

# Introduction to The Internet

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## ISP Workshops



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# Acknowledgements

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- ❑ This material originated from the Cisco ISP/IXP Workshop Programme developed by Philip Smith & Barry Greene
- ❑ Use of these materials is encouraged as long as the source is fully acknowledged and this notice remains in place
- ❑ Bug fixes and improvements are welcomed
  - Please email *workshop (at) bgp4all.com*

Philip Smith



# Introduction to the Internet

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

# Topologies and Definitions



What does all the jargon mean?

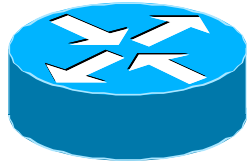
# Definitions

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- Network Operator
  - An organisation running an IP backbone
  - Provides access to end users or other network operators
  - Sometimes called a **Service Provider** or a **Network Provider**
- ISP
  - Internet Service Provider
  - Usually commercial, for profit
- REN
  - Research & Education Network
  - Providing access for Universities & Colleges
  - Non-commercial, educational use only

# Some Icons...

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Router  
(layer 3, IP datagram forwarding)



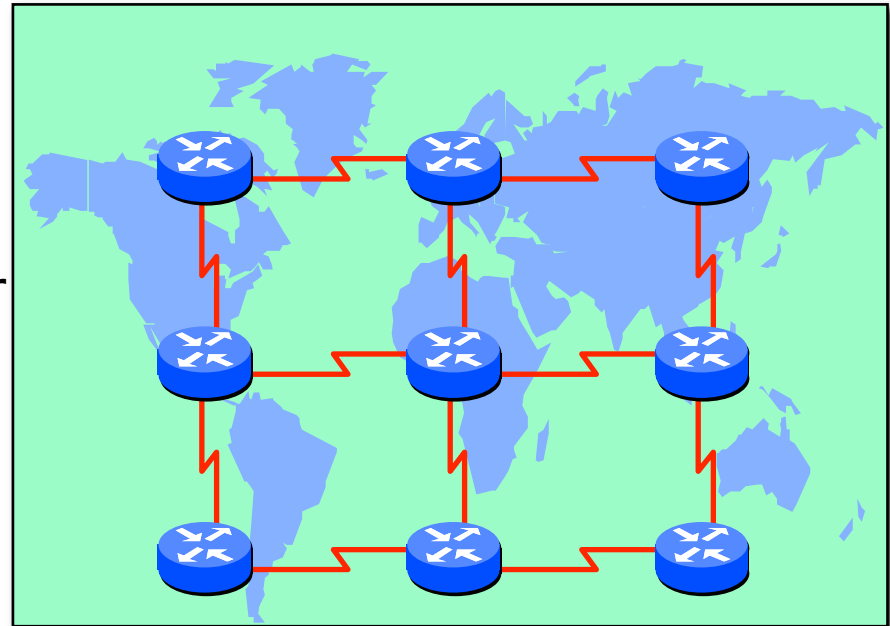
Ethernet switch  
(layer 2, packet forwarding)



Network Cloud

# Routed Backbone

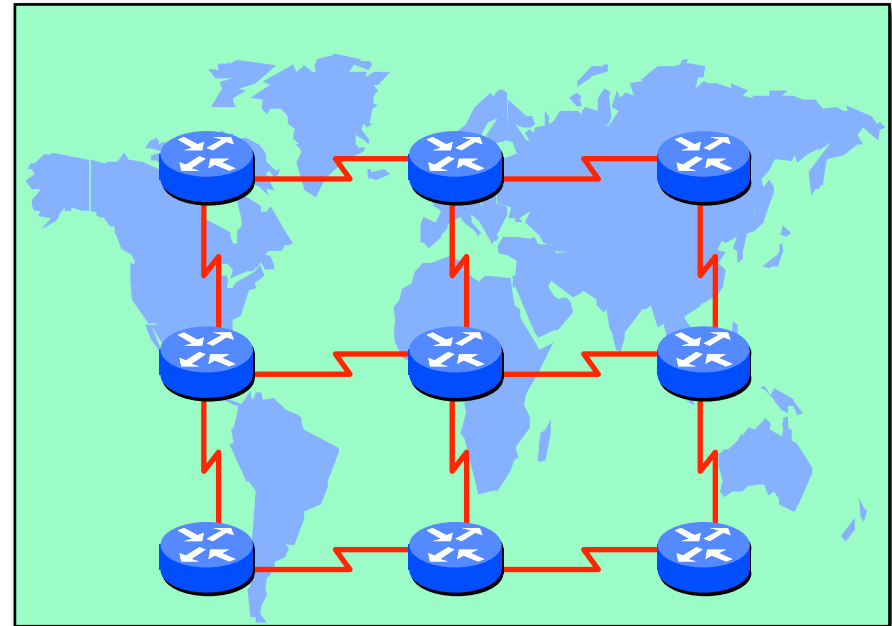
- ❑ Operators build networks covering regions
  - Regions can cover a country, sub-continent, or even global
  - Each region has points of presence built by the operator
- ❑ Routers are the infrastructure
- ❑ Physical circuits run between routers
- ❑ Easy routing configuration, operation and troubleshooting
- ❑ The dominant topology used in the Internet today



# MPLS Backbones

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- ❑ Some operators use Multi Protocol Label Switching (MPLS)
- ❑ MPLS is built on top of router infrastructure
  - Replaces old ATM technology
  - Tunnelling over IP network
- ❑ Main purpose is to provide VPN services
  - Although these can be implemented with other tunnelling technologies such as GRE





