IPv6 @ Cisco

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Agenda

- IPv6 Business Case
- IPv6 Protocols & Standards
- Integration and Transition
- Cisco IOS IPv6 Roadmap
- IPv6 Deployment scenarios
# IPv6 – Looking at the Crystal Ball

<table>
<thead>
<tr>
<th>Year</th>
<th>1996-2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007-2010</th>
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<td>Q1</td>
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**Cisco IOS IPv6 EFT**

- **Early adopters**
  - Application port: <= Duration 3+ years =>
  - ISP adoption: <= Duration 3+ years =>
  - Consumer adoption: <= Duration 5+ years =>
  - Enterprise adoption: <= Duration 5+ years =>

**Notes:**
- Hardware/software released
- Applications certified by IT department
- E-Europe, E-Japan, North-America IPv6 Task Force,…
IPv6 – Working out the Timeline

2002  2003  2004  2005  2006  2007-2010

Q 1  Q 2  Q 3  Q 4     Q 1  Q 2  Q 3  Q 4     Q 1  Q 2  Q 3  Q 4

- Identifying the business case
- Funding the project
- Training
- Registering for an IPv6 prefix
- Testing
- Deploying
- Production

How long is needed for each phase of an IPv6 deployment project?
The Scope of IPv6 Deployment

Integration & Co-Existence

IPv6 over IPv4 Tunnels
(Configured, 6to4, ISATAP, GRE)

Native IPv4 & IPv6
Cisco IOS is Multi-Protocol Since Day 1

IPv6 over MPLS
(ATOM, 6PE)

IPv6 Services – The Cisco IOS Emphasis

QoS
Multicast
Security
Network Management
IPv4-IPv6 Translation

IPv6 Forwarding & Routing protocols
(RIPng, OSPFv3, IS-ISv6, MP-BGP4)

Operations and Training

Server to Client
Home Information Services
Multimedia (Video Conf)
Peer to Peer (ie: Instant Messenger)
Campus
Enterprise WAN
Provider Edge
Provider Core
Home Area Networks
Provider Core
Enterprise WAN
Provider Edge
Campus

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Lessons from other migrations in the past

- IPv6 Integration and Co-Existence
  Business driven, no deadline, no D-day

- Application’s transition must be the main focus
  Remember that other protocols failed their widespread adoption

- IPv6 is IP
  No opposition as “ATM versus IP”
  No real alternative to scale the Internet growth

- Telecommunication’s Industry already went through several Renumbering & Protocol’s changes
  Telephone systems
  X.25, DECnet, Appletalk, IPX, SNA
IPv6 Deployment Scenarios

• Many ways to deliver IPv6 services to End Users
  End-to-end IPv6 traffic forwarding is the Key feature
  Minimize operational upgrade costs

• Service Providers and Enterprises may have different deployment needs
  Incremental Upgrade/Deployment
  ISP’s differentiate Core and Edge infrastructures upgrade
  Enterprise Campus and WAN may have separate upgrade paths

• IPv6 over IPv4 tunnels
• Dedicated Data Link layers for native IPv6
• Dual stack Networks
  IPv6 over MPLS or IPv4-IPv6 Dual Stack Routers
IPv6 over IPv4 Tunnels

- Several Tunnelling mechanisms defined by IETF
  Apply to ISP and Enterprise WAN networks
    GRE, Configured Tunnels, Automatic Tunnels using IPv4 compatible IPv6 Address, 6to4
  Apply to Campus
    ISATAP
  All of the above are supported on Cisco IOS
  Leverages 6Bone experience
- No impact on Core infrastructure
  Either IPv4 or MPLS
Native IPv6 over Dedicated Data Links

- Native IPv6 links over dedicated infrastructures
  - ATM PVC, dWDM Lambda, Frame Relay PVC, Serial, Sonet/SDH, Ethernet
  - All of the above are supported on Cisco IOS
  - No impact on existing IPv4 infrastructures
  - Only upgrade the appropriate network paths
  - IPv4 traffic (and revenues) can be separated from IPv6

- Network Management done through IPv4
IPv6 Tunnels & Native Case Study

- **ISP scenario**
  - Configured Tunnels or Native IPv6 between IPv6 Core Routers
  - Configured Tunnels or Native IPv6 to IPv6 Enterprise’s Customers
  - Tunnels for specific access technologies, eg. Cable
  - MP-BGP4 Peering with other 6Bone users
  - Connection to an IPv6 IX
  - 6to4 relay service

