# The Transport Layer

- Concepts
- UDP
- TCP
- Congestion control

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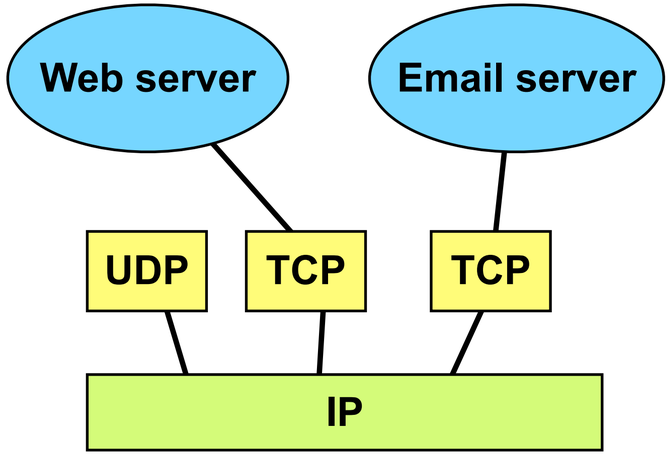
# TCP and UDP Transport




- IP network provides best effort service
  - Packets can be lost, duplicated, delayed, or re-ordered
- Transport isolates applications from the network
  - Demultiplexes traffic for different applications
  - Enhances network quality of service to offer appropriate reliability
  - Performs congestion control, adapts to network capacity

- Only two deployable transport protocols in the Internet:
  - **UDP** - user datagram protocol
  - **TCP** - transmission control protocol

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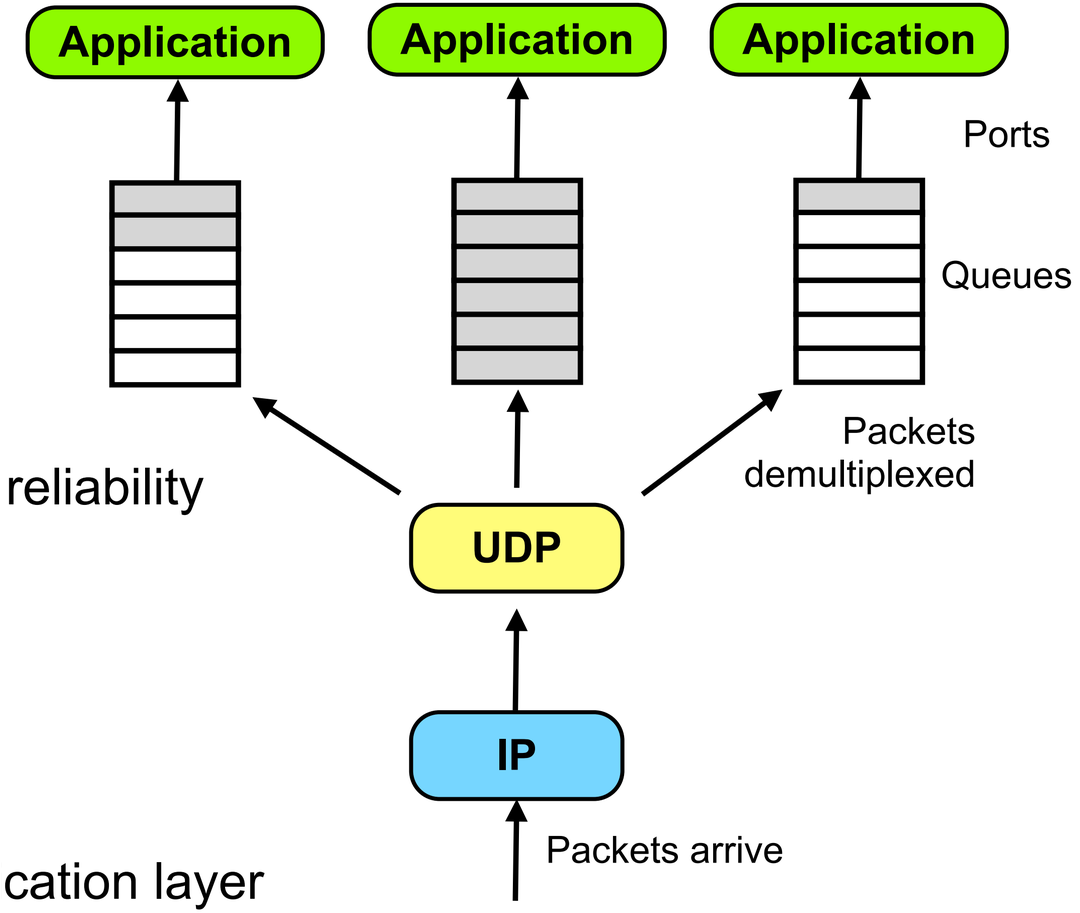
# UDP

