
CISCO SYSTEMS

ITU IPv6 Tutorial
Transition Scenarios

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Agenda

- IPv6 In Short
- IPv6 Co-existence and Transition
- IPv6 Deployment Scenarios
- Conclusion

IPv6
The Essentials ☺

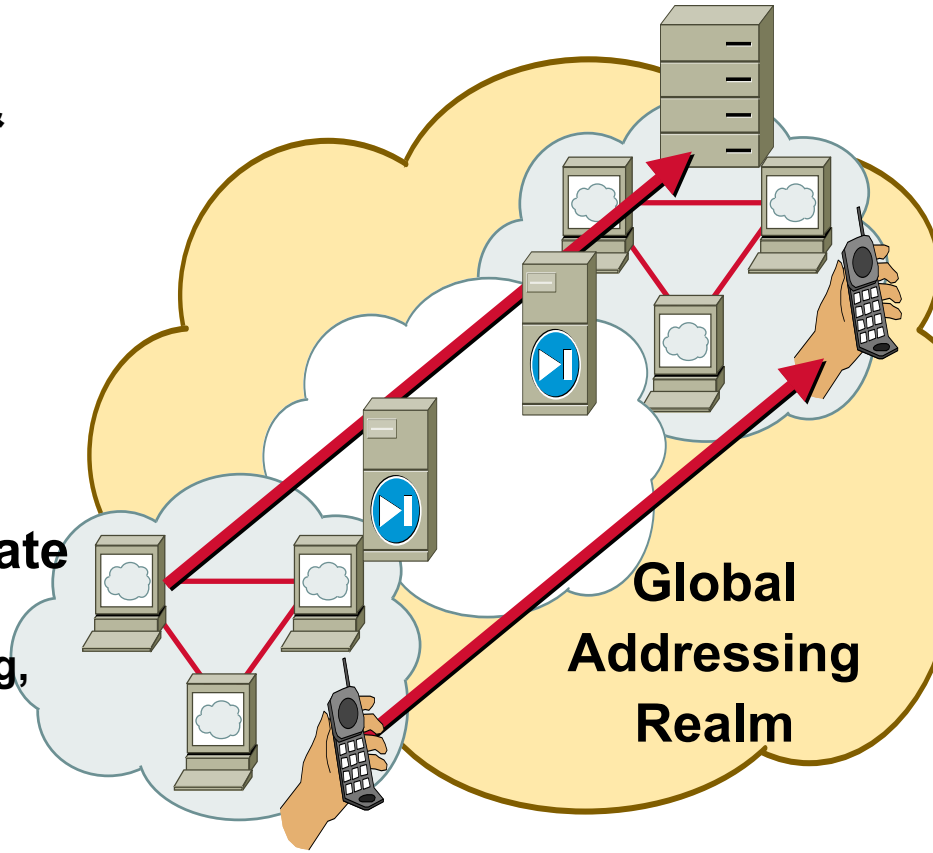
IPv6 Business Case

Only compelling reason: more IP addresses!

For billions of new users & new consumer's devices (Asia, Europe & America) & (mobile phones, cars, PDAs, home & industrial appliances,…)

For always-on access
(cable, xDSL, wireless, ethernet-to-the-home,…)

For applications that are difficult, expensive, or impossible to operate through NATs
(IP telephony, IP Fax, peer-to-peer gaming, home servers,…)



Integration of IPv6 Services

Large Address Space

The Ubiquitous Internet

Auto-Configuration

Enhanced Mobility

Summary

- Compelling reason of IPv6 = address space
- IPv4 will stay there for long time
  - Current networks, applications, knowledge and experience
- New areas require IPv6 adoption quickly
  - Geopolitical reasons
  - Business choice (competition, services)
  - Technological (real limitations)

IPv4-IPv6 Coexistence
IPv4 to IPv6 Transition

IPv4-IPv6 Co-Existence / Transition

- A wide range of techniques have been identified and implemented, basically falling into three categories:

  (1) techniques, to allow IPv4 and IPv6 to co-exist in the same devices and networks

  (2) techniques, to avoid order dependencies when upgrading hosts, routers, or regions

  (3) techniques, to allow IPv6-only devices to communicate with IPv4-only devices

- Expect all of these to be used, in combination

First define what is expected

IPv6 Transition – Tasks & Methods

- **Connect IPv6 Islands/Nodes over existing Infrastructure with IPv6 Nodes**

  Tunneling: Manually or automagically configured – 6to4, ISATAP, ...

  IPv6 over dedicated Link-Layer: ATM/FR/SDH/WDM or AToM/L2TPv3

  Dual-Stacked Network (i.e. hosts and routers)

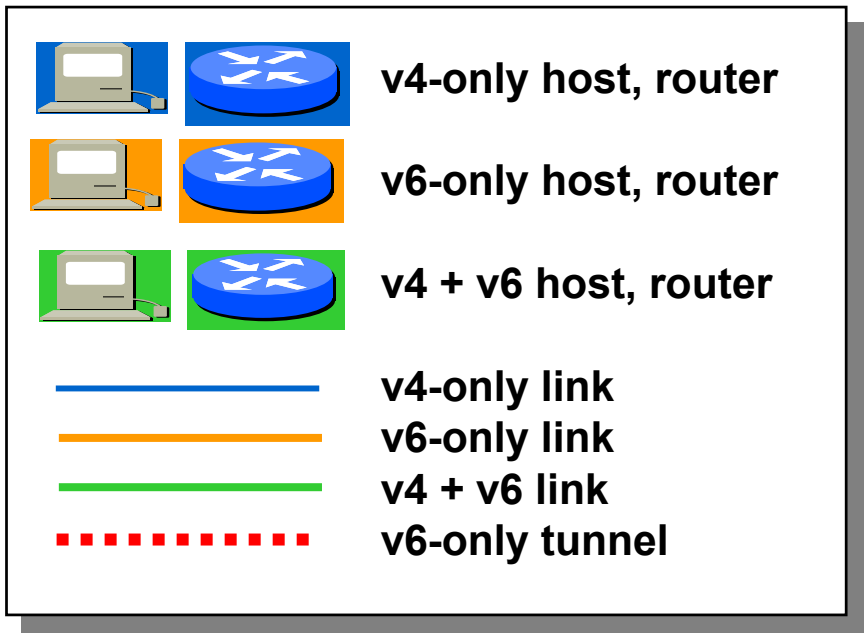
  IPv6 over MPLS: 6PE

Legend

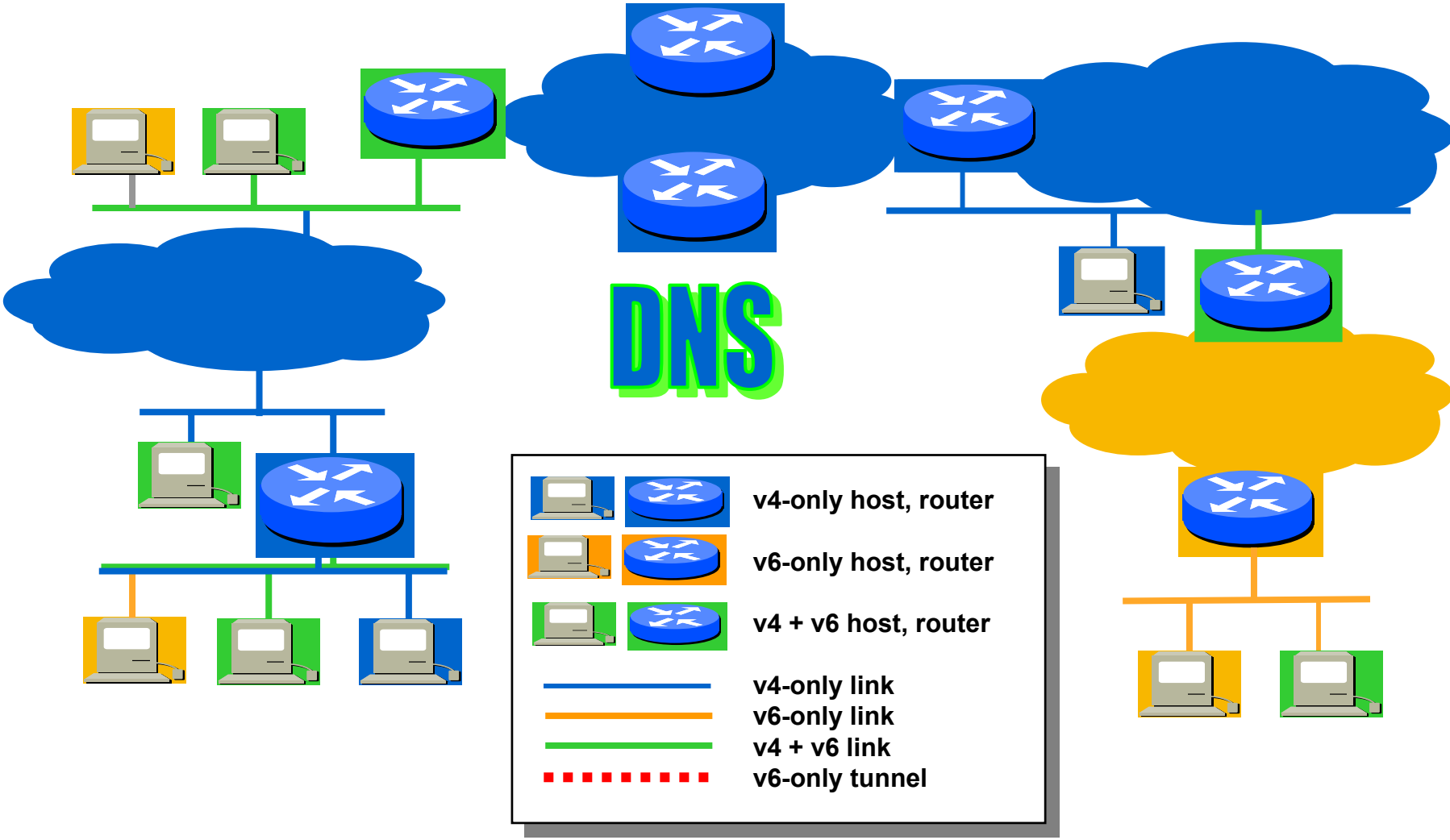
IPv6 only Domain

IPv6 and v4 Domain

IPv4 only Domain



IPv4 and v6 Mixed Networks



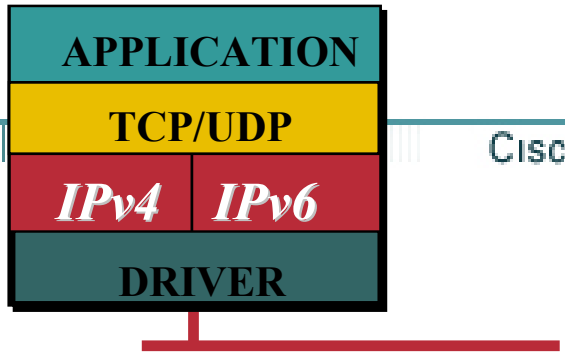
IPv6 and DNS

	IPv4	IPv6
Hostname to IP address	A record: www.abc.test. A 192.168.30.1	AAAA record: www.abc.test AAAA 3FFE:B00:C18:1::2 A6 record (now experimental) www.abc.test A6 0 3FFE:B00:C18:1::2
IP address to hostname	PTR record: 1.30.168.192.in-addr.arpa. PTR www.abc.test.	PTR record: 2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.1.0.0.0.8.1.c.0.0.0.b.0.e.f.f.3.ip6.int. PTR www.abc.test. (now experimental) \[x3ffe0c000c1800010000000000000002 /128].ip6.arpa. PTR www.abc.test.

