Introduction to Networks

CS587X Lecture 1
Fall, 2002

OSI 7-Layer Model

- Well-defined tasks for each layer
- Each layer depends on the services of the layer below
- Operating systems typically implement lower layers
- 7 Layers

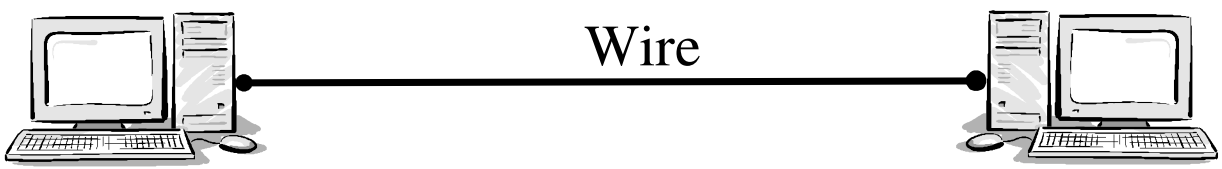
Application
Presentation
Session
Transport

Network
Link
Physical

Physical Layer

- Hardware (electrical/optical/mechanical)
- Usually the domain of electrical engineers
- Data transferred as electrical, optical, or other signals
  - Network interface devices
    - NIC, UART, modem, DSU/CSU
  - Copper or fiber optic cable
  - Carrier pidgeon
- Errors may occur

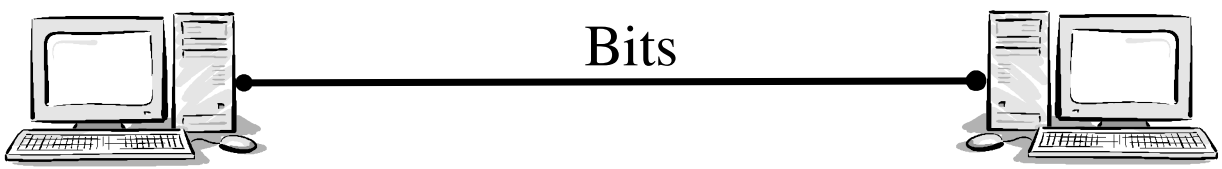
Physical



Link Layer

- Groups data together into frames
  - Special sequences mark start of frame and end of frame
- May provide error detection
  - Checksum, CRC
  - Erroneous frames are discarded
- Connects and addresses two or more hardware devices
  - Addresses are hardware-specific and local to the link

