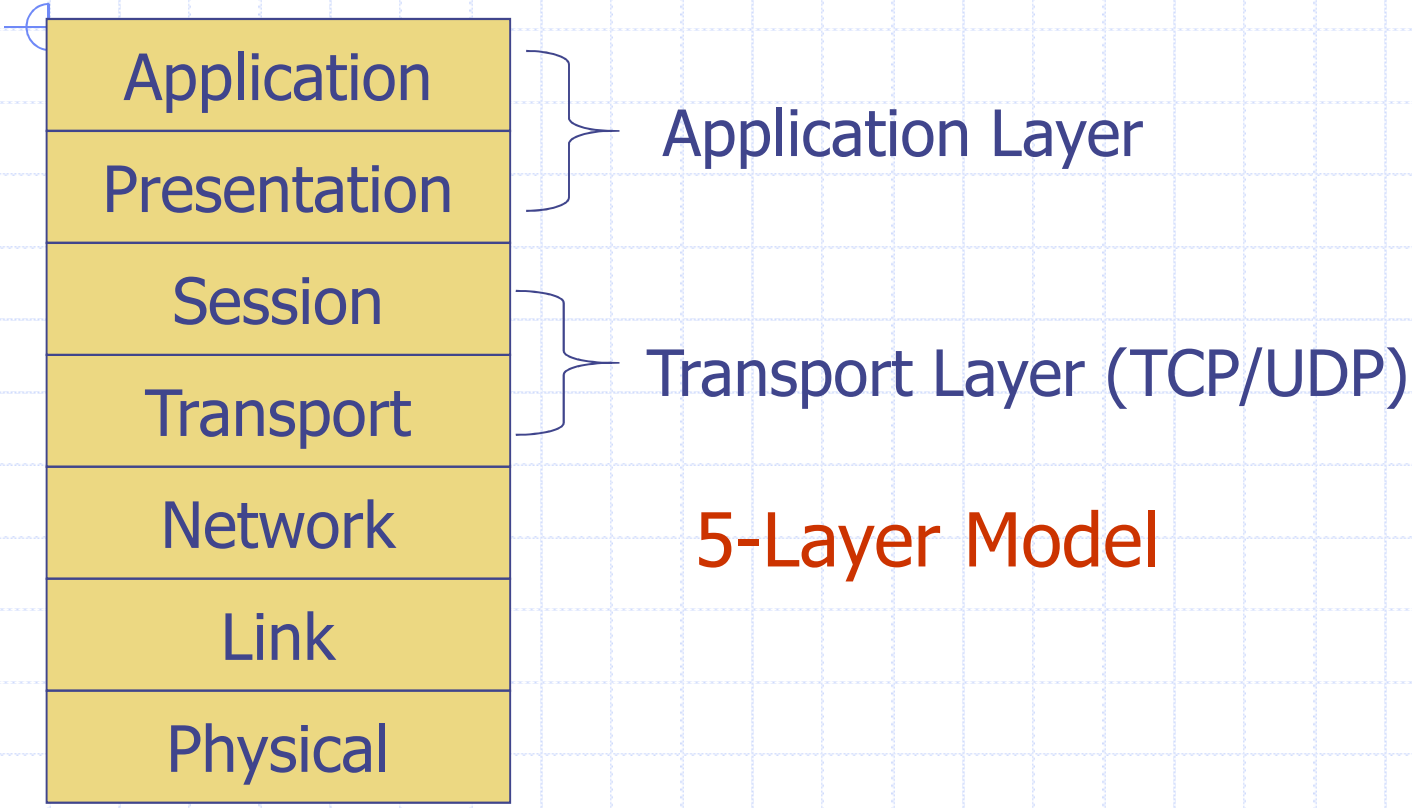
Introduction to Networks

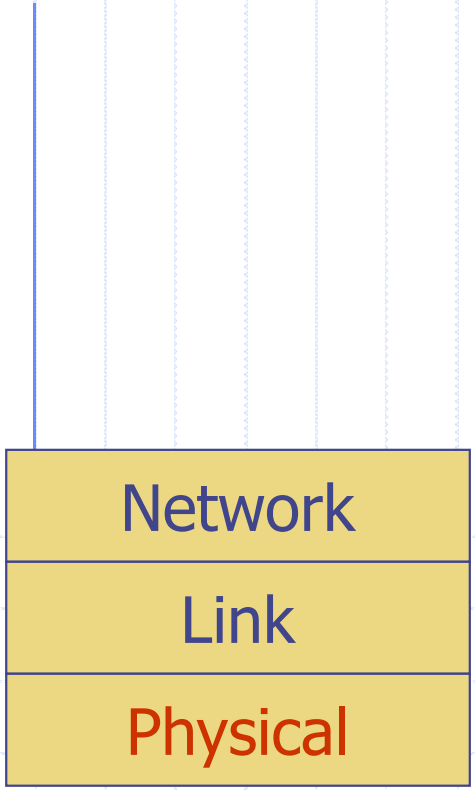
CS587x Lecture 1
Department of Computer Science
Iowa State University

Network Basics

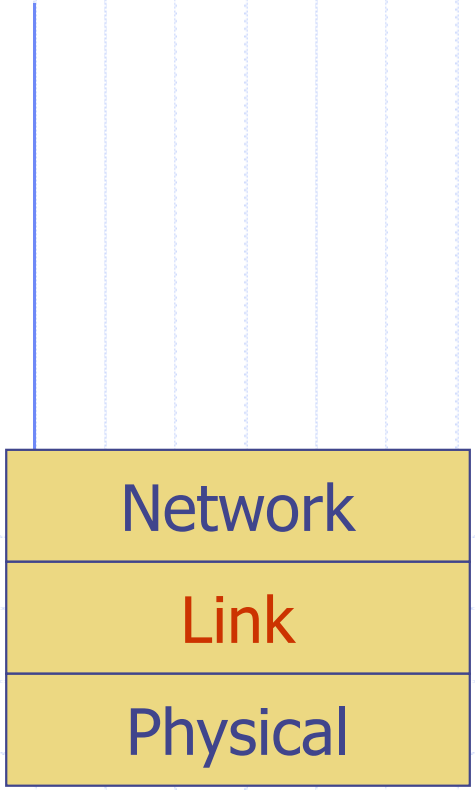
