Internet eXchange Points (IXPs), Peering, and ISP Interconnection

The Keystone of Internet Economy

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CISCO SYSTEMS

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Agenda

✓ **IXPs - The *keystone* to Internet Economy**

✓ **Why should I connect to an IXP?**

✓ **Transit and Peering**

✓ **Interconnections - A Short History**

✓ **Types of IXPs**

✓ **Examples of IXPs**
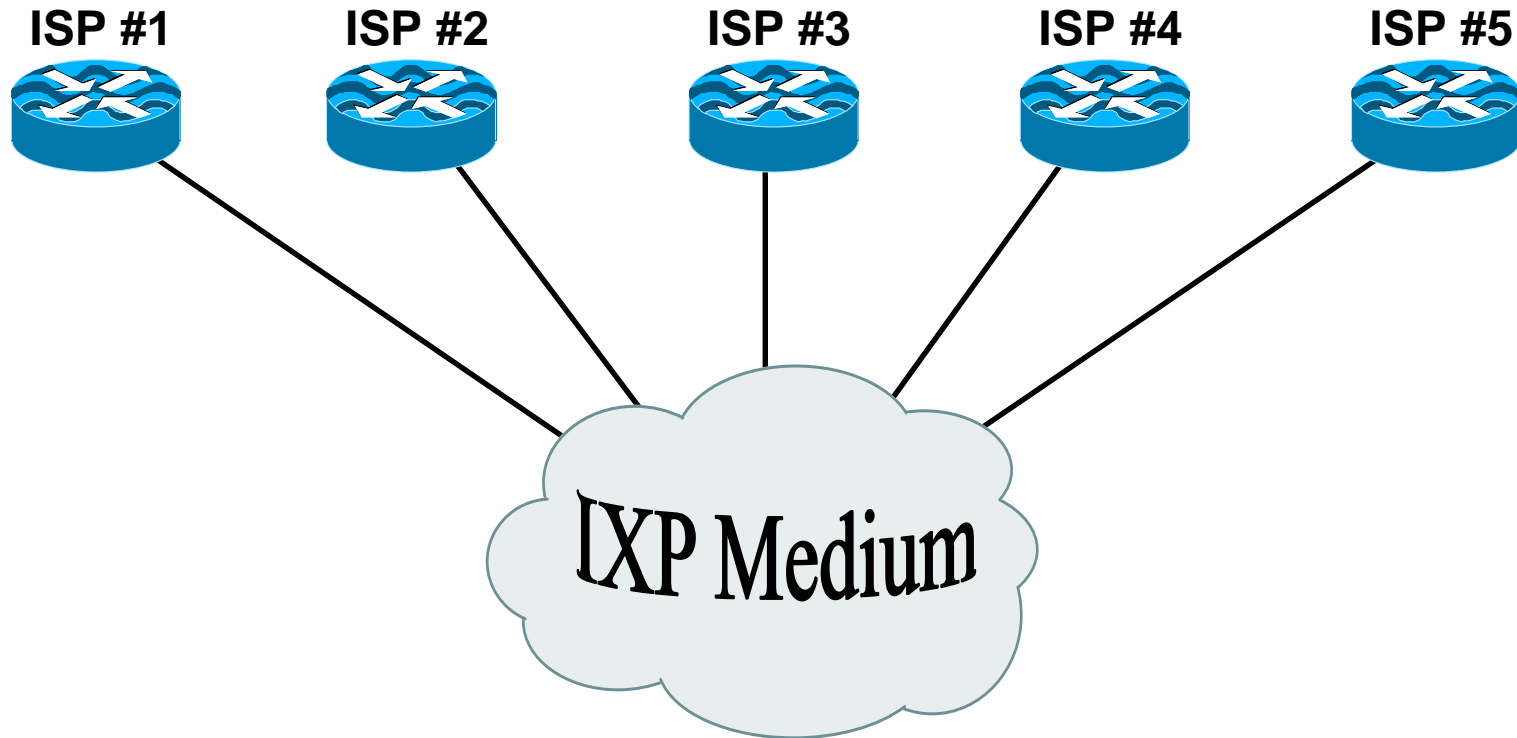
✓ **Cisco's Role**

✓ **Case Studies and Technical Addendum**

IXPs are the Keystone of the Entire Internet Economy

www.cisco.com

IXP is the Keystone to E-Commerce

What is a IXP?
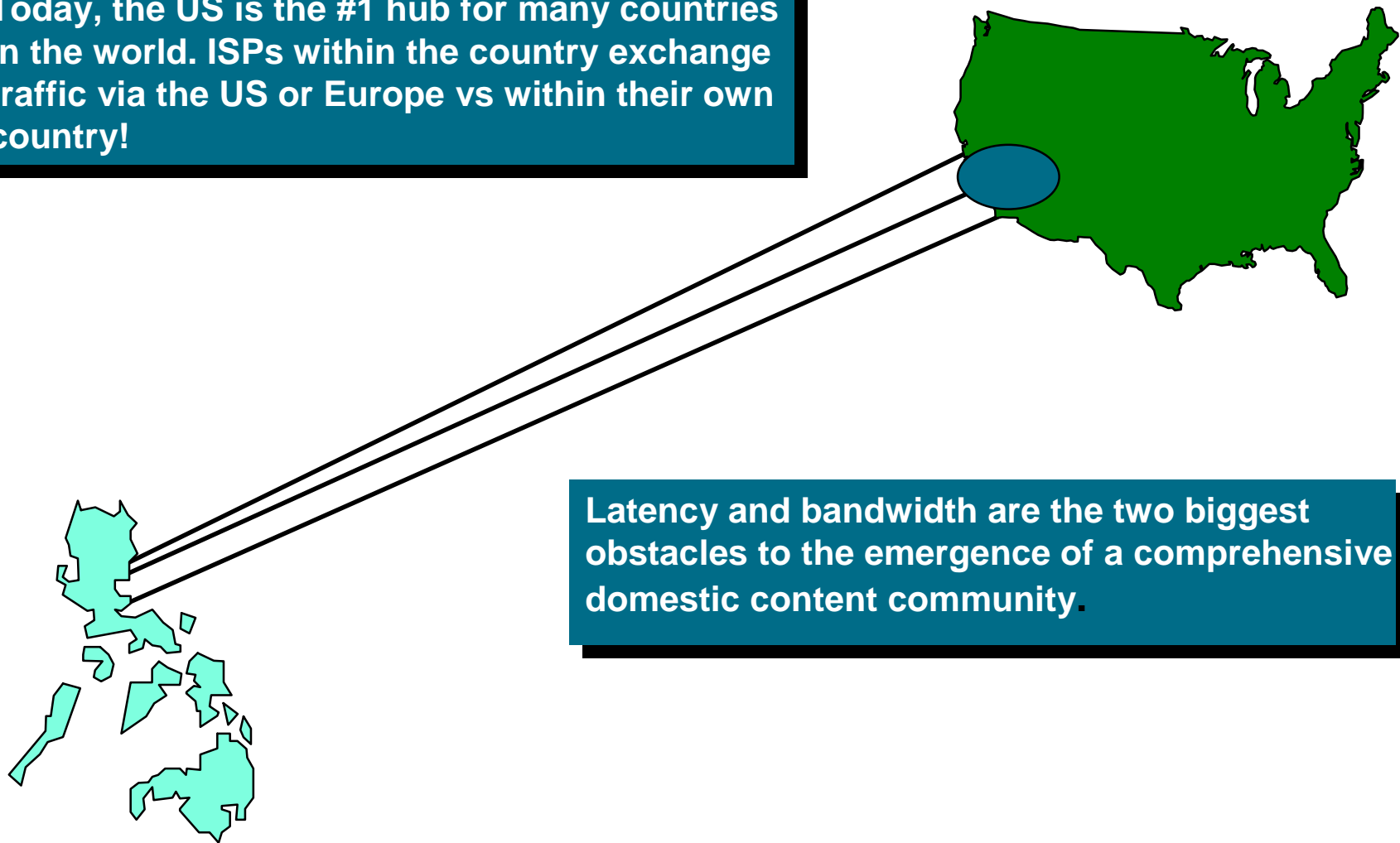
ISP #1 **ISP #2** **ISP #3** **ISP #4** **ISP #5**

IXP Medium
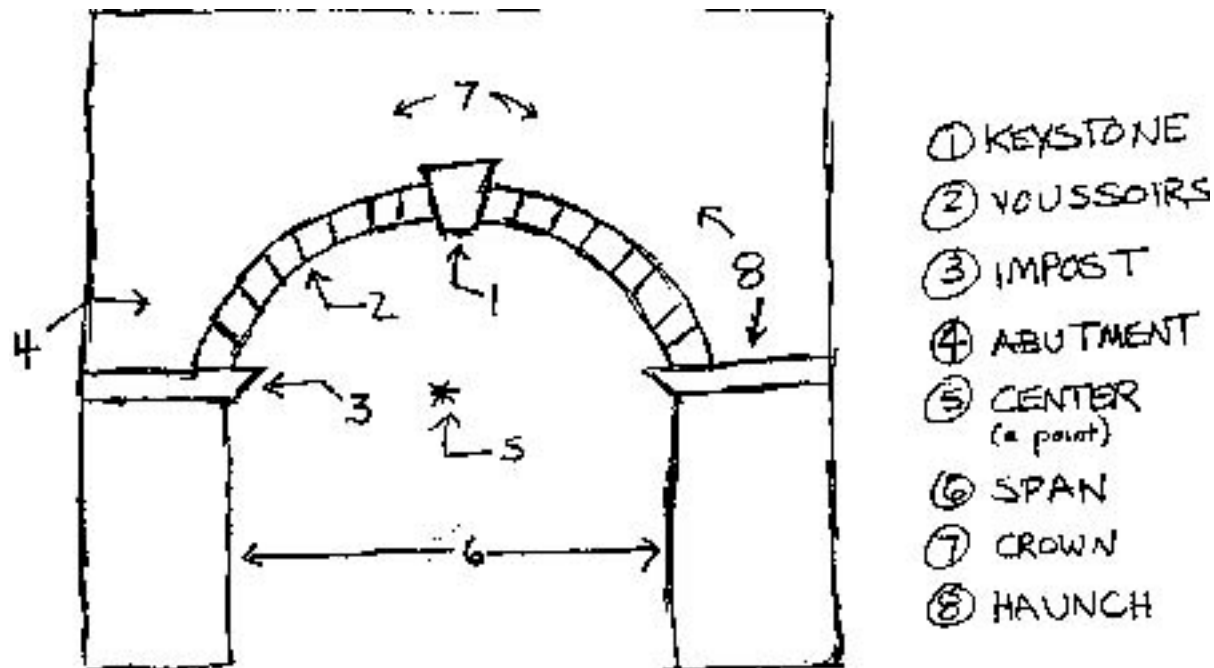
✓ **The Interconnection Points of the Internet**

✓ **Place where ISPs come to Interconnect with each other.**
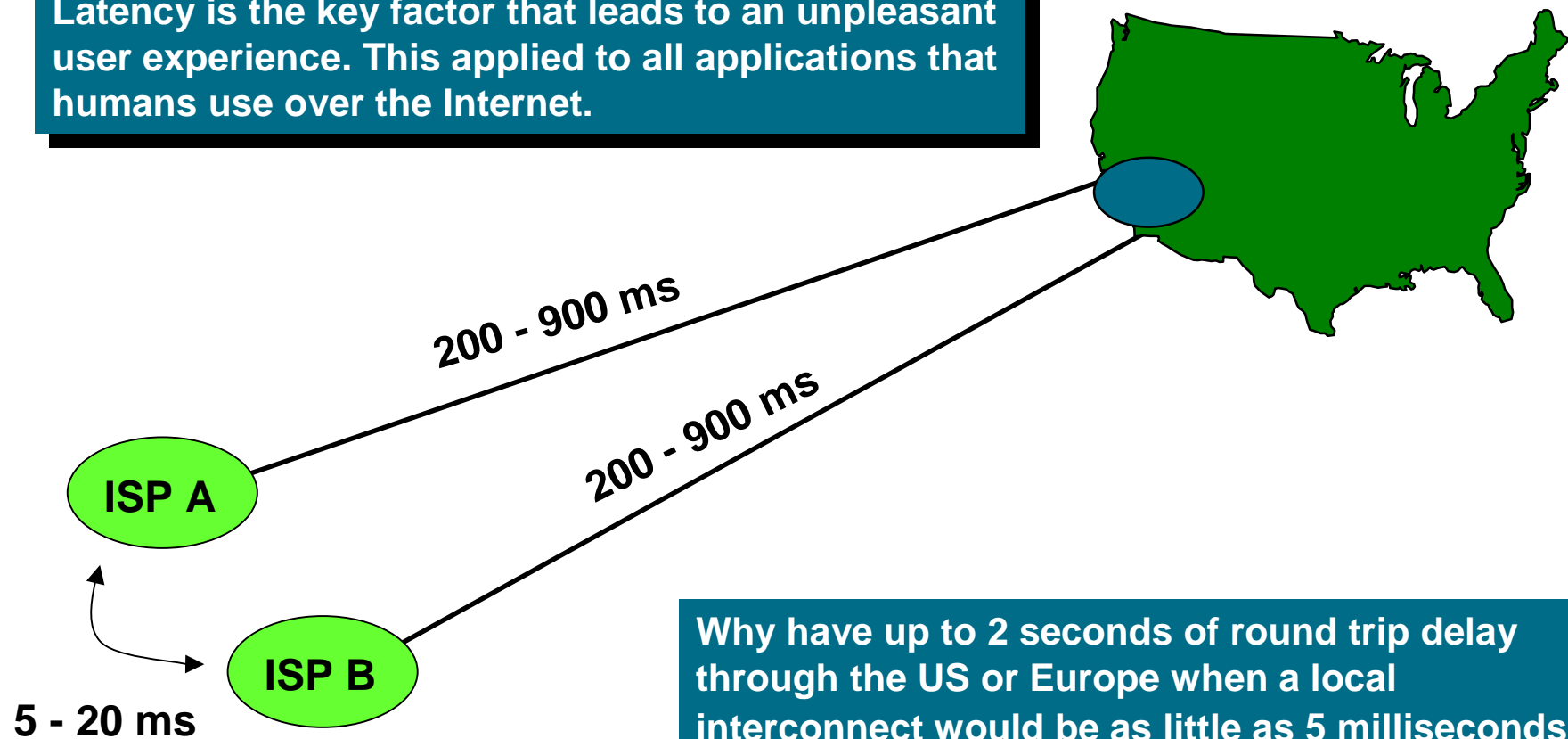
Using the US as a Internet Hub

Today, the US is the #1 hub for many countries in the world. ISPs within the country exchange traffic via the US or Europe vs within their own country!

Latency and bandwidth are the two biggest obstacles to the emergence of a comprehensive domestic content community.

Using the US as a Internet Hub

Latency is the key factor that leads to an unpleasant user experience. This applied to all applications that humans use over the Internet.

200 - 900 ms

200 - 900 ms

ISP A

ISP B

5 - 20 ms

Why have up to 2 seconds of round trip delay through the US or Europe when a local interconnect would be as little as 5 milliseconds?

Using the US as a Internet Hub

Links between countries outside the US are in general more expensive then the same Mbps link to the US.

$

$

$ $

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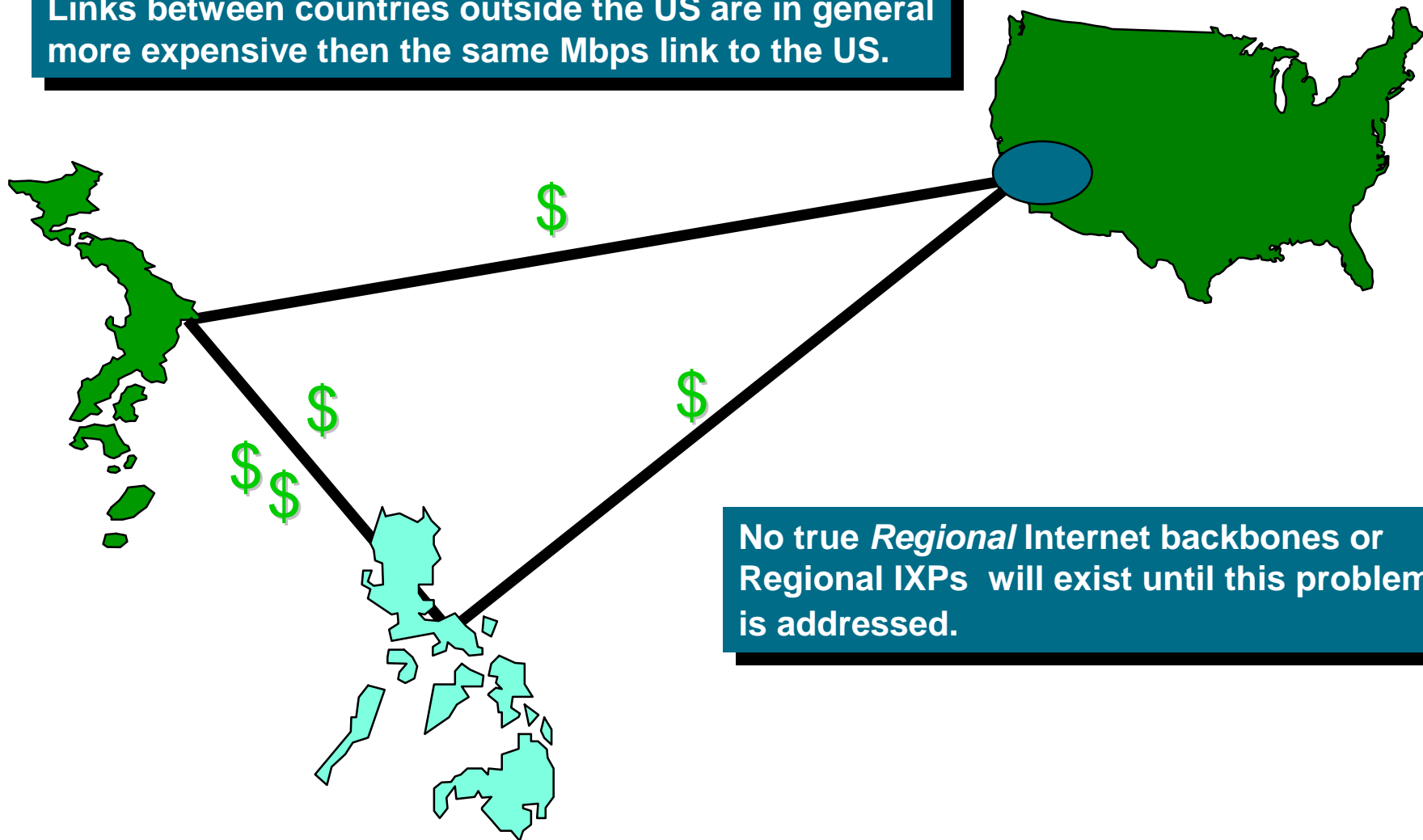
No true *Regional* Internet backbones or Regional IXPs will exist until this problem is addressed.

Why Connect to an Internet eXchange Points?

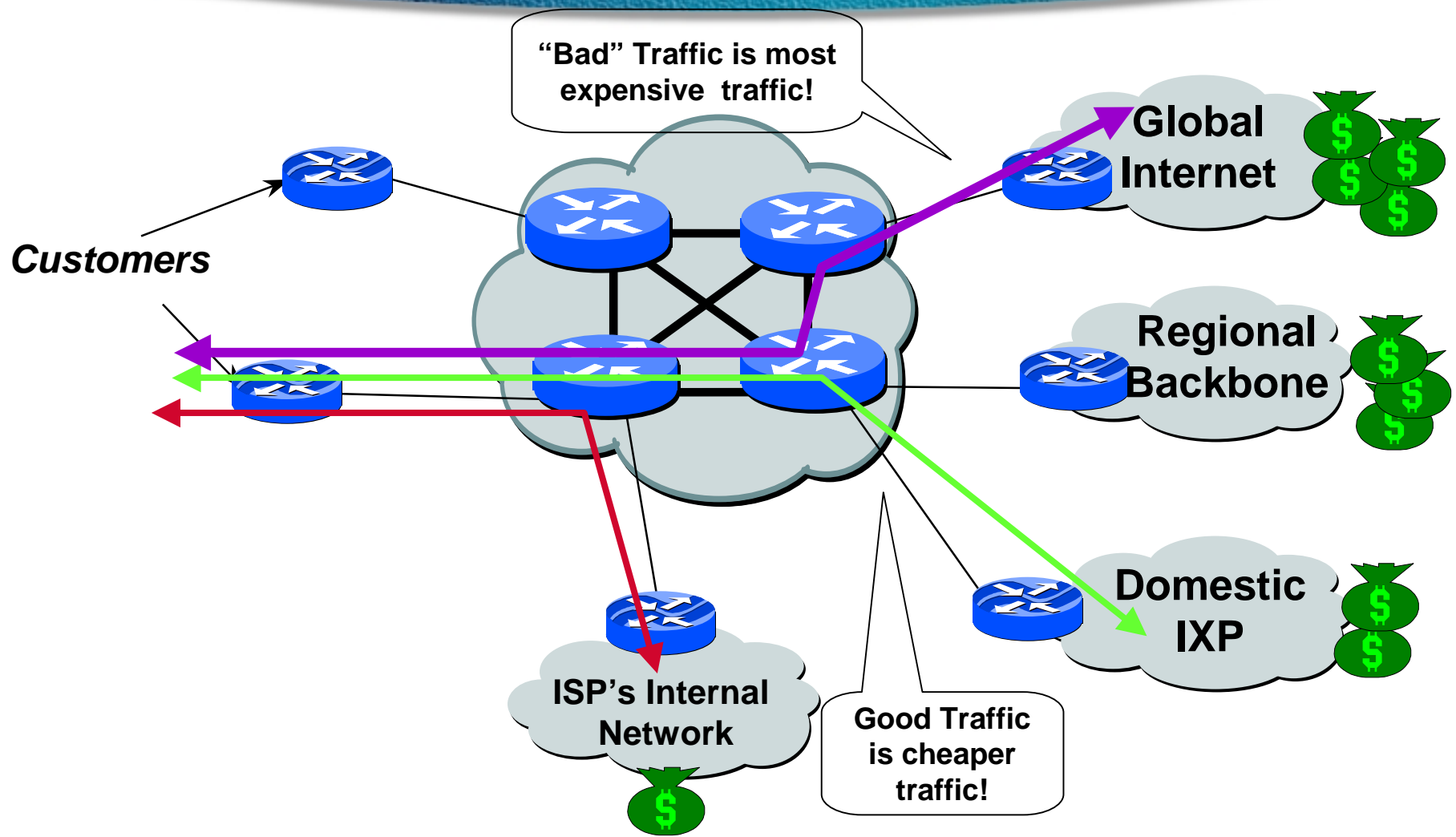*I'm doing OK now. Why do I need to spend money to connect to an IXP?*

Why Connect to an IXP?

- **It's about saving money!**

- **It's about adding value!**

- **It is about new *REVENUE OPPORTUNITIES***

Why Connect to an IXP?

"Bad" Traffic is most expensive traffic!

Customers

Global Internet

Regional Backbone

Domestic IXP

ISP's Internal Network

Good Traffic is cheaper traffic!

Why Connect to an IXP?

- **Many ISPs only have a link to the Global Internet.**

- **That means all their traffic is taking the most expensive path to a neighboring ISP**

  - ✓ (i.e. via the US/Europe)

- **Why do ISPs like loosing money?**

Customers

Global Internet

Regional Backbone

Domestic IXP

ISP's Internal Network
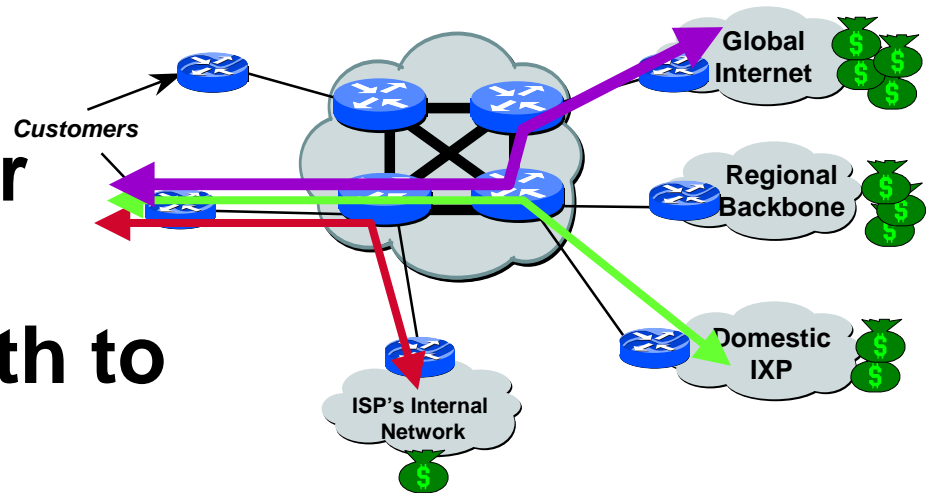
Why Connection to an IXP?