NGTrans Working Group

- Document operational requirements and recommended practises for major pieces of the Internet infrastructure in a mixed world of IPv4 only, IPv6 only and dual stack nodes.
- Serve as a review board and body of competence and coordination for IPv6 transition and operational issues that span multiple IETF working groups.
- Keep all IPv6 transition tool documents moving along publication / standardization track.
- http://www.ietf.org/html.charters/ngtrans-charter.html
- http://www.6bone.net/ngtrans/

Dual-Stack Approach



- When adding IPv6 to a system, do not delete IPv4
  - this multi-protocol approach is familiar and well-understood (e.g., for AppleTalk, IPX, etc.)
  - note: in most cases, IPv6 will be bundled with new OS releases, not an extra-cost add-on
- Applications (or libraries) choose IP version to use
  - when initiating, based on DNS response:
    - if (dest has AAAA or A6 record) use IPv6, else use IPv4 (or inverse)
  - when responding, based on version of initiating packet
- This allows indefinite co-existence of IPv4 and IPv6, and gradual, app-by-app upgrades to IPv6 usage

Dual-stack in Routers

- To route IPv4 and IPv6 packets
- As in IPv4, IPv6 has two families of routing protocols: IGP and EGP

  IGPs are RIPng (RFC 2080), OSPFv3 (RFC 2740) and Integrated IS-ISv6 (draft-ietf-isis-ipv6-02.txt) plus proprietary protocols like EIGRPv6 should be available in 2002

  EGP is MP-BGP4 (RFC 2858 and RFC 2545)
- IPv4 and IPv6 routing protocols can work separately or simultaneously

  Integrated versus “Ships in the Night”
- Routers do not only do routing: IPv6 features

  same, equivalent or others than for IPv4

Translations

- SIIT : IP header translation (RFC 2765)
- NAT-PT (RFC 2766)
- BIS : Bump-In-The-Stack (RFC 2767)
- TRT : Transport Relay Translator (RFC 3142)

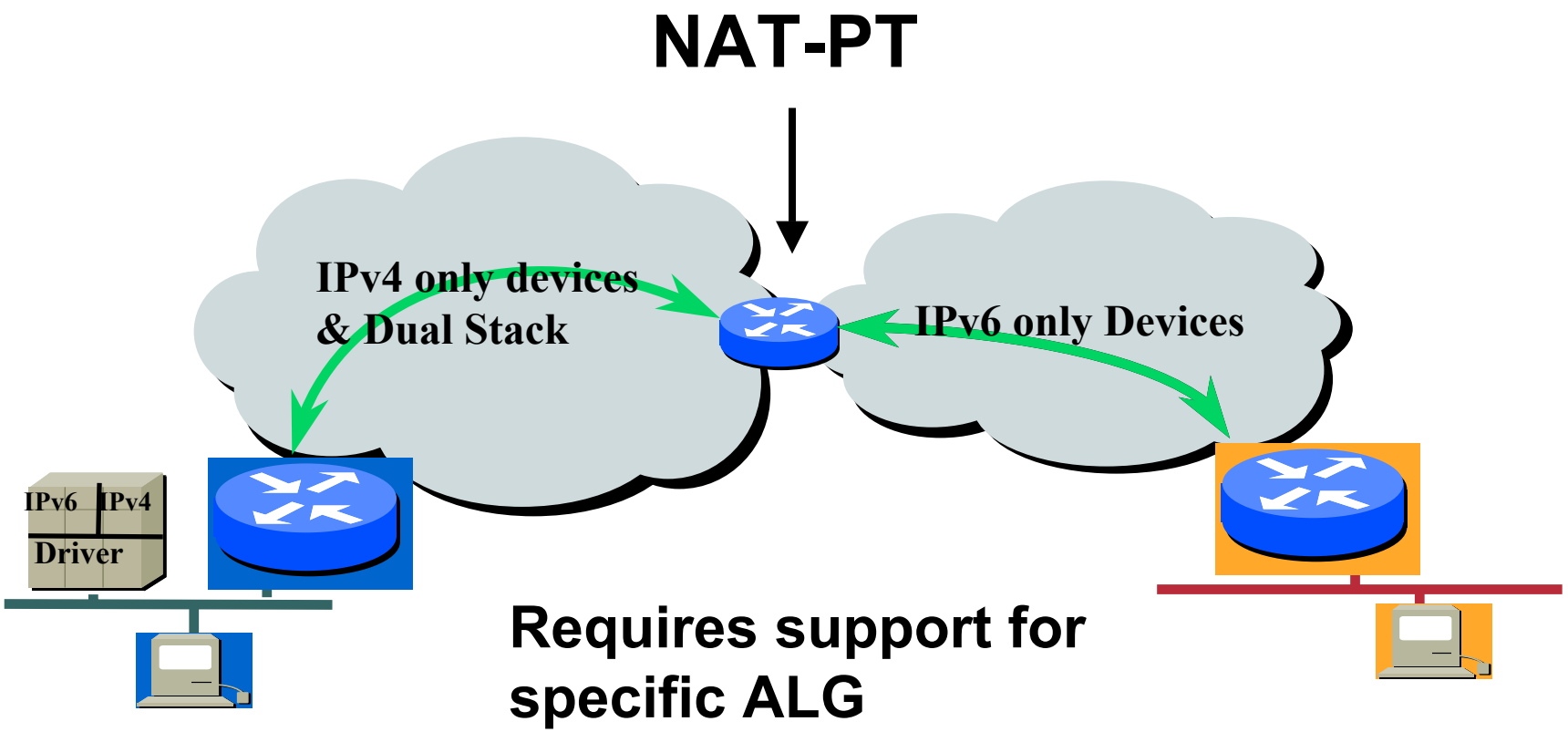
Translation

- **May prefer to use IPv6-IPv4 protocol translation for:**
  - **new kinds of Internet devices (e.g., cell phones, cars, appliances)**
  - **benefits of shedding IPv4 stack (e.g., serverless autoconfig)**
- **This is a simple extension to NAT techniques, to translate header format as well as addresses**
  - **IPv6 nodes behind a translator get full IPv6 functionality when talking to other IPv6 nodes located anywhere**
  - **they get the normal (i.e., degraded) NAT functionality when talking to IPv4 devices**
  - **methods used to improve NAT functionality (e.g, ALGs, RSIP) can be used equally to improve IPv6-IPv4 functionality**

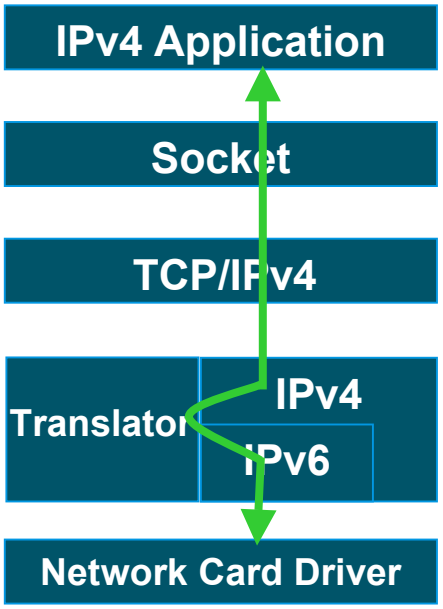
NAT-PT for IPv6

- NAT-PT (Network Address Translation - Protocol Translation) - RFC 2766
- NAT-PT allows native IPv6 hosts and applications to communicate with native IPv4 hosts and applications, and vice versa.
- easy-to-use transition and co-existence solution

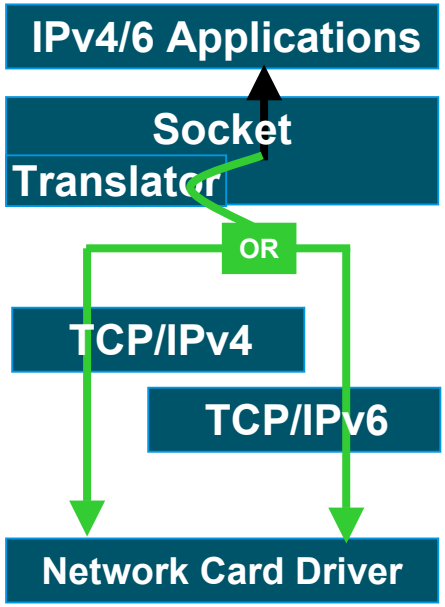
IPv4-IPv6 Alternative Transition: NAT-PT



Host Based Dual Stack Approach



BIS
No IPv6 stack
Apps are IPv4



BIA
Dual stack host but
some apps are not IPv6-ready

- **Bump-In-the-Stack (RFC 2767)**
- **Bump-In-the-API (draft-ietf-ngtrans-bia-05.txt)**

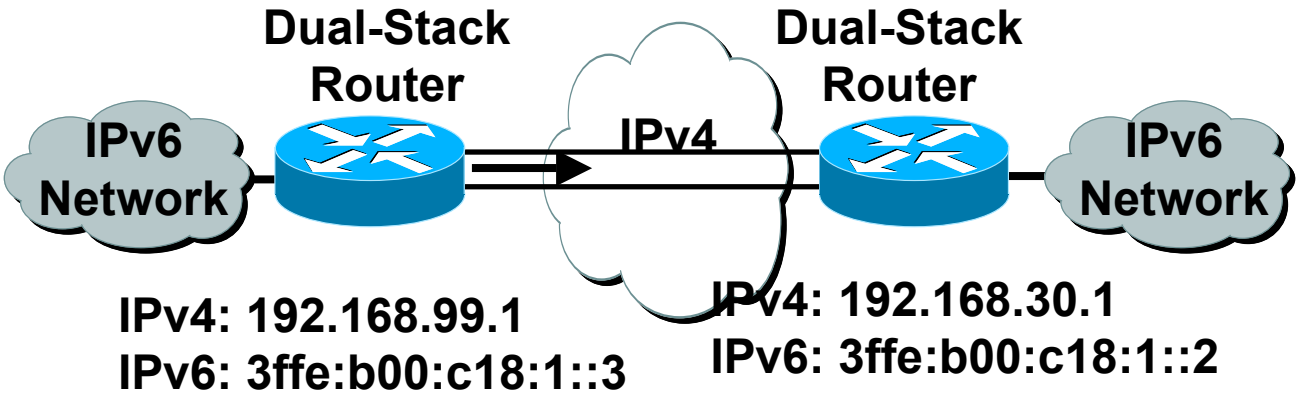
Tunnelling Methods

- Different modes
  - Configured (manual) tunnels
  - Automatic tunnels
- Different tools
  - 6over4 (RFC 2529)
  - Tunnel Broker (RFC 3053)
  - 6in4 (v6 in v4 Tunnel)
  - 6to4 (RFC 3056)
  - BGP tunnelling (e.g. MPLS 6PE)
  - ISATAP

