Introduction to Networking Protocols and Architecture

Raj Jain
Professor of CIS
The Ohio State University
Columbus, OH 43210
Jain@acm.org

These slides are available on-line at:
http://www.cis ohio-state.edu/~jain/cis677-00/
Overview

- Data Comm vs Networking vs Distributed Systems
- Types of Networks
- Protocol Layers: OSI and TCP/IP Models
- Connection-oriented vs connectionless
- Layered packet format
Data Communication vs Networking

- Communication: Two Nodes. Mostly EE issues.

- Networking: Two or more nodes. More issues, e.g., routing
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.
  - Nodes are autonomous.
  - [http://www.cis.ohio-state.edu/~jain/](http://www.cis.ohio-state.edu/~jain/)
Types of Networks

- **Point to point vs Broadcast**
  - WAN
  - Bus LAN
  - Ring LAN

- **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.
  - I believe there is a God!

Philosopher

Translator

Secretary

The Ohio State University
Raj Jain
Design Issues for Layers

- Duplexity:
  - Simplex: Transmit or receive
  - Full Duplex: Transmit and receive simultaneously
  - Half-Duplex: Transmit and receive alternately

- Error Control: Error detection and recovery
- Flow Control: Fast sender
ISO/OSI Reference Model

<table>
<thead>
<tr>
<th>Layer</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application</td>
<td>File transfer, Email, Remote Login</td>
</tr>
<tr>
<td></td>
<td>ASCII Text, Sound</td>
</tr>
<tr>
<td></td>
<td>Establish/manage connection</td>
</tr>
<tr>
<td></td>
<td>End-to-end communication: TCP</td>
</tr>
<tr>
<td></td>
<td>Routing, Addressing: IP</td>
</tr>
<tr>
<td></td>
<td>Two party communication: Ethernet</td>
</tr>
<tr>
<td>Physical</td>
<td>How to transmit signal: Coding</td>
</tr>
</tbody>
</table>

Two party communication: Ethernet

End-to-end communication: TCP
### Layering

<table>
<thead>
<tr>
<th>FTP</th>
<th>Trans Control Prot</th>
<th>User Datagram Prot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Telnet</td>
<td>Internet Protocol</td>
<td>Novell Netware (IPX)</td>
</tr>
<tr>
<td>Web</td>
<td>Ethernet</td>
<td>Token Ring</td>
</tr>
<tr>
<td>Email</td>
<td>Copper</td>
<td>Fiber</td>
</tr>
</tbody>
</table>

- Protocols of a layer perform a similar set of functions
- All alternatives for a row have the same interfaces
- Choice of protocols at a layer is independent of those of at other layers. E.g., IP over Ethernet or token ring
- Need one component of each layer ⇒ Null components

The Ohio State University

Raj Jain
- IDU = Interface Data Unit = ICI + SDU
- ICI = Interface Control Information
- SDU = Service Data Unit
- PDU = Protocol Data Unit = Fragments of SDU + Header or Several SDUs + Header (blocking)
- SAP = Service Access Point
Protocol Data Unit (PDU)

<table>
<thead>
<tr>
<th>Application</th>
<th>PPDU</th>
<th>Presentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Session</td>
<td>SPDU</td>
<td>Transport</td>
</tr>
<tr>
<td>Transport</td>
<td>TPDU</td>
<td>Network</td>
</tr>
<tr>
<td>Network</td>
<td>NPDU, Packet</td>
<td>Datalink</td>
</tr>
<tr>
<td>Datalink</td>
<td>DPDU, Frame</td>
<td>Physical</td>
</tr>
<tr>
<td>Physical</td>
<td>PhPDU, Frame</td>
<td>Application</td>
</tr>
</tbody>
</table>
Service Data Unit (SDU)

Application → PSDU
Presentation → SSDU
Session → TSDU
Transport → NSDU
Network → DSDU
Datalink → PhSDU
Physical
Connection-Oriented vs Connectionless

- Connection-Oriented: Telephone System
  - Path setup before data is sent
  - Data need not have address. Circuit number is used.
  - Virtual circuits: Multiple circuits on one wire.

- Connectionless: Postal System. Also known as datagram.
  - Complete address on each packet
  - The address decides the next hop at each routing point
Types of Services

Connection-oriented
- Reliable
- Unreliable

Datagram
- Reliable
- Unreliable

- Message
- Byte
- Sequence
- Stream
- Acknowledged
- Request-Reply

- Byte streams: user message boundaries are not preserved
- Request-reply: The reply serves as an acknowledgement also
- Message oriented or byte oriented approach can be used for unreliable connection-oriented communication
Service Primitives

- Indication = Interrupt


Unconfirmed service: No confirmation or response
TCP/IP Reference Model

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

TCP/IP Ref Model

<table>
<thead>
<tr>
<th>Application</th>
<th>FTP</th>
<th>Telnet</th>
<th>HTTP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport</td>
<td>TCP</td>
<td>UDP</td>
<td></td>
</tr>
<tr>
<td>Internetwork</td>
<td>IP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Host to Network</td>
<td>Ethernet</td>
<td>Packet Radio</td>
<td>Point-to-Point</td>
</tr>
</tbody>
</table>

TCP/IP Protocols

<table>
<thead>
<tr>
<th>Application</th>
<th>Presentation</th>
<th>Session</th>
<th>Transport</th>
<th>Network</th>
<th>Datalink</th>
<th>Physical</th>
</tr>
</thead>
</table>

The Ohio State University

Raj Jain
OSI vs TCP Reference Models

- OSI introduced concept of services, interface, protocols. These were force-fitted to TCP later. ⇒ It is not easy to replace protocols in TCP.
- In OSI, reference model was done before protocols. In TCP, protocols were done before the model.
- OSI: Standardize first, build later
  TCP: Build first, standardize later
- OSI took too long to standardize. TCP/IP was already in wide use by the time.
- OSI become too complex.
- TCP/IP is not general. Ad hoc.
Layered Packet Format

- Nth layer control info is passed as N-1th layer data.

![Layered Packet Format Diagram]

FTP Data
FTP Header
TCP Data
TCP Header
IP Data
IP Header
Ethernet Data
Ethernet Header
Ethernet Trailer

The Ohio State University
Raj Jain

2-18
Summary

- Communication, Networks, and Distributed systems
- ISO/OSI’s 7-layer reference model
- TCP/IP has a 4-layer model
- PDU, SAP, Request, Indication
Reading Assignment

- Read Sections 1.4, 1.5, Appendix 1A, 1B, Sections 2.2, and 2.3 of Stallings 6th Edition
  - 1.4 Protocols and Protocol Architecture
  - 1.5 Standards
  - Appendix 1A: Standards organizations
  - Appendix 1B: Internet Resources
  - 2.2 OSI
  - 2.3 TCP/IP
Homework

- Visit www.ietf.org and find the titles of RFC1 and RFC137
- Check newsgroup comp.protocols.tcp-ip and list any one of the current issues being discussed there
- Submit answers to Problems 2.4 and 2.7 of Stallings 6th Edition
  - Problem 2.4: Communications between France and China
  - Problem 2.7: Segmentation and Blocking