Broadband Update, 2009
MENOG 5, October 2009

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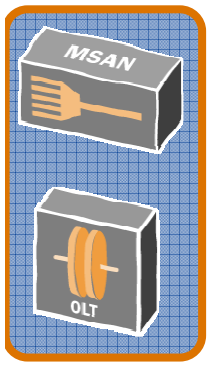
Agenda

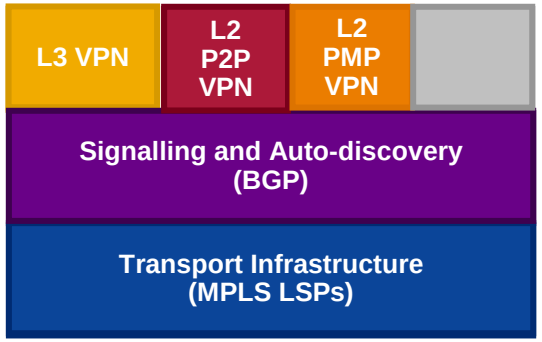
- Architecture Overview
- Access Network
  - IP Sessions
- Aggregation / Backhaul Network
  - Backhaul with MPLS
- Broadband Edge
  - Multi-edge, single edge
- Applications and Services
- Backbone
  - Loop Free Alternates
- Wholesale Broadband
- Broadband IPv6

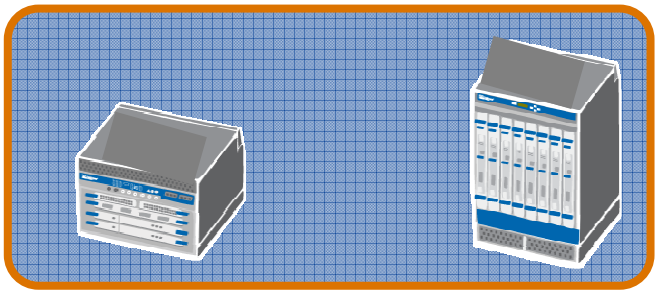
The IP Edge Today



Layer 2 Transport

Transport Infrastructure
(MPLS LSPs)





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Access Network

- The access network connects the home to the DSLAM or Access Node (AN).
- For DSL, the technology has been improving in increments – ADSL, ADSL2+, VDSL, VDSL2
  - Countries with ATM infrastructure started with PPPoA or PPPoEoA
  - Local loop encapsulation is normally Ethernet
  - VDSL can use Ethernet encapsulation
  - Even today, the majority of DSL lines are ADSL and ADSL2 – VDSL is expensive to roll out due to short local loop requirements
- For FTTx, physical speeds are much higher (10, 20, 50Mbps). Bandwidth is often limited at the BNG or in one direction at the OLT.

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Driving network change – PPP or DHCP?

- **Previously Residential DSL access was PPP based**
  - **Including wholesale access via L2TP**
- **DHCP driven by Triple Play DSLAM Multicast Capabilities**
  - **Despite standardisation of both DHCP and PPP multicast handling in DSL Forum TR 101**
  - **No wholesale Triple Play – walled garden solution**
- **DHCP prevalent in the Cable Access market**
  - **No wholesale requirements for Cable Access**
- **DSL Forum Subscriber Sessions aiming to standardise service provider DHCP access**

WT-146 IP Sessions Scope

- Or "*what to keep from old fashioned PPP for this new DHCP stuff*" (*)
- Covers - currently:
  - IP Session Detection and creation
  - Application of IP Session Policies
  - IP Session Termination
  - The Session Policy decisions follow recognized events and are aimed at accomplishing one or more of the following:
    - Session Authentication, Authorization and Accounting.
    - Session grouping
    - Session Monitoring
    - Change of policies including push, eg Change of Authorization, and pull, eg Radius AAA, methods.
    - IP Flow definition
    - IP Traffic policies
- (*) *BOOTP RFC 851, 1985 (A.D.) vs PPP RFC 1661, 1994*

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DHCP Authentication

Per Subscriber Authentication

DHCP

- Currently line based only - Option 82
- Requires Access Node support and configuration
- No user control:
  - ISP selection:
    - chris@isp
  - VPN access:
    - chellberg@juniper.net
- No true authentication (esp for VPN)
- Competing proposals
  - PANA
  - DHCP Auth
  - Chicken and Egg
  - DSLF and IETF

DHCP Session State

DHCP

Per Subscriber State

- Currently no coordinated state between:
  - Client
  - Network
  - AAA & Policy
  - DHCP Server – if used
- Only client can control state (renew or release)
- BFD is current proposal for session state:
  - Lightweight
  - Intended to be implemented in forwarding plane for scale
- ARP is optional

What are other providers using?

- The main SPs in EMEA around the world use PPP for Internet access
- Some specific areas, such as Scandanavia is into DHCP in a big way
- Start-up SPs tend to start with DHCP
- Many SPs offering triple play go with DHCP, although some still stick with PPP
- Taking the goodies from PPP and putting into DHCP will take some time yet. If services need strong provider control (e.g. session state, accounting, session disconnection), PPP is still relevant for the timebeing. Also wholesale?

