



# Introduction to The Internet

ISP/IXP Workshops

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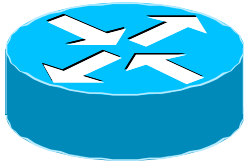
- Topologies and Definitions
- IP Addressing
- Internet Hierarchy
- Gluing it all together



# Topologies and Definitions

What does all the jargon mean?

## Some Icons...



**Router**  
(layer 3, IP datagram forwarding)



**ATM or Frame Relay switch**  
(layer 2, frame or cell forwarding)



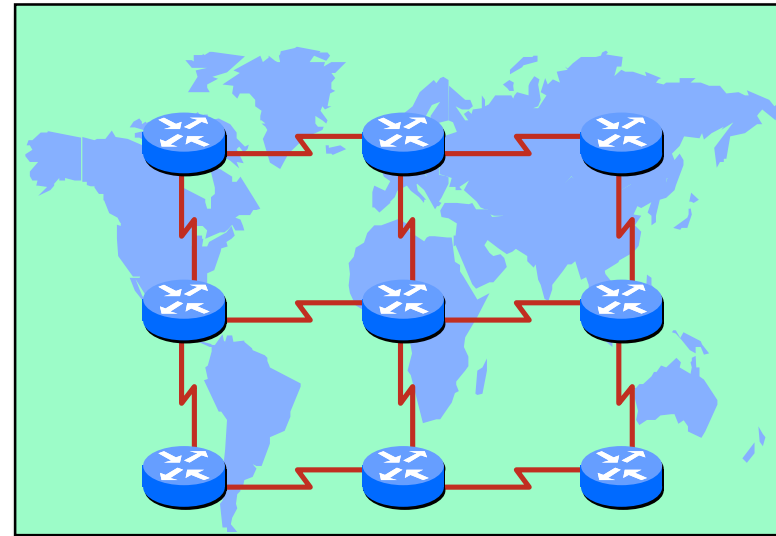
**Ethernet switch**  
(layer 2, packet forwarding)



**Network Cloud**

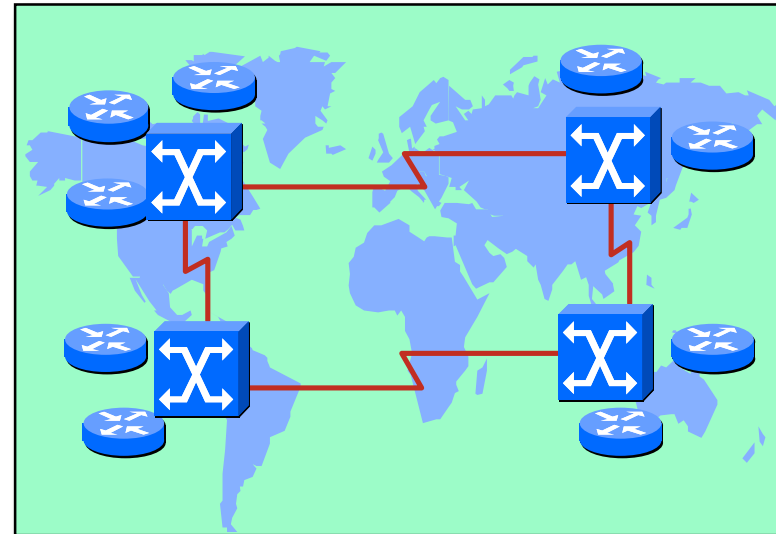
# Routed Backbone

- Routers are the infrastructure
- Physical circuits run between routers
- Easy routing configuration, operation and troubleshooting
- The dominant topology used in the Internet today



# Switched Backbone

- Frame relay or ATM
  - switches in the core
  - surrounded by routers
- Physical circuits run between switches
  - Virtual circuits run between routers
- more complex routing and debugging
- “traffic management”
- Virtually obsolete today



# Points of Presence

- PoP – Point of Presence

Physical location of ISP's equipment

Sometimes called a “node”

