Trend: Networking is Critical

- Communication more critical than computing
  - Bus performance vs ALU speed
  - I/O performance vs SPECMark
- User Location:
  - 1980: Desktop  1990: Mobile
- System Extent:
  - 1980: 1 Node within 10 m
  - 1990: 100 nodes within 10 km
Last 10 years: Individual computing  
Next 10 years: Cooperative computing  
Past: Corporate networks  
Future:  
- Inter-corporate networks  
- National Info Infrastructures  
- International Info Infrastructures  

Trend: Exponential Growth  
Number of Hosts on the Internet
Networking in Social Fabric

- USENET: Ten million news articles/month
- 18 on-line coffee houses in San Francisco
- National Public Radio Program
- Supreme court decision within one day
- Real estate, on-line catalog
- 137 countries reachable via Email

Data Communication vs Networking

- Communication: Two Nodes.
- Networking: Two or more nodes
Distributed Systems vs Networks

- Distributed Systems:
  - Users are unaware of underlying structure.
    E.g., trn instead of `\n\bone\0\trn`
  - Mostly operating systems issues.
  - Nodes are generally under one organization’s control.
- Networks: Users specify the location of resources.
  http://www.cis.ohio-state.edu/~jain/
- Nodes are autonomous.

Types of Networks

- Point to point vs Broadcast
- Circuit switched vs packet switched
- Local Area Networks (LAN) 0-2 km, Metropolitan Area Networks (MAN) 2-50 km, Wide Area Networks (WAN) 50+ km
Protocol Layers

- Problem: Philosophers in different countries speak different languages. The Telex system works only with English.

ISO/OSI Reference Model

| Layer 1: Physical | How to transmit signal: Coding |
| Layer 2: Datalink | Establish/manage connection, Two party communication: Ethernet |
| Layer 3: Transport | End-to-end communication: TCP, Routing, Addressing: IP |
| Layer 4: Network | File transfer, Email, Remote Login, ASCII Text, Sound |
| Layer 5: Session | Mary has a little lamb |
| Layer 6: Presentation | How to get the point across, make it clear and memorable |
| Layer 7: Application | I believe there is a God! |
Layering

- Protocols of each layer have to perform a set of functions
- All alternatives for a row have the same interfaces
- Choice of protocols at each layer is independent of those of at other layers. E.g., TCP works over IP or IPX (Novell’s IP)
- UDP = User Data Protocol
- Need one component of each layer ⇒ Null components
- Nth layer control info is passed as N-1th layer data.

<table>
<thead>
<tr>
<th>Layer</th>
<th>Protocol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application</td>
<td>APDU, Message</td>
</tr>
<tr>
<td>Presentation</td>
<td>PPDU</td>
</tr>
<tr>
<td>Session</td>
<td>SPDU</td>
</tr>
<tr>
<td>Transport</td>
<td>TPDU</td>
</tr>
<tr>
<td>Network</td>
<td>NPDU, Packet</td>
</tr>
<tr>
<td>Datalink</td>
<td>DPDU</td>
</tr>
<tr>
<td>Physical</td>
<td>PhPDU, Frame</td>
</tr>
</tbody>
</table>

Same Interfaces

Need one component of each layer ⇒ Null components

Nth layer control info is passed as N-1th layer data.
**Service Data Unit (SDU)**

- Application
- Presentation
- Session
- Transport
- Network
- Datalink
- Physical

**TCP/IP Reference Model**

- TCP = Transport Control Protocol
- IP = Internet Protocol (Routing)

- Application
- Presentation
- Session
- Transport
- Network
- Datalink
- Physical

- FTP
- Telnet
- HTTP
- TCP
- UDP
- IP
- Ethernet
- Packet
- Point-to-Point
- Radio
- Net

The Ohio State University

Raj Jain
ODN’s Four-Layer Model

- ODN = Open Data Networks
- Bearer Service: Bit level transport service
  - Includes links, switches, routers, network management
- Transport Layer: Enhanced end-to-end services
  - May include reliable, sequenced delivery, flow control
  - Can be realize either in the network or in the end nodes
  - Not a core part of the bearer service
- Middleware: Common higher level functions
  - file system support, privacy, authentication, name service, directory service
- Applications: Email, Airline reservation

Four Layer Model

ODN Bearer Service

Network Technology Substrate
Summary

- Networking is growing exponentially
- Communication, Networks, and Distributed systems
- ISO/OSI’s 7-layer reference model
- TCP/IP has a 4-layer model

Reading Assignment

- Read Chapter 1 of Stallings, particularly
  - Table 1.2
  - Section 1.4, 1.5
- Optional: You may want to read ahead Chapter 2.