Tunnels to Get Through IPv6-Ignorant Routers / Switches

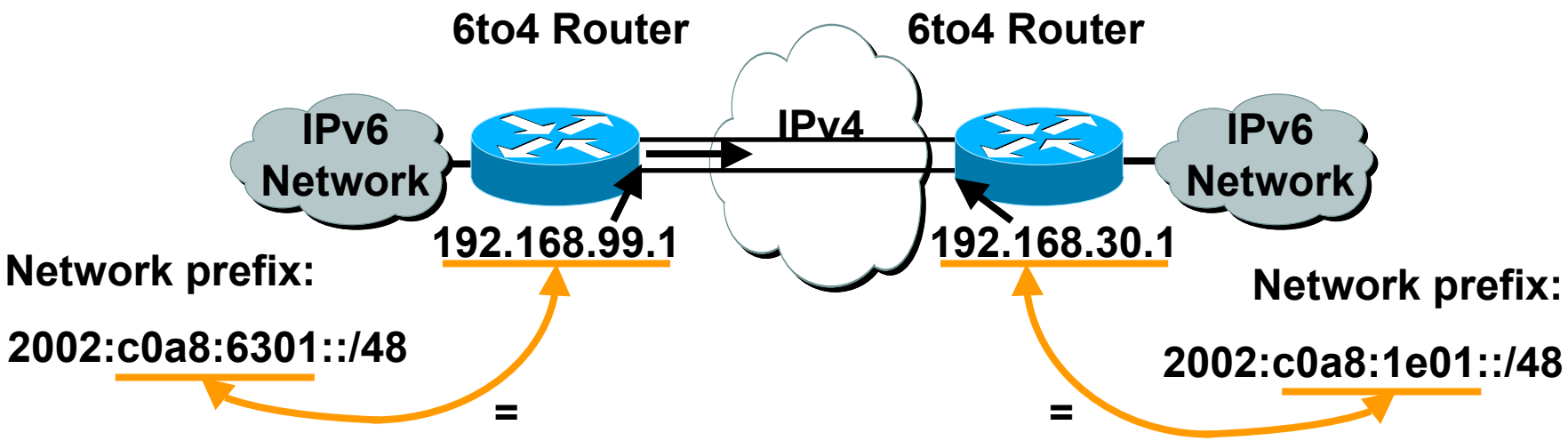
- Encapsulate IPv6 packets inside IPv4 packets (or MPLS frames)
- any methods exist for establishing tunnels:
  - manual configuration
  - “tunnel brokers” (using web-based service to create a tunnel)
  - “6-over-4” (intra-domain, using IPv4 multicast as virtual LAN)
  - “6-to-4” (inter-domain, using IPv4 addr as IPv6 site prefix)
- Can view this as:
  - IPv6 using IPv4 as a virtual link-layer, or
  - an IPv6 VPN (virtual public network), over the IPv4 Internet (becoming “less virtual” over time, we hope)

Configured Tunnel



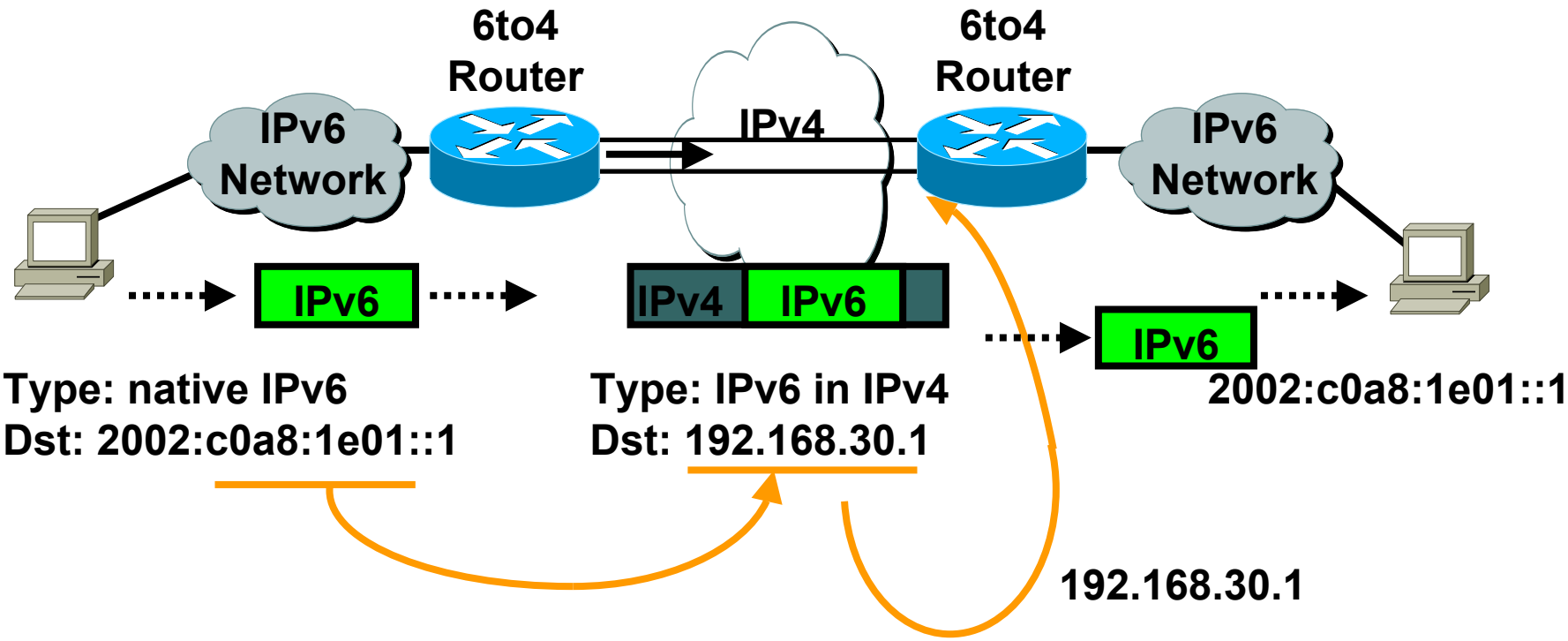
- **Configured tunnels require:**
  - **Dual stack end points**
  - **Both IPv4 and IPv6 addresses configured at each end**

6to4 Tunnel

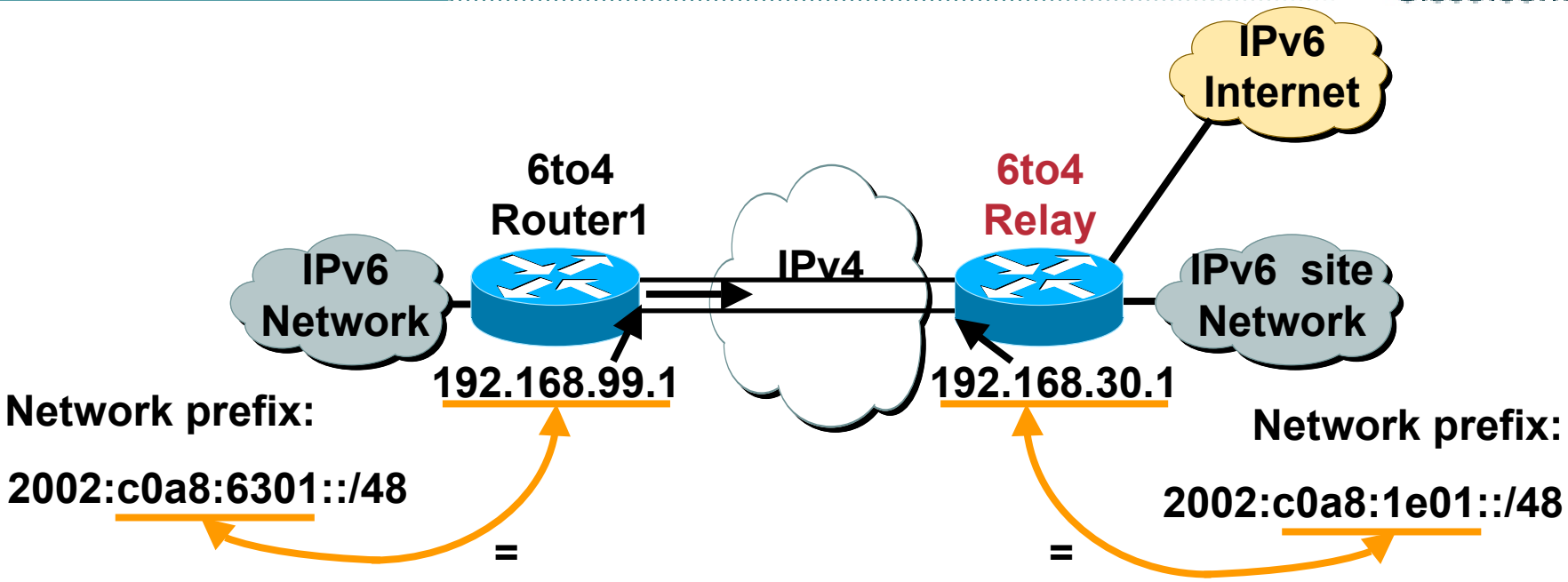


- **6to4 Tunnel:**
  - **Is an automatic tunnel method**
  - **Gives a prefix to the attached IPv6 network**

6to4 Tunnel (Cont.)

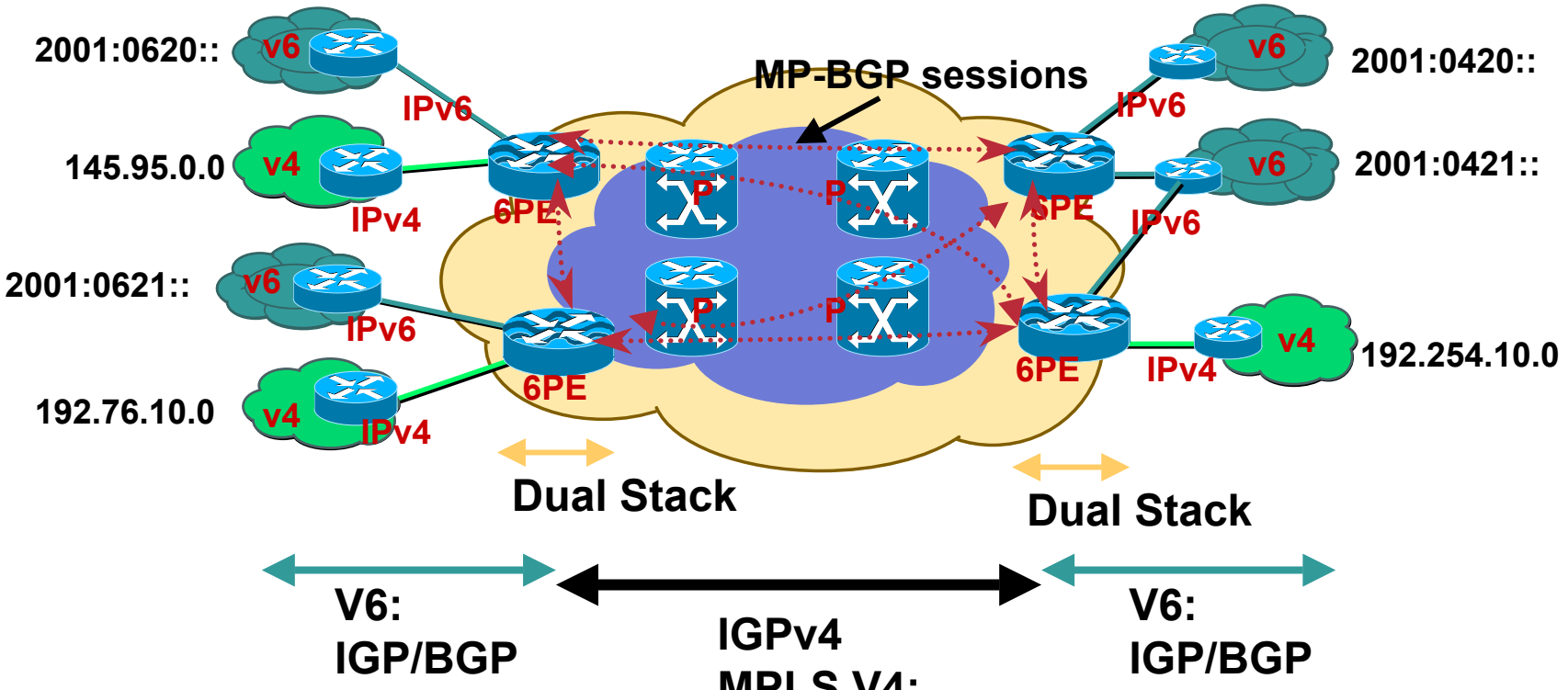


6to4 Relay



- **6to4 relay:**
  - **Is a gateway to the rest of the IPv6 Internet**
  - **Default router**