# Points of Presence

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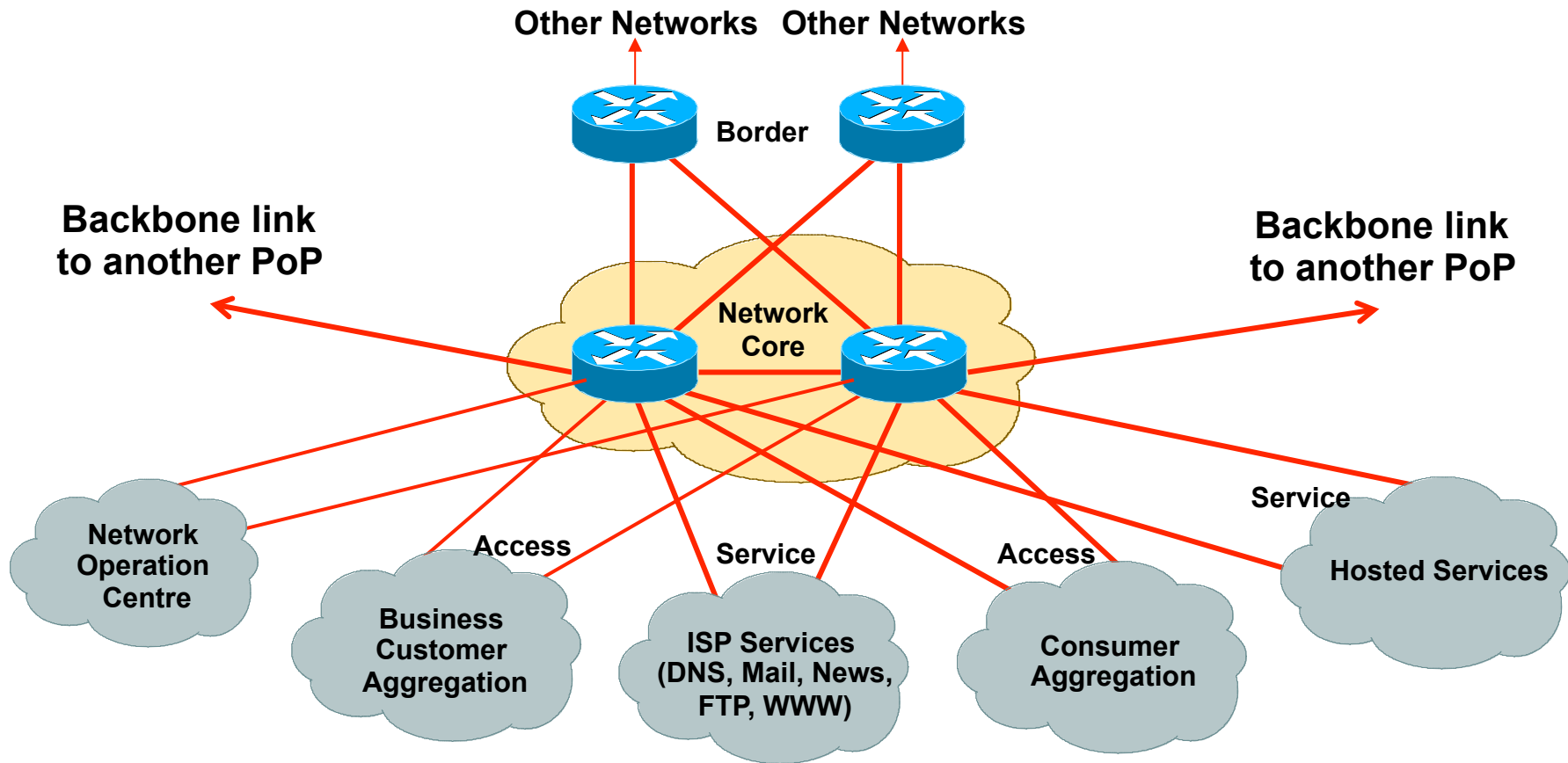
- PoP – Point of Presence
  - Physical location of operator's equipment
  - Sometimes called a “node”
- vPoP – virtual PoP
  - To the end user, it looks like an operator's location
  - In reality a back hauled access point
  - Used mainly for consumer access networks
- Hub/SuperPoP – large central PoP
  - Links to many PoPs

# PoP Topologies

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- **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