- vPoP – virtual PoP

To the end user, it looks like an ISP location

In reality a back hauled access point

Used mainly for consumer access networks

- Hub/SuperPoP – large central PoP

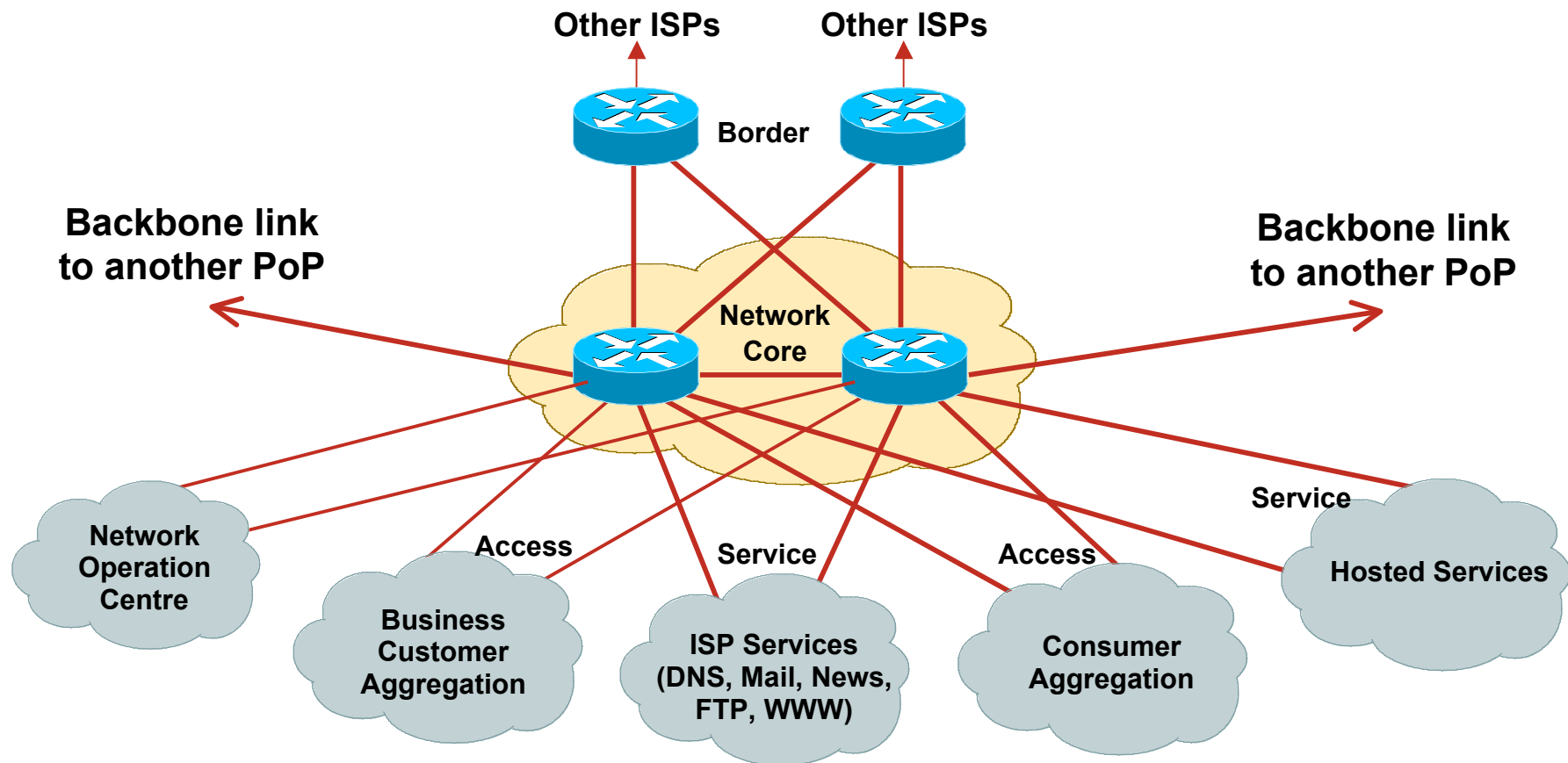
Links to many PoPs

# PoP Topologies

- **Core** routers  
high speed trunk connections
- **Distribution** routers  
higher port density, aggregating network edge to the network core
- **Access** routers  
high port density, connecting the end users to the network
- **Border** routers  
connections to other providers
- **Service** routers  
hosting and servers
- Some functions might be handled by a single router