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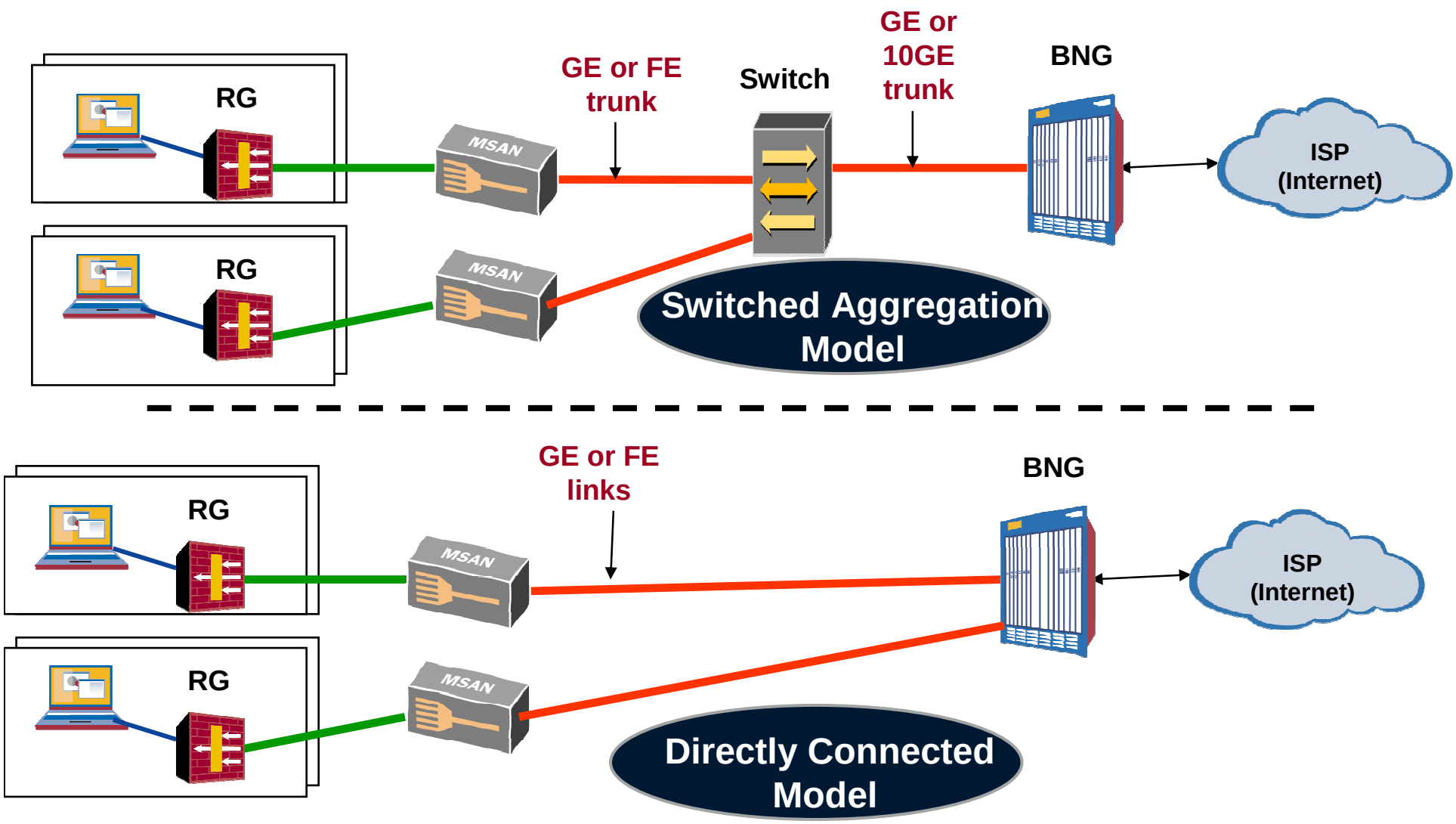
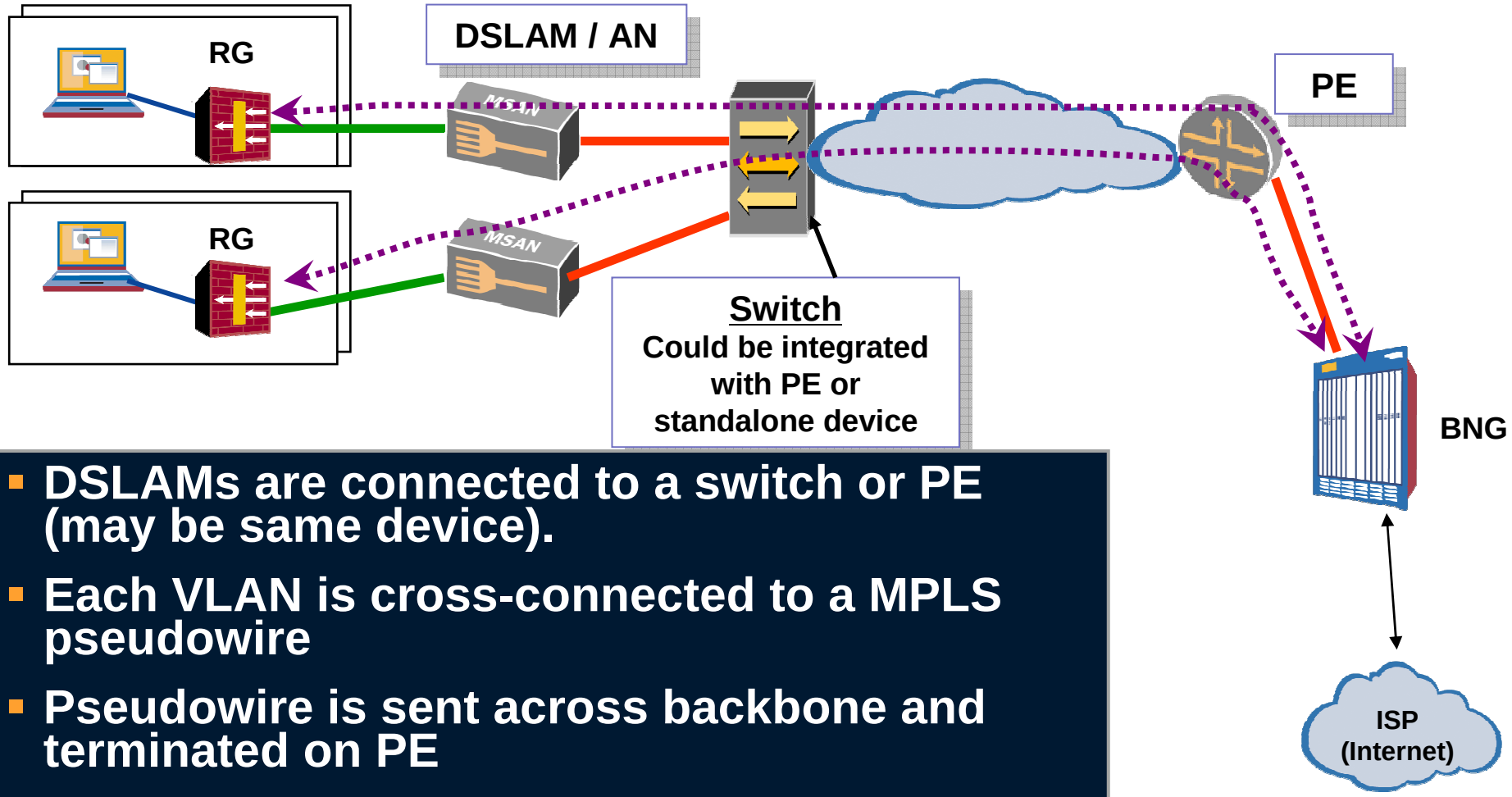
Aggregation / Backhaul Network



Aggregation / Backhaul Network

- The aggregation network has undergone some of the biggest changes.
- Move from ATM to Ethernet backhaul
- In some countries, ATM didn't exist – users went from dialup to DSL with GE backhaul.
- In the early days, two models of backhaul:
  - 1) DSLAMs directly connected to IP edge routers
  - 2) Switches aggregate ANs in front of BNGs
- Now, more common to see MPLS pseudowire backhaul (shown next)

Backhaul / Aggregation using MPLS



- DSLAMs are connected to a switch or PE (may be same device).
- Each VLAN is cross-connected to a MPLS pseudowire
- Pseudowire is sent across backbone and terminated on PE
- PE cross-connects BNG VLAN with pseudowire

MPLS aggregation - why

- By moving the MPLS layer closer to the access network, it compresses the aggregation domain
- Can help to avoid needing spanning tree, depending on topology.
- IP edge is pushed closer to user – same PE can terminate Layer 3 services

