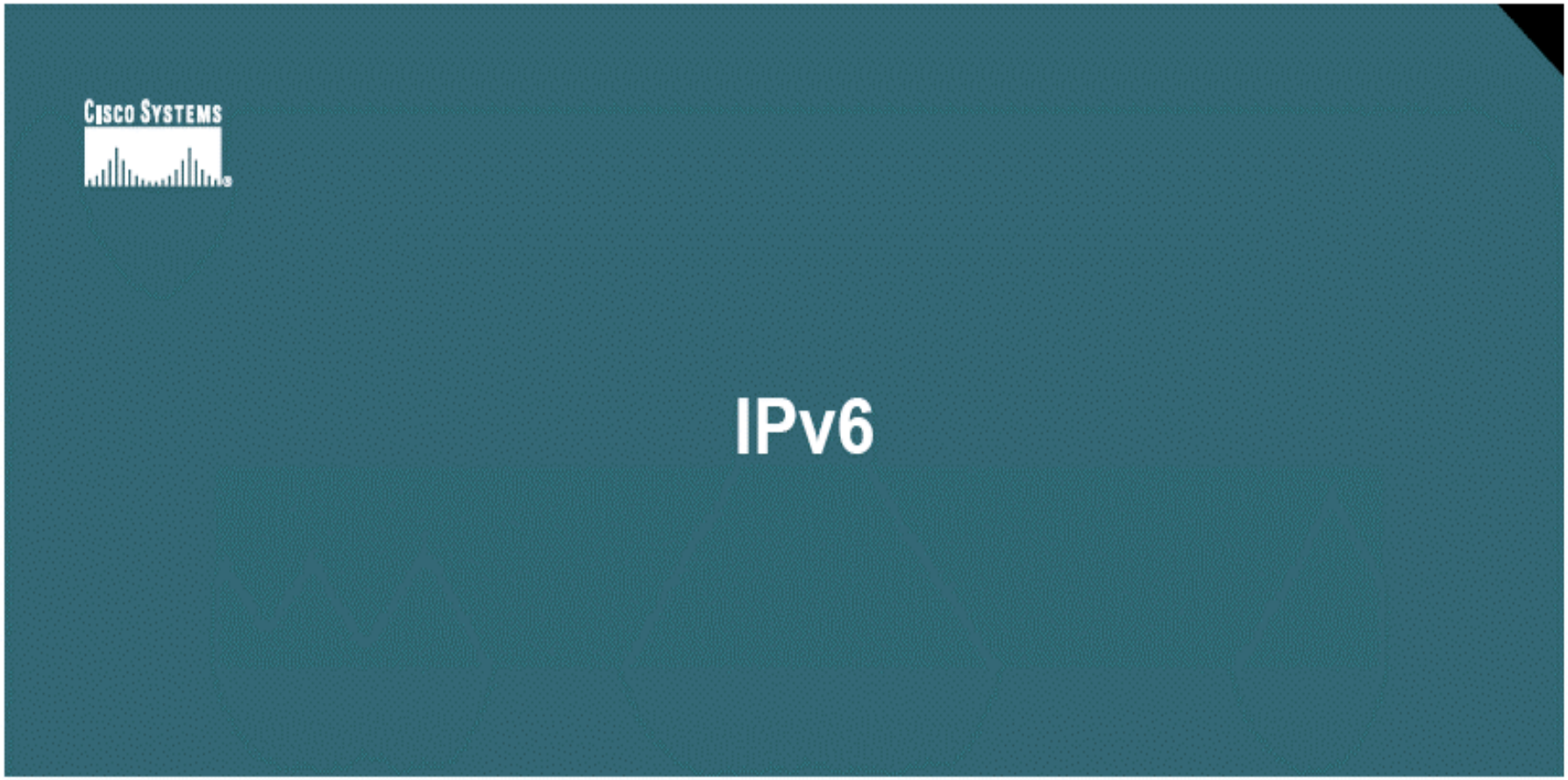

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Agenda

- Why IPv6?
- Adoption Guiding Principles
- IPV6 Deployment Approach
- Case Studies
- Conclusions

Why IPV6?

- Enable new services, innovate, protocol improvement/standards
- Depletion of the global IPV4 address
- Customers are Demanding for IPV6 service
- RFC 1918 – Insufficient address pool
- Adoption of New Services

Why IPv6? – Lesson

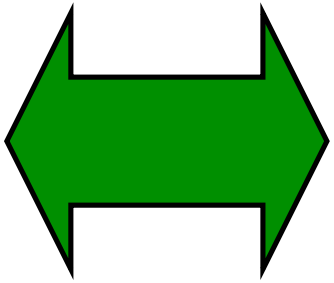
Insufficient private address space (RFC1918)

Argument and **Practice**

Not enough private IPv4 addresses to manage many devices.