6PE Overview



GP tunneling
raft-ietf-ngtrans-bgp-tunnel-04.txt

IPv6 unaware
No core upgrade

ISATAP

- Intra-Site Automatic Tunnel Adressing Protocol
- Connect IPv6 nodes to IPv6 routers within a predominantly IPv4 environment
- Ideal for sparse distribution of IPv6 nodes
- E.g. Campus Networks with IPv4-only L3-Switches
- draft-ietf-ngtrans-isatap-04.txt

Other (mixed) tools

- **Teredo/Shipworm**
  - **Tunneling IPv6 over UDP through IPv4 NATs**
  - **draft-ietf-ngtrans-shipworm-05.txt**
- **DSTM (Dual Stack Transition Mechanism)**
  - **DS host in IPv6-only network to IPv4-only host**
  - **Tunnel IPv4 in IPv6**

NGtrans projects status (IETF-52)

- MECH - at PS, working on how to move to DS
- SIIT - at PS, about to work on how to move to DS
- NAT-PT - at PS, new concerns
- 6TO4 - at PS waiting on more experience to move to DS
- 6TO4-ANYCAST – at PS waiting on more experience to move to DS
- 6TO4-DNS-00 - what next?
- 6TO4-DSTM-00 - waiting further work, ID timed out
- 6TO4-MULTICAST-00 - finished wg last call, wait new draft to forward to IESG (Mar 01), ID timed out
- BGP-TUNNEL-03 – what next?
- BIA-01 – ready for last call?
- DNS-OPS-REQ-03 - waiting discussion outcome
- DSTM-05 – decoupled from DHCPv6 work, what next?
- DSTMEXT1-AIIH-00 - waiting further work on DSTM, ID timed out
- HOMETUN-01 - waiting for wg comments, ID time out
- INTERACTION-00 - waiting further work, ID timed out
- IPv4SURVEY-01 - waiting further work and next draft
- IPv6-SMTP-REQUIREMENT-04 – changes to reforward?
- ISATAP-02 - waiting further work
- MIME-TYPE-03 – wait new draft then issue wg last call for PS
- MOVING-00 - waiting further work
- MTP-00 - waiting further work
- NATREQ4IPv6-00 – what next? ID timed out
- SHIPWORM-03 – at IESG for midcom eval
- SIIT-DSTM-01 - waiting further work
- TRANSITION-07 – ready for wg last call for Info

NGtrans WG status (IETF-52)

- **Major attempt to refocus group**

  WG has generated many specs and techniques (half a dozen tunneling schemes, multiple translation and dual-stack approaches)

  Is both too much and too little? (numerous redundant mechanisms, but possibly still some gaps)

  All current drafts-in-progress are being frozen, and group asked to develop transition/interoperation scenarios first, and then show how specific techniques fit into those scenarios

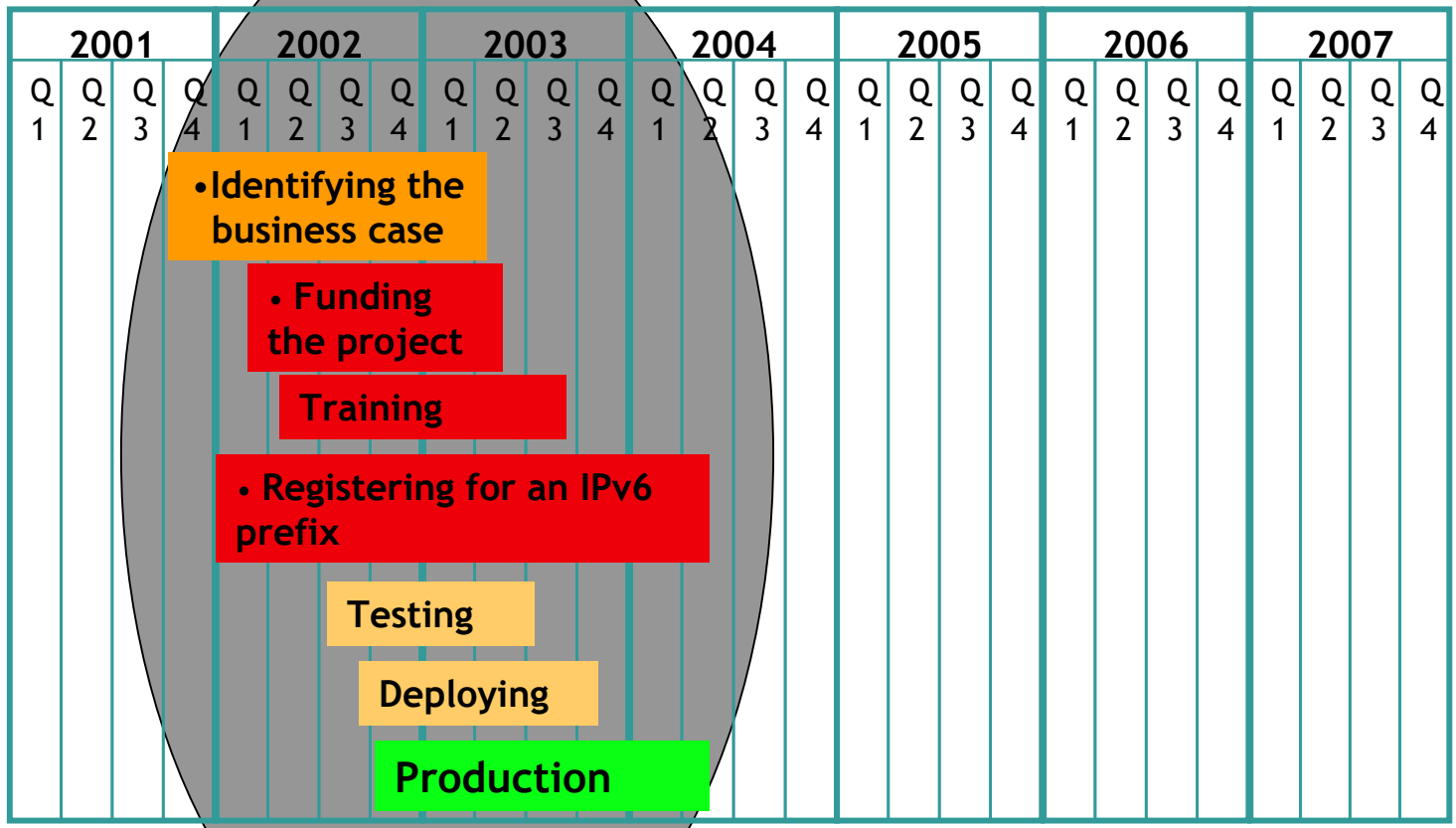
  Document how to use those tools in major transition scenarios and document how those tools interact together.

Summary

- No one way to go to IPv6
- Multiple factors before to decide
- IPv4 will still live for a while
- Need tools to support any evolution to IPv6
- Need to limit the number of tool to avoid overlapping and in guaranteeing their interaction

IPv6 Deployment

An IPv6 project Timeline
(A pragmatic projection)



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

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**

Deployment of IPv6 Services:
What our Customers are saying !

Satisfy Business Drivers, a.k.a. Applications requiring end-to-end IPv6 traffic forwarding, geographies with registry allocations issues

No Flag Day

No Performance Penalty, implementation must be scalable and reliable

Minimize operational upgrade costs and training expenses

- **Investment Protection & Low startup cost**

Incremental Upgrade/Deployment

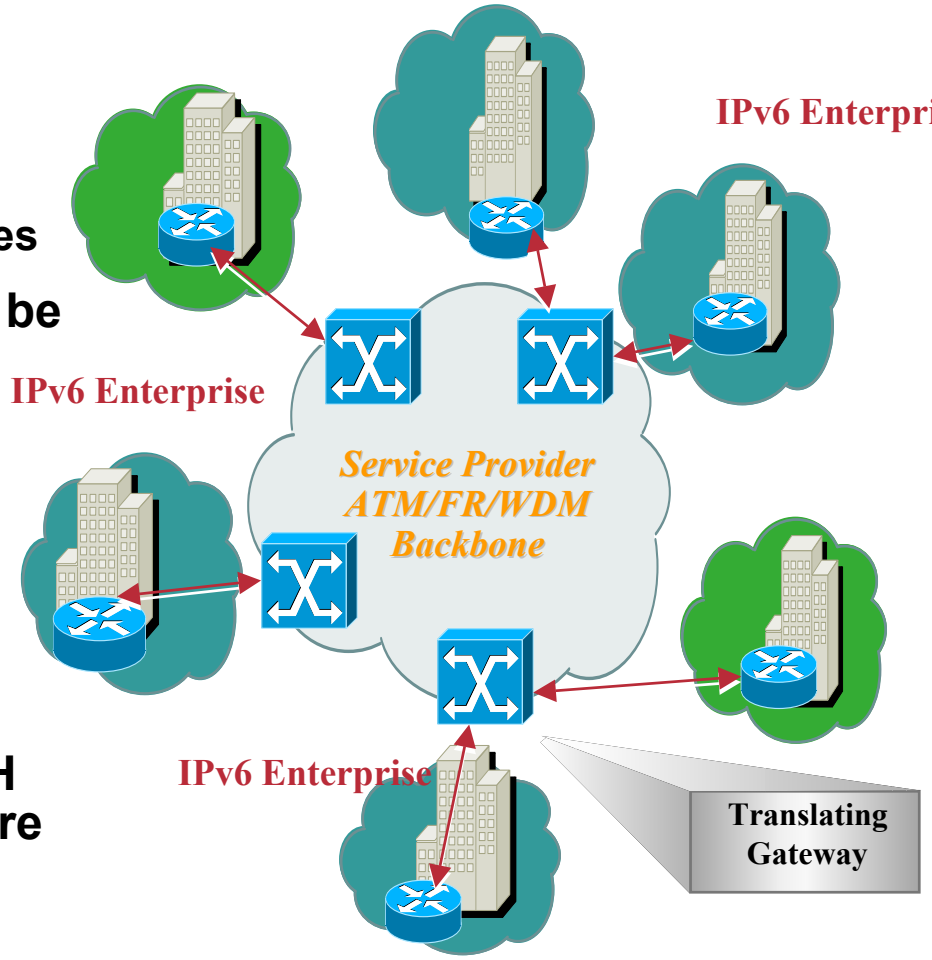
- **Preserve IPv6 - IPv4 connectivity/transparency**