People Adding Value

Metcalfe's law *The Magic of Interconnections*

Connect any number, "n," of machines - whether computers, phones or even cars - and you get "n" squared potential value.

Your get n^2 value from and given connection to the Internet.

Why Connection to an IXP?
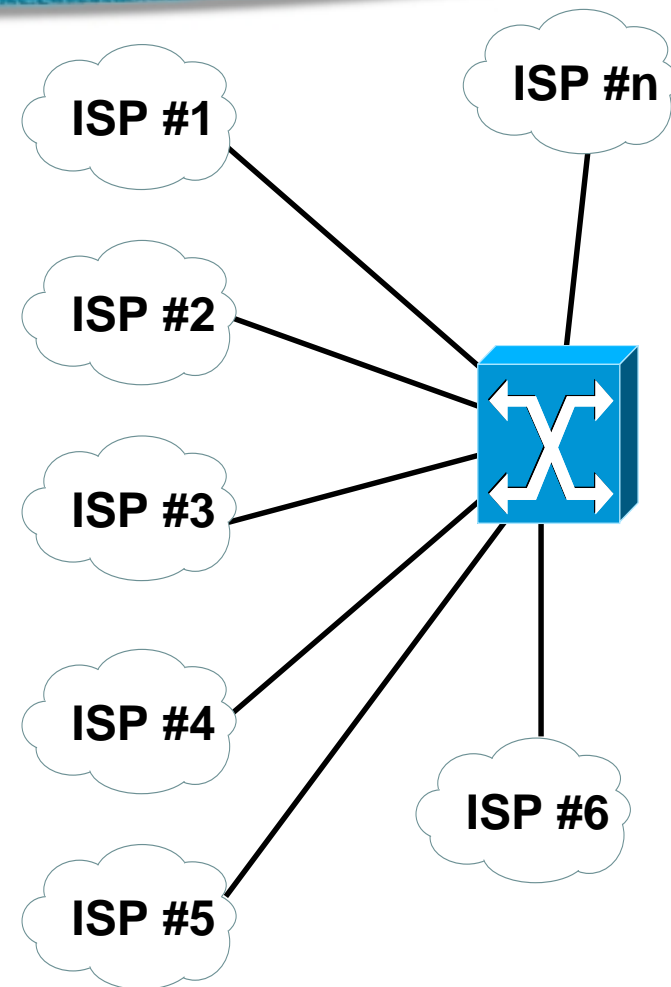
Metcalfe's law - *The Magic of Interconnections*

Hence, the real value of the Internet can be viewed as:

$$n^2_1 + n^2_2 + n^2_3 + n^2_4 + n^2_5 \ldots\ldots\ldots n^2_n$$

….and the Internet is more than doubling every year!
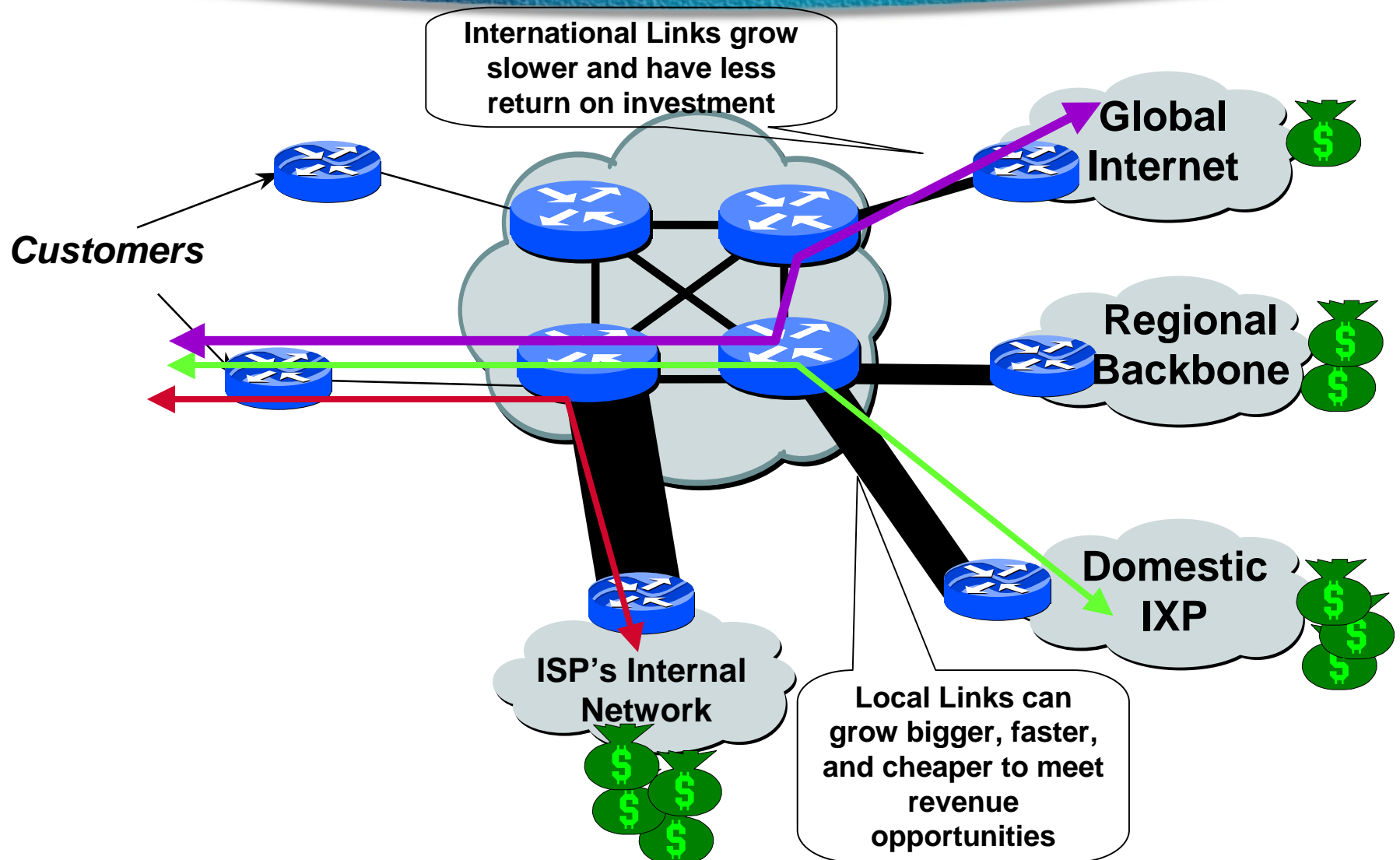
Why Connection to an IXP?

- **1 ISP = n^2_1**

- **2 ISPs = $n^2_1 + n^2_2$**

- **3 ISPs = $n^2_1 + n^2_2 + n^2_3$**

- **4 ISPs = $n^2_1 + n^2_2 + n^2_3 + n^2_4$**

- **etc.**

- **The more ISPs interconnect, the more value each individual ISP can offer it's customer!**

Why Connection to an IXP?

Your competitor's content is your content! Your competitor's customers are your potential customers! All you need to do is interconnect!

www.cisco.com

Revenue Opportunities

International Links grow slower and have less return on investment

Global Internet

Customers

Regional Backbone

Domestic IXP

ISP's Internal Network

Local Links can grow bigger, faster, and cheaper to meet revenue opportunities
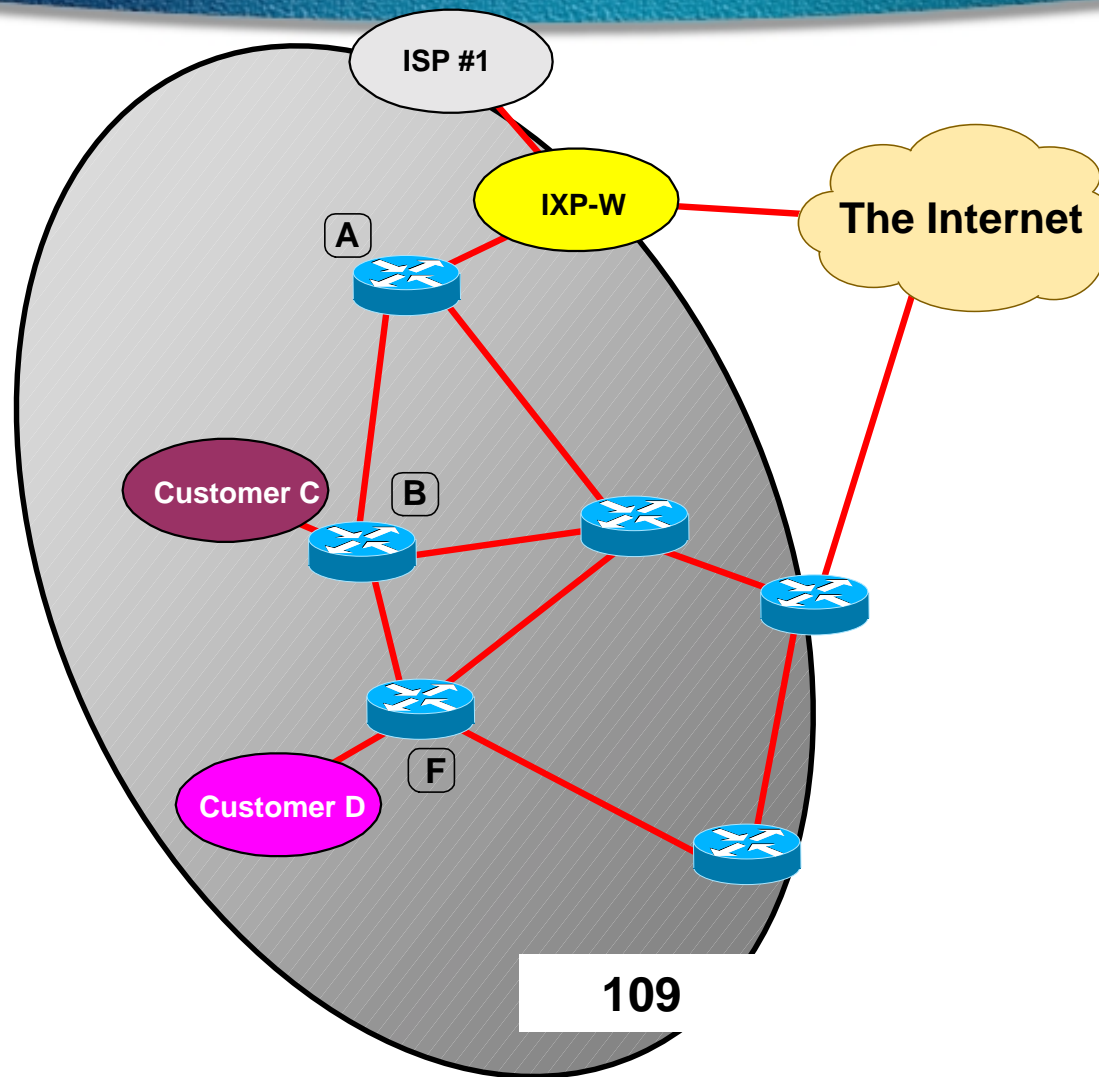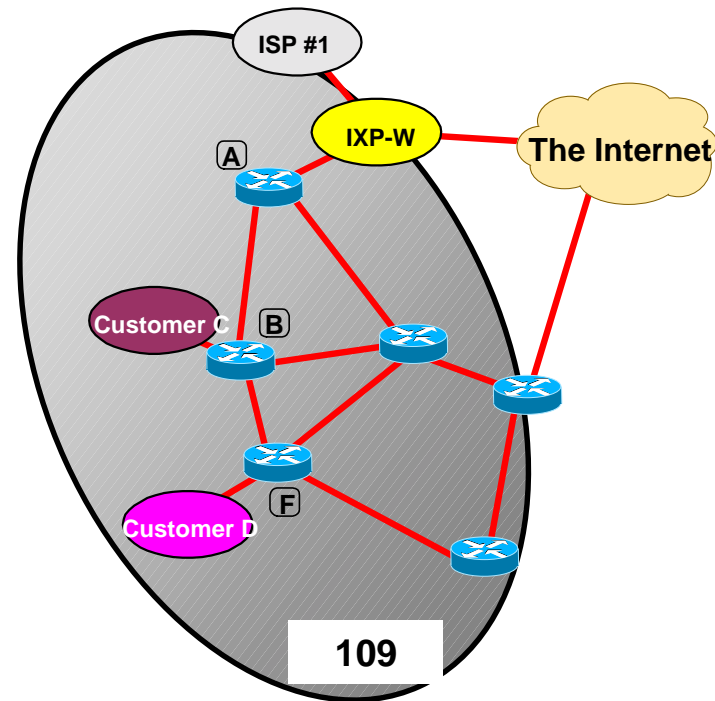
Transit and Peering

It is critical that you understand this fundamental principle ….

What is Transit?

What is Transit?
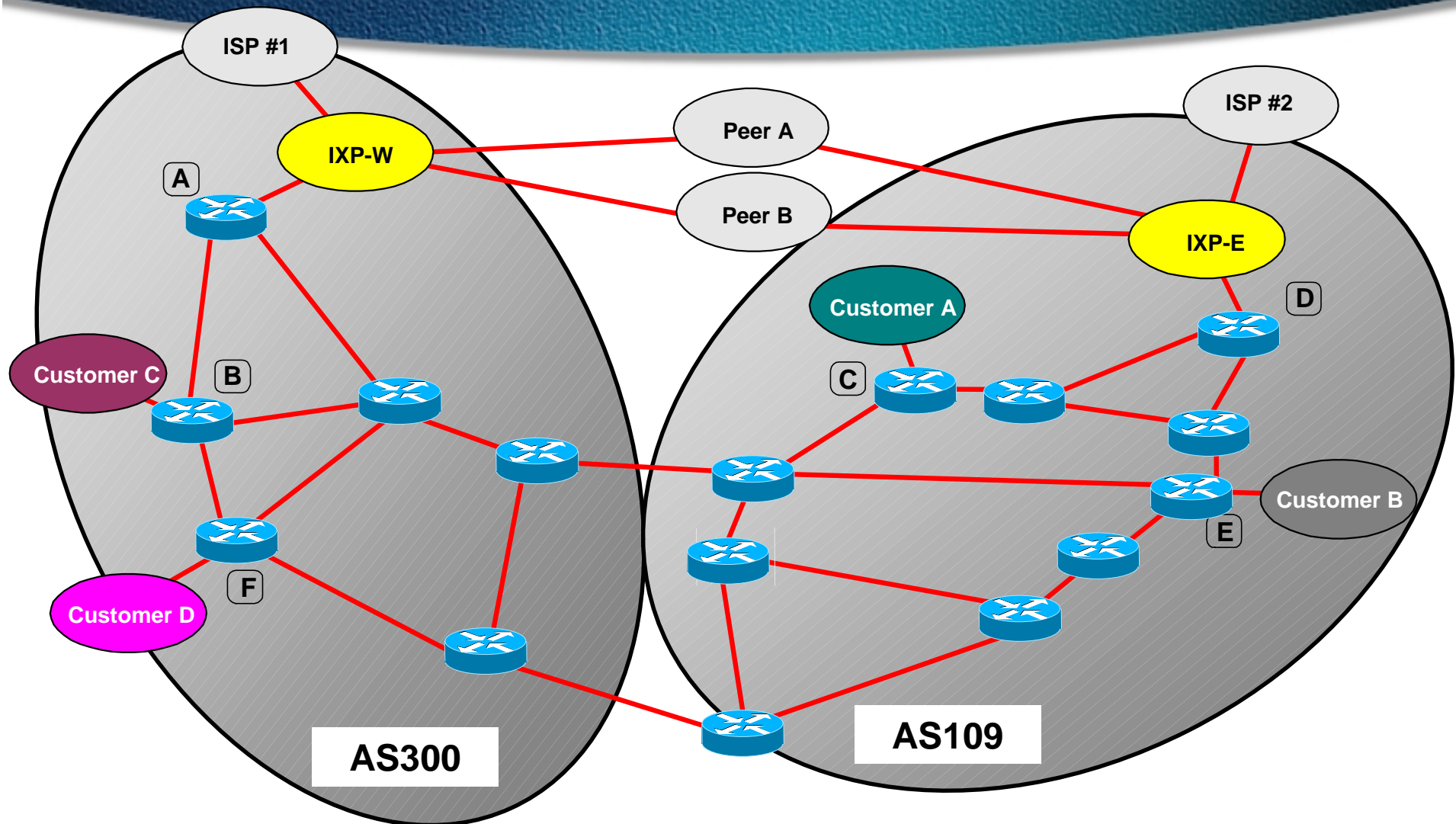
- **Transit is when a customer get routes from the entire _Internet._**

The diagram shows ISP #1 containing routers A, B, F, Customer C, Customer D, IXP-W connecting to The Internet. Labeled 109.
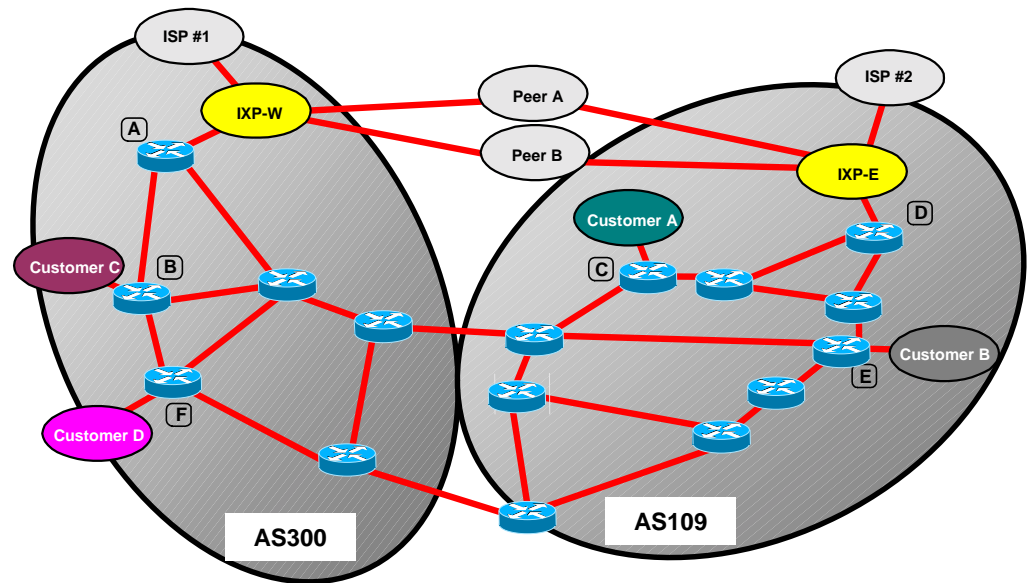
www.cisco.com

What is Peering?

What is Peering?

- **Peering is when two ISPs exchange the routes for each other's _transit customers_.**

- **Peering usually happens via IXPs or Private Peering**

Transit and Peering

- **Internet eXchange Points are a tool for peering.**

- **Once transit is offered on the IXP, it stops being an tool for peering and becomes a transit service.**

- **It is OK to buy transit with local peering from a transit service. That is what upstream ISPs (NSPs) sell.**
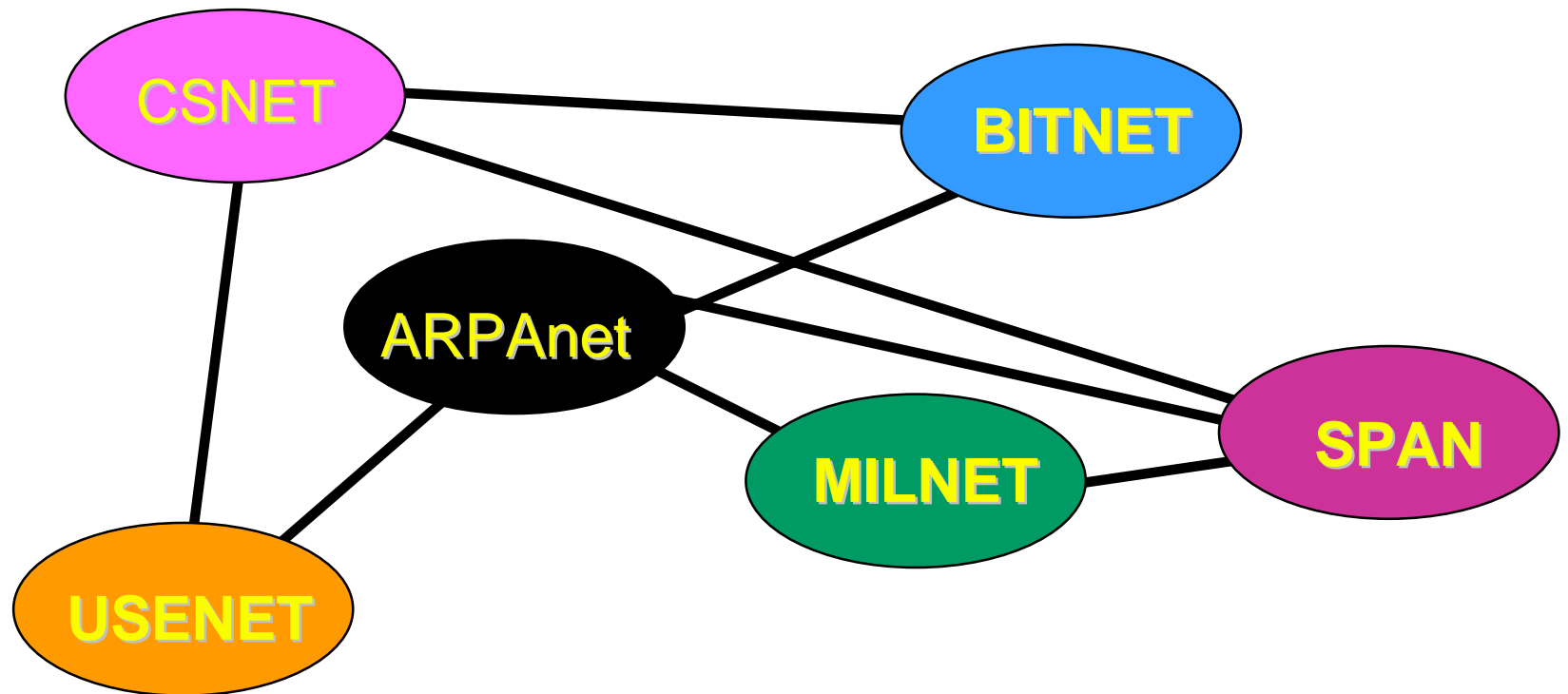
Interconnections - A Short History

How the Internet was tied together...

 www.cisco.com

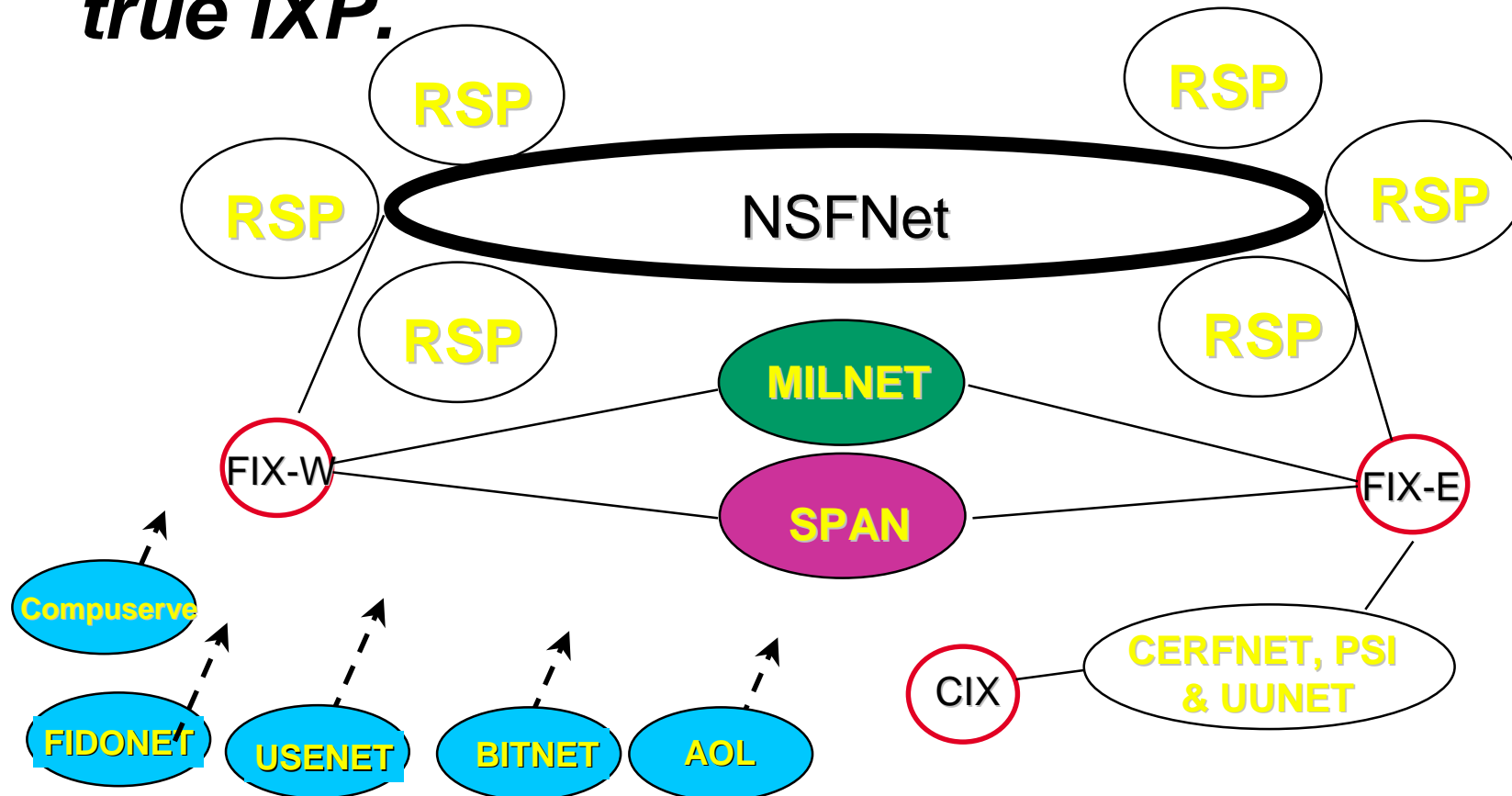# Internet Backbones….

