Announcements

More copies of the handout from lecture 1

Review

The lecturer

He talks too fast...

Best way to contact:
1. Verbally during Consultation Time for technical issues:
   - During session: Immediately after Wed & Fri lectures, until half past the hour
   - Study and Exam Periods: Two one-hour time slots (time TBD)
   - 2 Hours/90 students ➞ You would do well to ask questions progressively during the session, rather than leaving them for the last minute.
2. By email to tele3018admin AT ee.unsw.edu.au ➞ admin

Don’t try:
- Email to other addresses
- Telephone
- Visiting office

These avenues simply don’t scale well enough to deal with 400 students p.a.

About the slides

Use these to relate notes taken in lectures to slides printed out after lectures.
- May skip certain numbers (slides that are still “under construction”)
- * marks (approx) 130 most important slides
- ? marks some of the more advanced slides (HD material)

Source

⇒ From Kurose & Ross.
See copyright notice at end of this set.
⇒ From Tanenbaum
⇒ From Moors

Footnotes & references for sources of figures (T=Tanenbaum; others in first lecture. Source provides pointer for where to read for more info)

Lecture shorthand

Some abbreviations that you may see in lectures:
- standard mathematics: ⇒ implies, “⇐” implies
- ∃ there exists, ∀ for all
- ↑↓ increases/decreases
- ✔ advantages/disadvantages
- c.f. compare with
- s.t. such that
- wrt with respect to
- aka: also known as
- a la: in the manner of
- b bits, B bytes, k 1000, K 1024 ➞ at end of line implies topic will be covered in an ensuing slide e.g. Fun ➞
Course outline

Introduction to networks and protocols
Analog domain: Apps & transmission media
Links
Medium access control
Networks
End-to-end transport
Applications

Section outline

Introduction to networks and protocols:
- Entities involved in networks
- Protocols & layered structure of nodes
- Modes of network operation

More depth and detail about specific protocols and types of entity later in the course.

Outline

Applications of networks
Types of networks
  - Scale
  - Internetworks
Network components
  - Client-server paradigm
Internet history

“Cool” network appliances

IP picture frame
http://www.ceiva.com/

Smart dust
Solar powered, bidirectional comms, acceleration & ambient light sensing
~4.8 mm³ total displaced volume
http://www-bsac.eecs.berkeley.edu/~warneke/SmartDust/index.html

Web-enabled toaster+weather forecaster
Traditional network applications

Text / “data” transfer
- Interactive (e.g. 100ms response time)
  - remote login, e.g. telnet, X11
  - transactions, e.g. purchase airline ticket
- Non-interactive
  - File transfer
  - Email
  - News

Multimedia
- Images; Web
- Voice
- Video

Process control, meter reading, inventory management, etc

Network applications: some jargon

Process: program running within a host.
Within same host, two processes communicate using interprocess communication (defined by OS).
Processes running in different hosts communicate with an application-layer protocol

user agent: interfaces with user “above” and network “below”.
- implements user interface & application-level protocol
  - Web: browser
  - E-mail: mail reader
  - streaming audio/video: media player

Addressing processes:

For a process to receive messages, it must have an identifier.
Every host has a unique 32-bit IP address
Q: does the IP address of the host on which the process runs suffice for identifying the process?
Answer: No, many processes can be running on same host

Processes communicating across a network

Process sends/receives messages to/from its socket
Socket analogous to door
- sending process shoves message out door
- sending process assumes transport infrastructure on other side of door which brings message to socket at receiving process

† Which might be null, allowing direct access to transport layer services, e.g. sockets.