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## □ Transit

- Carrying traffic across a network
- Usually **for a fee**

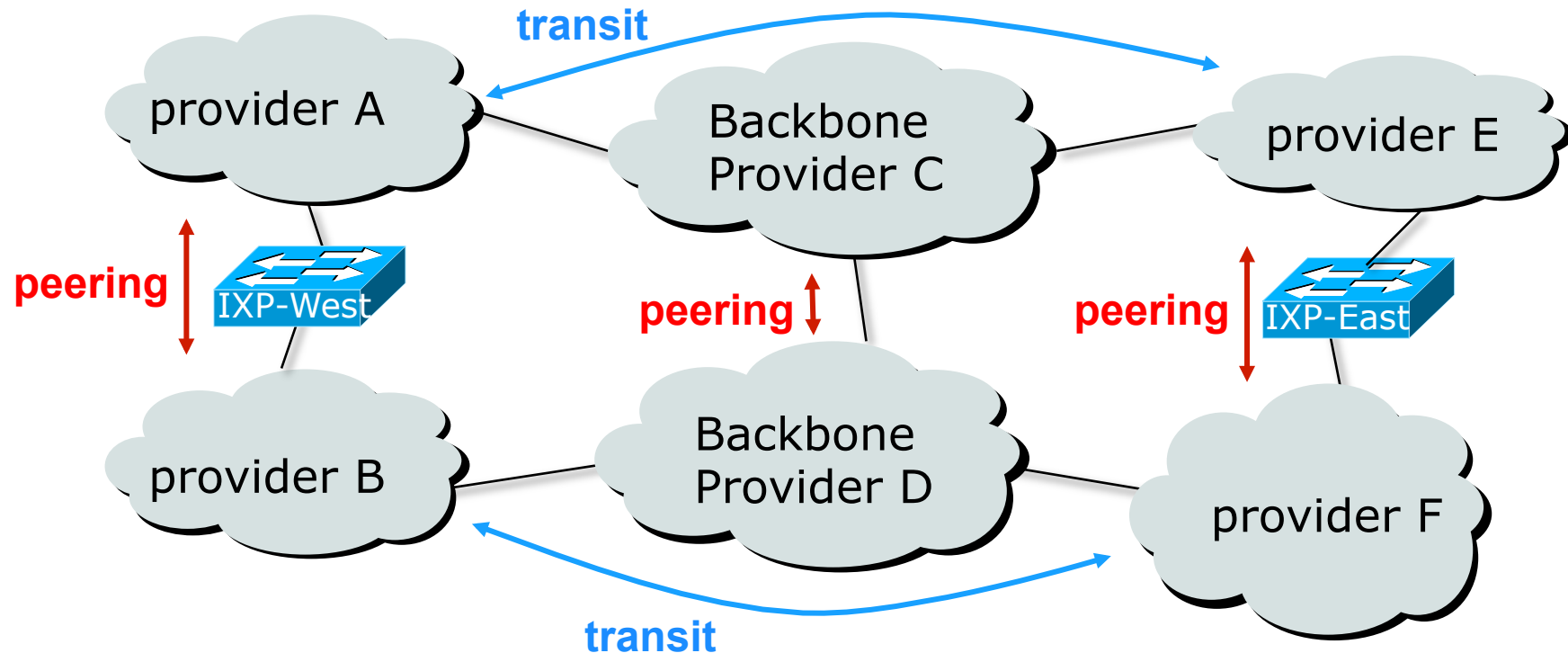
## □ Peering

- 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

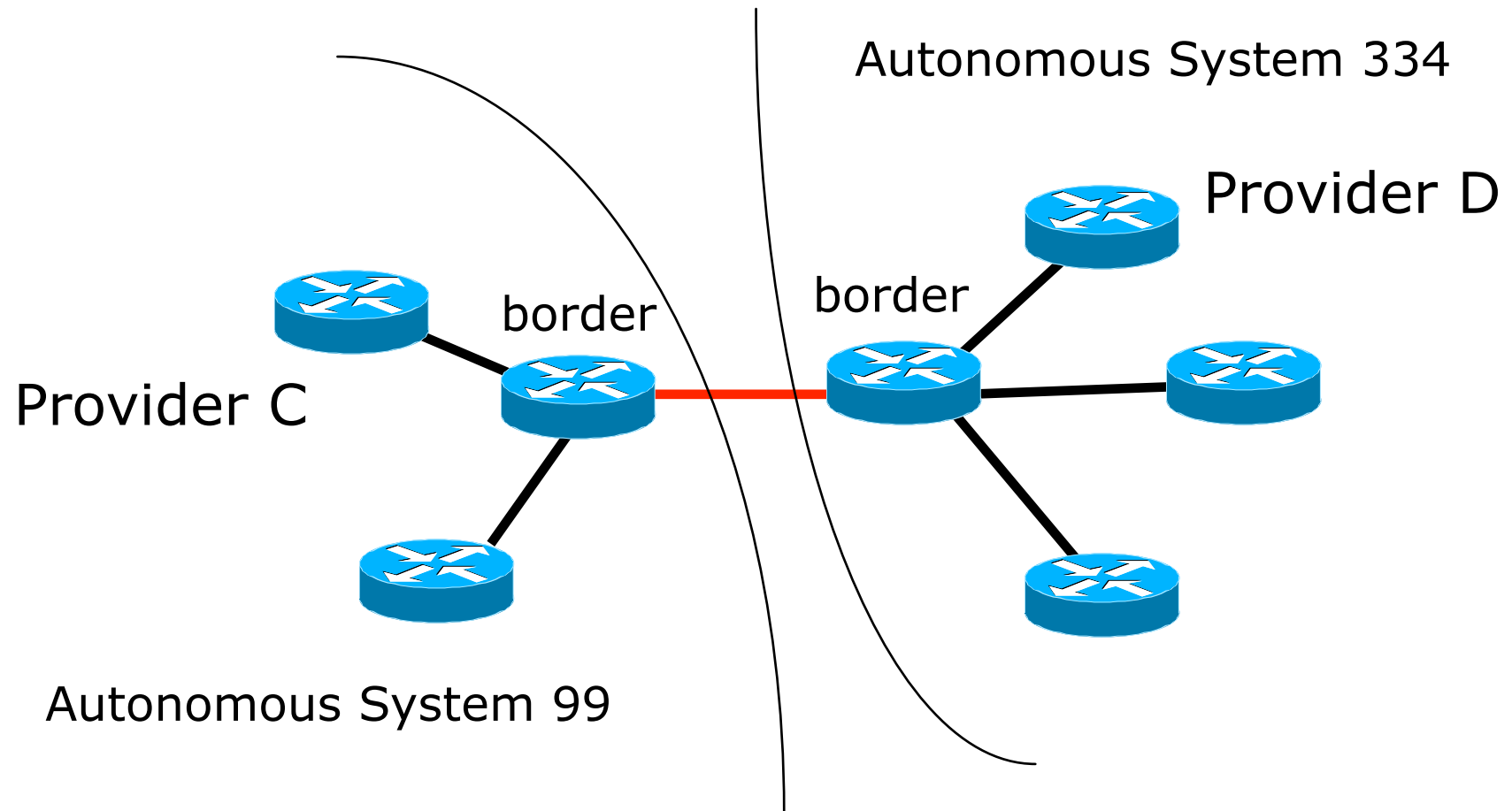
# Peering and Transit example



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

# Private Interconnect

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# Public Interconnect

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- A location or facility where several network operators 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

