Transmission Control Protocol (TCP)

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Outline

- Introduction to TCP
- Sequence numbers and acknowledgment numbers
- Timeouts and RTT estimation
- Reliable data transfer in TCP
- Connection management

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- Full-duplex service
  - both endpoints can both send and receive, at the same time

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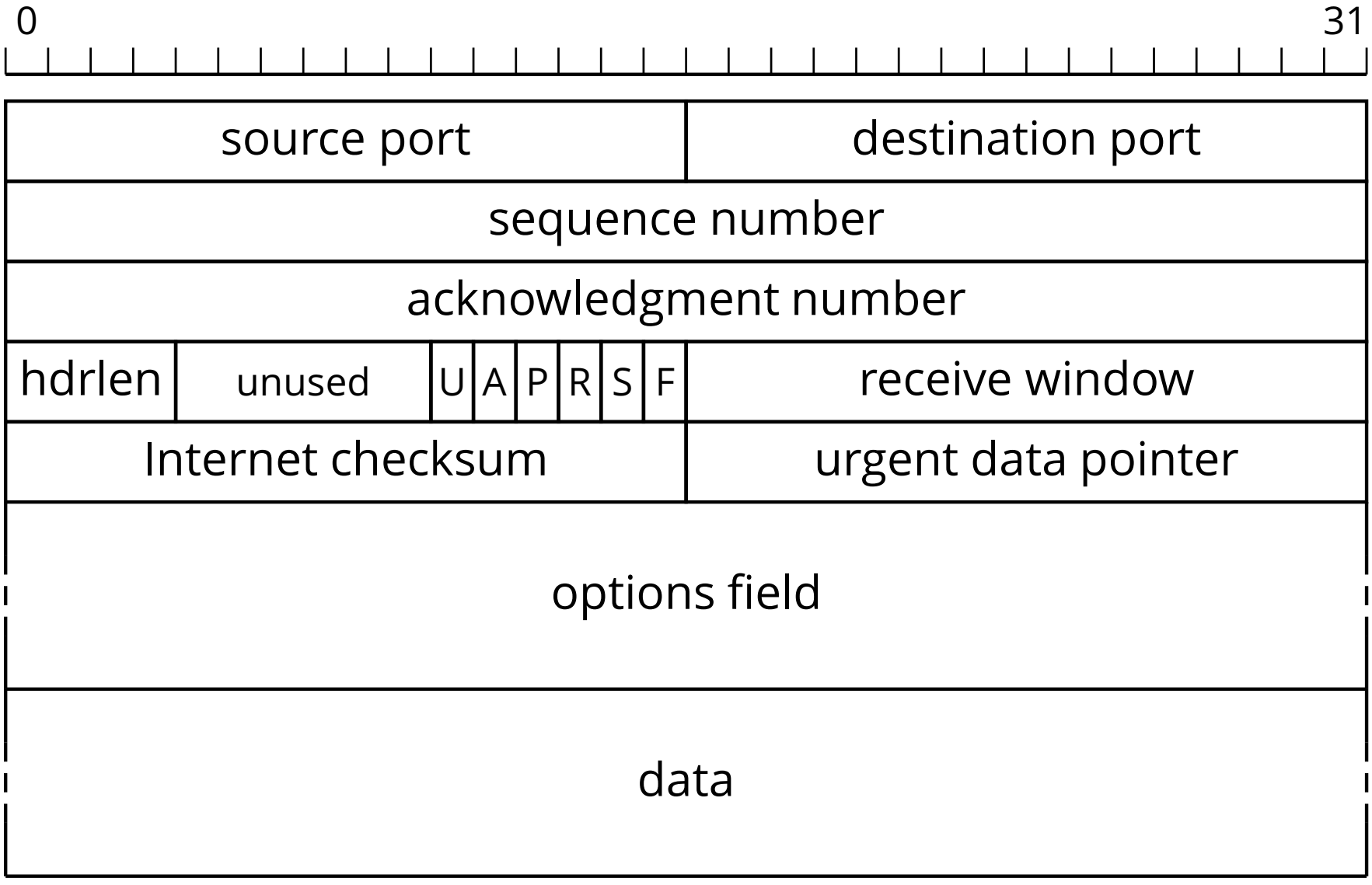
- *Maximum transmission unit (MTU):* largest link-layer frame available to the sender host
  - *path MTU:* largest link-layer frame that can be sent on all links from the sender host to the receiver host

TCP Segment Format



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- *Optional and variable-length options field:* may be used to negotiate protocol parameters

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- *Checksum:* (16-bit) used to detect transmission errors

