Case Study
A Service Provider’s Road to IPv6

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The Scenario

- Residential Network
- L3 MPLS VPN Network
- Public Network
The Scenario

What are we presenting, and why?

A large European service provider asked us to provide design for IPv6 rollout for various networks it operates:
- Residential (BRAS) network (LAC and LNS)
- L3 MPLS VPN network for business customers
- Public network for Internet Access

This presentation shows a typical service provider’s dilemma:
- Many multivendor networks
- Not just public Internet
- Inter-dependency of services across networks
The Scenario
Background and Assumptions

• Deployment Scenario is “Dual-Stack”
  ▪ Considered first step

• For now, only convert what is visible externally

• The rollout should be transparent to existing customers

• Current IPv4 transport models
  ▪ IPv4 only for Public network
  ▪ MPLS for the L3 MPLS VPN network
The Scenario

Background and Assumptions

• Devices Deployed
  ▪ E320/ERX Juniper routers
    ▪ As LAC and LNS
  ▪ Juniper T/M
    ▪ As P/PE MPLS VPN and Internet routers
  ▪ Cisco routers
    ▪ As Internet routers
  ▪ Alcatel
    ▪ As VPLS switches, transparent to IPv6
The Residential Network
Residential Network
Main Connectivity Models Supported by IPv6

- **Simple Routed Mode**
  - CPE establishes a PPP session to the LAC
  - Support for L3 Backhaul

- **L2TP Backhaul**
  - LAC has L2TP session to an LNS
  - **Enterprise service:** Subscriber terminates in MPLS VPN
  - **L2 Wholesale:** LNS is owned by another ISP
Residential Network

Our Choices for PPP Model—**Dual Stack or Dual Session**

- **One AAA interaction**
- **Most flexible**
- **CPE Driven**

- **Can be interesting for transition:**
  - IPv6 LNS?
Residential Network
E320/ERX IPv6 Configuration – Getting Started

• Many business questions
  • What are the offerings?
  • Do all IPv4 services make sense for IPv6?
  • Which customers should get an IPv6?
    • All or just new?

• Everything is influenced by scaling!
  • Scaling drives many of the design decisions

• License
  • IPv6 in JUNOSe required activation of a license key
Residential Network
E320/ERX IPv6 Configuration – Interfaces and Routing

- **Interfaces**
  - Need to have new IPv6 Addresses
  - Many choices for the subnetting: /126, /127, /64, ...

- **ISIS**
  - Will also carry the IPv6 topology info

- **BGP**
  - Two Options:
    - *Native IPv6 end-points*
    - *IPv4 BGP carrying IPv6 NLRI*  
      
      ![Solution Picked](Solution.png)

- **Policy**
  - Need to have IPv6 equivalents
Residential Network
Subscriber Addressing Model

1. PPP IPv6CP
   Local Interface Id

2. ICMPv6 RS =>
   <= ICMPv6 RA
   IPv6-NDRA-Prefix

3. DHCPv6 Inform =>
   <= DHCPv6 Reply
   Framed IPv6 Prefix
   DNS Server

IPv6 LAN
Address & Parameters

IPv6 WAN
Address & Parameters

IPv6 Host

LAN

RG

AAA

Attr: Interface Id
IPv6-NDRA-Prefix
Framed IPv6 Prefix
Framed IPv6 Pool
DNS Server

Host Allocation
DHCPv6
ND
Stateless
Residential Network
E320/ERX IPv6 Configuration – Address Assignment/Delegation

- Bigger addresses – /32 => /(64 + 64)
- We may get up to 3 addresses
  - Link Local
    - Is always there!
  - ICMPv6 (ND) – CPE WAN SIDE
    - IPv6-NDRA-Prefix
      - Our choice: Static, configured in the profile
  - DHCPv6 (PD) – CPE LAN SIDE
    - Framed-IPv6-Prefix or Framed-IPv6-Pool
      - Our choice: Static, assigned in the domain-map
• Subscriber interfaces
  • No new IPv6 specific configuration
  • Dynamic PPPoE / PPP stack

• Changes contained in profiles
  ▪ Attached to the subscriber interfaces at provisioning

▪ Profile modifications
  • The IPv6 loopback interface
  • Neighbor Discovery (ND)
  • IPv6 Policy
  • RPF check for IPv6 source validation
  • Other optional configurations
Residential Network
E320 IP Configuration – DNS Servers

• Specific to ERX/E320 Platforms

• DNS server can be configured in multiple locations
  • Using “aaa ipv6-dns” command
  • Under local address-pools
  • Through DHCPv6-LS configuration

• Choice driven by
  • How many DNS servers are needed
  • Need to override the static DNS assignment by RADIUS
Residential Network
E320/ERX IPv6 Configuration – Accounting and Counters

- **Radius Accounting**
  - Accounting of IPv6 services is equivalent to IPv4
  - All IPv6 attributes included in the Access-Accept from RADIUS can be included

- **Counters**
  - Access to the PPP session counters
    - IPv4 and IPv6 run on top of one PPP session
    - Session counters include the IPv4 and IPv6 packets
  - Separate counters for IPv6 are also supported
Residential Network
LNS Specific Configuration - Highlights

- Many concepts discussed for LAC also apply to the LNS
  - The L2TP tunnel end points stay on IPv4

- A few tweaks needed. Examples:
  - Some configurations applied to customer VRFs
    - All the address-assignment configurations
  - Communication with rest of L3VPN MPLS network
    - Need to turn on vpnv6 BGP address family
    - May be Service Interrupting
Summary

Residential Network

L3 MPLS VPN Network

Public Networks
**mplsvpn network:**

6VPE Architecture

- Relatively straight-forward
  - Operational model and configuration similar to IPv4 VPN
  - Can use same LSPs and same BGP sessions
  - Same features as for IPv4 VPN can be used
L3 MPLS VPN Network
Configuration- Core

• MPLS
  • MPLS used in the core for forwarding
  • In Junos, All routers need “ipv6-tunneling” under [protocols mpls]
    • So that IPv6 routes are resolved over the LSP tunnels.