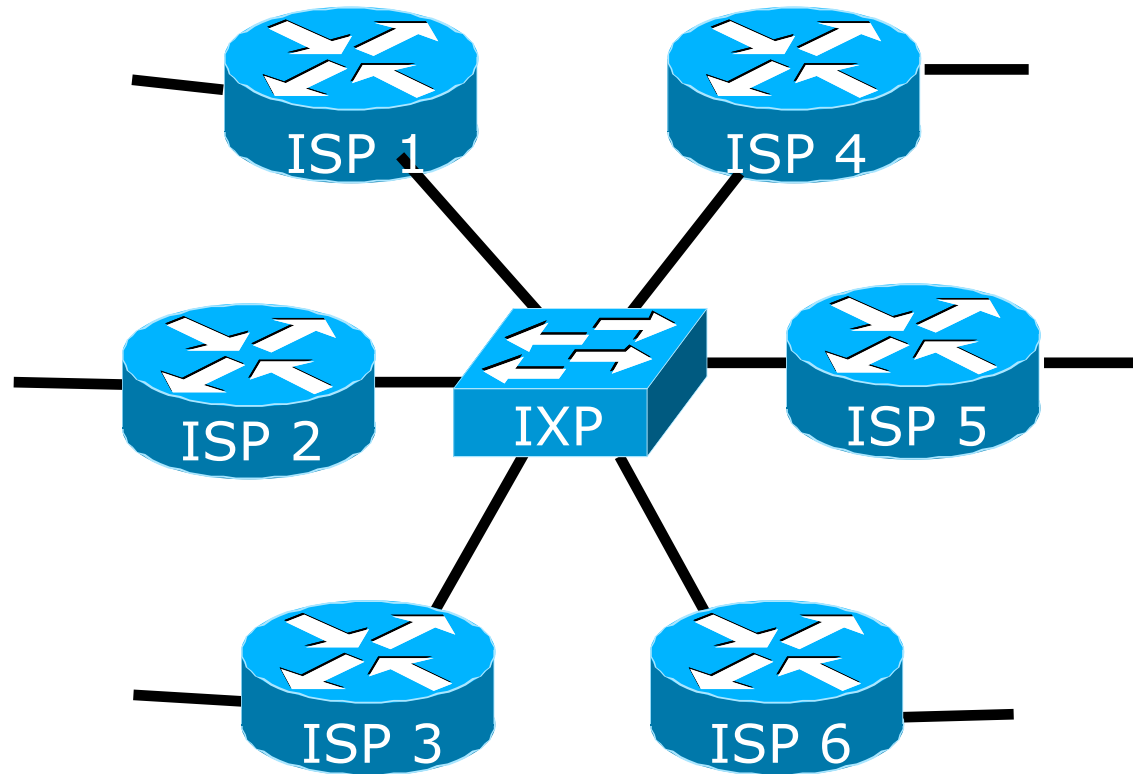
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- ❑ Centralised (in one facility)
- ❑ Distributed (connected via WAN links)
- ❑ Switched interconnect
  - Ethernet (Layer 2)
  - Technologies such as SRP, FDDI, ATM, Frame Relay, SMDS and even routers have been used in the past
- ❑ Each provider establishes **peering** relationship with other providers at IXP
  - Provider border router peers with all other provider border routers



# Public Interconnect

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

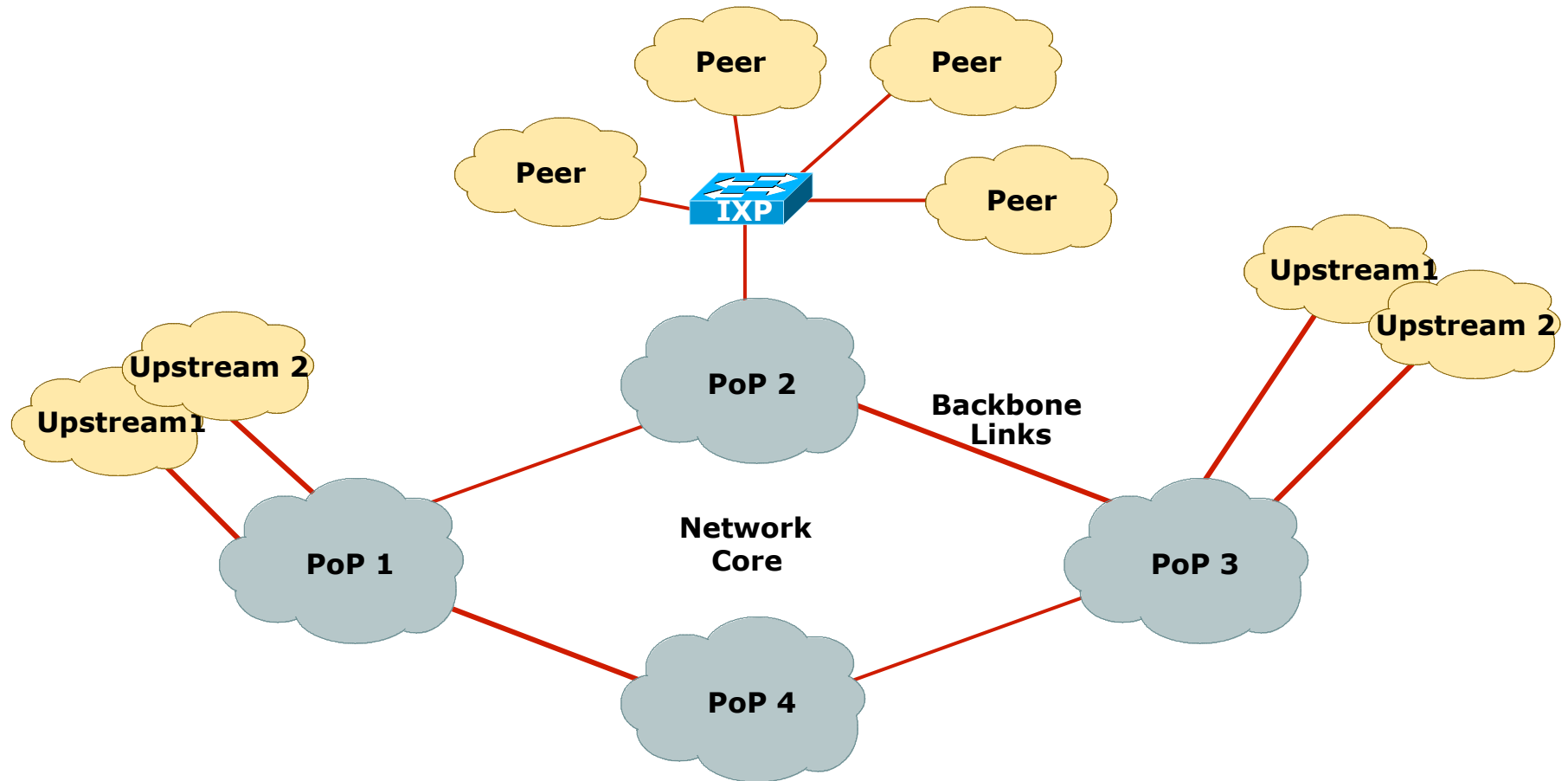
# Operators participating in Internet

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- Bringing all pieces together, Network Operators:
  - 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 Backbone Design