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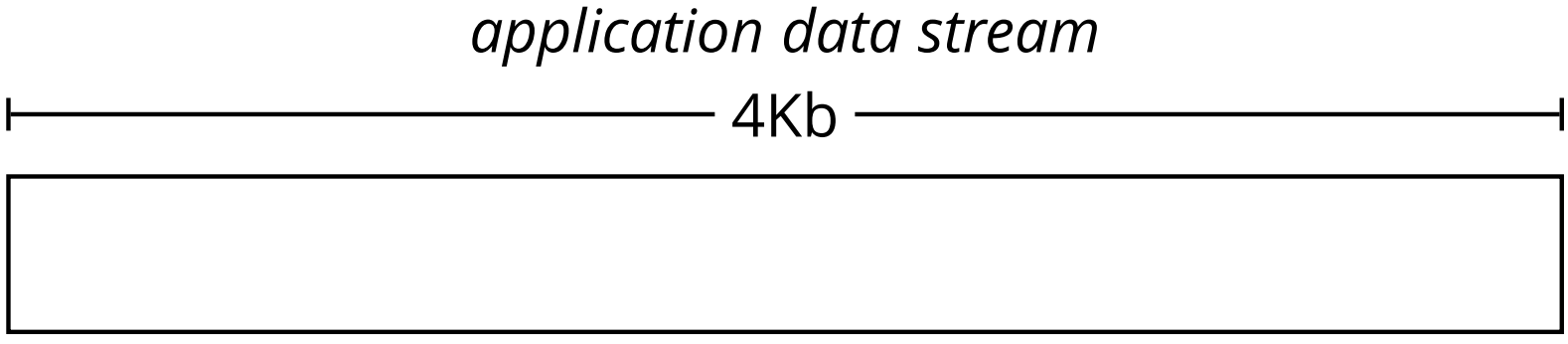

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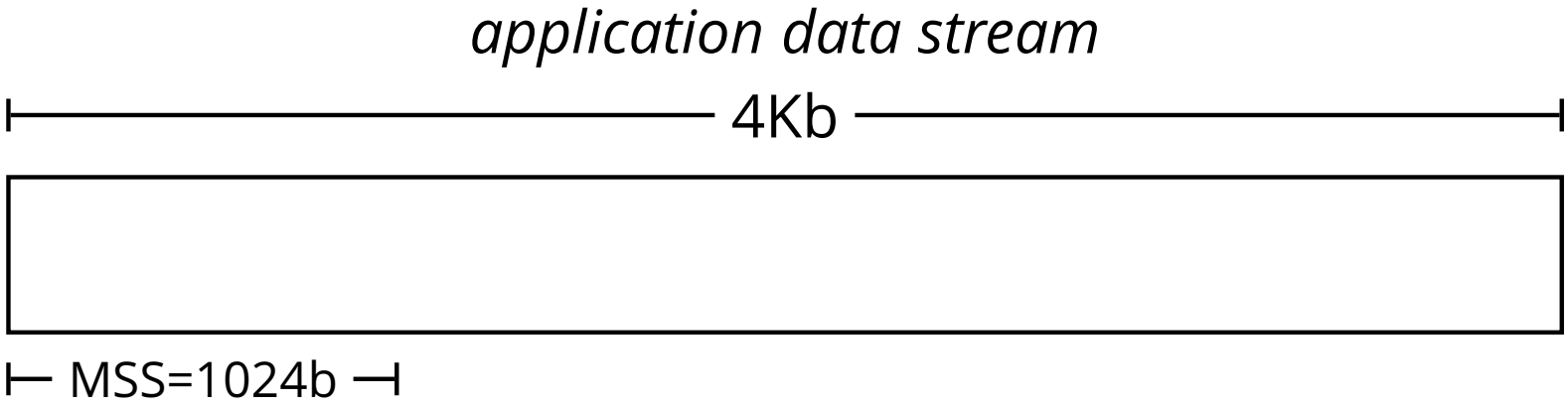