# Typical PoP Design



# More Definitions

- **Transit**

Carrying traffic across a network

Usually **for a fee**

- **Peering**

Exchanging routing information and traffic

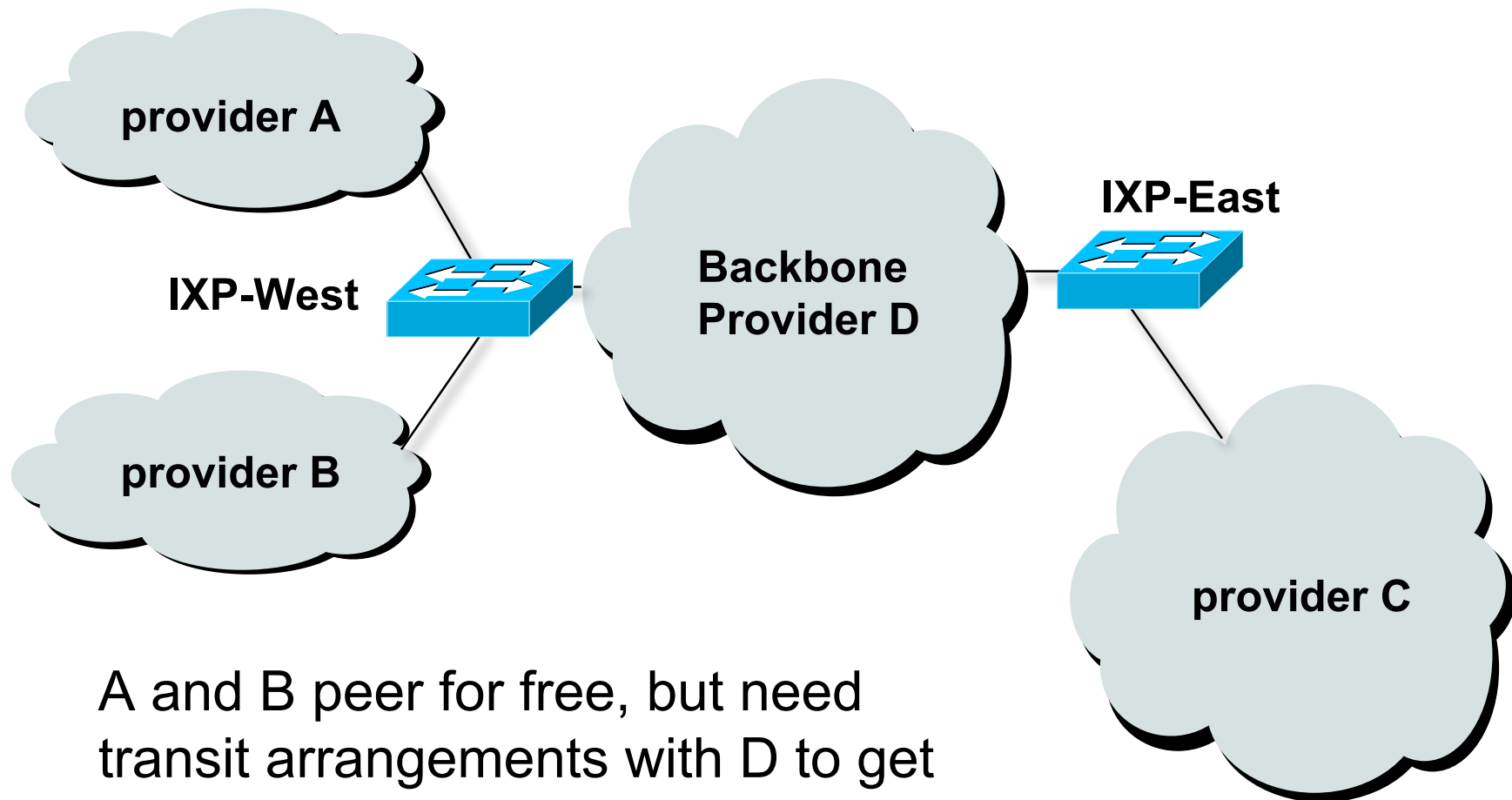
Usually **for no fee**

Sometimes called **settlement free peering**