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# IP Addressing



Where to get address space and  
who from

# IP Addressing Basics

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- Internet uses two types of addressing:
  - IPv6 – the new IP protocol
  - IPv4 – legacy IP protocol
- Internet uses classless routing
  - Routers must be CIDR capable
    - **C**lassless **I**nter**D**omain **R**outing
  - No routing assumptions made based on the address block
  - Engineers talk in terms of prefix length
  - For example: 158.43/16 and 2001:db8::/32

# History of IP Addressing

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- Pre-CIDR (before 1994)
  - Big networks got a class A
  - Medium networks got a class B
  - Small networks got a class C
- The CIDR IPv4 years (1994 to 2010)
  - Sizes of IPv4 allocations/assignments made according to demonstrated need – **CLASSLESS**
- **IPv6 adoption (from 2011)**
  - Network Operators get at least one /32
  - End Sites get /48
  - IANA's free pool is depleted (February 2011) – the size of IPv4 address allocations and assignments is now very limited

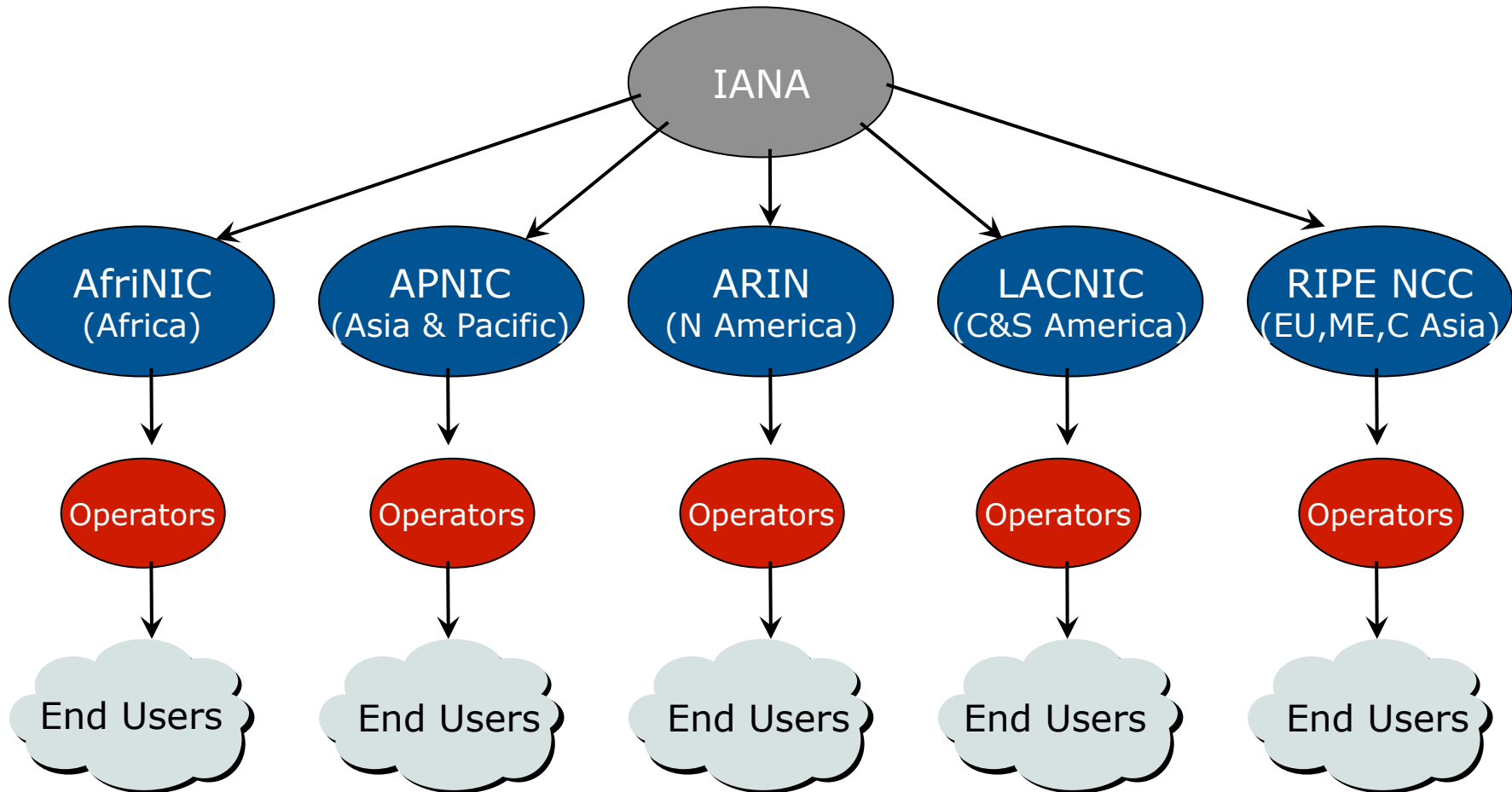
# IP Addressing

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- IP Address space is a resource shared amongst all Internet users
  - Regional Internet Registries delegated allocation responsibility by the Internet Assigned Numbers Authority (IANA)
  - AfriNIC, APNIC, ARIN, LACNIC & RIPE NCC are the five RIRs
  - RIRs **allocate** address space to Network Operators/ Local Internet Registries
  - Operators/LIRs **assign** address space to end customers or other Operators
- RIRs address distribution:
  - IPv6 is plentiful
  - IPv4 is very limited

# Address delegation hierarchy

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# Non-portable Address Space

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- “Provider Aggregatable” or “PA Space”
  - Customer uses RIR member’s address space while connected to Internet
  - Customer has to renumber to change provider
  - 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

