Introduction to The Internet

IPv6 Transition Strategies and Technologies Workshop
5th – 6th August 2014
Vientiane

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Preamble

- Course slides:
  - Please ask questions any time
  - This is an interactive workshop
Introduction to the Internet

- 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)
- Ethernet switch (layer 2, packet forwarding)
- Network Cloud
Routed Backbone

- ISPs build networks covering regions
  - Regions can cover a country, sub-continent, or even global
  - Each region has points of presence built by the ISP
- 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

- Some ISPs & Telcos 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

- **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

- Backbone link to another PoP
- Other ISPs
- Border
- Network Core
- Access
- Service
- ISP Services (DNS, Mail, News, FTP, WWW)
- Consumer Aggregation
- Hosted Services
- Business Customer Aggregation
- Network Operation Centre
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 C and D to get packets to/from E and F
Private Interconnect

Provider C

Autonomous System 99

border

Provider D

Autonomous System 334

border
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 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
  - 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 Basics

- Internet uses two types of addressing:
  - IPv6 – the new IP protocol
  - IPv4 – legacy IP protocol

- Internet uses classless routing
  - Routers must be CIDR capable
    - Classless InterDomain Routing
  - 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

- 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

- 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 ISPs and Local Internet Registries
  - ISPs/LIRs **assign** address space to end customers or other ISPs

- **RIRs address distribution:**
  - IPv6 is plentiful
  - IPv4 is very limited
Address delegation hierarchy
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
Global Internet: High Level View

Global Providers

Regional Provider 1

Access Provider 1

Content Provider 1

IXP

Regional Provider 2

Content Provider 2

Access Provider 2

Customer Networks
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

- 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
Categorising ISPs

Tier 1 ISP

Tier 1 ISP

Tier 1 ISP

Tier 1 ISP

Regional ISP

Regional ISP

Regional ISP

Regional ISP

Access ISP

Access ISP

Access ISP

Access ISP

Access ISP

Access ISP

Access ISP

Access ISP

Access ISP
Categorising ISPs

- **Tier-1 ISP – definition:**
  - A provider which peers with other Tier-1s and does NOT pay for transit
  - Caveat:
    - Many marketing departments call their ISP a Tier-1 – even though that ISP 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

- 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”
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
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 – supported by LACNIC

- **Middle East**
  - MENOG (Middle East Network Operators Group)
  - [www.menog.net](http://www.menog.net)
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...

- **Europe**
  - RIPE meetings, working groups and mailing lists
  - e.g. Routing WG: 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
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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