Introduction to Networking

ISP/IXP Workshops

Network Topology and Definitions

- Definitions and icons
- Network topologies
- PoP topologies
- Interconnections and IXPs
- IP Addressing
- 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)

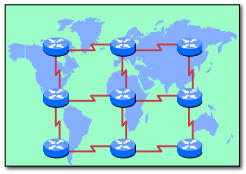
Ethernet switch
(layer 2, packet forwarding)

Network Cloud

Network Topologies

Routed backbone

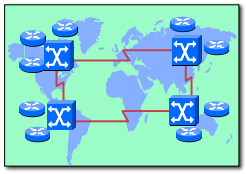
- Routers are the infrastructure
- Physical circuits run between routers
- Easy routing configuration, operation and troubleshooting
- The dominant topology used in the Internet today



Network Topologies

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



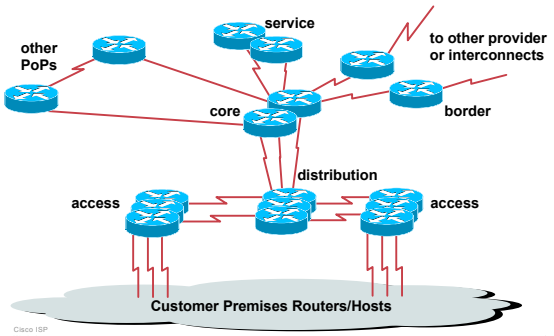
Definitions

- 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

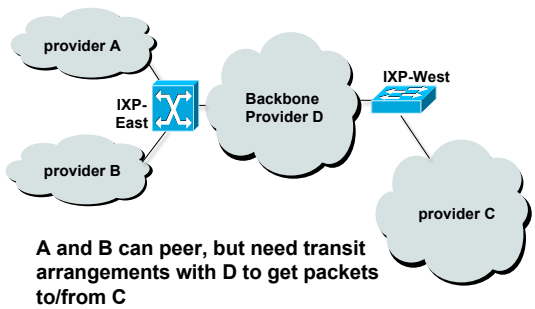
PoP Topologies



Definitions

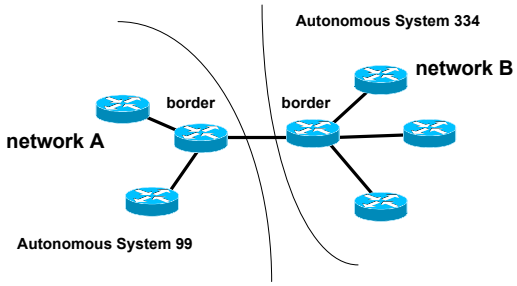
- Transit
  - carrying traffic across a network, usually for a fee
- Peering
  - exchanging routing information and traffic
- Default
  - where to send traffic when there is no explicit match in the routing table

Peering and Transit example



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

Private Interconnect



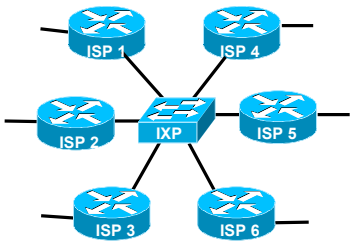
Public Interconnect Point

- 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 Point

- Centralised (in one facility)
- Distributed (connected via WAN links)
- Shared, 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

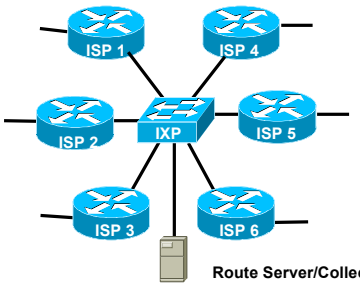
Route Server

- Purpose:
  - Collects all the routes heard from ISPs at the IXP and sends them to all ISPs at the IXP
- Advantages:
  - reduces resource burden on border routers (CPU, memory, configuration complexity)
  - reduces administrative burden on providers
- Disadvantages:
  - must rely on a third party (for management, configuration, software updates, maintenance, etc)

Route Collector

- Purpose:
  - Collects all the routes heard from ISPs at the IXP
- Advantages
  - Allows IXP participants to see destinations available at the IXP
  - Useful for troubleshooting, information, “IXP Marketing”
- Disadvantages
  - Needs to be maintained, but not critical to IXP operation
  - Information is only as good as that which ISPs send to it
- Basically a Route Server without the ability to send routing information to participant ISPs