- Simplest transport protocol
- Exposes raw IP service to applications
  - Connectionless, best effort packet delivery: framed, but unreliable
  - No congestion control
  - Adds 16 bit port number to identify services
- Used by applications preferring timeliness over reliability
  - Voice-over-IP
  - Streaming video
  - Gaming
- Must be able to tolerate some loss of data
- Must be able to adapt to congestion in the application layer

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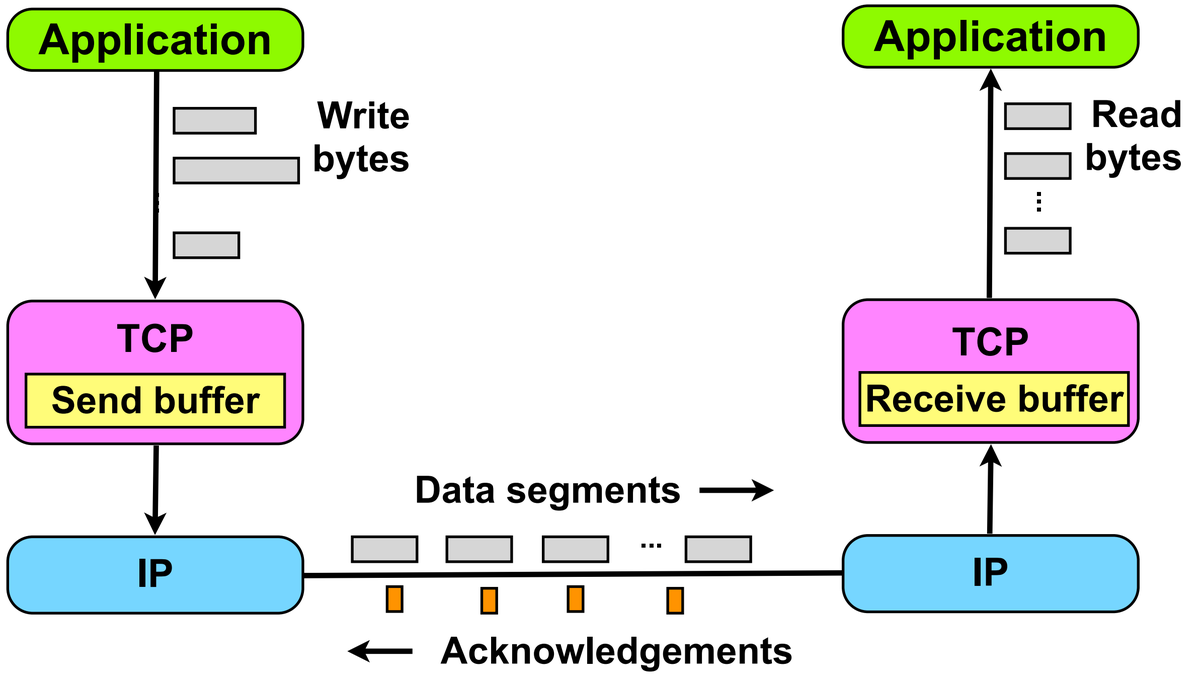
# TCP




- Reliable, ordered, byte stream delivery service running over IP
  - Lost packets are retransmitted; ordering is preserved; message boundaries **are not** preserved
  - Adapts sending rate to match network capacity → congestion control
  - Adds port number to identify services
- Used by applications needing reliability → default choice for most applications