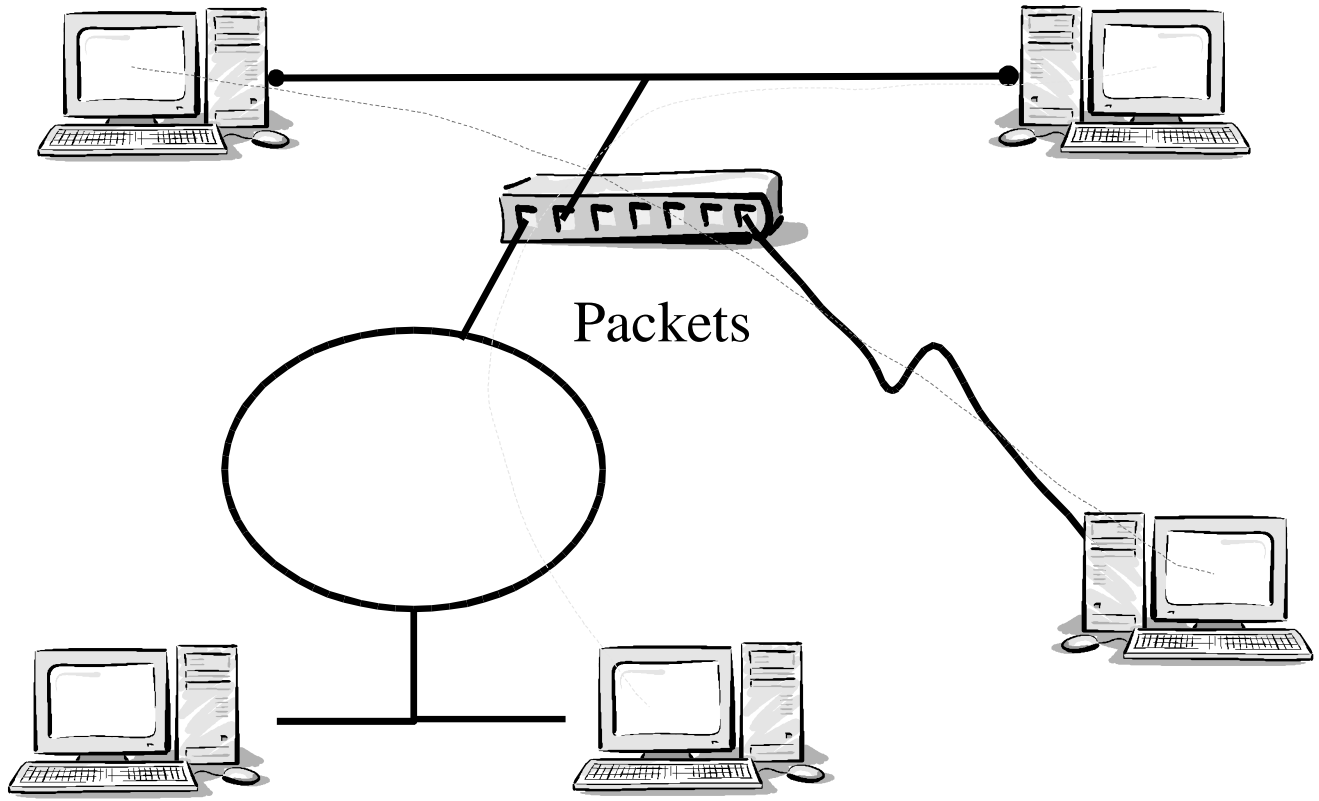
Link



Network Layer

- Data grouped into “packets”
- Network-uniform addresses
  - Requires translation to link-layer addresses
- Packets can be routed between different links
  - E.g., Packets can be routed from Ethernet to PPP to Token Ring to FDDI

