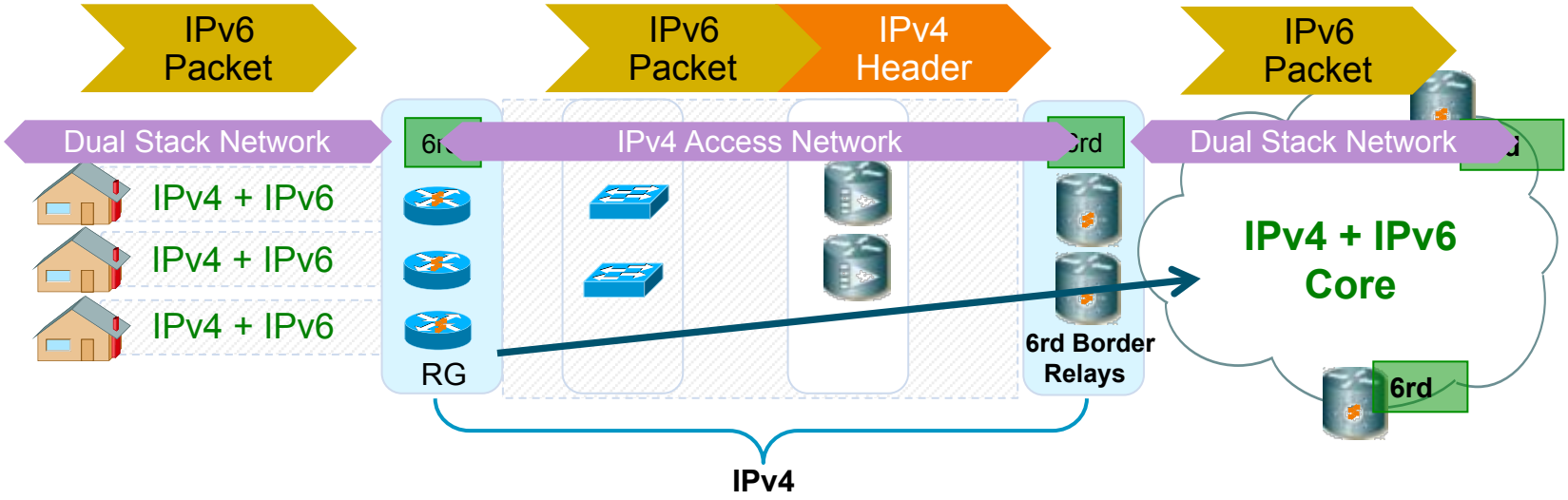


ISP 6rd IPv6 Prefix = 2001:1001:100:/40 IPv4 common bits=8, BR = 10.1.1.1



If (dstv6) match ISP 6rd IPv6 Prefix, then (dstv4) derived from (dstv6)