Proven true by:

- **Mobile providers (Fixed/Wireless Conv.)**
- **MSOs**
- **Large Enterprises**



MSOs are aggressively pursuing IPv6:

- **Currently testing IPv6 in the core with low traffic**
- **Manage CM, MTAs, setop boxes over IPv6 followed by IPv6 services**

Why IPv6? – Lesson

Re-design old service or deploy new ones.

Argument **and** **Practice**

- **Re-design services that don't seem to scale as expected**
- **Deploy the next generation services**

- **Use of IPv6 multicast to deliver content to schools**
- **Revenue generating, IPv6 multicast based content delivery service.**

IPv6 Deployment – Guiding Principles

- **The migration to IPv6 project has the following principles:**

  Deploying IPv6 must be minimally disruptive to the operations of existing networks and devices

  IPv6 must be included in the roadmap of next generation equipment and devices

  Network operations, infrastructure and systems must become ready to support IPv6-enabled devices

Basic Perspectives

The Network Manager Perspective

Infrastructure focus

Must IPv6 enable their infrastructures (network backbones)

The End-User Perspective

Applications focus

Integration per application model

IP Agnostic

IPV6 Deployment Approach

Training, Training , Training

Test in a small lab environment

IPV6 Deployment Approach

1. Obtain IPv6 address space (/32)
2. Devise an IPv6 address allocation plan
3. Study the available tools for network management and monitoring and establish operational procedures
4. Select the appropriate transition path for IPv6 transport over the provider network infrastructure. (Dual-stack, MPLS/6PE)
   Incremental deployment plan
5. Select the appropriate IPv6 routing protocol and policies

IPV6 Deployment Approach:

6. Deploy necessary transition aids (i.e., 6to4 relay)

7. IPv6 enable required services (DNS, QoS, Multicast)

8. Follow the best practice for secured transition mechanism deployment

IPv6 Deployment Approach

Plan for IPv6 deployment *NOW, Network Readiness Assessment*

Evaluate the impact of IPv6 integration;May be split in several phases

Infrastructure – networking devices

Hosts, Servers and applications

Upgrade costs evaluation and planning

Hardware type, memory size, interfaces, CPU load,…Software version, features enabled, etc

IPv6-capable definition, knowledge of the environment and applications, design goals

A cost analysis: Upgrade expenses for hosts/network devices, human resource, training and project execution; Cost built into normal upgrade cycle

Case Study - NREN

- Primary objective is to deploy IPv6 for Research, enable new services, Protocol Improvement, provide Intellectual Property.
- Architecture: dual-stack at the core, Configured Tunnel/6PE at Regional

  Deployment consists of co-existence and dual stack in the core networks

  Deployment approach:
  Edge to Core initially, now from the core to the edges

  Backbone -> Regional Networks ->CAMPUSes -> Devices
- Follow same operational model as with IPv4

Case Study - MSO (Address Driven)

- **Primary objective is to deploy IPv6 for the IP address of the CM & STB.**
- **Architecture: dual-stack at the core, v6-only at the edges**

  Deployment consists of co-existence and dual stack in the core networks , and IPv6-only at the edge (CM, STB, MTA…) for next gen. devices.

- **Deployment approach: from the core to the edges**

  Backbone -> Regional Networks ->CMTS -> Devices

Case Study - MSO (Address Driven)

This is an incremental deployment; existing deployments will be unaffected in the beginning.

- **Follow the same operational model as with IPv4**

Case Study – Address Driven

MSO deployment of IPv6

- **Problem** – Need more address space to manage devices (Cable Modems, Setop boxes, etc.)
- **Solution** – Deploy IPv6 just for management first and leave the services over IPv4 for now
- **Approach** – Keep the long term goals in mind, deploy dual-stack

Case Study – Address Driven (cont.)

