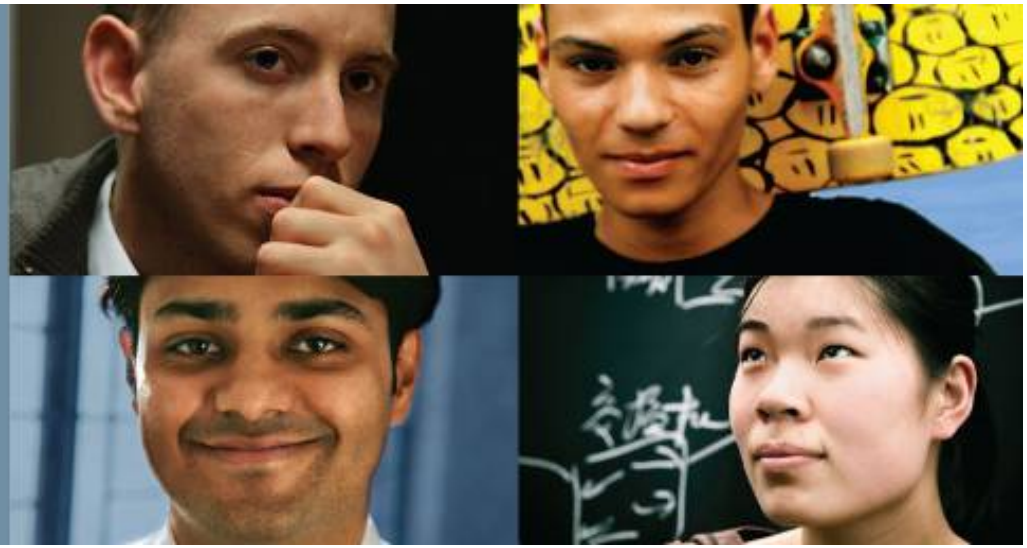
TNE10006/TNE60006: Networks and Switching



TCP Flow Control

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TCP Connection Establishment

Three Way Handshake

- Establishes that the destination device is available and has an active service on the destination port number
- Agrees on initial sequence numbers to use for actual transmission
- Happens before any data is transferred

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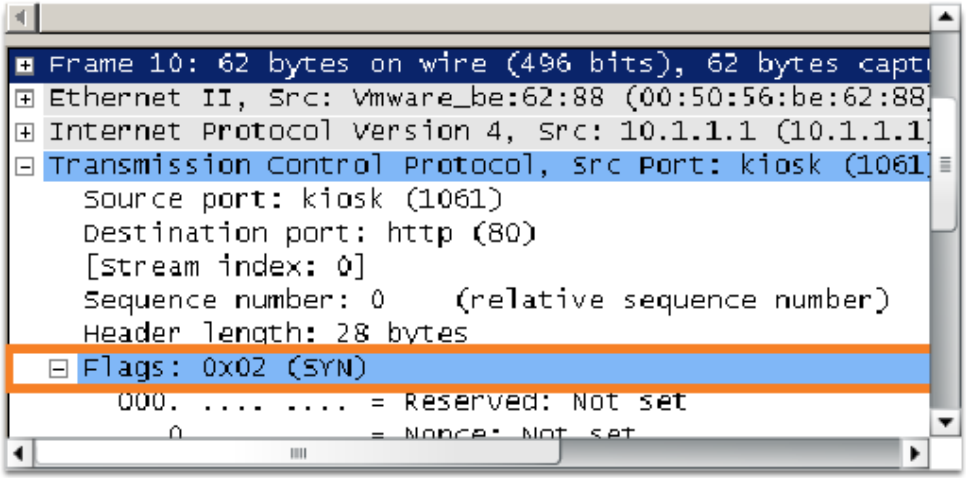
9.2.1.5 Video Notes - TCP 3-Way Handshake.pdf

TCP Connection Establishment

Three Way Handshake

TCP 3-Way Handshake (SYN)