Strategy that reflects this …

Starting with Edge upgrades enable IPv6 service offerings now

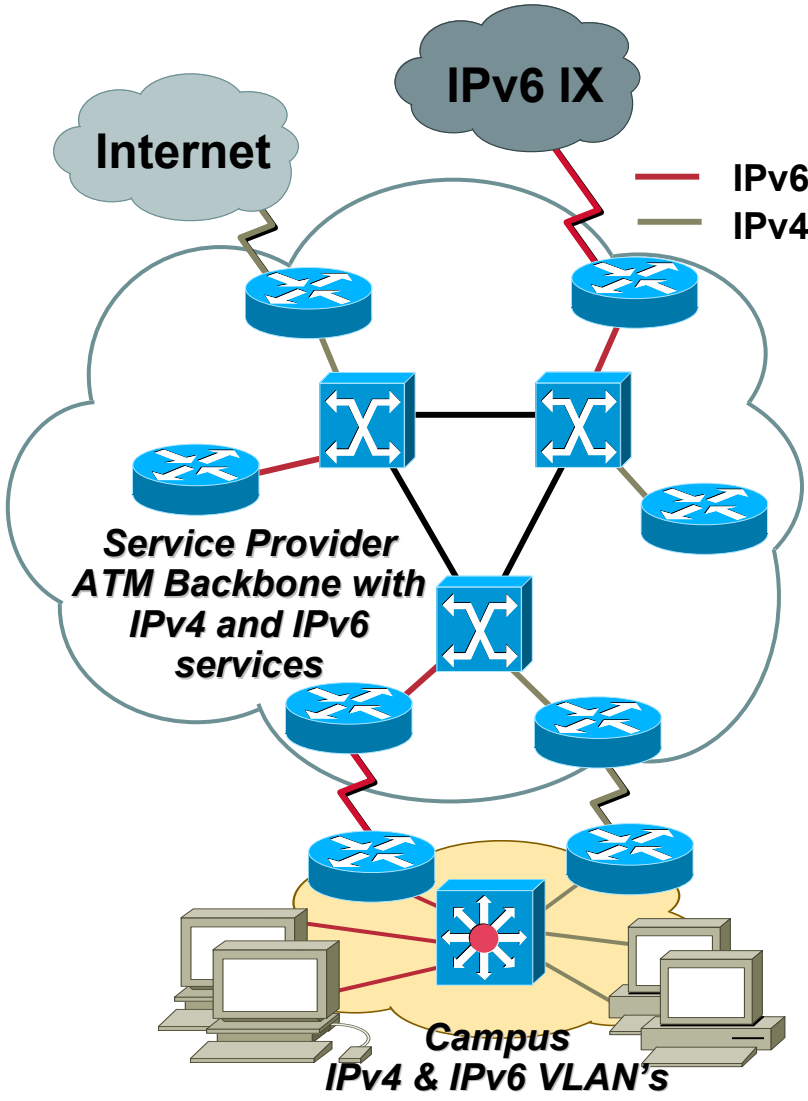
Native IPv6 over Dedicated Links

- **Native IPv6 links over dedicated infrastructures**
  - **No impact on IPv4 traffic and revenues**
- **Any Cisco IOS 12.2(1)T routers can be configured**
  - **ATM & Frame Relay PVC's**
  - **Serial Lines, Sonet/SDH, FE/GE**
- **Cisco 12000 with Sonet/SDH interfaces can get IPv6 support**
  - **Today, EFT on private 12.0ST branch**
- **IPv6 over FE/GE, ATM or Sonet/SDH can run over an optical infrastructure (dedicated lambda)**



Native IPv6 over Dedicated Data Links Case Study

- **ISP scenario**
  - Dedicated Data Links between Core routers
  - Dedicated Data Links to IPv6 Customers
  - Connection to an IPv6 IX
- **Enterprise scenario**
  - Experimental LAN segment, eg. Dedicated Ethernet or VLAN
  - Between Campus over a MAN infrastructure

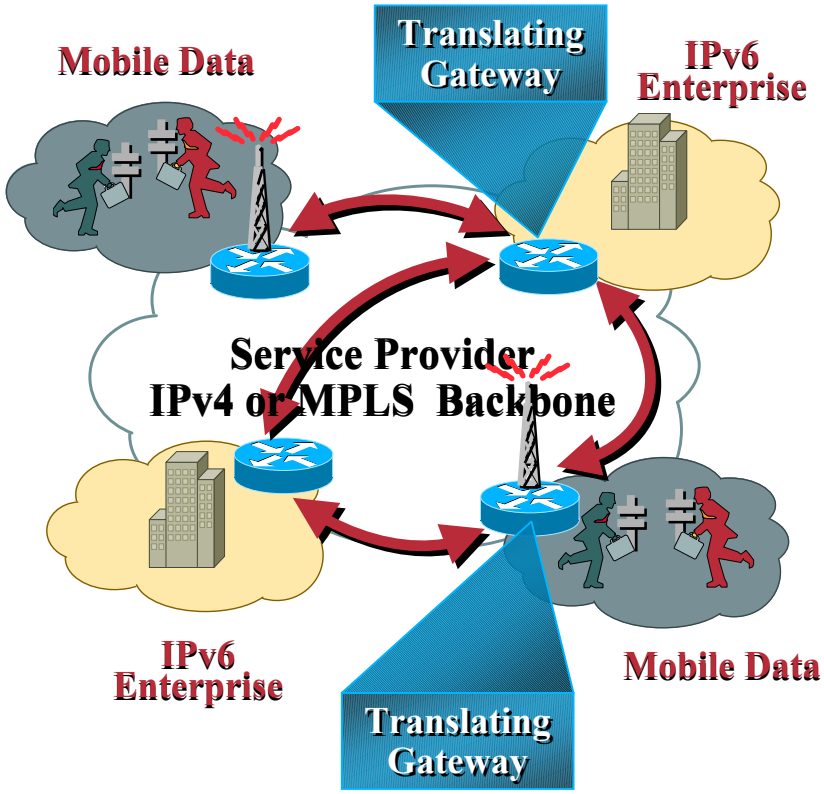


IPv6 Tunnels over IPv4 or MPLS Infrastructure

- IPv6 over IPv4 Internet
  - ala 6Bone
- Any Cisco IOS 12.2(1)T routers can be used as IPv6 router
  - 6to4 Tunnel
  - Manual Tunnel
  - Automatic Tunnel
- Leveraging defined Tunneling Technology
- No impact on existing IPv4 or MPLS infrastructure
  - using high-speed POS interfaces

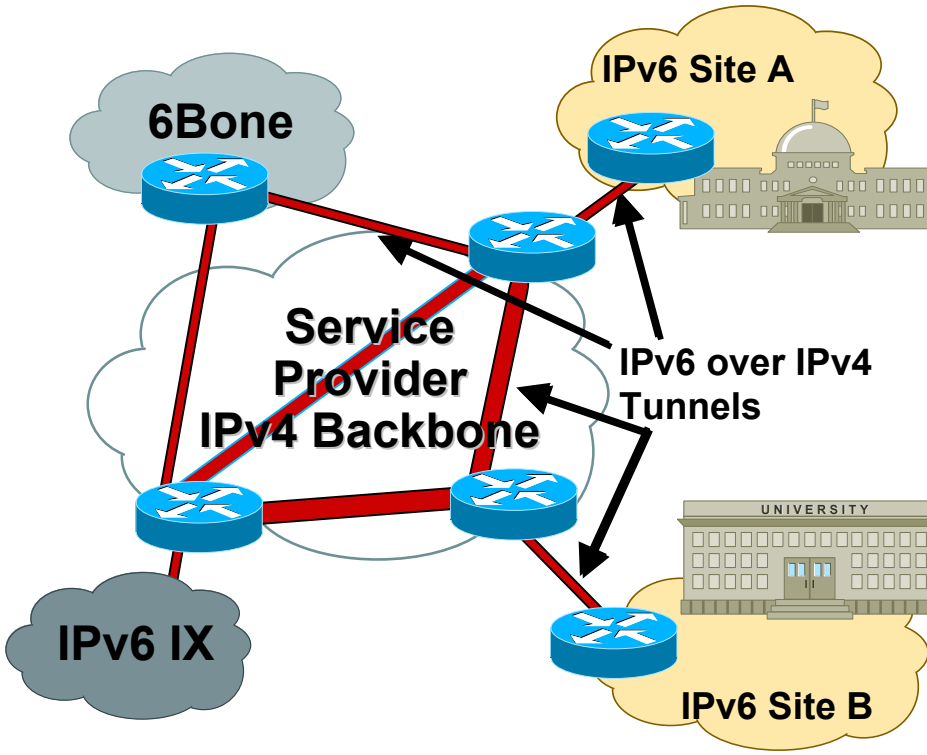
Edge IPv6 Infrastructure:

IPv6 over IPv4 Internet:



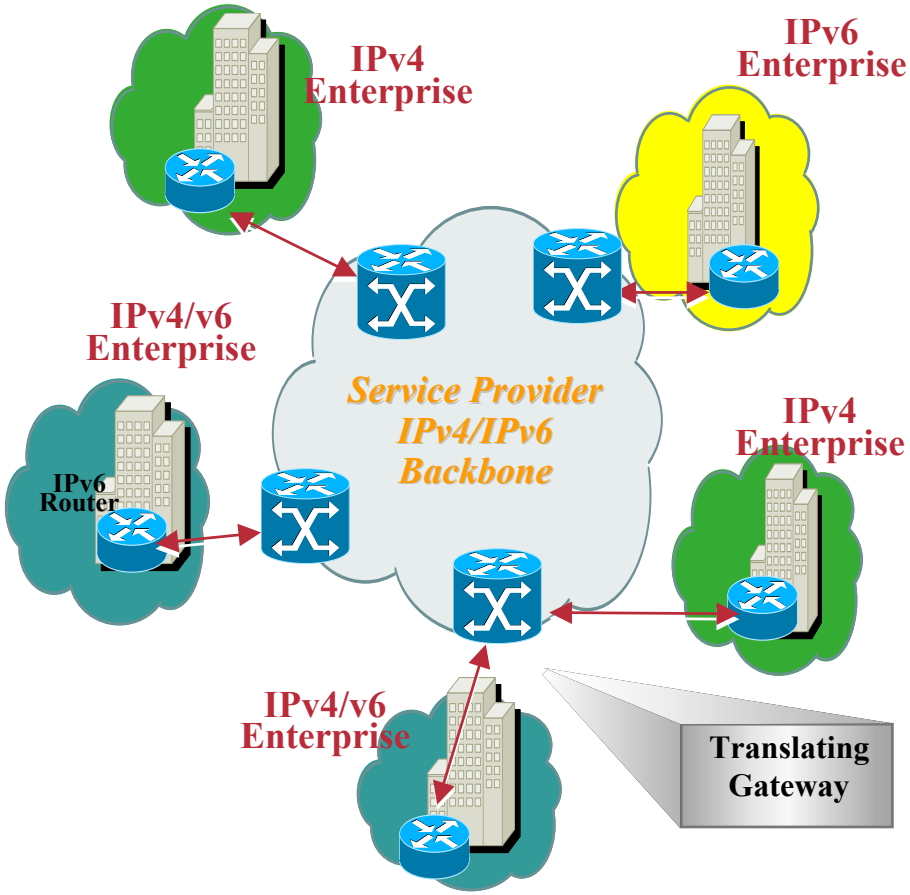
IPv6 over IPv4 Tunnels Case Study

- ISP scenario
  - Configured Tunnels between IPv6 Core Routers
  - Configured Tunnels to IPv6 Customers
  - MP-BGP4 Peering with other 6Bone users
  - Connection to an IPv6 IX
  - 6to4 tunnels to IPv6 Customers
  - 6to4 relay service
- Enterprise scenario
  - 6to4 tunnels between sites
  - Or ISATAP in Campus
  - Configured tunnels between sites or to 6Bone users

