IPv6 Workshop: Bridging the Digital Divide

20 - 21 March, 2003
Bangkok, Thailand

APEC Telecommunications and Information Working Group
June 2004

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Algonquin College

APEC Telecommunitcations and Information Working Group IPv6 Workshop: Bridging the Digital Divide

20 - 21 March, 2003

Held at:
Bangkok, Thailand
HRD Department
TOT Corporation Public Company, Limited

Selected Presentations:

IPv6 The Road to IPv6 Yves Poppe, Hexago

IPv6 Transitional Issues Yves Poppe, Hexago

IPv6 in Thailand Sinchai Kamolphiwong Prince of Songkla University

IPv6 Transitional Issues Chin-Chou Chen, Chungwha Telecom Labs

IPv6 Features Chin-Chou Chen, Chungwha Telecom Labs

IPv6 Deployment Status in Chinese Taipei Chin-Chou Chen, Chungwha Telecom Labs

Workshop Photos:

IPv6 Attendees - Group Photo

Note:

The use of the term 'Taiwan' in this publication is either in a reference to the proper name of a conference (e.g. Latif LADID, 2002 IPv6 Forum Taiwan) or a network title (e.g. Taiwan Academic Network TAN). Where the reference is the economy, the term 'Chinese Taipei' is used.

The road to IPv6: Time has come

APEC-Tel IPv6 workshop

Bangkok, March 20-21st 2003

Yves Poppe

Dir. Business Development

Agenda

- Why is IPv6 becoming a hot topic ?
- IPv6: time to deploy

HEXAGO

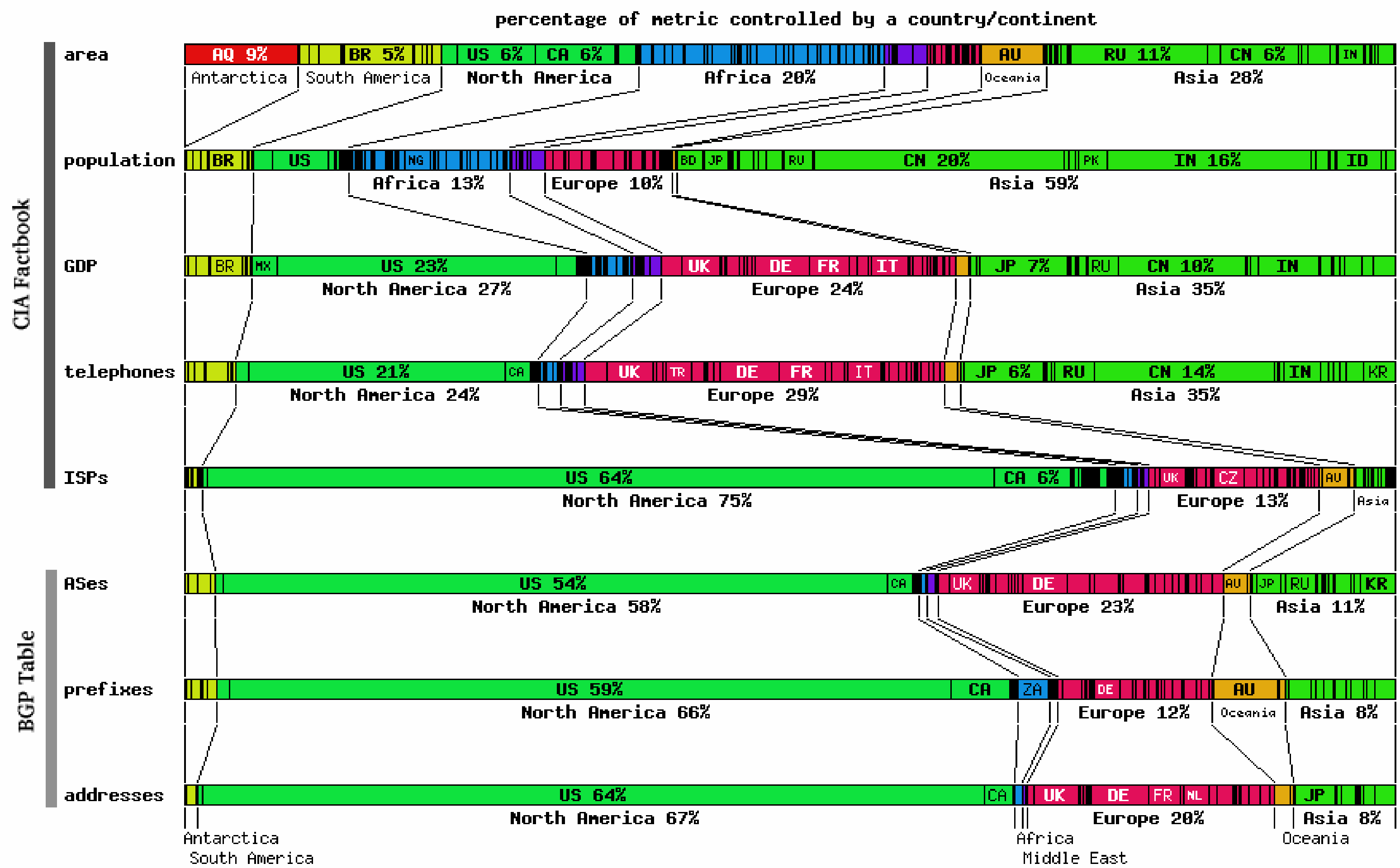
IPv6 Short History

1990	Prediction of the exhaustion of IPv4 Class B by 1994
1991	ROAD group formed to address routing
1992	Prediction of the exhaustion of IPv4 addresses by 2005-2011
1993	IPng Proposals solicitation (RFC 1550)
1994	CATNIP, SIPP, TUBA analyzed. SIPP+ chosen. IPng wg started
1995	First specification: RFC 1883
1996	6bone started
1997	First attempt for provider-based address format
1998	First IPv6 exchange: 6tap
1999	Registries assign IPv6 prefixes. IPv6Forum formed
2000	Major vendors bundle IPv6 in their mainstream product line
2001	First pre-commercial deployments
2002	Major R&E networks deploy dual stack core networks

Scaling of internet addressing

- Jan 1st 1983 “flag day” IPv4 replaces Network Control Protocol (NCP) in Arpanet. Had 8 bit network and 24 bit host addresses. See RFC 760
- 1984: RFC 791 inaugurates the familiar A, B, C, D, & E class system for address allocation. RFC 917 formalizes the practice of subnetting.
- 1989: RFC 1105 launches BGP as EGP did not scale anymore
- Exhaustion of Class B space leads to early 1993 RFC 1466 directing assignment of blocks of Class C's instead of Class B's. As a result the number of entries in the "core" routing tables began to grow exponentially which resulted in BGP4 and CIDR prefix addressing.
- Network Address Translators (NATs) further delay address exhaustion at the cost of sacrificing internet’s underlying p2p or e2e principle.

Resource distribution

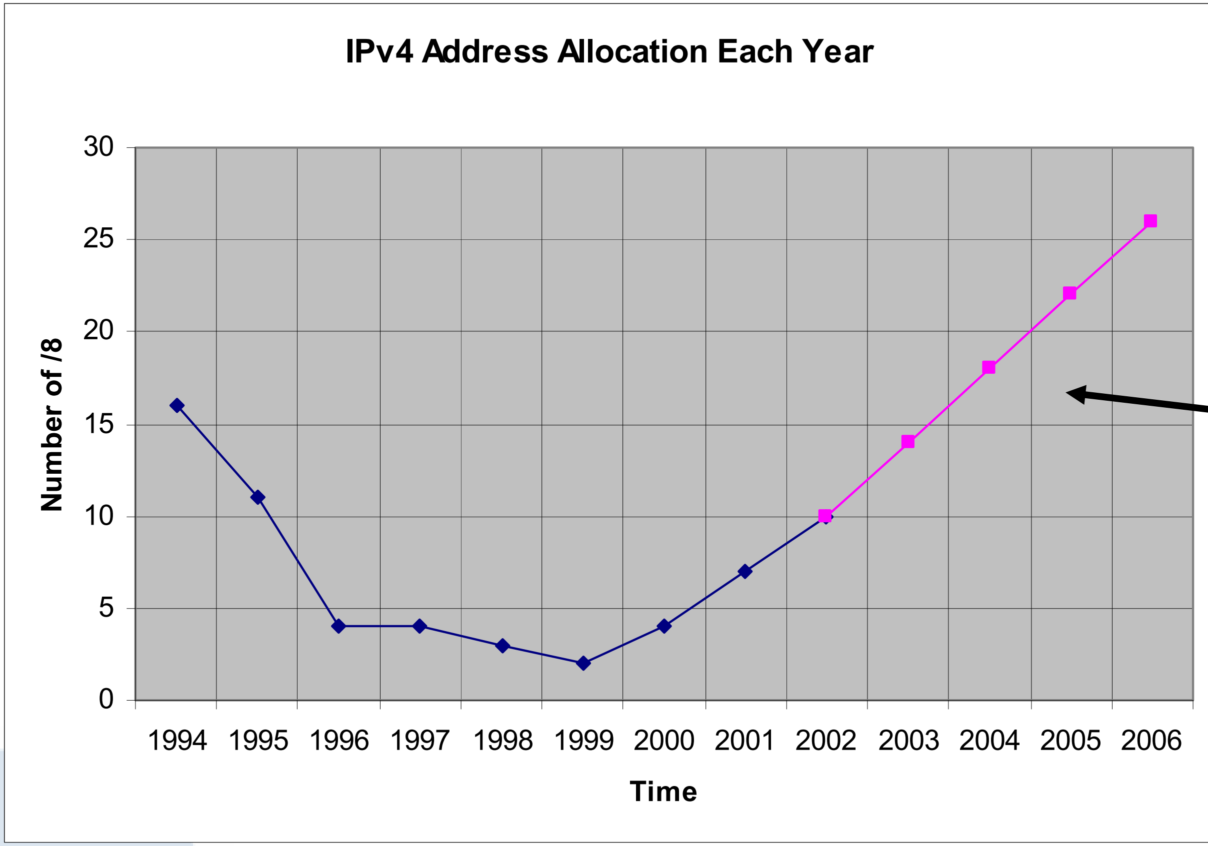


Thanks to Prof Xing Li , Cernet, presented at IPv6 Forum Feb 2003

A real Shortage of IPv4 addresses?

- IPv4 addresses are effectively being rationned
  - consumption statistics do not reflect real shortage
  - Dec 2002: had to fight with our new ISP to get 128 addresses; they only wanted to give four!
- Shortage is further hidden by the proliferation of NAT-ALGs
- NAT's risk strangling and killing next generation of Internet services, devices and revenue opportunities:
  - VoIP, peer2peer appplications, end to end security
  - mobile IP : PDA's, cellphones, wi-Lan devices, location based services, telemetry, embedded devices…
- NAT's compromise robustness, security and manageability of the internet.

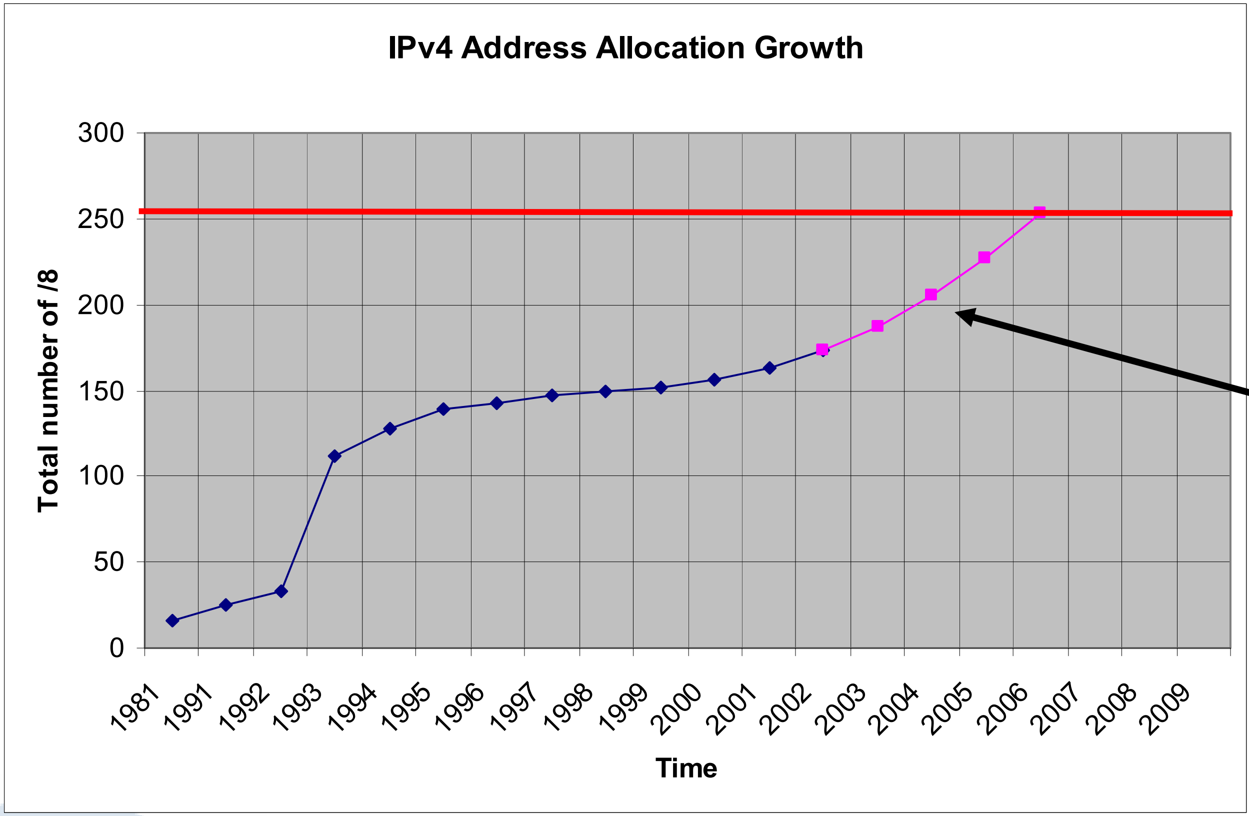
IPv4 Allocation Each Recent Year



Linear extrapolation

HEXAGO

IPv4 Allocation Growth



Cumulative using previous slide linear prediction

* A linear model on the first derivative gives 2006 as complete exhaustion.

Start of IETF IPng WG (1994)

- IETF recommendation (RFC1752):
  - to form an IPng working group
  - to form a transition working group (ngtrans) to handle the issues for migration to IPv6.
- Ngtrans:
  - worked hard on translation and transition mechanisms.
  - was the home of the 6bone initiative for a test network for IPv6 deployment.

IETF Ngtrans

- What ngtrans did:
  - Looked at proposed ideas. A lot of them:
    - IPv4-compatible auto-tunnel, 6over4, 6to4, Isatap, Shipworm/Teredo, Tunnel Broker, TSP, DSTM, BIS, BIA, NAT-PT, NATv4v6,Transport translator, SOCKS, …
    - Led to a proliferation of translation and transition mechanisms:
- No single solution to all issues/scenarios:
  - Some solutions have:
    - Constrained applicability
    - Important security issues
    - Scalability issues
  - A few are broader in scope.

From ngtrans to v6ops (2002)

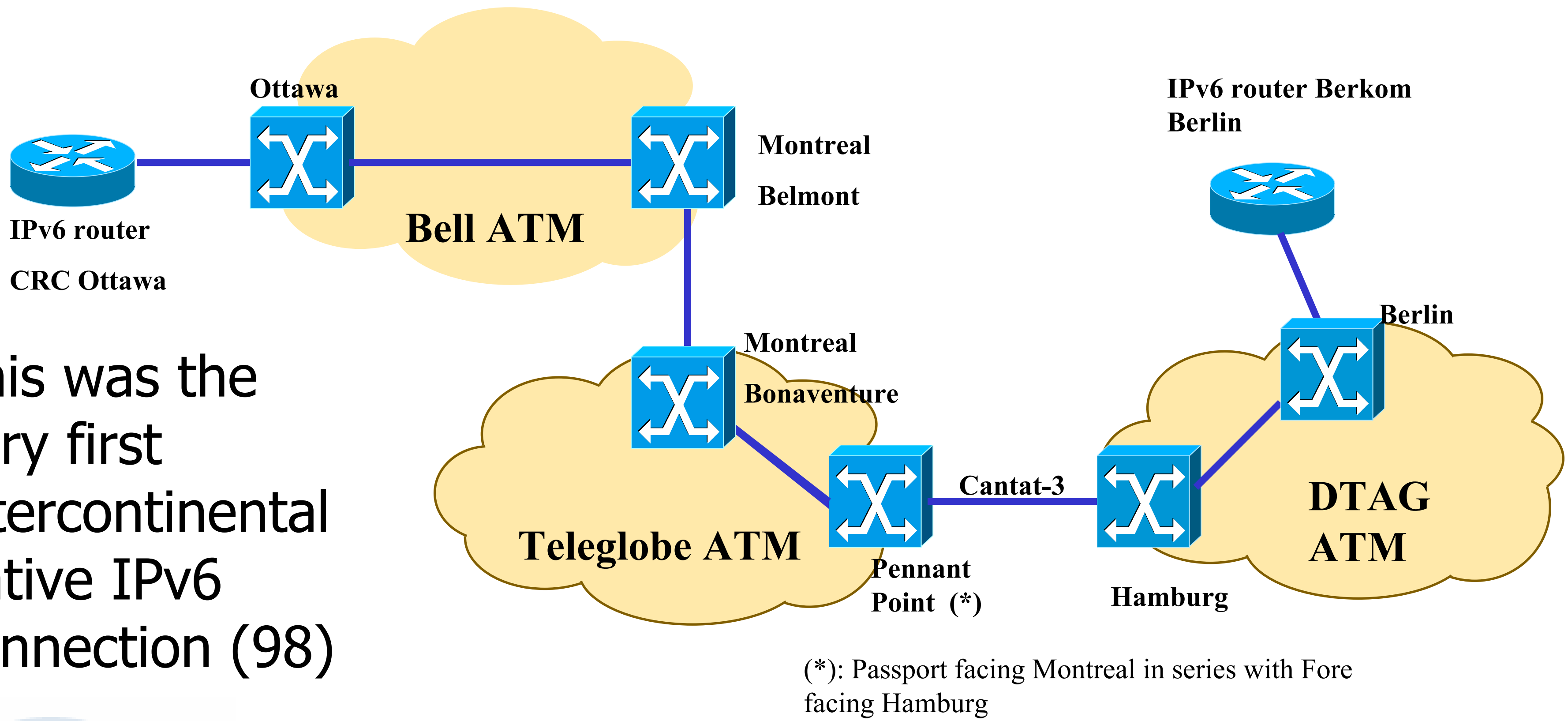
- IPv6 starts to have some momentum
  - Too many transition mechanisms makes the market think that IPv6 is complicated.
  - Keep it simple. Limit the number of tools: only the ones needed.
  - IESG agreed on new charter with more operational focus.
    - Does not inherit the ngtrans tools.
    - Consequence: All the previous work is in limbo.

- V6ops does not consider tools for the moment; back to the requirements phase:
  - By sketching the possible scenarios of deployment, using « design teams »:
    - 3G
    - Unmanaged
    - Enterprise
    - Provider
  - Then identify/invent/modify tools to fit with these scenarios.

Agenda

- Why is IPv6 becoming a hot topic ?
- IPv6: time to deploy

HEXAGO CRC - Berkom native IPv6 connectivity



This was the very first intercontinental native IPv6 connection (98)

ATM based PVC : VBR-Rt SCR=2mbps, PCR=4mbps

The transition to IPv6: Why act now?

- The telecom industry sees the end of the recession and a new wave of revenue opportunities based on anytime, anywhere, access with peer to peer communication with multifunctional multimedia mobile devices. Impossible without IPv6
  - Microsoft Windows, Apple Jaguar, IBM are IPv6 ready
  - Xbox and Playstation2 are IPv6 ready
  - Nokia, Ericson, Siemens trial mobile IPv6 and prepare 3G
  - Juniper, Cisco, Hitachi, Fujitsu, NEC are IPv6 ready
  - Tremendous success of on-line gaming
  - Endorsement of Grid computing and data mining by IBM

- The USA woke up to the security advantages of IPv6
  - The Cybersecurity report to the White House recommends IPv6
  - The US military will mandate IPv6 support by 2005

- The address shortage issue finally becomes more acute with the rise of always on ADSL and cable TV connection, home routers and Wi-Fi. NAT's become a major hindrance for future growth

How will the IPv4-IPv6 Transition happen?

- No “Flag Day” this time around
  - January 1st 1983 midnight Arpanet went from NCP to TCP (IPv4)
- This time transition will be incremental: maybe 5 to 10 years
  - Transition from the core?
  - Transition from the edge?
  - Comprehensive transition toolbox from IETF Ngtrans WG
- IPv6 was designed assuming IPv4/IPv6 coexistence.
- The transition is already under way and accelerating
  - The major catalyst was the Abilene/internet2 decision in May 2002 to support native IPv6 in the core, followed by other R&E networks
  - Tunnel support for the campus “IPv6 last mile”

IPv6 makes network life easier

- Security:
  - IPv6 provides mandatory host to host Ipsec for sender authentication and data encryption by default; in IPv4 optional extension to IPv4
- Plug and play:
  - with automatic configuration, a computer or appliance can be plugged in and be Internet-ready: no more manual entry of address information by system manager
- End of carrier/ISP lock-in
  - Easy renumbering of IPv6 hosts: a new prefix added to the router; the old prefix deprecates.
  - No downtime during transition
- Easier network management
  - Add,remove change routers without disruption
- Merging networks finally easy
  - In case of mergers, acquisitions integrating IP networks has been a daunting task.
  - Host and router renumbering

The transition to IPv6

From 6bone to freenet6 and commercial deployment

APEC-Tel IPv6 workshop

Bangkok, March 20-21st 2003

Yves Poppe

Dir. Business Development

Hexago and IPv6

- Viagénie spin-off with concentration on IPv6
  - Advanced R&D projects in cooperation with the Canadian R&E Netwok Organization Canarie: IPv6, OBGP, WDD
  - Active participant and contributor to IETF Ngtrans working group
  - Founding member of IPv6 Forum, leading member of NAv6TF, participant in APAN, Terena, Internet2
  - Developer of 6TAP, Freenet6 and IPv6 migration broker
  - Developer of the Tunnel Set-up Protocol (TSP)
  - IPv6 consultation, course development & training

6Bone

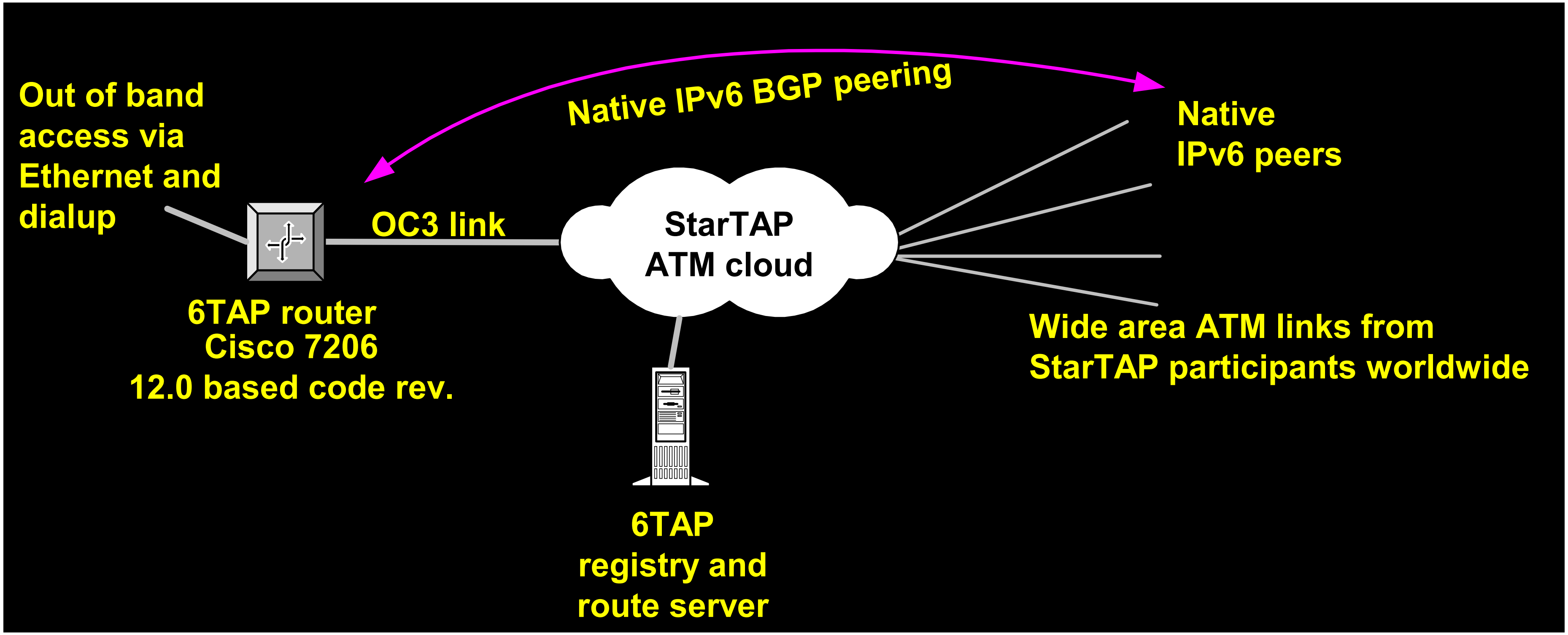
- The IETF IPng WG identified the need for a global testbed for IETF IPv6-related drafts and standards based product development.
- 6bone started in march 1996 and as of jan 2003 had 134 networks connected
- 6bone is layered on the existing IPv4 based internet using a mesh of IPv6 over IPv4 tunnels and has its own block of IPv6 addresses which it can assign.