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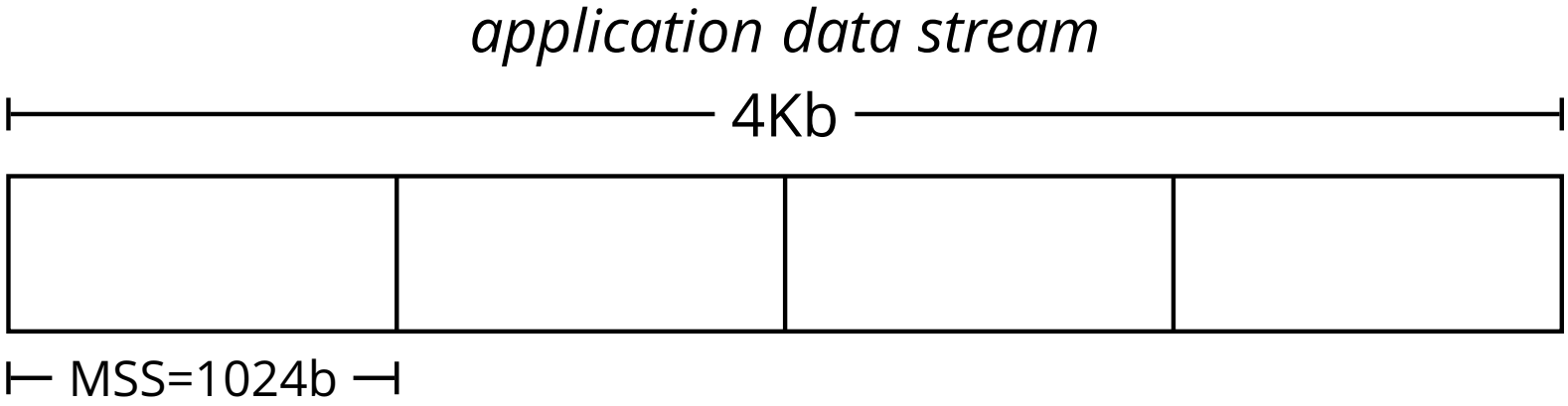

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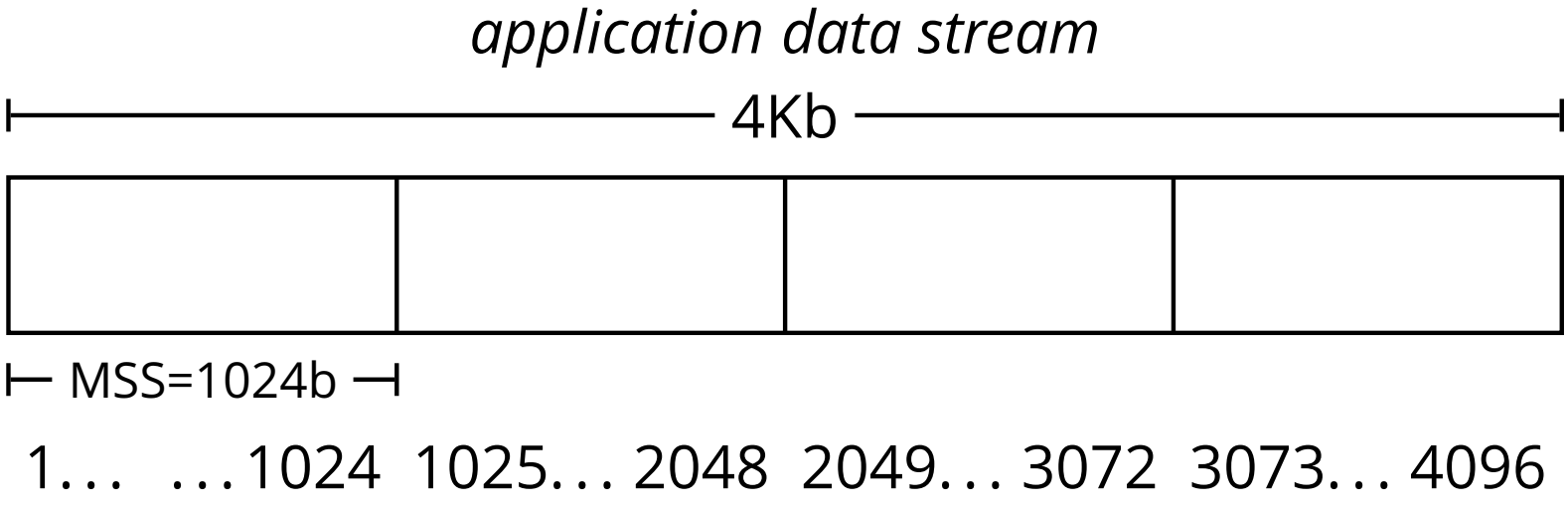