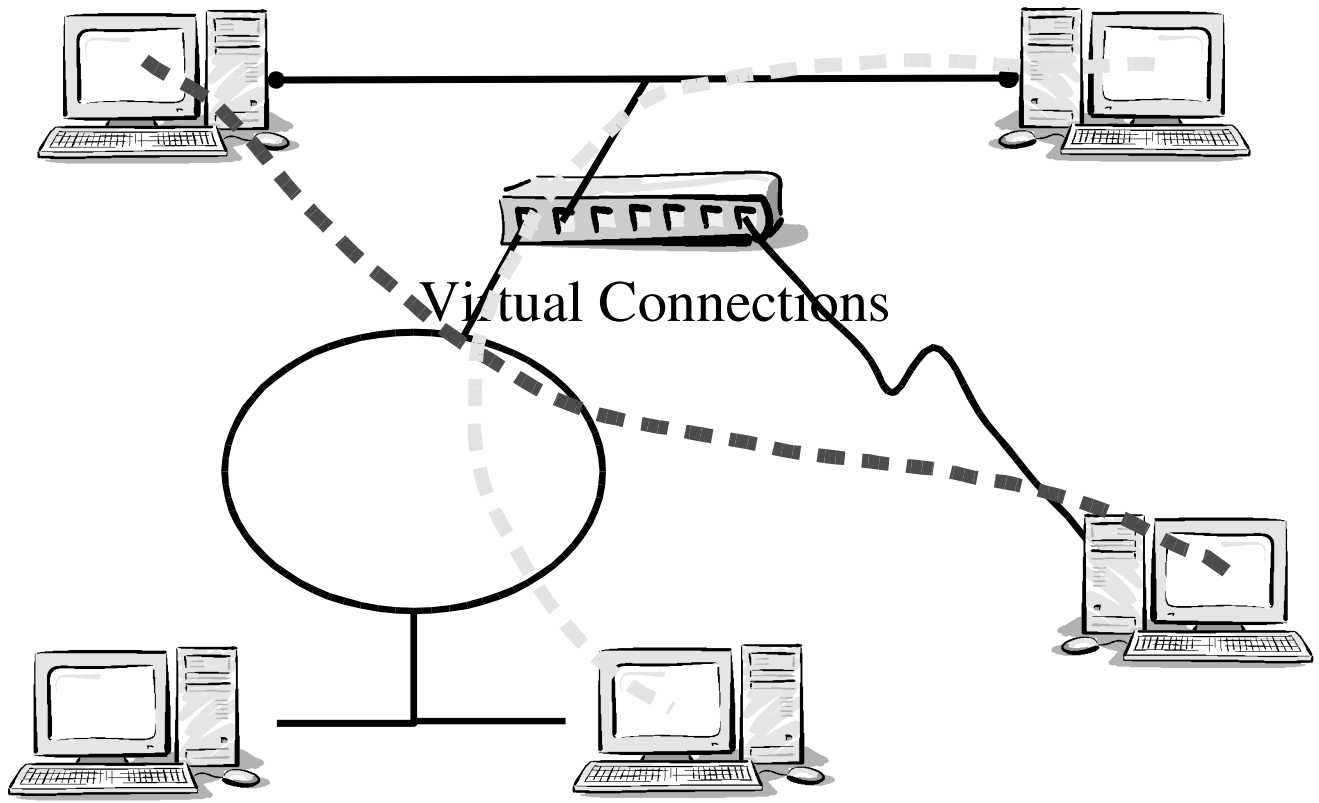
Network



Transport Layer

- Error detection and correction
- Flow control
- Lowest layer to which application programs are typically written