• BGP
  • BGP needs modifications in the core
    • family inet6-vpn added
  • Interprovider VPNs
    • Same configuration to be followed for Option C peers
EBGP, Static and RIP-NG

- EBGP
  - Chose to configure using a new peer-groups
- Static
  - Very simple
    - Follows the IPv4 model and syntax
- RIP-NG
  - Similar to BGP, routing policies need to be converted to IPv6
L3 MPLS VPN Network
Configuration - Quality of Service

- QOS in the core is untouched
  - MPLS EXP in the core is blind to IPv6
- Customers use BA and MF classifiers
  - BA Classification
    - New code point alias table.
    - Create new equivalent IPv6 classifiers
  - MF Classification
    - Create new equivalent IPv6 filter or filter-policer
- Watch for hardware restrictions!
L3 MPLS VPN Network
Configuration - Router Security

• Core uses 6vPE
  • No global IPv6 loopbacks
  • The control plane rides on top of IPv4
  • No new IPv6 loopback filter required

• Edge
  • Per customer VRF loopbacks
  • New IPv6 filter required.
    • Considers also OSPFv3 and RIPng, VRRP
  • Simple packet filters also used
  • RPF check for IPv6 works the same way as IPv4
Public Network

Summary

Residential Network

L3 MPLS VPN Network
Public Network
Configuration- Architecture

• Native IPv6 forwarding in the public network
  • BGP over IPv6 end points riding TCPv6
  • ISIS carries both IPv4 and IPv6 prefixes
  • Shared fate only on the IGP side
Public Network
Configuration- Routing (ISIS/BGP)

- **ISIS**
  - JUNOS needs no additional configurations to carry IPv6 routes

- **IBGP**
  - *Configured within a new “IPv6 Specific” peer-group*
  - Export policies can be re-used if there is no specific reference to IPv6 addressing

- **EBGP**
  - *Two separate BGP sessions, one for IPv4 and one for IPv6*
  - Consistent with the core IBGP model
Public Networks
Configuration- Filters and QOS

- Changes similar to the those discussed for MPLS network
  - One addition: DSCP Re-write to reset customer DSCP settings
  - Created the equivalent for DSCPv6

- Filters are used in every network in the project
  - MF classifiers, policing, simple packet filters, etc
  - All the filters need to have IPv6 equivalents
Public Networks
Configuration- Router Security

**Core**
- New global IPv6 loopback needs a new IPv6 filter
  - Create equivalent terms from IPv4 to IPv6
    - BGP, SSH, etc
  - As compared to per VRF filters discussed earlier
    - No OSPFv3, RIPng, etc
    - But may need other protocols such as NTP

**Edge**
- RPF Check
- Filters that deny packets to illegal/internal addresses
  - New IPv6 filters are defined
What did we learn?

Dual Stack is only the first step

• Does not really help with IPv4 exhaustion
  • Customers want to know what is next

• Our Client believes CGN is part of the puzzle
  • Had to accommodate future CGN plans
  • Independent routing-domains
    • Used to separate public and private address subscribers
    • May involve moving customers from one virtual router (routing-domain) to another after authentication

• Customer is evaluating various solutions
  • CGN, DS-Lite, others.
What did we learn?

Service definition is key

• First
  • Generate an inventory of current IPv4 services
  • This is more time consuming that is sounds
  • Often no central list of current IPv4 services exists

• Second,
  • Decide what should (or is worth) move to IPv6

• Finally a technical question
  • Does the model need a new architecture for IPv6?
    • Example: BRAS model of fixed IP address customers
      • Being able to log in from any BRAS device
      • Leaking all IPv6 access routes may not be an option!
What did we learn?
The Devil is in the Implementation

• **Scaling, Scaling, Scaling**
  • The single most important issue
  • Simple: Know your device
    • Don’t’ assume a linear scaling behavior
      • Number of routes in the Control Plane
      • Number of routes in the Data Plane
      • Number of Dual-Stack interfaces
      • Number of DHCPv6 leases
      • On and on…

• **Don’t assume features work equally for IPv4 and IPv6**
  • Test carefully: Trust but verify!
  • Our experience:
    • Data plane is where most culprits are!
What did we learn?
IPv6 deployment touches everything

• Migration to IPv6 requires organizational commitment
  • More than just a technical issue

• It crosses lines of various organizations
  • Provisioning systems
  • Billing Systems
  • Marketing
  • Peering Agreements
  • On and on …

• What made our project successful
  • “Sense of urgency in all levels of the organization”
Thank You

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