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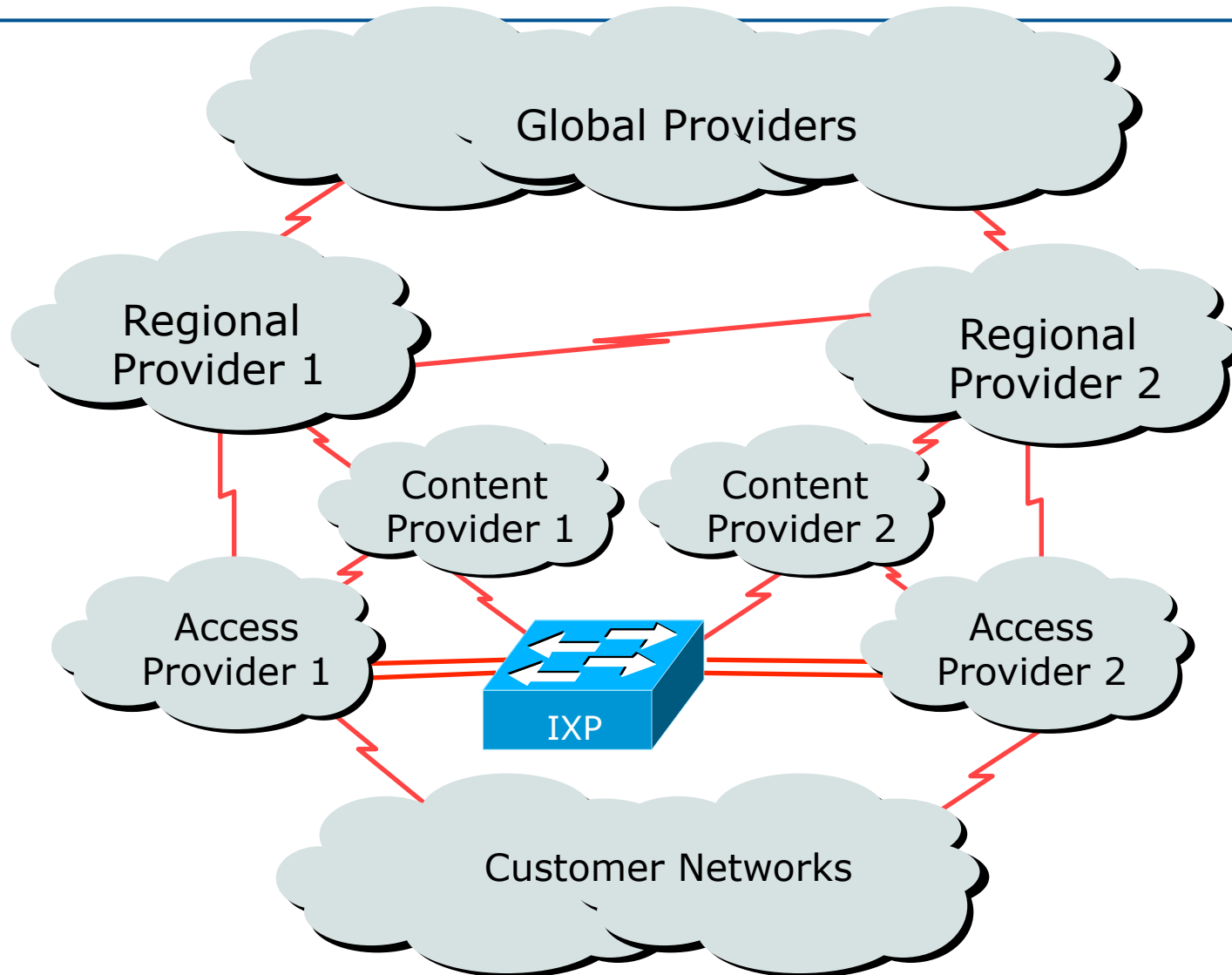
- “Provider Independent” or “PI Space”
  - Customer gets or has address space independent of their provider
  - Customer keeps addresses when changing provider
  - Is very bad for size of Internet routing table
  - Is very bad for scalability of the routing system
  - → PI space is rarely distributed by the RIRs