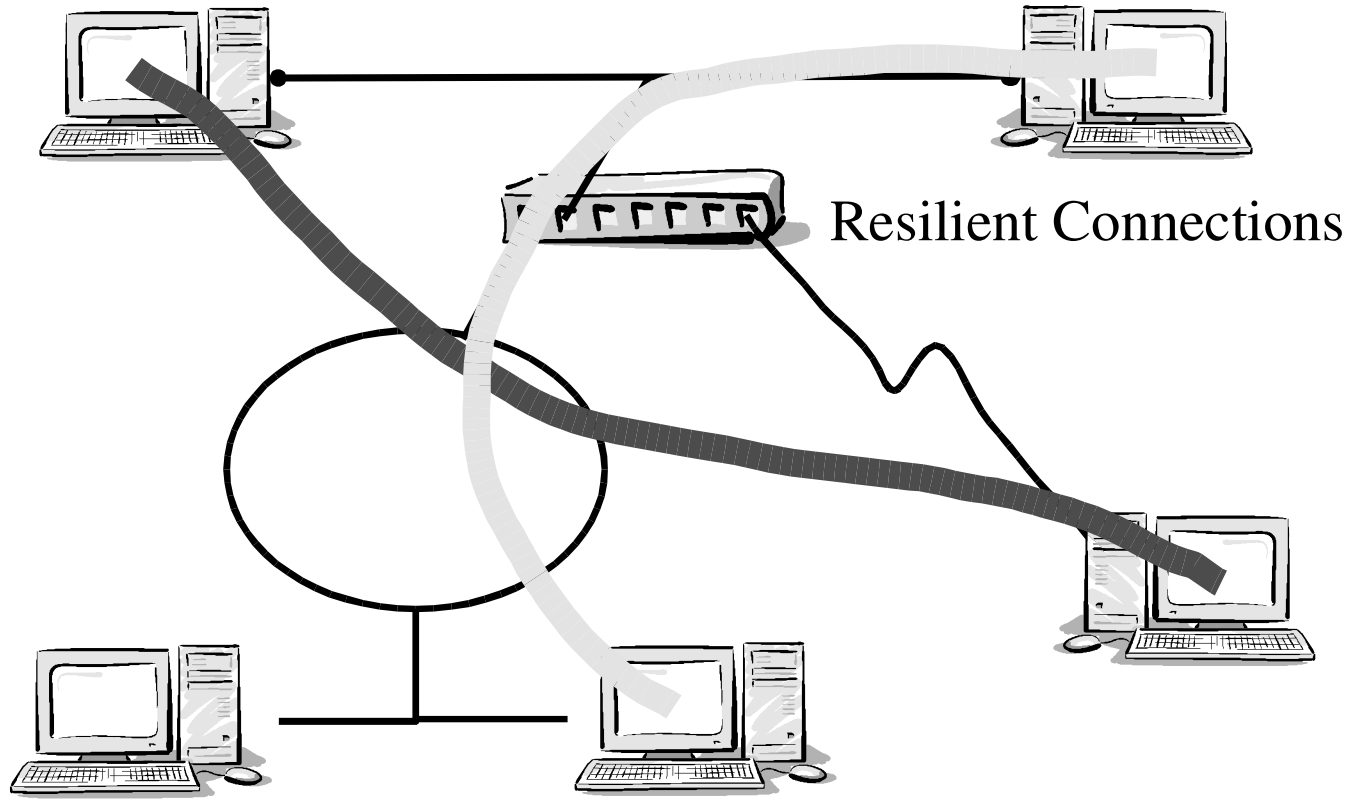
Transport



Session

- Application to application data exchange
- Session
  - Establishment
  - Synchronization
  - Re-establishment