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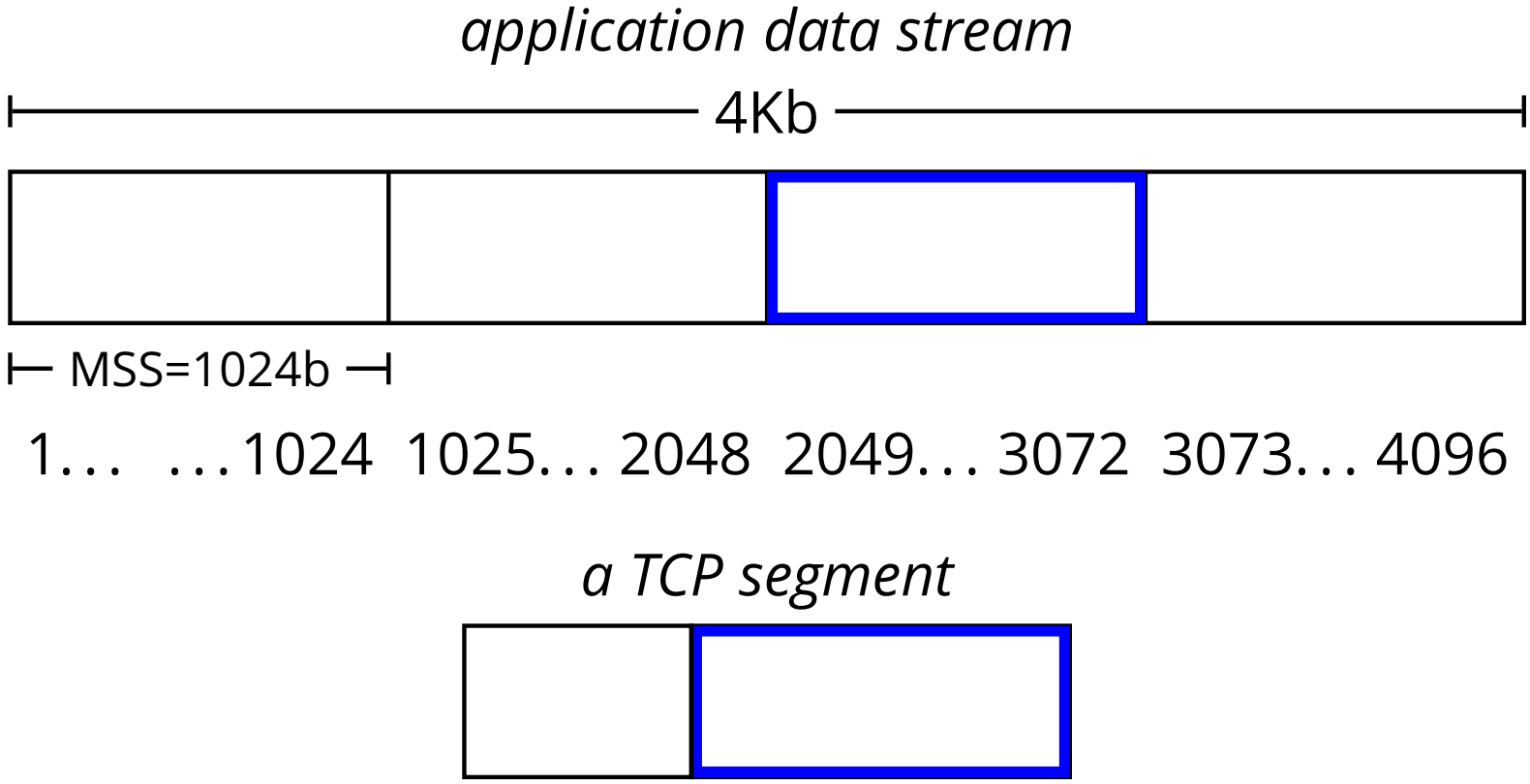