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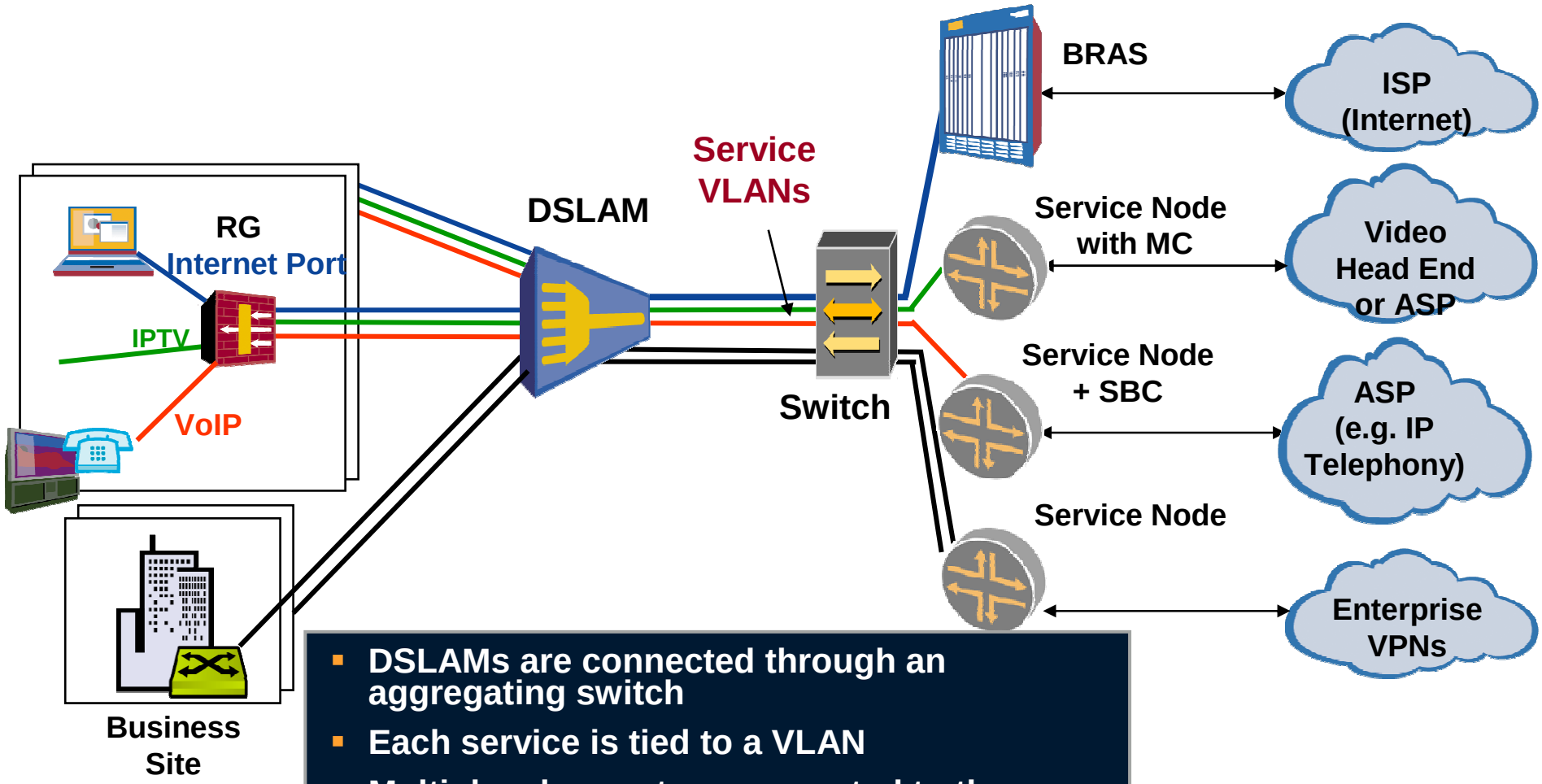
Broadband Edge

- The BBNAS, BAS, BRAS, BNG, BSR or even just IP edge is the where services are defined. All acronyms are used interchangeably (luckily!)
- Could be single edge or multi-edge (described next)
- Single edge broadband edge routers are usually more subscriber aware because they need to support a wide range of services.
- Multi-edge broadband tends to be a mixture of device types. Some devices for PPP-based services and other edge routers for video and voice-type services

Multi-edge topology



- DSLAMs are connected through an aggregating switch
- Each service is tied to a VLAN
- Multiple edge routers connected to the aggregation network. Each router handles one or more services
- The aggregating switches direct each VLAN to the appropriate service node / BRAS

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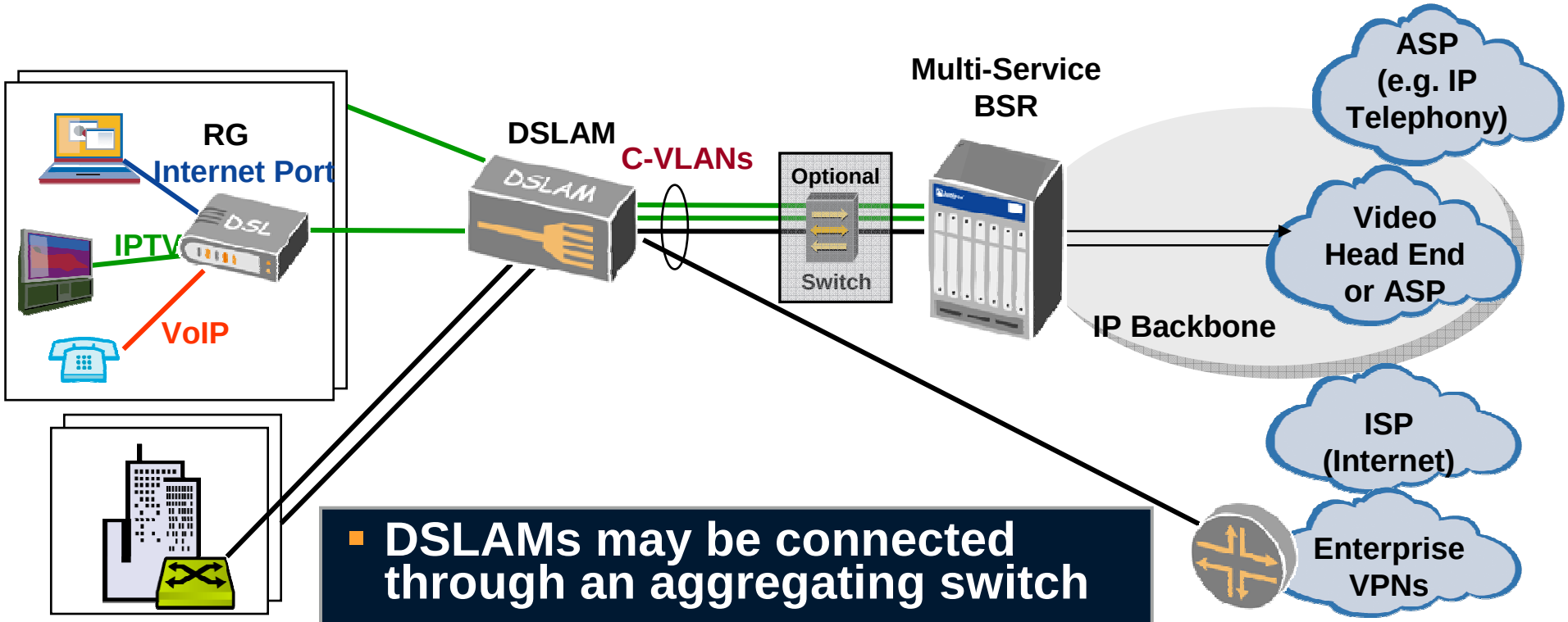
Single-broadband edge topology



- DSLAMs may be connected through an aggregating switch
- A single router delivers multiple-services to the home
- Sometimes a dedicated router router is used for business services
- Usually a single VLAN for all services (except multicast)

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Applications and Connectivity Requirements