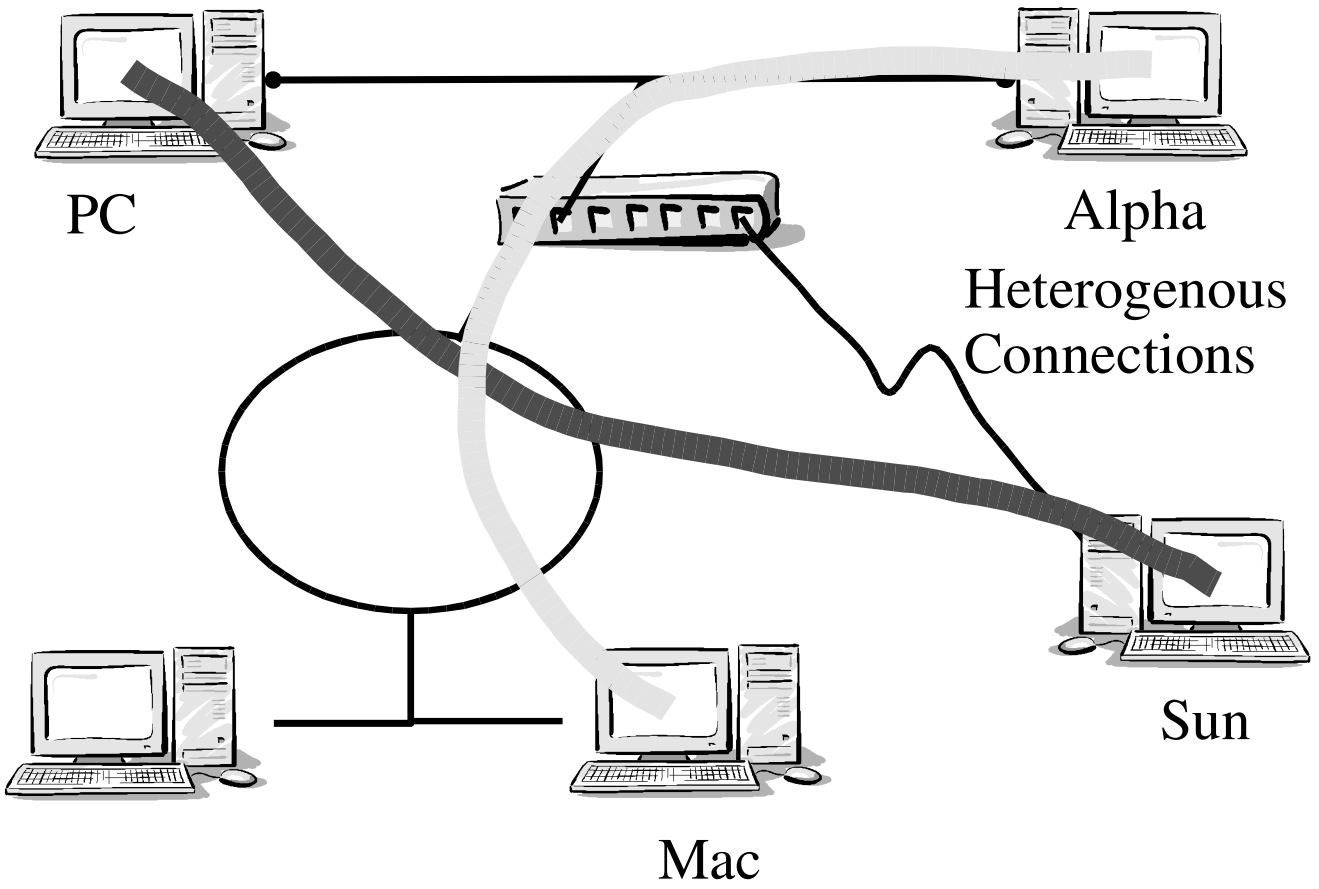
Session



Presentation Layer

- Data representation and conversion
  - Character representation
    - ASCII
    - UTF-8
    - Unicode
  - Integer representation
    - Little-endian
    - Big-endian
    - 32-bit vs. 64-bit
  - Floating point representation
    - IEEE 754
    - VAX
- Data compression