OSI 7-Layer Model



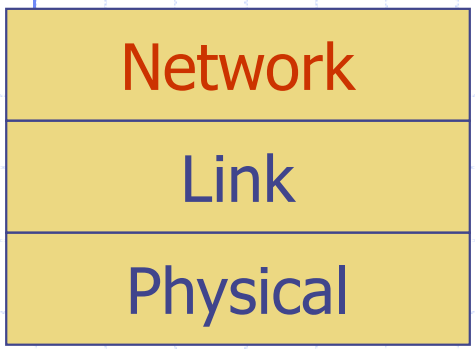
5-Layer Model



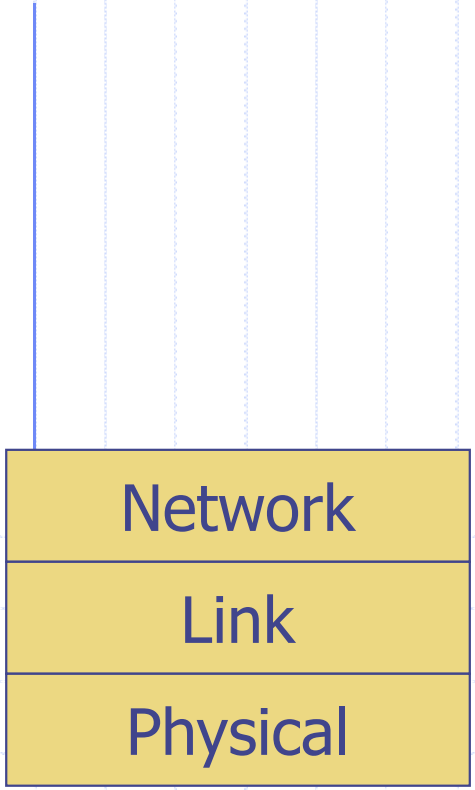
- Bit
  - Communication media (copper, fiber, air, etc.)
  - Signal processing (0/1 representation, speed, etc.)