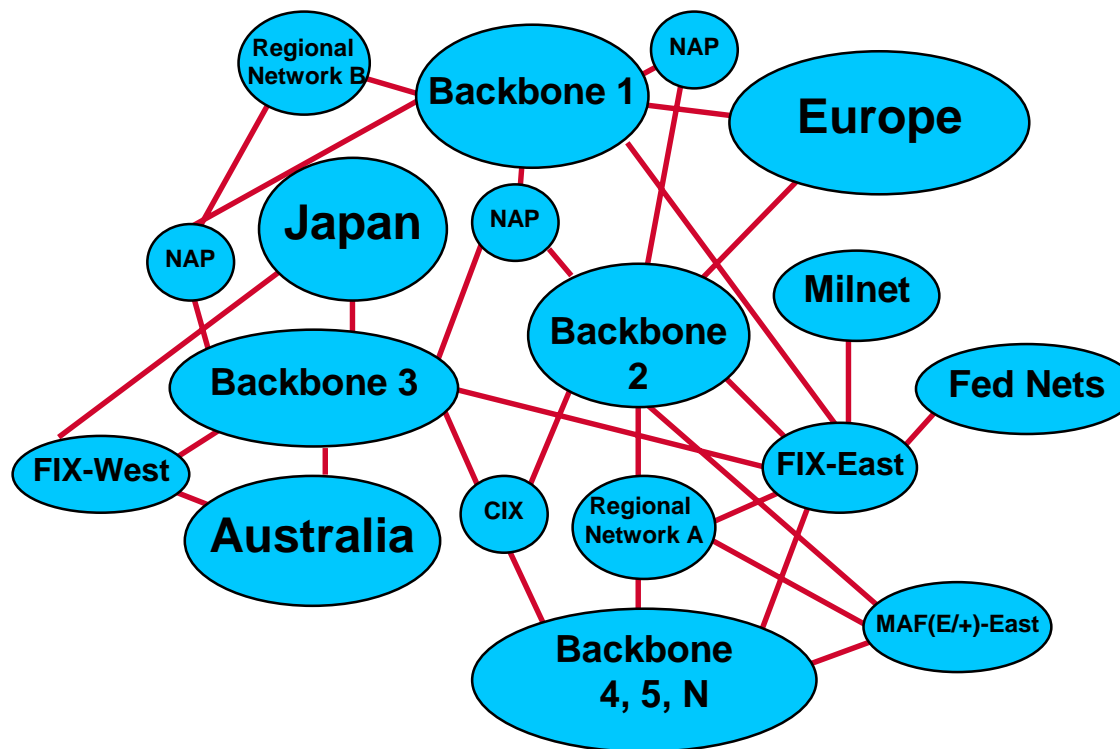- **In the beginning, there was no *Internet Backbone*…people just *interconnected..***

The NSFNet Created the first concept of *Internet Backbone. FIX East was the first true IXP.*

Cisco Scales Internet Routing

Current Internet Architecture

- **Less explicit interconnection**

- **Tiered architecture**

- **No explicit backbone**

- **Commercially operated**
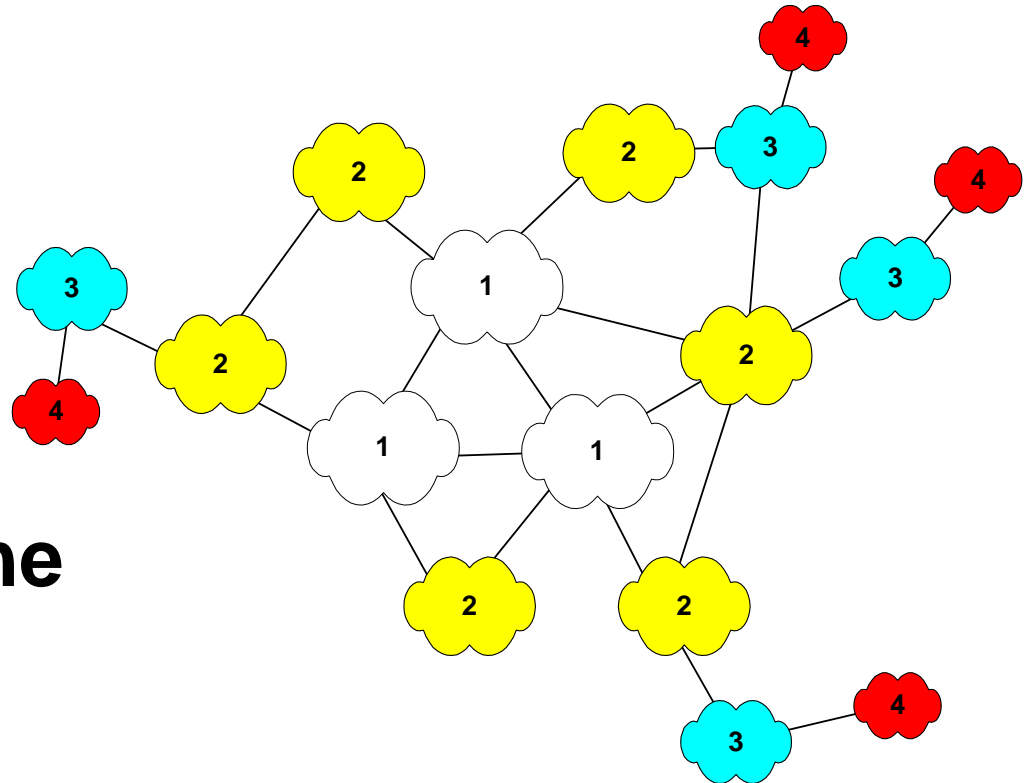
Categorizing ISPs - US Centric POV

New World Landscape

DSL Services
Transport
IP
Voice
VPN

ILEC/CLEC DSL Access

ISP-Tier 1 IP/OPTIC

ILEC/CLEC DSL Access

ILEC/CLEC TDM Access

Cable MSO

IXC IP/OPTIC ATM

International

PSTN/TDM Services
Transport
IP
Voice
VPN

ILEC TDM Access

Greenfield IXC IP/OPTIC ATM

Cable MSO

Cable Services
IP
Voice

ISP-Tier 2

ISP-Tier 2
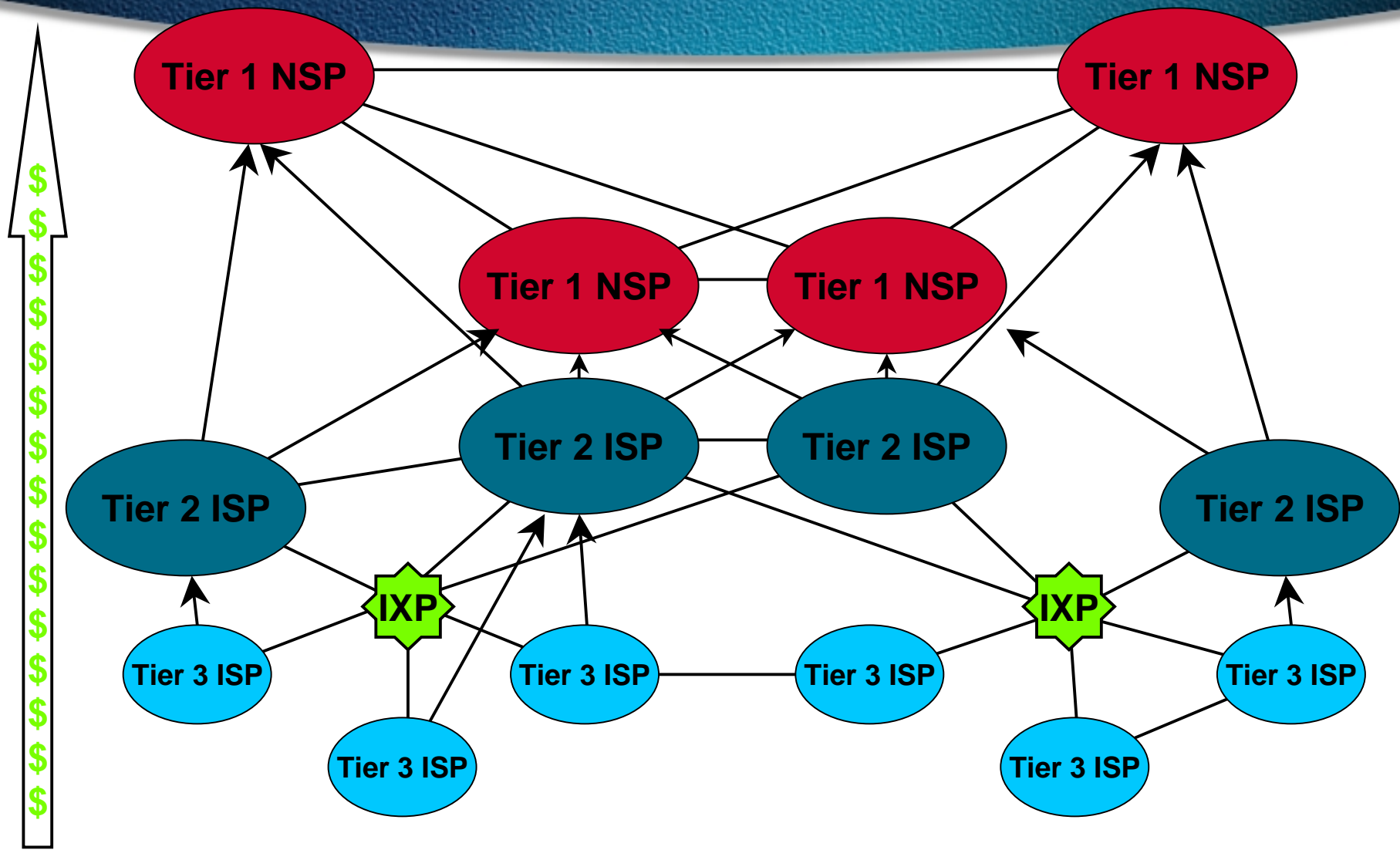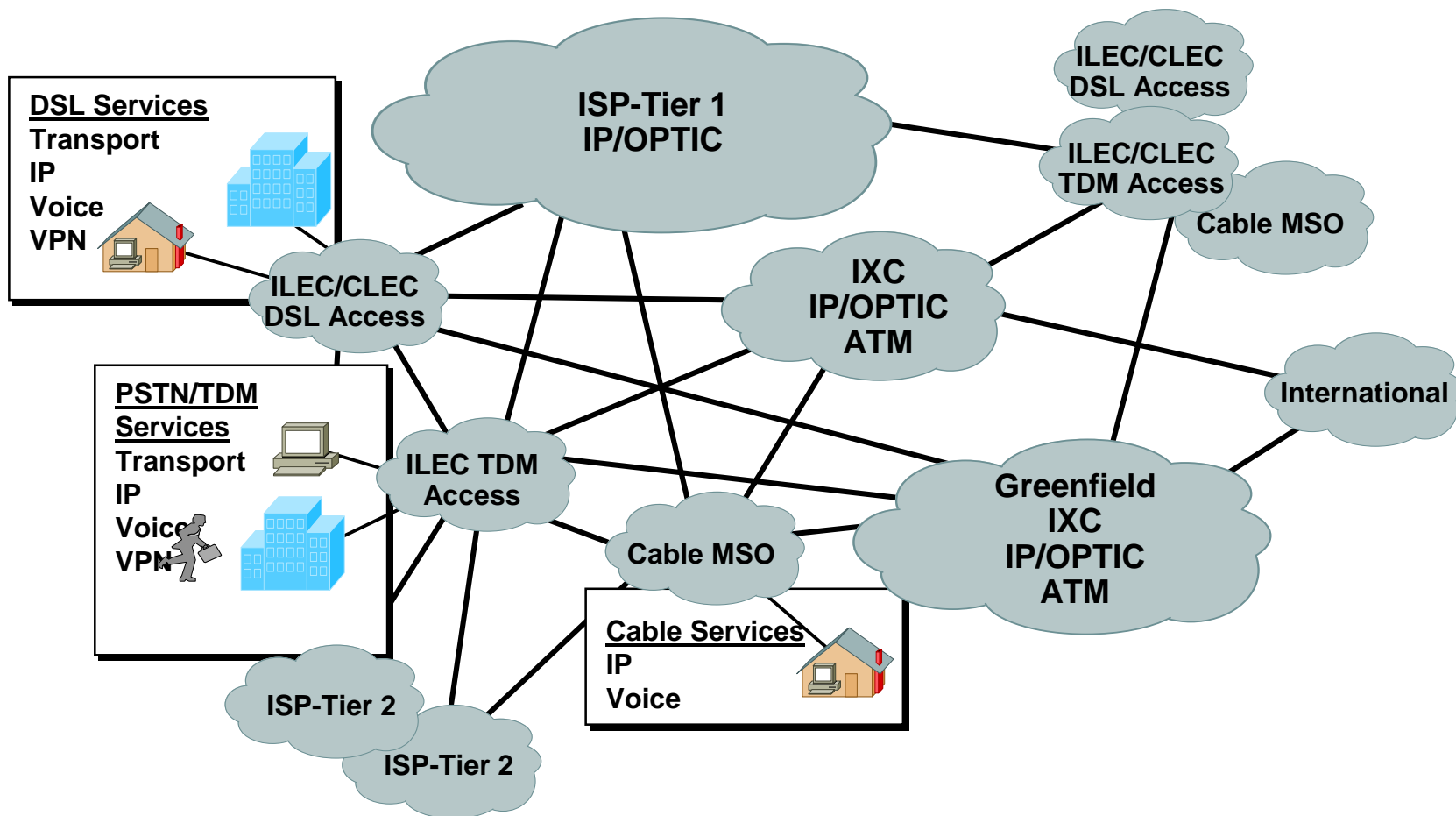
Macro Map - 1997

Does not include International NSP Backbones

Europe

Japan

Mongolia

Korea

China

U.S.A.

Taiwan

U.S.A.

Hawaii

Nepal

Hong Kong

Guam

Pakistan

Laos   Macau

India

Vietnam

U.S.A.

Bangladesh

Philippines

Thailand

Cambodia

U.S.A.

U.S.A.

Malaysia

Brunei

Sri Lanka

Seychelles

Singapore

Papua New Guinea

Indonesia

Europe

U.S.A.

New Caledonia

Fiji
Tonga
Vanuatu
Solomon Islands

Australia

Legend

●   Leased Line

▲   Dial-up or X.25

New Zealand
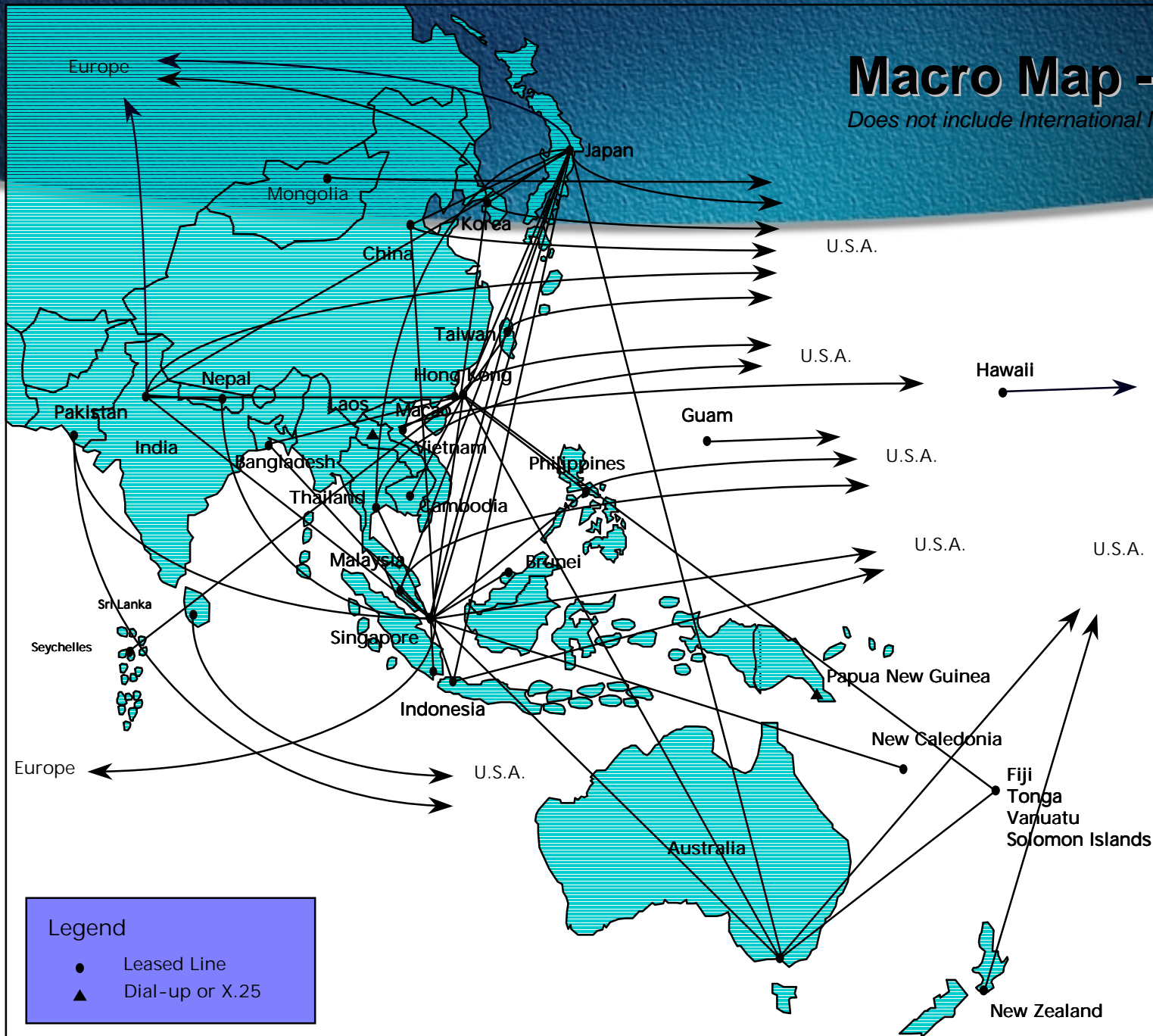
ISP/IXC Interconnection Points
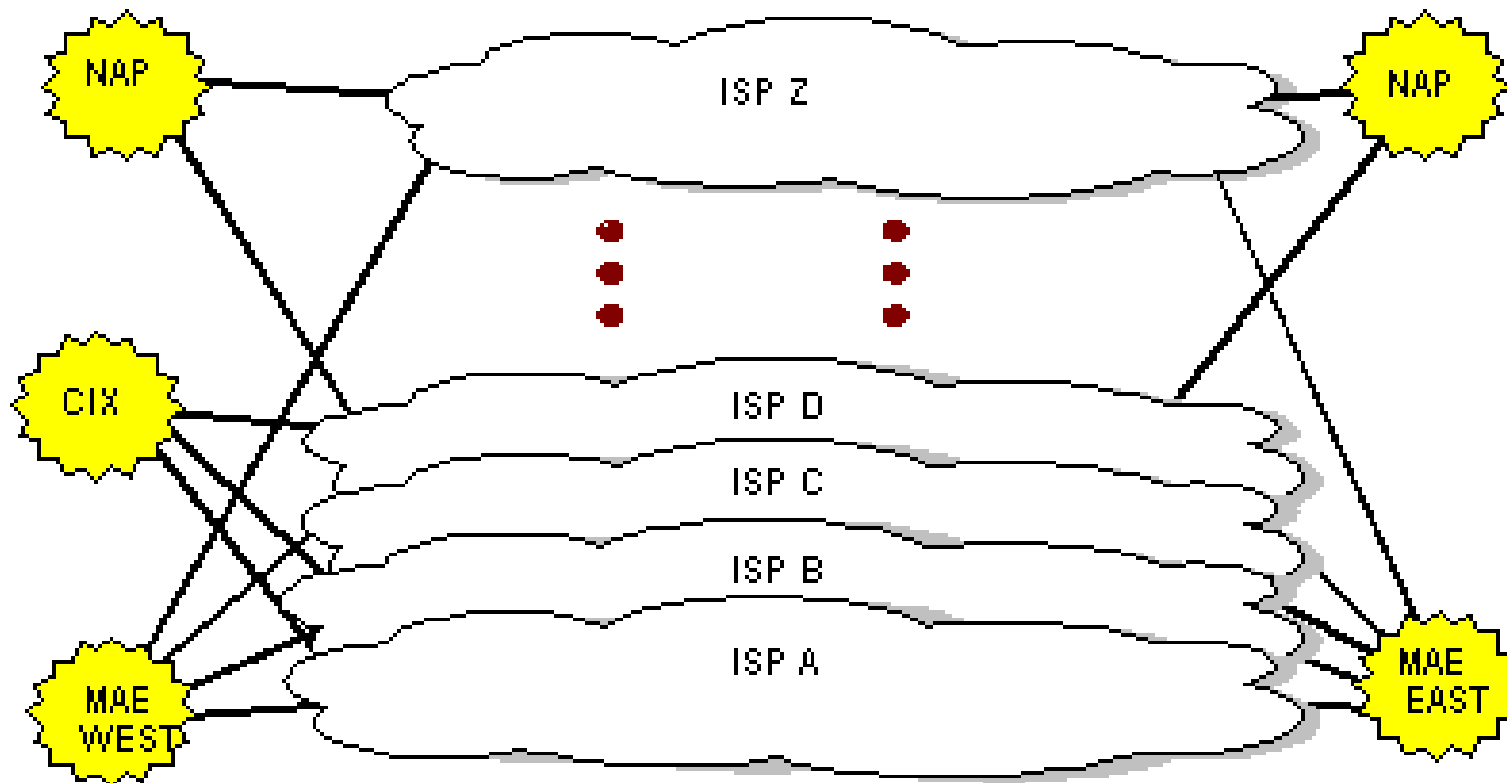
Source: WorldCom MAE Services

Major Types of IXPs in use Today

Different ways ISPs Interconnect with each other

IXPs - The Bottom Line

- The Commercial Internet world is built on the following theme:

Aggressive Competition Publicly

Aggressive Collaboration Privately

Typical IXP.....