Route Server/Collector



Route Server/Collector

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IP Addressing

Where to get address space and who from

IP Addressing

- Internet is classless
- Concept of 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
  - Classless InterDomain Routing
  - 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
  - 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
- 67% of usable IPv4 address space has been allocated

Definitions

- Non-portable – 'provider aggregatable' (PA)
  - 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
  - May fragment provider block when multihoming
- PA space is allocated to the RIR member with the requirement that all assignments made by the RIR member to end sites are announced as an aggregate to the rest of the Internet

Definitions

- Portable – 'provider independent' (PI)
  - Customer gets or has address space independent of ISP
  - Customer keeps addresses when changing ISP
  - Considered bad for size of Internet routing table
  - PI space is rarely distributed by the RIRs

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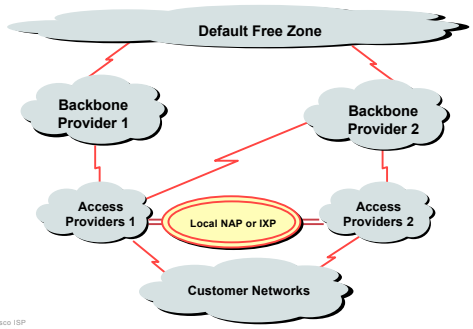
Internet Hierarchy

The pecking order

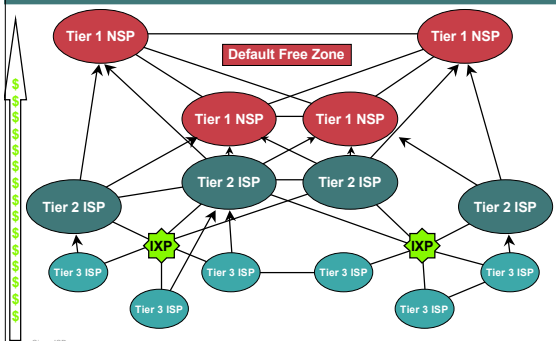
Default Free Zone

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.

High Level View of the Global Internet



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"

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Gluing it together

Gluing it together

- Who runs the Internet?
  - No one
- 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 talking to each other!

Engineers keep talking to each other...

- North America
  - NANOG (North American Network Operators Group)
  - NANOG meetings and mailing list
  - www.nanog.org
  - To subscribe: majordomo@merit.edu
    - `subscribe nanog-post xxxx@yyyy.zzzz`
    - `subscribe nanog xxxx@yyyy.zzzz`
- Latin America
  - Foro de Redes

Engineers keep talking to each other...

- Europe
  - RIPE meetings, working groups and mailing lists
  - Routing WG: www.ripe.net/mailman/listinfo/routing-wg
  - EOF (European Operators Forum)
  - www.ripe.net/mailman/listinfo/eof-list

Engineers keep talking to each other...

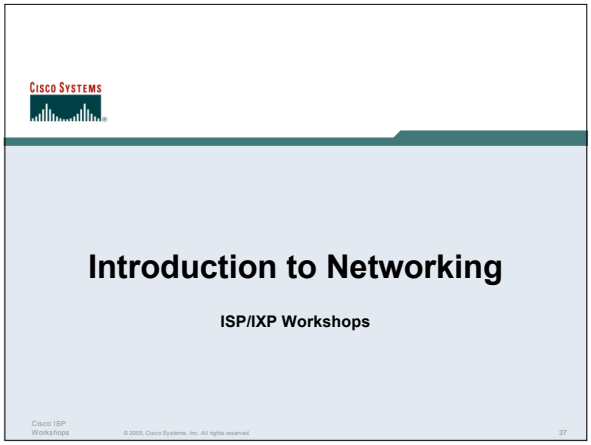
- Asia & Pacific
  - APRICOT annual conference
    - www.apricot.net
  - APOPS & APNIC-TALK mailing lists
    - mailman.apnic.net/mailman/listinfo/apops
    - mailman.apnic.net/mailman/listinfo/apnic-talk
  - PacNOG (Pacific NOG)
    - mailman.apnic.net/mailman/listinfo/pacnog
  - SANOG (South Asia NOG)
    - E-mail to sanog-request@sanog.org

Engineers keep talking to each other...

- Africa
  - AfNOG meetings and mailing list
    - listserv2.cfi.co.ug/mailman/listinfo/afnog
- And many in-country ISP associations and NOGs
- IETF meetings and mailing lists
  - www.ietf.org

Summary

- Network Topologies and Definitions
- IP Addressing
  - PI versus PA address space
- Gluing it all together
  - Engineers co-operate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