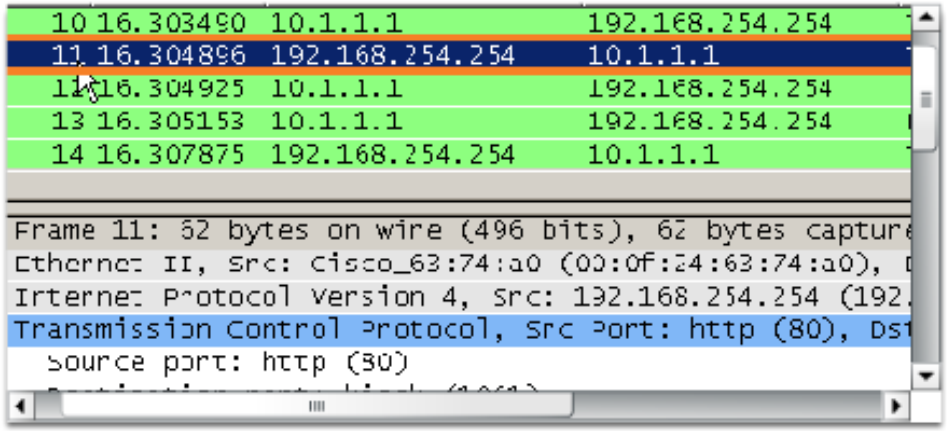


A protocol analyzer shows initial client request for session in frame 10

TCP segment in this frame shows:

- SYN flag set to validate an Initial Sequence Number
- Randomized sequence number valid (relative value is 0)
- Random source port 1061
- Well-known destination port is 80 (HTTP port) indicates web server (httpd)

TCP 3-Way Handshake (SYN, ACK)



A protocol analyzer shows server response in frame 11

- ACK flag set to indicate a valid Acknowledgement number
- Acknowledgement number response to initial sequence number as relative value of 1
- SYN flag set to indicate the Initial Sequence Number for the server to client session
- Destination port number of 1061 to corresponding to the clients source port
- Source port number of 80 (HTTP) indicating the web server service (httpd)

ACK

A protocol analyzer shows client response to session in frame 12

The TCP segment in this frame shows:

- ACK flag set to indicate a valid Acknowledgement number
- Acknowledgement number response to initial sequence number as relative value of 1
- Source port number of 1061 to corresponding
- Destination port number of 80 (HTTP) indicating the web server service (httpd)

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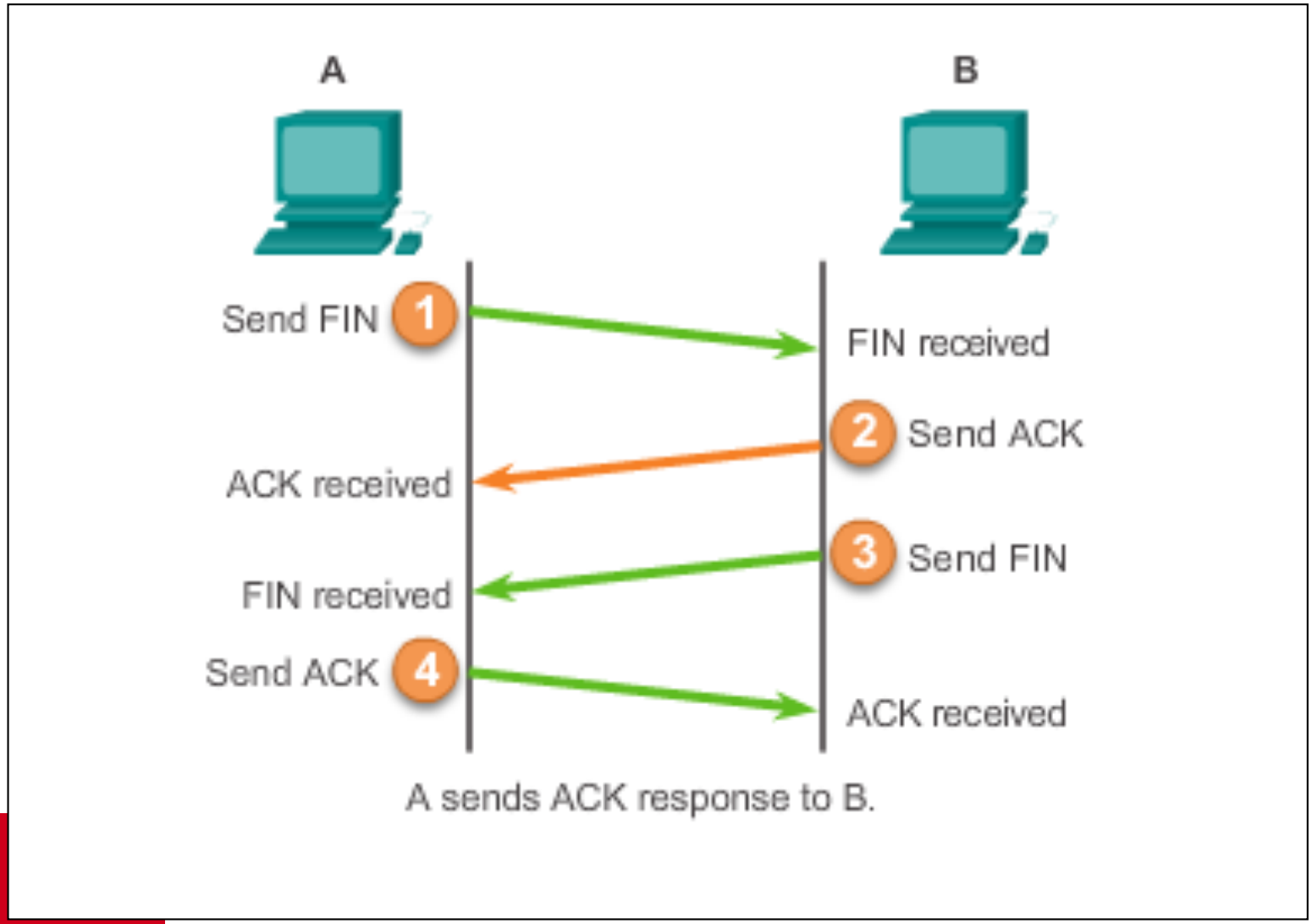
TCP Connection Termination