ISP #1   ISP #2   ISP #3   ISP #4   ISP #5

IXP Medium
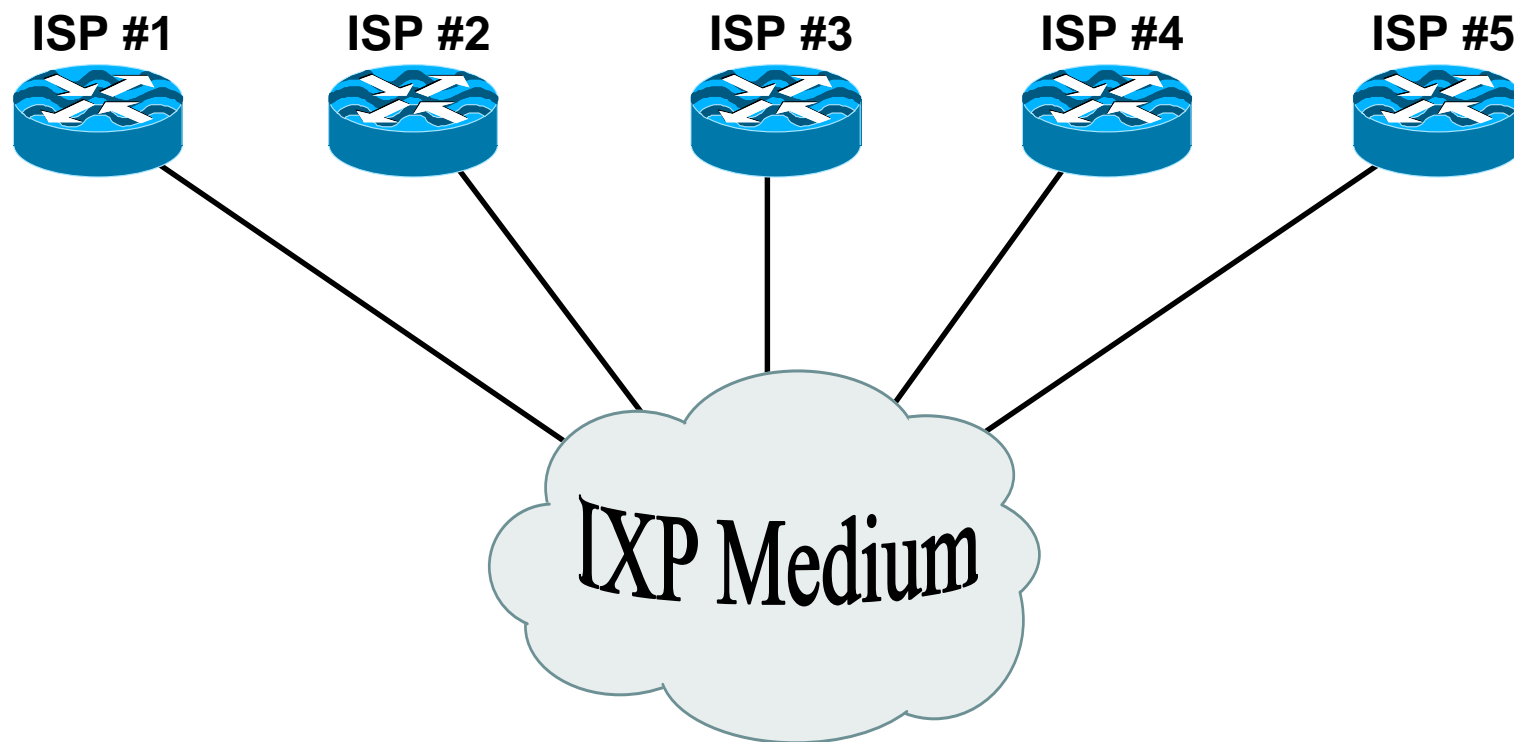
Types of IXPs

- **Three major categories of interconnecting ISPs:**

  ✓ Layer 2

  ✓ Private Interconnect

  ✓ Ring

- **Several Alternatives used to Interconnect**

  ✓ Layer 3

  ✓ Network Service Provider (NSP)

  ✓ Specials & Hybrids

  ✓ GigaPOP

Layer 2 IXPs

- ## Layer 2

  - ✓ Uses a common network medium like ethernet, FDDI, SMDS, or ATM
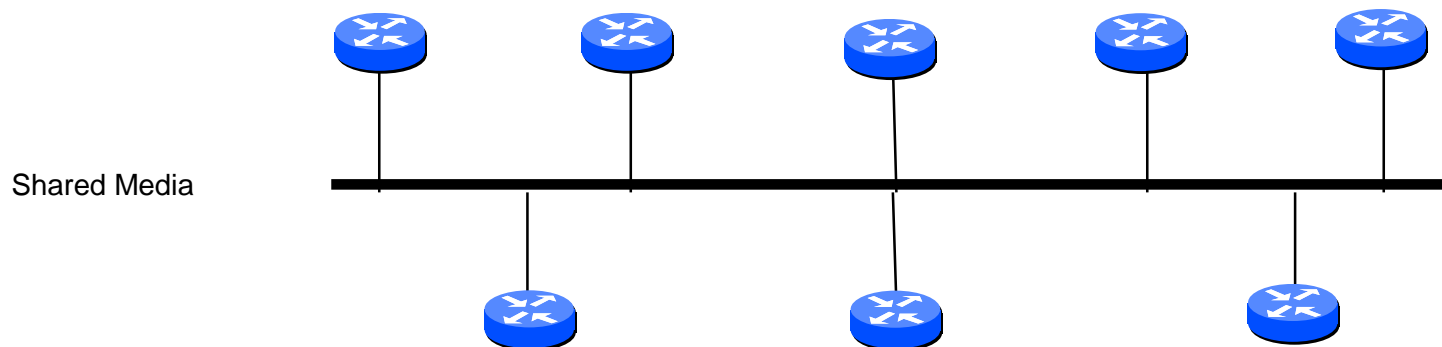
  - ✓ Members bring their own routers and circuits from their backbone.

  - ✓ No Transit or customer connections

  - ✓ Members of the IXP determine who they peer with. You do not have to peer with everyone.

  - ✓ MAE-E, MAE-W, PAC-Bell, Sprint, D-GIX, LINX, NSPIXP, HKIX

Layer 2 IXPs

- **Layer 2 Exchange -** All traffic is exchanged *outside* routers that are connected to a shared media (i.e. ethernet, FDDI, Switched FDDI, or ATM)

Layer 2 IXP

Shared Media

Layer 2 Exchange

ISP 6

ISP 5

ISP 4

IXP Services:
TLD DNS,
Routing Registry
Looking Glass,
news, etc

IXP
Management
Network

Ethernet Switch

ISP 1

ISP 2

ISP 3

Layer 2 Exchange

ISP 6

ISP 5

ISP 4

IXP Services:
TLD DNS,
Routing Registry
Looking Glass,
news, etc

IXP
Management
Network

Ethernet Switches

ISP 1

ISP 2

ISP 3
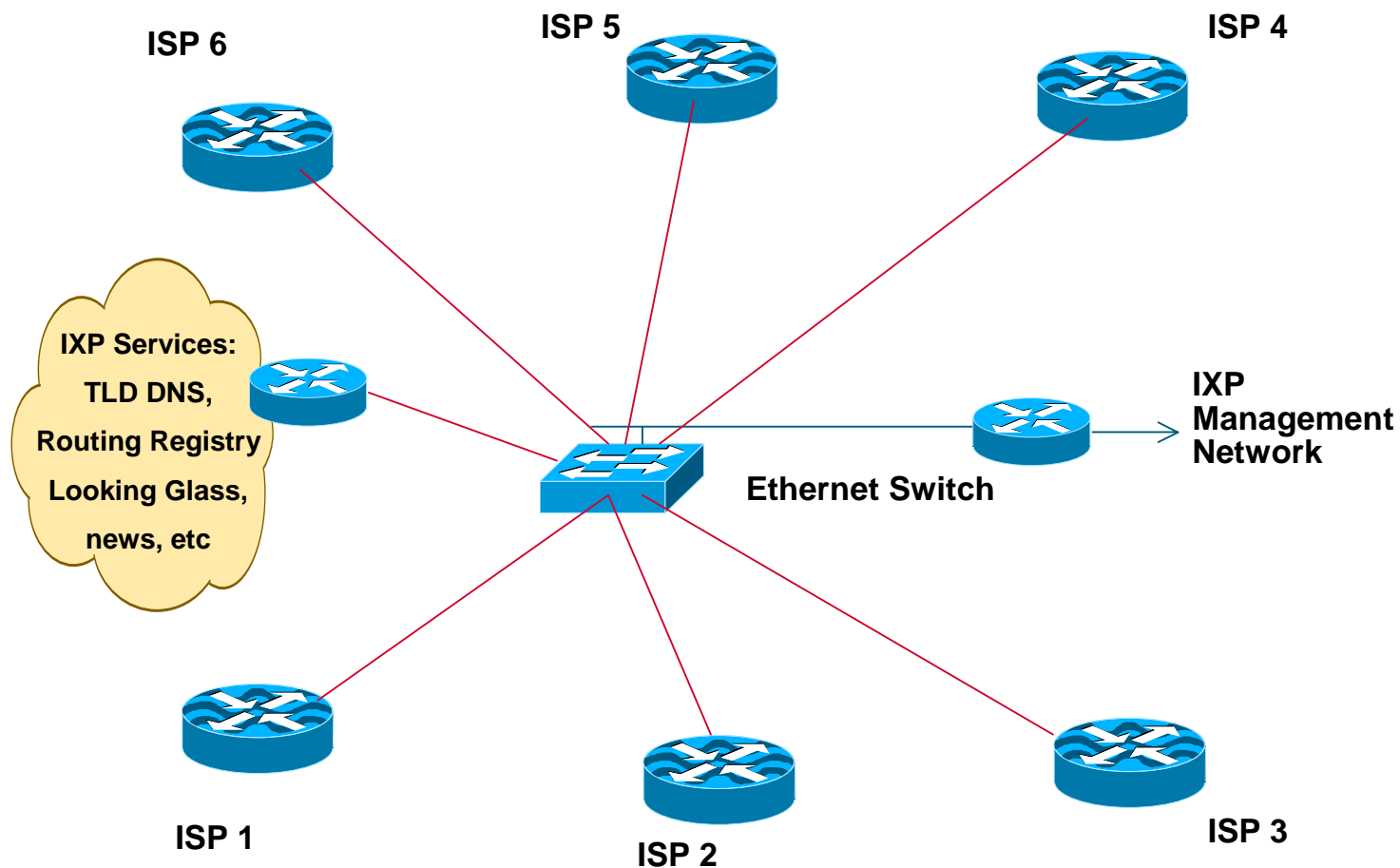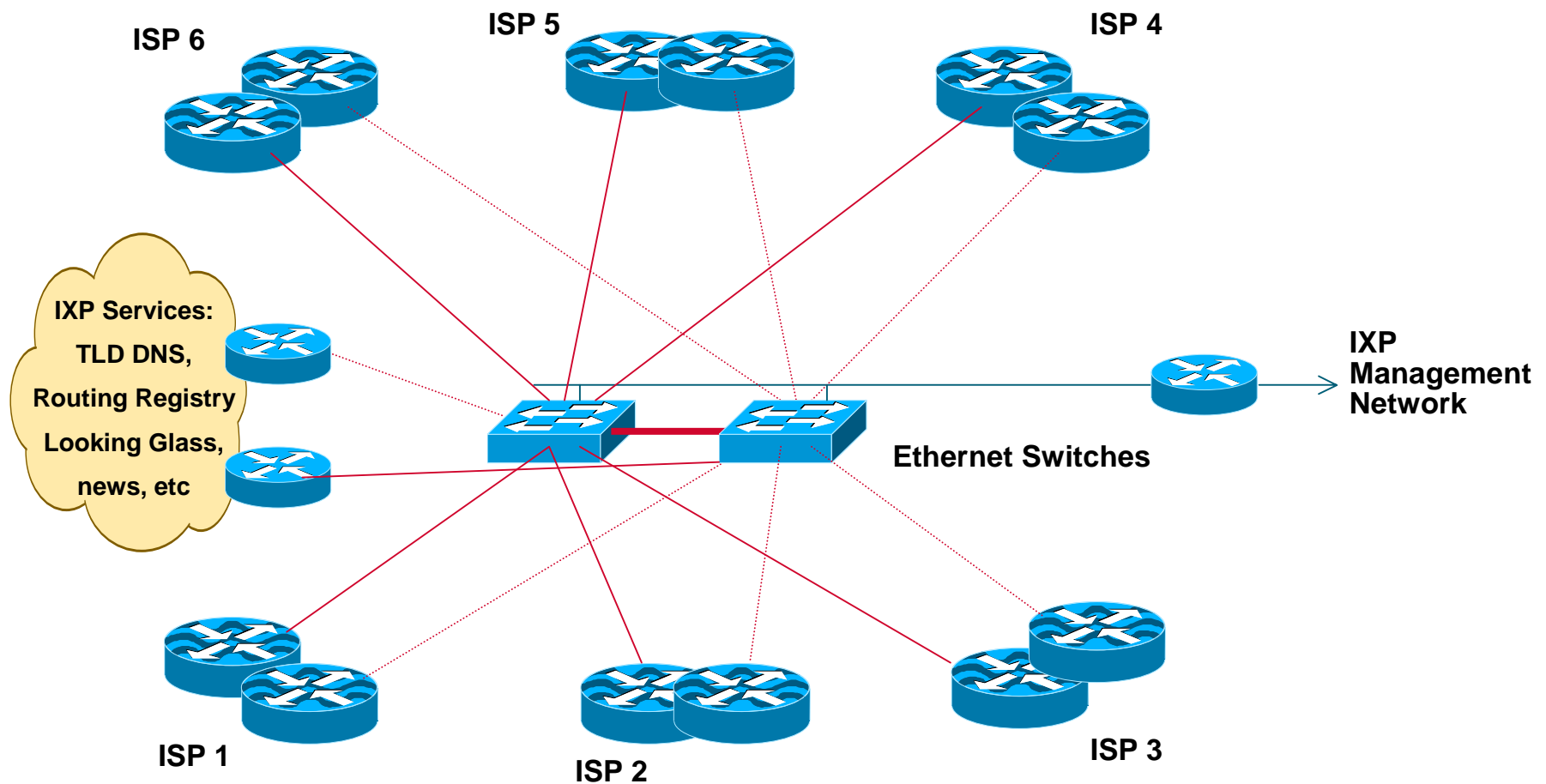
Layer 2 Exchange

- **Two switches for redundancy**

- **ISPs use dual routers for redundancy or loadsharing**

- **Offer services for the "common good"**

  - ✓ **Internet portals and search engines**

  - ✓ **DNS TLD, News, NTP servers**

  - ✓ **Routing Registry and Looking Glass**

Layer 2 Exchange

- **Requires neutral IXP management**

  - ✓ **usually funded equally by IXP participants**

  - ✓ **24x7 cover, support, value add services**

- **Secure and neutral location**

- **Configuration**

  - ✓ **private address space if non-transit and no value add services**

 - ✓ **ISPs require AS, basic IXP does not**

Layer 2 IXPs

- **Layer 2 - Business Case**

  ✓ Based on Facilities Management - not telecommunications services.

  ✓ Space, security, power, air con, level 1 maintenance and a interconnect medium.

  ✓ New services emerging:

    ⇨ Route server, content co-location, proxy/cache

Private Interconnects

- **Private Interconnect**

  - ✓ **Two ISPs or NSPs negotiate a bi-lateral "private" interconnection.**

  - ✓ **One or two Lease Line connections**

  - ✓ **Shared WAN Medium - SMDS or ATM**

  - ✓ **Back-to-Back router connection at a router**

  - ✓ **Speeds from 128Kbps to OC-48 (and soon OC-192)**

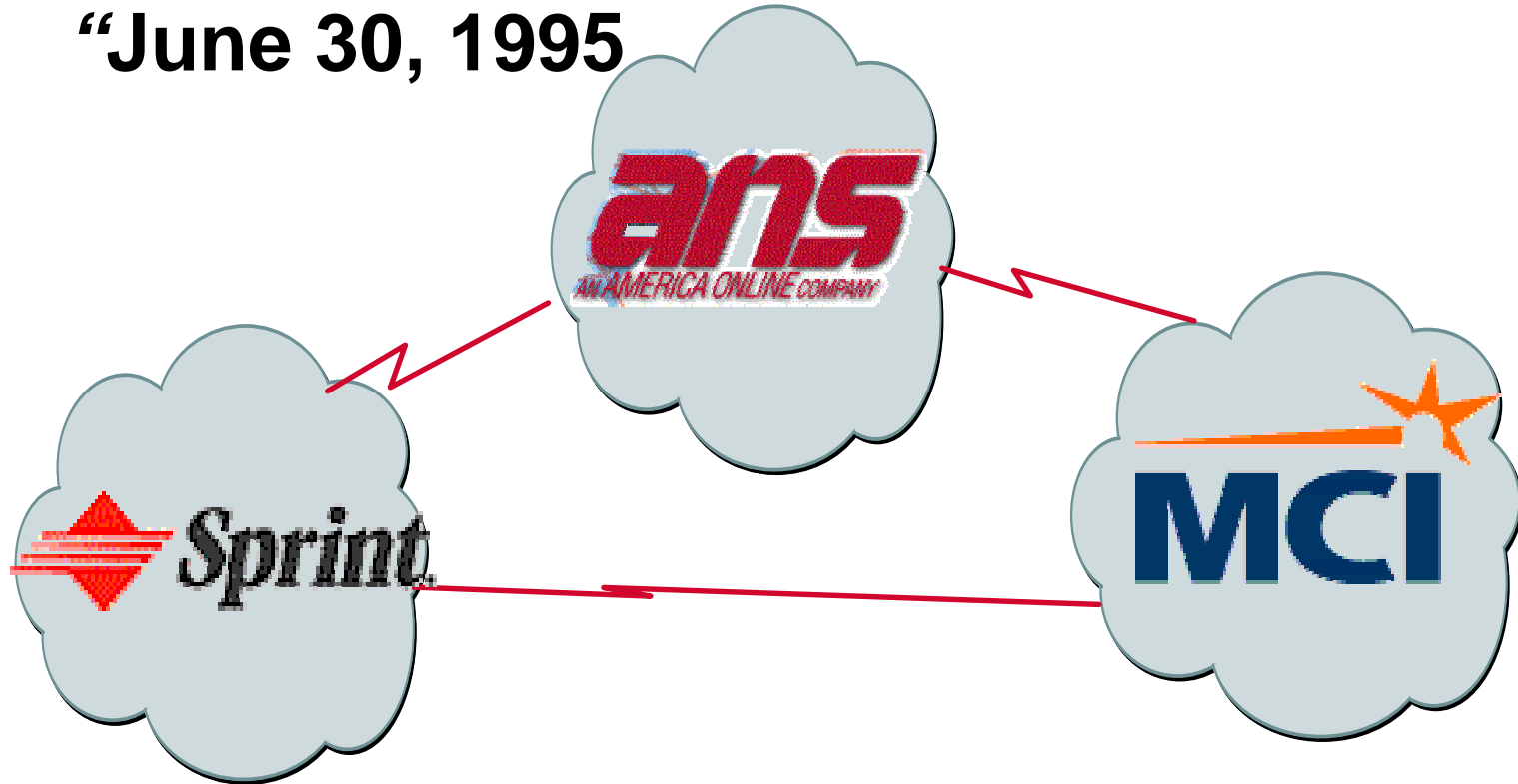# Private Interconnects

- **Private Interconnects usually exchange routes between two Autonomous Systems (AS).**

AS 1

AS 2

BGP
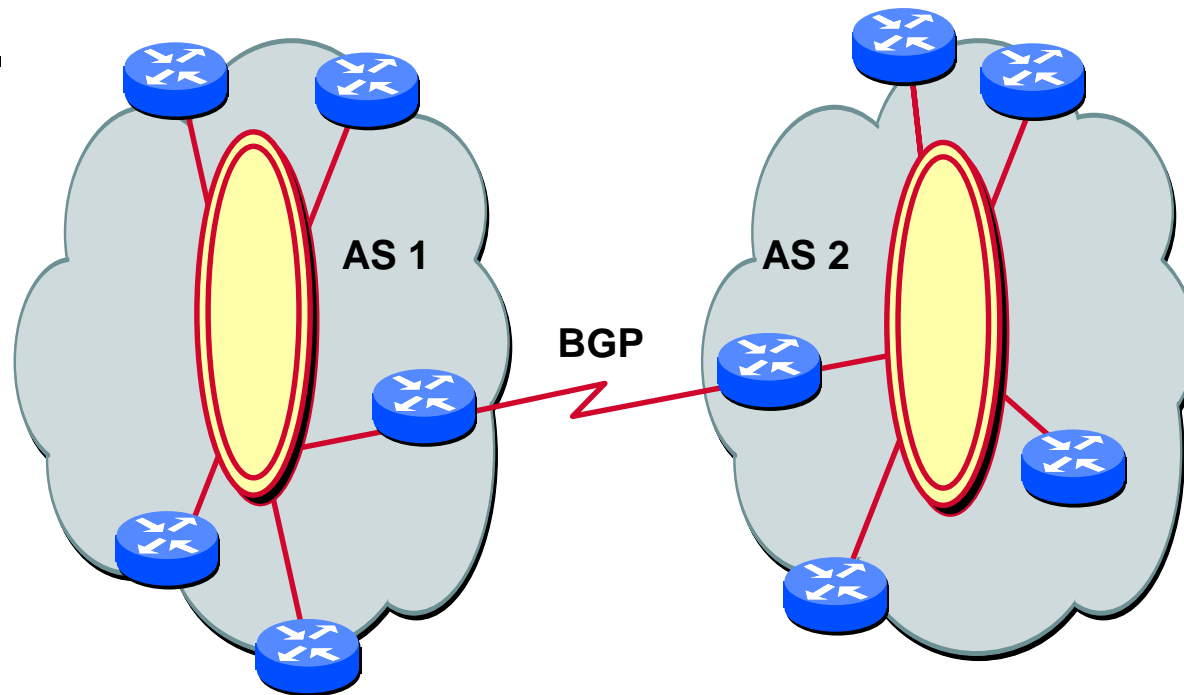
Private Interconnects

"ANS, MCI and Sprint Sign Agreements for Direct Exchange of Internet Traffic "June 30, 1995

IP over SDH/SONET

Optimal Backbone for IP/Internet Services

Performance

Scalability to multigigabit rates

Lower costs

Optimum utilization of bandwidth for IP

Time to market

IP feature transparency

High availability

SONET/SDH resilience

OC12

OC3

SONET ADM

SONET ADM

Access or Backbone Ring

SONET ADM

OC12

SONET ADM

OC3

OC3
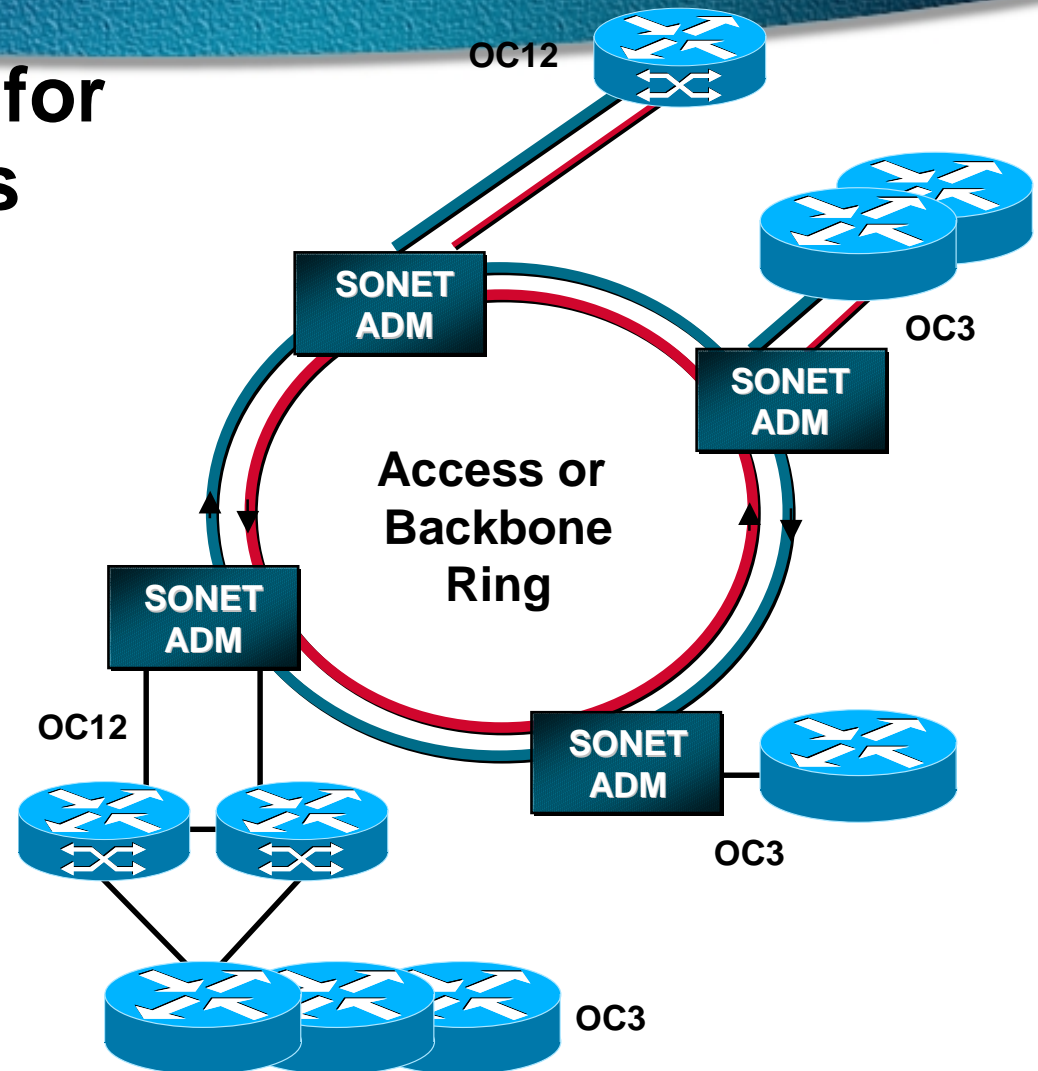
Exchange Point Ring Architecture

ISP A

ISP B

IXP (single facility or distributed)