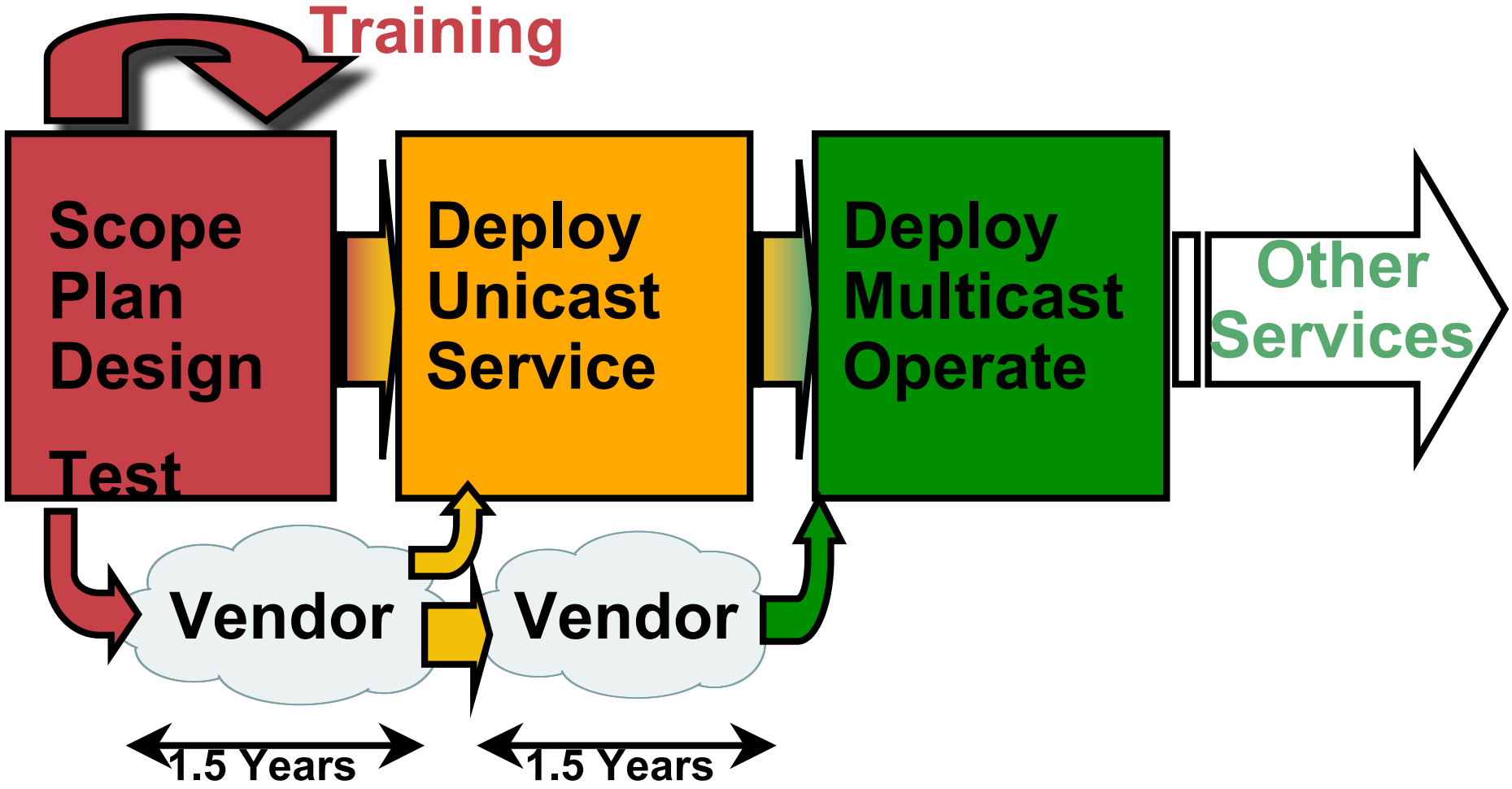
MSO deployment of IPv6

Advantages of this approach:

- **Deployment scope is limited yet immediately useful**
- **Little IPv6 traffic limiting resource contention with IPv4**
- **Closed environment reduces security threat exposure**
- **Prepared the network management and operations tools and policies**
- **Familiarization with the protocol**

Case Study – Address Driven (cont.)

SP deployment of IPv6 – Activities and Timeline



Case Study – ISP (Customer Driven)

- **Primary objective is to deploy IPv6**
  Customers are demanding : enterprise, Mobile etc.
- **Architecture: MPLS core and 6PE, or dual-stack at the core,**
  2001:XXXX::/21
- **/32 per country and /40 per site; /48 customers; /64 all links**

NO Stateless configuration anywhere

Case Study – ISP (Customer Driven)

Deployment consists of co-existence and dual stack in the core networks

Deployment approach:
Edge to Core initially, now from the core to the edges

- Stringent Certification Process and regression testing

Case Study – Service Driven

SP deployment of IPv6

- **Problem – A wholesale SP has a PPP based deployment architecture for broadband access. This infrastructure does not scale for multicast services**
- **Solution – Deploy a native IPv6 infrastructure to deliver multicast based services**
- **Approach – Keep the long term goals in mind, deploy dual-stack. PIM-SSM, MLDv2**

Case Study – Service Driven (cont.)