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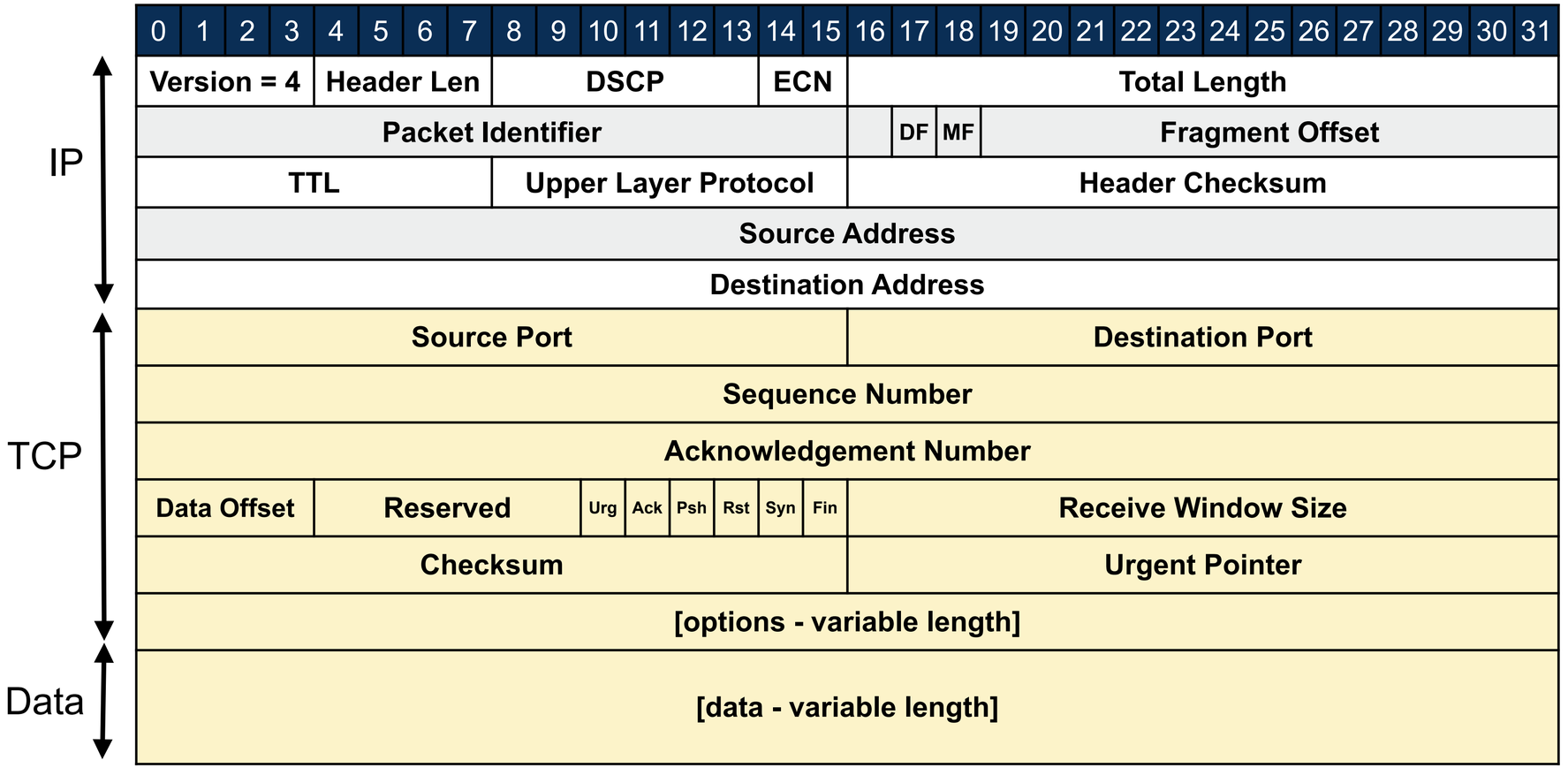
# TCP Packet Format