Ring Interconnect

ISP C

ISP D

ISP E

ISP F

ISP G

 www.cisco.com
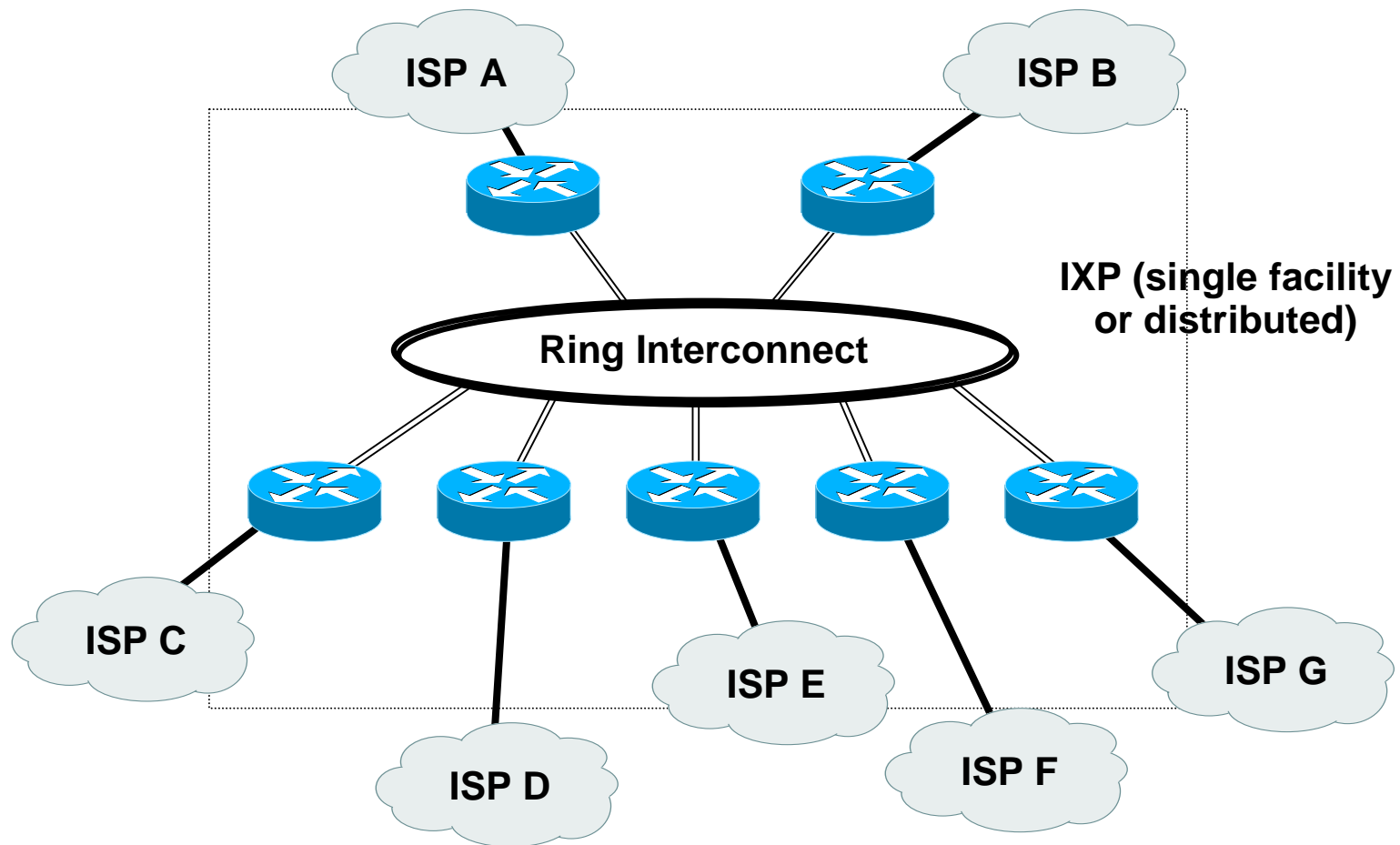
Other ways ISPs Interconnect

Special Types and Old IXP Models

Layer 3 IXPs

- **Layer 3 Internet eXchange Point -** All traffic is exchanged *inside* a router. Old Technique that is not the best option in today's Internet.
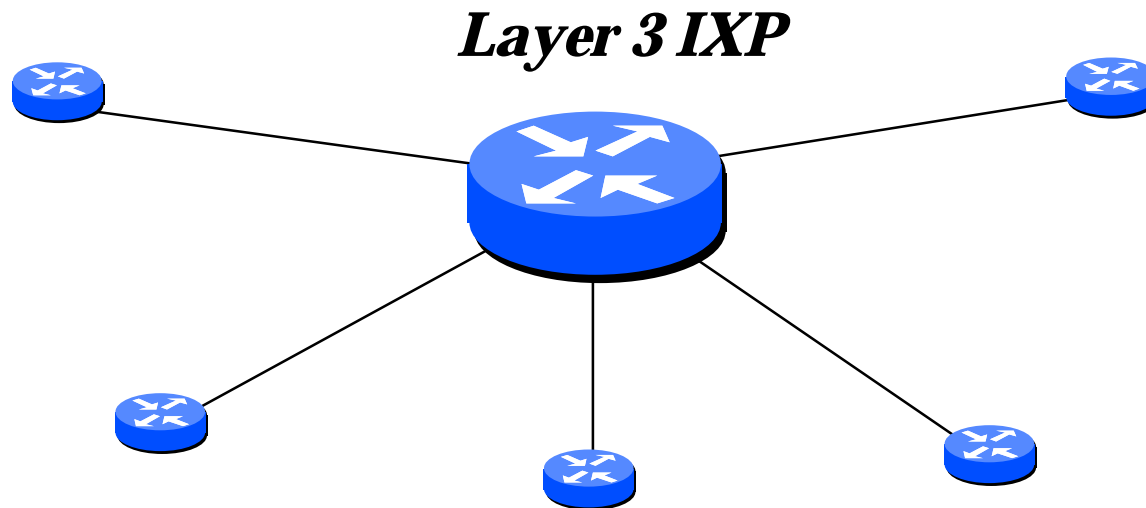
Layer 3 IXP

Layer 3 IXPs

- **Layer 3 IXPs limit the autonomy of the members.**

- **Someone has to manage the router in the middle.**

- **Yet, Layer 3 IXPs are quick and cheap for developing regions.**

- **Do Layer 3 IXPs still have a role to play?**

Layer 2 versus Layer 3

- ## Layer 3

  - ☹ **IXP team requires good BGP knowledge**

  - ☹ **Rely on 3rd party for BGP configuration**

  - ☹ **Less freedom on who peers with whom**

  - ☹ **Could potentially compete with IXP membership**

  - ✓ **Easier to distribute over wide area**

- ## Layer 2

  - ✓ **IXP team does not need routing knowledge**

  - ✓ **Easy to get started**

  - ✓ **More complicated to distribute over wide area**

  - ✓ **ISPs free to set up peering agreements with each other as they wish**
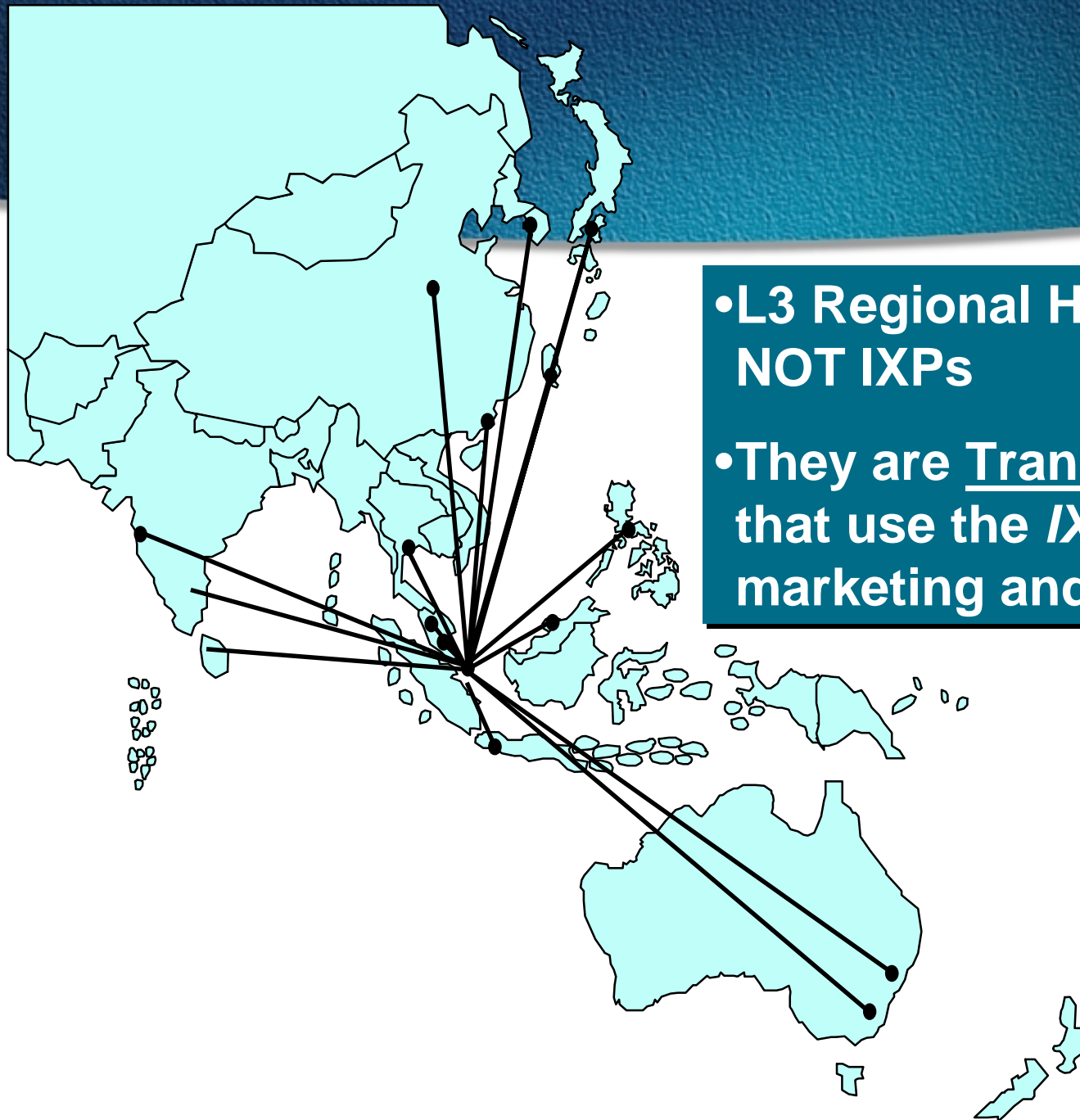
- **L3 Regional Hubs are NOT IXPs**

- **They are <u>Transit Services</u> that use the *IX* term for marketing and sales.**

National Gateways are NOT IXPs

Domestic + International Transit Together
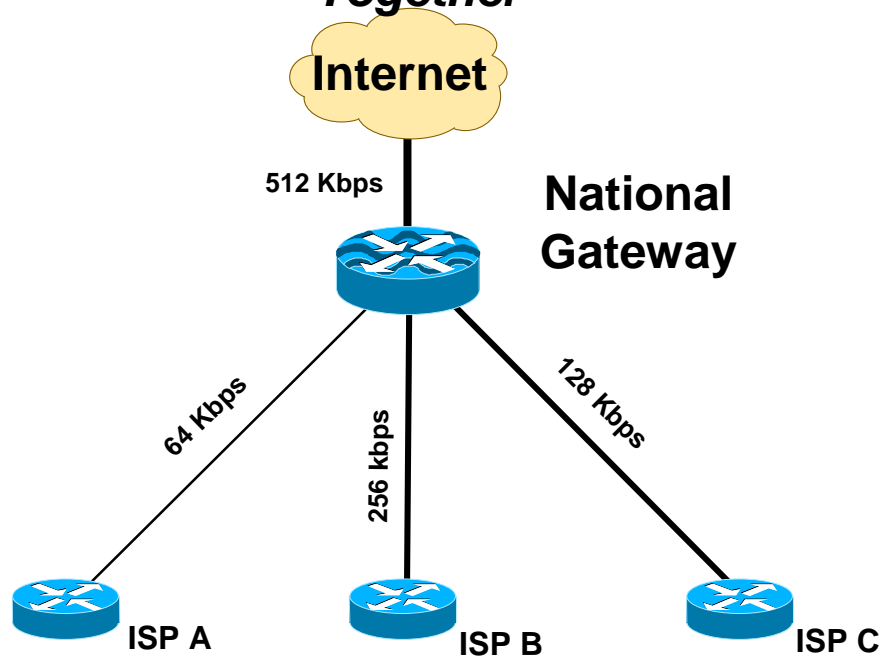
Domestic + International Transit Separate

Internet

512 Kbps

National Gateway

64 Kbps

256 kbps

128 Kbps

ISP A

ISP B

ISP C

Internet

National Gateway

64 Kbps

256 kbps

128 Kbps

ISP A

ISP B

ISP C

2 Mbps

4 Mbps

512 Kbps

IXP
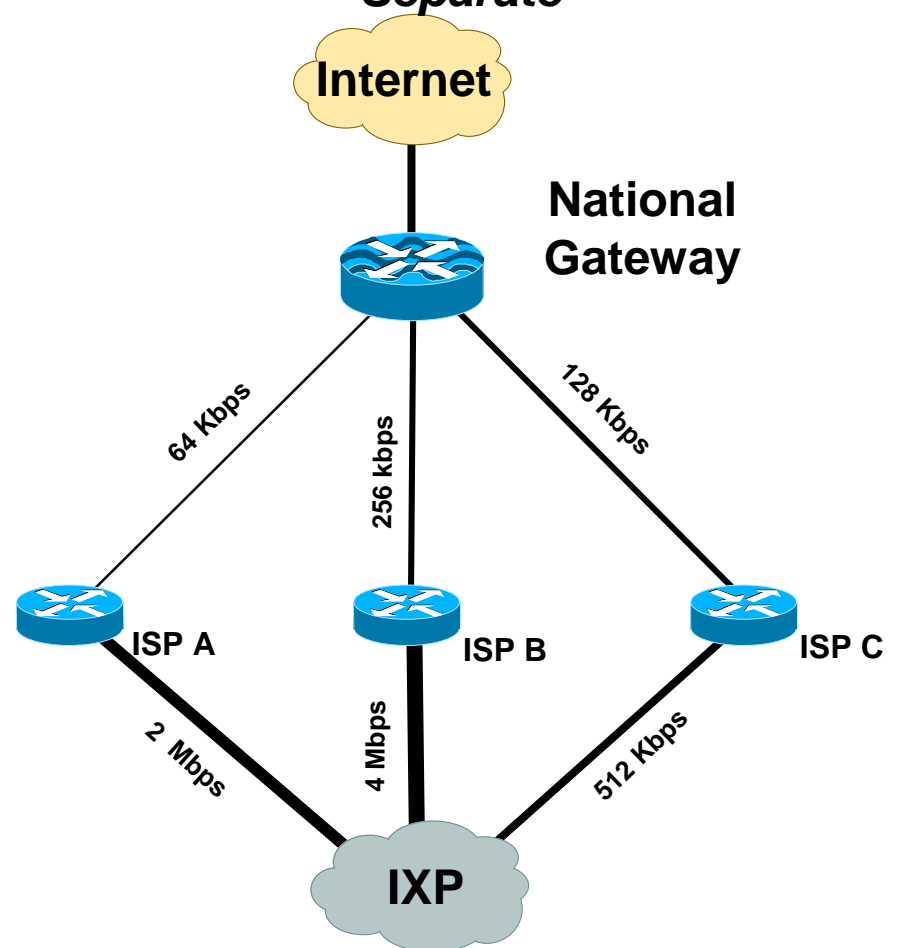
NSPs as IXPs

- **Network Service Providers**

  ✓ ISP of ISPs

  ✓ First NSP was the NSFNet

  ✓ Sprint, WorldCom/UUNET, PSI, Ebone, vBNS

The Old NSFNET Backbone

45 Mb/s National Network Facility

Alaska

NORTHWESTNET

NEARNET

NYSERNET

BARRNET

CICNET

JVNCNET

PREPNET

CERFNET

MIDNET

WESTNET

Hawaii

SURANET

SESQUINET

- NSFNET Backbone
- Mid-level Connections
- Geographic Area of Mid-level Network
- ● Mid-level Network Hub
- ▲ Supercomputer Center & Mid-level Network Hub
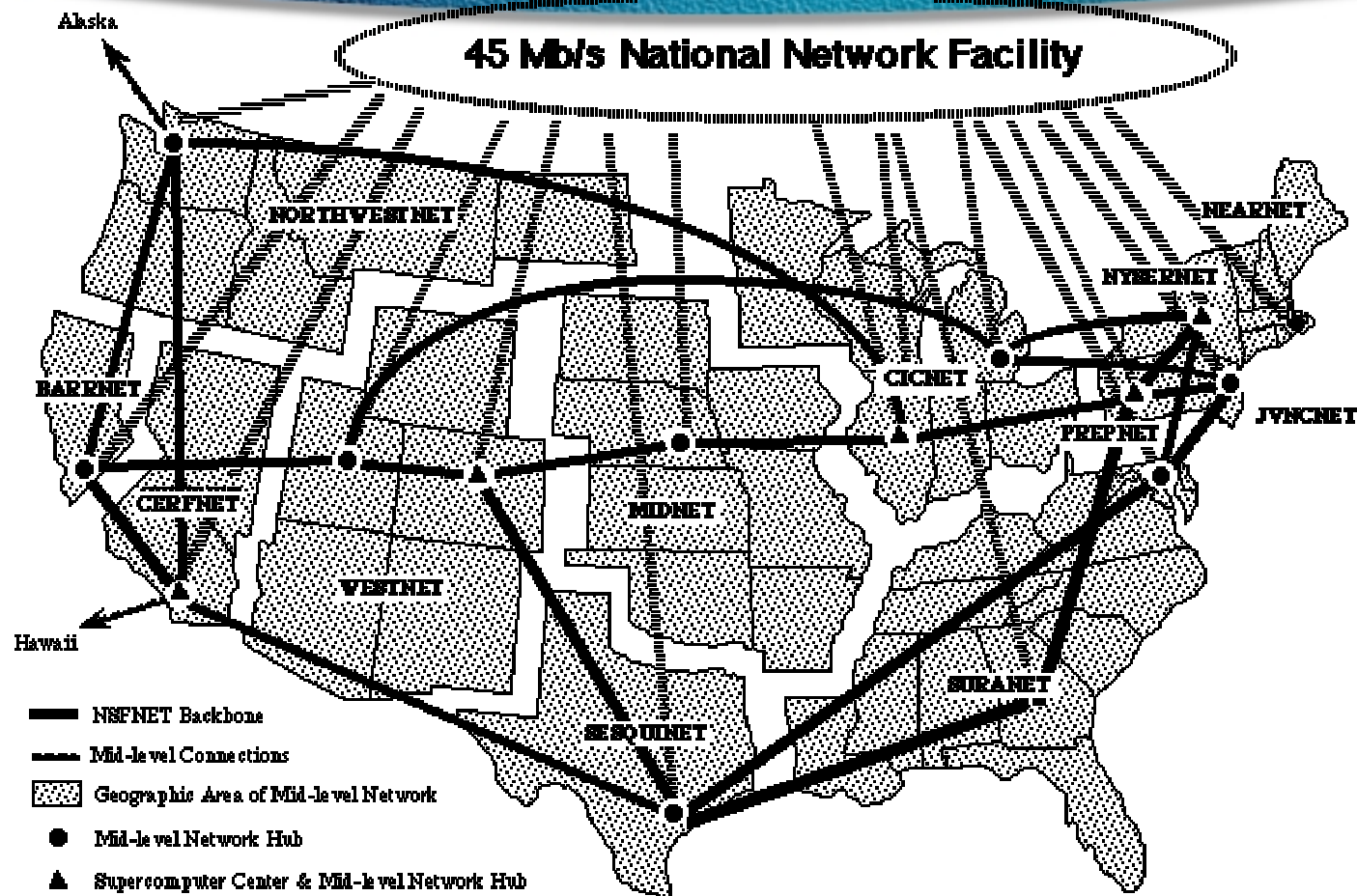
New NSFNET Architecture

NSP #3

NSP #2

NSP #1

VBNS

REGIONAL

REGIONAL

REGIONAL

REGIONAL

Palo Alto, CA

NCAR Boulder, CO

NCSA Champaign, IL

Chicago, IL

PSC Pittsburg, PA

Cornell Ithaca, NY

New York, NY

Washington, DC

SDSC San Diego, CA
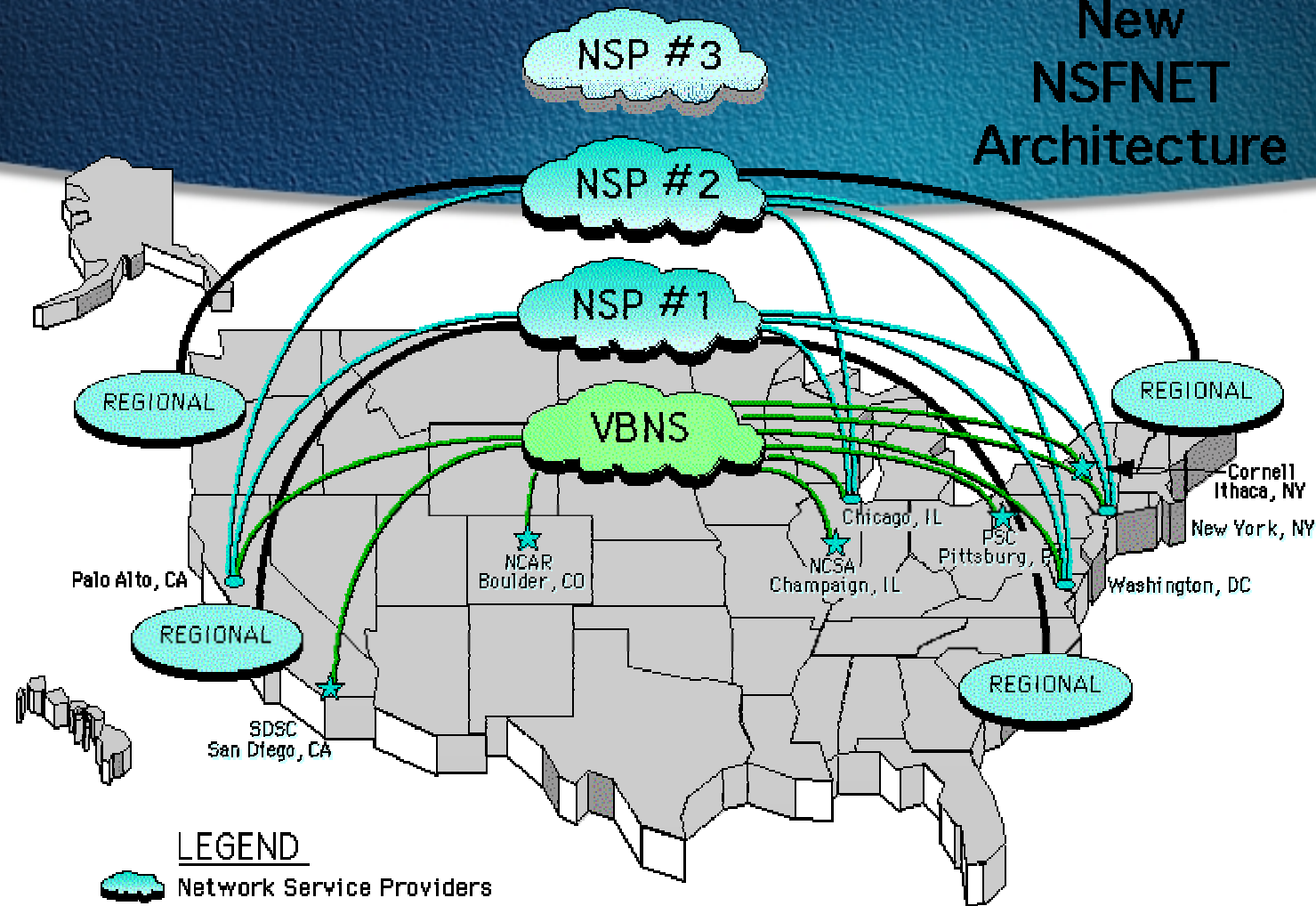
LEGEND

Network Service Providers

Regional and Midlevel Networks

Network Access Points (NAPs)

Supercomputer Centers

Note: Supercomputer centers have additional connections for commodity traffic.