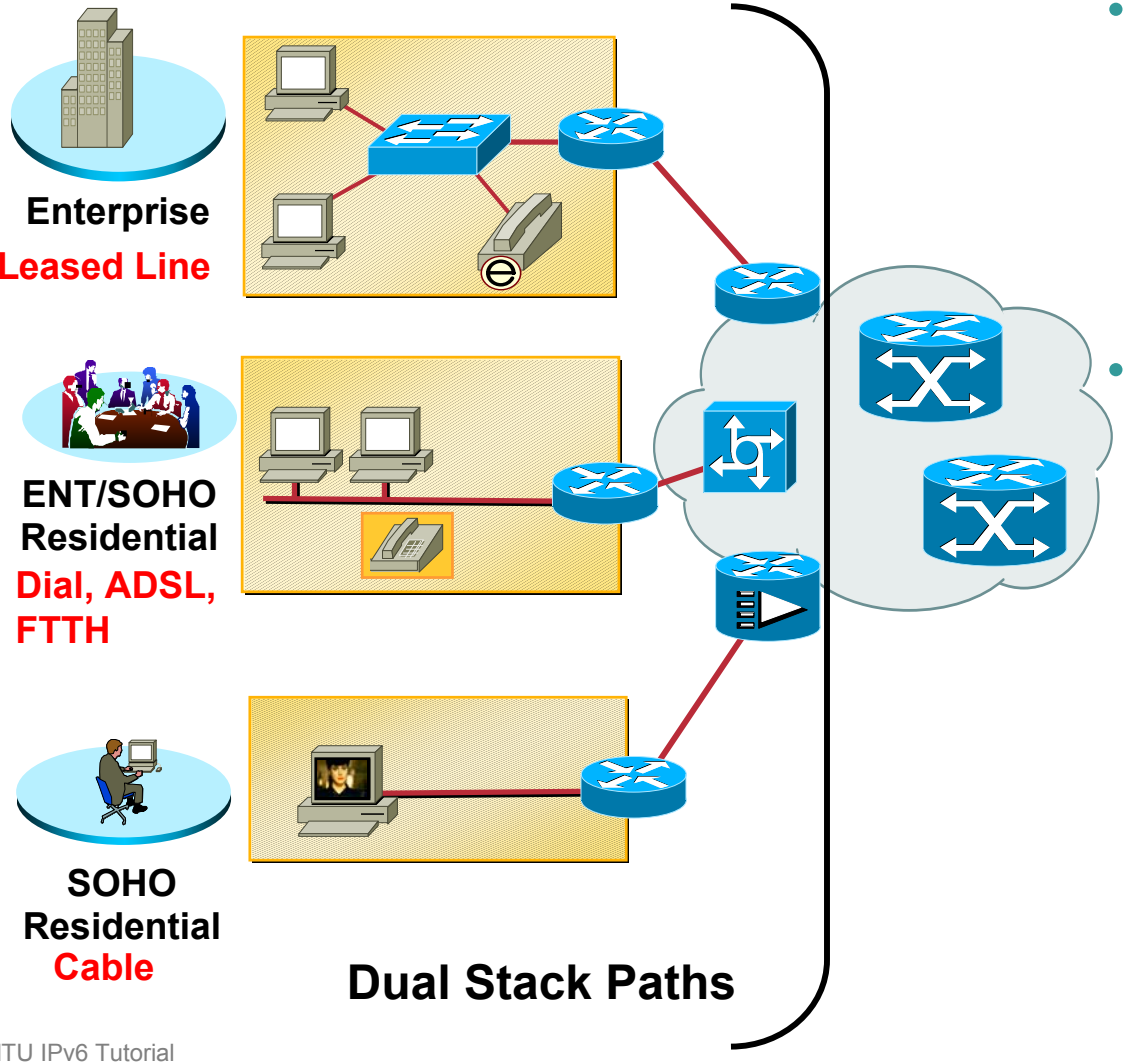


Dual Stack IPv4-IPv6 backbone

- Can be achieved beginning with Cisco IOS 12.2(1)T but have to consider the following:
  - IPv4 Hardware Forwarding versus IPv6 Software Forwarding
  - Memory size for IPv4 and IPv6 routing tables
  - Should IPv4 and IPv6 route to a single dual-stack edge router the same?
  - Dual stack management?
- IPv4 and IPv6 traffic should not impact each other
  - Require more feedback & experiments



Dual Stack IPv4-IPv6 Case Study



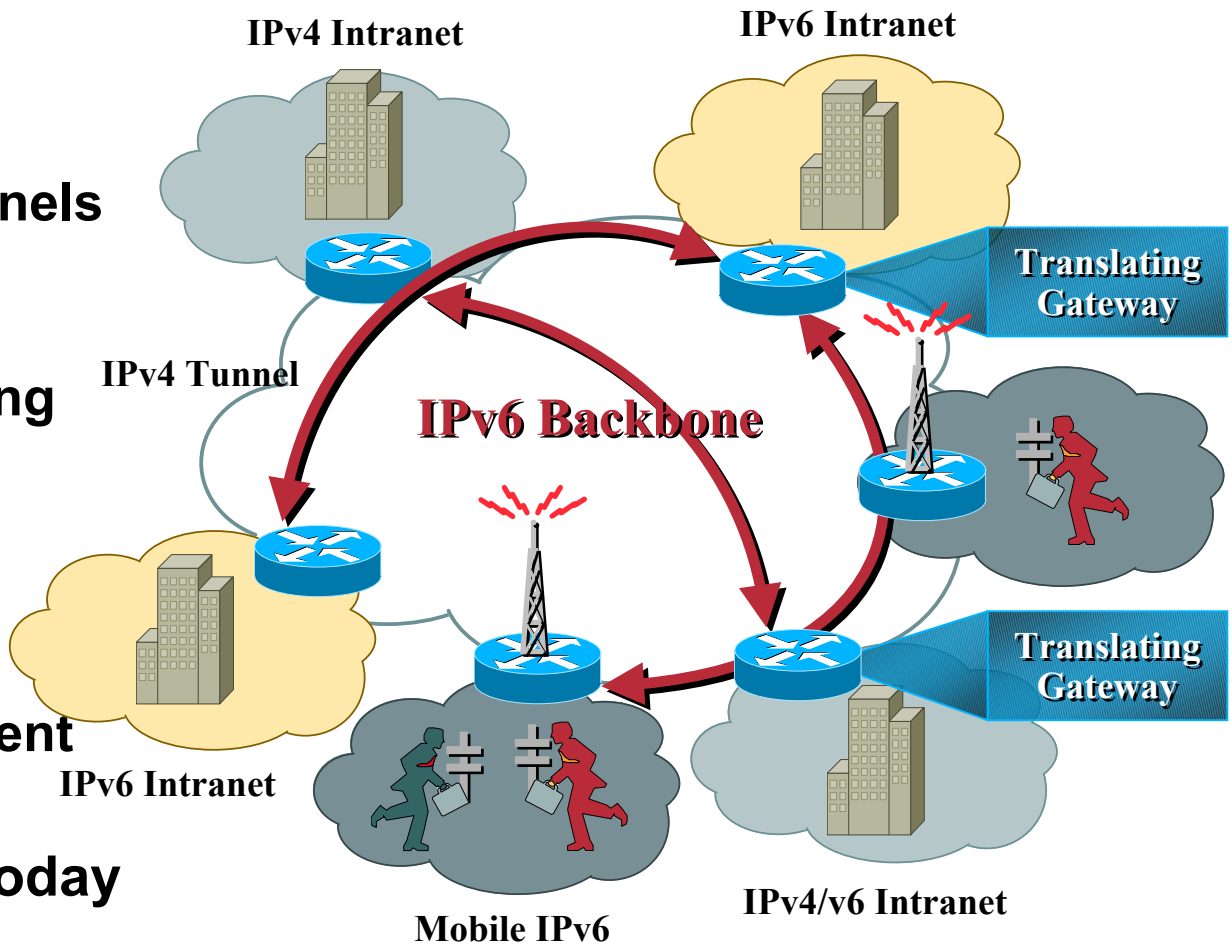
- **Campus scenario**
  - Upgrade all layer 3 devices to allow IPv6 hosts deployment anywhere, similar to IPX/IP environment
- **ISP**
  - Access technologies may have IPv4 dependencies, eg. Cable for network management
  - Transparent IPv4-IPv6 access services
  - Core may not go dual stack for sometime, to avoid a full upgrade

Native IPv6-Only Backbone?

Requires:

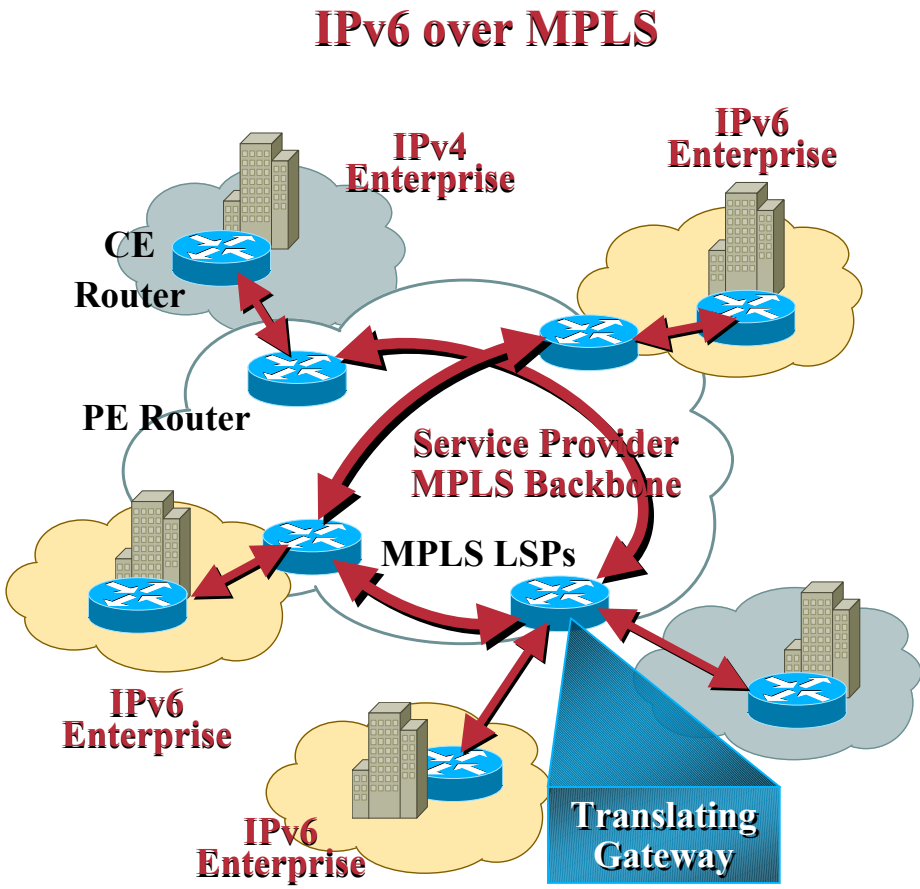
- IPv4 over IPv6 Tunnels for IPv4 traffic
- Hardware forwarding for IPv6
- NAT-PT for IPv4-IPv6 communications
- Network Management over IPv6

Not recommended today



IPv6 over MPLS

- IPv6 may become the "Multiprotocol" portion of MPLS
- Multiple implementation's options … Scalable & Reliable
  - IPv6 on CE only, not really MPLS
  - IPv6 on PE, IPv4 Control Plane,
  - MPLS Data Plane means No Forklift
  - Native IPv6 Control Plane
- Leverages MPLS feature set
  - VPN Support
  - Traffic Engineering capabilities
  - Services Transparency - e.g. Provisioning, QoS, Security.



roviders can therefore readily offer IPv6 Addresses while preserving investment

Open Challenges

- Determining future IPv6 routing table size
- IPv6 performance level needed, based on REAL IPv6 traffic expectations and features
  - Next 12 months? 24 months?
- Mobile IPv6
  - Clients, Application and Network design
- IPsec versus Firewall on IPv6 networks
- Network Management tools
- Transition Tools, which ones?
  - NAT-PT ALG support?
- Field Training
- Interoperability
- Others ?