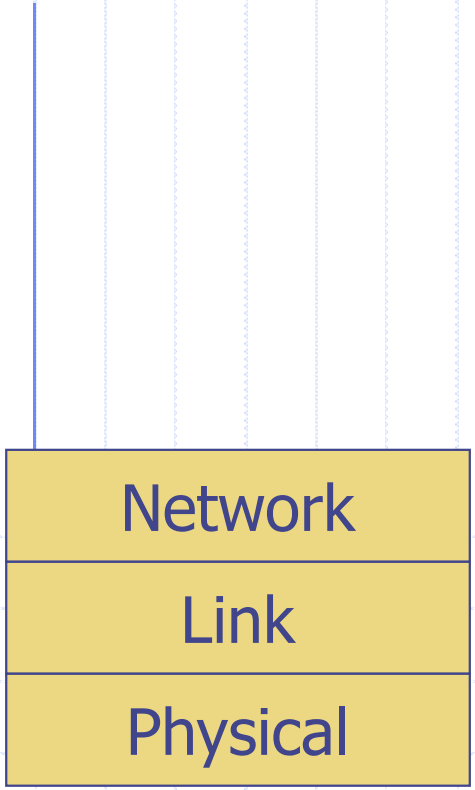
- Frame
  - Typically contains a few hundreds of bytes
  - Special mark for start and end of each frame
  - Checksum error detections
  - Erroneous frames can be discarded or retransmitted



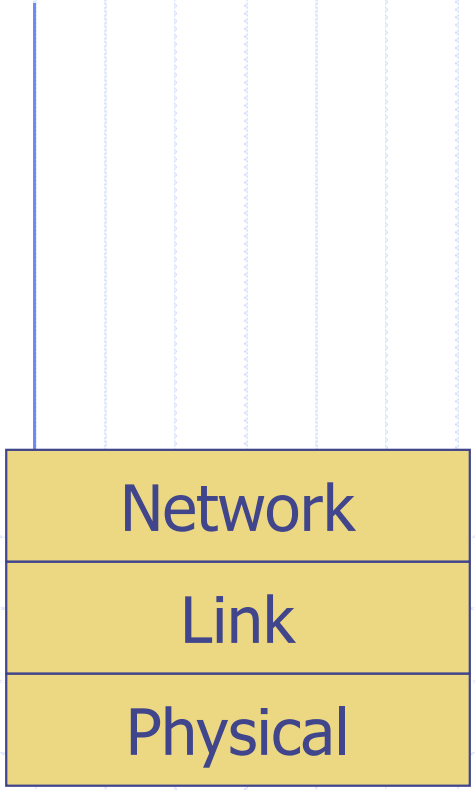
- Packets, also known as datagram
  - Packet routing and congestion control
- Challenges of path finding
  - Network heterogeneity
    - e.g., from Ethernet to Token Ring to FDDI
  - Multi-hop
    - A data packet may have to go several hops before reaching its destination
  - Multi-path
    - The shortest route is not always the best route
    - What really matters is the amount of delay on a given route



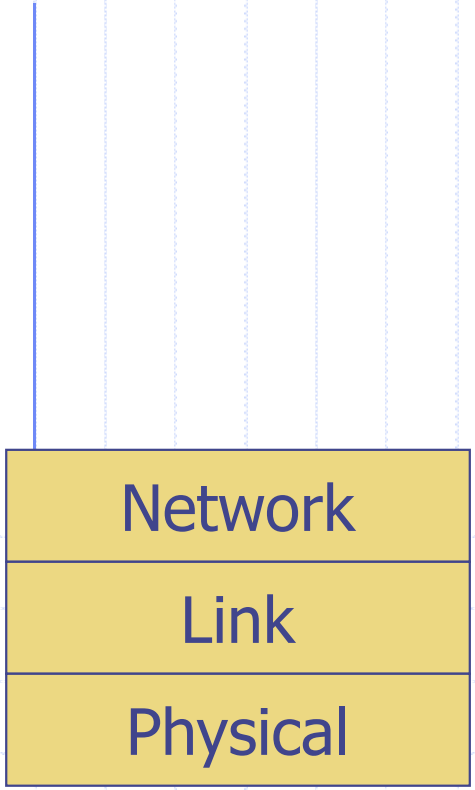
- Data stream
  - Provide a virtual tunnel for end-to-end connection
- Flow control
  - Partition data into packets and assign each one a sequence number
  - Provide service to assemble the received packets back into their original order
  - Error detection and correction
- Lowest layer to which application programs are typically written