6TAP

1999: 6TAP becomes the 6Bone IPv6 exchange

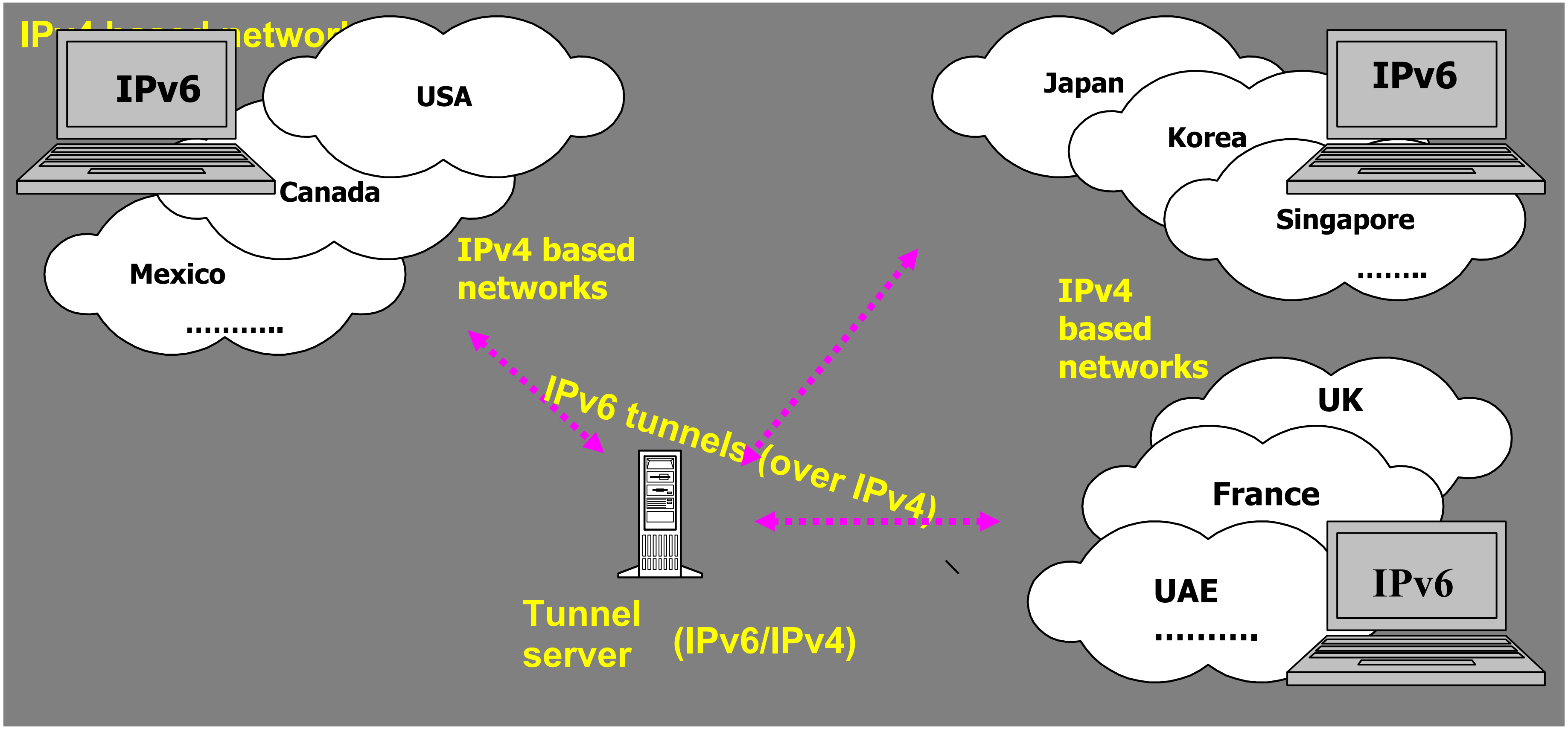
members include APAN, NTT, Surfnet, CERN, Renater, Heanet, Ca*net, DREN, Esnet, vBNS….

Original 6TAP architecture



- Most R&E networks were using ATM for layer 2 connectivity: PVC's to 6TAP router

From ATM to layer 3 tunneling



•**Tunnel server provides IPv6 connectivity between IPv6 end sites at extremities of networks through the existing IPv4 based infrastructure.**

Future of 6bone and 6TAP

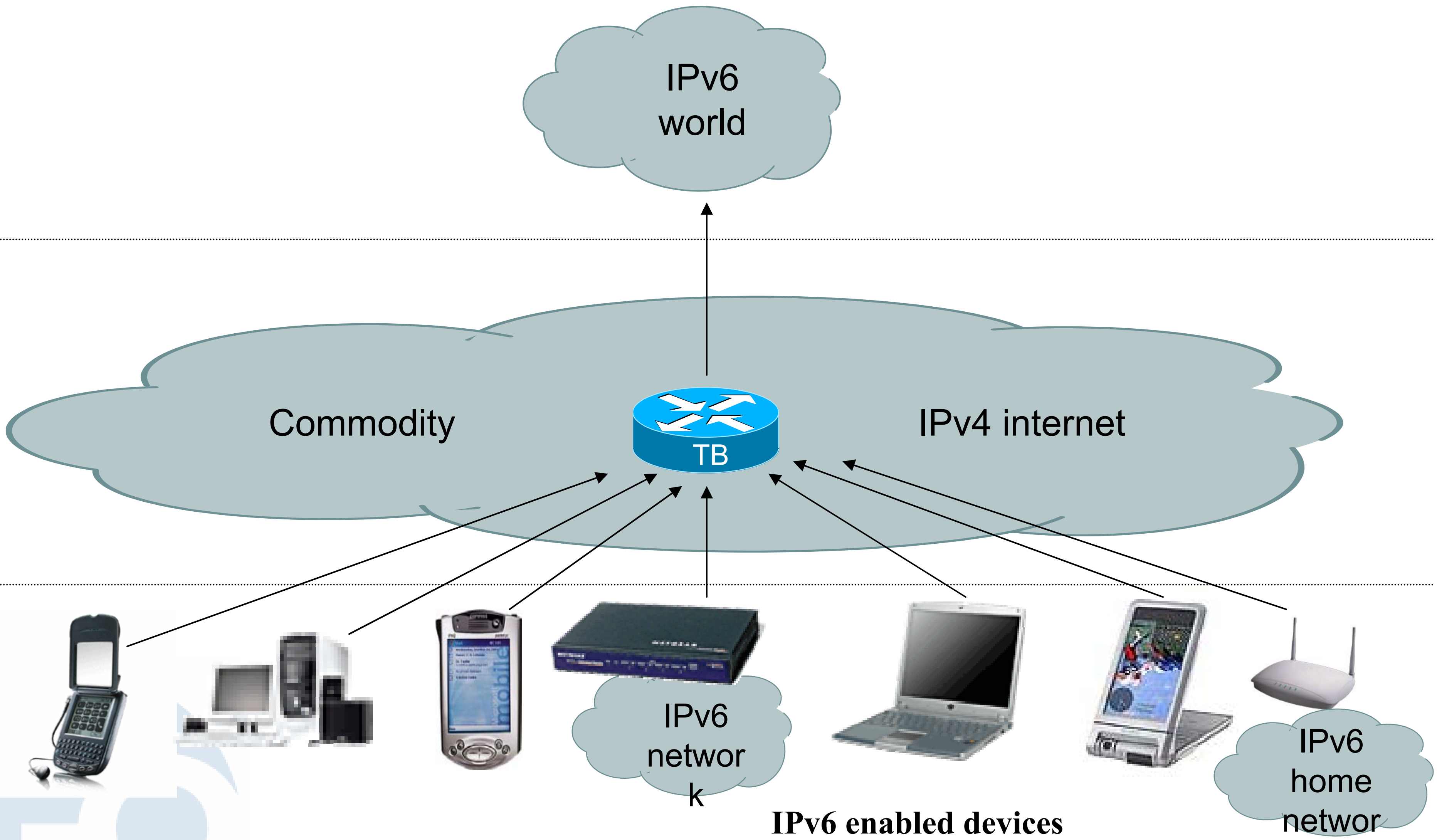
- In recent years, ESnet has expanded 6TAP services to New York (60 Hudson) and PAIX Palo-Alto; the Chicago 6TAP was moved to STARLIGHT at NWU (Feb 2002).

- With the RIR's issuing more and more IPv6 address blocks and IPv6 reaching maturity, IETF proposed a gradual phase-out of the experimental 6bone
  - No more 6bone addresses issued after july 2004
  - Termination of 6bone in july 2006

Freenet6.net initiative

- Initiated in cooperation with Canarie
- 1st release of freenet6.net: February 1999
  - Implementing original tunnel broker idea
  - Interface via Web, requiring user interaction
- 2nd release of freenet6.net : may 2001
  - Based on user comments
  - Defining a new generation of tunnel broker
  - Control protocol is defined to negotiate the tunnel parameters
  - Fully automated from the user point of view
  - Supports « IPv4 mobility »
  - User base passes 150,000 tunnels in late 2002!

Freenet6


IPv6
world
Commodity
TB
IPv4 internet
IPv6
networ
k
IPv6
home
networ
k
IPv6 enabled devices

Freenet6 characteristics

- Tunnel broker using the Tunnel Setup Protocol (TSP)
- Users request and get:
  - A tunnel
  - Stable address
  - A /64 or /48 prefix
  - IPv4 mobility (a change of IPv4 address reconfigures the tunnel, while not changing the IPv6 address or prefix)
- Completely automated. No admin intervention.
- TSP client is open-source and bundled in Linux and BSD distributions.
- Windows, Solaris, Cisco, QNX, … ports are available too.
- Freenet6 is accessible at http://www.freenet6.net

freenet6 leads to the IPv6 Broker

- Growing number of requests for a freenet6 “product version” for deployment in various regions of the world.
  - Easy and cost-effective way to connect IPv6 islands (hosts or networks) without full network upgrade
- Automation of tunnel establishment
  - control: no open relays as other transition tools
  - security: authentication/authorization for the use of the service
  - Attributes: permanent addressing for hosts, prefix assignments for networks, DNS delegation, routing, NAT detection and traversal. IPv4 mobility

Tunnel Setup Protocol (TSP)

- Control protocol to set up a tunnel between two tunnel endpoints
- XML based messenging over TCP or UDP

- Client and server negotiation
  - Authentication type
    - Anonymous, Digest-MD5, Kerberos, etc.
  - Tunnel type
    - IPv6 over IPv4, IPv4 over IPv6, IPv6 over IPv6, IPv6 over UDP/v4, etc.
  - Address and prefix assignment
  - DNS delegation
  - Routing
    - Static, IGP (RIP, OSPF, …), EGP (BGP)

TSP Client

- Authenticates the user
- Negotiates IPv6 parameters and configures tunnel on the local device
- Currently supported platforms:
  - Microsoft Windows (NT, 2000, XP)
  - MacOS X
  - Linux (all distributions)
  - FreeBSD, NetBSD, OpenBSD
  - Solaris
  - QNX
  - Cisco routers (through external client)
- HTTP access to TSP is also available

Agenda

- 6bone , 6TAP and freenet6
- IPv6 transition scenarios

Moving to IPv6

- Router upgrades : 3 approaches
  - Upgrade the core and PE to dual stack : new equipment or upgrade OS version for IPv6; means additional RAM and/or flash.
  - Upgrade only PE routers only to dual stack, use MPLS to traverse core (Cisco 6PE approach)
  - Install a small number of Tunnel Brokers to gauge uptake of demand. Move the core and PE's gradually to dual stack when traffic builds up and justifies investment.

- Service upgrades:
  - DNS, mailserver, webserver,firewall

- Host upgrades:
  - OS and application IPv6 support
  - enable address autoconfig

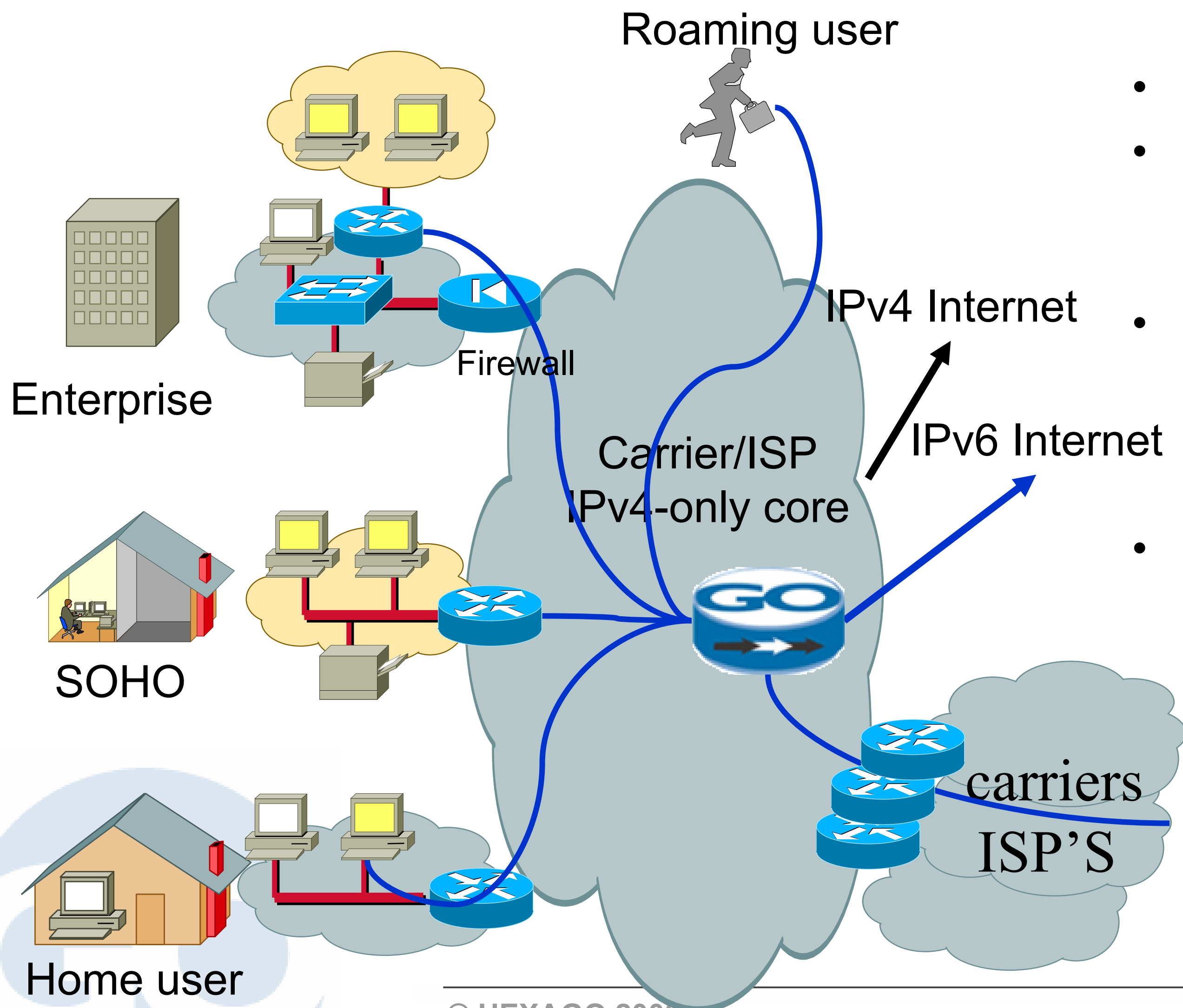
Vendor IPv6 support

- Router vendors:
  - Cisco, Juniper, Hitachi, NEC,Fujitsu…
- Server vendors
  - Sun, HP, Ericsson, IBM, 3com
- Appliance vendors
  - Xbox, Playstation, IP phones (Nokia, Ericsson…)
- OS vendors
  - Windows XP, Windows CE, .net, MAC OS X, Solaris 8, Linux, freeBSD

IPv6 ready applications

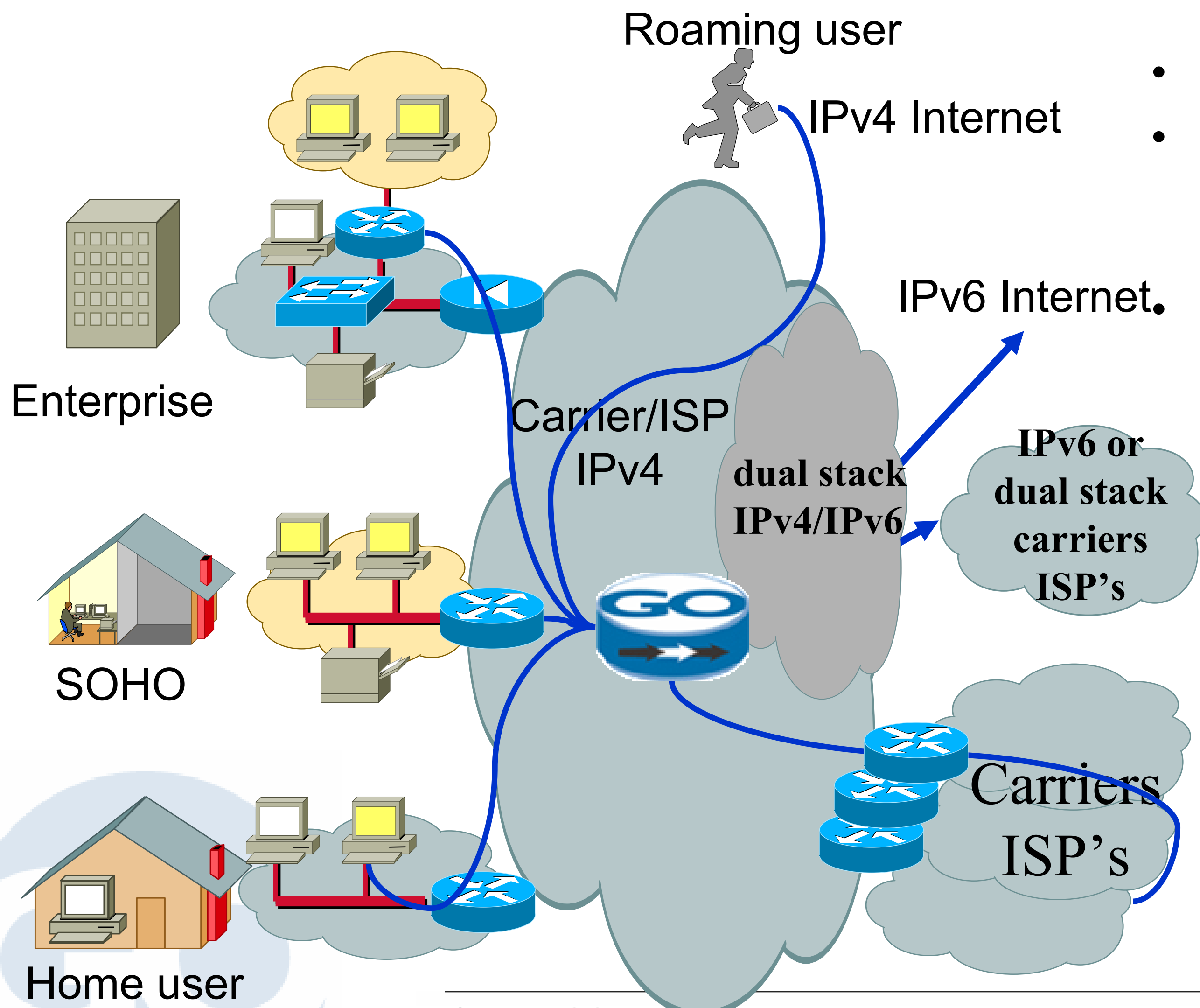
- Mail : Qmail, Sendmail, Fetchmail
- Webserver: Apache 2.0
- Security: Ipsec (mandatory end to end support)
- DNS: Bind9
- telnet,ftp,SSH
- Firewall: ipfilter (freeBSD),netfilter (Linux)
- VoIP: Vocal
- Grid: Globus 2.0

Carrier/ISP IPv6 Deployment phase I



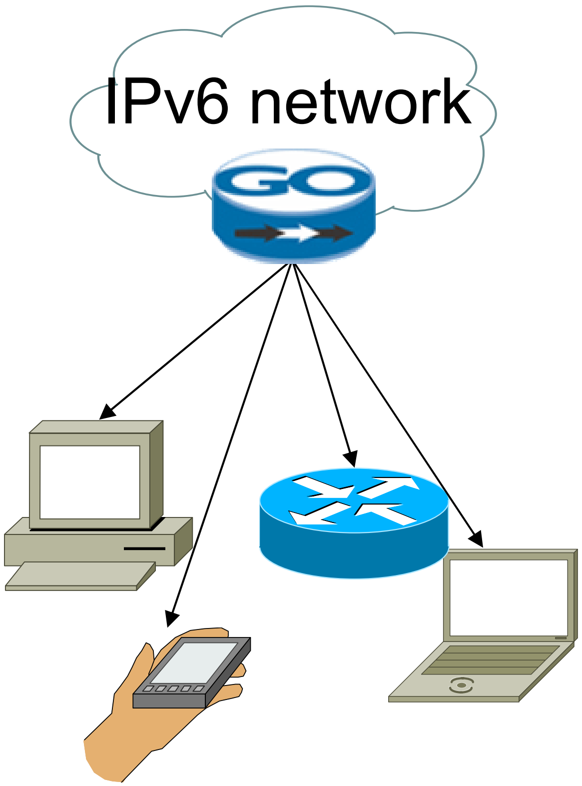
- IPv4 core
- Migration Broker used in the core or aggregation points for major customers
- End-users are authenticated and assigned a fixed (stable) IPv6 prefix
- Carrier/ISP can offer IPv6 access to the end-users of its tier 2 and access customers and to its corporate end-users

Carrrier/ISP IPv6 Deployment phase II



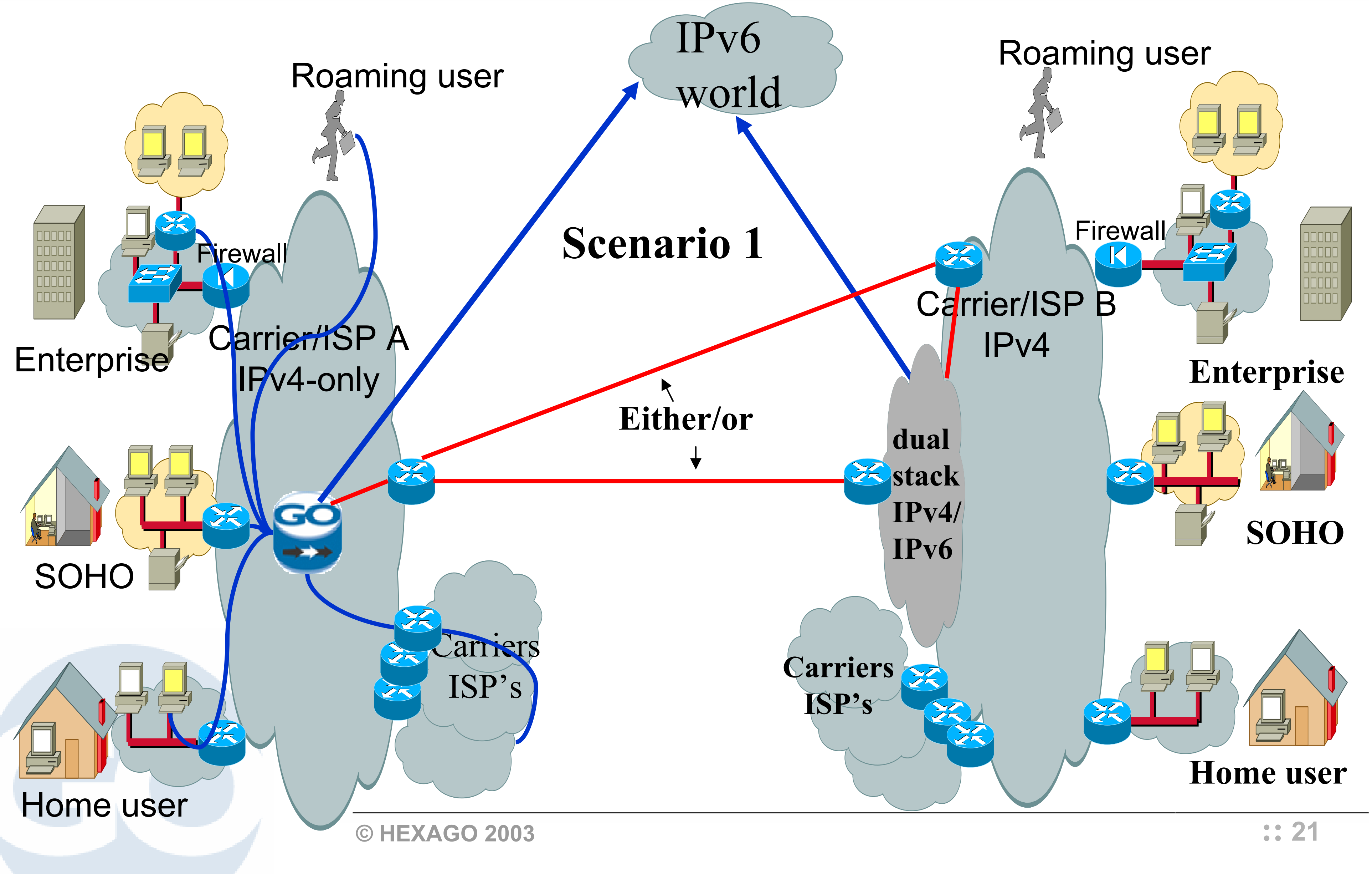
- Partial dual stack core
- Migration Broker used as aggregation points for major customers
- End-users are authenticated and assigned a fixed (stable) IPv6 prefix
- Carrier/ISP can offer IPv6 access to the end-users of its tier 2 and access customers and to its corporate end-users
- Distribute tunnelbrokers on periphery of dual core and in customer networks

