MODULE 11: The Internet Protocol Suite

Lecture 11.1
Transmission Control Protocol (TCP)

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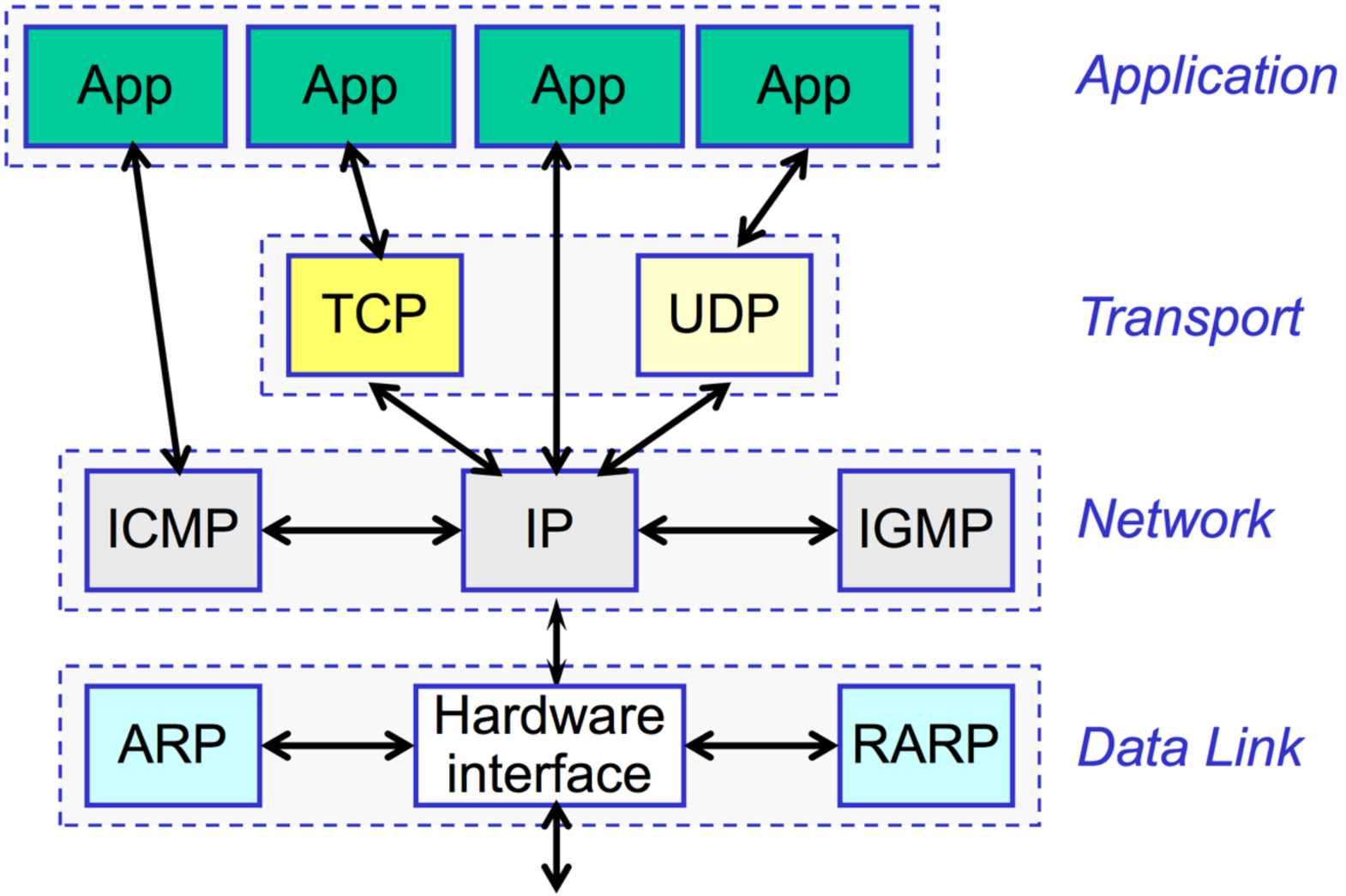
Lecture 11.1 Objectives