- Enable data exchange between application to application
  - Establishment
  - Synchronization
  - Re-establishment

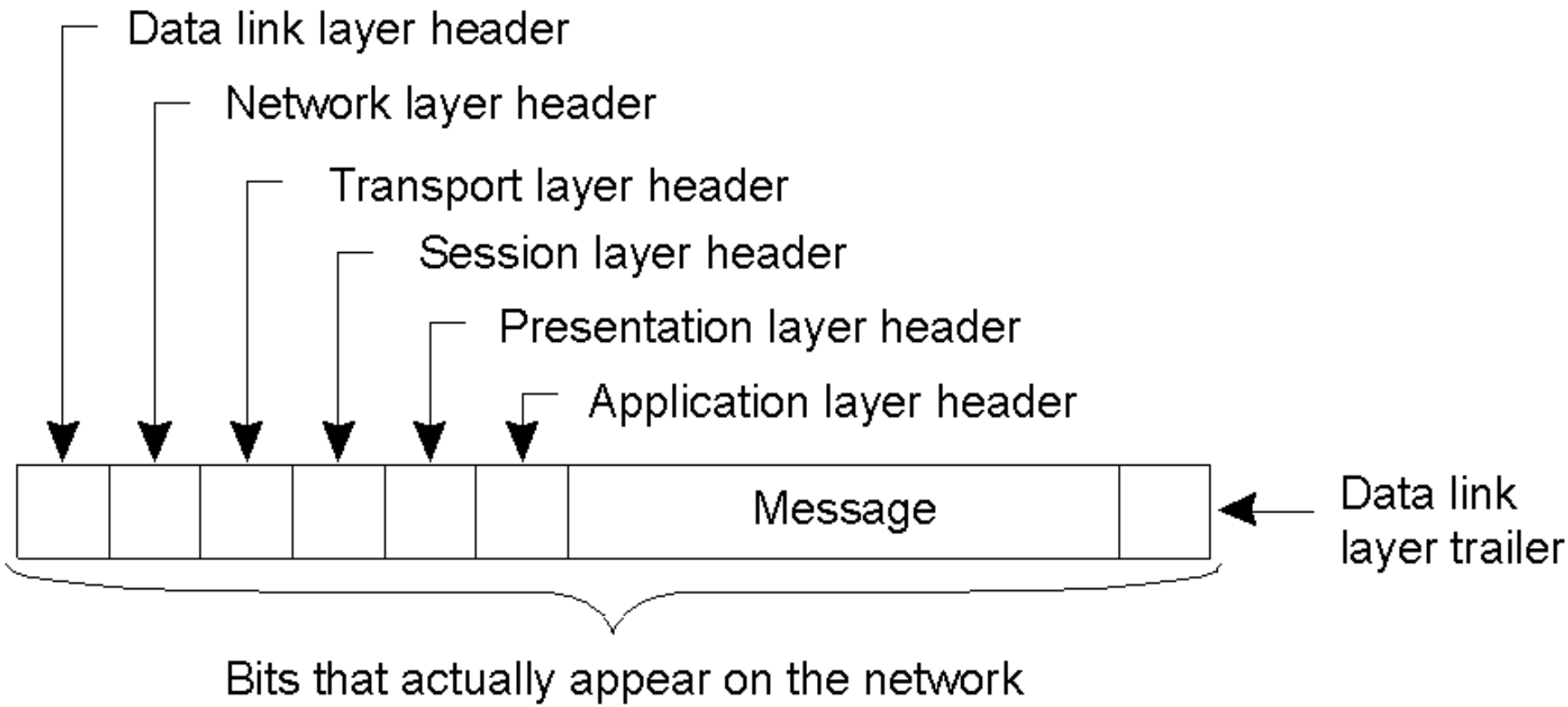


- Data representation and conversion
  - Character representation
    - ASCII, UTF-8, or Unicode
  - Integer representation
    - Little/Big-endian, 32/64-bit
  - Floating point representation
    - IEEE 754, VAX
- Data compression/decompression