The Migration Broker approach

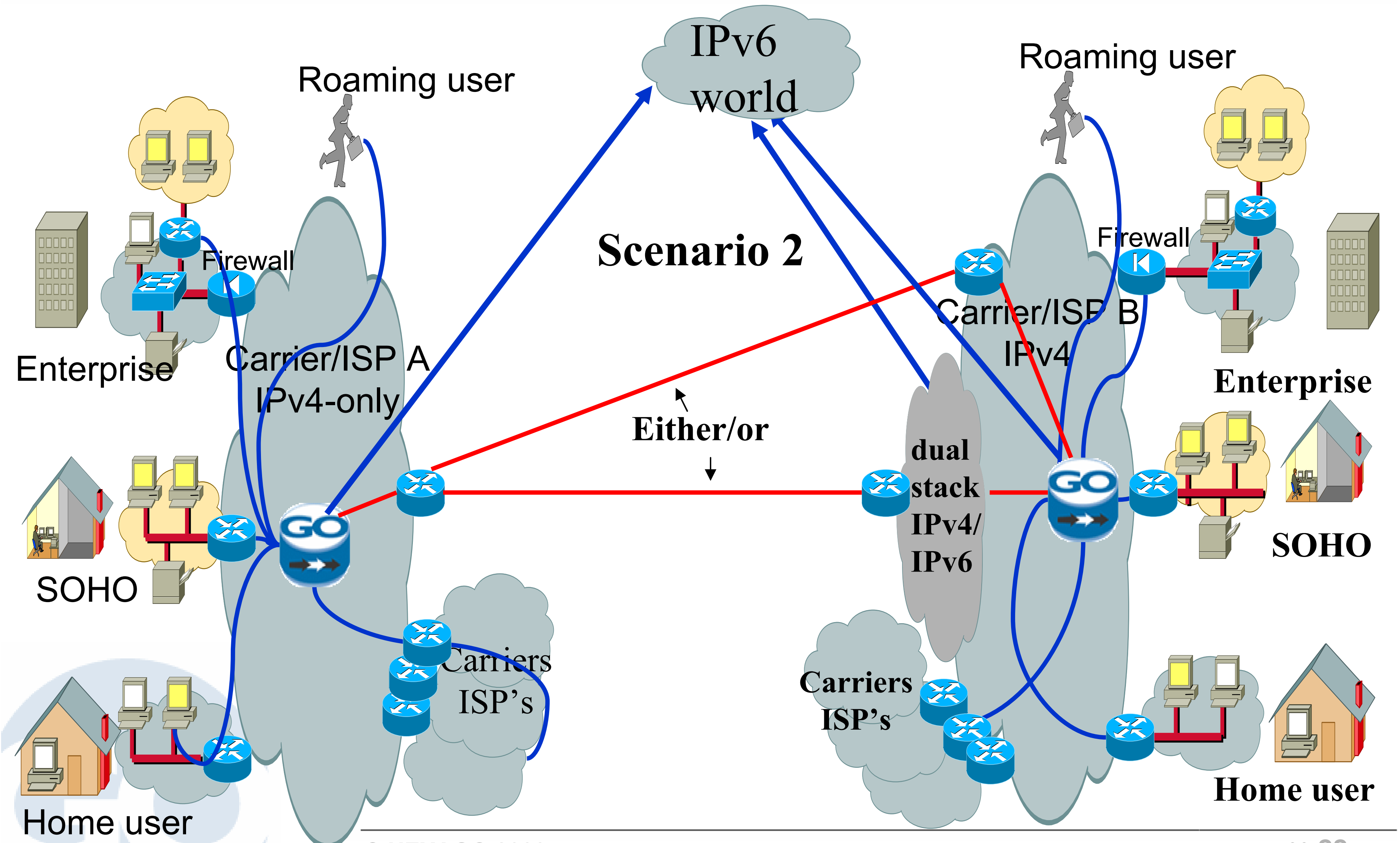


- Dual stack router
- Delivers IPv6 connectivity
- Allows IPv6 deployment with minimal impact on IPv4 infrastructure
- Automatically assigns IPv6 addresses and can automatically delegate IPv6 prefixes to devices
- Addresses and prefixes automatically registered in DNS
- Most cost-effective scenario for early deployment and fast entry
- To be redeployed in periphery of dual stack core and in major customer networks when traffic grows.

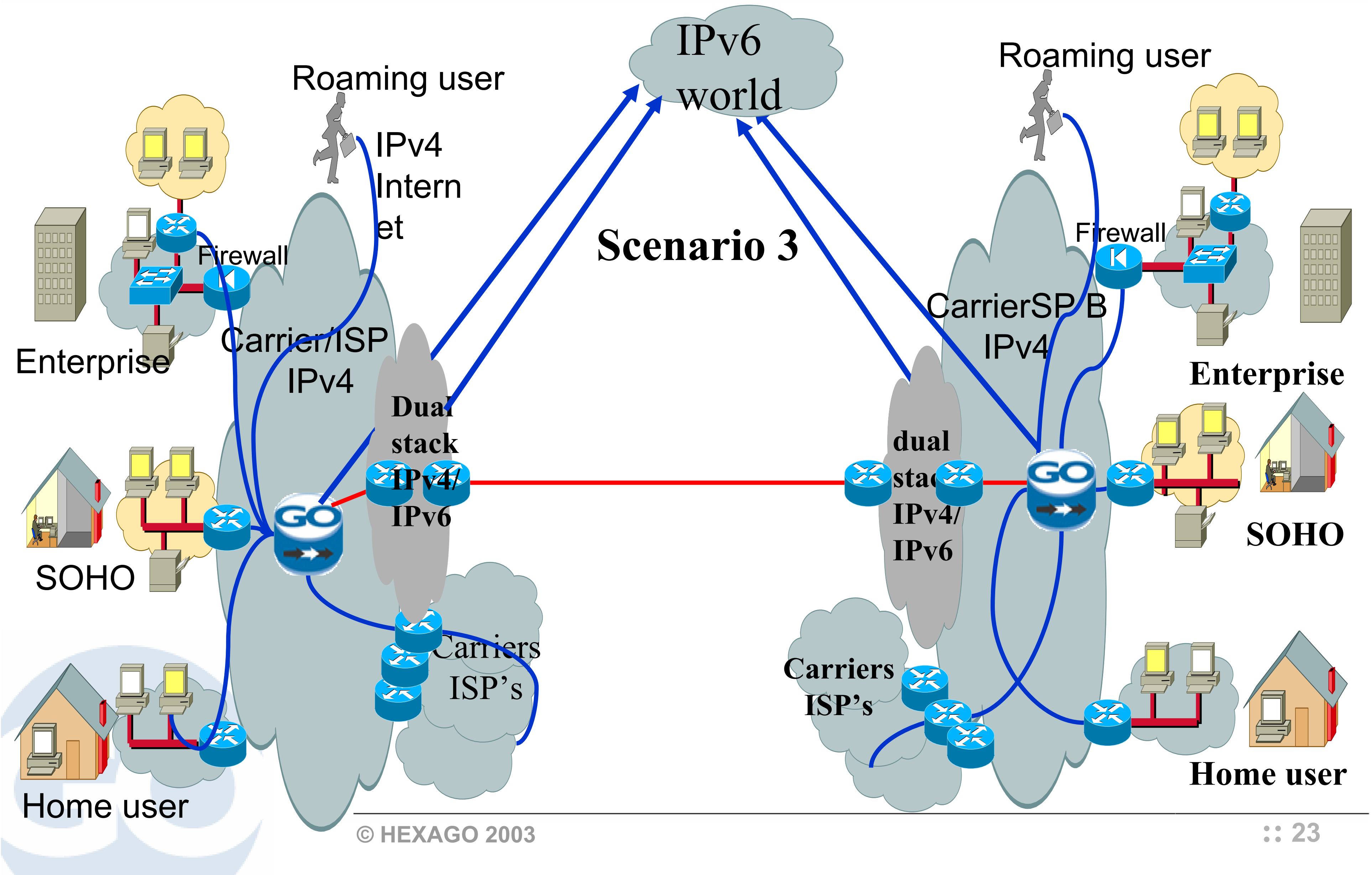
Intercarrier IPv6 interconnect



Intercarrier IPv6 interconnect



Intercarrrier IPv6 interconnect



Joint testing of IPv6 applications

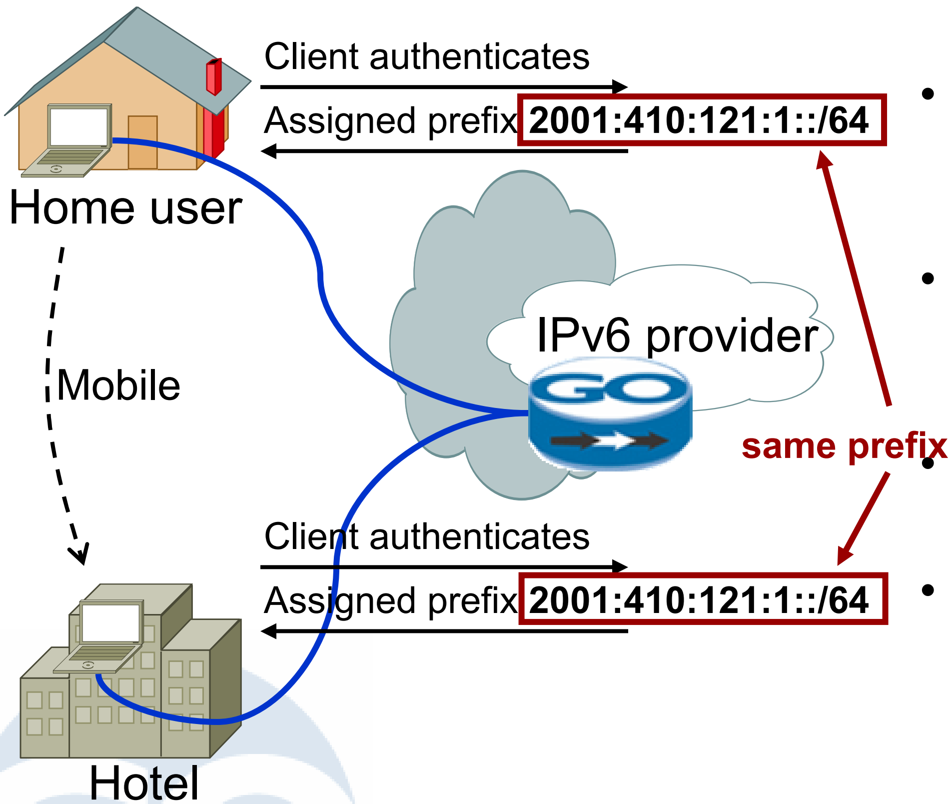
- Successful IPv6 deployment necessitates solution of the « IPv6 first mile » and the stimulation of peer to peer customer applications and experience

- It will now be possible to assign stable (non-dynamic) address space to carriers/ISP's A and B end- users with automatic address and prefix allocation, autoconfiguration and plug and play connectivity

- Automatic host renumbering will be possible

- Test new end to end services made possible by globally reachable IPv6 addresses
  - Trial peer to peer applications including VoIP
  - Verify end to end encryption and security
  - Trial unrestricted terminal mobility and plug and play.
  - Test IPv6 QoS and VPN

Address and Prefix Assignments



- Addresses and prefixes are allocated from a carrier defined IPv6 pool
- An authenticated user is automatically allocated a stable IPv6 address (or prefix)
- The user retains his IPv6 address/prefix even when his local configuration changes (IPv4 address, mobile, etc.)
- The Teleglobe IPv6 address pool assigned by ARIN could be used.
- For users based in the Emirates, the Etisalat IPv6 address pool assigned by RIPE.

Migration Broker Specifications

- Two 10/100 Mbps Ethernet interfaces (RJ45)
- Serial console port
  - Direct management access
- 256MB RAM, 64MB flash
  - No hard drive: Reliable
  - Store multiple software image simultaneously
- Rack-mountable (1U format)

Migration Broker Management

- Telnet and SSH protocols for remote access
- Traffic filtering (access control lists)
- AAA models for authentication policies
  - User authentication
  - Tunnel parameters
- Logging and troubleshooting commands
- Cisco compatible CLI commands

IPv6 in Thailand

APEC Telecommunications and Information Working Group
20-21 March 2003
Bangkok, Thailand

Sinchai KAMOLPHIWONG, Ph.D.
Associate Professor

Centre for Network Research (CNR)
Department of Computer Engineering
Faculty of Engineering
Prince of Songkla University

Out-Line

- Our experience,
- IPv6 Testbed project,
- What we have done,
- What we are doing,
- What we plan to do,
- Conclusion.

IPv6 Deployment

It involves several components

- Clients,
- Servers,
- Routers,
- Domain Name System (DNS),
- A link of IPv6 Networks.

Simple Core applications

- **DNS**
  - BIND 9 offers native IPv6 DNS lookups,
  - preparing IPv6 root name server
- **World Wide Web**
  - Apache server,
  - Microsoft IE, Netscape, and Mozilla browsers.
- **E-mail**
  - Sendmail 8.10 has IPv6 built-in,
- SNMPv6

Our Experience of IPv6 in Thailand

- Not really take off yet,
- A small number of people have awareness of IPv6,
- Introduction of IPv6 into IPv4 networks will require a number of different approaches (and timely).

Our Experience of IPv6 in Thailand (cont.)

Activities

- Some short seminars were organised by UNINET, NECTEC and some router vendors,
- Only a full workshop was done last year,
- Some activities in universities, mostly are student projects.

IPv6 Working Groups

- IPv6 Working Group in UNINET (Inter-University Network), Ministry of University Affairs,
- IPv6 Working group in ThaiSarn-3, NECTEC (National Electronics and Computer Technology Centre),

IPv6 Testbed at CNR

- We just received a research fund from NECTEC, to investigate IPv6 deployment in Thailand,
- 5 lecturers and 11 students involve the testbed project,
- Leading IPv6 Alliance of Thai Universities.

Objectives

- To gain operational experience with IPv6,
- To study of some of IPv6 lesser known parts. In particular, the study will determine the which is the best method to discover a node's site local address and what modifications (if any) are needed to nodes to make this work.

Objectives (cont.)

- The study will also discover whether A6, and the other new IPv6 DNS records are suitable for use, or if not, whether they could be rescued by any changes to their specifications.

Objectives (cont.)

- This will also provide a local knowledge base in Thailand of IPv6 experienced engineers, ready for when IPv6 networks start to be deployed as genuine operational nets, taking over from the current IPv4 networks.

Objectives (cont.)

- It will also raise Thailand's profile in the international Internet community, as input to the IPv6 standardisation efforts comes from Thailand (most currently originates in North America, Japan, Australia, and Europe - France in particular).

What we will achieve in our research project

- To gain operational experience with IPv6, including the study of some of its lesser known parts and it alternative choices,

What we will achieve in our research project

- To enhance the IPv6 stack or libraries of the free Unix implementations of IPv6,
- To provide a local knowledge base in Thailand of IPv6 experienced engineers,
- An operational IPv6 network in Thailand.

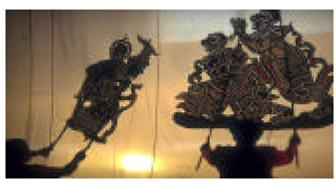
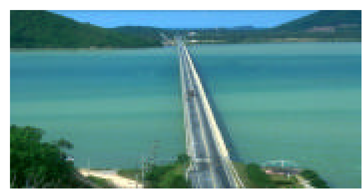
What we have already done

- Multiple OSs for IPv6 clients and servers are running,
- Permanent Tunnel to 6BONE via PSU (and Melbourne University) was created (since April 2000),
- IPv6 Tunnel between CNR and UNINET.

What we have already done (cont.)

First Workshop on IPv6: Fundamentals and Practical

23-24 May 2002

Organised by
Department of Computer Engineering, Faculty of Engineering,
Prince of Songkla University
http://www.coe.psu.ac.th/IPv6
Sponsored by
Office of Information Technology Administration for Educational Development
Ministry of University Affairs

What we have already done (cont.)

2 Working Groups

- IPv6 Working Group in UNINET (Chair), MUA
- IPv6 Working Group in ThaiSARN-3, NECTEC

We are discussing to form IPv6 Task Force, Thailand

- Address space of IPv6 has already been allocated from APNIC (to UNINET).

What are we doing?

IPv6 Testbed Project

- Investigate DNS mechanism,
- v6 renumbering,
- 4to6 transition,
- Multi-homing, Mobile IP,
- Supporting tools,
- Porting some applications.

Some problems with DNS and Addressing

- How to decide when site local addresses should be used?
- How to find the site local addresses of the destination?
- What are performance, advantages and disadvantages of AAAA and A6 when dealing with multiple ISPs and Interfaces?

Coming shortly (cont.)

- Porting some applications of v4 to v6
  - SIP-Based 3GPP Video Telephony,
  - Interactive Distance Learning,
  - 3G Protocol Stack,
  - SNMP.

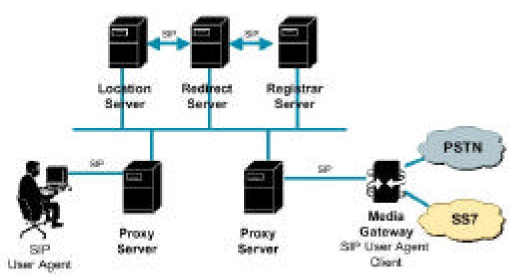
Multimedia Applications (cont.)

- 3G SIP-Based Voice and Video Telephony

Multimedia Applications (cont.)

We have a complete set of SIP

- SIP based on IETF (rfc-2543, rfc-3261)
- SIP based on 3GPP



SIP mobility over IPv6 based on 3G

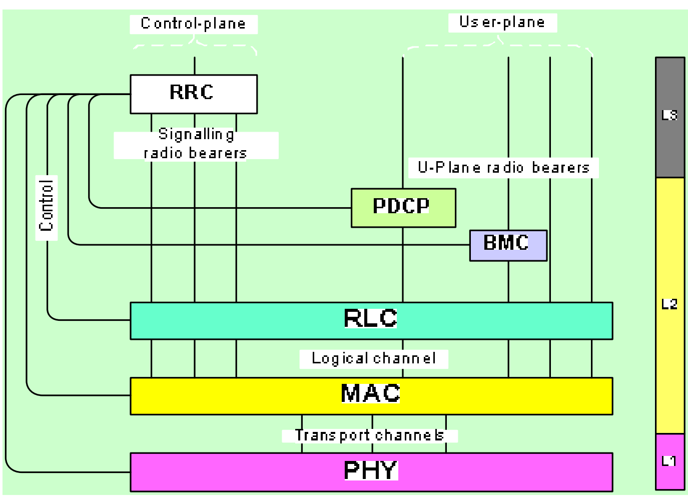
Multimedia Applications (cont.)

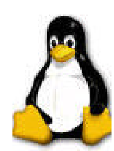
Interactive Distance Learning

(based on Java Technology: Jini, JMF)

Core Applications (cont.)

3G Protocol Stack based on 3GPP



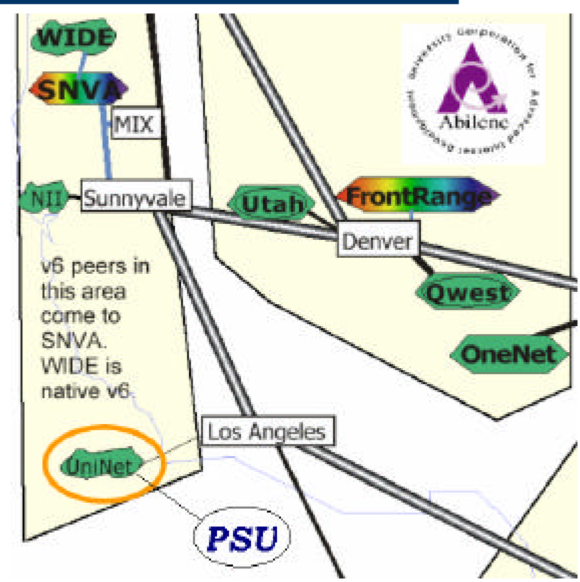


JAVA

Coming shortly

- Native IPv6 network via UNINET to the Abilene Network

Expect to be done in this summer.



Coming shortly (cont.)

Network Link at CNR

- 2 Mbps dedicated link From CNR to NECTEC,
- 34 Mbps link of all campus users to UNINET,
- 128 kbps dedicated link by Loxinfo

Coming shortly (cont.)

- The Department of Computer Engineering at PSU planes to run IPv6 network for the whole department (almost 300 PCs and 20 various servers) within this year.

To organise IPv6 workshops:

- 26-28 March 2003, open to public, in co-operation with ThaiSARN3 and NECTEC,
- 28-30 May 2003, for UNINET members.

2nd Workshop on IPv6: Fundamentals and Practical

26-28 March 2003

Organised by

Department of Computer Engineering,
Faculty of Engineering, Prince of Songkla University

Sponsored by

ThaiSARN-3, NECTEC

http://cnr.coe.psu.ac.th

3rd Workshop on IPv6: Fundamentals and Practical

28-30 May 2003

Organised by
Department of Computer Engineering,
Faculty of Engineering,Prince of Songkla University
http://cnr.coe.psu.ac.th

Sponsored by
Office of Information Technology Administration for Educational Development
Ministry of University Affairs

Conclusion

Must still to do

- Deployment has just only begun,
- Much training works need to be done (e.g. application developers, network administrators),
- Implementation are not as advanced (e.g. with respect to performance, multicast/anycast support),

Conclusion (cont.)

- Much work needs to be done moving applications, middleware, and management software for IPv6,
- Many advanced features of IPv6 need to be specified and employed
- We need to do it seriously (with supporting from high level policy)

IPv6 Transitional Issues

For APEC-TEL 27 IPv6 Workshop, Bangkok
March 20~21, 2003

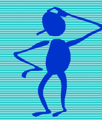
Chin-Chou Chen
chinchou@cht.com.tw
Chunghwa Telecom Labs.

NICI IPv6 Steering Committee, Chinese Taipei

中華電信股份有限公司
Chunghwa Telecom Co., Ltd.

Contents

- **Why** *should Internet evolve?*

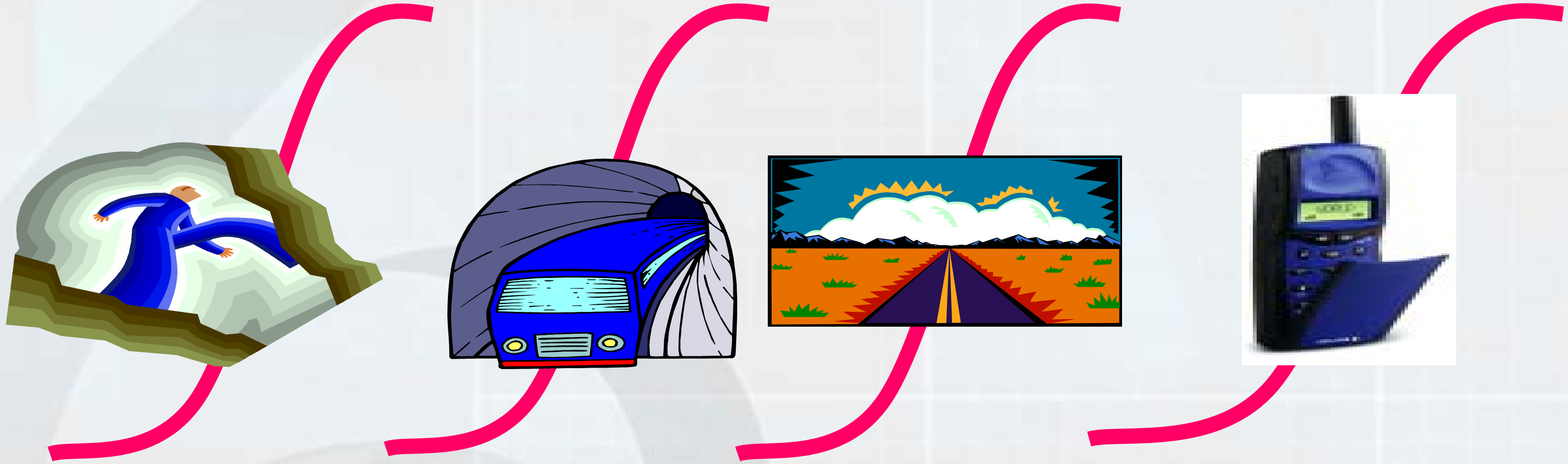


- **What** *are the considerations*

- **How** *are the Steps --- IPv6 Transition*

Technology & Progress Waves

Canals Railways Highways Telecommunications



1750	1800	1850	1900	1950	2000	2050

GOODS

PEOPLE

INFORMATION

中華電信股份有限公司
Chunghwa Telecom Co., Ltd.