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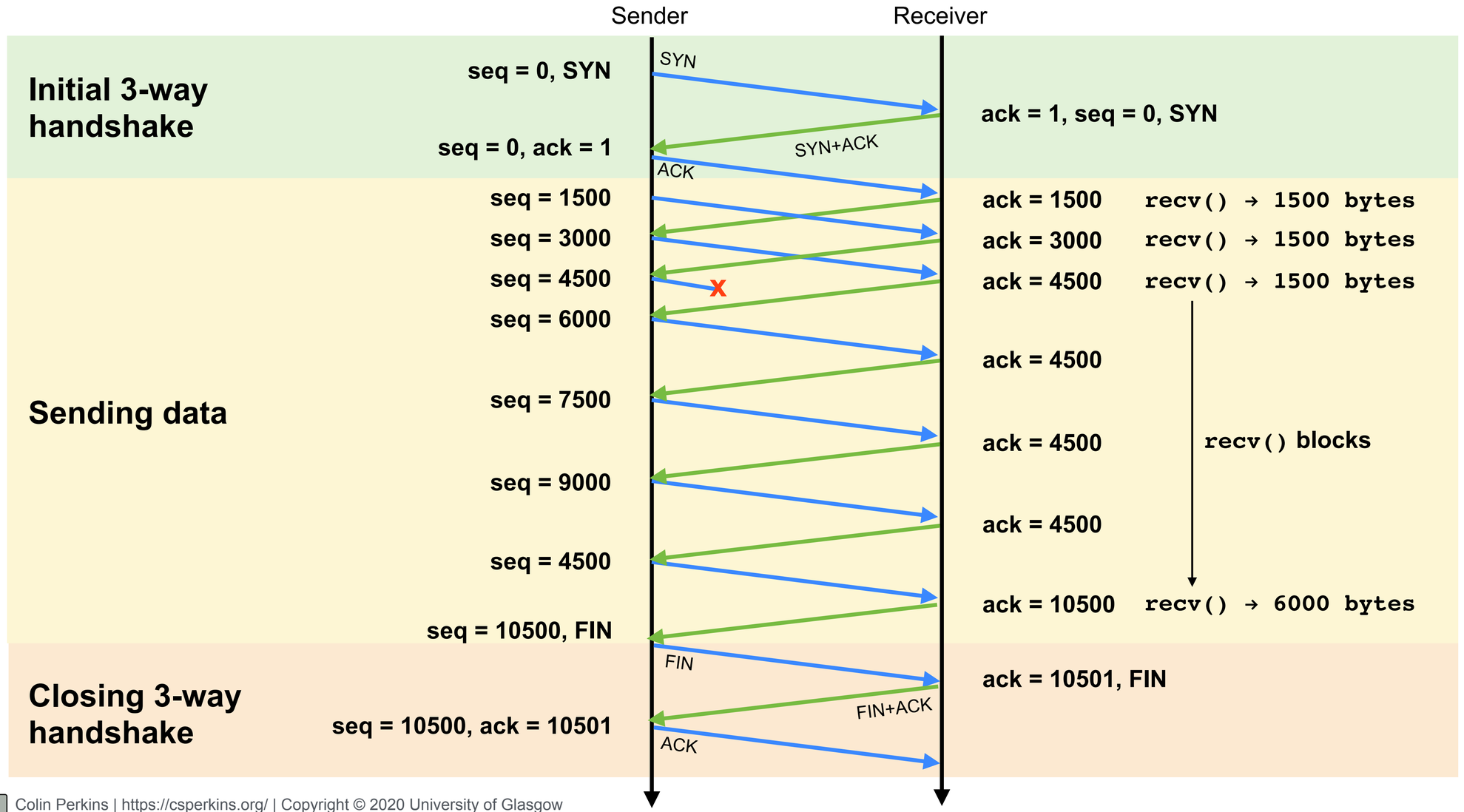
# TCP Connection Timeline (Example)