- **Default**

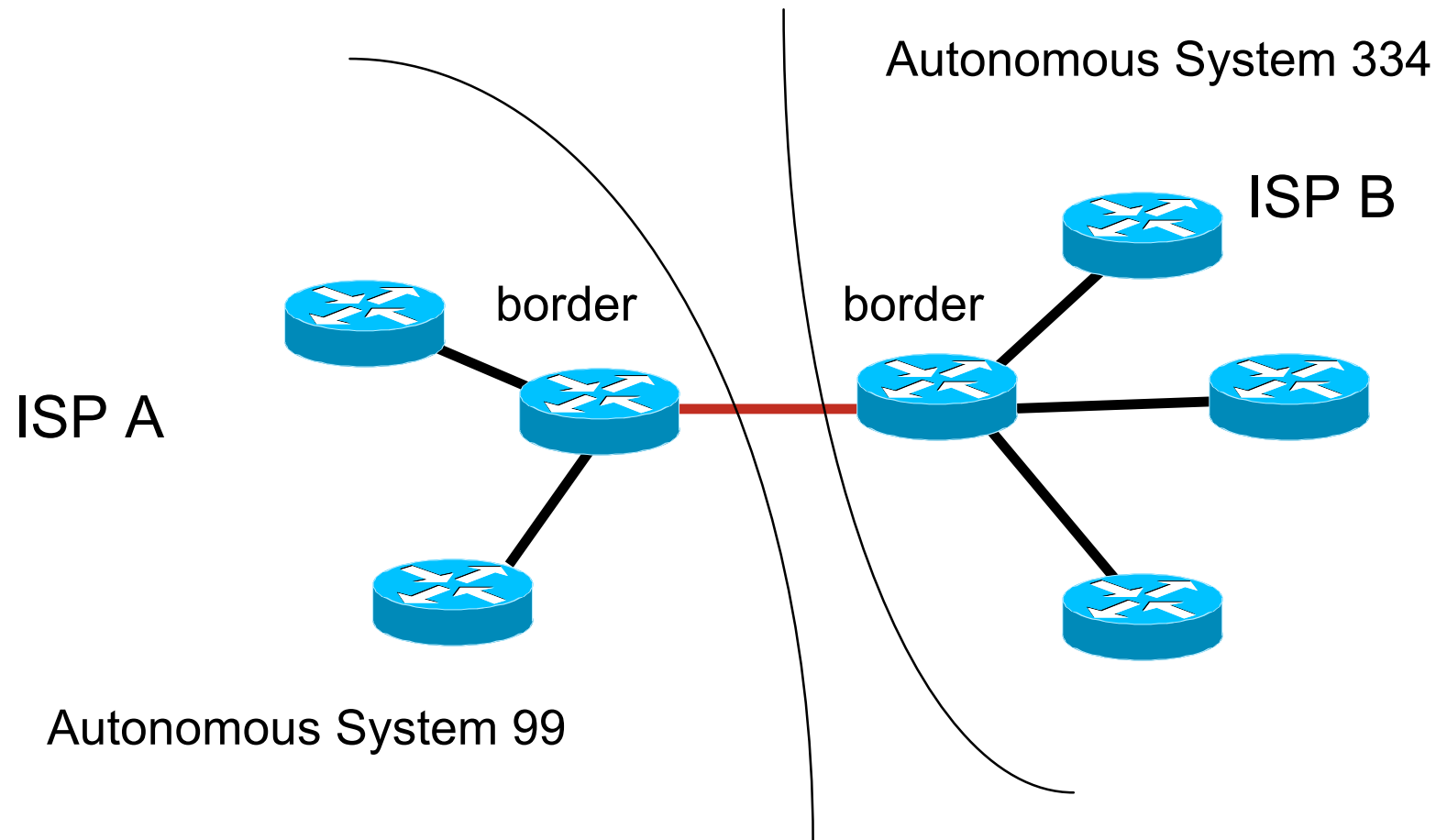
Where to send traffic when there is no explicit match in the routing table

# Peering and Transit example



A and B peer for free, but need transit arrangements with D to get packets to/from C