Conclusion

..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**
- **Security concerns with transition tools**
- **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

IPv6 Ready for Production Deployment?

- Evaluate IPv6 products and services, as available
  - Major O.S., applications and infrastructure for the IT industry
  - New IP appliances, e.g…3G, gaming, consumers…
  - IPv6 services from ISP
- Plan for IPv6 integration and IPv4-IPv6 co-existence
  - Training, applications inventory, and IPv6 deployment planning
  - Deploying IPv6 Networks (now), ABCs of IP Version 6 (coming)
- Run IPv6 on Cisco IOS: the confluence of IPv4/v6
  - www.cisco.com/ipv6


CISCO SYSTEMS
EMPOWERING THE
INTERNET GENERATION

ITU IPv6 Tutorial

What are the business benefits of implementing IPv6 scenarios

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What does an enterprise expect?

- Deploy new applications to improve productivity and/or competitivity
- Reduce operational costs

➔ Nothing really to do with IPv6

But…

- New applications can use benefits of IPv6
  - Mobile IP
  - Peer-to-peer apps to improve communication
- IPv6 can help in reducing cost
  - Plug&Play devices
  - Less administration burden (avoiding NAT)
  - Addressing: ease the networks renumbering (due to acquisition or merging)
  - Mobile applications: IPv6 de facto in IMS

Drivers to IPv6

- **These will likely drive IPv6 deployment**
  - **Wireless Internet/Intranet**
  - **Prolific VOIP**
  - **Remote Sensing**
  - **Remote Control**
  - **….**
- **Enhanced security**
- **Others organizations utilizing IPv6**

Enterprise

- Volume market won't start before CY 2003
  - Microsoft .NET server, Applications
  - Validation from IT department
  - Business justification, ie: IP mobility
- But what do we consider as an Enterprise customer? IPv6 opportunities exist now for some vertical markets
- IPv6 impacts the overall IT infrastructure
  - LAN, WAN, Applications, Network Management
  - Project similar to Y2K without a deadline
- Consulting opportunity
  - eg. Native6Group

Active IPv6 Enterprise Markets

- Academia
- Government Organizations
- Military
- Software/Hardware Developpers
- Consulting firms

IPv6 O.S. & Applications support

- All Operating Systems have an IPv6 stack at some stage of completeness

  All Unix flavours (Sun Solaris, HP Unix, Compaq True64, SGI, IBM AIX, BSD (kame), Linux,…

  Microsoft Windows flavours, MacOS X, Compaq OpenVMS,…

- Focus is now on the Applications

  Ie: Microsoft .NET server, BSD Kame project

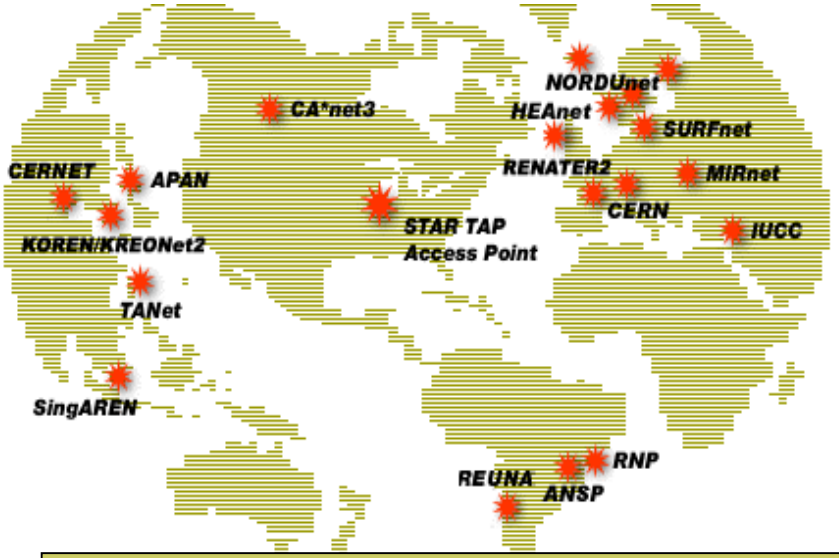
- But still need additional vendors

  Ie: Oracle & SAP

- See playground.sun.com/ipv6 and www.hs247.com for latest update

Academic & NREN

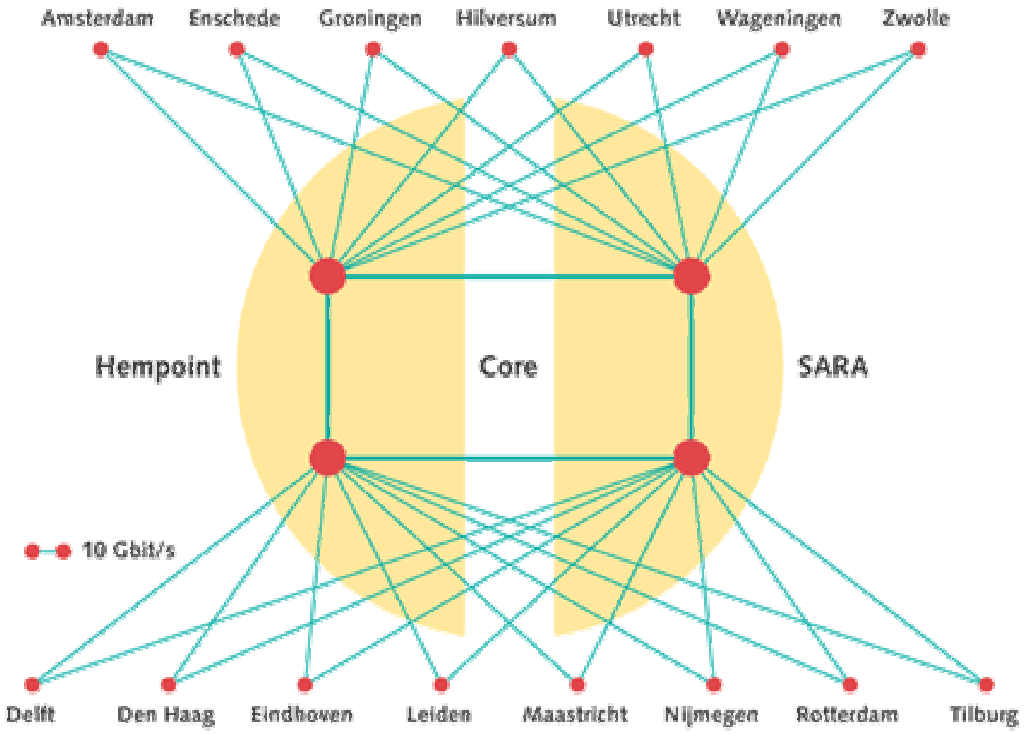
- IPv6 Early Adopters
  - Technology Enthusiasts
  - Source of initial product or service references
  - Test bed for introducing modifications to products or services



Abilene, Belnet, Canarie*4, Cernet2, Cesnet, Esnet (6TAP), Garr, Internet-2, JGN, Koren, Renater3, Singaren, SuperSinet, Surfnet5, Switch, Tanet2, Ukerna,…

Surfnet5 IPv6 Deployment

- 19 x Cisco 12400 Series
  - additional Cisco 7500
  - OC-192
  - RIPng (may evolve to Multi-Topology IS-IS)
  - MP-BGP4
- Dual Stack IPv4-IPv6 services
  - 6NET partner
- IPv6 IX connectivity
  - 6TAP, AMS-IX



http://newsroom.cisco.com/dlls/prod_111201b.html

IPv6 & Geo-Politics

- China
  - Is establishing an IPv6 collaboration with Japan
- Europe
  - European IPv6 Task Force, www.ipv6-taskforce.org
    - IPv6 2005 roadmap recommendations – Jan. 2002
  - European Commission IPv6 project funding: 6NET & Euro6IX
- Japan
  - Formal announce to support IPv6 in the “e-Japan Initiative” plan, 2000
  - IPv6 Promotion council
  - Tax incentive program, 2002-2003
- U.S.
  - North-America IPv6 Task Force
- Router’s vendors from every region are entering the IPv6 market

Korea

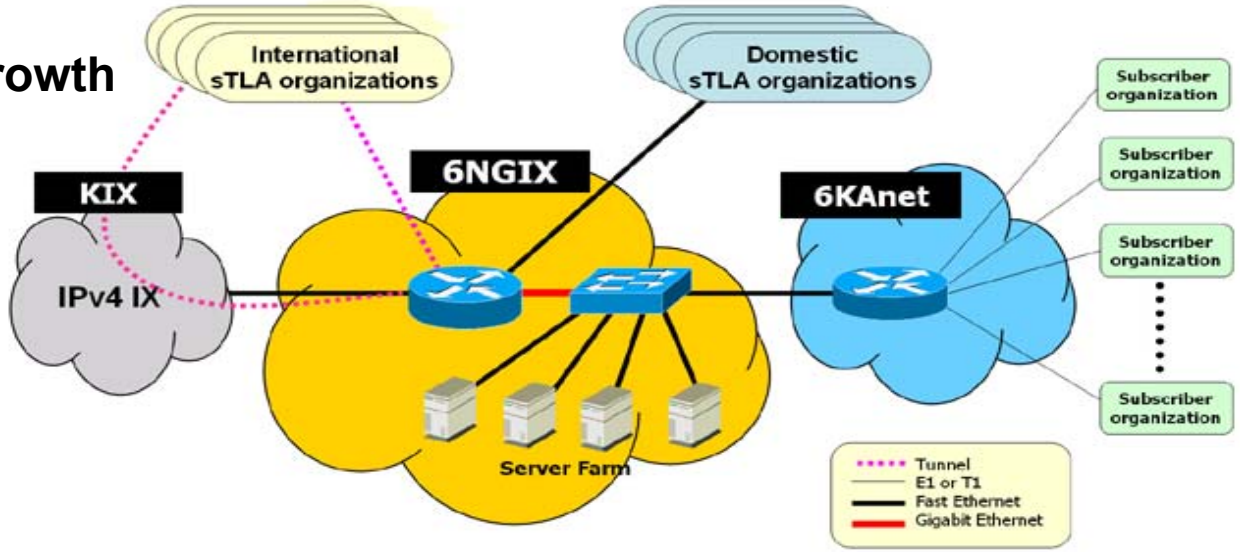
Tremendous Internet growth

28M Internet users (01/02)