Internet: Global Connectivity
IS the Service

IPTV
Mostly AS Local

VoIP
Controlled
Connectivity

SBC

VoIP
Controlled
Connectivity

Enterprise
Controlled
Connectivity

SFW
NAT

Internet

Services and the future of the Broadband Edge

- A service can be as simple as an IP interface on a router, sharing a VLAN with hundreds of other customers.
- Or it can be as complex as a dedicated VLAN for each customer with data accounting, traffic shaping and policies on the subscriber session.
- What is a service?
  - QoS profiles (shaping, guaranteed transfer rates rates, traffic prioritisation, etc), IP policies, accounting, subscriber authentication and authorisation, security to name a few.
- IPTV adoption

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Backbone

- In larger providers, the backbone is typically MPLS-signalled.
- The typical reasons for connecting the BRAS with MPLS are (not all applicable to everyone):
  - virtualisation of traffic, reducing number of backbone routing protocols and protocol machinery, Layer 2 and 3 VPNs, security
- Needed for pseduowire L2 wholesale (described later) increases need for MPLS in the backbone.
- Interesting advance in core technology is loop free alternates (described next)

Loop Free Alternates

- Loop Free Alternates (LFAs) bring MPLS RSVP fast-reroute / facility protection to both vanilla IP and LDP next-hops

- OSPF and IS-IS link-state machines are modified to do additional SPF calculations for remote links.
- Like fast-reroute, alternate paths are pre-programmed into the forwarding hardware for fast switching in the event of link failure.

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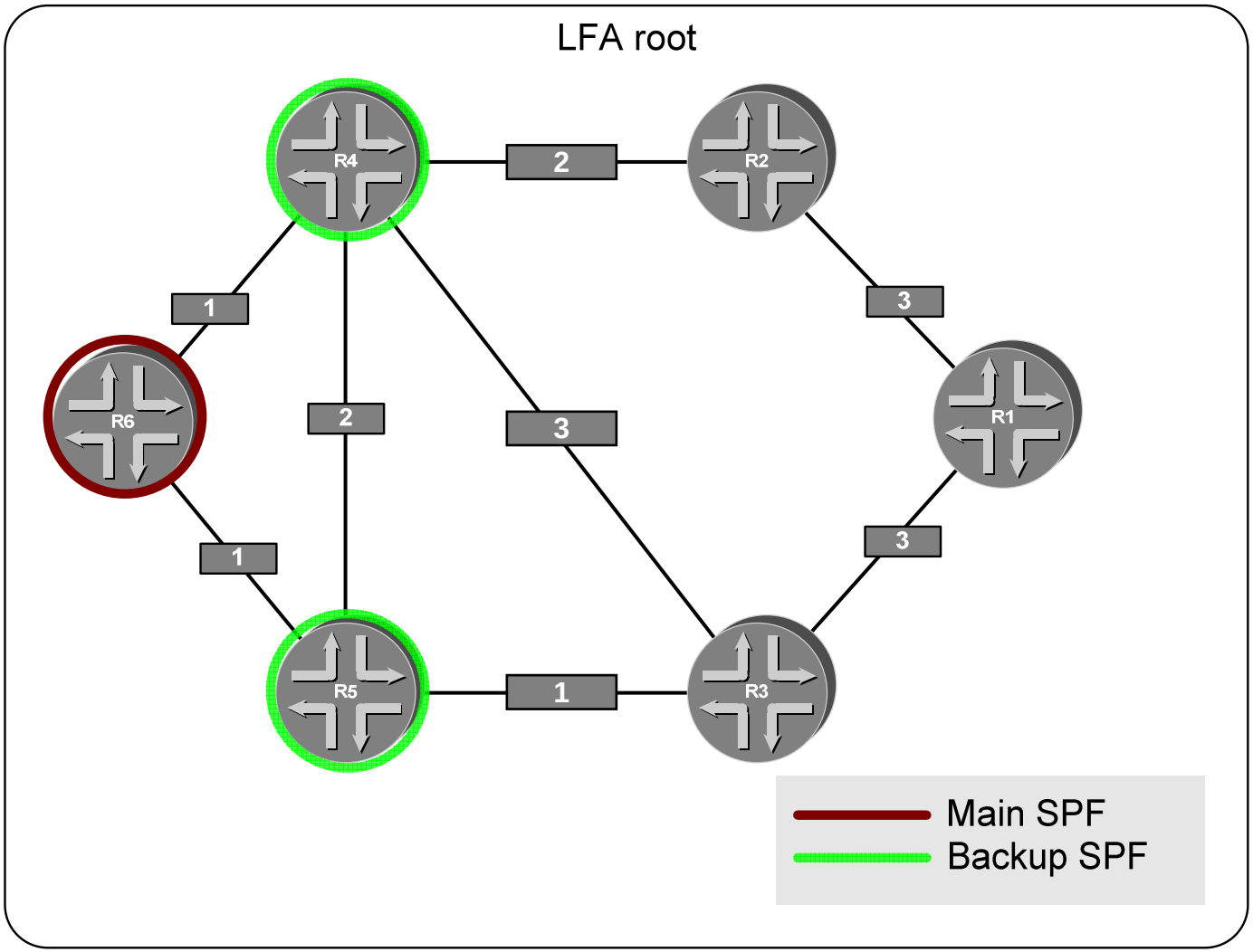
SPF Roots & LFA illustrated



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Layer 2 Wholesale
Current Solutions

- **Standards (DSLF/BBF)**
  - **L2TP for PPP users**
  - **Static VLAN backhaul (TR 101)**
- **Industry Practice:**
  - **Local Loop Unbundling (LLU) – SP DSLAM**
  - **Layer 2 backhaul – static VC or VLAN backhaul**
  - **Layer 3 Wholesale – L2TP/PPP Dynamic Wholesale**
  - **Layer 3 Wholesale – PPP to VRF Dynamic Wholesale**
  - **Layer 3 Wholesale – DHCP L3 Wholesale**
    - **Static VLAN to VRF mapping for C-VLAN**
    - **Proprietary Dynamic Configuration**
    - **Not in scope of standardisation as part of fortcoming WT-146 IP Sessions**