FIN-ACK Sequence



Sequence Numbers

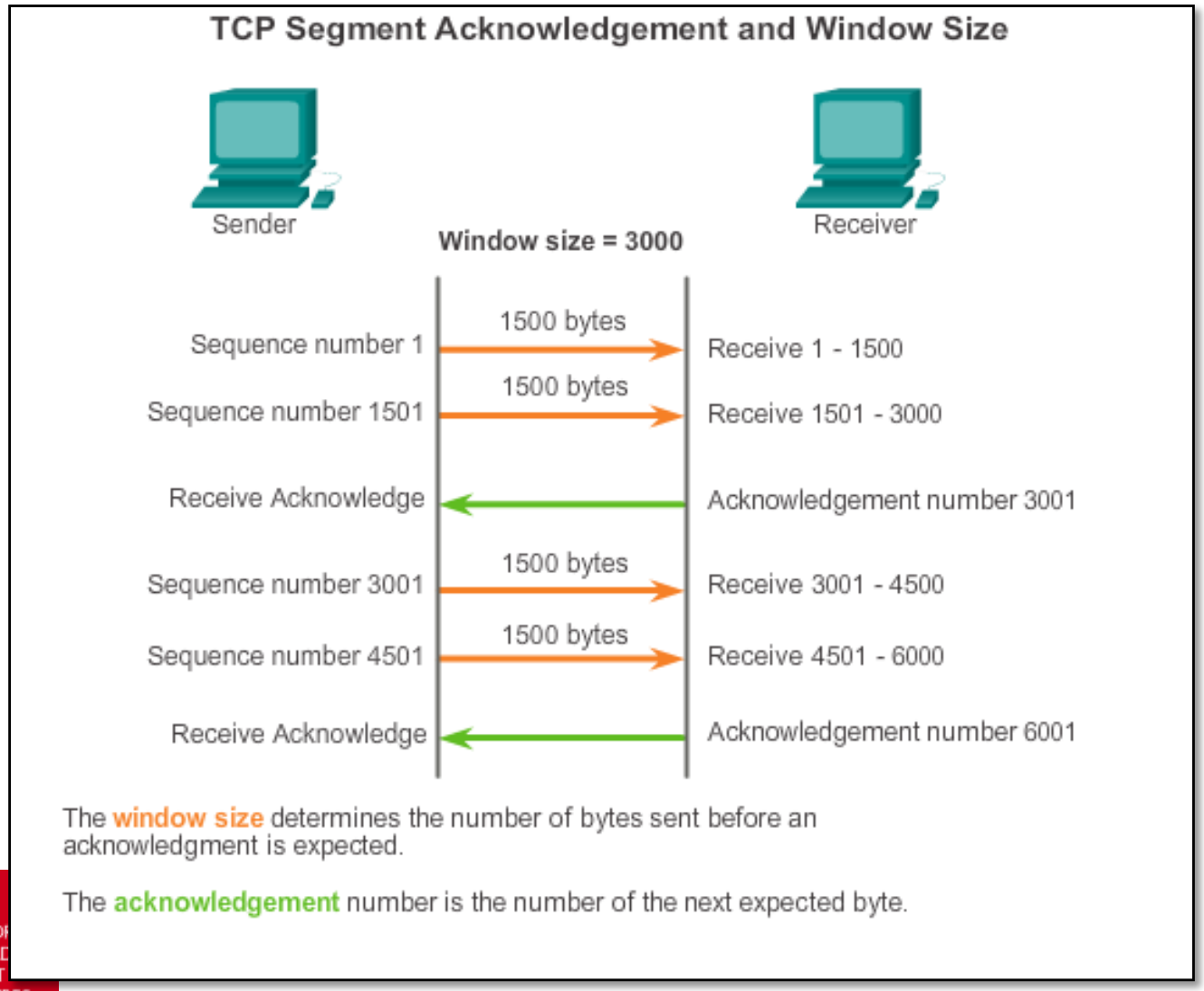
- Based on number of bytes transmitted not segments
  - Allows retransmitted segments to be larger or smaller
- Initial sequence numbers exchanged in SYN and SYN-ACK packets
  - Why aren't the initial sequence numbers 0?