Presentation



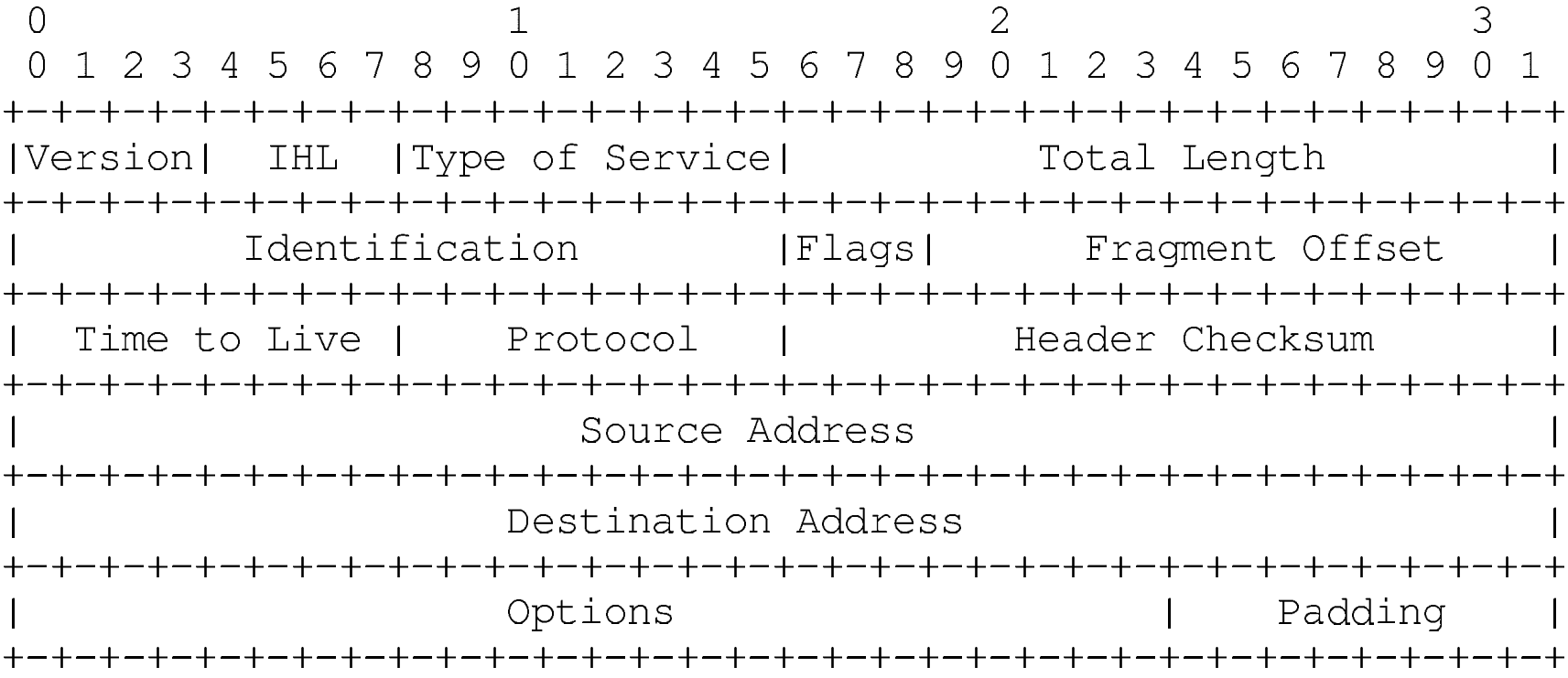
Internet

- Resource sharing
- Hardware and software independence
- Reliability and robustness
- Simple, efficient protocols
- Distributed management and control

IP Protocol

- Layer 3 protocol
- Packet-switched network
  - Each packet routed independently
  - 0 to 65515 bytes of payload
  - Only the header is checksummed
  - Best-effort delivery
- Not generally available to users
  - Raw socket access to privileged users in UNIX

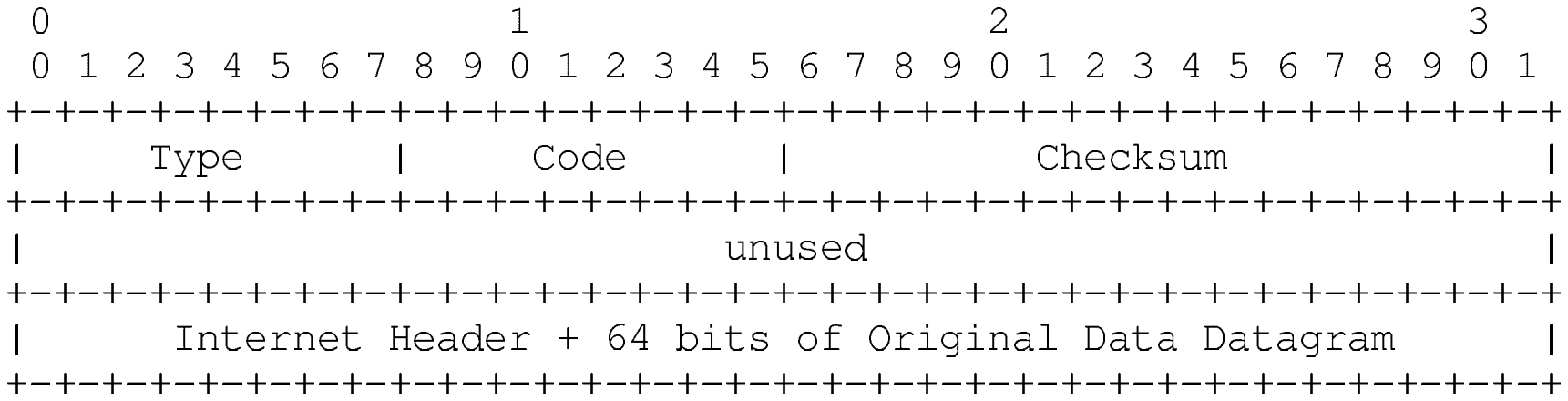
IP Header


0 1 2 3
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
Version
IHL
Type of Service
Total Length
Identification
Flags
Fragment Offset
Time to Live
Protocol
Header Checksum
Source Address
Destination Address
Options
Padding