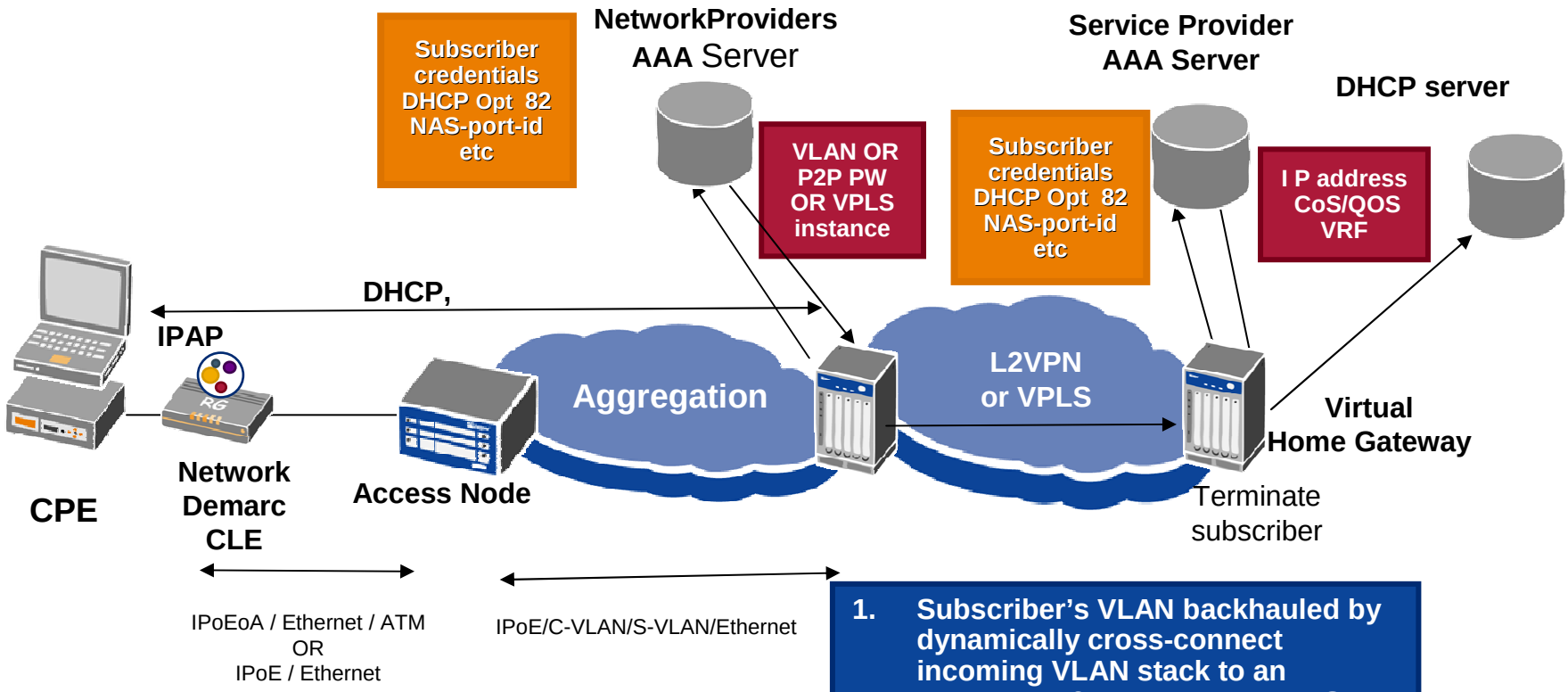
Wholesale Requirements To Date

- **Ease of provisioning**
  - **Automagic mapping of subscribers to Wholesale Domain**
- **Scaling**
  - **For 10s of Millions of customers**
- **Unicast**
- **Best Effort or limited QoS SLA**

Wholesale: New Requirements

- **ISP VLAN Hand off required by regulators**
  - **Countries in APAC – public access network funding**
  - **OfCom & Network Sharing discussions in UK**
  - **Network Sharing in Germany**
- **Multicast Capable Wholesale**
  - **VPLS as wholesale**
  - **Needs additional link to Access Node**
  - **As proposed in ANCP**
- **Migration to DHCP**

L2 Wholesale Selection Concept



1. Subscriber's VLAN backhauled by dynamically cross-connect incoming VLAN stack to an upstream L2VPN PW or a VPLS instance via AAA interaction.
2. This DHCP L2 wholesale is similar to L2TP in case of PPP. Virtual home gateway is akin to LNS.
3. The cross-connect VLAN or L2VPN PW or VPLS instance is returned by AAA server.

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IPv6 at the Broadband Edge
24 Times Bigger and Better than IPv4

- **Bigger addresses – /32 => /(64 + 64)**
- **In case that's not enough, we get 3 addresses:**
  - **Link Local**
  - **CPE WAN Side from ICMP ND/RA**
  - **CPE LAN Side from DHCPv6-PD**
- **And to save us having to choose between PPP and DHCP, we get both**