# Internet Hierarchy



The pecking order

# Global Internet: High Level View



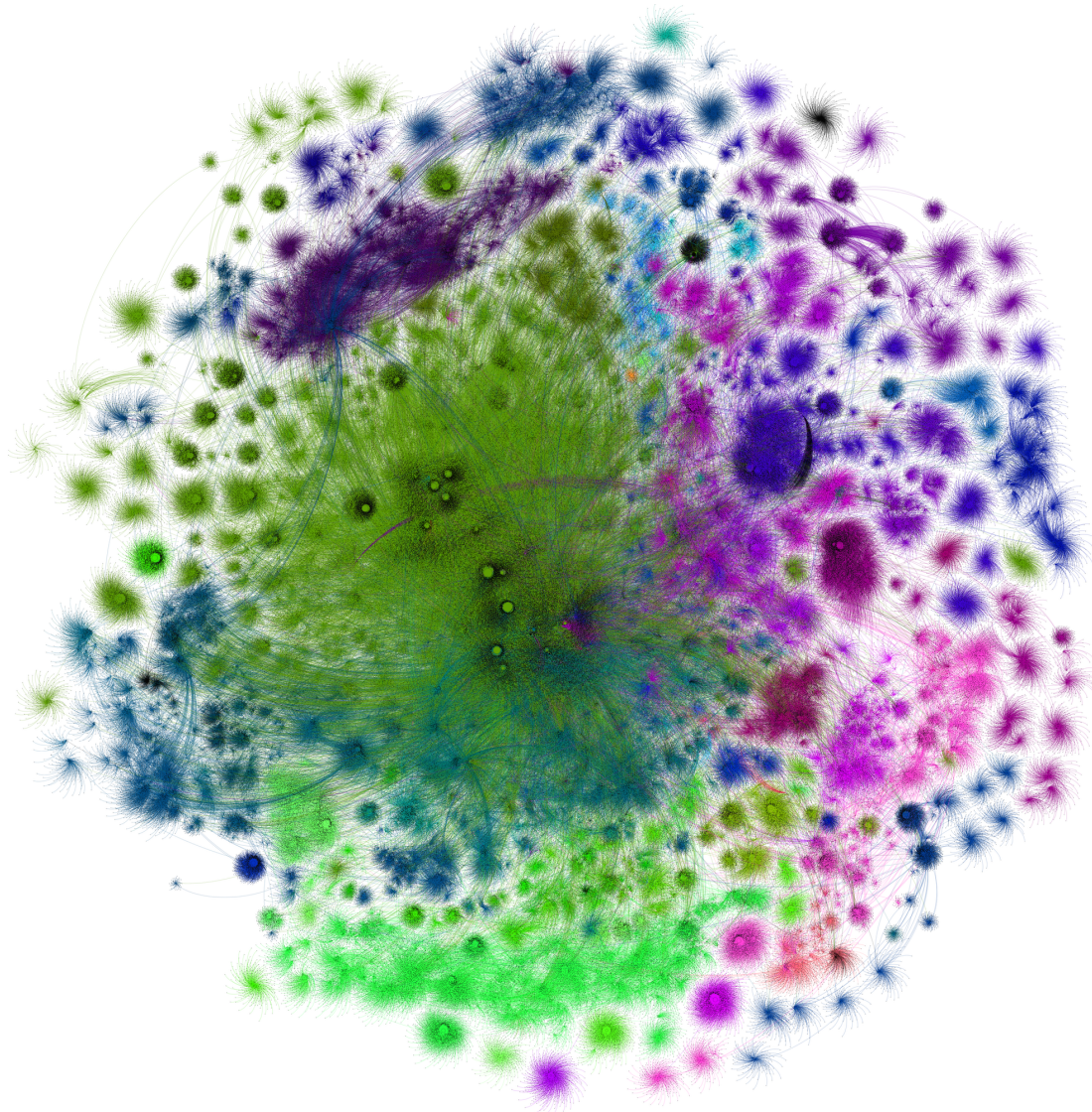
# Detailed View of the Global Internet

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- 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
- Content Providers
  - Cross-connect to Access Providers
  - Peer at IXPs (free traffic to Access Providers)
- Access Providers
  - Connect to each other across IXPs (free peering)
  - Provide access to the end user

# IPv4 Internet by BGP Peerings

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## The IPv4 Default Free Zone, June 2016

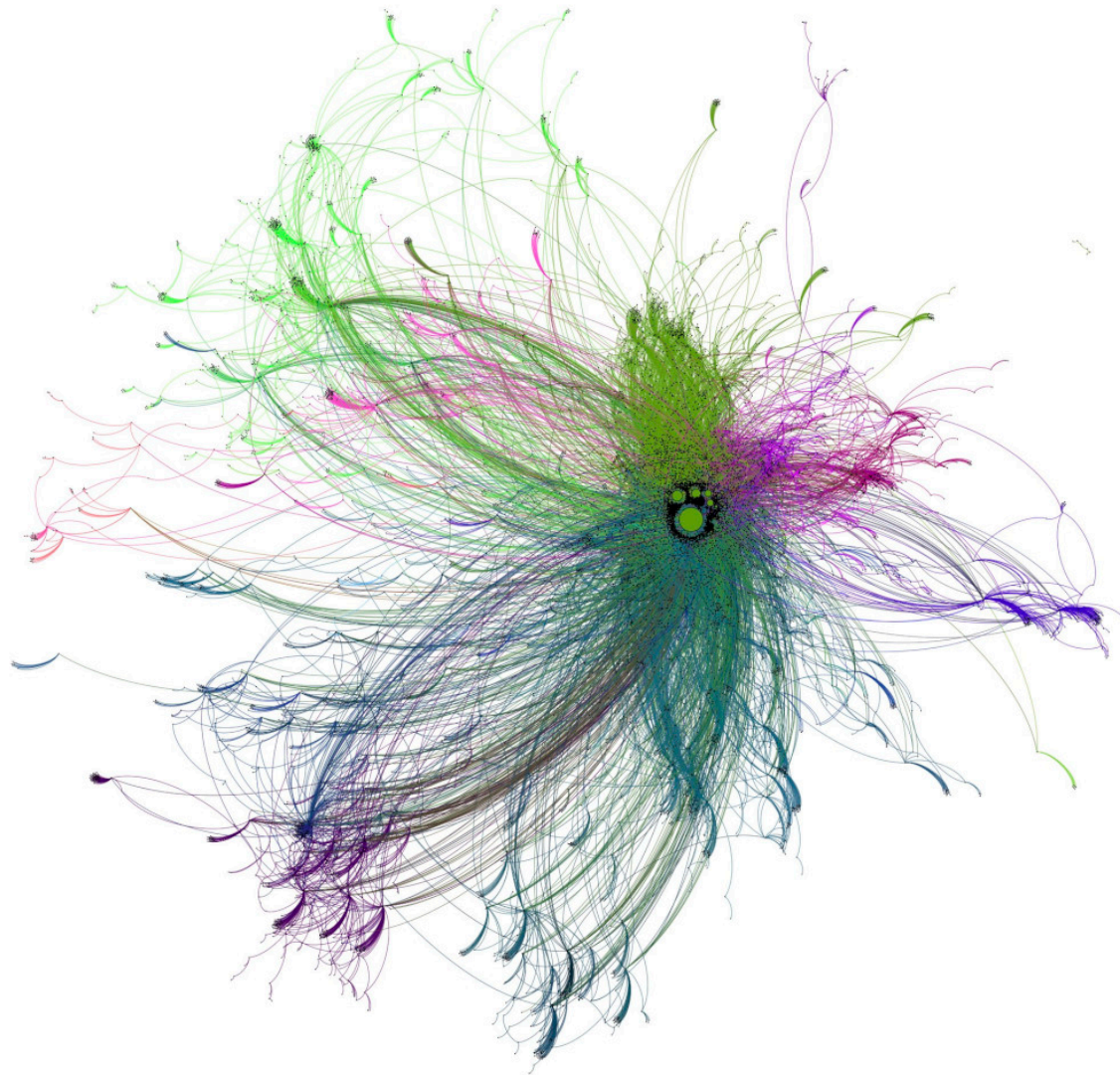
- ASN
- BGP Peering
- Number of Peerings

Credit to Blair Harrison  
<http://jedi.school.nz/sg2015/>  
and Dean Pemberton

Also look at  
<http://thyme.apnic.net/BGP> for  
regional breakdown and  
interactive graphic