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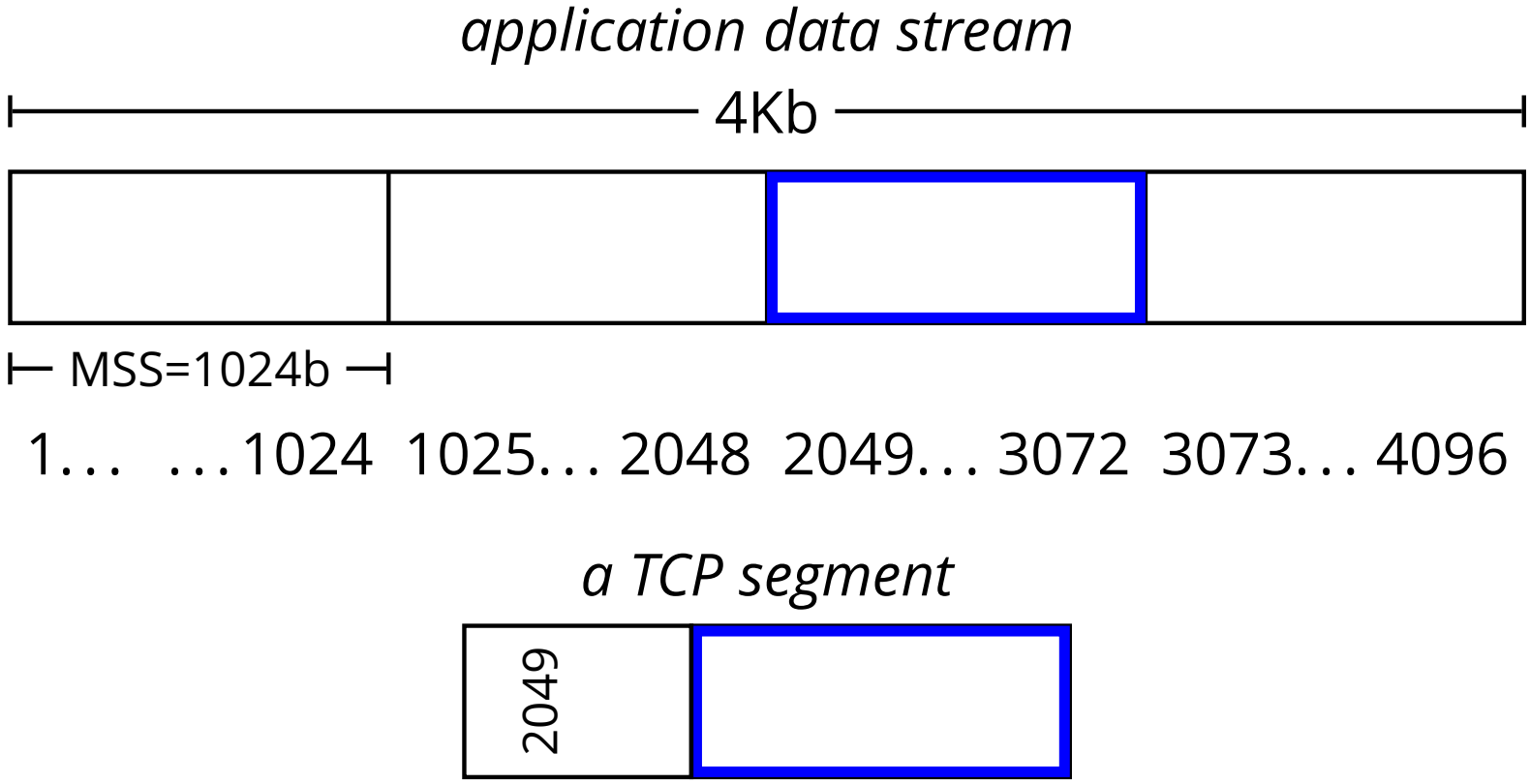

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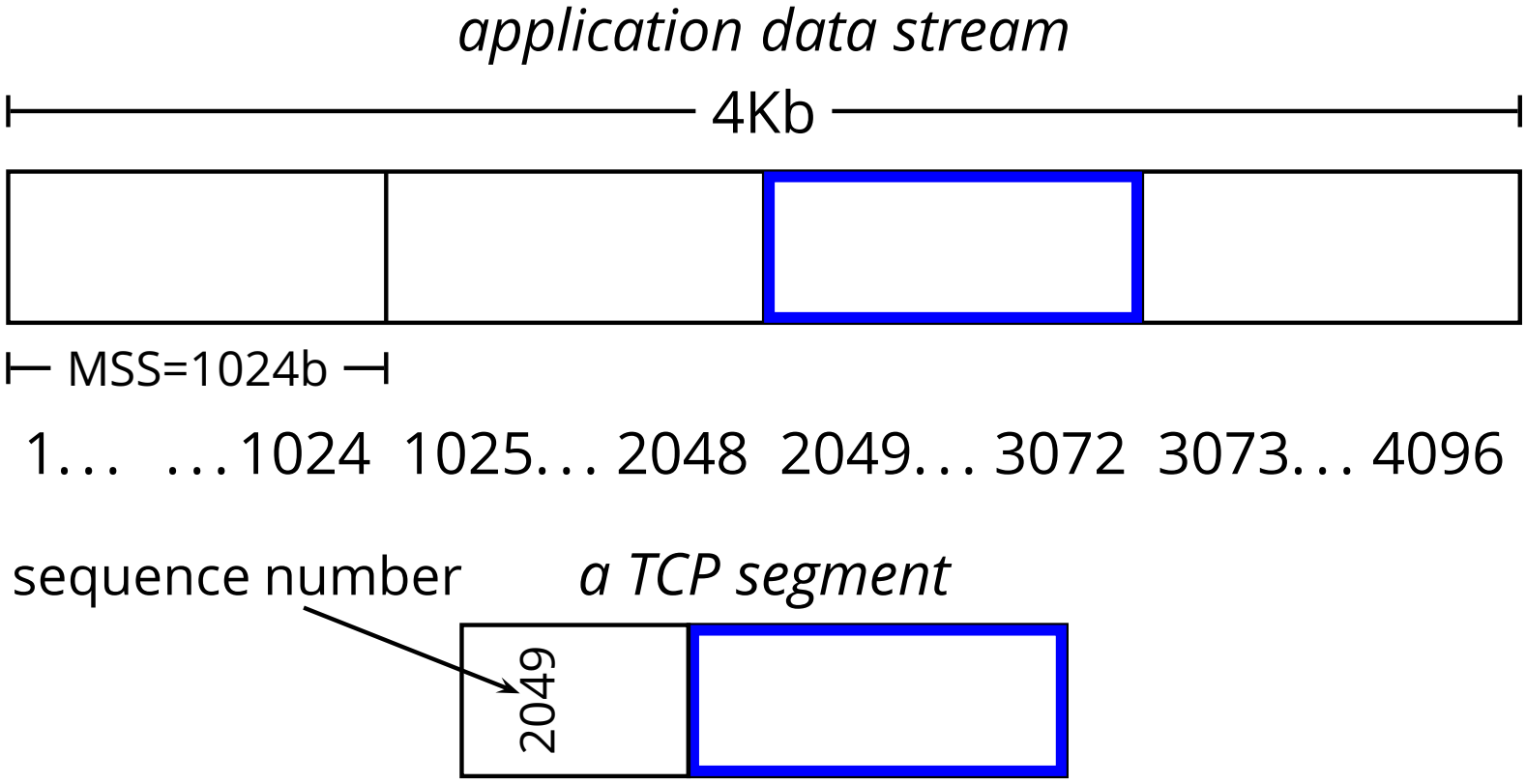