# Private Interconnect



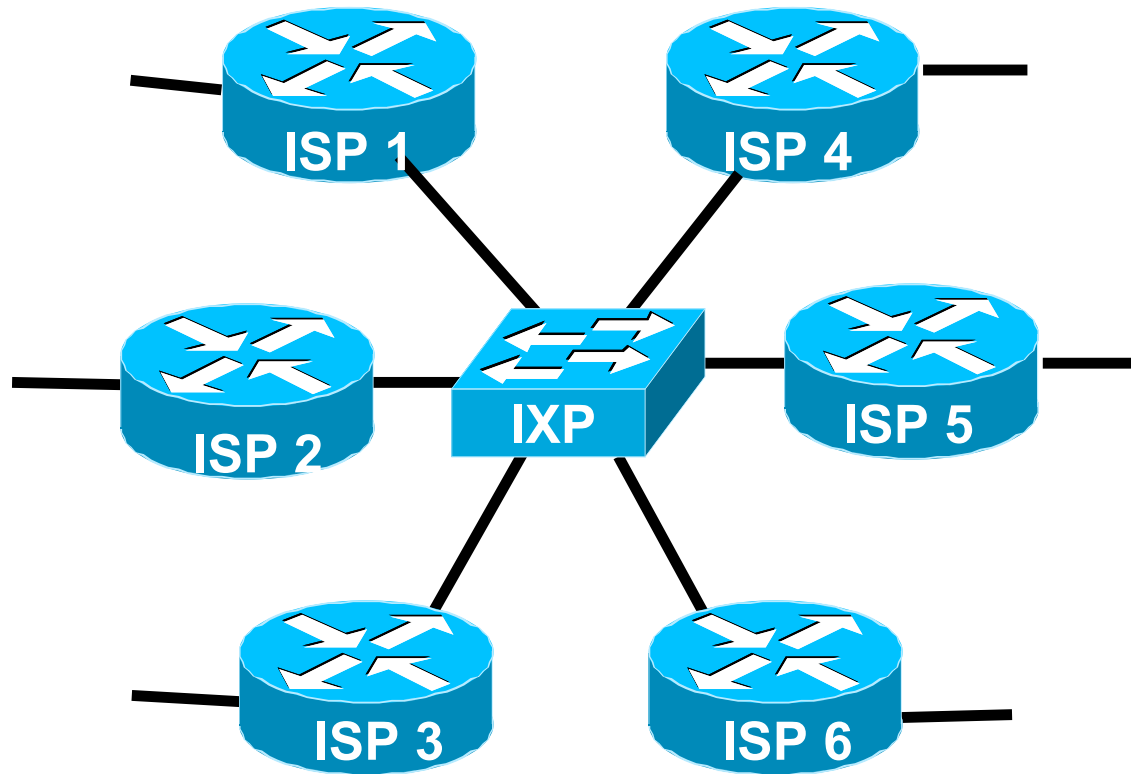
# Public Interconnect

- A location or facility where several ISPs are present and connect to each other over a common shared media
- Why?
  - To save money, reduce latency, improve performance
- IXP – Internet eXchange Point
- NAP – Network Access Point

# Public Interconnect

- Centralised (in one facility)
- Distributed (connected via WAN links)
- Switched or routed interconnect
  - Router (Layer 3) or Ethernet (Layer 2)
  - Technologies such as FDDI, ATM, Frame relay & SMDS have been used in the past
- Each provider establishes **peering** relationship with other providers at IXP
  - ISP border router peers with all other provider border routers

# Public Interconnect



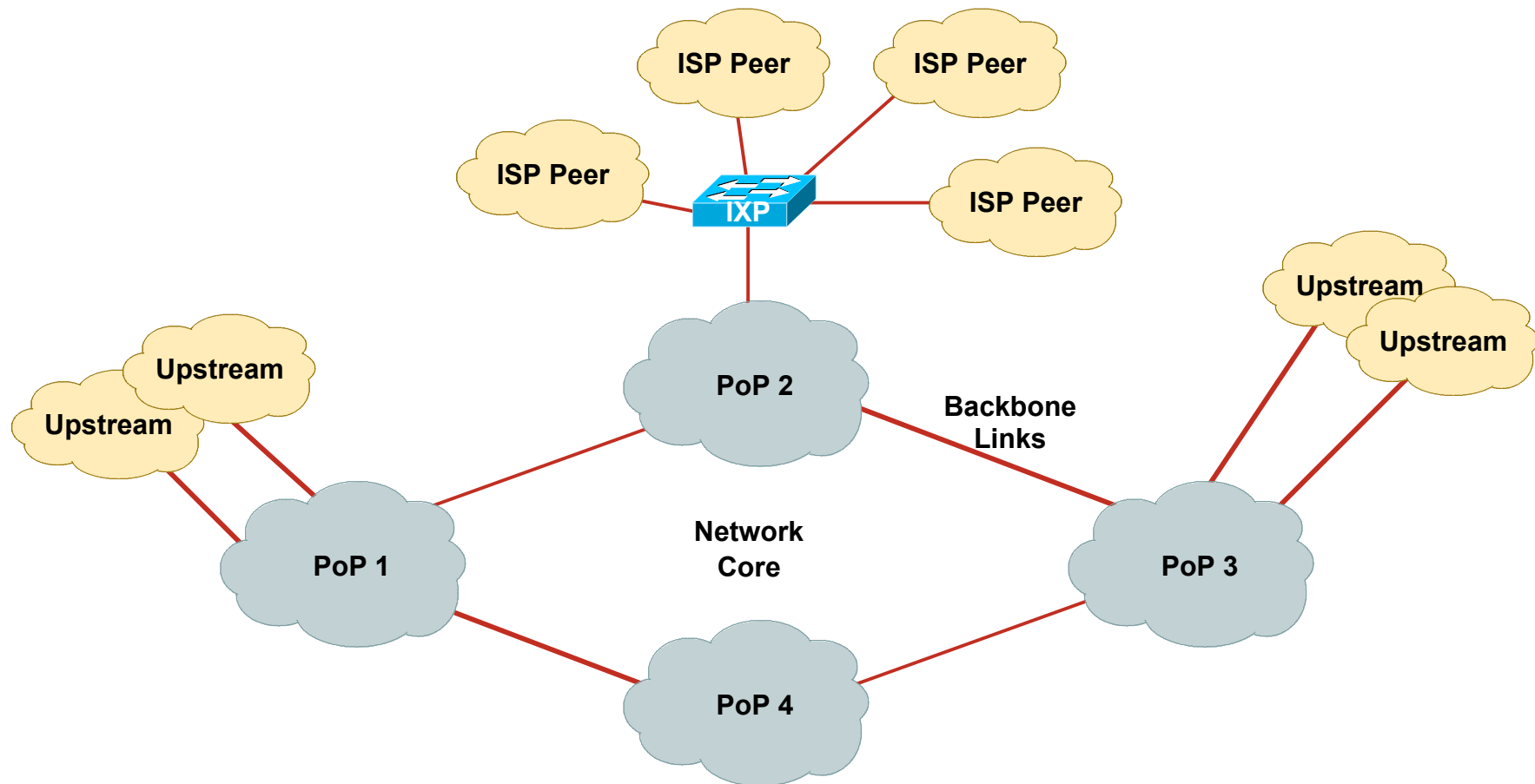
**Each of these represents a border router in a different autonomous system**