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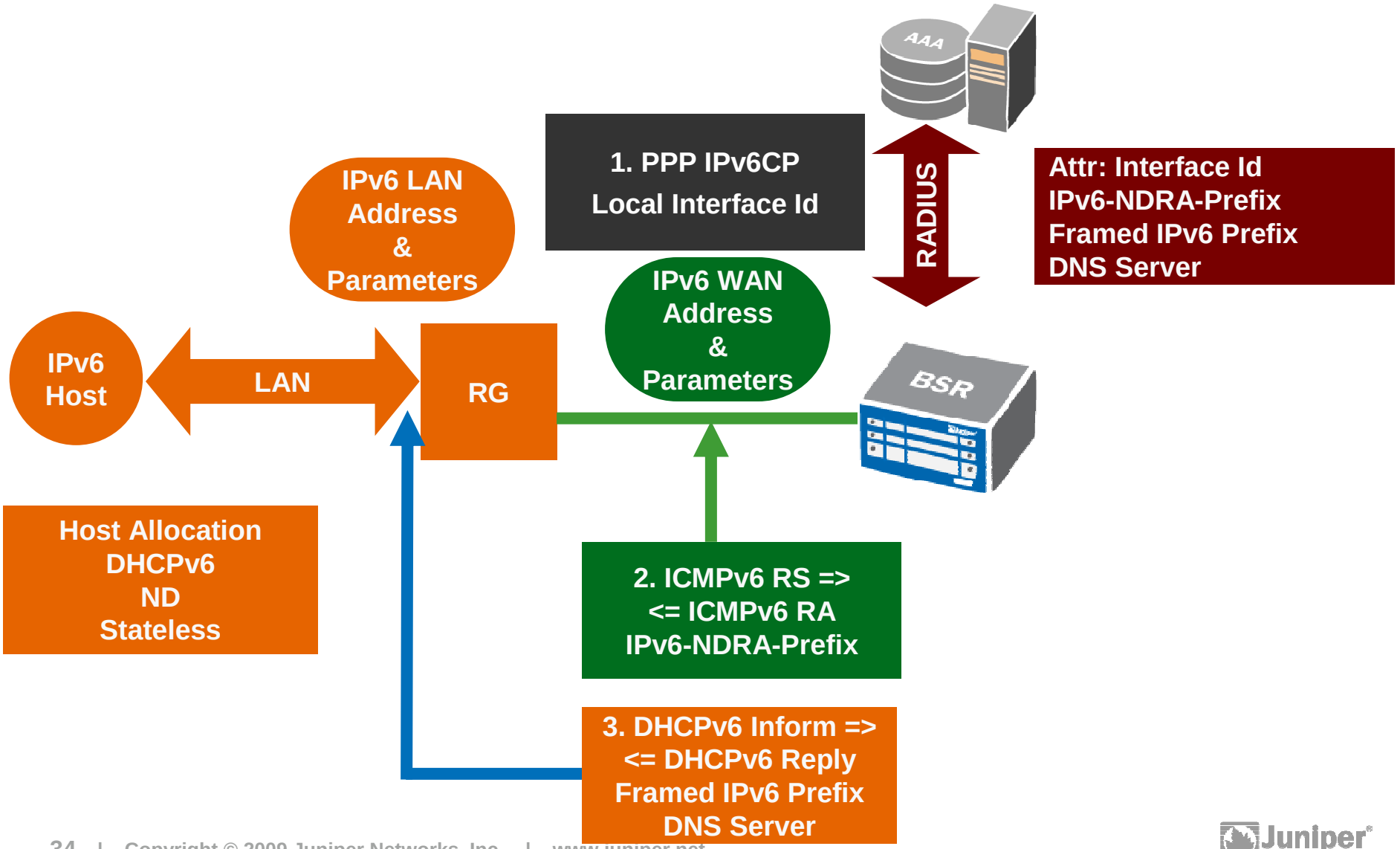
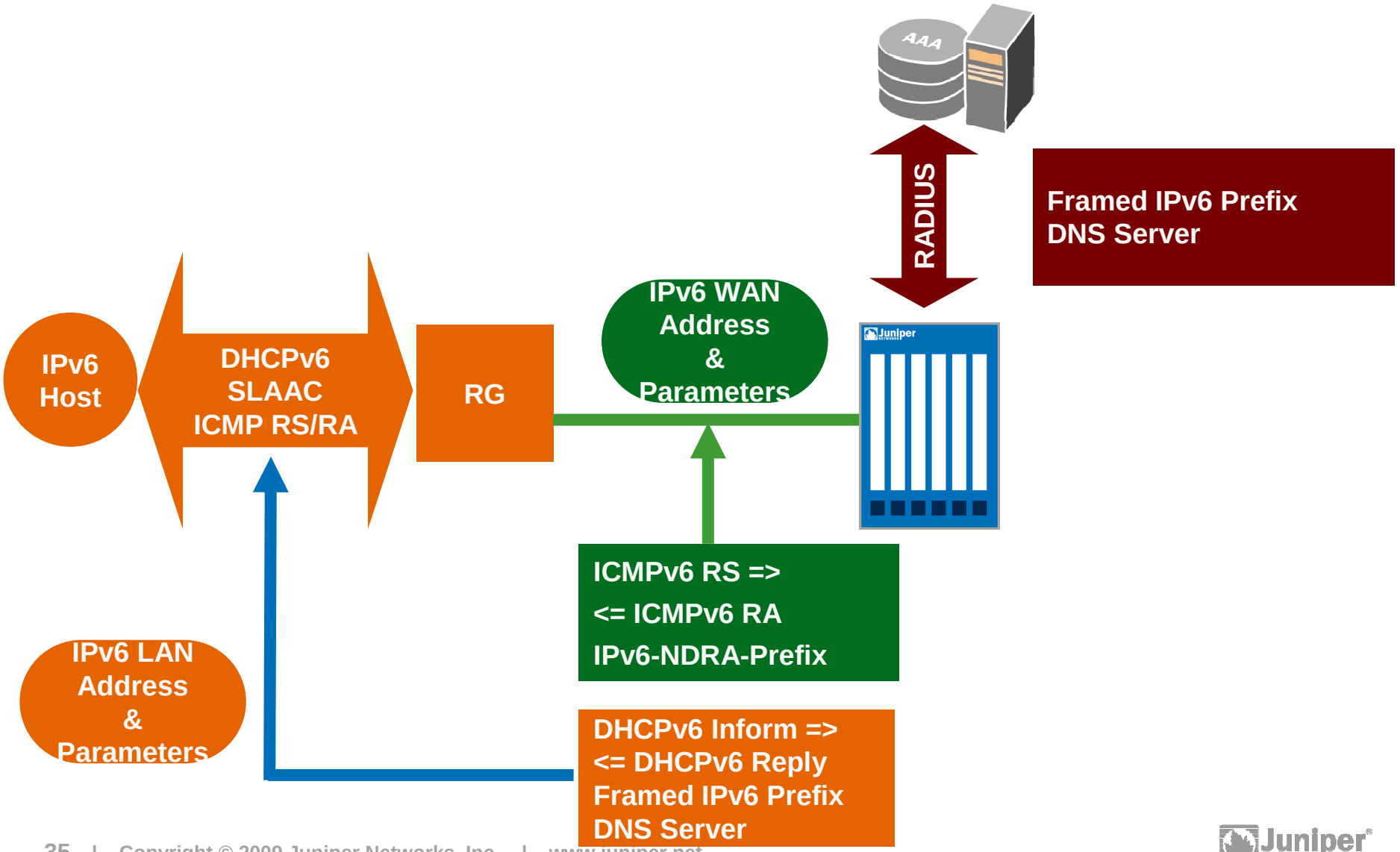
Broadband Edge PPP Model



Broadband Edge
DHCPv6 Subscriber Management



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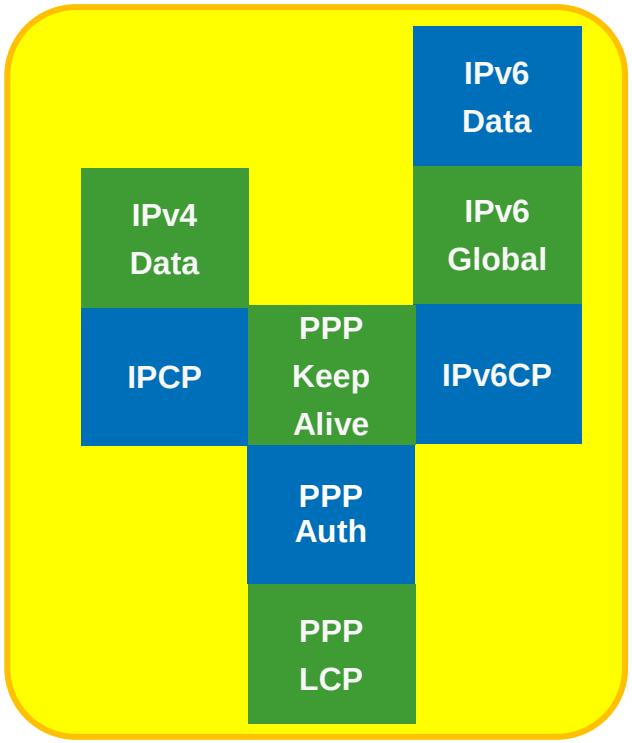
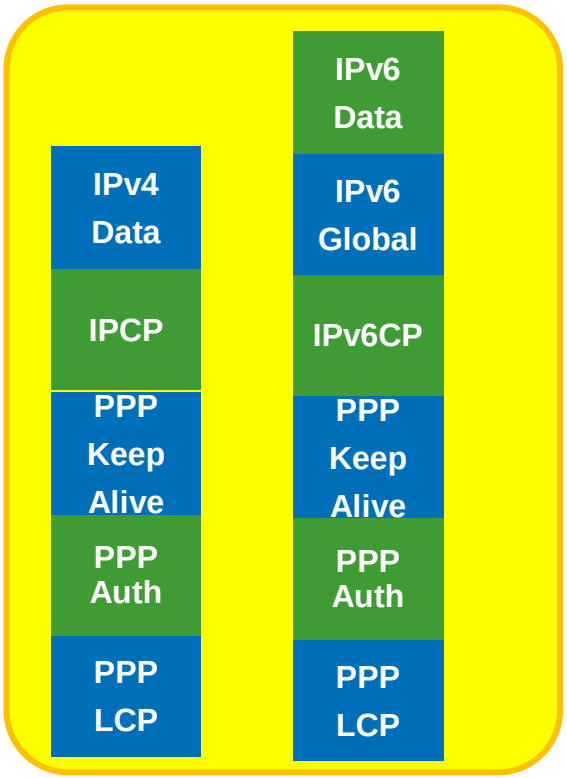
Broadband Edge
PPP Models – Dual Stack or Dual Session