6rd Packet Encapsulation out of domain



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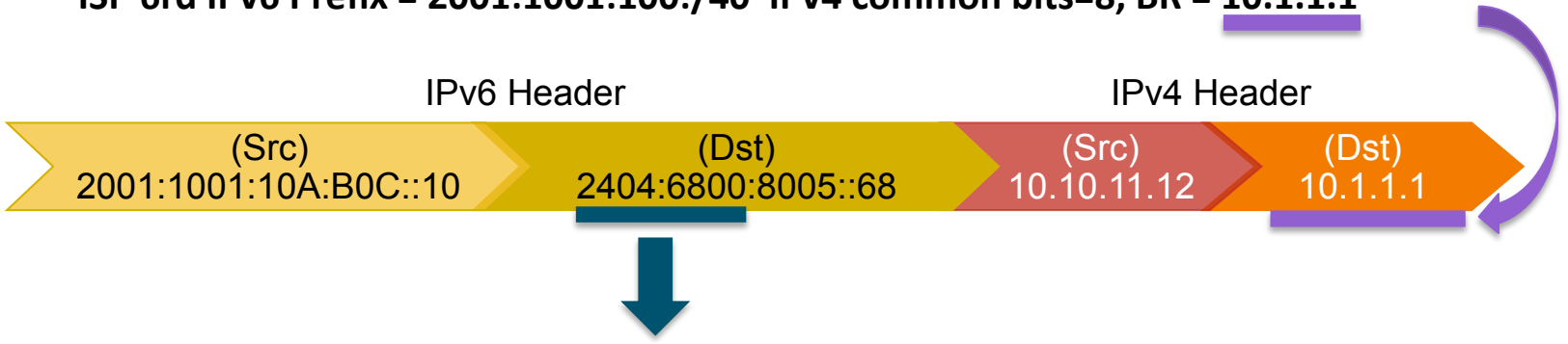
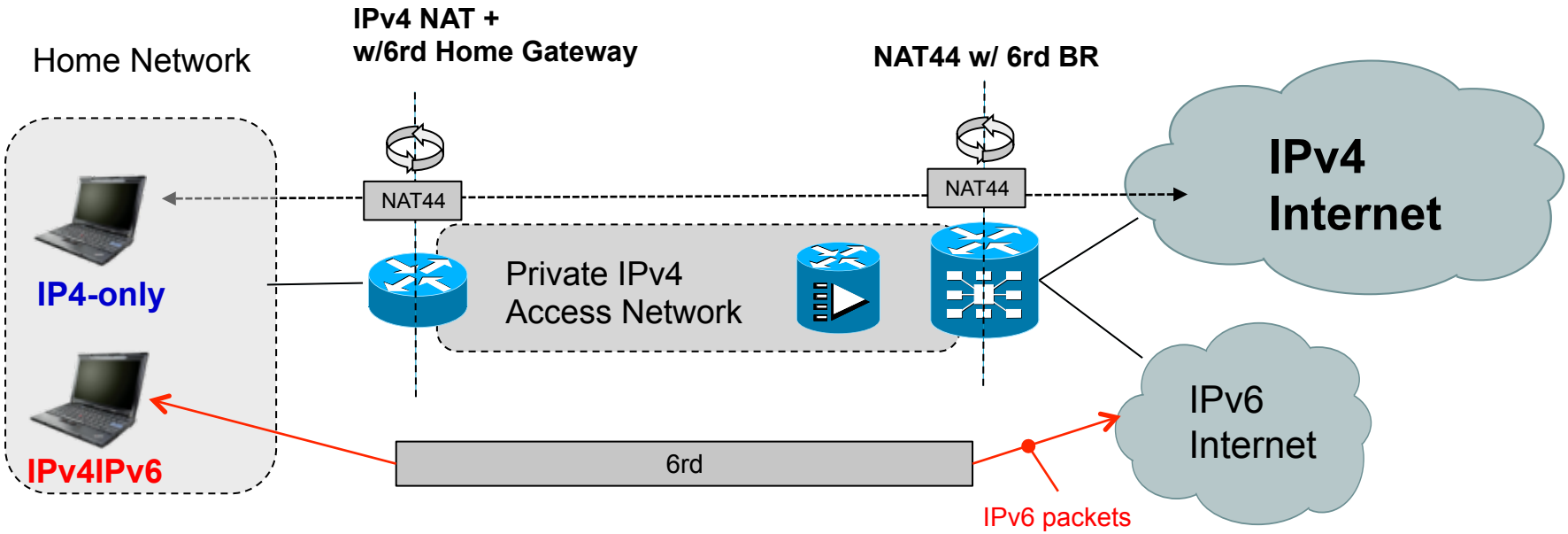


If (dstv6) not match ISP 6rd IPv6 Prefix, then (dstv4) = BR

Border Relay via Anycast

- 6rd is stateless, so no need for packets within a flow to traverse the same Relay
- Allows use of IPv4/IPv6 routing for load-balancing, resiliency and redundancy
- Border Relays are installed only in strategic locations where native IPv6 is available:
  - IPv6 Internet uplinks
  - Edge of internal IPv6-enabled network
  - BR placement is a function only of IPv6 traffic, not the number of sites

Combining NAT44 and 6rd



- Addresses IPv4 run-out and enables incremental IPv6 subscriber connectivity over existing IPv4 infrastructure
- 6rd connectivity becomes a NAT44 offload
  - as more and more IPv4 content becomes IPv6-accessible
- Carrier, Content Provider, and User benefit when traffic runs over IPv6