# ISPs participating in Internet

- Bringing all pieces together, ISPs:
  - Build multiple PoPs in a distributed network
  - Build redundant backbones
  - Have redundant external connectivity
  - Obtain transit from upstream providers
  - Get free peering from local providers at IXPs



# Example ISP Backbone Design





# IP Addressing

Where to get address space and who from

# IP Addressing

- Internet uses **classless** routing
- Concept of IPv4 class A, class B or class C is **no more**  
Engineers talk in terms of prefix length, for example the class B 158.43 is now called 158.43/16.
- All routers must be CIDR capable  
**C**lassless **I**nter**D**omain **R**outing  
RFC1812 – Router Requirements

# IP Addressing

- Pre-CIDR (<1994)

  - big networks got a class A

  - medium networks got a class B

  - small networks got a class C

- Nowadays

  - Sizes of IPv4 allocations/assignments made according to demonstrated need – **CLASSLESS**

# IP Addressing

- IPv4 Address space is a resource **shared** amongst **all** Internet users
  - Regional Internet Registries delegated allocation responsibility by the IANA
  - AfriNIC, APNIC, ARIN, LACNIC & RIPE NCC are the five RIRs
  - RIRs **allocate** address space to ISPs and Local Internet Registries
  - ISPs/LIRs **assign** address space to end customers or other ISPs
- 86% of usable IPv4 address space has been allocated

# Non-portable Address Space

- “Provider Aggregatable” or “PA Space”

- Customer uses RIR member’s address space while connected to Internet

- Customer has to renumber to change ISP

- Aids control of size of Internet routing table

- Need to fragment provider block when multihoming

- PA space is allocated to the RIR member

- All assignments made by the RIR member to end sites are announced as an aggregate to the rest of the Internet

# Portable Address Space

- “Provider Independent” or “PI Space”