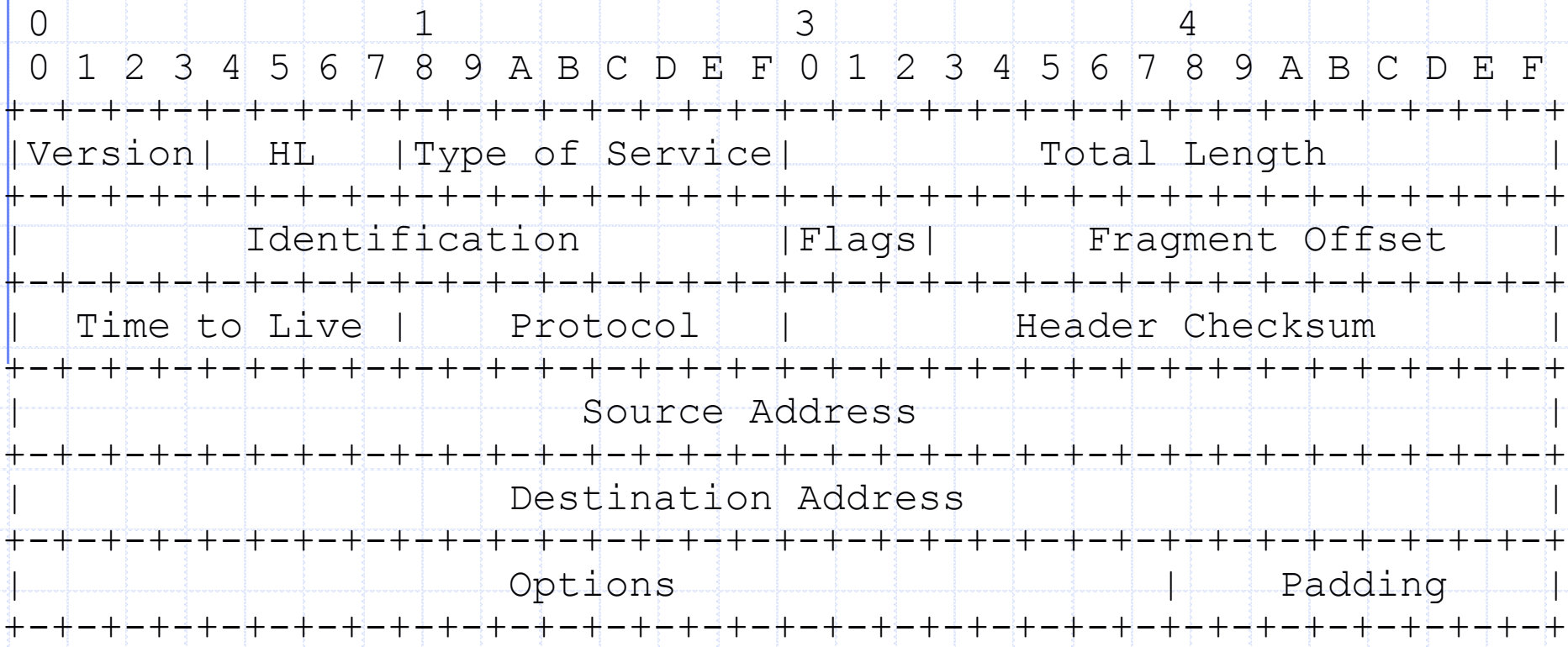
- Dictate the semantics of how requests for services are made, such as requesting a file or checking for email.
- The container for all applications and protocols
  - Telnet, HTTP, POP, SMTP, Finger, FTP, etc.
- Virtually all distributed systems are applications
- In Java, almost all network software written will be for the application.