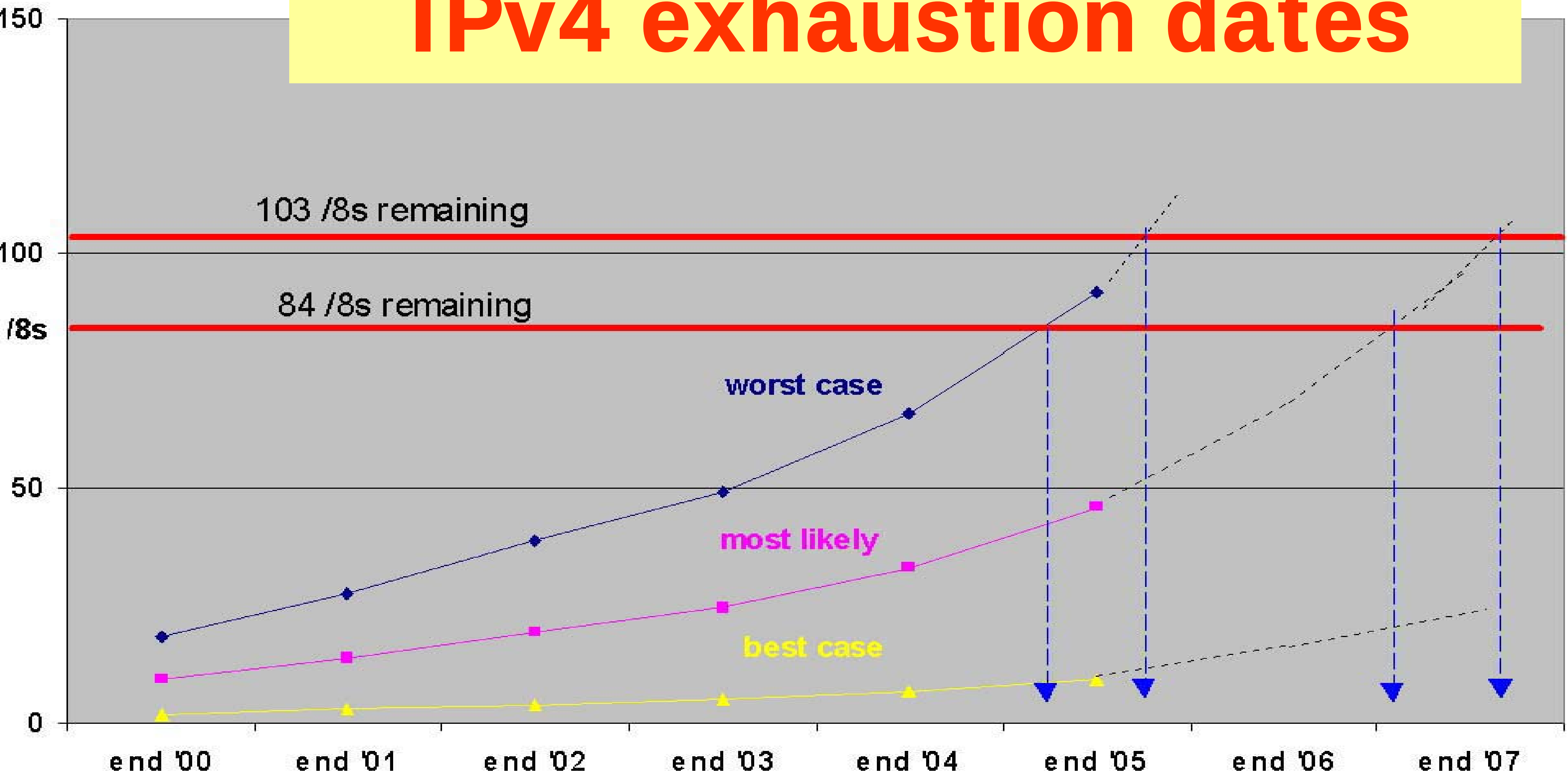
Source: Latif LADID, 2002 IPv6 Forum Taiwan

Market Trend *What do customers want ?*

- Everything goes to the Internet
  - New behavior
  - New business
- Everywhere reachable by Wireless
  - Global mobility
  - Global access
- Internet at Anywhere in Anytime
  - Wireless Internet and IP mobility
  - Global unique address No dialups

IPv6 should be in operation before 2004

IPv4 exhaustion dates



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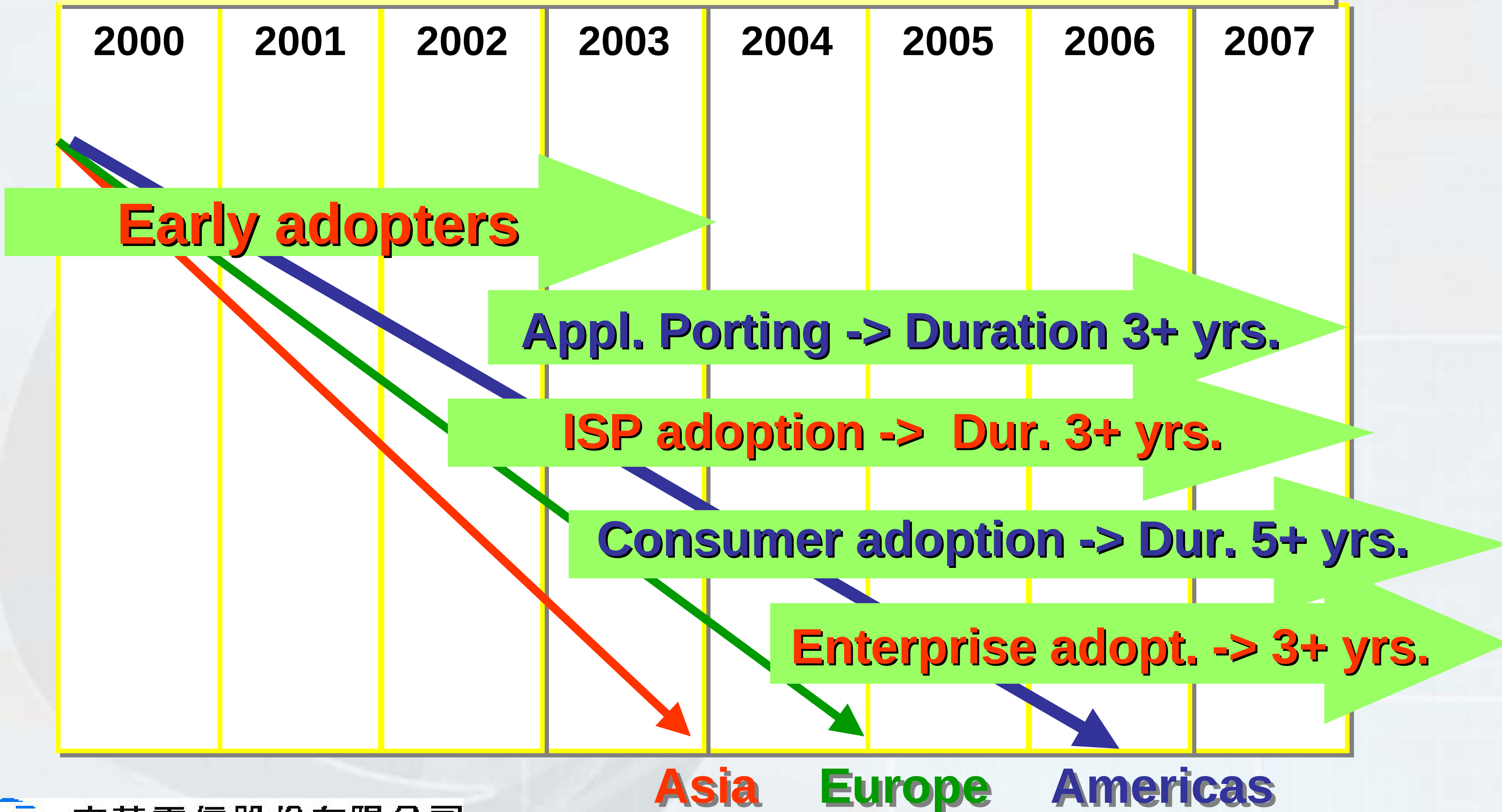
Chunghwa Telecom Co., Ltd.

Global demand for Cellular and ADSL/Cable modem - exhaustion dates (ICANNのAdhoc)

Contents

- ***Why* should Internet evolve?**
- ***What* are the considerations**
- ***How* are the Steps --- *IPv6 Transition***

IPv6 Adoption Timeline
(A pragmatic projection)



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Chunghwa Telecom Co., Ltd.

Source: Latif LADID, 2002 IPv6 Forum Taiwan

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- **Why** *should Internet evolve?*
- **What** *are the considerations*
- **How** *are the Steps --- IPv6 Transition*
  - *Technical Steps*
  - *Promotion Steps*

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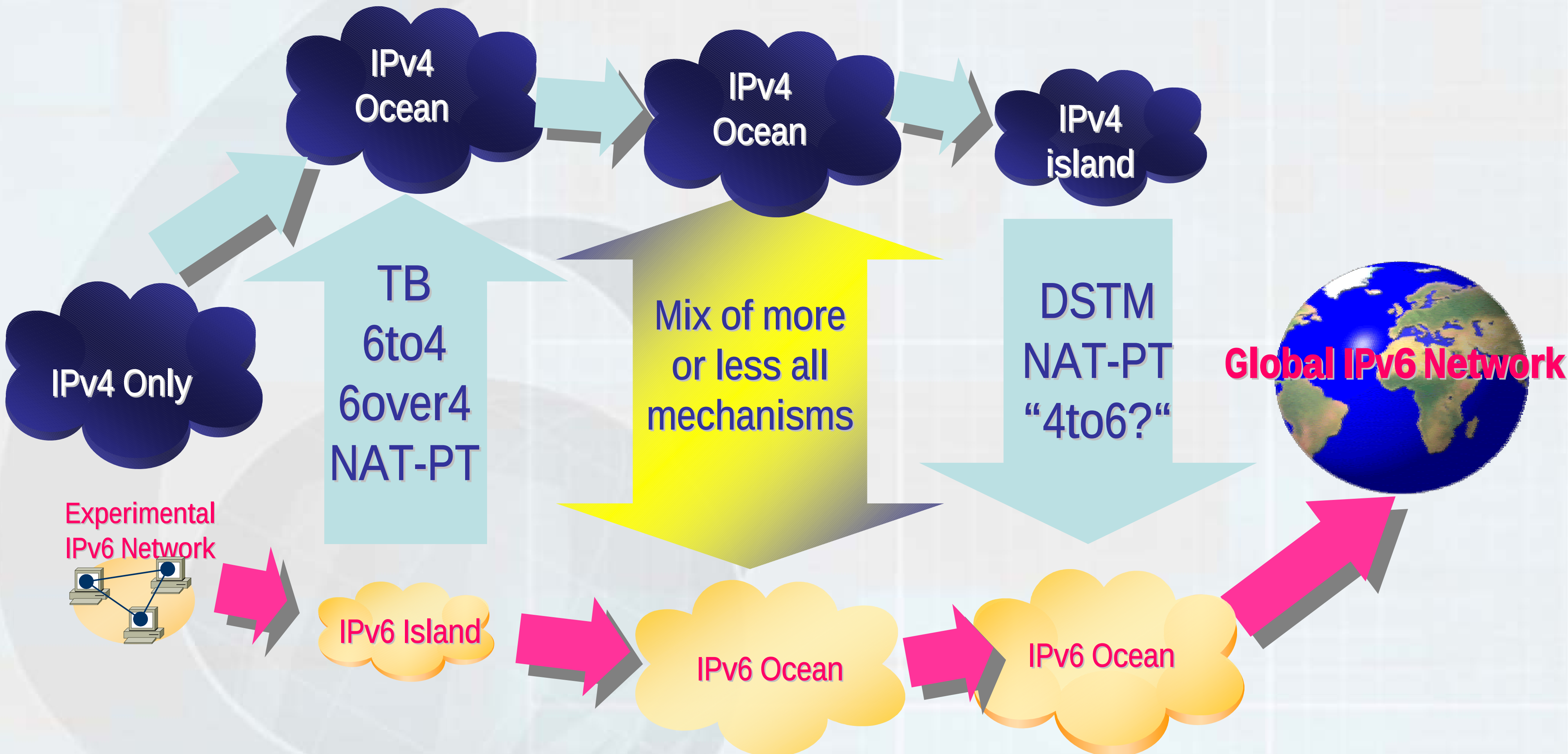
Chunghwa Telecom Co., Ltd.

Steps for transition



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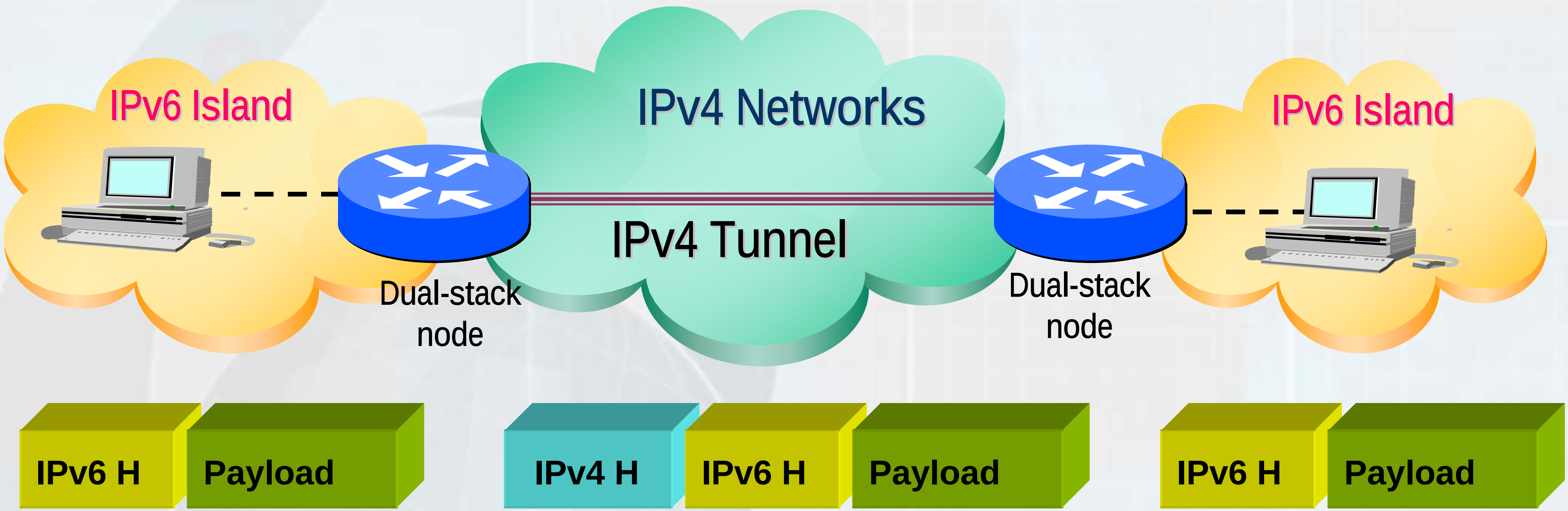
Chunghwa Telecom Co., Ltd.

IPv4/v6 Transition Mechanisms

- **Connecting IPv6 islands**
  - Configured tunnels
  - Automatic tunnels
  - Tunnel broker
  - 6to4
  - 6over4

- **Communication between IPv4 and IPv6 hosts**
  - Dual stack
  - SIIT (Stateless IP/ICMP Translation)
  - NAT-PT
  - BIS (Bump In the Stack)
  - BIS/BIA ((Bump In the Stack/Bump In the API)
  - SOCKS gateway
  - Transport relay

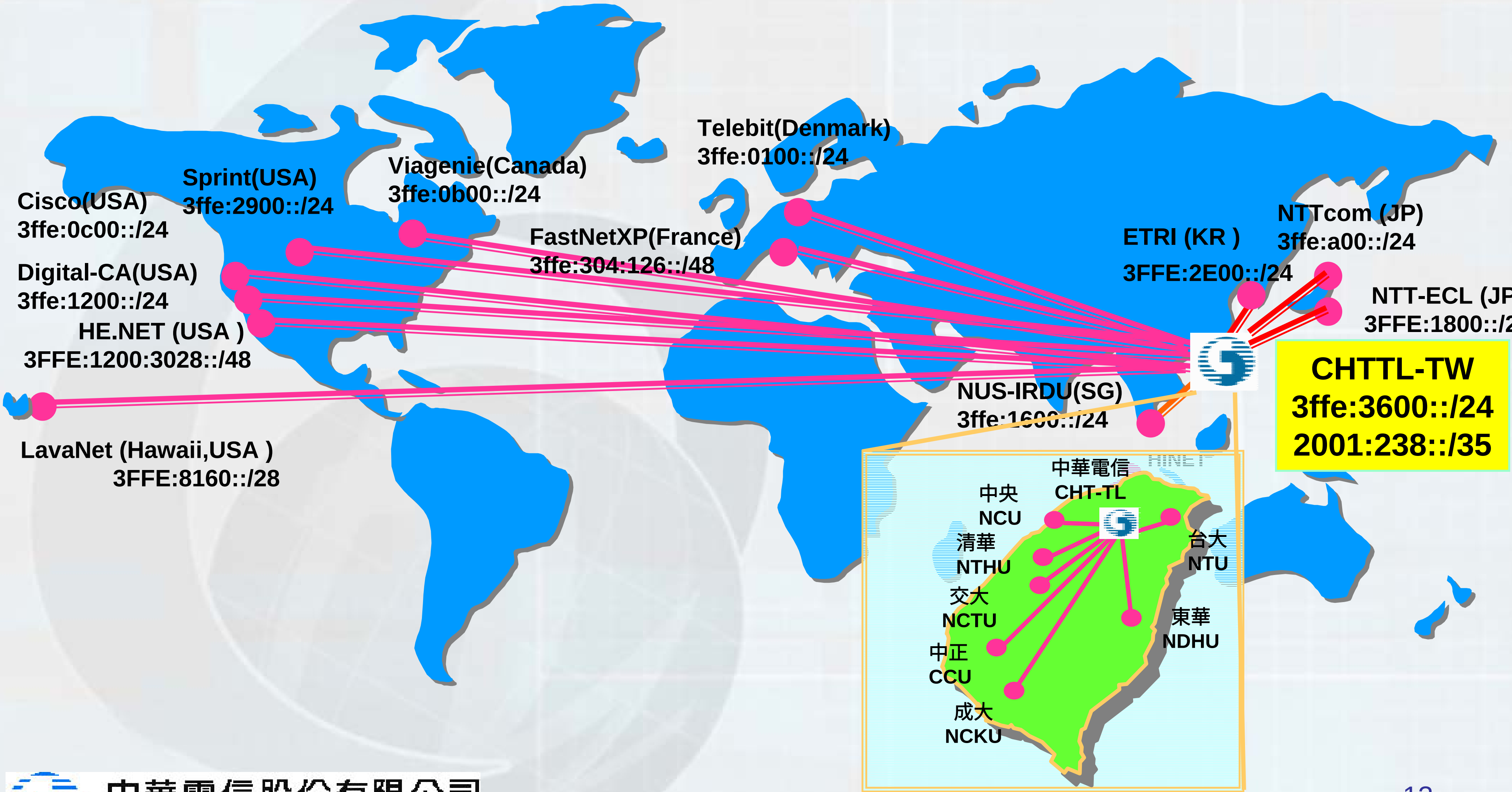
Configured Tunnels



Configured Tunnels：6-BONE

- An independent outgrowth of IETF IPng project
- Virtual network
  - Layered on IPv4-based Internet to support routing of IPv6 packets
- make test carried out
  - implementation
  - inter-operability
- To provide the early policies and procedures for IPv6 transport
- Operational from June/July on 1996
- Will be replaced in a transparent way by
  - production ISP
  - user network IPv6 Internet-wide transport

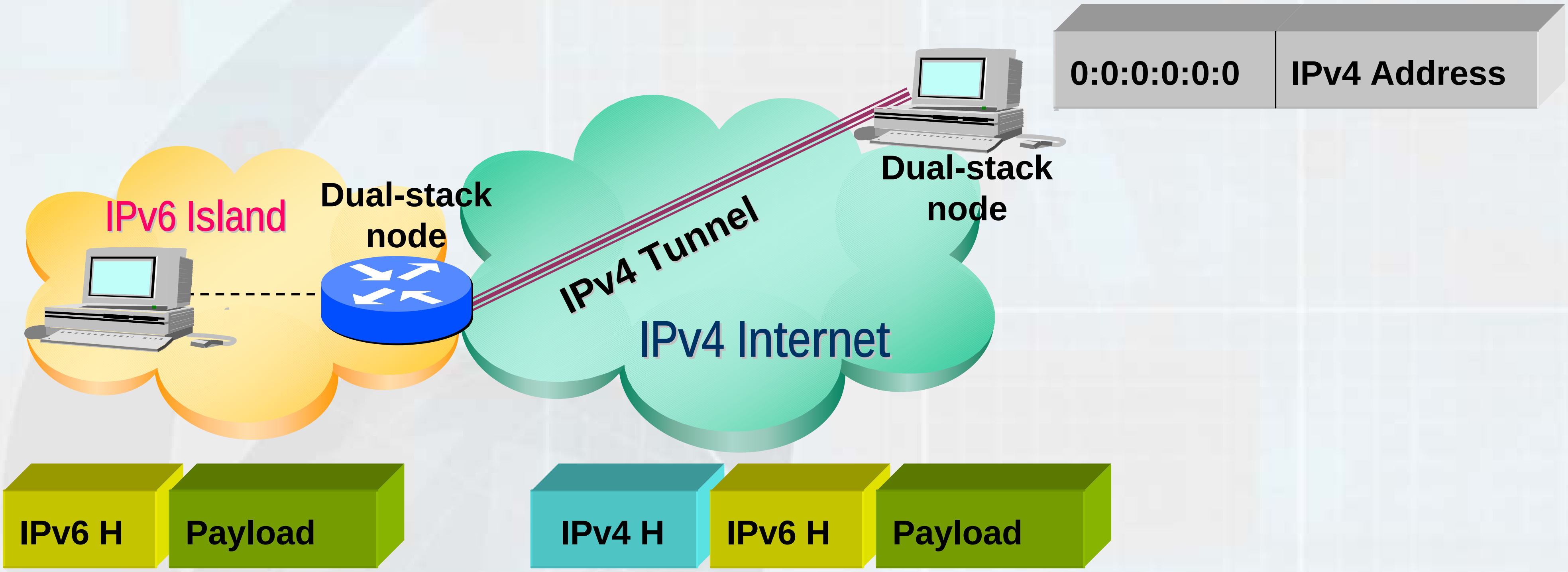
CHT-TL 6Bone International Tunnels



Automatic Tunnels

- Node is assigned an IPv4 compatible address
  - ::140.112.1.101
- If destination is an IPv4 compatible address, automatic tunneling is used
  - Routing table redirects ::/96 to automatic tunnel interface