# IPv6 Internet by BGP Peerings

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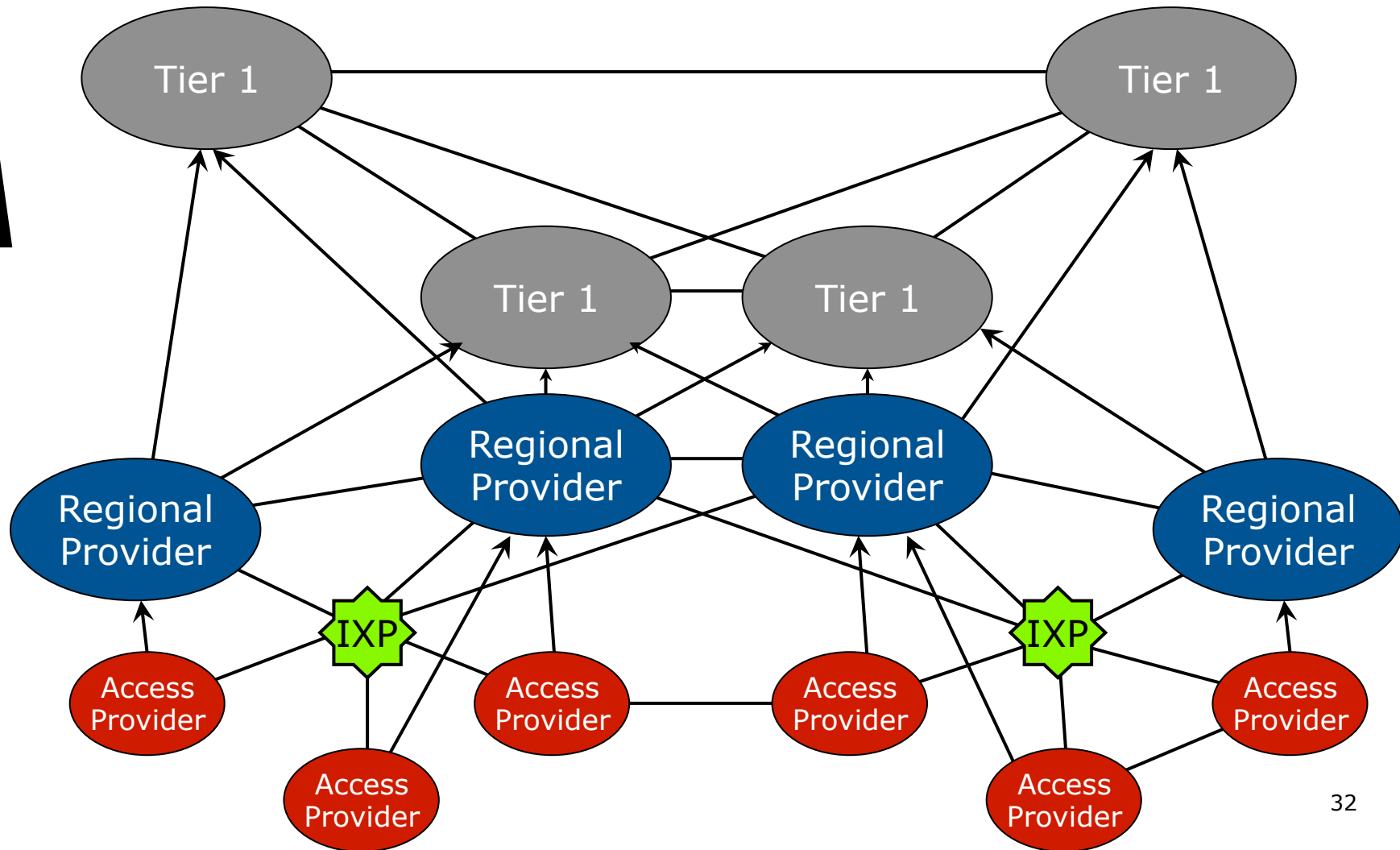
**The IPv6 Default Free Zone, June 2015**

- ASN
- BGP Peering
- Number of Peerings

Credit to Blair Harrison  
<http://jedi.school.nz/sg2015-v6/>  
and Dean Pemberton

Also look at  
<http://thyme.apnic.net/BGP> for  
interactive graphic

# Categorising Network Operators





# Categorising Network Operators

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- Tier-1 – definition:
  - A provider which peers with other Tier-1s and does NOT pay for transit
  - Caveat:
    - Many marketing departments call their service provider a Tier-1 – even though that provider may still pay for transit to some parts of the Internet
- Regional providers often have the reach of Tier-1s but still have to rely on maybe one or two Tier-1s to access the whole Internet
  - They often provide access too, via in country domestic access networks
- Access providers work exclusively in their locale

# Inter-provider relationships

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- Peering between equivalent sizes of service providers (e.g. Regional to Regional)
  - 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

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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

**NB: is not related to where an ISP is in the hierarchy**

# Gluing it together



# Gluing it together

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- 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...

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- 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 – supported by LACNIC
- Middle East
  - MENOOG (Middle East Network Operators Group)
  - [www.menog.org](http://www.menog.org)

# Engineers keep talking to each other...

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- Asia & Pacific
  - APRICOT annual conference
    - [www.apricot.net](http://www.apricot.net)
  - APOPS mailing list
    - [mailman.apnic.net/mailman/listinfo/apops](http://mailman.apnic.net/mailman/listinfo/apops)
  - PacNOG (Pacific NOG)
    - [mailman.apnic.net/mailman/listinfo/pacnog](http://mailman.apnic.net/mailman/listinfo/pacnog)
  - SANOG (South Asia NOG)
    - [lists.sanog.org/mailman/listinfo/sanog](http://lists.sanog.org/mailman/listinfo/sanog)

# Engineers keep talking to each other...

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- Europe
  - RIPE meetings, working groups and mailing lists
  - e.g. Routing WG: [www.ripe.net/mailman/listinfo/routing-wg](http://www.ripe.net/mailman/listinfo/routing-wg)
- Africa
  - AfNOG meetings and mailing list
- Caribbean
  - CaribNOG 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

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- 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

# Introduction to The Internet



ISP Workshops