OSI 7-Layer Model



- An implementation of network layer
  - Designed for packet-switched network
    - Each packet contains no more than 64K bytes
  - Connectionless
    - Each packet is routed independently with sender and receiver address (what is the advantage?)
  - Best-effort
    - Packets could be discarded during transmission because of the exhaustion of resources or a failure at the data link or physical layer
  - Unreliable
    - Reliability is ensured at higher layer, such as TCP

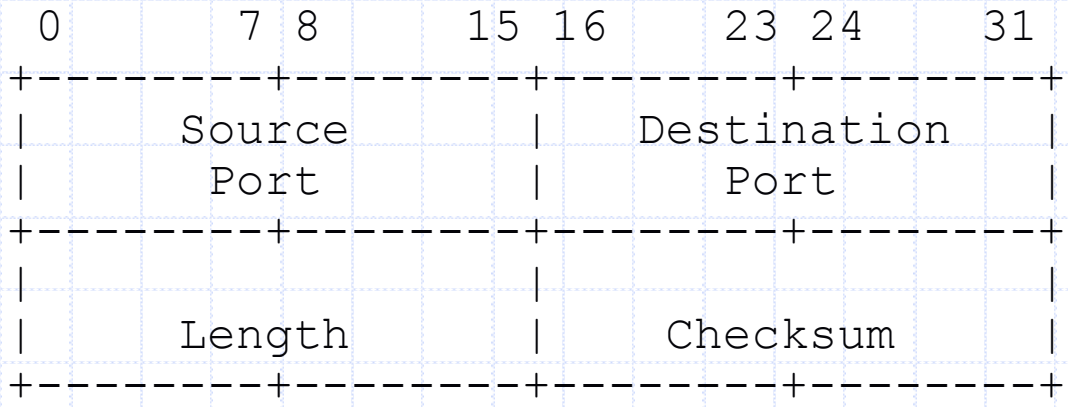
IP Header


0 1 3 4
0 1 2 3 4 5 6 7 8 9 A B C D E F 0 1 2 3 4 5 6 7 8 9 A B C D E F
Version
HL
Type of Service
Total Length
Identification
Flags
Fragment Offset
Time to Live
Protocol
Header Checksum
Source Address
Destination Address
Options
Padding

- Version: 4 bits
  - helps smooth the transition to future version of IP
- Header length: 4 bits
  - limits the header to 15 * 32bits = 60 bytes
- Type of Service: 4 bits
  - Specify a tradeoff between fast service and reliable service, not commonly used
- Total length: 16 bits
  - Limits each packet to 64K bytes
- Time-To-Live (TTL): 8 bits
  - limit the life of the packet on the network
    - Initialized to thirty
    - Decremented each time the packet arrives at a routing step
    - Discarded when it is equal to 0
- Identification (16 bits), Flags (3 bits), and Fragment Offset (13 bits)
  - Partition a datagram into packet if it is too large
    - Each packet must be no larger than 64K
    - The maximum number of fragments per datagram is 8192