- **Enterprise/Home scenario**
  - 6to4 tunnels between sites, use 6to4 Relay to connect to the IPv6 Internet
  - Configured tunnels between sites or to 6Bone users
  - ISATAP tunnels or Native IPv6 on a Campus

Use the most appropriate
Dual Stack IPv4-IPv6 Infrastructure

- It is generally the goal when IPv6 traffic and users will be rapidly increasing.
- May not necessarily apply to the overall infrastructure. One may begin on network’s portion such as Campus or Access or core networks.
- Network design must be well planned.
  - Memory size to handle the growth for both IPv4 & IPv6 routing tables.
  - IGP options & its management: Integrated versus “Ships in the Night”.
  - Full network upgrade impact.
- IPv4 and IPv6 Control & Data planes should not impact each other.
Dual Stack IPv4-IPv6 Case Study

Campus scenario
Upgrade all layer 3 devices to allow IPv6 hosts deployment anywhere, similar to IPX/IP environment

ISP
Access technologies may have IPv4 dependencies, eg. for User’s management
Transparent IPv4-IPv6 access services
Core may not go dual-stack before sometimes to avoid a full network upgrade
Campus Deployment Scenario

- Full Layer 3 infrastructure upgrade to implement Dual Stack
  Software or Hardware/Software dependent of expected performances
- Native IPv6 Router(s) on a Stick
  VLANs are terminated on one or more IPv6 interfaces/routers
- Native IPv6 Routers on dedicated LANs interconnected using configured tunnels.
- ISATAP tunnels
ISATAP Details

Use IANA's OUI 00-00-5E and encode IPv4 address as part of EUI-64

- Automatic discovery of ISATAP routers
  - DNS "isatap.domainname" A record lookup
  - Automatic deprecation when end system receives native IPv6 router advertisements

<table>
<thead>
<tr>
<th>64-bit Unicast Prefix</th>
<th>0000:5EFE: IPv4 Address</th>
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<tbody>
<tr>
<td>32-bit</td>
<td>32-bit</td>
</tr>
<tr>
<td>Interface Identifier</td>
<td>(64 bits)</td>
</tr>
</tbody>
</table>

draft-ietf-ngtrans-isatap-11
draft-ietf-ngtrans-isatap-scenario-01
Cisco IOS 12.2(15)T, 12.2(14)S
Supported in Windows XP Pro SP1

The tunnel source command must point to an interface with an IPv4 address configured.

Configure the ISATAP IPv6 address, and prefixes to be advertised just as you would with a native IPv6 interface.

The IPv6 address has to be configured as an EUI-64 address since the last 32 bits in the interface identifier is used as the IPv4 destination address.
Evaluating an IPv6 Multicast environment

- **Client/Server applications**
  Server can be dual stack, serving IPv4 and IPv6 clients.

- **Peer-to-Peer applications**
  All hosts run IPv6

- **Both require an IPv6 Multicast aware infrastructure.**
Enterprise Solutions and Deployments

- Campus deployment scenarios:
  - PIM-SM with RP, PIM-bidir with RP, PIM-SSM
    - scoped PIM domains
  - MLDv1 or MLDv2 with support for EXCLUDE mode

Native IPv6 Multicast

Non-native v6, host<->router

Note: ISATAP does not currently support mcast
Service Provider Solutions and Deployment

- **Intra-AS**
  - With Access Customers
- **Inter-AS:**
  - Among transit or peers

**PIM-SSM with MLDv2**

**PIM-SM**
- embedded RP addressing
- scoped for non-global groups
- shared domains for global groups

**mBGP with v6 mcast SAFI support**
IPv6 over MPLS Infrastructure

- Service Providers have already deployed MPLS in their IPv4 backbone for various reasons
  - MPLS/VPN, MPLS/QoS, MPLS/TE, ATM + IP switching
- Several IPv6 over MPLS scenarios
  - IPv6 Tunnels configured on CE (no impact on MPLS)
  - IPv6 over Circuit_over_MPLS (no impact on IPv6)
  - IPv6 Provider Edge Router (6PE) over MPLS (no impact on MPLS core)
    - Native IPv6 MPLS (require full network upgrade)
- Upgrading software to IPv6 Provider Edge Router (6PE)
  - Low cost and risk as only the required Edge routers are upgraded or installed
  - Allows IPv6 Prefix delegation by ISP
Minimum Infrastructure Upgrade for 6PE

- MPLS/IPv4 Core Infrastructure is IPv6-unaware
- PEs are updated to support Dual Stack/6PE
- IPv6 reachability exchanged among 6PEs via iBGP (MP-BGP)
- IPv6 packets transported from 6PE to 6PE inside MPLS
3GPP/UMTS Release 5: a 6PE application