NSPs as IXPs

The National Science Foundation Very-High-Speed Backbone Network Service

Logical Network Map
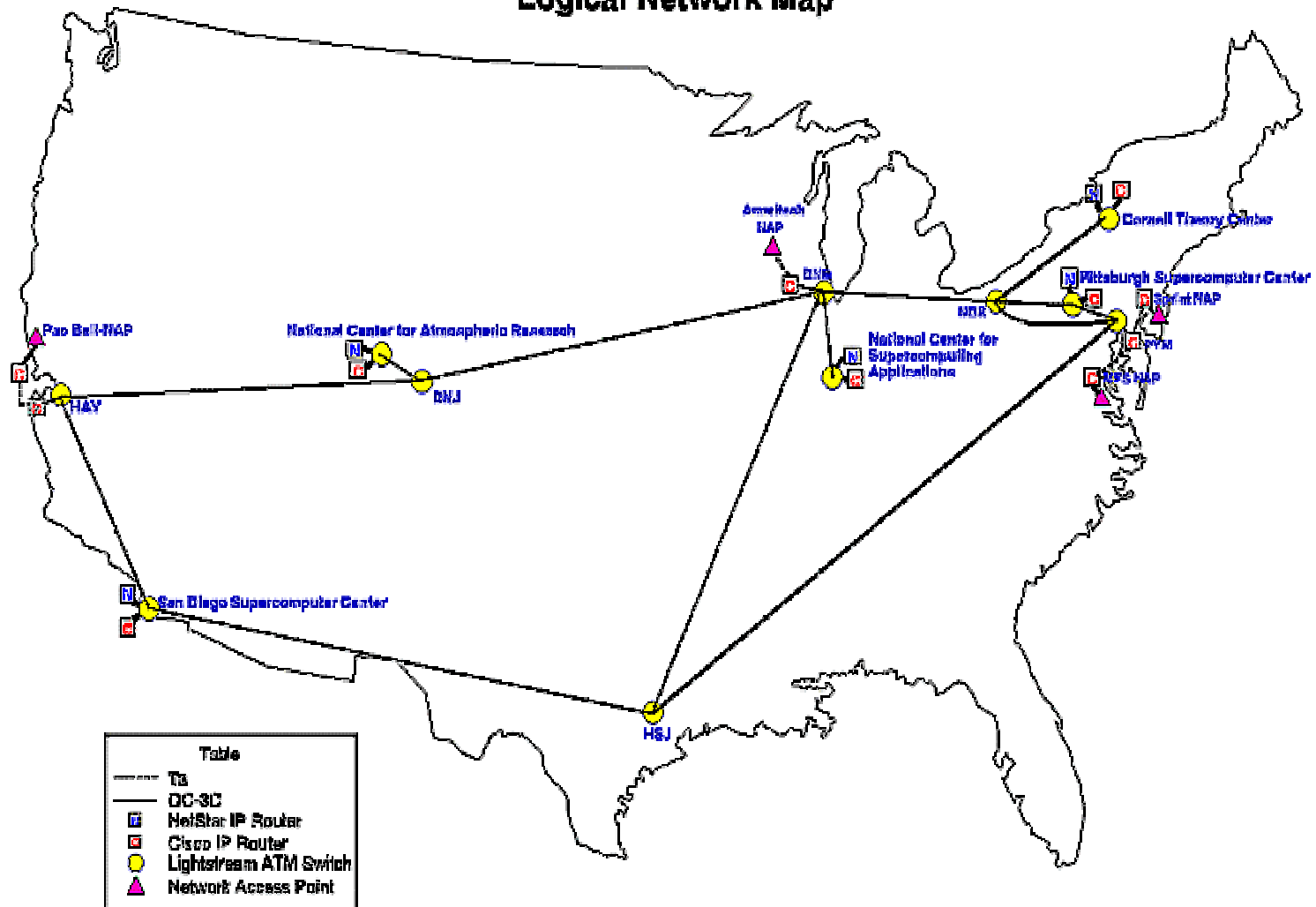
Hybrid IXPs

- ## CIX Hybrid IXP - Topology

56K - 34M

SMDS

CIX Router

Cisco 7513

PAIX (Digital)

**FDDI
Dual Ring**

56K - 2M
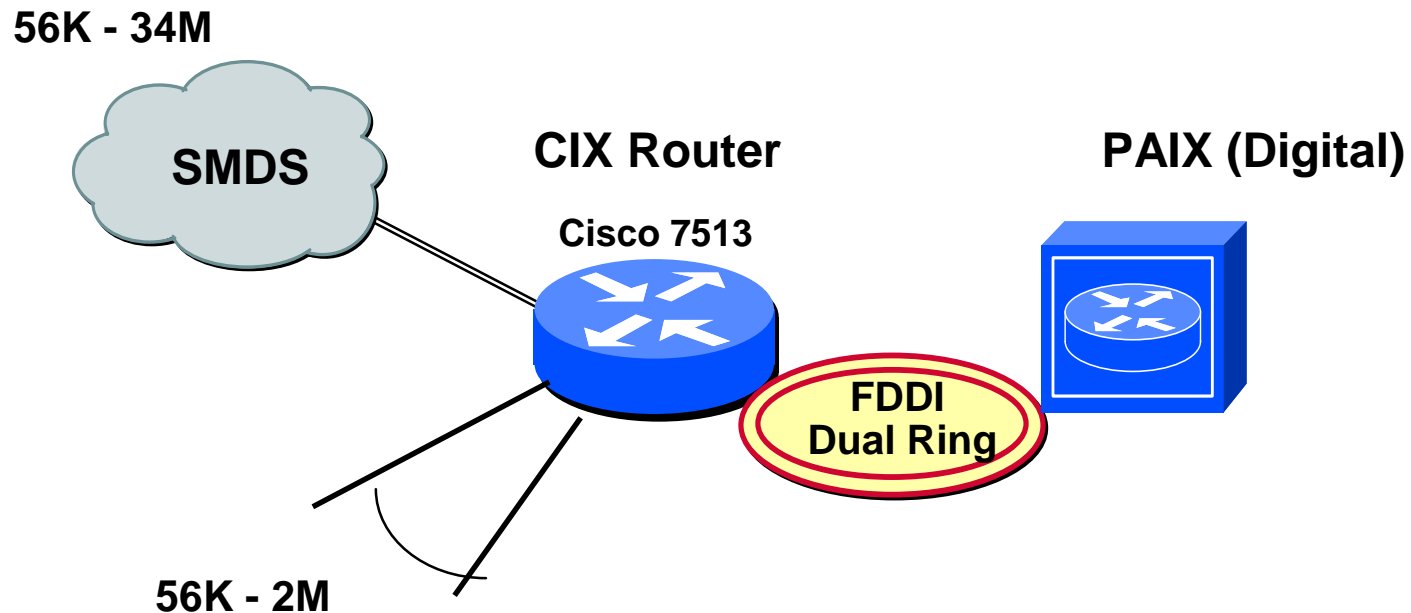
IXP Business Models

IS there a *IXP Business Case?*

© 1999, Cisco Systems, Inc.   www.cisco.com

IXP Business Models

"

Some people think there is something called an *IXP Business Case.* The reality is that there has never been a profitable IXP Business case.

"

ISP Organizational / Business Models

- **Commercial**

- **Non-Profit**

- **Government/Educational**

Commercial IXPs

- **Commercial IXPs are built and operated by a Telco or Co-Location provider**

  - ✓ **Profit is not from the IXP Services, but from the services that support the IXP.**

  - ✓ **Co-Location space, telecommunications services, etc. are where the money is made – not from the *IXP Service.***

- **Examples: MAE, PacBell NAP, Equinix, AboveNet**

Non-Profit IXPs

- **Non-Profit IXPs are a collective effort by several ISP.**

    ✓ **Incorporate a non-profit in order to operate the IXP.**

    ✓ **Some times refereed as the "club" IXP model.**

- **Examples: LINX, Kenya IX, APE (NZ)**

Government/Educational IXPs

- **Government and Educational Institutions build IXPs to enhance their own connectivity.**

  - ✓ **Federal Internet eXchanges (FIXs) were the first IXPs to interconnect US Gov Networks**

  - ✓ **Internet2's GigaPOPs are private IXPs for Universities.**

  - ✓ **StarTap is a IXP for the R& D Networks.**

IXPs are a Tool to a Business Case

- **Bottom Line – IXPs are a tool for interconnection – not a independent business case.**

  - ✓ **IXPs are used to enhanced attract customers to other services (i.e. to a co-location service)**

  - ✓ **The *"IX"* name is used to sell and market transit services (i.e. STIX).**

- **There has yet to be a successful (i.e. huge profits) IXP Business.**

Examples of IXPs

There are many ways to solve the problem ….

www.cisco.com

Layer 2 IXPs

PACIFIC ✖ BELL
N E T W O R K

- ## PA-Bell NAP

  ✓ **ATM L2 IXP built w/ BPXs**

  ✓ **PVCs between each ISP**

Palo Alto
Cisco BPX

Oakland

Cisco BPX   Cisco BPX

OC-3

DS-3   ISP

DS-3   DS-3

ISP   OC-3

ISP   OC-12   ISP

OC-3   OC-3   OC-3   OC-3

OC-3   OC-3

ISP   ISP   ISP   ISP
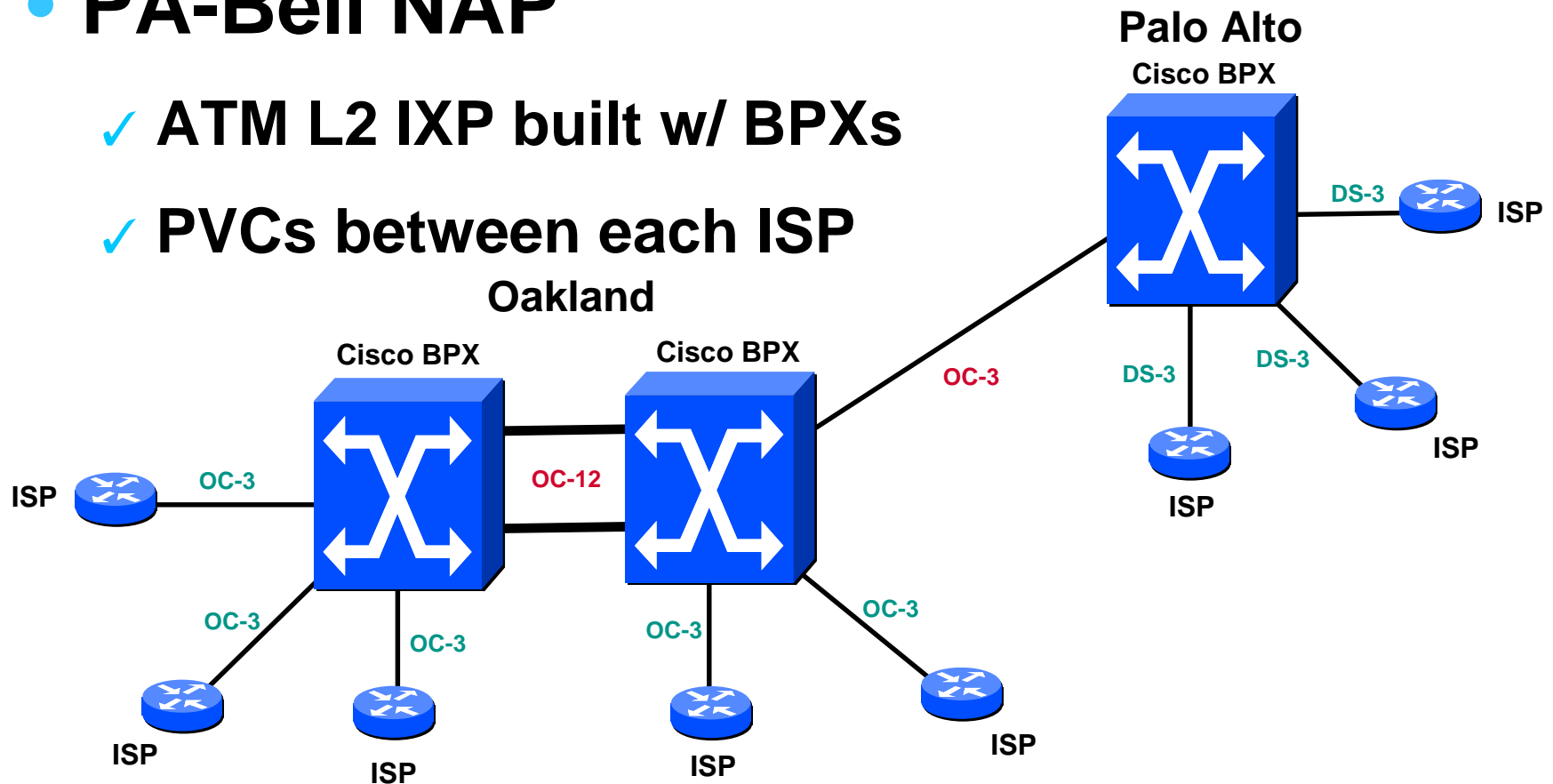
An Example: Ameritech NAP
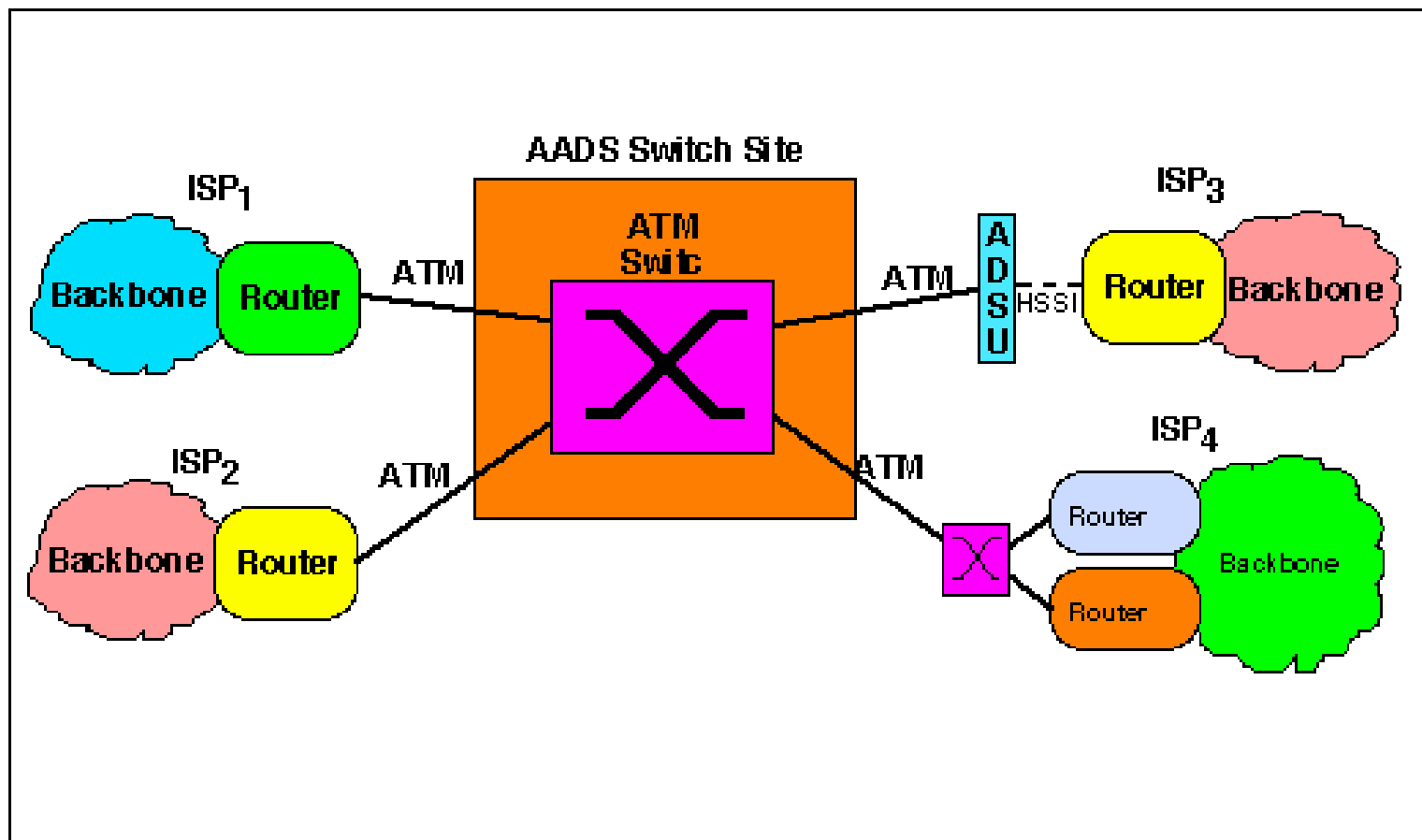
Source: Ameritech

Malaysia IX

TMNET's Border Router @ Brickfields

Jaring's Border Router @ Brickfields

10BaseT   **C7507**   **Cat2900**   10BaseT   **C4500**

- **Malaysia Internet Exchange (IX) -- Catalyst 2900 (10/100 Ethernet Switch)**

- **TMNET & Jaring's Brickfields' Border routers connect to the Malaysian IX.**

- **BGP *route maps* are used to insure only routes from local ASNs are exchanged.**

Malaysia IX

TMNET
AS 4728

100BaseT

Cat2900

100BaseT

Jaring
AS 2042
AS1238
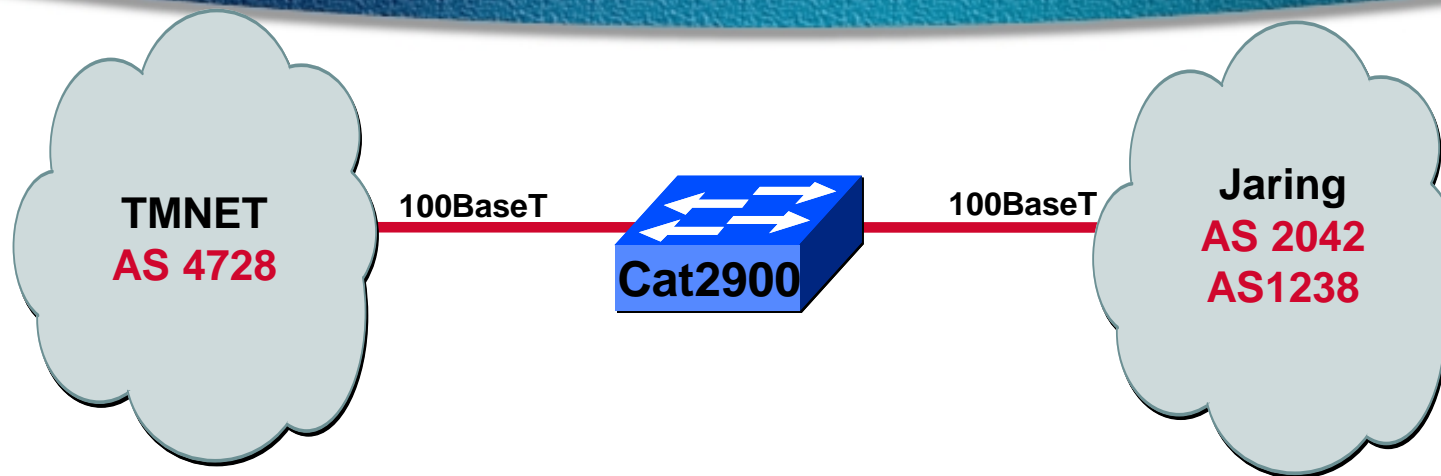
- **Exchange of local routes keeps traffic within Malaysia. Saves <u>bandwidth</u> & reduces <u>latency.</u>**

- **Each redistributes local information into their IGP (OSPF or iBGP) for proper forwarding decisions in their backbone.**

Hong Kong Internet eXchange

- **Hong Kong Internet Exchange (HKIX)**

  - ✓ Set up by Computer Services Center (CSC) Chinese University of Hong Kong (CUHK) in Apr 95

  - ✓ Mainly for intra-Hong Kong traffic

  - ✓ Serve ISPs only

  - ✓ 68 ISPs connected now

  - ✓ Everybody gains benefits but arguments and politics are inevitable.