ICMP

- Internet Control Message Protocol
- Network-layer info & error messages
- Errors:
  - Destination unreachable, bad parameter, redirect, source quench, time exceeded
- Information:
  - Echo, echo reply, address mask, address mask reply
- ICMP not generally available to users
- Example: ping

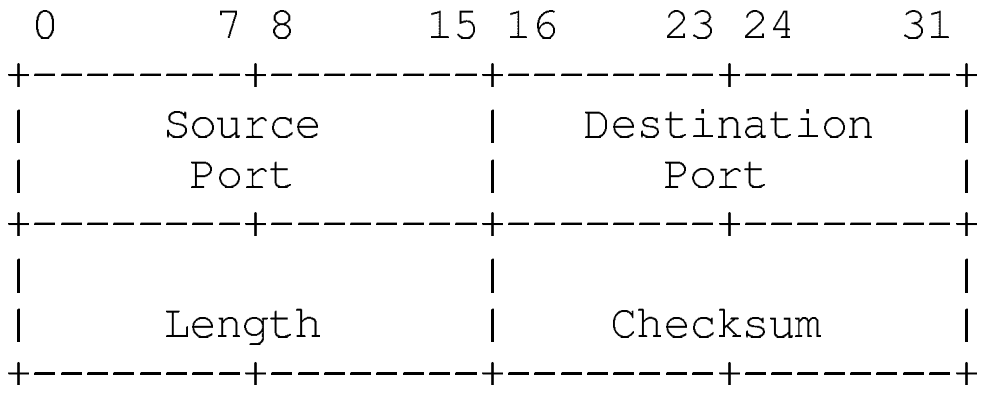
ICMP Header (Typical)



UDP

- Unreliable datagram protocol
- Layer 4 (Transport)
- Add port identification numbers and payload checksum to IP
  - Ports allow multiplexing of data streams
- Low overhead
- Typically used for latency-sensitive or low-overhead applications
  - Video
  - Time
  - DNS