GPRS Access Network

PS Domain

Applications & Services

alternative Access Network

Legacy mobile signaling network

IPv6 Mandated

Multimedia IP Networks

IM Domain

MPLS offers ATM + IP + IPv6 switching

MS Circuit Switch Access Network

CS Domain

Applications & Services

Signalling Interface

Signalling and Data Transfer Interface

IM Domain is now a sub-set of the PS Domain

*) those elements are duplicated for figure layout purpose only, they belong to the same logical element in the reference model
IPv6 on Broadband Infrastructure Requirements

How do we get the configuration information and prefixes from the ISP provisioning system, to the PE, from the PE to the user CPE, and from the CPE to the end user hosts? Routes for delegated prefixes/addresses also need to be injected into the ISP’s routing system.

Prefix Delegation
Assignment of variable length prefixes
Independent of end user topology
Media independent
Additional Informations (DNS, NTP, SMTP, POP, etc)
DHCPv6 PD

- Media independence
  - eg. ADSL, FTTH
  - Only knows identity of requesting router

- Leases for prefixes

- Flexible deployments
  - Client/Relay/Server model

- Requesting router includes request for prefixes in DHCP configuration request

- Delegating router assigns prefixes in response along with other DHCP configuration information

draft-ietf-ipv6-prefix-delegation-requirement-00.txt
The PE can also send RA's on the PE-CPE link, and the CPE can auto-configure an "uplink" address. Prefix should be different from the prefix assigned to the user.

1. CPE configures addresses on the prefix on its interfaces, and sends an RA. O-bit is set to on.
2. PE sends RADIUS request for the user.
3. RADIUS responds with user's prefix(es).
4. PE sends DHCP REPLY, with Prefix Delegation options.
5. CPE configures addresses from the prefix on its downstream interfaces, and sends an RA. O-bit is set to on.
6. Host configures addresses based on the prefixes received in the RA. As the O-bit is on, it sends a DHCP INFORMATION-REQUEST message, with an ORO = DNS.
7. CPE sends a DHCP REPLY containing request options. Note that the CPE is configured as a DHCP client upstream, and as a DHCP server downstream. The DHCP downstream server acts as a cache, and uses the options received on the upstream interface.
Moving IPv6 to Production, running Cisco IOS

- **Enterprise**
  - WAN: 6to4, IPv6 over IPv4, Dual Stack
  - 6to4 Relay
  - Cable
  - IPv6 over IPv4 Tunnels
- **Residential**
  - DSL, FTTH, Dial
  - IPv6 over IPv4 tunnels or Dual stack
- **Telecommuter**
  - IPv6 over IPv4 tunnels or Dual stack
  - ISATAP
- **Enterprise**
  - Dual Stack or MPLS & 6PE
  - Aggregation
  - IPv6 over IPv4 tunnels or Dedicated data link layers
- **ISP’s**
  - 6Bone
  - IPv6 over IPv4 tunnels or Dedicated data link layers
  - ISP’s
..a lot to do still..

Though IPv6 today has all the functional capability of IPv4:

- Implementations are not as advanced (e.g., with respect to performance, multicast support, compactness, instrumentation, etc.)
- Deployment has only just begun
- Much work to be done moving application, middleware, and management software to IPv6
- Much training work to be done (application developers, network administrators, sales staff,...)
- Some of the advanced features of IPv6 still need specification, implementation, and deployment work
IPv6—Conclusion

Moving IPv6 to Production?

- Core IPv6 specifications are well-tested & stable
  Some of the advanced features of IPv6 still need specification, implementation, and deployment work
- Application, middleware and Scalable Deployment scenario are IPv6 Focus and Challenge.
- Plan for IPv6 integration and IPv4-IPv6 co-existence
  Training, applications inventory, and IPv6 deployment planning
- Cisco is committed to deliver advanced IPv6 capabilities to the Internet industry
  IPv6 Solutions, ABC of IPv6, e-Learning/Training, ISD,…
See http://www.cisco.com/ipv6
Questions?
More Information

• CCO IPv6 - http://www.cisco.com/ipv6
• The ABC of IPv6
  c_abc_ios_overview.html
• IPv6 e-Learning [requires CCO username/password]
• IPv6 Access Services :
  cess_wp_v2.pdf
• ICMPv6 Packet Types and Codes TechNote:
  http://www.cisco.com/warp/customer/105/icmpv6codes.html
• Cisco IOS IPv6 Product Manager – pgrosset@cisco.com
Discover all that’s possible on the Internet