Hong Kong Internet eXchange

- ## HKIX - Technical Aspects

  - ✓ **CUHK provides space (open racks), electricity, air-conditioning and manpower for coordination and operations.**

  - ✓ **Ethernet coax initially**

  - ✓ **Upgraded to Ethernet switch in Dec 95**

  - ✓ **Use BGP4**

  - ✓ **Mandatory multilateral peering agreement (MLPA)**

  - ✓ **Use Cisco 2501 as route server/route reflector**

  - ✓ **Routing information distribution controlled by IP network address or Origin AS access lists in the route server**

  - ✓ **Minimum speed: T1**

  - ✓ **Two T3 links now**

Hong Kong Internet eXchange

ISP1

ISP n+1 ->

T1

T1

T3

Cisco
2501

Cisco
2501

Cisco CAT 5000

Cisco
7206

10M

10M

100M

10M

100M

Router Reflector
Cisco 2501

Cisco 7000
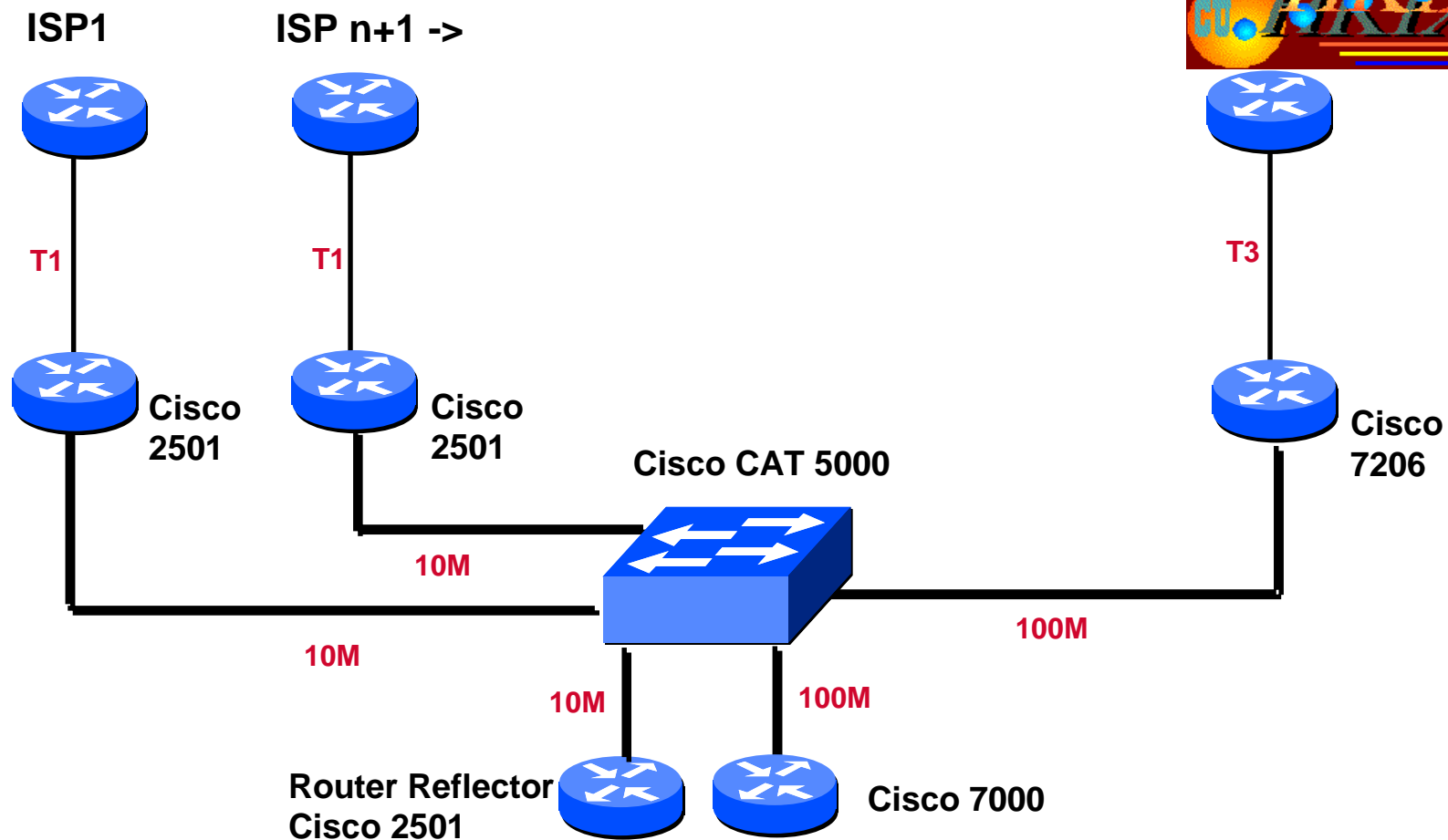
Hong Kong Internet eXchange

- ## Success of HKIX

    - ✓ **Operated by a relatively neutral and non-profit party so little competition seen by participants**

    - ✓ **Free-of-charge service**

    - ✓ **Low set-up cost and simple configuration**

    - ✓ **MLPA and no settlement (Free to set up bilateral agreements among participants)**

    - ✓ **Everyone is equal; No discrimination**

    - ✓ **ISPs' Need of highly efficient network infrastructure**

    - ✓ **Enthusiasm of CSC staff**

Indonesia - APJII

Satelindo Router

IIX-Sat Et 198.32.204.192/26

Indosat Router

IIX-Ind Et 198.32.204.128/26

IIX-Sat

IIX-Ind

SatelIndo

IndoSat

**Telekom
Indonesia**

IIX-Tel

cbn.net.id	202.158.0.0/20 AS4787
mega.net.id	202.149.240.0/20

IIX-Tel Et 198.32.204.64/26
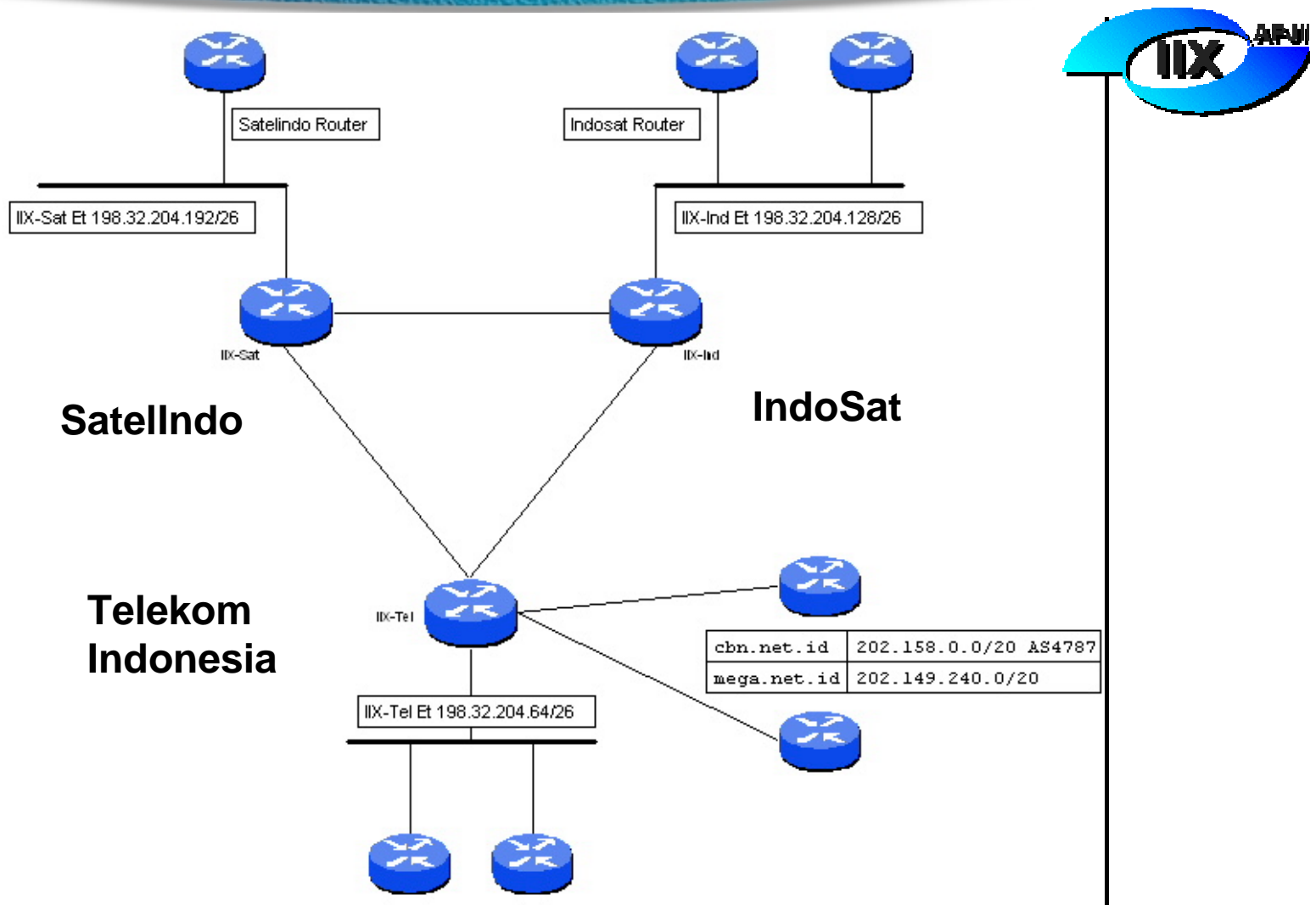
Internet Circuit Termination

Teleglobe
AS6453

France Telecom
AS 5511

SAIX
AS 5713

E1/512K

E1

E1

2 x E1

Africa Telecom ShowNet

AS 8414

www.cisco.com
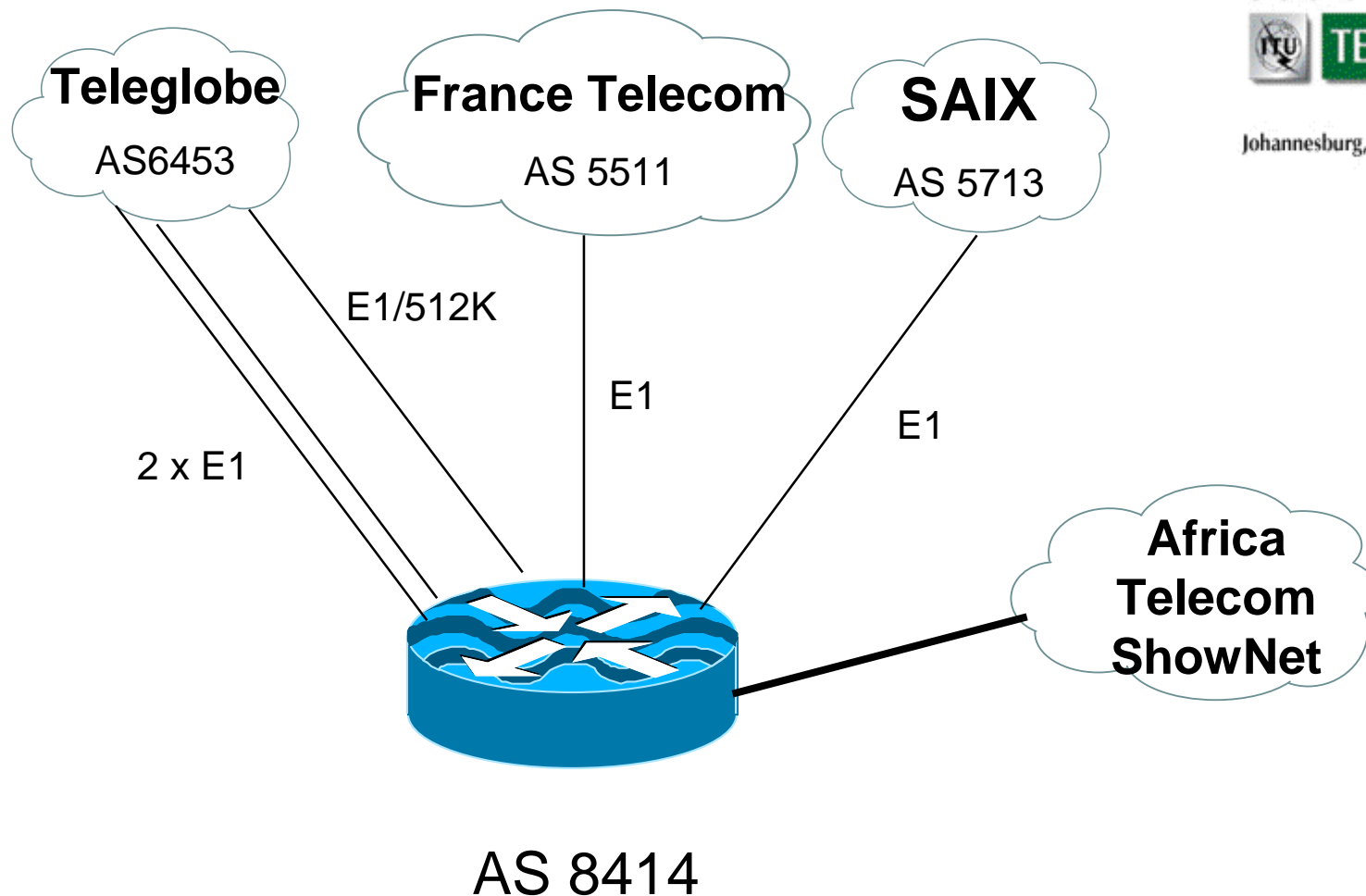
PAC Bell NAP

✓ **ATM L2 IXP built w/ BPXs**

✓ **PVCs between each ISP**

✓ **Distributed L2 IXP**

Palo Alto
Cisco BPX

DS-3 — ISP

Oakland

Cisco BPX   Cisco BPX

ISP — OC-3

OC-12   OC-3

DS-3   DS-3

ISP

ISP   ISP

OC-3   OC-3   OC-3   OC-3

ISP   ISP   ISP   ISP

PACIFIC ✱ BELL
N E T W O R K
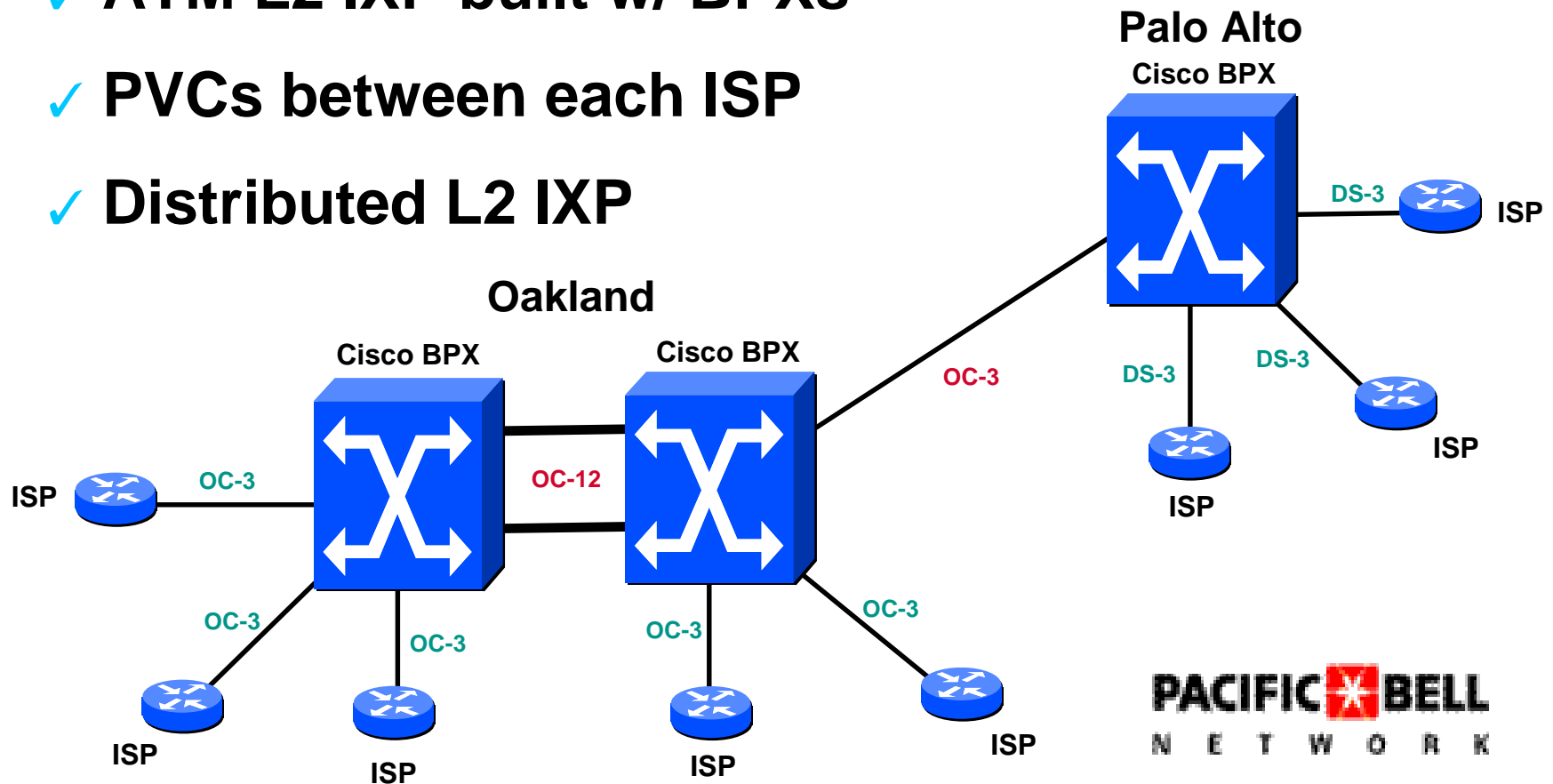
PAC Bell NAP

- **Cisco's Stratacom ATM Platform in use since March 1996:**

  - ✓ **52 Customers using 62 Ports**

    - ⇨ **35 DS-3 Customers - 75% Growth since Jan '98**

    - ⇨ **27 OC-3 Customers - 150% Growth since Jan '98**

- **Evolution**

  - ✓ **OC12 ports**

  - ✓ **all trunks upgraded to OC12**

 **www.cisco.com**

Amsterdam IX: AMSIX

- **AMS-IX Shared Infrastructure:**

  - ✓ **Two locations (SARA & NIKHEF, Amsterdam)**

  - ✓ **Switching hardware, and router & service LANs**

  - ✓ **Gig Ether trunk, plus backup**

  - ✓ **10BaseT and 100BaseTX connections**

  - ✓ **Dropped FDDI some years ago**

- **Many private interconnects**

  - ✓ **lots of fibers available for private ix's**

- **250Mbps of aggregate traffic**

Erik-Jan Bos <bos@surfnet.nl>
SURFnet bv
Eugene, OR - NANOG16#

Amsterdam IX: AMSIX

AMS-IX Topology Map
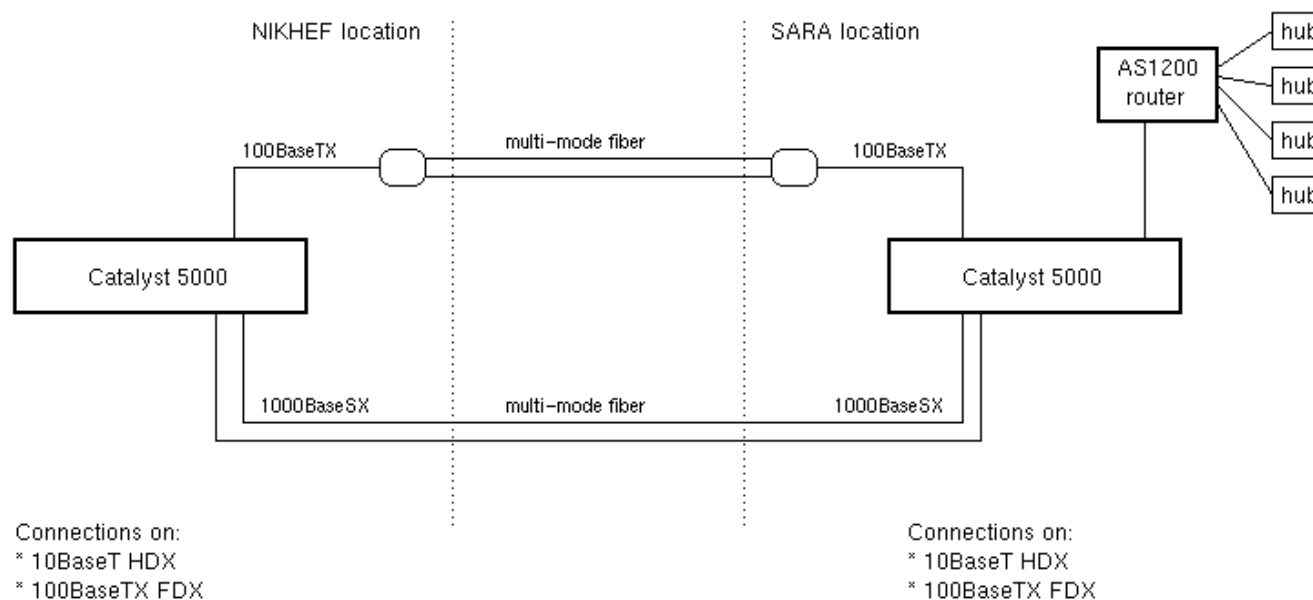
(C) EJB 15 Sep 1998

Erik-Jan Bos <bos@surfnet.nl>
SURFnet bv
Eugene, OR - NANOG16#

www.cisco.com

London EP: LINX

- **91 members**
  - ✓ **UK: 39, US: 9, Fr: 4, DE: 9…**

- **Content Providers**
  - ✓ **BBC**

- **Technology**
  - ✓ **Gigabit Ethernet**
  - ✓ **multiple locations**
    - ⇨ **2 now, later 4 interconnected with dark fiber**
    - ⇨ **evolution to DWDM**

- **Feb00 Traffic: 1.2Gbps**

LINX™

LINX and Peering Facilitation

- **Template Peering Agreement**

  ✓ **http://www.linx.net/joininfo/peering/agreement-v4.html**

  ✓ **Sample inter-provider contract**

  ✓ **Non-mandatory**

- **Dispute Resolution Procedure**

  ✓ **http://www.linx.net/joininfo/dispute_resolution.html**

  ✓ **e.g. peering**

  ✓ **Voluntary, non-binding**

LINX

  www.cisco.com

LINX: Other Infrastructure

- **Route Servers**

  - ✓ **little interest (feedback given at NANOG18)**

- **Pilot Multicast Exchange**

  - ✓ **~10 participants**

- **3 Cesium NTP Stratum 1 atomic clocks**

  - ✓ **"Greenwich e-Time" (really UTC)**

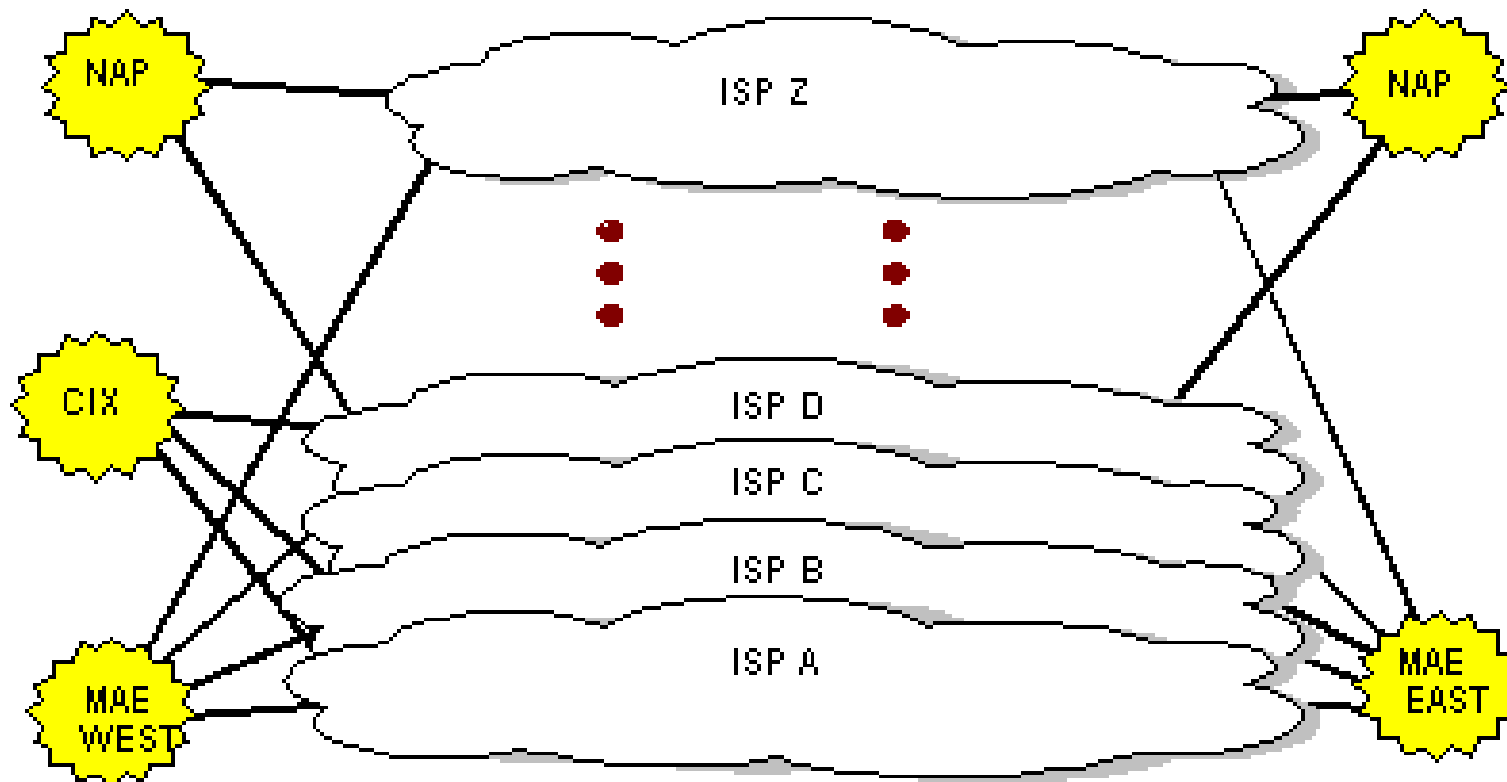 - ✓ **http://www.GeT-time.org**

LINX

MAE-East History

- **Started in 1992: shared Ethernet over DS3 ring**

- **1993: Migrated to switched Ethernet**

- **1994: Added shared FDDI**

- **1995: Added switched FDDI (Gigaswitch)**

- **1997: Multiple Gigaswitches, star topology**
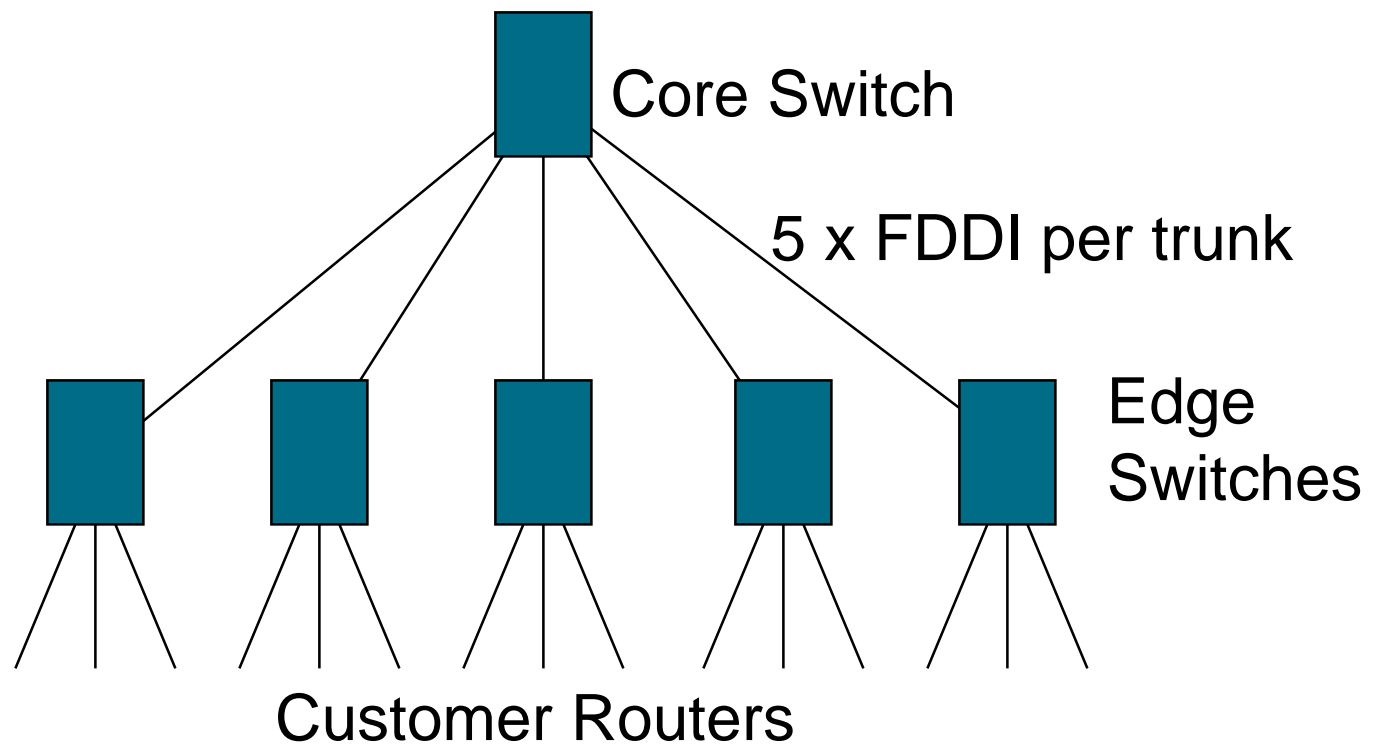
- **1998: MAE-ATM introduced**