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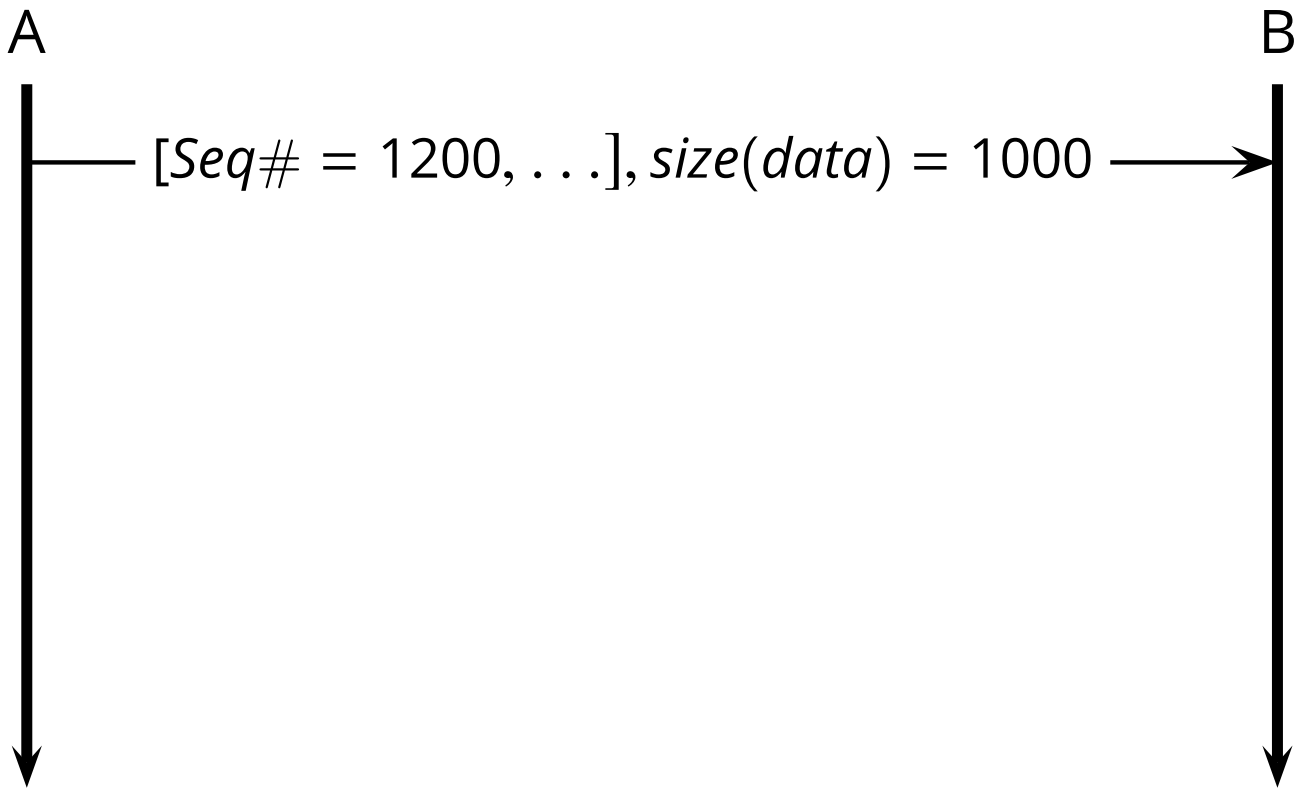