- Describe the TCP service and its role in the TCP/IP protocol suite
- Provide an overview of TCP's functions, including multiplexing, error recovery, and flow and congestion control
- Describe the motivation for TCP connection establishment
- Show the TCP segment format

IP Layering



Overview of TCP

- TCP provides connection-oriented, reliable, byte-stream service
- TCP performs typical transport layer functions
  - Segmentation – breaks message into segment, and merges messages to form larger segments
  - Error recovery – built on top of unreliable IP service
  - End-to-end flow control – to avoid buffer overflow at the receiver
  - Congestion control mechanism – to avoid sending too much data into the network
  - Multiplexing and demultiplexing of application sessions

TCP Service

- Reliable
- Connection-oriented – virtual circuit service
- Full duplex – concurrent transfers can take place in both directions
- Stream-oriented – users exchange streams of data bytes
- Buffered – TCP accepts data and transmits when appropriate

TCP Addressing and Multiplexing

- TCP identifies connections as socket pairs
  - Socket address includes Internet address plus a port
  - Host Internet address provided to IP
  - Port uniquely identifies user or process ID on the host
- Example:
  - A connection to port 21 on 128.173.92.96 connects to an FTP server on the designated host
  - Port 21 is the “well known” port number for FTP

Reliable Data Transfer

- TCP is built on IP, an unreliable datagram service
  - IP can lose datagrams
  - IP can deliver datagrams out of order
- TCP uses a “sliding window” mechanism for error recovery
  - Operates at the byte level rather than on packets
  - Bytes are numbered sequentially
  - At most W outstanding (un-acknowledged) bytes at any one time
  - Sender will retransmit data if no ACK is received within a variable timeout period

TCP Flow Control

- Prevents sender from “swamping” receiver with data
  - Typical problem is a fast server sending data to a slow client
- TCP provides end-to-end flow control by varying the size of the sliding window
  - Limits amount of data that can be sent without an acknowledgment
  - Can lead to significant performance problems in high- bandwidth, high-latency networks

CHECK POINT

As a checkpoint of your understanding, please pause the video and make sure you can do the following:

- Describe the TCP service and its role in the TCP/IP protocol suite
- Provide an overview of TCP's flow control, multiplexing, and error recovery functions

If you have any difficulties, please review the lecture video before continuing.