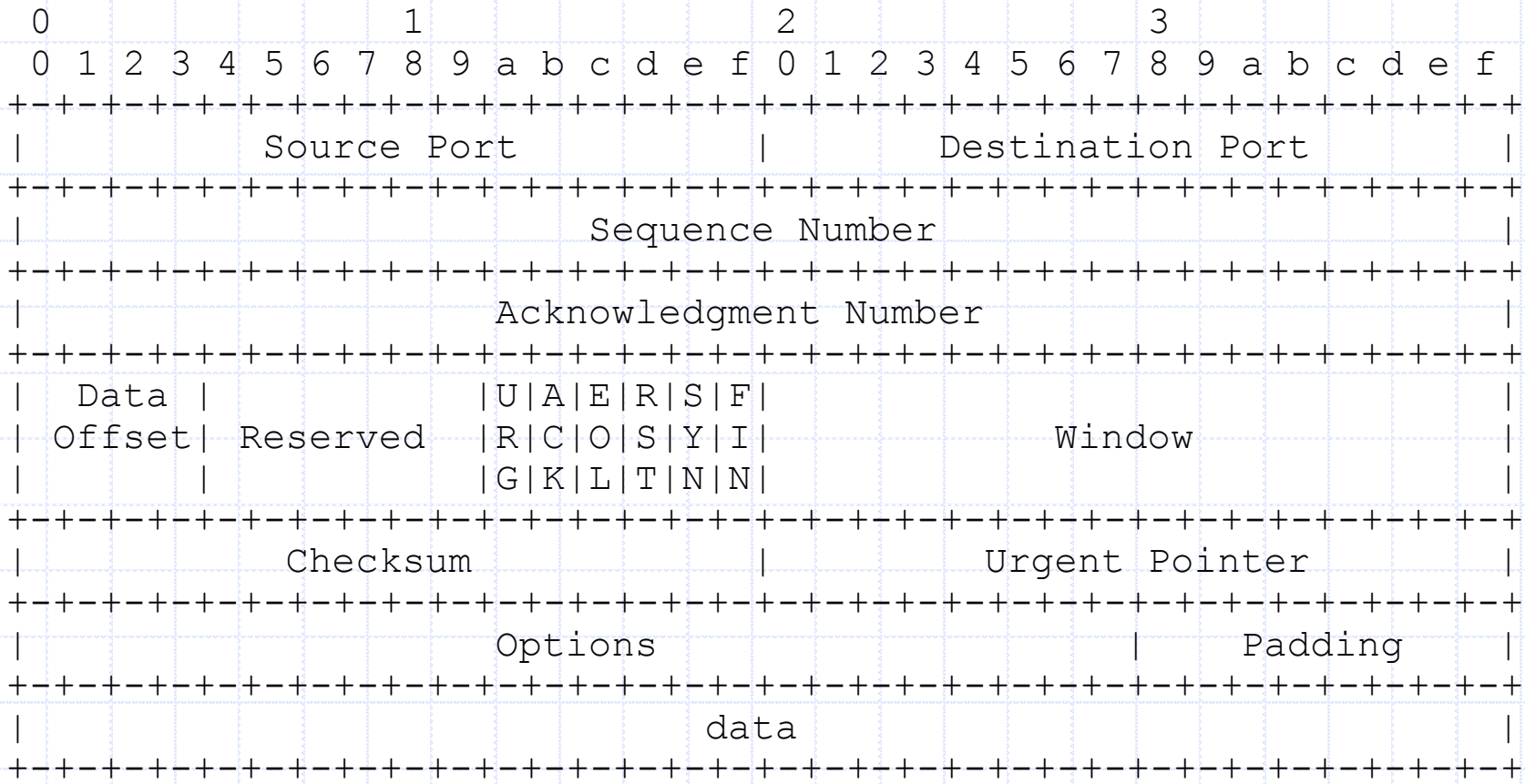
- An implementation of transport layer on top of IP
- Unreliable data transmission
  - No guaranteed on delivery
  - Packets could be received out of order
- Add port identification numbers and payload checksum to IP
  - Ports allow multiplexing of data streams
- Highly efficient because of low overhead
  - Suitable for delivering data that is small amount and needs to be sent frequently
  - Typically used for latency-sensitive or low-overhead applications (video, time, DNS, etc.)

UDP Header


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

- An implementation of transport layer on top of IP
- Reliable data transmission that can be used to send a sequence of bytes
  - Provide guaranteed delivery and ordering of bytes, i.e., data are always received in their original order
- Port numbers, like UDP
- Checksums payload
- Flow control
  - Sensitive to packet loss and round-trip time
- Error recovery: retransmit lost/corrupted packets

TCP Header


0 1 2 3
0 1 2 3 4 5 6 7 8 9 a b c d e f 0 1 2 3 4 5 6 7 8 9 a b c d e f
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

- Resource sharing between networks
  - Information sharing
  - Computing resource sharing
- Hardware and software independence
  - Interoperable with any CPU architecture, operating system, and network interface card
- Reliability and robustness
  - Data can be rerouted if necessary in order to reach its destination, regardless of the state of intermediary networks
- Distributed management and control