MCI WORLDCOM

MAE Interconnection Points

Source: WorldCom MAE Services

MAE East Topology

Core Switch

5 x FDDI per trunk

Edge
Switches

Customer Routers

MAE-East Status

- **As of early Feb. 1999**

- **116 Connections**

- **over 2.1 Gbps traffic (typical peaks)**
  - ✓ **was 2.0 Gpbs at Nov. NANOG**
  - ✓ **1.6 Gpbs in August 1998**

MCI WORLDCOM

MAE-East Current Issues

- **Head-of-line blocking**

- **Overloaded trunk**

- **Overloaded access ports**

- **Doesn't scale**

  - ✓ **Number of users**

  - ✓ **Port speeds beyond 100 Mbps**

MCI WORLDCOM

MAE-ATM

- **Local ATM service**

- **Three Cisco/Stratacom BPX switches**

- **Fixed-bandwidth PVCs among providers**

- **"Virtual private peering"**

- **"PeerMaker" for customer provisioning**

- **Port speeds up to OC12c (622 Mbps) today**

- **Not interconnected with FDDI MAE**

MCI WORLDCOM

MAE-ATM Topology

3 x OC12c per trunk

Customer Routers

MCI **WORLD**COM

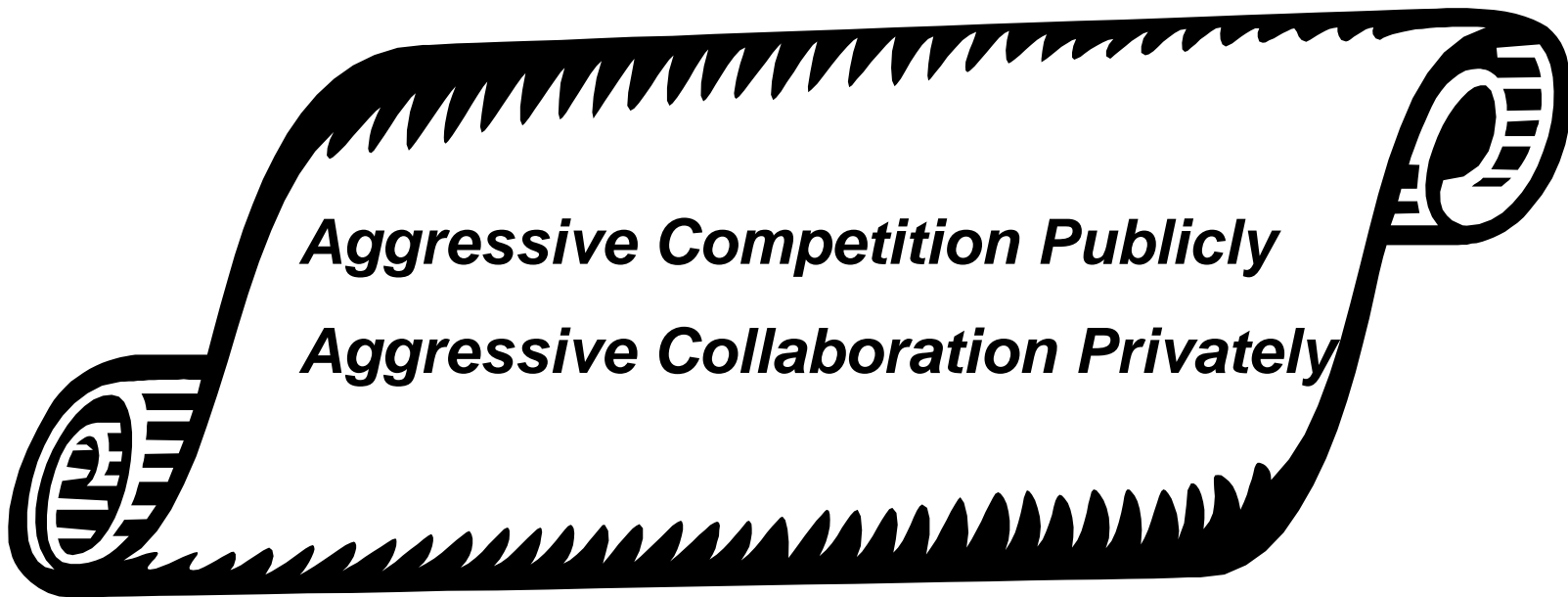   www.cisco.com
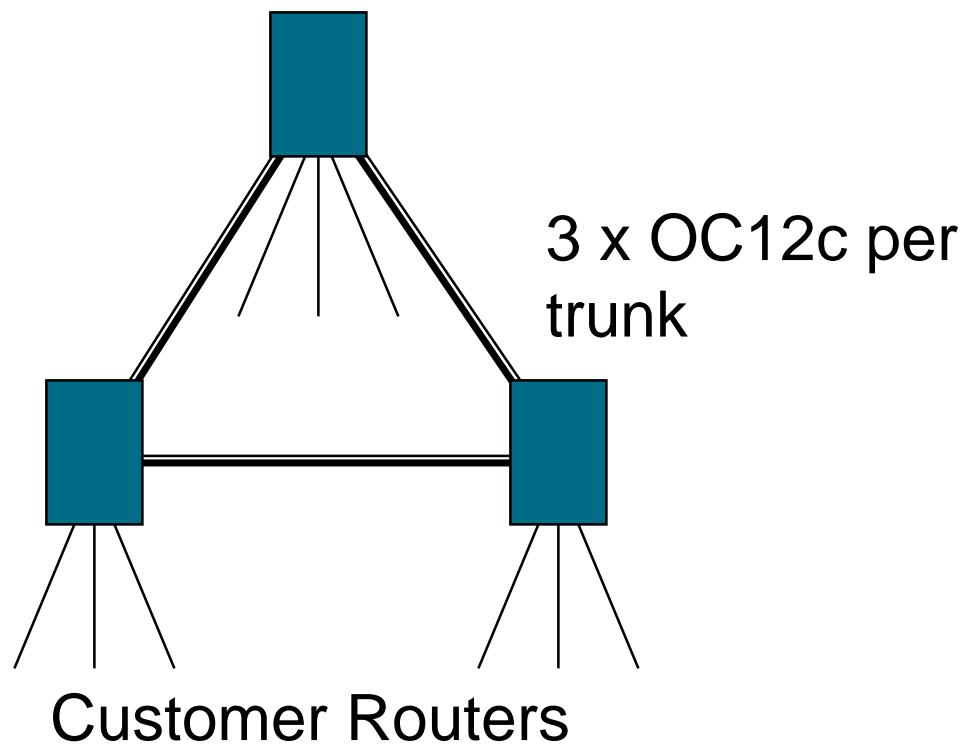
MAE's PeerMaker^{TM}

- **Web-based PVC provisioning tool**
    - ✓ **customers provision their own PVCs**
    - ✓ **no human intervention by MCI Worldcom!**
    - ✓ **enforces bilateral agreements**
    - ✓ **enforces no oversubscription**
- **Beta test in progress**

MCI WORLDCOM

MAE-East What Next?

- **FDDI**

  - ✓ **Possible replacement for Gigaswitch**

  - ✓ **Fast Ethernet for FDDI**

- **ATM**

  - ✓ **Evaluating bigger switches**

  - ✓ **Estimated need by summer**

- **Other**

  - ✓ **POS/MPLS?**

MCI WORLDCOM

The Bottom Line

- The Commercial Internet world is built on the following theme:

Aggressive Competition Publicly

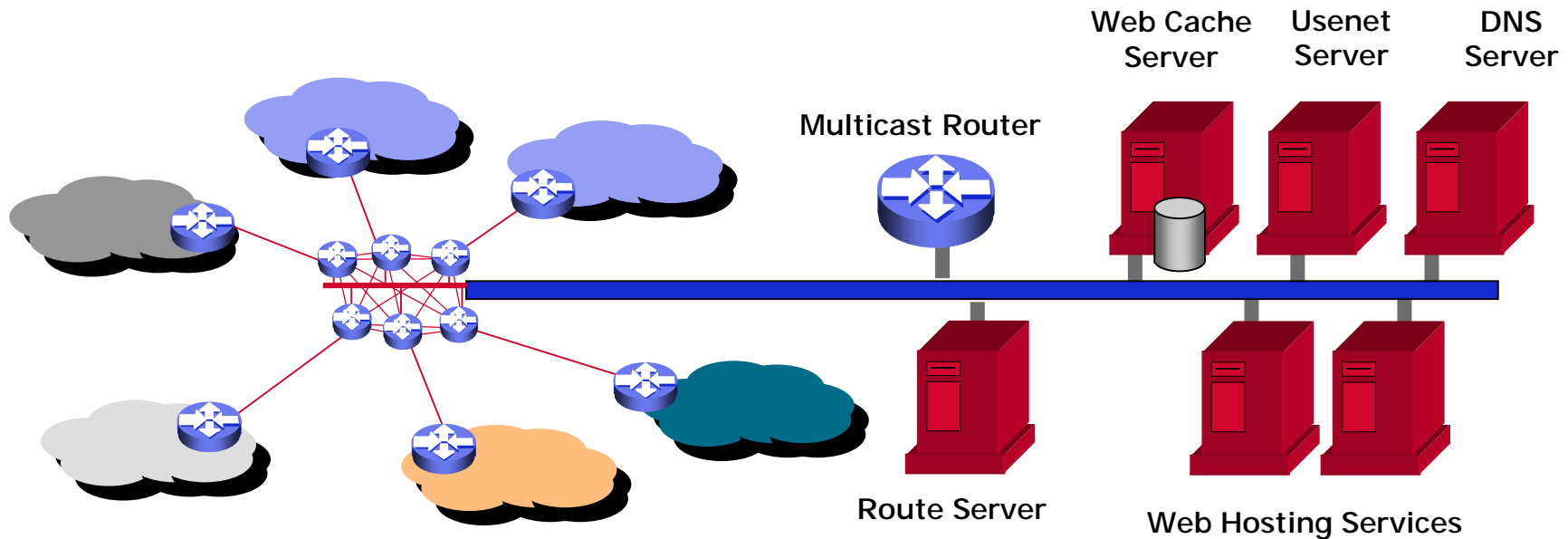*Aggressive Collaboration Privately*

IXP Services

What services should a IXP offer to be successful?

Adding Value to the Exchange

- **exchanges represent a very efficient centralized service launch point**

Service Environment

Eg. equinix

Web Cache Server   Usenet Server   DNS Server

Multicast Router

Route Server

Web Hosting Services

IXP Services

- ## The Basics….

  ✓ **Contractual Maintenance** - ISPs peering at the IXP should be able to rely on a level agreed upon maintenance level.

  ✓ **WWW Pages** - IXP Web pages containing information on the IXP, the status, contact information, IXP statistics, etc.

  ✓ **Router Server -** A route server helps the IXP scale from a few peering members (1-10) to many peering members (10-80).

IXP Services

- **Other Ideas….**

  ✓ **WWW Proxy/Cache** - Pool WWW Proxy/Cache resources via a IXP Proxy/Cache server.

  ✓ **Multicast Server** - Coordinate Multicast traffic (Mbone) via a IXP Multicast router (Cisco with PIM or a UNIX workstation with Mrouted).

  ✓ **Content Co-Location** - Co-locate strategic content at the IXP site (Internet Railroad/Worlds Fair project) or sell Co--location services (Digital's IXP).
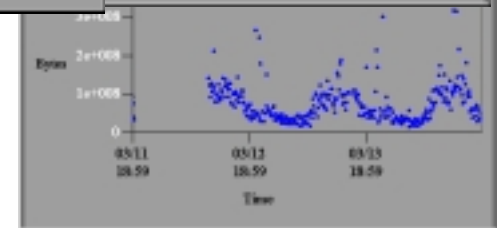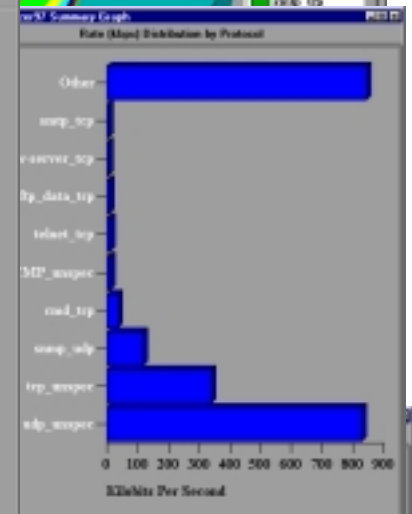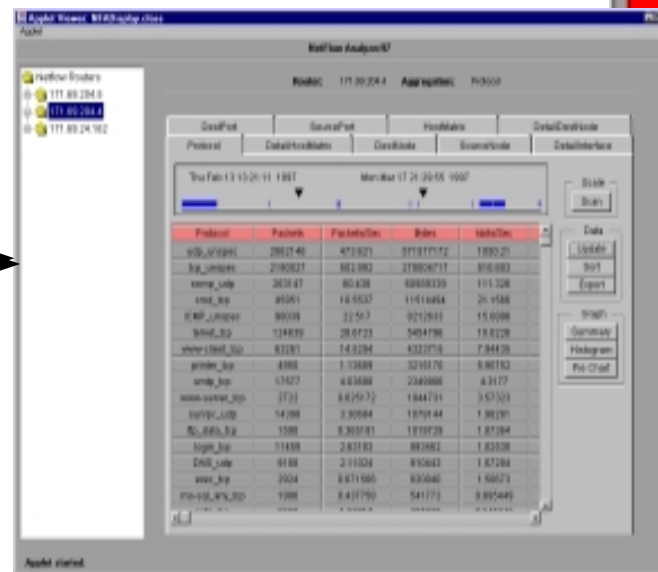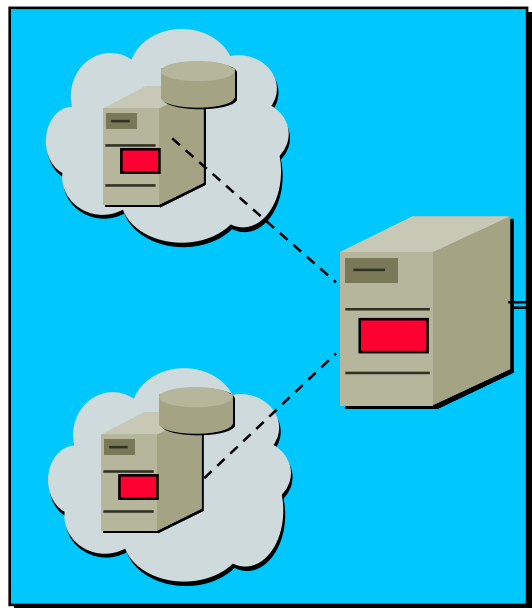
IXP Services

- **Other Ideas….**

  - ✓ **Statistical Analysis Tools:**

    - ⇨ **Traffic Flow Analysis** CAIDA (http://www.caida.org)

    - ⇨ **NetFlow** - Analysis and IP switching technology build into Cisco's IOS.
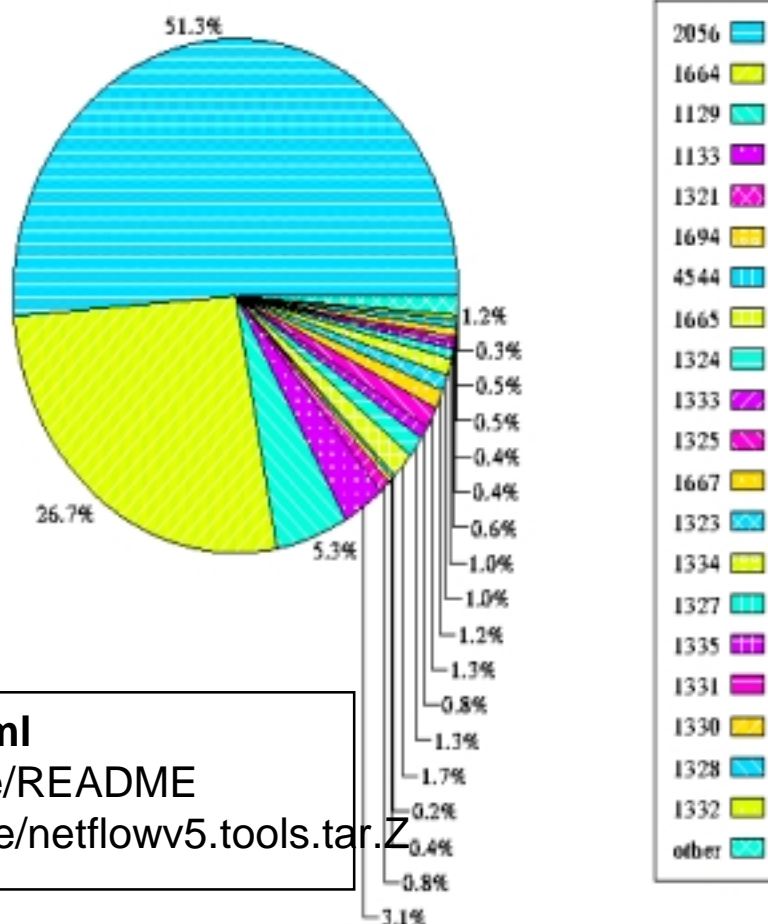
NetFlow FlowAnalyzer

- *Collection Configuration & Control*
- *Visualization Policy*
- *Data Analysis*
- *Graphical Visualization*
- *Spreadsheet Data Export*

NetFlow Provides Open Interfaces

Cflowd
by ANS & BBN

mae-east2.ans.net Traffic (bytes) By Destination AS
12/12/96 23:55 - 12/13/96 23:55 GMT

http://engr.ans.net/cflowd/index.html
ftp://ftp-eng.cisco.com/ftp/NetFlow/fde/README
ftp://ftp-eng.cisco.com:/ftp/NetFlow/fde/netflowv5.tools.tar.Z

IXP Services

- ## Other Ideas….

  - ✓ **Route Policy Registry** - IXP members can registry their peering policies at a central site.

  - ✓ **NTP Servers -** Network Time Protocol is very important to the Internet community. It keeps all the clocks in sync. A IXP could install a Stratum 1 server and provide Stratum 2 NTP connections for a fee.

IXP Services

- **Other Ideas….**

  ✓ **USENET News Server** - Offer USENET News services to IXP members. Allows for local USENET interconnect and saves them bandwidth.

  ✓ **Secondary TLD DNS Server** - Connect a Secondary DNS server for a country code's TLD directly (or one hop off) the IXP. Speeds up access, look-ups, and provides more equal access to the server.

Selecting an Router for IXP Peering

What equipment should an ISP have to support their peering at a IXP?

Choosing an IXP Edge Router

- Factors to consider:

  - ✓ **Physical IXP Interconnection** - What is the physical interconnect medium?

  - ✓ **Traffic** - How much traffic will be sent across the IXP?

  - ✓ **Routes** - the number advertised, the number received, the size of the routing tables, and the growth rate of each?

  - ✓ **Peer Connections** - How many? Will there be a router service or router reflector?

Choosing an IXP Edge Router

- Factors to consider:

  ✓ **Policy Enforcement** - How large do the filters need to be?

  ✓ **Dampening** - Can your router withstand route flapping on the IXP?

  ✓ **Network Ingress and RFC 1918 Filtering** - Minimizing the effects your network will have on the Internet.

  ✓ **Security** - Filters needed to protect your router and network from attack.

Choosing an IXP Edge Router

- Factors to consider:

  ✓ **Internal Network** - How is your network designed - physical, routing protocols, etc.

  ✓ **Statistics Tools** - Do you want to turn NetFlow on for gathering traffic statistics on the IXP edge router.

  ✓ **Multicast Support** - Do you want to have Mbone distributed through the IXP Router.

Cisco Role in building IXPs

How Cisco's Historical Leadership in IXP technology can help IXPs grow and evolve.

Cisco's Role to help ISP Interconnect

- **Cisco has helped the development of IXPs throughout the world.**

  - ✓ **Technical Consulting**

  - ✓ **IOS Features specifically designed for IXPs**

  - ✓ **Special IOS images**

  - ✓ **New products (Cat 5000, POSIP, Duplex FDDI, LS 1010, etc.)**

  - ✓ **ISP/IXP Seminars and Workshops**
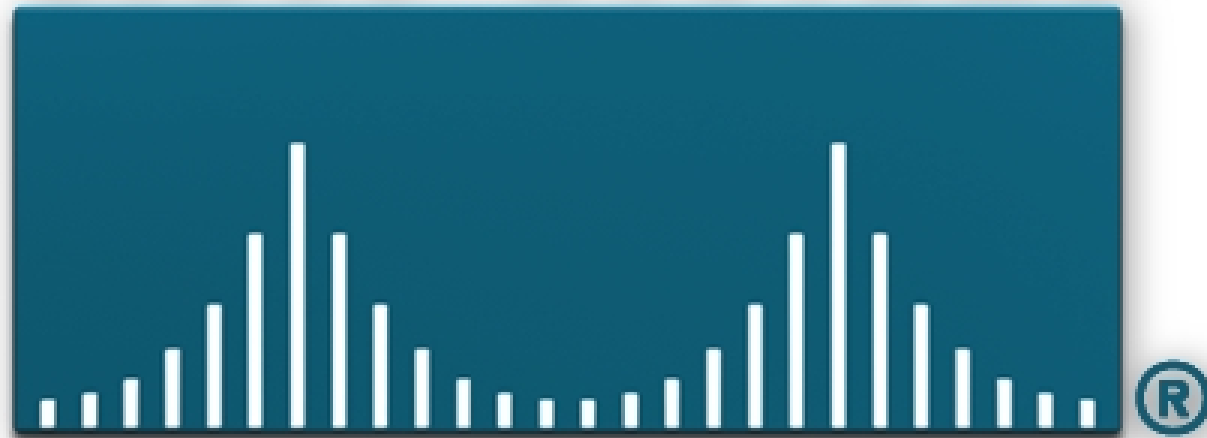
Cisco's Role to help ISP Interconnect

- ## ISP/IXP Seminars and Workshop

  - ✓ **Special training to help ISPs learn how to:**

    - ⇨ **build their network**

    - ⇨ **interconnect with other ISPs**

    - ⇨ **get the maximum value from their Cisco investment**

  - ✓ **Program is expanding world wide.**

  - ✓ **Send a mail to** con-serv-isp-workshop@cisco.com **for more details**

Where to Get More Information

http://www.cisco.com/

www.cisco.com