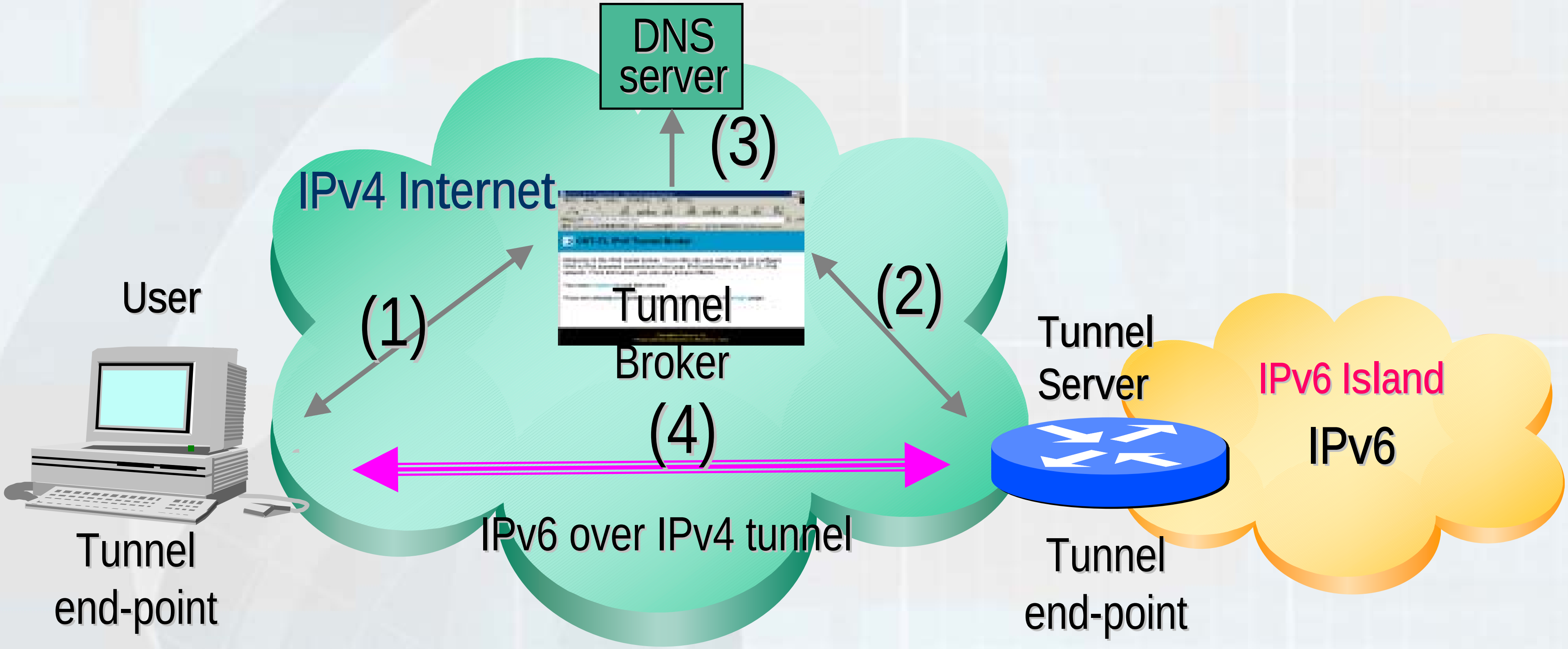
Automatic Tunnels



Tunnel Brokers

- Tunnel broker automatically manages tunnel requests coming from the users
  - The Tunnel Broker fits well for small isolated IPv6 sites, especially isolated IPv6 hosts on the IPv4 Internet
- Client node must be dual stack (IPv4/IPv6)
- The client IPv4 address must be globally routable (no NAT)
- RFC 3053

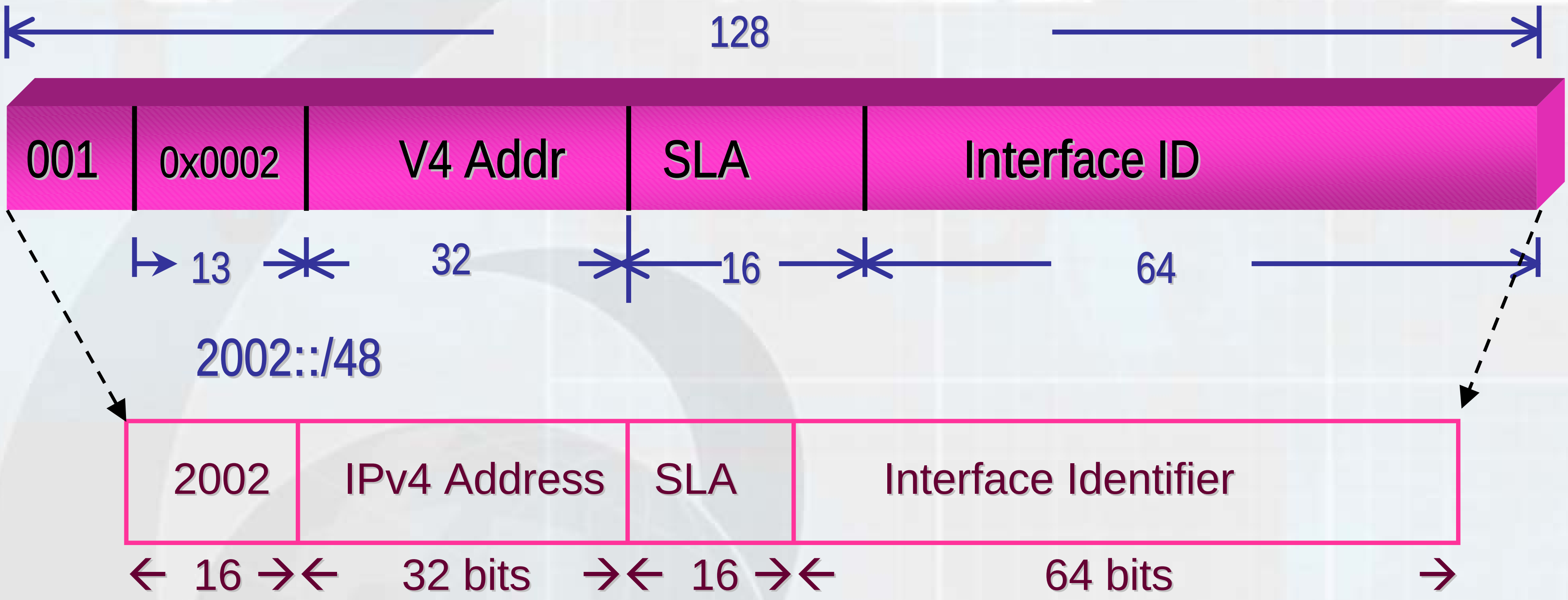
Tunnel Brokers



6to4

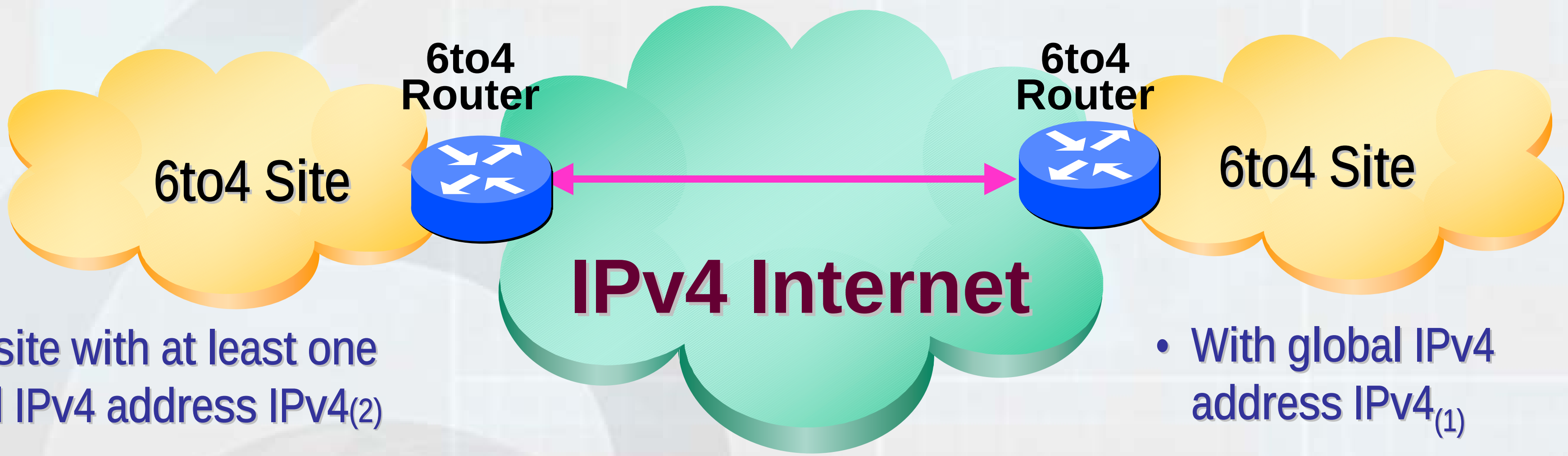
- Interconnection of isolated IPv6 domains in an IPv4 world
- No explicit tunnels
  - No scaling issues
- The egress router of the 6to4 site must
  - Have a dual stack (IPv4/IPv6)
  - Have a globally routable IPv4 address
  - Implement 6to4
- The site uses the 6to4 TLA (0x0002) for the site IPv6 prefix
- RFC 3056

Address Prefix for 6to4

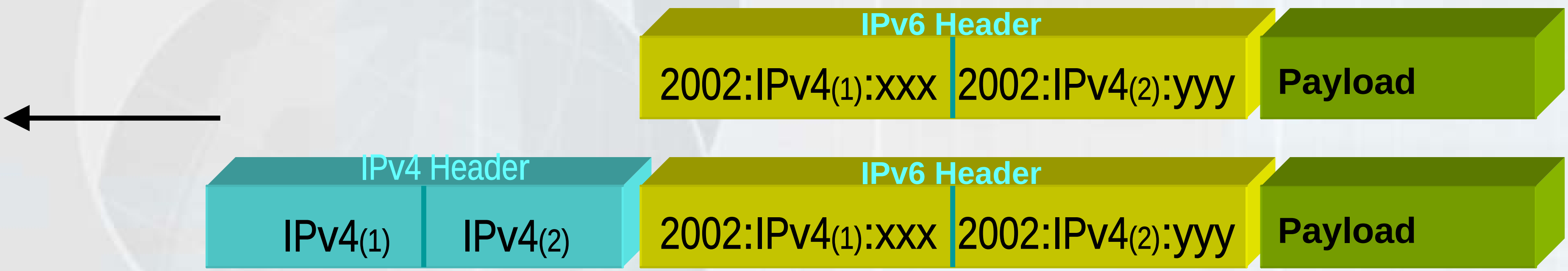


- Site creates a 48 bit prefix using its gateway router's public IPv4 address
  - 2002:A.B:C.D::/48 for IPv4 address A.B.C.D

6to4



- Each site with at least one global IPv4 address IPv4(2)
- With global IPv4 address IPv4(1)



Communication between IPv6 and IPv4 nodes

- Previous transition mechanisms take care of interconnecting IPv6 domains
- How do IPv6 hosts communicate with legacy IPv4 only hosts ?
  - Old printers, network equipment, …
- Many ways to do this, the simplest one is the dual stack host

Dual Stack

- Dual stack host
  - When the host initiates a communication, the DNS will provide either an IPv6 address, an IPv4 address or both.
- The host will then establish the communication using the appropriate IP stack.
- Same scenario for a server: listens on both IPv4 and IPv6 network socket.
- But every hosts needs an IPv4 address.

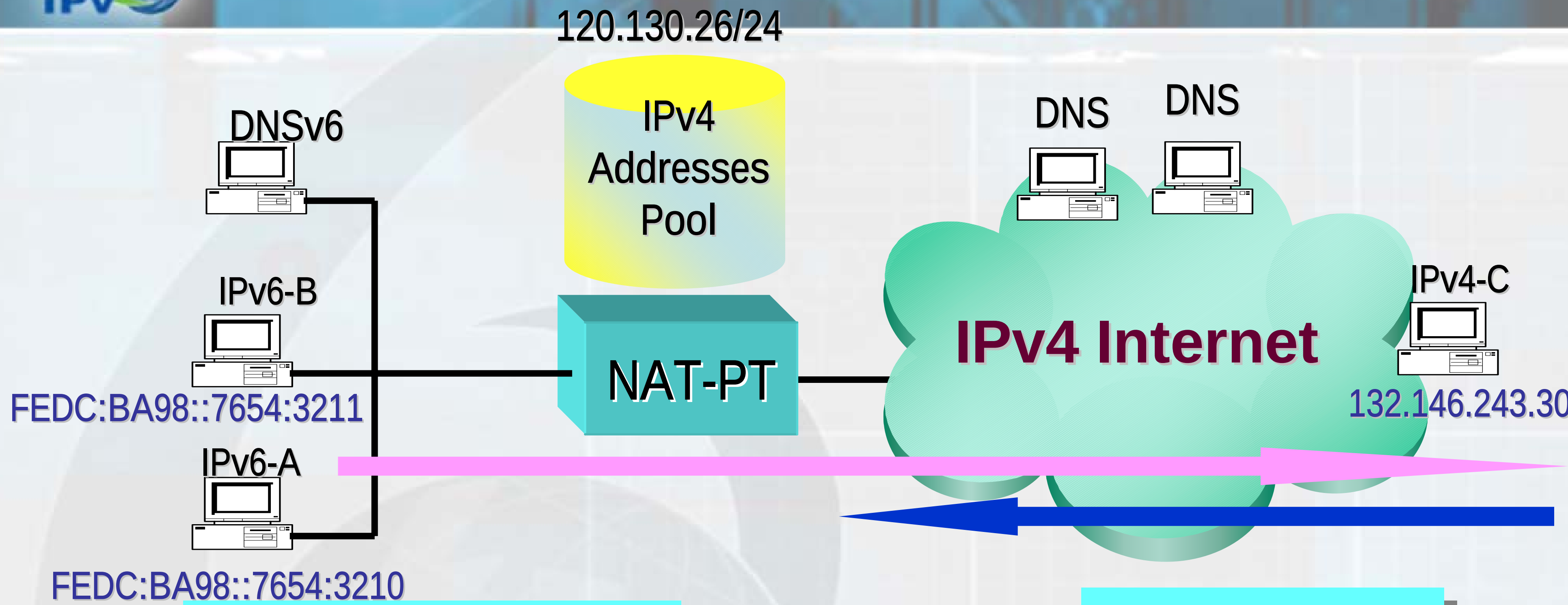
NAT-PT (Network Address Translation-Protocol Translation.)

- Allows IPv6-only hosts to talk to IPv4 hosts and vice-versa
- Stateful translation
- Requires at least one IPv4 address per site
- Traditional NAT-PT
  - Sessions are unidirectional, outbound from the v6 network
  - Two variations: Basic-NAT-PT and NAPT-PT
- Bi-directional-NAT-PT
  - Session can be initiated from hosts in v4 network as well as the v6 network
  - A DNS-ALG (application level gateway) must be employed to facilitate name to address mapping
- similar to NAT in IPv4 network
- RFC 2766

NAT-PT (Network Address Translation-Protocol Translation.)

- Limitations
  - all requests and responses pertaining to session should be routed via the same NAT-PT router.
  - A number of IPv4 fields have changed meaning in IPv6 and translation is not straightforward.
  - Ex. Option headers, details found in [SIIT]
  - Applications that carry the IP address in the high layer will not work. In this case ALG need to be incorporated to provide support for these applications.
  - Lack of end-to-end security

NAT-PT



A packet with
SA=FEDC:BA98::7654:3210
TCP Src port=3017
DA=prefix::132.146.243.30
TCP Dst port=23

A packet with
SA=120.130.26.10
Src port=1025
DA=132.146.243.30.
Dst port=23

ISATAP

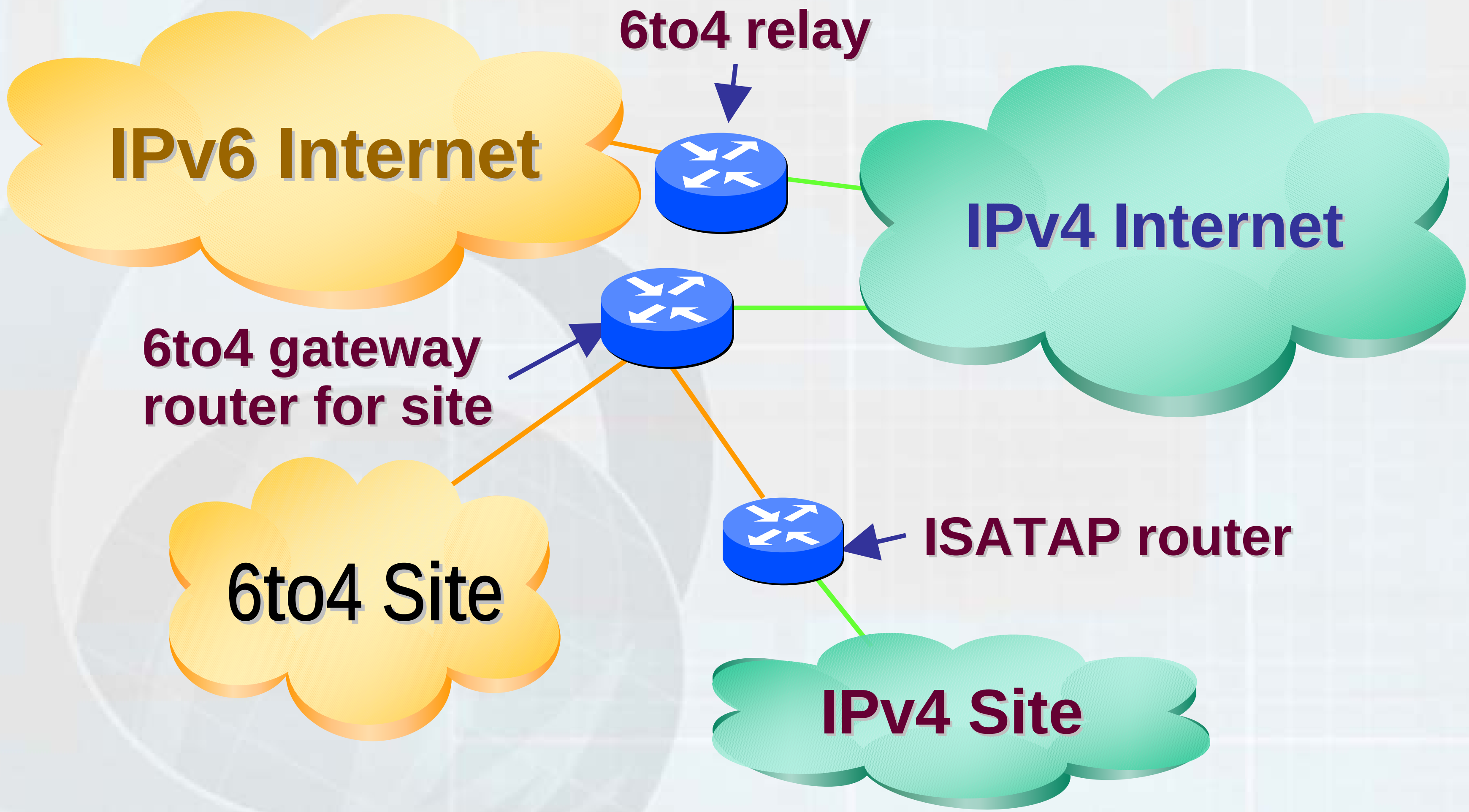
Intra-Site Automatic Tunnel Addressing Protocol

- Method for automatically connecting IPv6 nodes over an IPv4 network
  - Local IPv4 network appears as a single IPv6 subnet
  - Can use public or private IPv4 addresses

Subnet Prefix	0 : 5efe	IPv4 Address
← 64 bits →	← 32 bits →	← 32 bits →

- Nodes communicate by tunneling packets to the IPv4 address encoded in the suffix

6to4 and ISATAP



Contents

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  - *Technical Steps*
  - *Promotion Steps --- the case in Chinese Taipei*

Broadband+Wireless+Homenetwork

Home Network
Internet
Home Network
Internet
Appliance, Smart building

Broadband
By 2008:
- **95% FTTH coverage**
- **6 million broadband subscribers**

IPv6

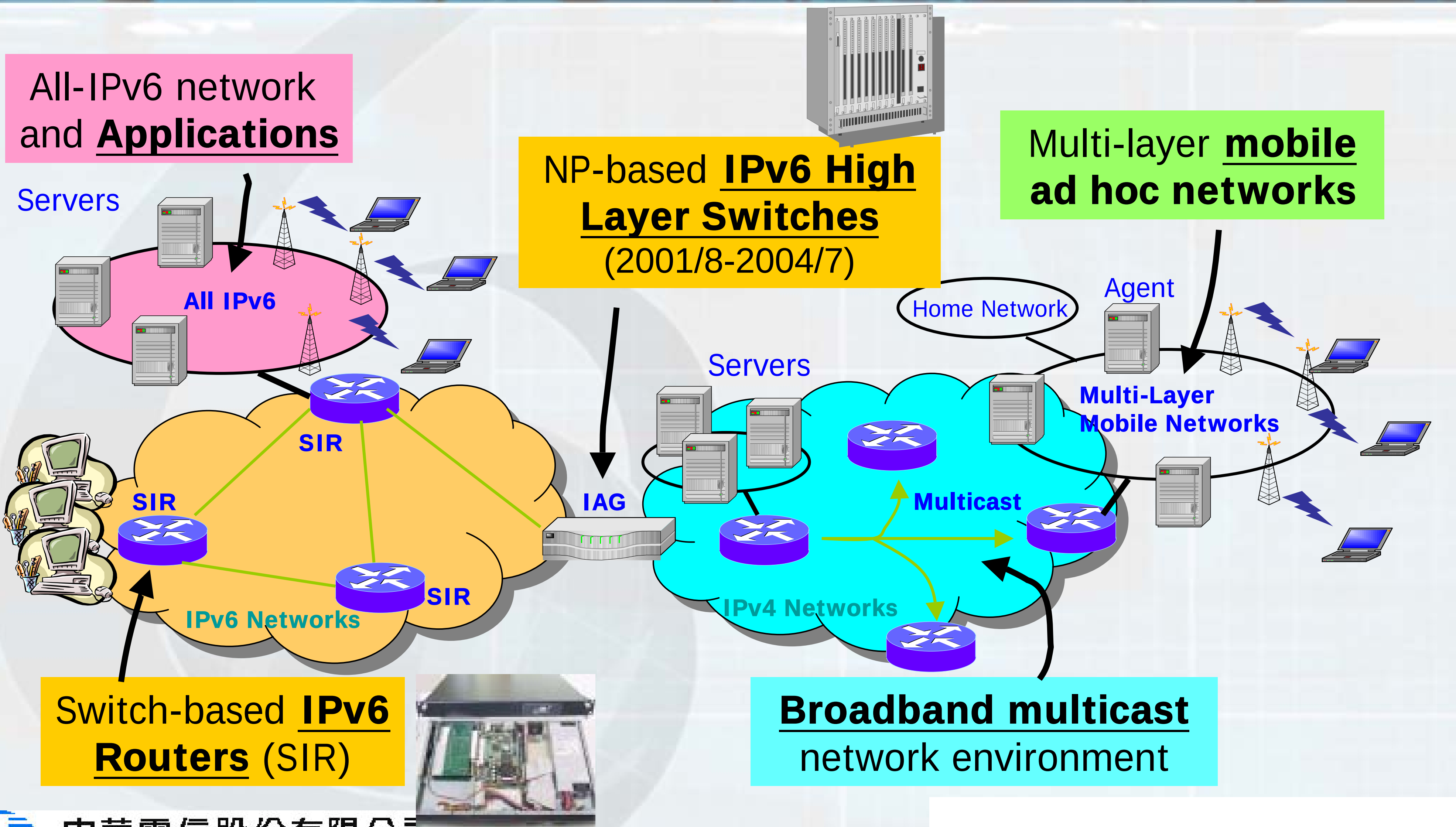
Wireless Internet
- **3G services to be launched in 3Q 2003**
  - **"Public Hotspots deployment plan" to make Chinese Taipei a "Wireless Island"**

Ubiquitous Network Environment

1. More IP addresses will be consumed

2. More advanced features will be required

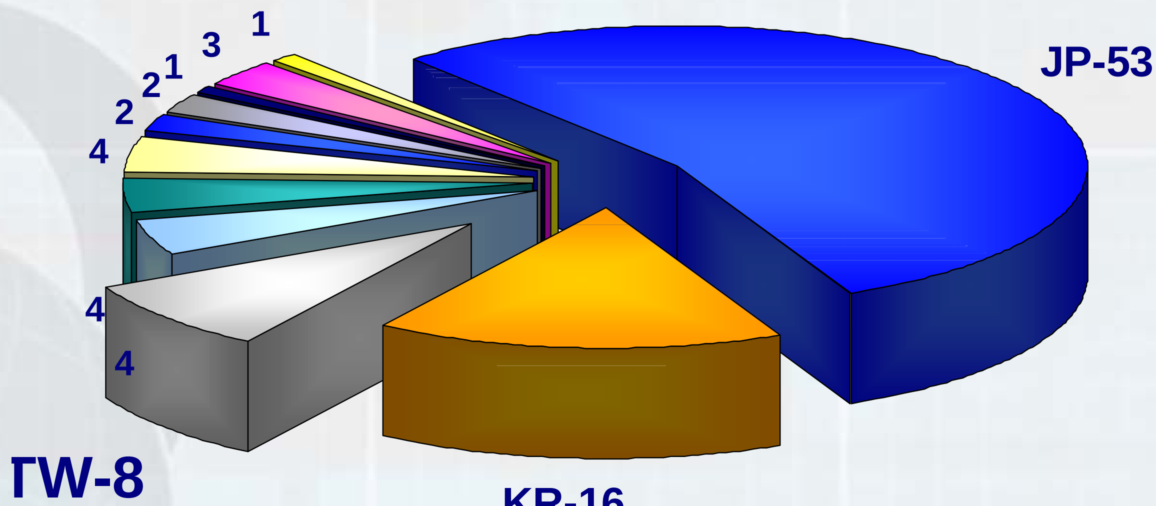
National Telecom. Project Office



中華電信股份有限公司
Chunghwa Telecom Co., Ltd.