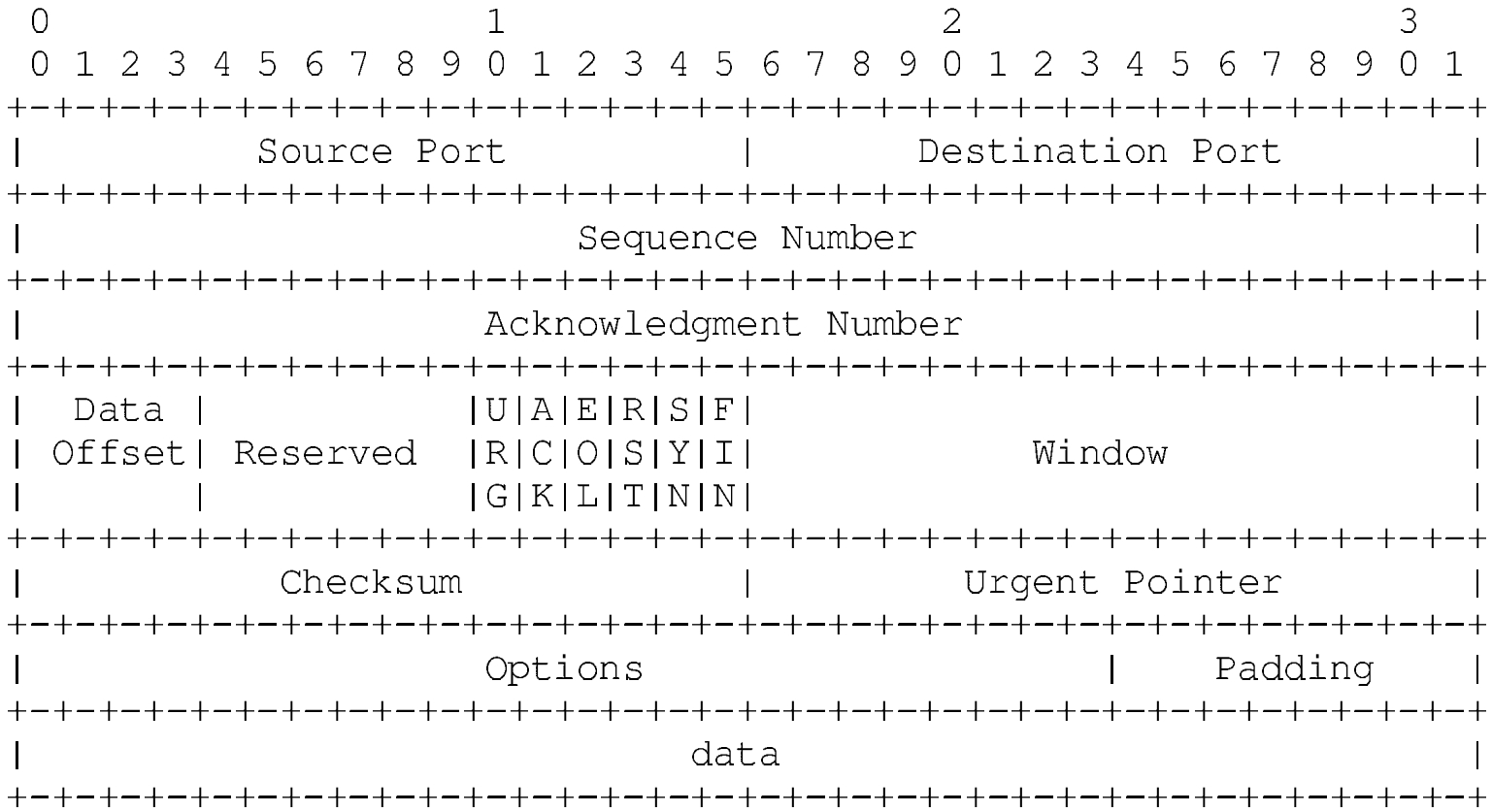
UDP Header


0 7 8 15 16 23 24 31
Source Port
Destination Port
Length
Checksum

TCP

- Transmission Control Protocol
- Layer 4 (Transport)
- Reliable, ordered byte stream
- Port numbers, like UDP
- Checksums payload
- Flow control
  - Sensitive to packet loss and round-trip time
- Error recovery
  - Retransmission of lost or corrupted packets
- High-throughput
  - Windowed with piggy-back acknowledgment

TCP Header


0 1 2 3
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
Source Port
Destination Port
Sequence Number
Acknowledgment Number
Data Offset
Reserved
U R G
A C K
E O L
R S T
S Y N
F I N
Window
Checksum
Urgent Pointer
Options
Padding
data

Internet Applications

- Telnet
- FTP
- SMTP
- POP3
- IMAP
- HTTP
- Finger
- NNTP
- Whois

Internet Security

- Security originally left to Application Layer
- IPsec
- SSL/TLS
- Firewalls
  - Perimeter security
  - Filter packets by IP protocol, IP address, UDP/TCP port, and/or application data
- Proxies
  - Controls user access to external resources
  - Authenticate end users
  - Limit user access to certain protocols & systems

Summary

- Introduction to networks
- OSI 7-layer model
- Internet Protocols: IP, ICMP, UDP, TCP, applications
- Brief intro to security