- One AAA interaction
- Most flexible
- CPE Driven



- Can be interesting for transition:
  - IPv6 LNS
  - PPPoE Pass Through

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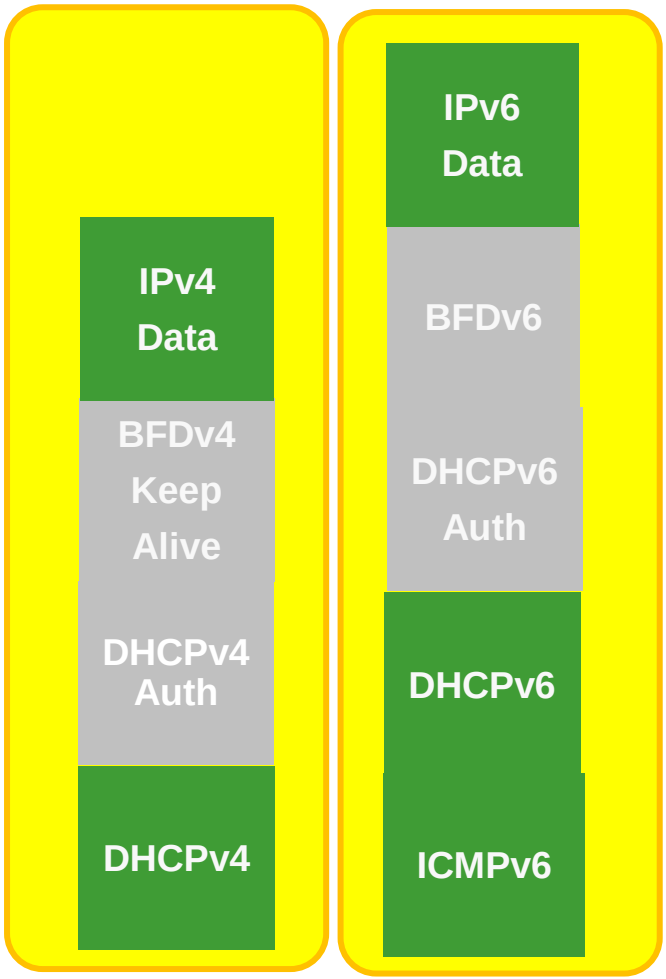
Broadband Edge
DHCP Models – Dual Sessions

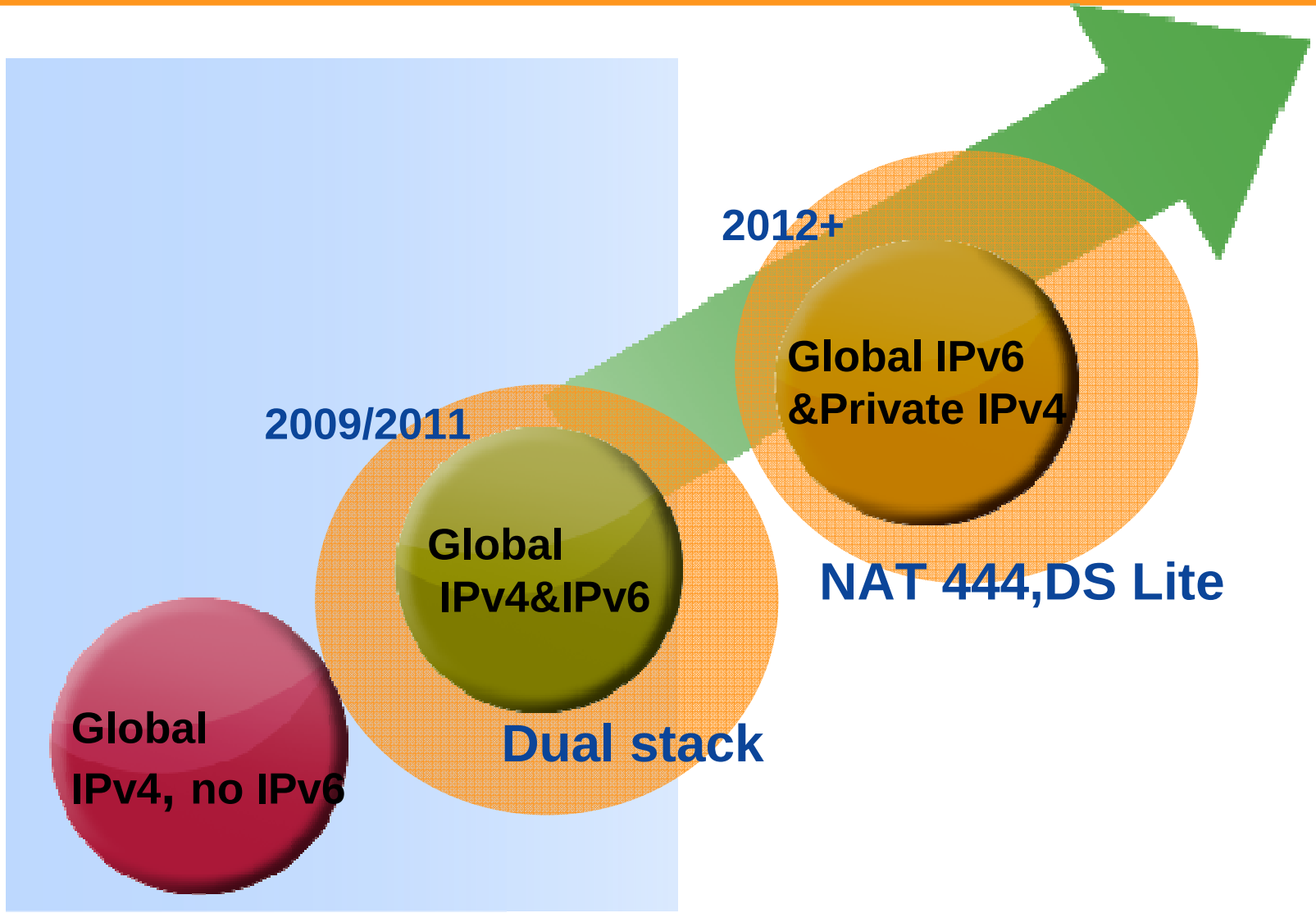


- **DHCP Must Use Dual Sessions**
  - **DHCPv4 and DHCPv6 are different protocols**
  - **2 separate state machines**

IPv6 Transition Goals

- To enable an IPv6 Internet
  - Any to any IPv6 Connectivity
- If this is not possible before IPv4 is depleted:
  - Can try and extend life of IPv4
    - “Anti-depletion” tools
  - Must enable interworking between IPv4 and IPv6 worlds to ensure any to any connectivity