ISPs are moving

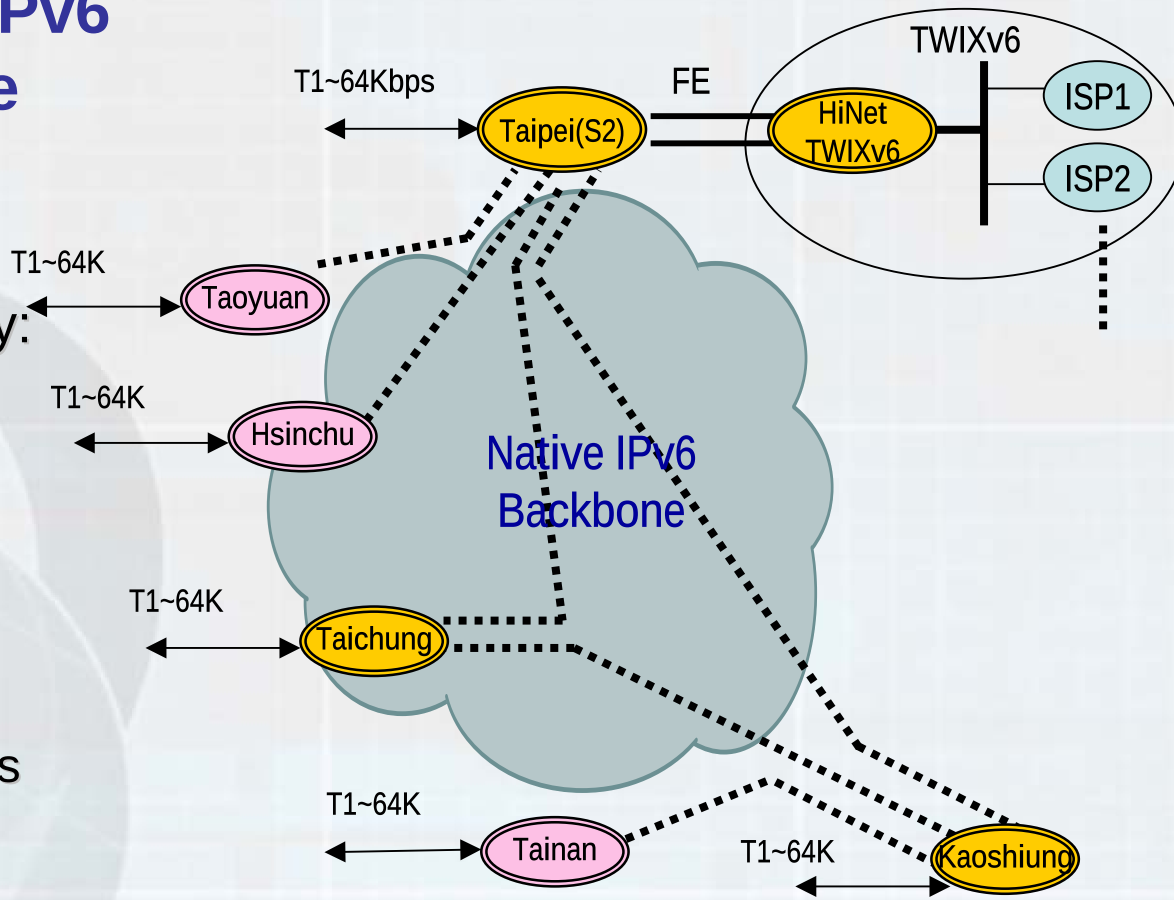
HiNet	2001:0238::/32
TANet	2001:0288::/32
ASNet	2001:0C08::/32
TTN	2001:0C50::/32
6REN	2001:0C58::/32
CHTTL	2001:0CA0::/32
TWIX	2001:07FA:0001::/48
SeedNet	2001:0CD8::/32
TFN	2001:????::/32



Source: APNIC

HiNet

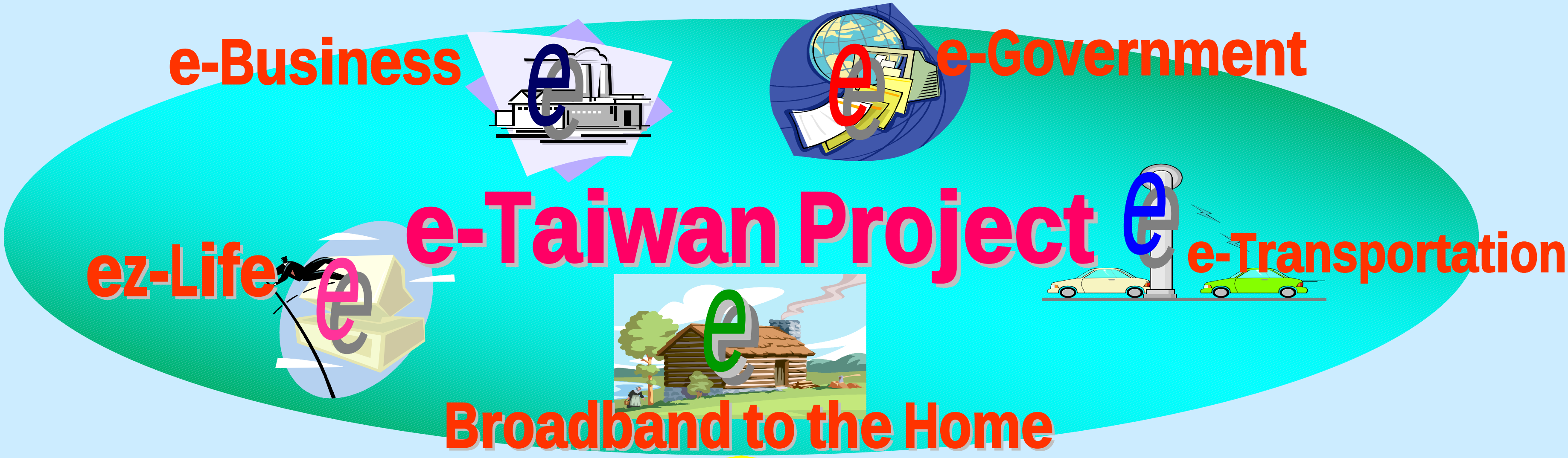
- **The first ISP launched IPv6 commercial trial service since July, 1, 2001**
  - 6 IPv6 POPs in the island
  - LL, ADSL IPv6 connectivity:
    - Native connection
    - 6to4Relay
    - Tunneling
    - TWIXv6 peering
- **2003 plan:**
    - Introduce high-end routers
    - Add some more POPs
    - IPv6 content



Source: HiNet, Chunghwa Telecom .

"Challenging 2008"

2002-2007 Six Years National Development Projects



5 Flagship Plan

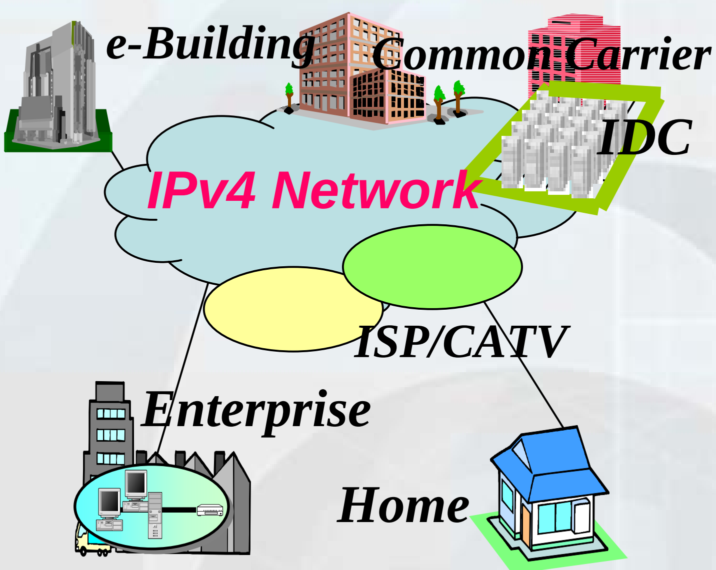
- 6 Million Broadband Subscribers
- Broadband Wireless Access
- **IPv6**
- Broadband to Mid- and Small-Enterprise
- Secure Environment for Information Communication

IPv6 Deployment & Development Plan

- **Proposed by NICI IPv6 Steering Committee**
- **Missions:**
  - To help the **upgrade** of public Internet infrastructure to IPv6
  - To enhance the **competitiveness** of local industry
  - To **integrate** existing IPv6 resources and efforts from the government, industry, and research institutes

IPv6 Deployment & Promotion Plan

NOW



- . Insufficient address space
- . Poor mobility & security
- . Limited application

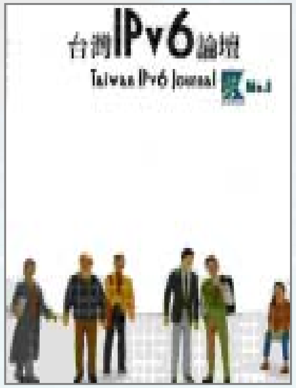
2008

- . Get rid of address space limitation
- . Enhanced mobility & security
- . Encouraged IP-based application

Promotion Activities

- Promoting the use and user awareness of IPv6
  - IPv6 demo in IT month fair, 2001, 2002
  - IPv6 demo & Tutorial in TANET2001, 2002 conference
  - Trained over 1,000 IT professionals on IPv6 in 2002
  - Computex Taipei (2003)

- Sponsoring and hosting IPv6 events
  - IPv6 Forum Taiwan opening, Apr.2002
  - APRICOT and the 1st IPv6 Summit in AP, Feb.2003(attendees 1069 , the new record)
  - IPv6 Industrial Seminar (2003)



- IPv6 publications
  - IPv6 Journal (bi-annually)
  - IPv6 e-News (bi-monthly)
  - IPv6 Website

IPv6 Features

For APEC-TEL 27 IPv6 Workshop, Bangkok
March 20~21, 2003

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IPv6 Is Not Only Unlimited Address Space

QoS

Flow Bits?

…

…

Reliability

Simplicity

STRING of Technology PERLS

Flexible

Renumbering

Dynamic Routing

Transition

Tool Box

Multicast v6

e2e Security

Mobile IPv6

Autoconfiguration

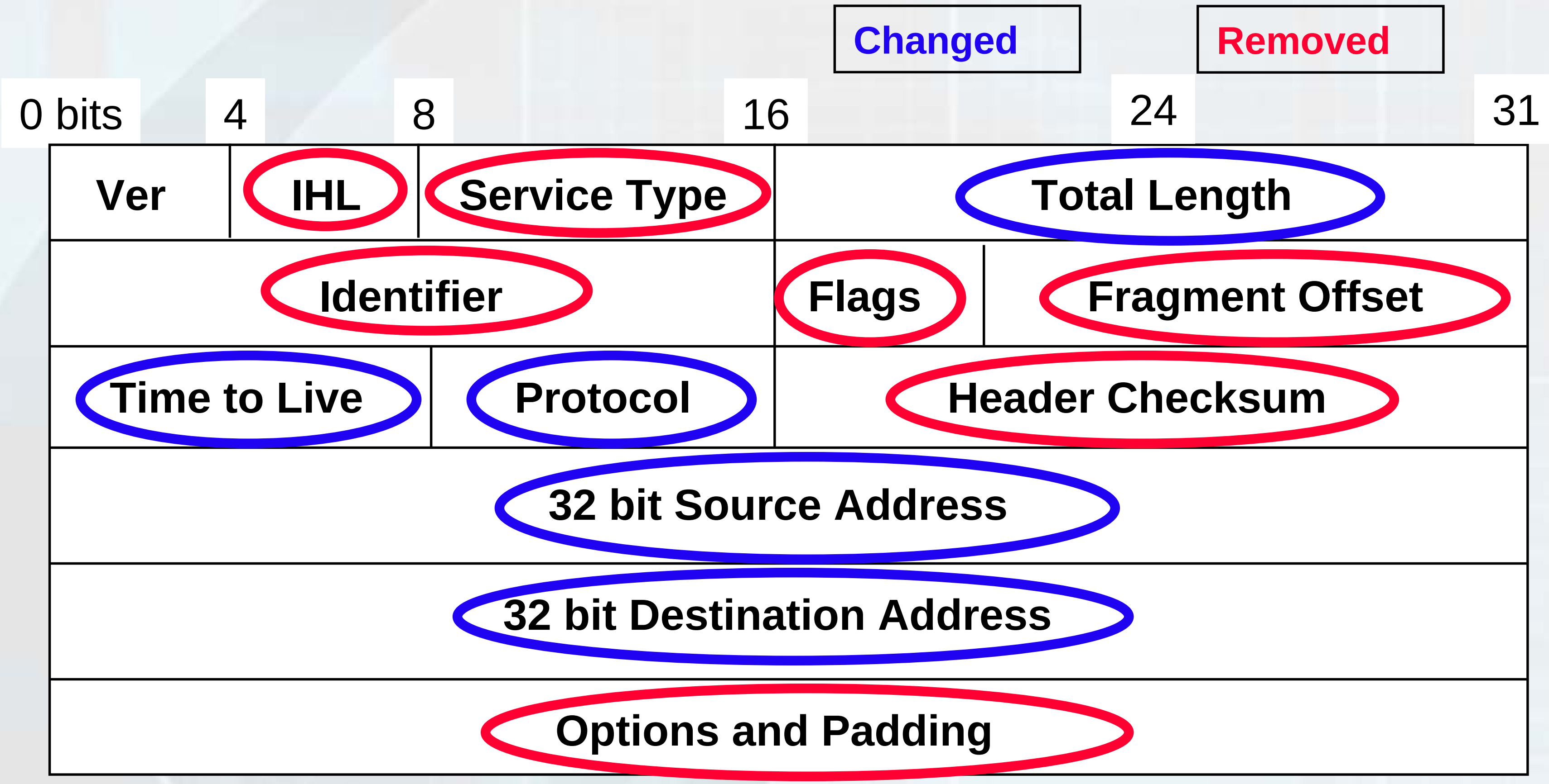
Plug & Ping

End-2-end

Transparency

IPv4 move to IPv6

20 Octets+Options : 13 fields, include 3 flag bits



IPv6 Header

40 Octets, 8 fields

<table>
<tr><th>0</th><th>4</th><th>12</th><th>16</th><th>24 … 31</th></tr>
<tr><td>Version</td><td>Class</td><td colspan="3">Flow Label</td></tr>
<tr><td colspan="3">Payload Length</td><td>Next Header</td><td>Hop Limit</td></tr>
<tr><td colspan="5">128 bit Source Address</td></tr>
<tr><td colspan="5">128 bit Destination Address</td></tr>
</table>

- Redundant header options dropped:
  - Type of service
  - Flags
  - Identification
  - Fragmentation offset (IPv6 uses path MTU discovery)
  - Header Checksum (most encapsulation procedures include this function eg: IEEE 802 MAC, PPP Framing, ATM adaption layer)

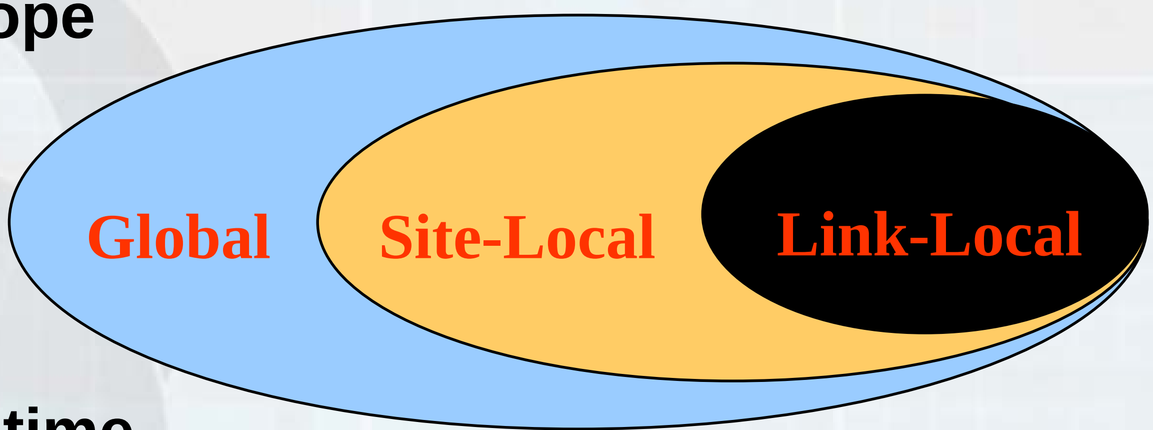
- Some fields re-named:
  - length => payload
  - protocol type => next header
  - time to live => hop limit
- One field revised:
  - Option mechanism (variable length field replaced by fixed length extension header)
- Two fields added:
  - Priority
  - Flow Label

IPv6 Addressing

- 128 bits long. Fixed size
- $2^{128} = 3.4 \times 10^{38}$ addresses => 6.65×10^{23} addresses per m^2 of earth surface
- If assigned at the rate of $10^6/\mu s$, it would take 20 years
- Allows multiple interfaces per host
- Allows multiple addresses per interface

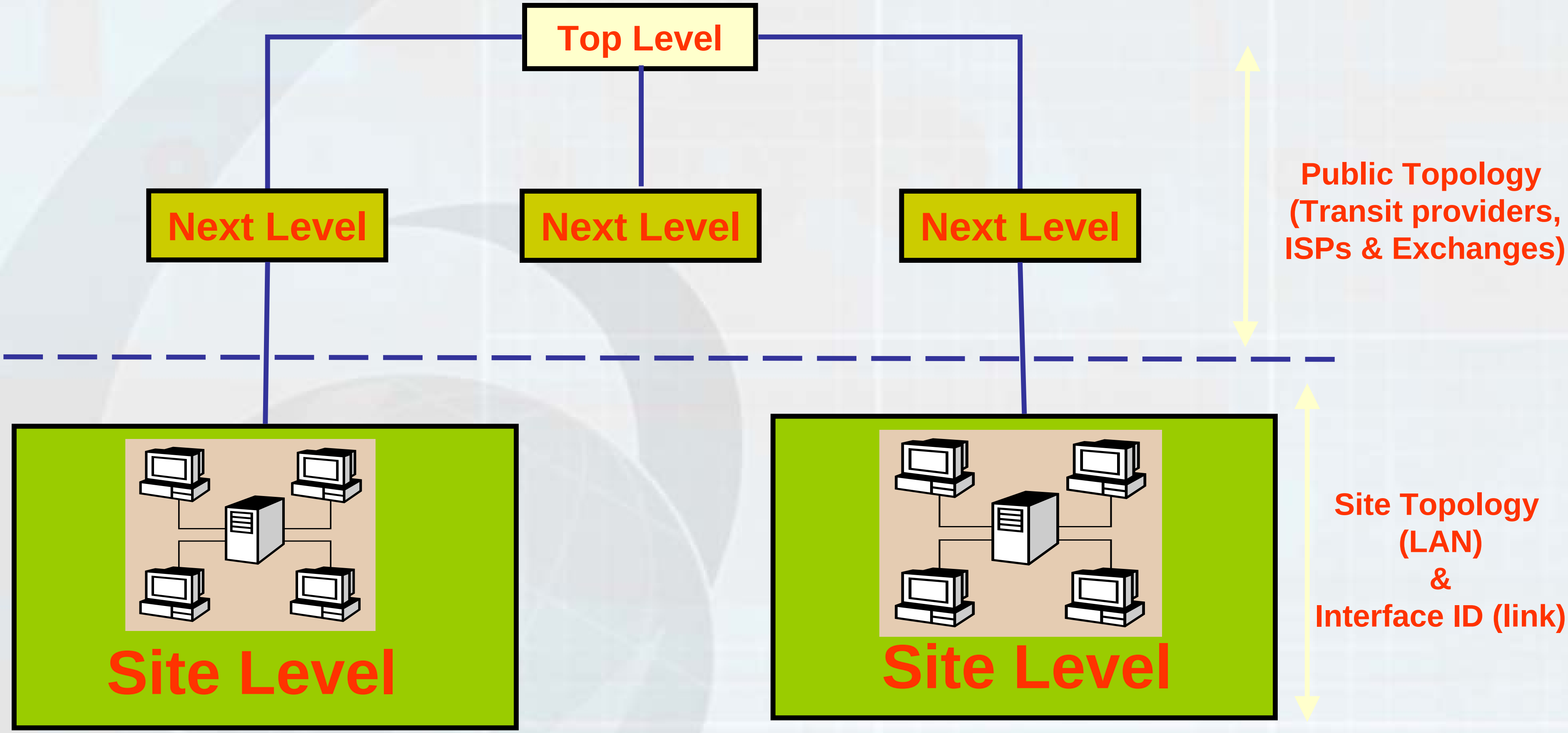
IPv6 Addressing

- Addresses are assigned to interfaces
  - No change from IPv4 Model
- Interface 'expected' to have multiple addresses
- Addresses have scope
  - Link Local
  - Site Local
  - Global



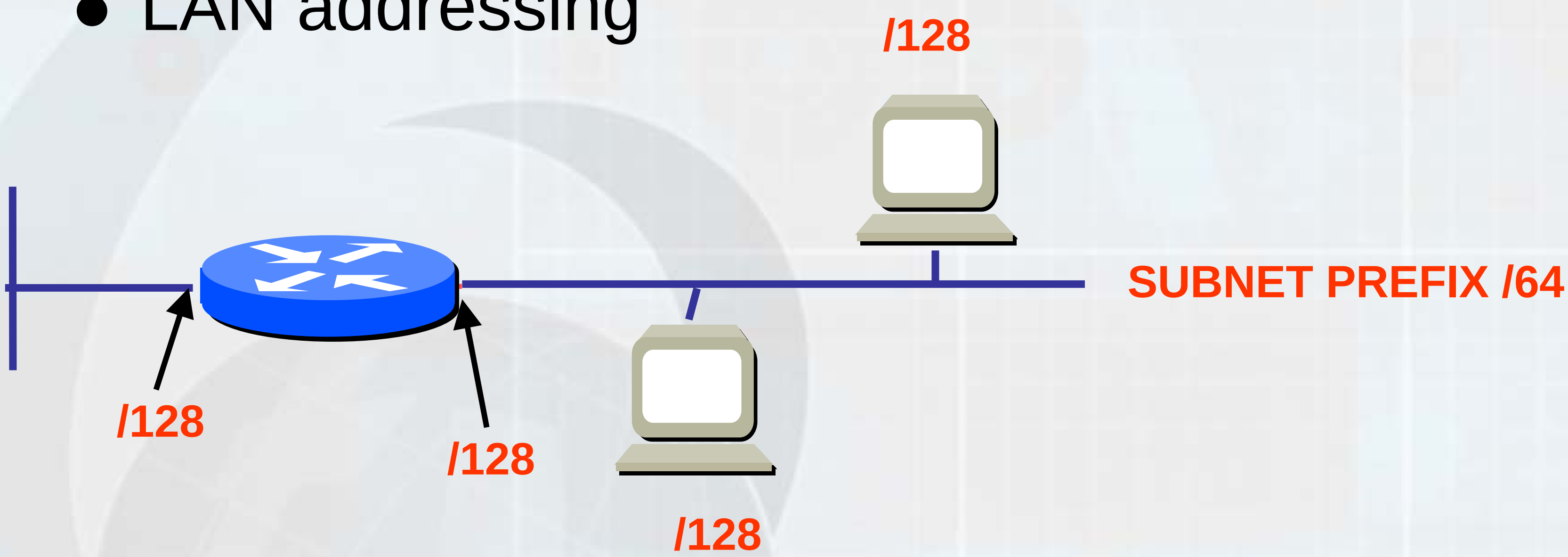
- Addresses have lifetime
  - Valid and Preferred lifetime

IPv6 Addressing



IPv6 Addressing

- LAN addressing



  – Subnet prefix + MAC address = /128

IPv6 Addressing

- Address syntax
  - Hexadecimal values of eight 16 bit fields
    - X:X:X:X:X:X:X:X (X=16 bit number, eg: A2FE)
    - 16 bit number is converted to a 4 digit hexadecimal number
- IPv6
  - Preferred form: 1080:0:FF:0:8:800:200C:417A
  - Compressed form:FF01:0:0:0:0:0:0:43 becomes FF01::43
  - IPv4-compatible: 0:0:0:0:0:0:211.72.211.1 or ::211.72.211.1
- IPv4
  - 211.72.211.1

IPv6 Addressing

- Unicast
  - Address of a single interface
  - Delivery to single interface
- Multicast
  - Address of a set of interfaces
  - Delivery to all interfaces in the set
- Anycast
  - Address of a set of interfaces
  - Delivery to a single interface in the set
- No more broadcast addresses