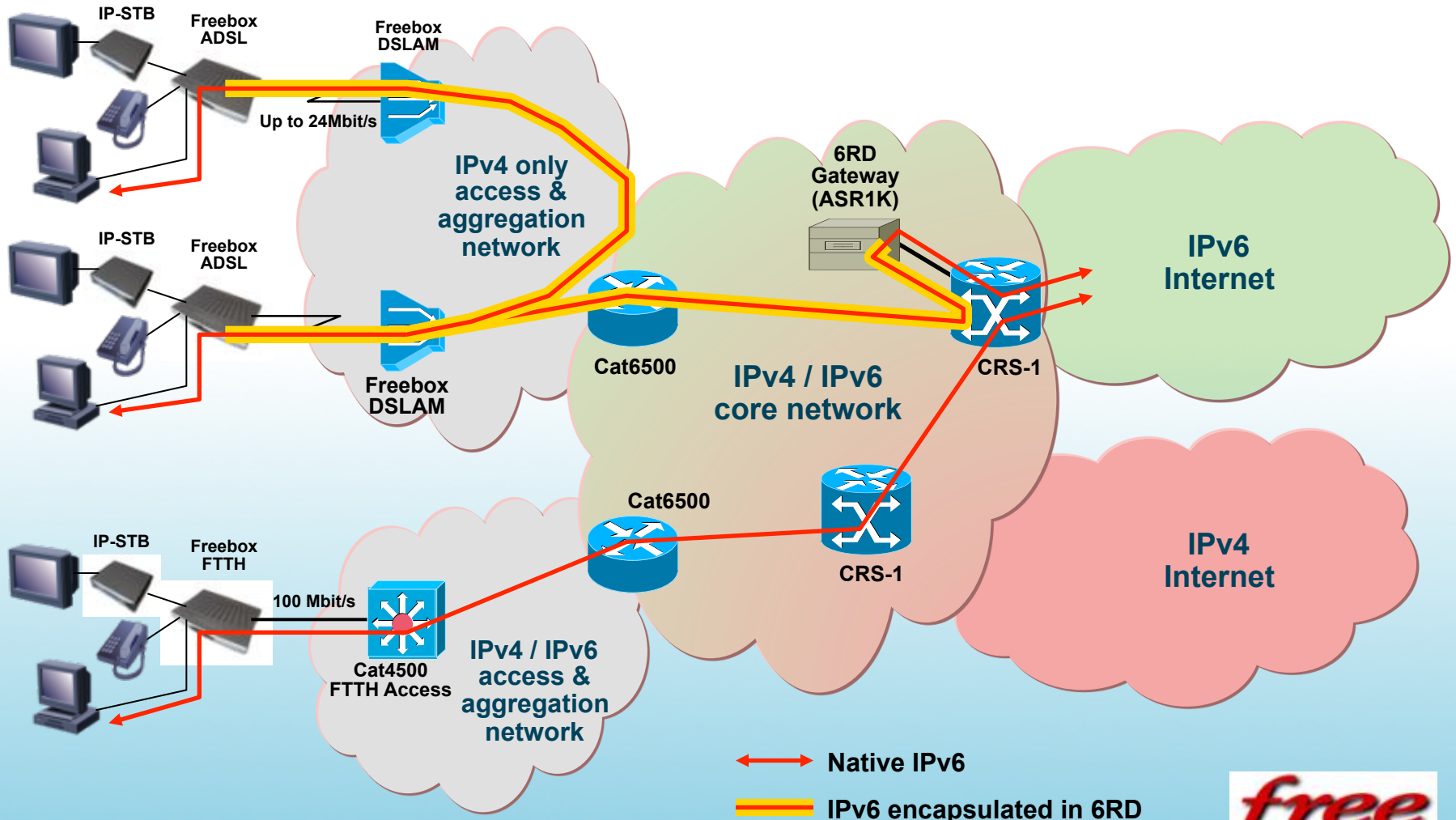
6rd Technical Summary

- IPv6 Prefix Delegation derived from IPv4
  - Global IPv4 or Natted IPv4 in same deployment
- Stateless mapping and Encapsulation of IPv6 over IPv4 (RFC 4213)
  - IPv4 encapsulation automatically determined from each packet's IPv6 destination
  - All tunnel interfaces are multipoint, one virtual interface per gateway
  - No per-site tunnel state or provisioning
- IPv4 and IPv6 Anycast to reach Border Routers

6rd Deployment Consideration

- 6rd deployment components
  - SP side: BRs (From Linux server to Carrier Grade Routers)
  - CPE side: RG w/ sw upgrade or new RG
    - Not applicable to non-RG CPE, e,g desktop and laptop
- Still need one ipv4 address per CPE, not a real transition to IPv6
- 6rd BR address should not be accessible outside SP network.
- 6rd can be deployed in dsl, ftth, cable and OTP operators, but not applicable to mobile operators.
  - PPPoE deployment need extra care for MTU setting

6rd deployment at Free (Illiad Group, France)