or 60% overall population

8M Broadband access

94 ISP



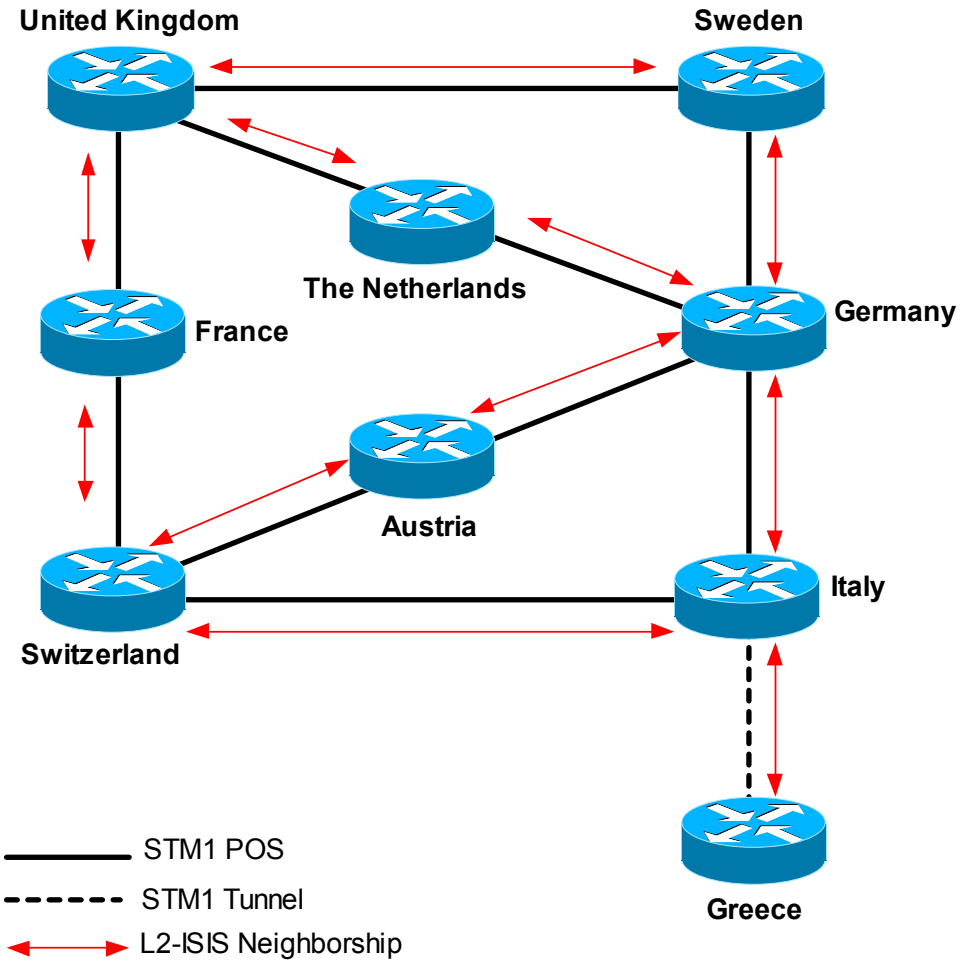
- **Ministry of Information & Communication officially declared the strong intention of IPv6 adoption (Feb. 2001)**

  83 M$ funding to develop IPv6-applied high speed Internet equipments

  Mandating new ISP to adopt IPv6, Tax incentives and Government organizations buying IPv6 products as next steps

6NET Project Overview

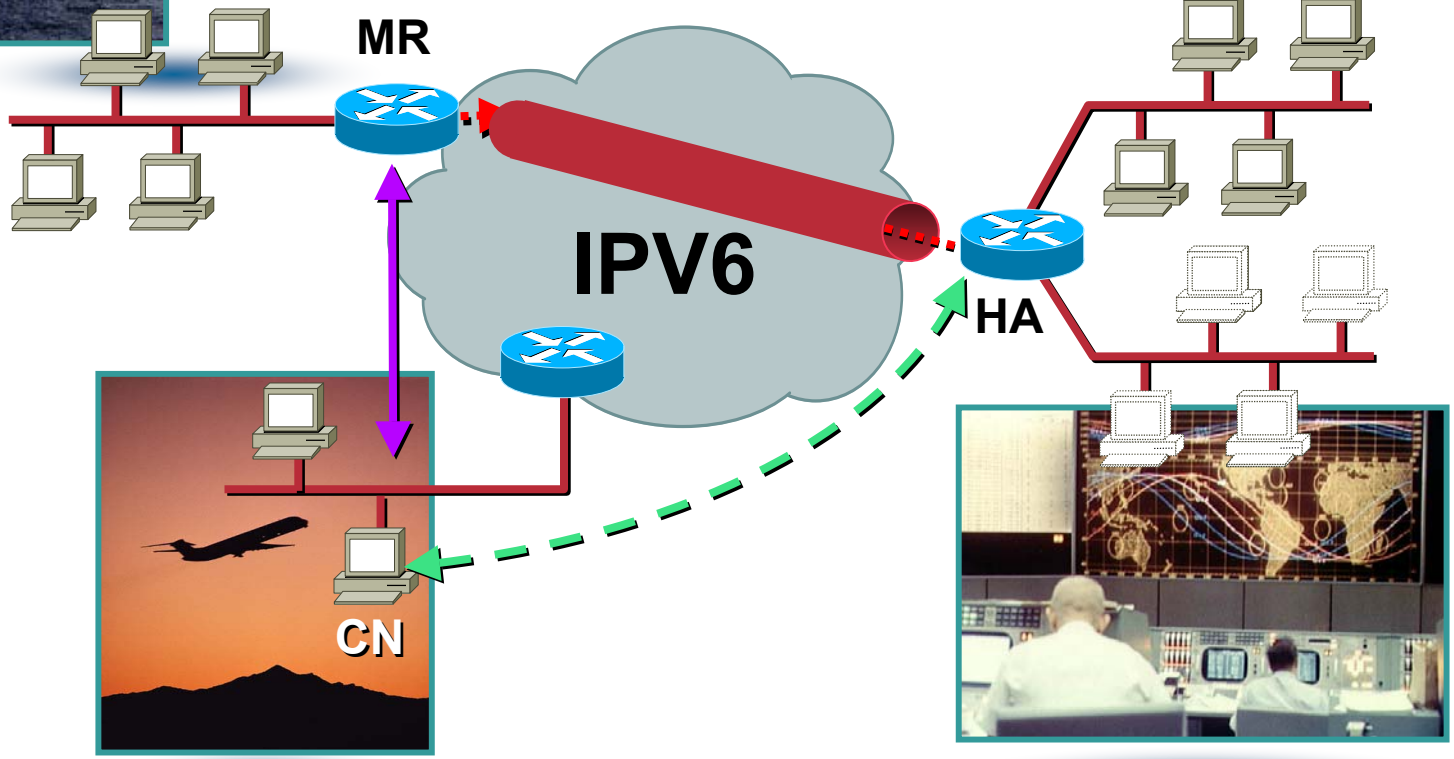
- **An IPv6 testbed for the European Community**
  - 3 year research project
  - European Commission funding: 9,5M €
- **31 partners**
- **7 Work Packages**
- **www.6net.org**
- **Cisco 12400 and 7200 series**



Objectives

- Install and operate an international pilot IPv6 network with both static and mobile components in order to gain a better understanding of IPv6 deployment issues. This network will primarily use native IPv6 links, although encapsulation over IPv4 infrastructure may be necessary in some cases.
- Test the migration strategies for integrating IPv6 networks with existing IPv4 infrastructure.
- Introduce and test new IPv6 services and applications, as well as legacy services and applications on IPv6 infrastructure.
- Evaluate address allocation, routing and DNS operation for IPv6 networks.
- Collaborate with other IPv6 activities and standardisation bodies.
- Promote IPv6 technology.

“Networks in Motion” – Mobile IP (v4/v6) routers



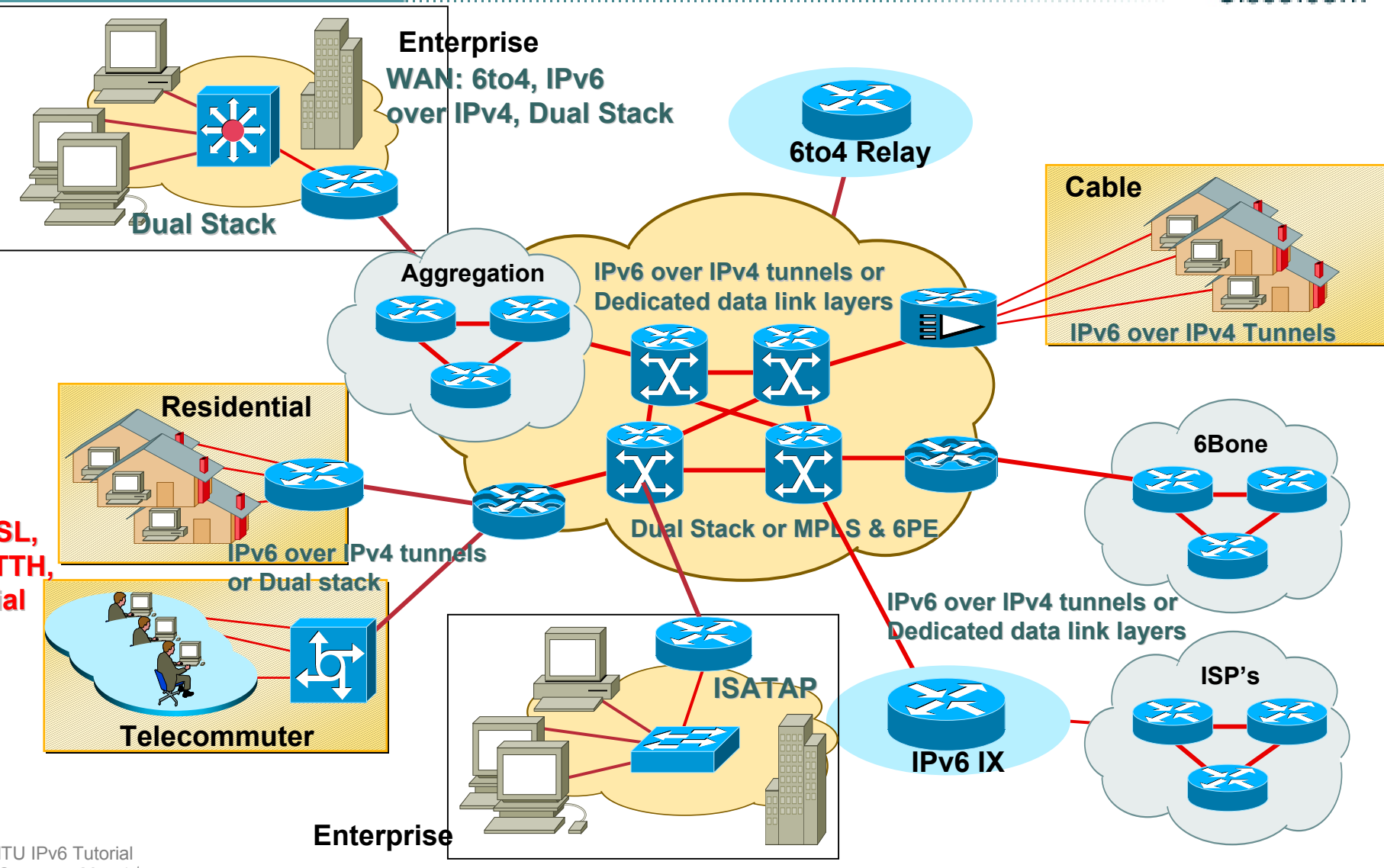
Mobile IP router Markets

- **Military and emergency services**
  - **IP based system using COTS product**
  - **IP connectivity to vehicles, command centers, soldiers…**

- **Public Transport Services**
  - **IP connectivity to passengers**
  - **IP based applications for transport service delivery (traffic, delay…for the public service)**

- **Fleet management and Telematics**
  - **IP based services (traffic, navigation, entertainment, remote diagnostic, Internet access…)**

Moving IPv6 to Production

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