Acknowledgement Numbers

- Positive Acknowledgement
  - Acknowledge next byte we are expecting
  - Do not acknowledge last byte received
  - Included in every packet, including those with data
- No acknowledgement is used as a signal of loss and data is retransmitted

Flow Control

Window Size



Unpredictable Transfer Times

- All data within the sliding window is available for immediate transmission
- A sliding window means:
  - Packets retransmitted late
  - Packets have to wait for transmission
- When applications sends data using TCP
  - Data is queued in the TCP stack
  - The stack segments the data and decides when to send
  - Transfer may not be as soon as possible

Flow Control

Sliding Window Size

- How do we determine the window size
  - High-bandwidth or long transmission delay links means more un-acknowledged segments can be in transit at the same time
  - We want to maximise throughput
- Window size too small
  - Network bandwidth not utilised
- Window size too large
  - Offering too much data concurrently
  - Queues will form
  - Packets will be dropped

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Flow Control

Adjustable Window

- Problem is addressed with a Window size that is adjustable
- Initially TCP was programmed to increase the Window size slowly and try to stop at the ideal size to maximise throughput
  - If segment are acknowledged, increase window size
  - As soon as first segment is dropped, fix window size
- This has problems

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Congestion Types

Receiver Congestion

- End-to-End Flow Control
- Receiver informs source of optimal sliding window size
- Receiver not swamped with more datagrams than it can handle

Network Congestion

- Handled by the Slow Start and Congestion Avoidance algorithms
- Protocol maintains a congestion window size
- This size is modified by the Slow Start and Congestion Avoidance algorithms in response to network congestion