† unique & 32-bit for traditional IPv4
Outline

Classification of interconnected processors by scale

<table>
<thead>
<tr>
<th>Interprocessor distance</th>
<th>Processors located in same</th>
<th>Example</th>
<th>System networks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 m</td>
<td>Square meter</td>
<td></td>
<td>Personal area network</td>
</tr>
<tr>
<td>10 m</td>
<td>Room</td>
<td></td>
<td>Local area network</td>
</tr>
<tr>
<td>100 m</td>
<td>Building</td>
<td></td>
<td>Metropolitan area network</td>
</tr>
<tr>
<td>1 km</td>
<td>Campus</td>
<td></td>
<td>Wide area network</td>
</tr>
<tr>
<td>10 km</td>
<td>City</td>
<td></td>
<td>The Internet</td>
</tr>
<tr>
<td>100 km</td>
<td>Country</td>
<td></td>
<td>Storage Area Networks</td>
</tr>
<tr>
<td>1000 km</td>
<td>Continent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10,000 km</td>
<td>Planet</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The scale determines what technology is suitable

Personal Area Networks

For interconnecting devices that a person may carry
- PDA (visual output; manual input)
- headset (audio I/O)
- mobile phone (wide-area connectivity)
- video input: cameras
- medical monitoring (pacemaker, heart rate, hearing aid)

For interconnecting peripherals to a computer
- keyboard, mouse, printer, monitor

Often wireless:
- Ease of association (don’t have to worry about what plugs into what)
- Less clutter (no cables)

Issue: how to power these objects?

Local Area Networks

With a broadcast transmission medium, one station’s transmission is directly received by all other stations. Other stations filter out information not destined to them. With a point-to-point transmission medium: Transmission by one station is received by only one other station. That station may forward the information towards other stations.
Metropolitan Area Networks
Community Area cable TV: Provide reception for a region with poor broadcast reception.

IEEE 802.16 Wireless MANs

Wide Area Networks
Relation between hosts on LANs and the subnet.

Internetworks
Motivated by the desire to interconnect varied networks

Internet: "network of networks"
- loosely hierarchical
- public Internet versus private intranet

What’s the Internet: "nuts and bolts" view
- millions of connected computing devices: hosts, end-systems
  - PCs, workstations, servers
  - PDAs, phones, toasters
- running network apps
- communication links
  - fiber, copper, radio, satellite
- transmission rate = "bandwidth"
- routers/switches: forward packets (chunks of data)
- protocols control sending, receiving of msgs
  - e.g., TCP, IP, HTTP, FTP, PPP

Ad hoc & peer-to-peer systems blur the distinctions between hosts/routers & workstations/servers
A closer look at network structure:

- **network edge:**
  - applications and hosts

- **network core:**
  - routers
  - network of networks
  - access networks
  - physical media: communication links

Internet structure: network of networks

- roughly hierarchical
- at core: "Tier-1" ISPs (e.g., UUNet, BBN/Genuity, Sprint, AT&T), national/international coverage
  - treat each other as equals

  Tier-1 providers also interconnect at public network access points (NAPs)

Tier-1 ISP: e.g., Sprint

Sprint US backbone network

"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)

Information passes through many networks on its path from source to destination!

Path from UNSW to www.irtf.org

Clouds

Often when we’re not concerned about the internals of the network, we draw the network as a cloud (Tanenbaum uses ovals).
Outline

Client-server paradigm

Typical network app has two pieces: client and server

Client:
- initiates contact with server ("speaks first")
- typically requests service from server
- Web: client implemented in browser; e-mail: in mail reader

Server:
- provides requested service to client
- one server usually serves many clients
- e.g., Web server sends requested Web page, mail server delivers e-mail

Evolution towards greater node symmetry

1970s: Mainframe and dumb terminals
All processing / storage capacity in mainframe.

1980s/90s: Client/server
Clients have limited processing / storage capacity. LANs interconnect clients and servers. Server is usually more capable. Exceptions, e.g.: X11 protocol: screen provides service, computer requests service.

1990s/21st C: Peer-to-peer and ad hoc
Distinction between clients/servers diminishes ("servents"). Distinction between end-systems and routers diminishes.

Peer-to-peer
In peer-to-peer system there are no fixed clients and servers. Each node can both initiate requests and serve requests.