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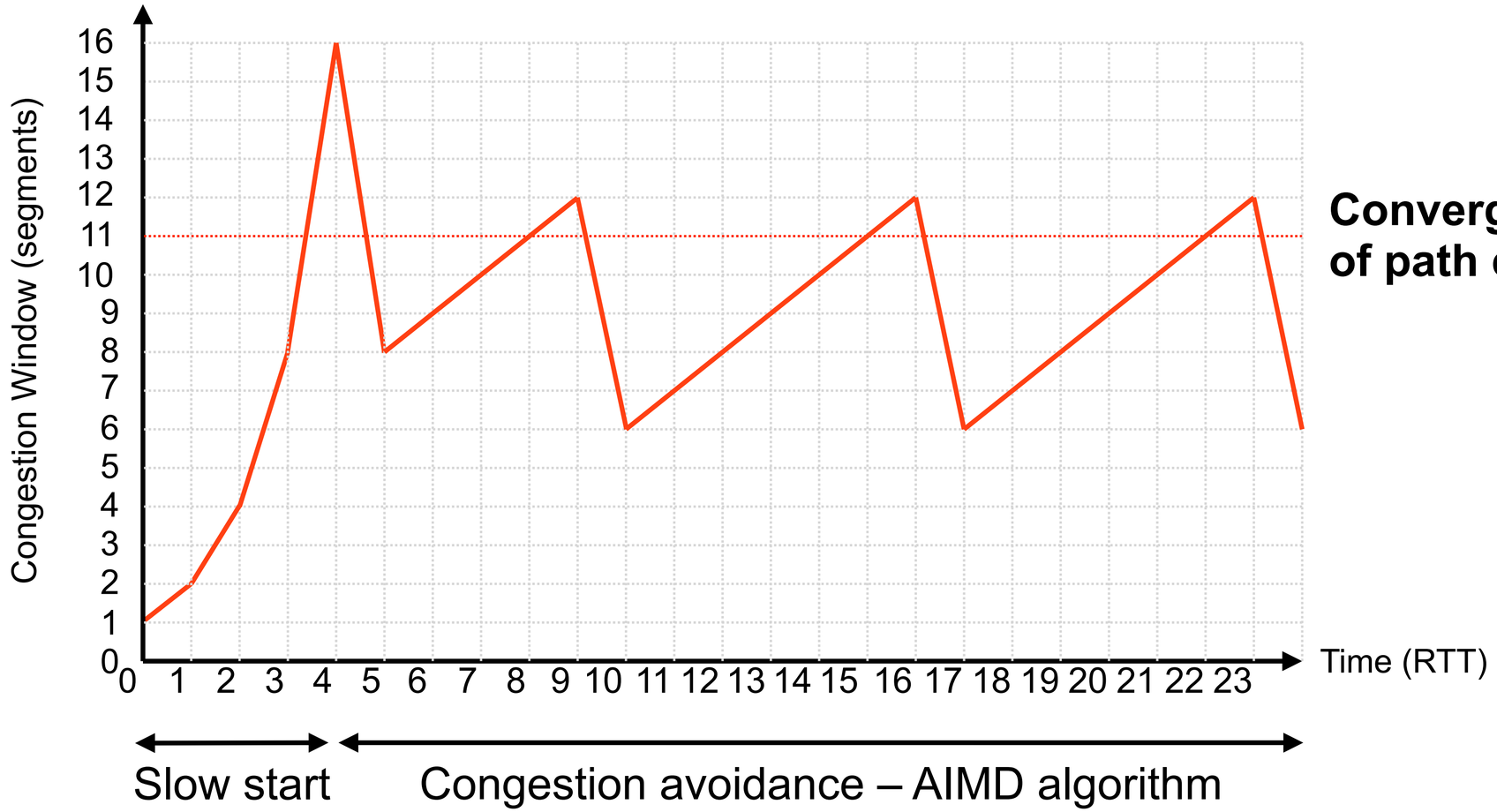
# TCP Congestion Control

Typical evolution of TCP window, assuming $W_{init}$ = 1




**Converge on fair share of path capacity**

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BY ND