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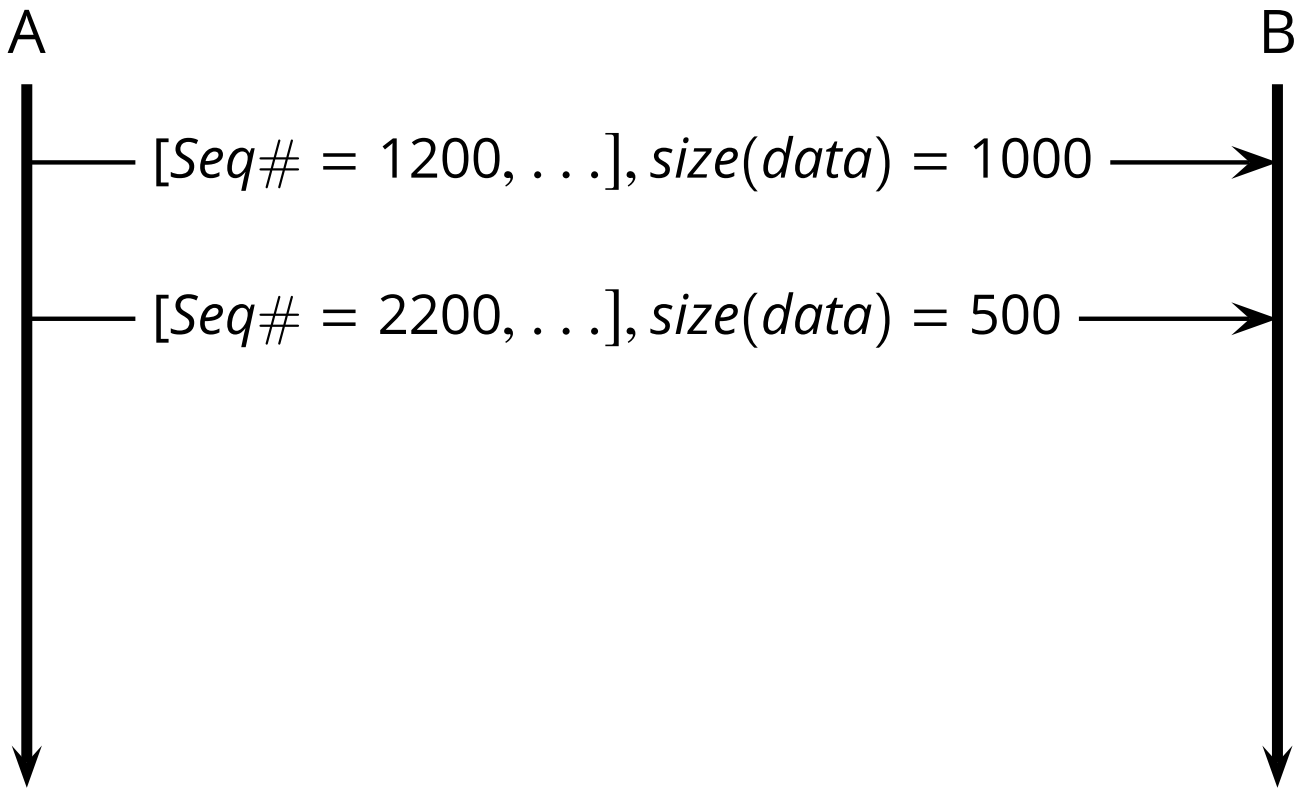