IPv6 Addressing

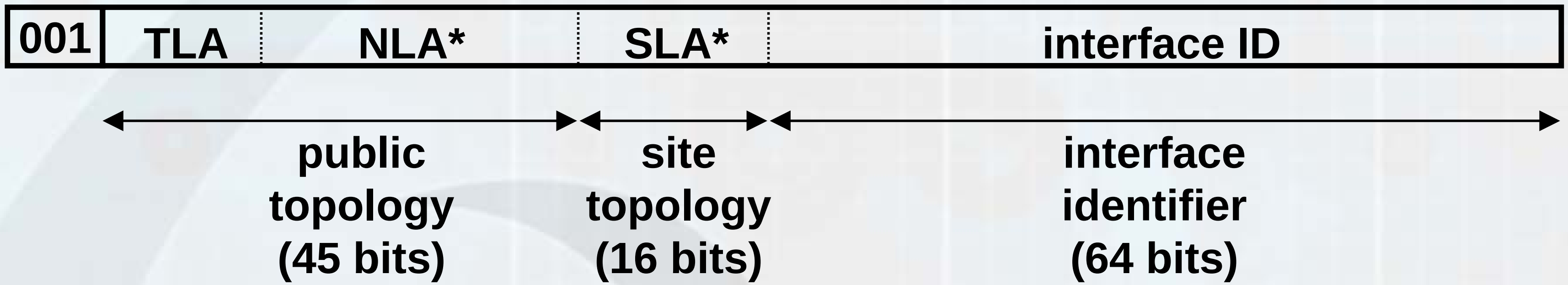
- IPv6 allocation of RIR's
  - APNIC 2001:0200::/23
  - ARIN 2001:0400::/23
  - RIPE NCC 2001:0600::/23
- 6Bone 3FFE::/16
- 6to4 tunnels 2002::/16
- APNIC IPv6 allocation
  - http://www.apnic.net/apnic-bin/ipv6-subtla-request.pl

Address Type Prefixes

Address type	Binary prefix
IPv4-compatible	0000...0 (96 zero bits)
global unicast	001
link-local unicast	1111 1110 10
site-local unicast	1111 1110 11
multicast	1111 1111

- all other prefixes reserved (approx. 7/8ths of total)
- anycast addresses allocated from unicast prefixes

Global Unicast Addresses



- TLA = Top-Level Aggregator
  NLA* = Next-Level Aggregator(s)
  SLA* = Site-Level Aggregator(s)
- all subfields variable-length, non-self-encoding (like CIDR)
- TLAs may be assigned to providers or exchanges

Special Unicast

- unspecified address
  - 0:0:0:0:0:0:0:0
  - similar to 0.0.0.0 of IPv4
- loopback address
  - 0:0:0:0:0:0:0:1
  - similar to 127.0.0.1 of IPv4

Link-Local and Site-Local

Link-local addresses for use during auto-configuration and when no routers are present:

1111111010	0	interface ID

Site-local addresses for independence from changes of TLA / NLA*:

1111111011	0	SLA*	interface ID

Interface IDs

Lowest-order 64-bit field of unicast address may be assigned in several different ways:

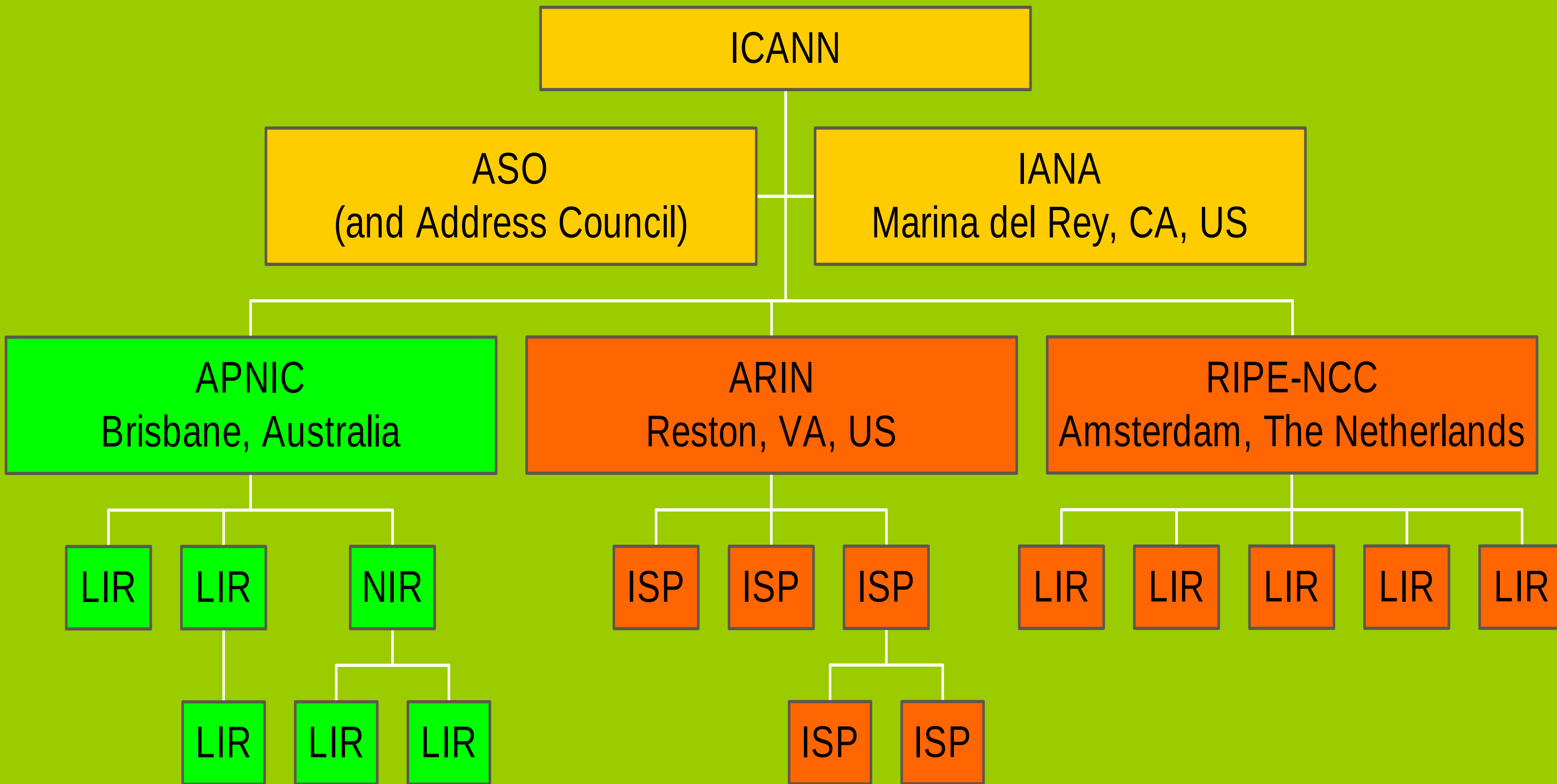
- auto-configured from a 64-bit EUI-64, or expanded from a 48-bit MAC address (e.g., Ethernet address)
- auto-generated pseudo-random number (to address privacy concerns)
- assigned via DHCP
- manually configured
- possibly other methods in the future

Address Space

Allocation Space	Prefix (binary)	Fraction of Address Space
Reserved	0000 0000	1/256
Unassigned	0000 0001	1/256
Reserved for NSAP Allocation	0000 001	1/128
Reserved for IPX Allocation	0000 010	1/128
Unassigned	0000 011	1/128
Unassigned	0000 1	1/32
Unassigned	0001	1/16
Unassigned	001	1/8
Provider-Based Unicast Address	010	1/8
Unassigned	011	1/8
Reserved for Geographic-Based Unicast Addresses	100	1/8
Unassigned	101	1/8
Unassigned	110	1/8
Unassigned	1110	1/16
Unassigned	1111 0	1/32
Unassigned	1111 10	1/64
Unassigned	1111 110	1/128
Unassigned	1111 1110 0	1/512
Link Local Use Addresses	1111 1110 10	1/1024
Site Local Use Addresses	1111 1110 11	1/1024
Multicast Addresses	1111 1111	1/256

Address Allocation

Address Allocation



Routing in IPv6

- As in IPv4, IPv6 supports IGP and EGP routing protocols:
  - IGP for within an autonomous system are
    - RIPng (RFC 2080)
    - OSPFv3 (RFC 2740)
    - Integrated IS-ISv6 (draft-ietf-isis-ipv6-02.txt)
  - EGP for peering between autonomous systems
    - MP-BGP4 (RFC 2858 and RFC 2545)
- IPv6 still uses the longest-prefix match routing algorithm

Routing in IPv6

- RIPng
  - –RIPv2, supports split-horizon with poisoned reverse
  - –RFC2080
- IS-ISv6
  - –Shared IGP for IPv4 & IPv6
  - –Route from A to B same for IPv4 & IPv6
  - –Separate SPF may provide SIN routing
- OSPFv3
  - –« Ships in the Night » routing
  - –Need to run OSPFv2 for IPv4
  - –Route from A to B may differ for IPv4 & IPv6

Routing in IPv6

- BGP4+
  - –Added IPv6 address-family
  - –Added IPv6 transport
  - –Runs within the same process - only one AS supported
  - –All generic BGP functionality works as for IPv4
  - –Added functionality to route-maps and prefix-lists

IPv6 Security

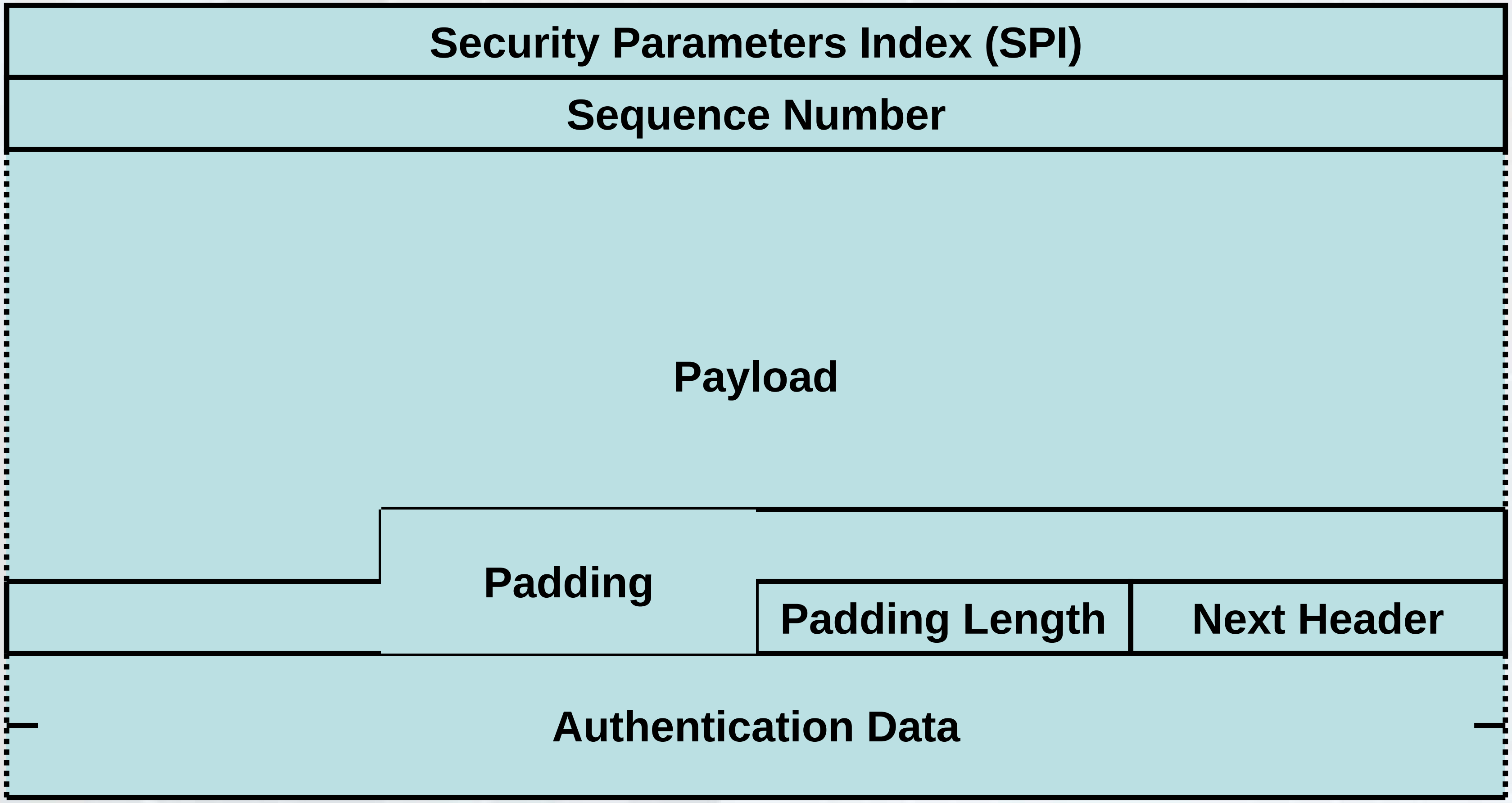
- All implementations required to support authentication and encryption headers (“IPsec”)
- Authentication separate from encryption for use in situations where encryption is prohibited or prohibitively expensive
- Key distribution protocols are under development (independent of IP v4/v6)
- Support for manual key configuration required

Authentication Header

Next Header	Hdr Ext Len	Reserved
Security Parameters Index (SPI)		
Sequence Number		
Authentication Data		

- Destination Address + SPI identifies security association state (key, lifetime, algorithm, etc.)
- Provides authentication and data integrity for all fields of IPv6 packet that do not change en-route
- Default algorithm is Keyed MD5

Encapsulating Security Payload (ESP)



IPv6 Deployment Status in Chinese Taipei

For APEC-TEL 27 IPv6 Workshop, Bangkok

March 20~21, 2003

Chin-Chou Chen
chinchou@cht.com.tw
Chunghwa Telecom Labs.

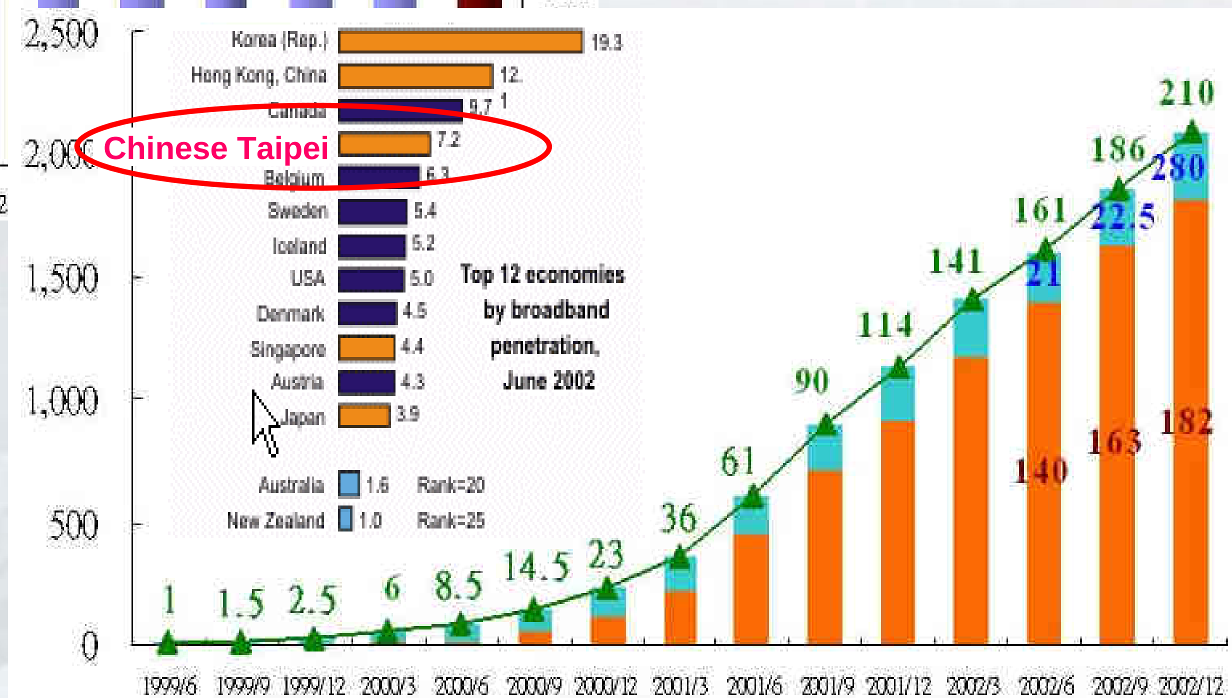
中華電信股份有限公司
Chunghwa Telecom Co., Ltd.

NICI IPv6 Steering Committee, Chinese Taipei

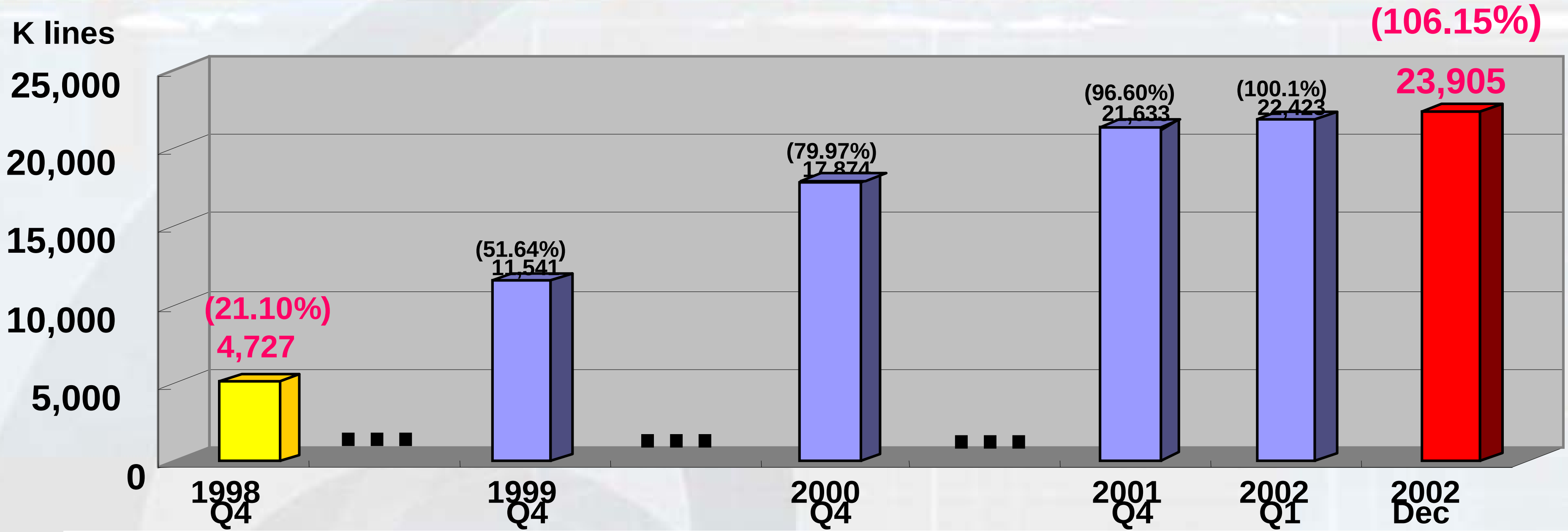
CONTENTS

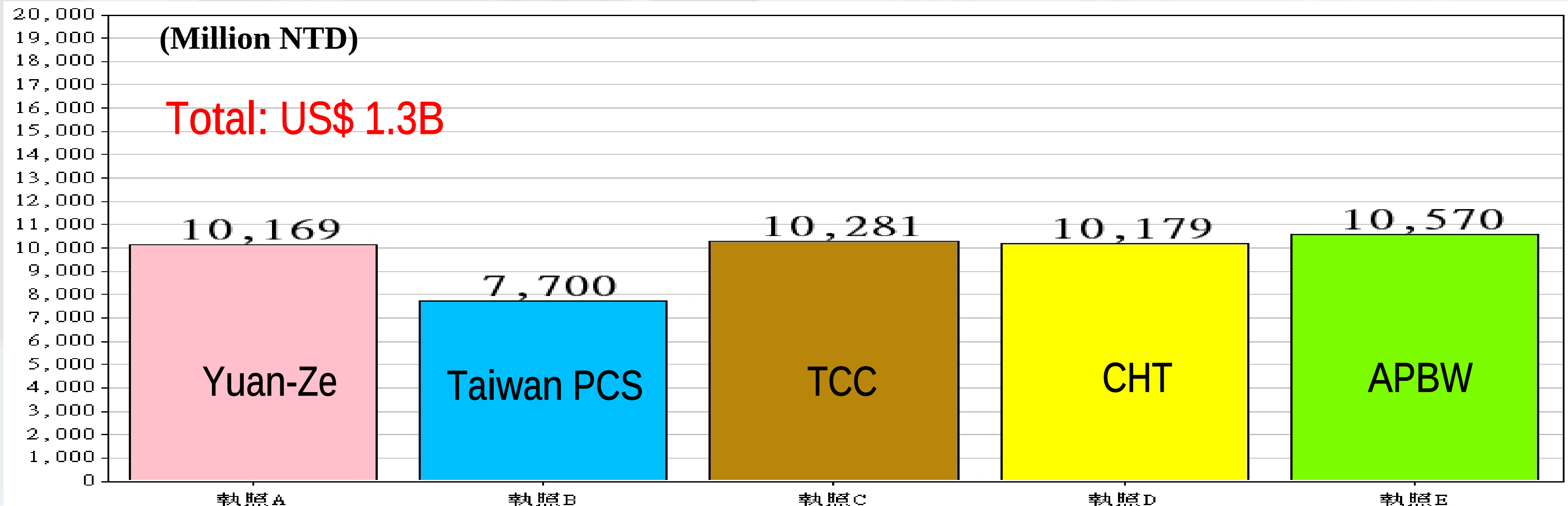
Internet/BB Users are growing

Source: ECRC-FIND
Demember.2002



Mobile Telecom. is exploding





Broadband+Wireless+Homenetwork

Home Network Internet
Appliance, Smart building

Broadband
By 2008:
•95% FTTH coverage
•6 million broadband subscribers

IPv6

Wireless Internet
•3G services to be launched in 3Q 2003
•"Public Hotspots deployment plan" to make Chinese Taipei a "Wireless Island" beyond 3G

Ubiquitous Network Environment

1. More IP addresses will be consumed

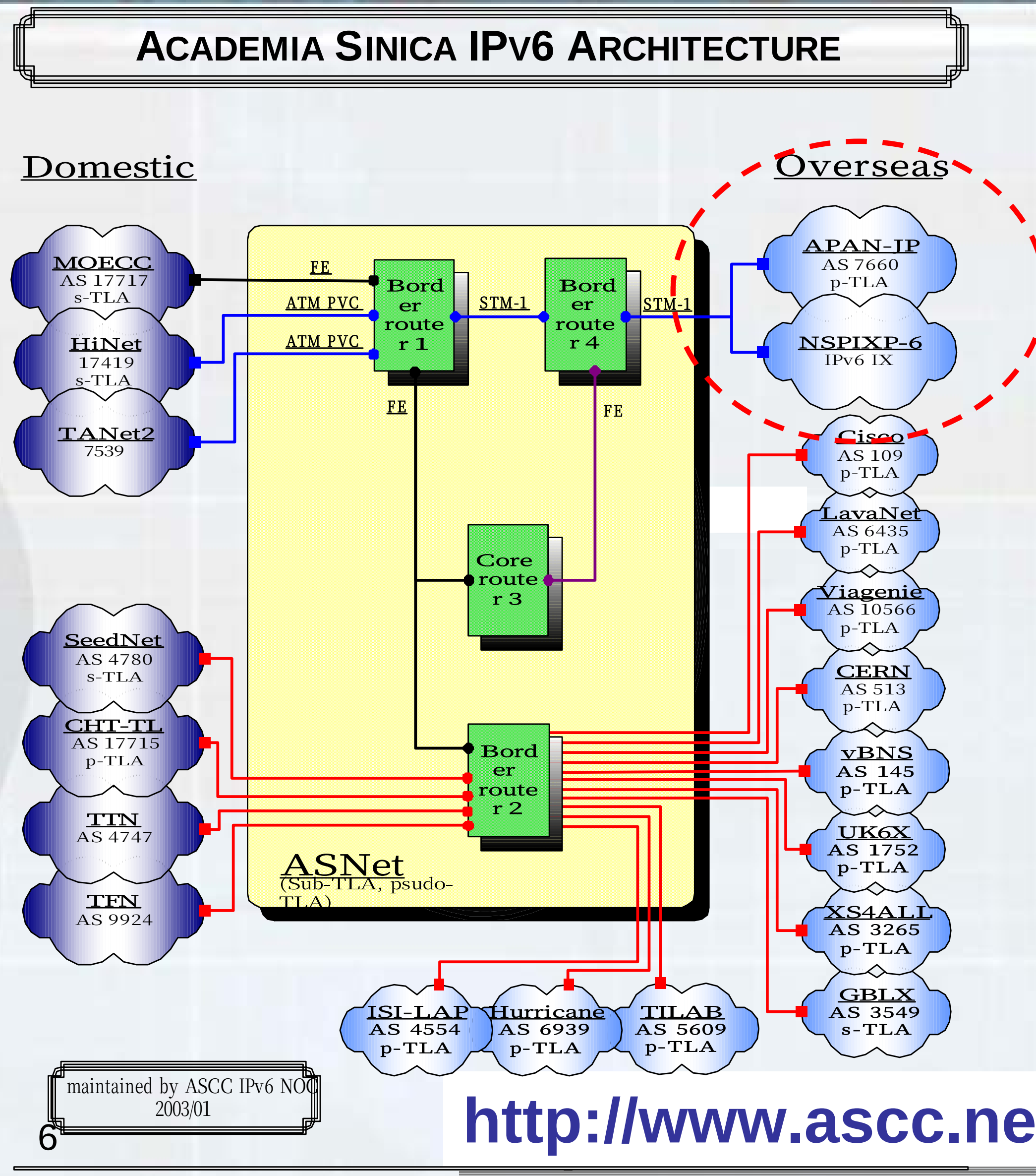
2. More advanced features will be required