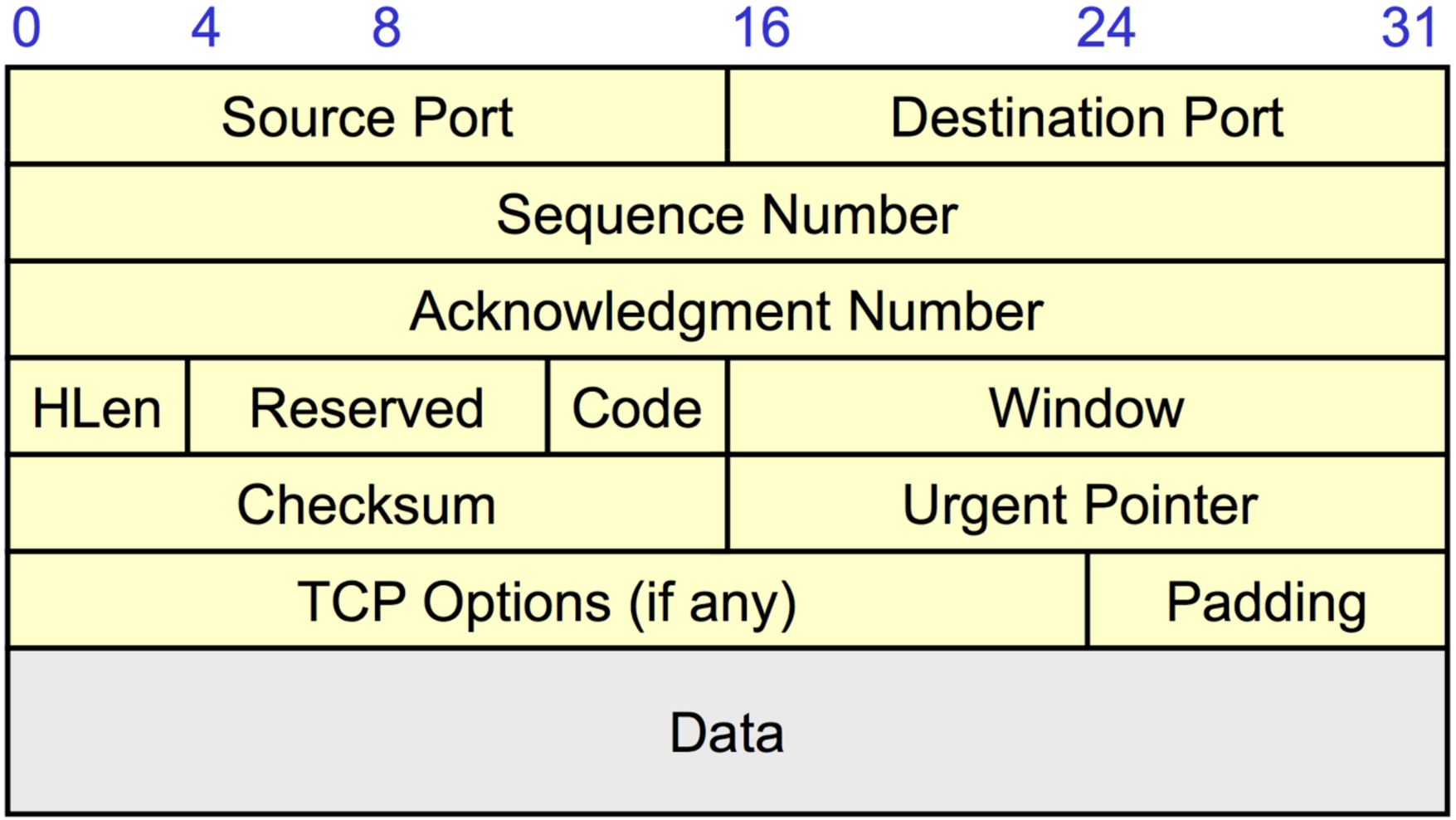
TCP Congestion Control

- Attempts to avoid or reduce congestion in the network
- Operates based on implicit feedback from the network
  - Segment delays
  - Lost segments
- Sender limits transmissions based on this feedback

TCP Connections

- TCP uses a “three-way handshake” (balanced protocol) to establish a connection
  - Either host can initiate a connection (or both can initiate a host simultaneously)
  - Peer-to-peer protocol
- Ensures that:
  - Both nodes are ready
  - Synchronizes per-byte sequence numbers needed for error recovery and flow control

TCP Segment Format



TCP: Selected Header Fields

- Source Port and Destination Port: identify applications at ends of the connection
- Sequence Number: position of the data in the sender's byte stream in bytes
- Acknowledgment Number: position of the byte that the source expects to receive next (valid if ACK bit set)
- Code Bits:
  - ACK acknowledgment
  - SYN, FIN used to set up and close a connection
- Header Length: header size in 32-bit units
- Window: advertised window size in bytes

CHECK POINT

As a checkpoint of your understanding, please pause the video and make sure you can do the following:

- Provide an overview of TCP's congestion control function
- Describe the motivation for TCP connection establishment
- Show the TCP segment format

If you have any difficulties, please review the lecture video before continuing.

Summary

- TCP provides transport layer services
- Connection-oriented, byte stream service
- Reliable service through use of a sliding window mechanism
- Connections are established using three-way handshake
- TCP segment format, including 20-byte header
- Specifies port numbers for multiplexing and demultiplexing
- Specifies sequence number, acknowledgement number, and window for error recovery and flow control

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