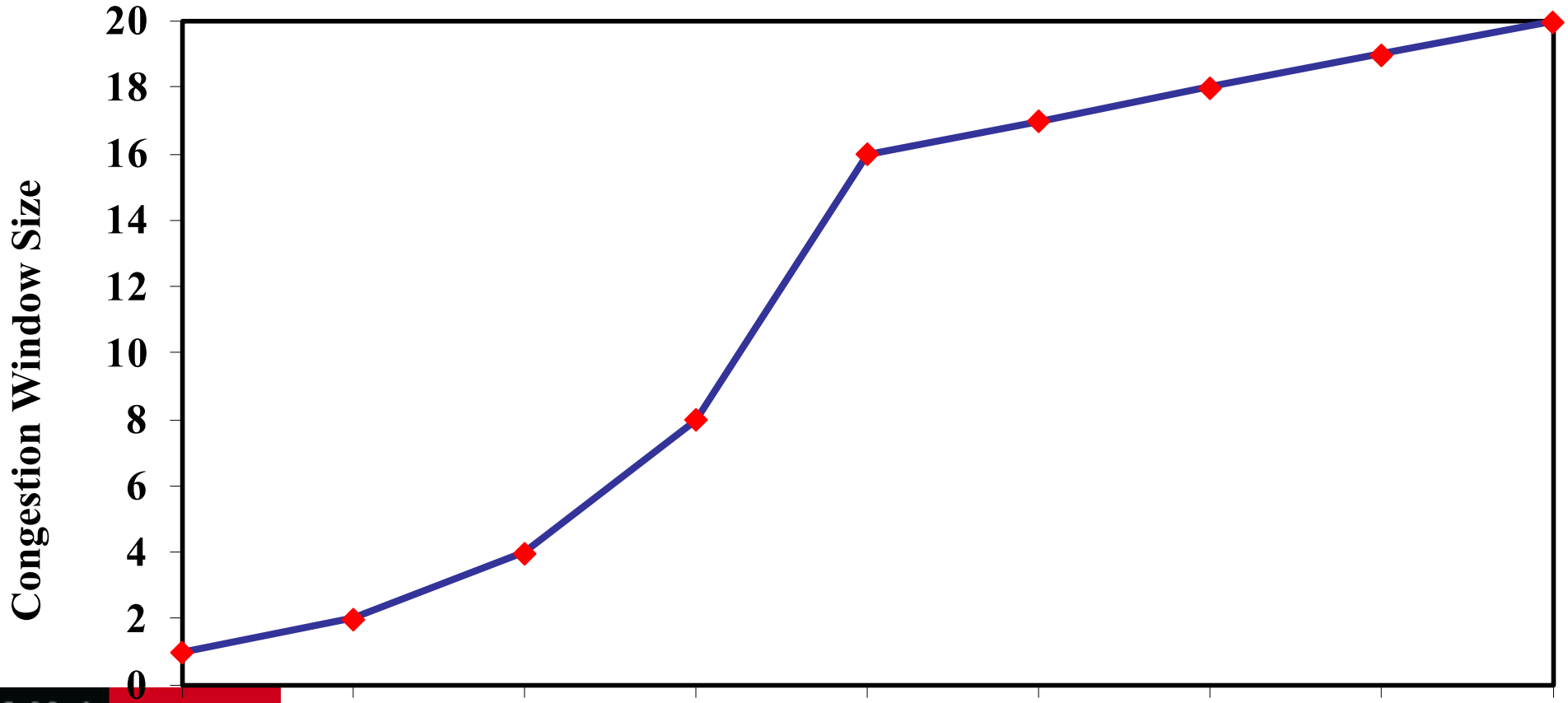
- Sliding Window Size = min(receiver window size, congestion window size)

Congestion Window Management

- The congestion window size begins at one
- When an acknowledgement is received the window size is incremented
  - This causes the window size to increase exponentially!
  - Once window size reaches a threshold value or half the previous maximum value (whichever is greater):

    Size is incremented by one only if all segments in the window are acknowledged
  - This slows down the rate of increase

Congestion Window Management



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Congestion Window Management

- When a timer times out on receiving an acknowledgement
  - Congestion window size is halved
  - Timeout wait period is extended
- This has the immediate effect of exponentially reducing transmission bit rate and alleviating network congestion
- Congestion has
  - Exponential traffic back-off
  - Exponential traffic rise up to a certain value and then linear

Traffic Characteristics

- TCP flows adjust to
  - Transmit at the available bandwidth
  - Share bandwidth evenly

- Continuous work to define new Congestion Control Schemes

  Improve overall throughput without affecting TCP fairness

Interaction of Traffic Classes

- TCP flows behave nicely in a congested network
- What about UDP?
- How does UDP traffic affect TCP traffic?
- How does TCP traffic affect UDP traffic?