Academia Sinica Network

- **IPv6 links**
  - **Native Links**

    Domestic: TANet, HiNet, TANet2

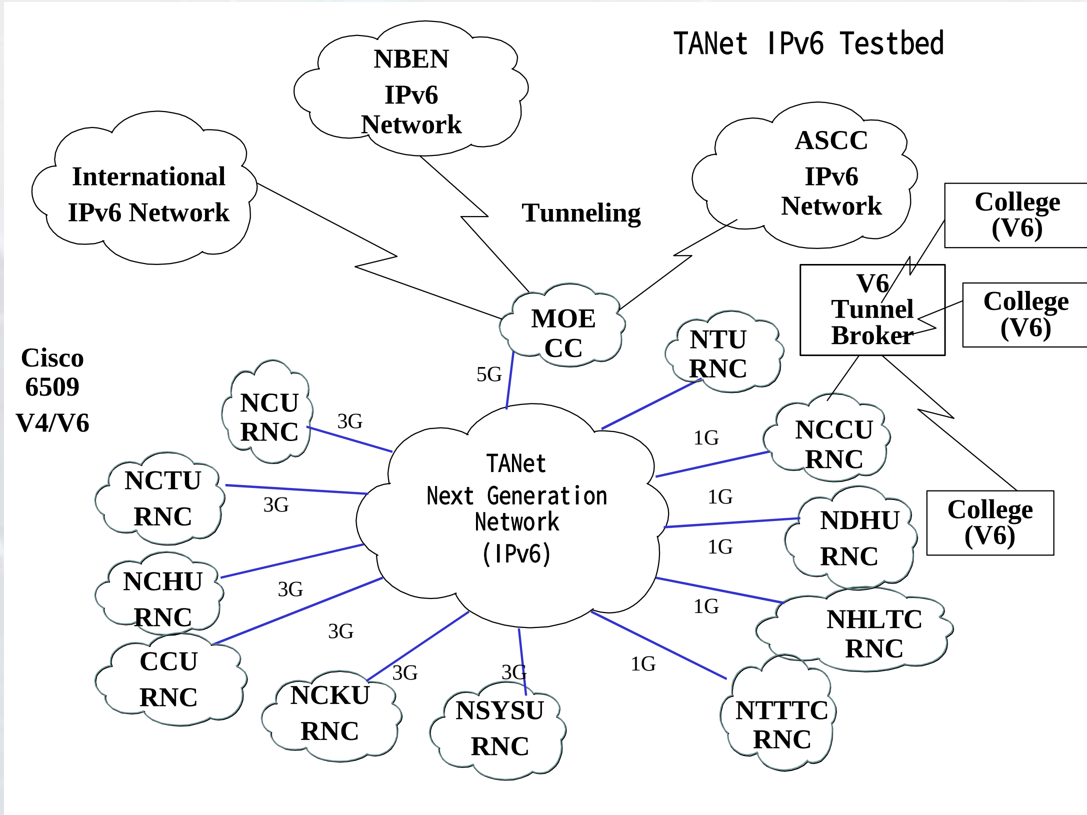
    Oversea: APAN-JP, NSPIXP-6
  - **Tunnel Links** to 20 organizations
- **providing IPv6 transit to local organizations**
- **IPv6 Services provided:**
  - Native Link
  - Tunnel Broker,
  - 6to4 relay router
  - BGP4+ AS path viewer
  - MRLG



http://www.ascc.ne

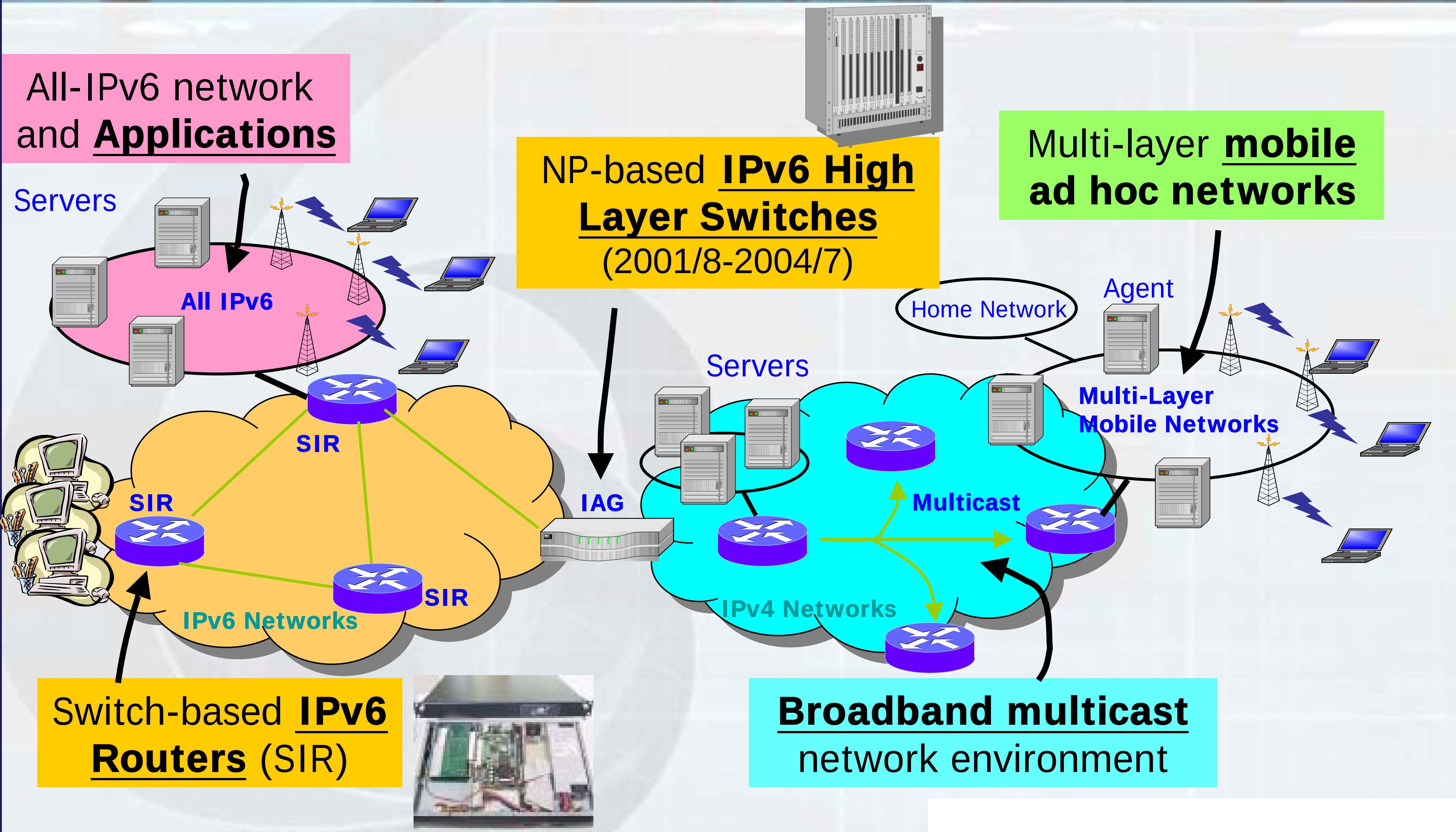
TANET, Ministry Of Education
Taiwan Academic Network

- 100% connectivity to the public academia institutes
- 3.5 million user base
- transparent IPv6 to IPv6, IPv4 to IPv6 and IPv6 to IPv4 communications by 2004.



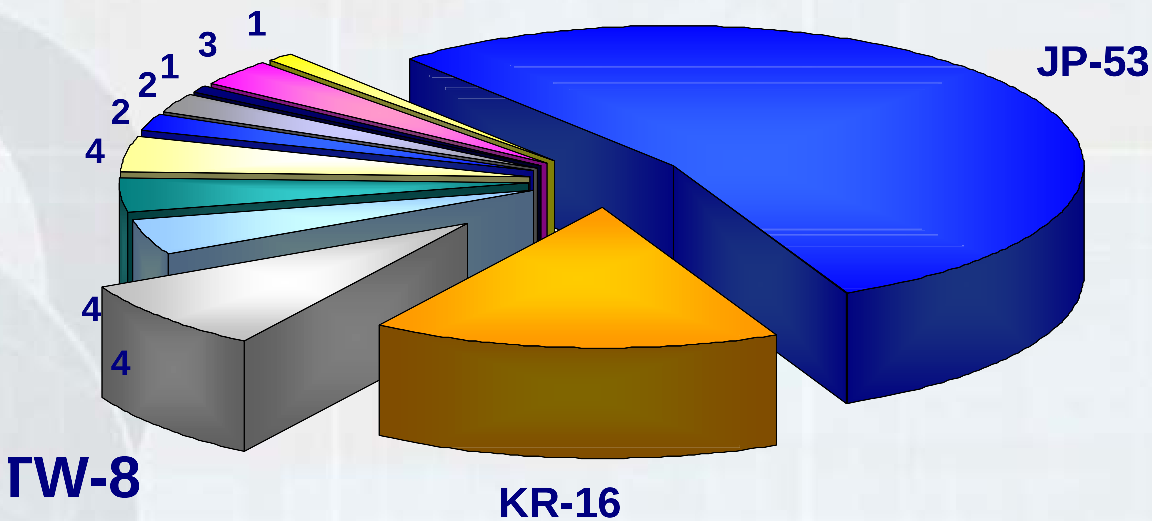
http://www.edu.tw/tanet/

National Telecom. Project Office



ISPs are moving

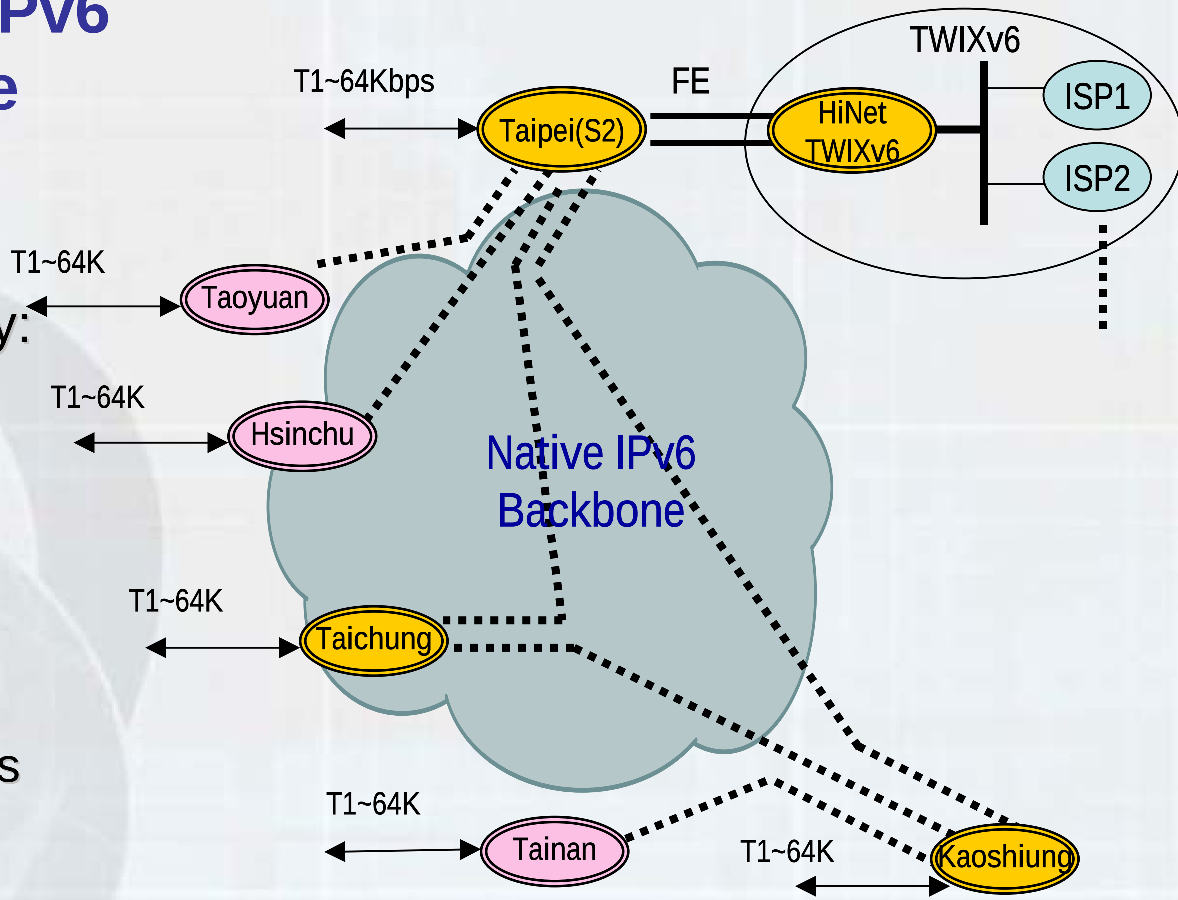
HiNet	2001:0238::/32
TANet	2001:0288::/32
ASNet	2001:0C08::/32
TTN	2001:0C50::/32
6REN	2001:0C58::/32
CHTTL	2001:0CA0::/32
TWIX	2001:07FA:0001::/48
SeedNet	2001:0CD8::/32
TFN	2001:????::/32



Source: APNIC

HiNet

- **The first ISP launched IPv6 commercial trial service since July, 1, 2001**
  - 6 IPv6 POPs in the island
  - LL, ADSL IPv6 connectivity:
    - Native connection
    - 6to4Relay
    - Tunneling
    - TWIXv6 peering
- **2003 plan:**
    - Introduce high-end routers
    - Add some more POPs
    - IPv6 content



Source: HiNet, Chunghwa Telecom .

http://www.ipv6.hinet.net

Chunghwa Telecom Labs. (CHTTL)

- 6bone backbone site since 1999/2.
- Directly v6 connetions to university
- Provide oversea transit
- Agressively involved in IPv6 network deployment and research projects.
- In charge of the creation of a **National IPv6 Interoperability Testing Lab**.

http://www.chttl.com.tw

e-Taiwan Project

- Holds the key to the success of "***Challenge 2008: the 6-year National Development Plan***"
- 5 major parts in e-Taiwan project
  1. **e-Infrastructure**

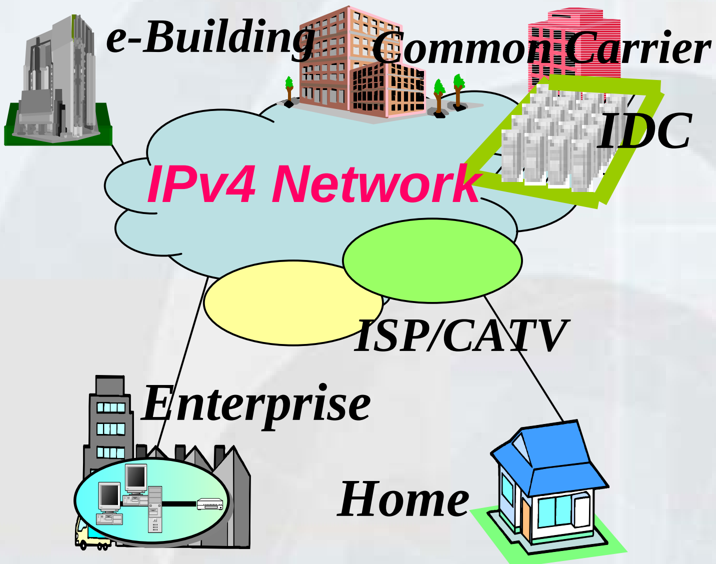
     "Broadband networks will be fully installed with implementation of IPv6 and wireless LAN environment"
  2. **Ez Life**
  3. **e-Industry**
  4. **e-Government**
  5. **e-Transportation**

IPv6 Deployment & Development Plan

- **Proposed by NICI IPv6 Steering Committee**
- **Missions:**
  - To help the **upgrade** of public Internet infrastructure to IPv6
  - To enhance the **competitiveness** of local industry
  - To **integrate** existing IPv6 resources and efforts from the government, industry, and research institutes

IPv6 Deployment & Promotion Plan

NOW



- . Insufficient address space
- . Poor mobility & security
- . Limited application

2008

- . Get rid of address space limitation
- . Enhanced mobility & security
- . Encouraged IP-based application

NICI IPv6 Steering Committee

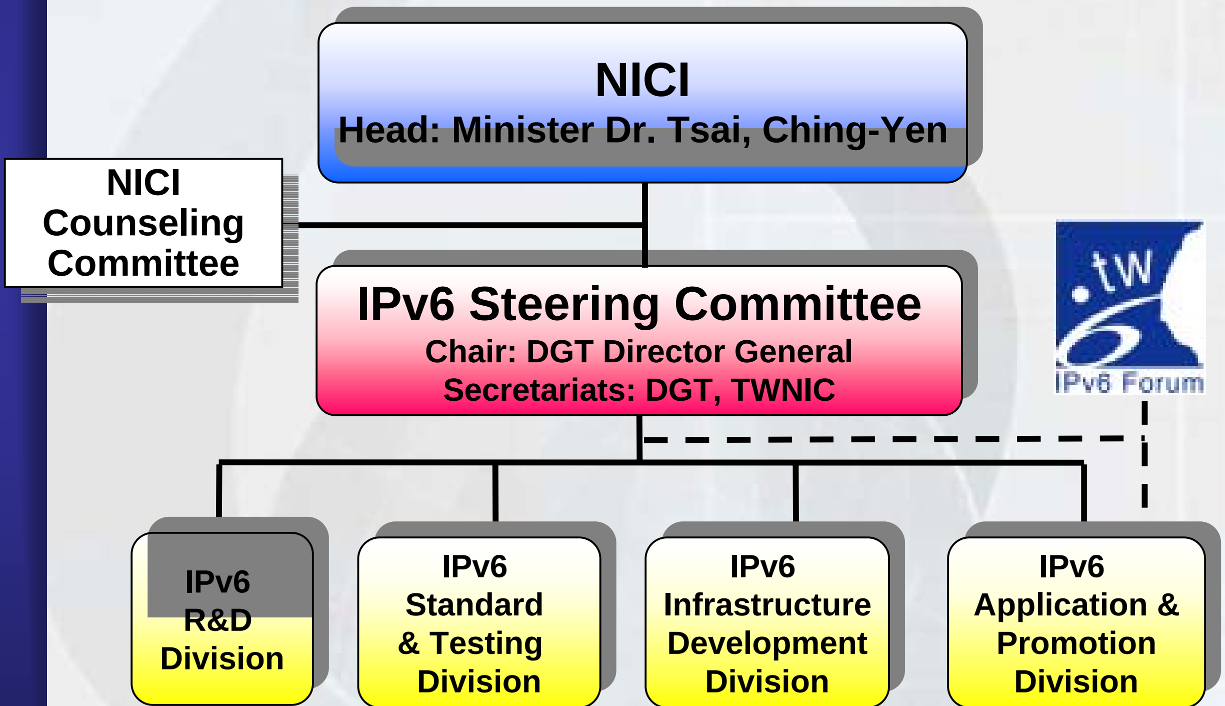
and

IPv6 Forum Taiwan

NICI IPv6 Steering Committee

Established in October 2001 by NICI

(National Initiatives for Communication and Information)



R&D Division

- Led by NTPO, NSC
- Researches on Protocols, Transition mechanism, Mobility, 6ADSL, Security

Standard & Testing Division

- Led by CHTTL and III (Institute for Information Industry)
- National testing lab establishment, IPv6 HW/SW Product certification

Infrastructure Develop. Division

- Led by NCHC, Academia Sinica, Ministry of Education
- IPv6 Infrastructure development, operational technology support

Application & Promotion Division

- Led by ITRI and TWNIC
- Promotion and Training, Events and publications, Fund raising
- Work closely with **IPv6 Forum Taiwan**

R&D Projects in 2003

- 6TIME (IPv6 TransItion for Mobile Environment)
  - Design and Development of a Home Network Proxy using the IPv6 Multihoming Technique
  - Design and Implementation of an Multi-Hop Routing Protocol on Integrated IPv6-based Mobile Ad-Hoc Networks
- 6GIANT (IPv6 Gallop Internet AppliaNce of Taiwan)
  - The implementation of an IPv6 xDSL access support system
  - The Development and Research of Attack, Defense and Cryptographic Module in IPv6
  - Design and Implementation of IC-card-based IPv6 Security Mechanism
- 6TANET (IPv6 TrAnsition Network Environment of Taiwan)
  - Analysis of IPv6 Upper-Layer Protocols
  - The Design and Implementation of Gigabit Ethernet IPv6/IPv4 Translator
  - Tunneling IPv6 through NATs
  - The Address-Concealed Network Detection and Management for IPv6

Infra. Develop. Division Projects in 2003

HiNet IPv6 Multimedia Service

Tele-science on Tomography via IPv6

Telescience Grids Construction over IPv6 infrastructure

Pacific
Rim
Application
Grid
Middleware
Assembly

NCHC will host 5th PRAGMA in Oct. 2003

IPv6 Forum Taiwan

- Established in April, 2002
- Chaired by Dr. Paul Lin, CCL/ITRI
- Mission:
  - To improve market and user awareness of IPv6
- A membership organization
- Organized by:
  - **ITRI** (Industrial Technology Research Inst.)
  - **TWNIC** (Taiwan Network Information Center)
- Major focuses:
  - IPv6 Promotion
  - IPv6 Education
  - IPv6 International Cooperation
  - IPv6 Market Opportunities

IPv6 Forum Taiwan

- 3 Focused Areas
- 10 Working Groups

Chairman
Dr. Paul Lin
CCI/ITRI

Advisory Committee

Secretariat
ETRI, TWNIC, TCA

- **Promotion**
  - Promotion WG
  - International Coop. WG
  - Education WG
- **Technical**
  - Mobile IP WG
  - Security WG
  - QoS WG
  - XDSL WG
  - NAS WG
- **Industrial Application**
  - Industrial promotion WG
  - Application Development WG

IPv6 Industrial R&D Alliance

Members:

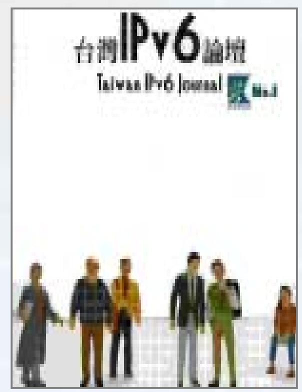
Accton, ADMtek, ASKEY, Chunghwa, CyberTan, D-Link, EBT, Loop, Z-Com,etc.

Promotion Activities

- Promoting the use and user awareness of IPv6
  - IPv6 demo in IT month fair, 2001, 2002
  - IPv6 demo & Tutorial in TANET2001, 2002 conference
  - Trained over 1,000 IT professionals on IPv6 in 2002
  - Computex Taipei (2003)

- Sponsoring and hosting IPv6 events
  - IPv6 Forum Taiwan opening, Apr.2002
  - APRICOT and the 1st IPv6 Summit in AP, Feb.2003(attendees 1069 , the new record)
  - IPv6 Industrial Seminar (2003)

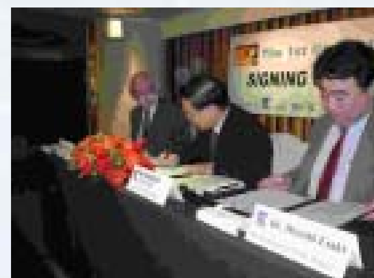
- IPv6 publications
  - IPv6 Journal (bi-annually)
  - IPv6 e-News (bi-monthly)
  - IPv6 Website



International Cooperation

- **Cooperation Meeting**
  - Japan
    - 1st : Dec. 21. 2002 in Yokohama, Japan
    - 2nd: Feb. 24. 2003 in Taipei, Chinese Taipei
  - EU, Korea, China, India…

- **Cooperation Agreements / MoU**
  - **Singed on Feb.24th**
    - with IPv6 Promotion Council of Japan
    - with Eurov6 Project



IPv6 Steering Committee & IPv6 Forum Chinese Taipei

Next Generation Internet Environment

NICI IPv6 Steering Committee

IPv6 Forum