Source: http://www.ripe.net/ripe/meetings/ripe-58/content/presentations/ipv6-free.pdf

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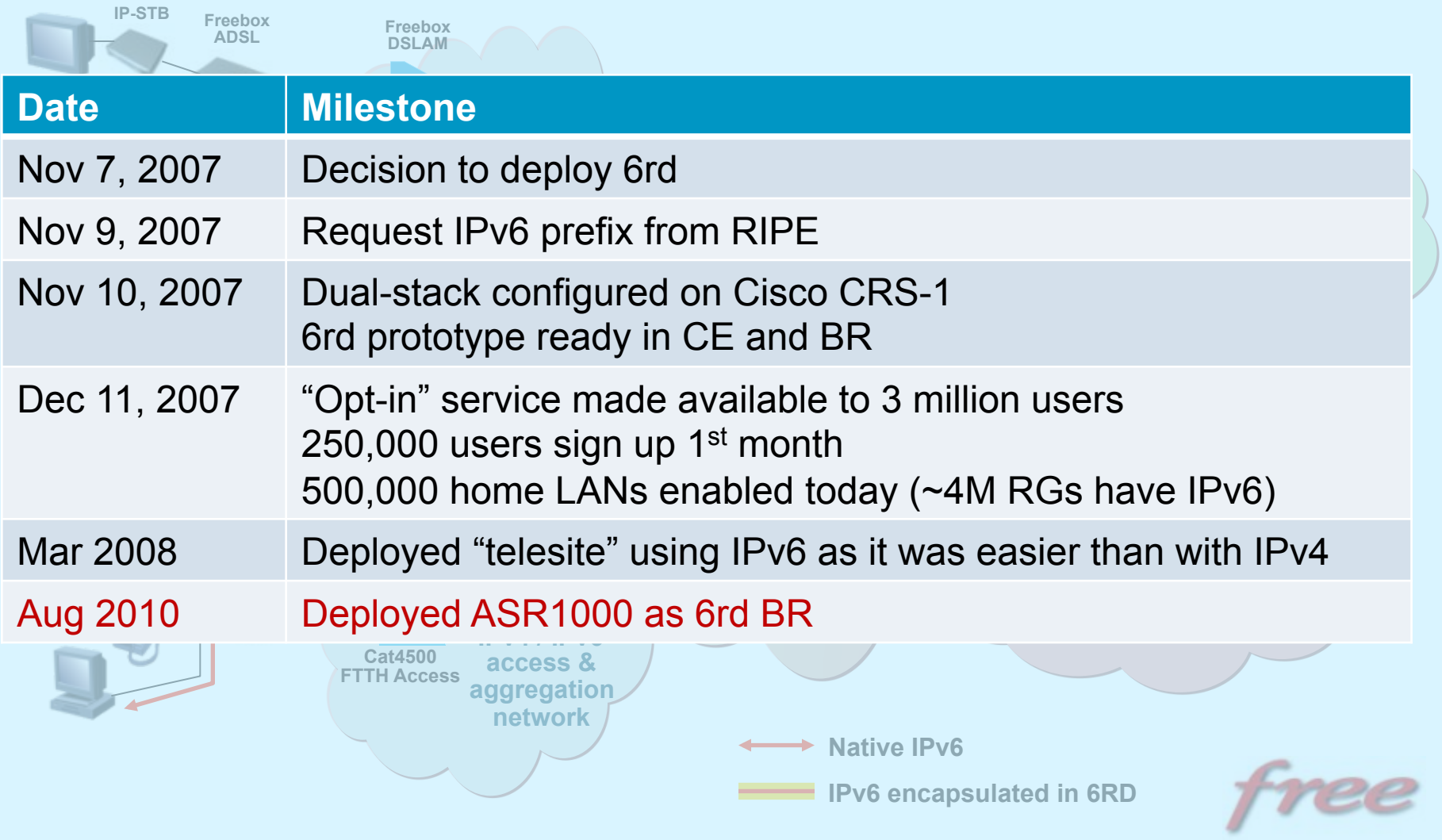
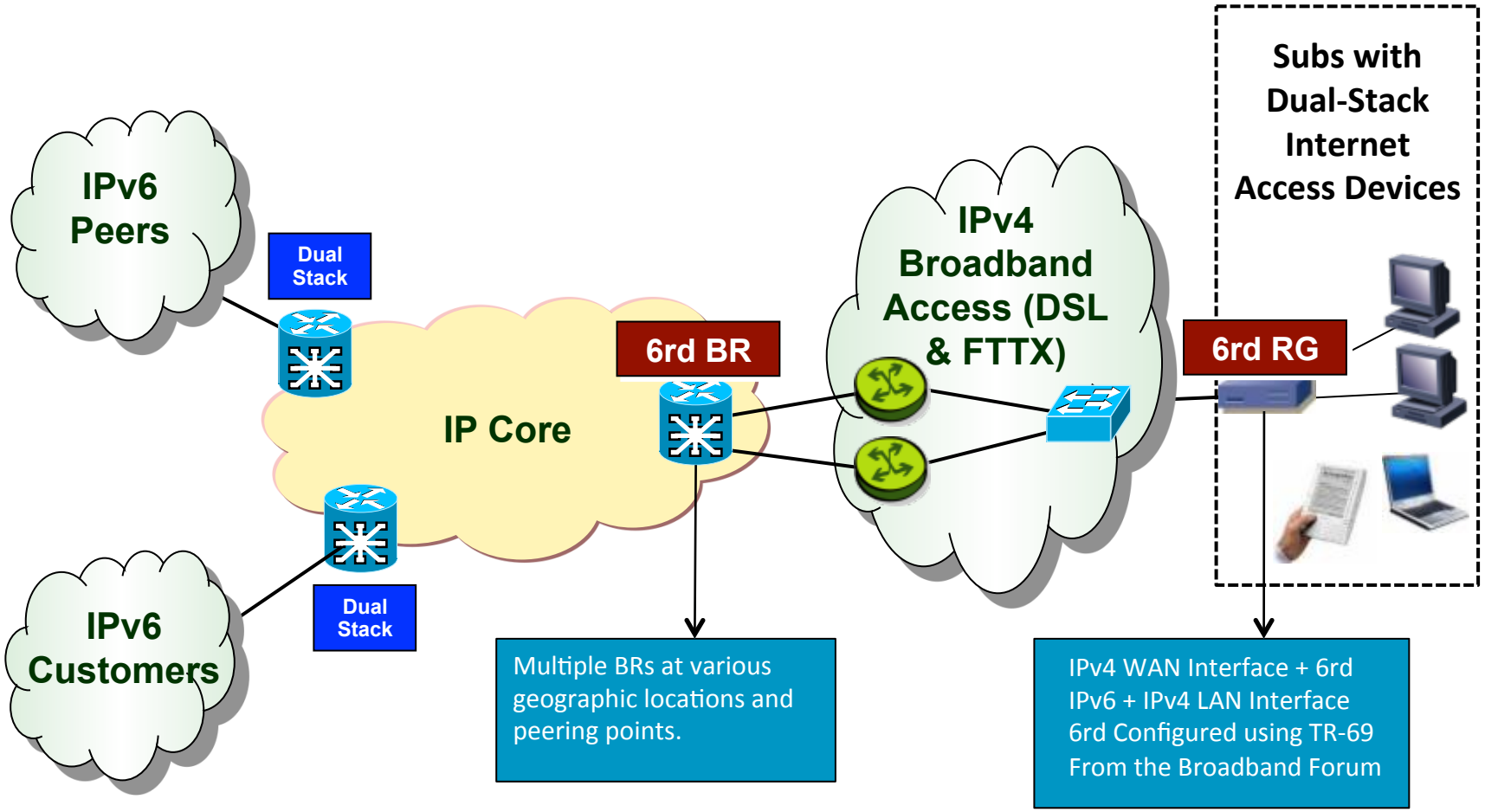


Date	Milestone
Nov 7, 2007	Decision to deploy 6rd
Nov 9, 2007	Request IPv6 prefix from RIPE
Nov 10, 2007	Dual-stack configured on Cisco CRS-1 6rd prototype ready in CE and BR
Dec 11, 2007	“Opt-in” service made available to 3 million users 250,000 users sign up 1st month 500,000 home LANs enabled today (~4M RGs have IPv6)
Mar 2008	Deployed “telesite” using IPv6 as it was easier than with IPv4
Aug 2010	Deployed ASR1000 as 6rd BR

6rd deployment at a US SP



6rd Summary

- Delivers Production-Quality IPv6 by only touching edge points around your network
- Capitalizes on what access networks do well, provisioning and transport of IPv4, adapted for carrying IPv6
- Stateless operation, simple to provision, low overhead
- Proven deployment, RFCs published
- Fast TTM to enable dual stack services