SP deployment of IPv6

Advantages of this approach:

- **Simplified deployment in a native network**
- **Service separation with this overlay**
- **Closed environment reduces security threat exposure. Used for content distribution**
- **Prepared the network management and operations tools and policies**
- **Opportunity to see the benefits of a native (non-PPP) network**

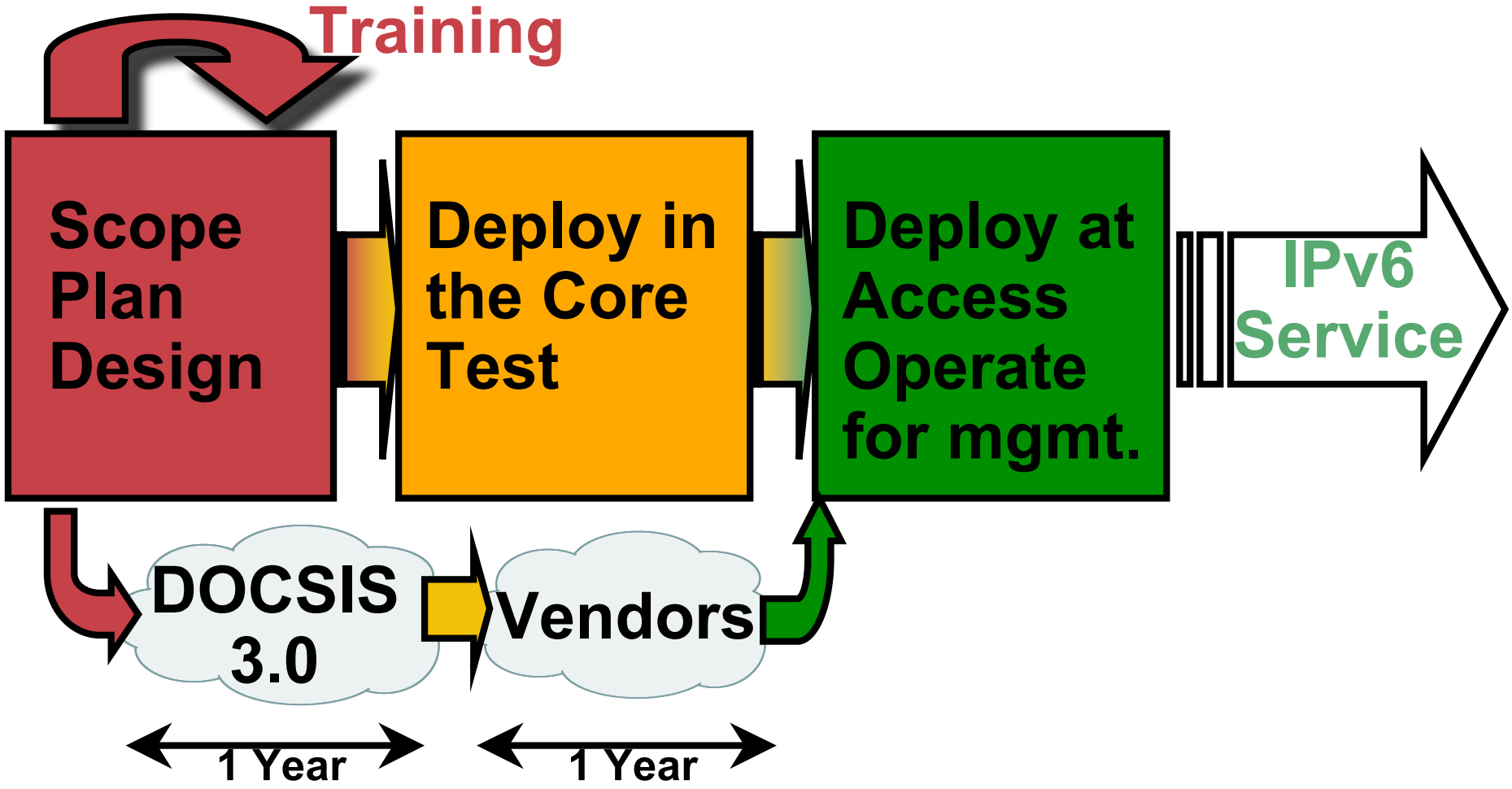
Case Study – Service Driven (cont.)