Customer gets or has address space independent of ISP

Customer keeps addresses when changing ISP

Is very bad for size of Internet routing table

Is very bad for scalability of the routing system

→ PI space is rarely distributed by the RIRs

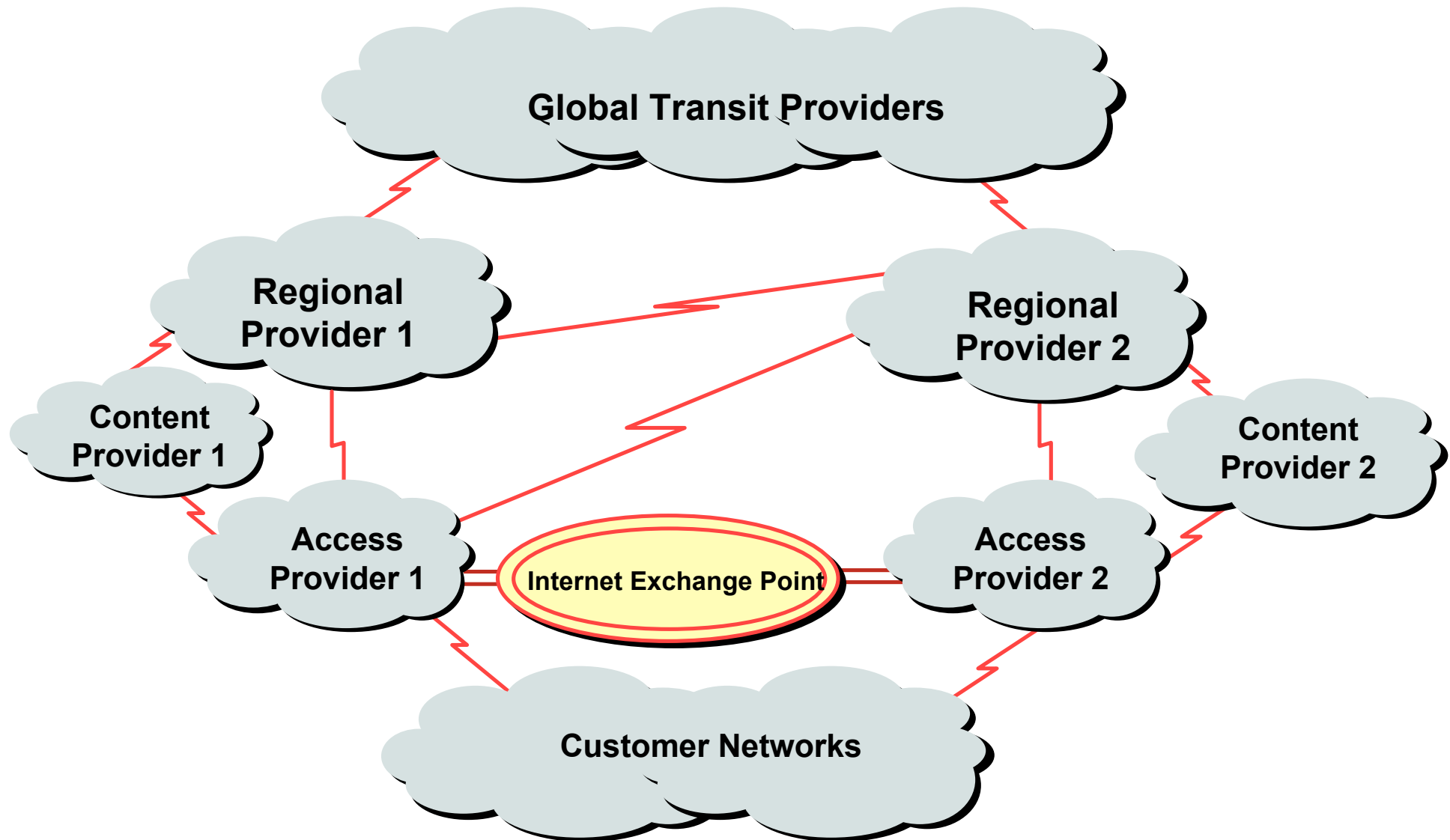


# Internet Hierarchy

The pecking order



# High Level View of the Global Internet



# Detailed View of the Global Internet

- Global Transit Providers

  - Connect to each other

  - Provide connectivity to Regional Transit Providers

- Regional Transit Providers

  - Connect to each other

  - Provide connectivity to Content Providers

  - Provide connectivity to Access Providers

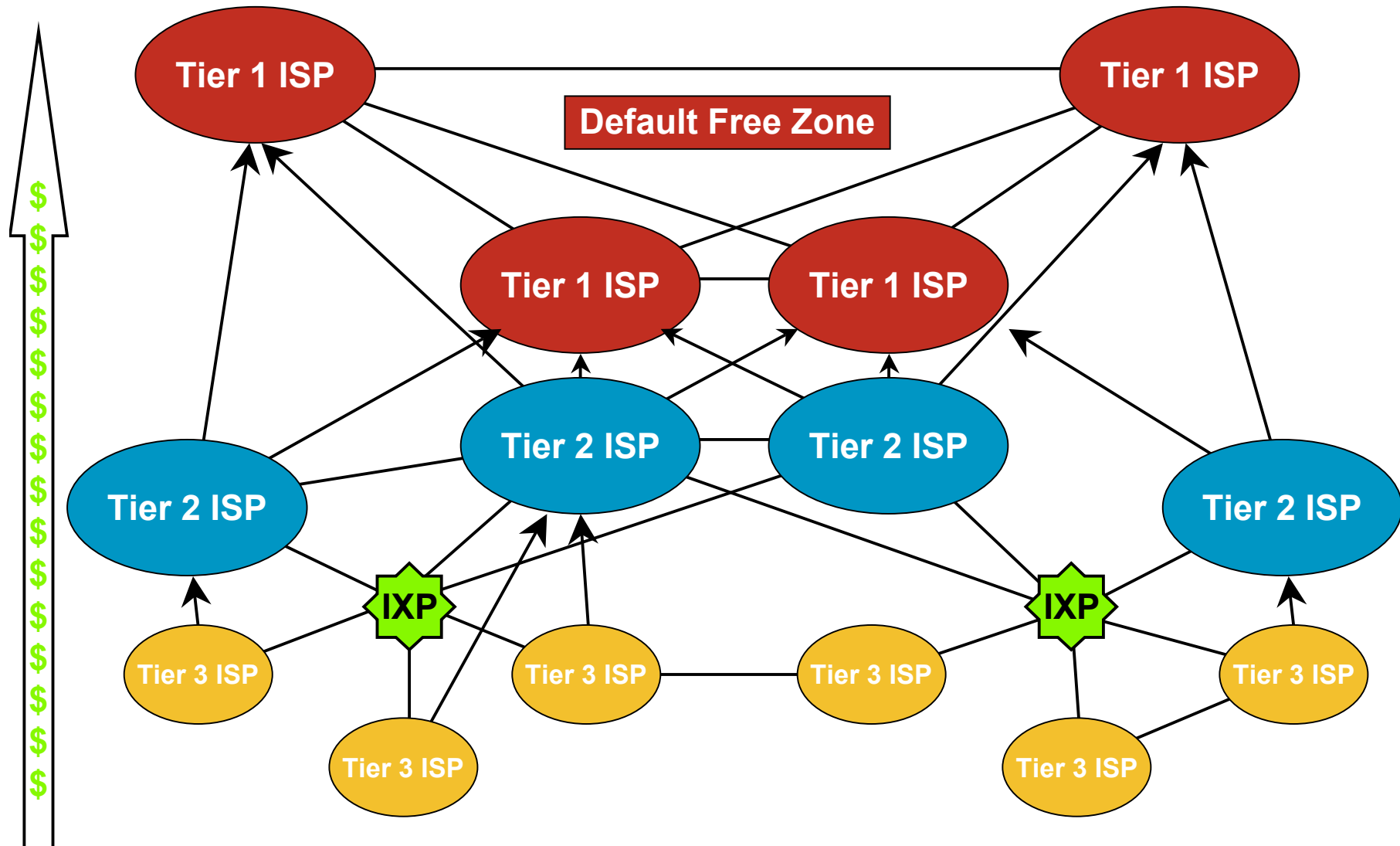
- Access Providers

  - Connect to each other across IXPs (free peering)

  - Provide access to the end user

  - Provide access for Content Providers

# Categorising ISPs



# Inter-provider relationships

- Peering between equivalent sizes of service providers (e.g. Tier 2 to Tier 2)
  - Shared cost private interconnection, equal traffic flows
  - No cost peering
- Peering across exchange points
  - If convenient, of mutual benefit, technically feasible
- Fee based peering
  - Unequal traffic flows, “market position”

## Default Free Zone

- The default free zone is made up of Internet routers which have explicit routing information about the rest of the Internet, and therefore do not need to use a default route



Gluing it together

# Gluing it together

- Who runs the Internet?

No one

(Definitely not ICANN, nor the RIRs, nor the US,...)

- How does it keep working?

Inter-provider business relationships and the need for customer reachability ensures that the Internet by and large functions for the common good

