

The Internet; Its Edge and Core

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1 Administrivia

Announcements

Assignment

Read 1.4–1.7.

From Last Time

Introduction

Outline

1. More on the Internet.
2. Network edge.
3. Network core.

Coming Up

Problems and protocols.

2 More on the Internet

Infrastructure view:

1. A network of networks.

2. Unit of transmission: the packet.

USPS analogy. A data stream is split into discrete packets.

3. Connected via “packet switches”: switches and routers.

How do packets move about the network? Store and forward; routing.

4. Protocols: TCP, UDP, IP.

What is a protocol?

Example SMTP protocol exchange:

```
bluebird:~/Class/Cs325/Lectures
% Mail -v -s "Protocol illustration" kelliher@phoenix.goucher.edu
SMTP protocol demonstration.
Cc:
kelliher@phoenix.goucher.edu... Connecting to [127.0.0.1] via relay...
220 bluebird.goucher.edu ESMTP Sendmail 8.13.8/8.13.8; Thu, 31 Jan 2008 18:36:28 -0
>>> EHLO bluebird.goucher.edu
250-bluebird.goucher.edu Hello bluebird.goucher.edu [127.0.0.1], pleased to meet yo
250-ENHANCEDSTATUSCODES
250-PIPELINING
250-8BITMIME
250-SIZE
250-DSN
250-ETRN
250-AUTH GSSAPI DIGEST-MD5 CRAM-MD5
250-DELIVERBY
250 HELP
>>> MAIL From:<kelliher@bluebird.goucher.edu> SIZE=94 AUTH=kelliher@bluebird.gouche
250 2.1.0 <kelliher@bluebird.goucher.edu>... Sender ok
>>> RCPT To:<kelliher@phoenix.goucher.edu>
>>> DATA
250 2.1.5 <kelliher@phoenix.goucher.edu>... Recipient ok
354 Enter mail, end with "." on a line by itself
```

```
>>> .
250 2.0.0 m0VNaSul003537 Message accepted for delivery
kelliher@phoenix.goucher.edu... Sent (m0VNaSul003537 Message accepted for delivery)
Closing connection to [127.0.0.1]
>>> QUIT
221 2.0.0 bluebird.goucher.edu closing connection
```

“Doing it yourself” via a telnet connection to SMTP port (25).

Protocols in TCP/IP:

The five-layer TCP/IP model

5. Application layer

DHCP · DNS · FTP · Gopher · HTTP · IMAP4 · IRC · NNTP · XMPP · POP3 · SIP · SMTP · SNMP · SSH · TELNET · RPC · RTCP · RTSP · TLS · SDP · SOAP · GTP · STUN · NTP · (more)

4. Transport layer

TCP · UDP · DCCP · SCTP · RTP · RSVP · IGMP · (more)

3. Network/Internet layer

IP (IPv4 · IPv6) · OSPF · IS-IS · BGP · IPsec · ARP · RARP · RIP · ICMP · ICMPv6 · (more)

2. Data link layer

802.11 (WLAN) · 802.16 · Wi-Fi · WIMAX · ATM · DTM · Token ring · Ethernet · FDDI · Frame Relay · GPRS · EVDO · HSPA · HDLC · PPP · PPTP · L2TP · ISDN · ARCnet · (more)

1. Physical layer

Ethernet physical layer · Modems · PLC · SONET/SDH · G.709 · Optical fiber · Coaxial cable · Twisted pair · (more)

This box: [view](#) · [talk](#) · [edit](#)

5. The role of ISPs.

Services view:

1. A foundation for distributed applications: HTTP, SMTP, SSH, DNS, POP, IMAP, etc.

2. Properties of the foundation (Qos, etc.)
3. APIs.

3 Network Edge

1. Hosts — clients, servers.

How does peer-to-peer fit in?

Distributed applications.

2. Access from the edge. Residential and commercial.

- (a) Dial-up modems through POTS to traditional ISPs.

Length limits bandwidth

- (b) DSL access.

Phone company is ISP. Shorter link length means higher speed. Still, there's only so much bandwidth available in twisted pair.

Dedicated access.

- (c) Cable modem access.

Coaxial cable has much higher bandwidth.

Shared broadcast.

- (d) Fiber to the home — Verizon's FIOS.

Much higher bandwidth.

- (e) T1 (1.544 mb/s; copper or fiber), T3 (43.232 mb/s; fiber?), OC3 (155 mb/s).

Commercial access.

A cable modem gives access approximately equal to a T1.

Goucher: four T1 lines in 2002. How many today? Why doesn't Goucher just use cable modems?

(f) Wireless access — 802.11.

Network integrity, security issues.

4 Network Core

1. Circuit switching

(a) Roots in telephone service.

(b) Guaranteed connection, guaranteed bandwidth.

(c) Overhead for establishing the circuit.

(d) Unused bandwidth for one circuit can't be used by another (waste).

(e) Time division multiplexing. CPU scheduling. Slots in a frame.

(f) Frequency division multiplexing. Radio broadcasts. Use a unique slice of the available bandwidth.

2. Packet switching

(a) Roots in computer networks.

(b) Best-effort service. Bottlenecks — consider the Beltway. Leads to packet loss.

(c) No overhead.

(d) Dynamic allocation of bandwidth built in.

(e) Store-and-forward from link to link — no “pipelining.”

3. Connectivity between ISPs.

- (a) Tier 1: a tier 1 ISP is connected to every other tier 1 ISP — maximum redundancy.

Peering.

Connections to a large number of tier 2 ISPs (clients).

- (b) Tier 2: connects to a small number of tier 1 ISPs and perhaps some other tier 2 ISPs.

Connections to a large number of tier 3 ISPs (clients).

- (c) Tier 3: Consumer access to the Internet.