SP deployment of IPv6 – Lessons

- Start with the long term goal in mind and take small steps towards it. Turn on parts of the network that support IPv6 and expand with the refresh cycle
- Initiate training, design and purchasing policies early
- Engage your vendors to get what you need, existent or future features. Engage early, collaborate
- Two-Three years to roll out the services

Case Study – Address Driven (cont.)

MSO deployment of IPv6 – Activities and Timeline



Case Study – Address Driven (cont.)

MSO deployment of IPv6 – Lessons

- Start with the long term goal in mind and take small steps towards it
- Initiate training, design and purchasing policies early
- Engage your vendors to get what you need, existent or non-existent yet features. Engage early, collaborate
- Two years minimum before having all elements to deploy the full service

IPv6 Strategy that Works

- **Initiate the Education and Training process** –you need knowledgeable staff for the other steps
- **Design your future IPv6 network** – understand where you want to go, identify the feature needs and define purchasing policies
- **Network assessment** – evaluate costs in the light of the IPv6 design
- **Plan the deployment** – grow as the network becomes ready, re-use equipment

Education and Training

Knowledgeable staff makes better decisions

- **Formalized training used to train-the-trainer**
- **Global resources:**
  (http://www.6net.org)
  IPv6 Forum (http://www.ipv6forum.com)
  IPv6 Task Force (http://www.ipv6tf.org)
    - **North- America (http://www.nav6tf.org)**
    - **Europe (http://www.ipv6tf.org/meet/tf/eutf.php)**
    - **Japan (http://www.v6pc.jp/en/index.html)**

IPv6 Deployment Scenario for Enterprises

	Environment	Scenario	Cisco IOS support
WAN	IPv6 services available from ISP	Dual Stack	Yes
	Dedicated Data Link layers, eg. LL, ATM & FR PVC, dWDM Lambda	Dual Stack	Yes
	No IPv6 services from ISP or experimentation – few sites	Configured Tunnels	Yes
	No IPv6 services from ISP or experimentation – many sites, any to any communication	6to4	Yes
Campus	L3 infrastructure – IPv6 capable	Dual Stack	Yes
	L3 infrastructure – not IPv6 capable, or sparse IPv6 hosts population	ISATAP	Yes

IPv6 Deployment Scenario for ISP

	Environment	Scenario	Cisco IOS support
Access	Few customers, no native IPv6 service form the PoP or Data link is not (yet) native IPv6 capable, ie: Cable Docsis	Tunnels	Yes
	Native IPv4-IPv6 services between aggregation and end-users	Dual Stack	Yes
	Dedicated circuits – IPv4 – IPv6	Dual Stack	Yes
Core	Native IP – Core is IPv6 aware	Dual Stack	Yes
	MPLS – Core is IPv6 unaware	6PE/6VPE	Yes

Network Assessment

- A key and mandatory step to evaluate the impact of IPv6 integration
- May be split in several phases
  - Infrastructure – networking devices
  - Hosts, Servers and applications
- Must be as complete as possible to allow upgrade costs evaluation and planning
  - Hardware type, memory size, interfaces, CPU load,…
  - Software version, features enabled, license type,…
- Difficult to complete if a set of features is not defined per device's category for a specific environment
  - IPv6-capable definition, knowledge of the environment and applications, design goals

Assessment Example: IPv6 Router Performances

Dual-stack means adding more load on a given device

- **Control Plane**

  Software – CPU and memory shared by routing protocols, network management tasks

- **Services (Packet filtering, QoS, Encryption,…)**

  Hardware or software – service dependent – same rules as IPv4 – but hardware must know how to perform deep lookup

- **Data Plane**

  Hardware or software – same rules as IPv4. Forwarding packets from input to output interfaces, address lookup,…

  Line rate up to OC-768 (CRS-1), 10Gb/s (C12000, C7600, C6500) – C3750/3560, C10720 and C10000 – sharing physical layer

Cost Analysis

- A cost analysis must include the upgrade expenses for elements such as hosts and network devices, but also labour for project planning, education and execution
- Cost to build a new network or to execute a “one shot” full network upgrade is far higher than working through products recycling and purchasing policies
- Applications should be developed as IP Agnostic to reduce the cost of future upgrade

Plan the Deployment

After all it is a new protocol in the network

- **Phased approach**
- **Start with parts of the network and with less ambitious services**
- **Initiate trials with little traffic (use it for aspects of management, internal content for the web browser)**
- **Benchmark your network at every step**

Conclusions

- **IPv6 is an Evolution not a Revolution, GO FOR IT.**