Internet Routing

Review of Networking Principles
Principles of the Internet

- Edge vs. core (end-systems vs. routers)
  - Dumb network
  - Intelligence at the end-systems
- Different communication paradigms
  - Connection oriented vs. connection less
  - Packet vs. circuit switching
- Layered System
- Network of collaborating networks
The network core

- Mesh of interconnected routers
- *The* fundamental question: How is data transferred through net?
  - Circuit switching: Dedicated circuit per call: telephone net
  - Packet switching: Data sent through net in discrete “chunks”
Routing

- **Goal**
  Move pkts among routers from src to dst

- **Datagram network**
  - *Destination address* determines next hop
  - Routes may change during session

- **Virtual circuit network**
  - Each packet carries tag (virtual circuit ID), tag determines next hop
  - Fixed path determined at *call setup time*, remains fixed through call
  - Routers maintain per-call state
Internet protocol stack

- **Application**: supporting network applications
- **Transport**: host-host data transfer
- **Network**: uniform format of packets, routing of datagrams from source to destination
- **Link**: data transfer between neighboring network elements
- **Physical**: bits “on the wire”
Layering: Logical communication

Each layer:
- Distributed
- “Entities” implement layer functions at each node
- Entities perform actions, exchange messages with peers
Layering: Physical communication
Internet structure: Network of networks

- Roughly hierarchical
- National/international backbone providers (NBPs)
  - E.g., BBN/GTE, Sprint, AT&T, IBM, UUNet
  - Interconnect (peer) with each other privately, or at public Network Access Point (NAPs)
- Regional ISPs
  - Connect into NBPs
- Local ISP, company
  - Connect into regional ISPs
Internet structure: Network of networks

- Roughly hierarchical
- At center: “tier-1” ISPs (e.g., UUNet, BBN/Genuity, Sprint, AT&T), national/international coverage
  - Treat each other as equals

Diagram:
- Tier-1 providers interconnect (peer) privately
- Tier-1 providers also interconnect at public network access points (NAPs)
Internet structure: Network of networks

- “Tier-2” ISPs: smaller (often regional) ISPs
  - Connect to one or more tier-1 ISPs, possibly other tier-2 ISPs

- Tier-2 ISP pays tier-1 ISP for connectivity to rest of Internet
- Tier-2 ISP is customer of tier-1 provider

- Tier-2 ISPs also peer privately with each other, interconnect at NAP
Internet structure: Network of networks

- “Tier-3” ISPs and local ISPs
  - Last hop ("access") network (closest to end systems)

Local and tier-3 ISPs are customers of higher tier ISPs connecting them to rest of Internet.
Example Tier-1 ISP: Sprint
The Operator View

- Tier 1 and 2 operators divide their networks in different ways
  - Architectural – access, aggregation, core
  - Service – WAN, data center, wireless

- Helps in network management and service provisioning
  - Traffic/Routing view optimizes equipment utilization and management
  - Service view facilitates offering customers specific kinds of services
The Operator View: Architectural

Access Network
Oversubscribed

Aggregation Network

"BGP less" Core Network:
MPLS Mesh, All Optical, Overprovisioned

Enterprise /Campus Network Gateway

Broadband Network Gateway (BNG)

DLSLAM, PON, or other FTTH Terminator

To Metro Agg. B

To Metro Agg. C

To Metro Agg. D

BGP Speaker

Internet

Note: Often equipment is deployed in pairs for redundancy.
The Operator View: xDSL Detail

The Operator View: Service

Wide Area Network (WAN)

Data Center

Internet

Wireless
The Operator View: Service Offerings

- **WAN**
  - L3 VPN
  - L2 VPN
  - Internet

- **Data Center**
  - Web hosting
  - Data storage

- **Wireless**
  - Voice Minutes
  - Data bundles
  - Texts