IPv6 Transition



IPv6 Transition Tool Kit

IPv6 Transport Solution

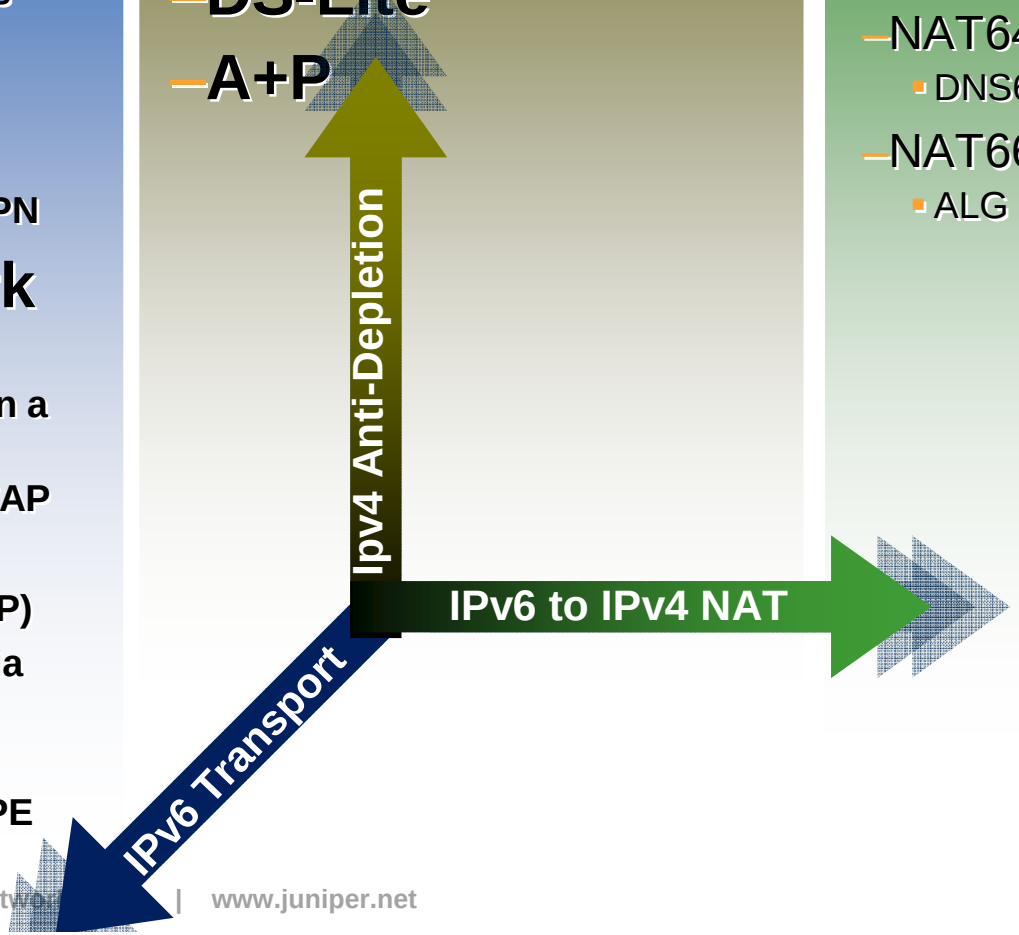
- **Core Backbone**
  - Dual Stack
    - 2 routing protocols
  - 6PE
    - IPv6 over MPLS
  - 6VPE
    - IPv6 over MPLS VPN
- **Access Network**
  - Dual Stack
  - Enabling IPv6 Access on a IPv4 Network:
    - 6to4, Teredo, ISATAP
    - 6rd
    - IP6 over IPv4 (IPoIP)
  - Enabling IPv6 Access via agnostic network:
    - L2TP LNS IPv6
    - PPPoE Bridged CPE
    - Layer 2 Backhaul

IPv4 Depletion Mitigation

- **NAT444**
  - End point independent NAT
- **DS-Lite**
- **A+P**

IPv6 to IPv4 NAT

- NAT-PT
  - ICMP, Tracert ALG
  - DNS ALG
- NAT64
  - DNS64
- NAT66
  - ALG



IPv4 Anti Depletion Tools

IPv4 Depletion Mitigation

- NAT444
  - End point independent NAT
- DS-Lite
- A+P

- NAT 444 exists today
  - Used by SPs who already have reached point of depletion
- NAT, DS-Lite, A&P distribute the functionality of IPv4 address reuse in different ways
  - Multiple Private IPv4 addresses share a Public IPv4
- Do not help reach the end goal

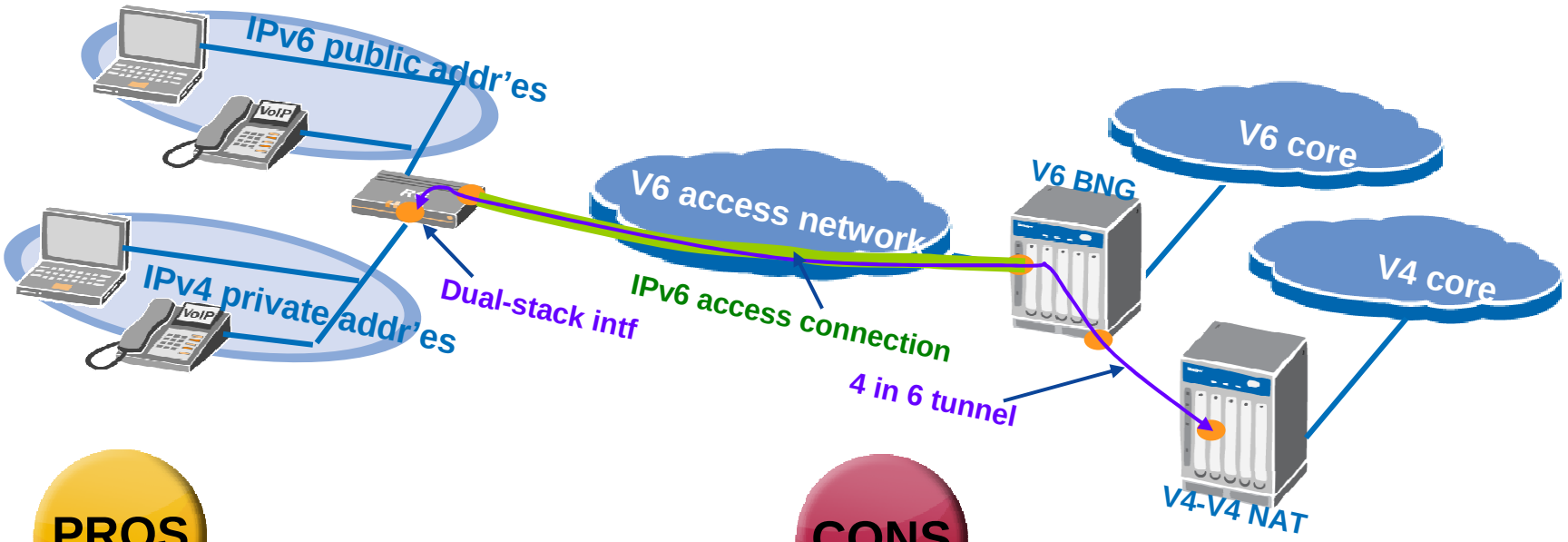
IPv6 IPv4 Translation Tools

IPv6 to IPv4 NAT

- NAT-PT
  - ICMP, Tracert ALG
  - DNS ALG
- NAT64
  - DNS64
- NAT66
  - ALG

- **IPv6 / IPv4 never needed between 2 dual stack end points**
- **Interworking required between v4 only end point and v6 only end point**
  - **Open where to optimally place this IW**
    - **Client side CPE**
    - **Network Core**
    - **Server Side CPE**
- **NAT from IPv4 to IPv6 add on to Enterprise VPN Internet break out**
  - **IPv4 / IPv4 NAT already performed there – small delta**

IPv6 Access Models: Dual Stack Lite



PROS

- V4 and V6 traffic is handled separately
- CPEs get private IPv4 address
- BNG is pure IPv6
- Good for green field deployments

CONS

- Existing networks cannot be upgraded
- Separate AAA/Policy/LI/Mgmt infrastructure
- Multiple boxes to manage
- Dual stack lite spec not finalized

THANK YOU