- Any facilities to help keep it working?

Not really. But...

Engineers keep working together!

# Engineers keep talking to each other...

- North America

NANOG (North American Network Operators Group)

NANOG meetings and mailing list

[www.nanog.org](http://www.nanog.org)

- Latin America

Foro de Redes

NAPLA

LACNOG – just launched



# Engineers keep talking to each other...

- Asia & Pacific

APRICOT annual conference

[www.apricot.net](http://www.apricot.net)

APOPS & APNIC-TALK mailing lists

[mailman.apnic.net/mailman/listinfo/apops](mailto:mailman.apnic.net/mailman/listinfo/apops)

[mailman.apnic.net/mailman/listinfo/apnic-talk](mailto:mailman.apnic.net/mailman/listinfo/apnic-talk)

PacNOG (Pacific NOG)

[mailman.apnic.net/mailman/listinfo/pacnog](mailto:mailman.apnic.net/mailman/listinfo/pacnog)

SANOG (South Asia NOG)

E-mail to [sanog-request@sanog.org](mailto:sanog-request@sanog.org)

# Engineers keep talking to each other...

- Europe

RIPE meetings, working groups and mailing lists

Routing WG: [www.ripe.net/mailman/listinfo/routing-wg](http://www.ripe.net/mailman/listinfo/routing-wg)

EOF (European Operators Forum)

[www.ripe.net/mailman/listinfo/eof-list](http://www.ripe.net/mailman/listinfo/eof-list)

- Africa

AfNOG meetings and mailing list

- And many in-country ISP associations and NOGs

- IETF meetings and mailing lists

[www.ietf.org](http://www.ietf.org)

# Summary

- Topologies and Definitions
- IP Addressing
  - PA versus PI address space
- Internet Hierarchy
  - Local, Regional, Global Transit Providers
  - IXPs
- Gluing it all together
  - Engineers cooperate, common business interests



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## ISP/IXP Workshops