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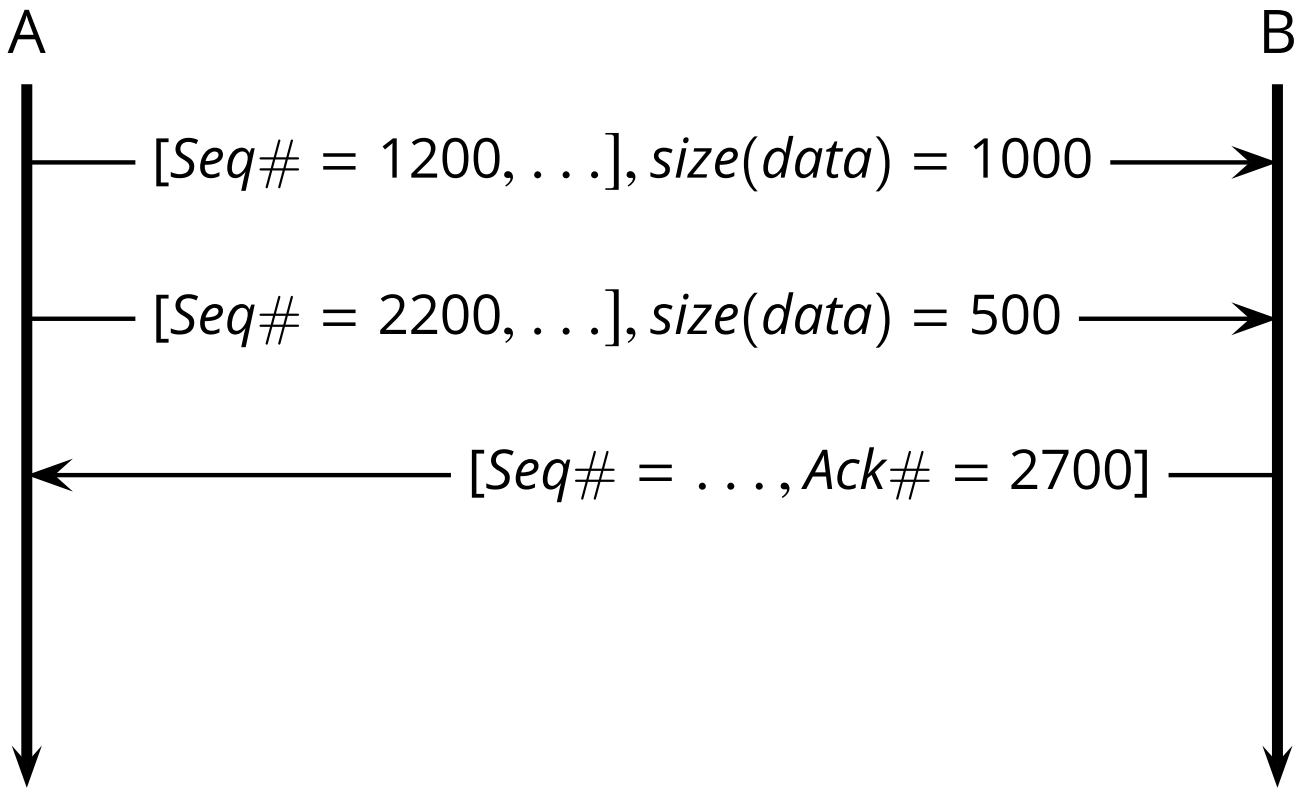

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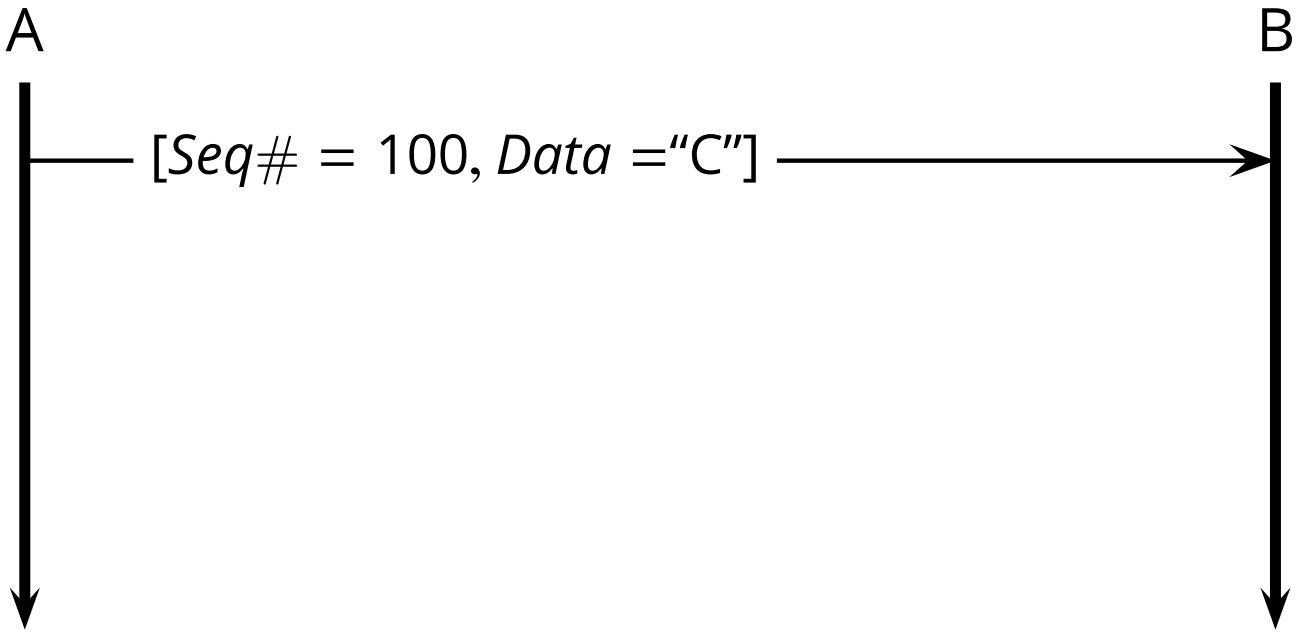

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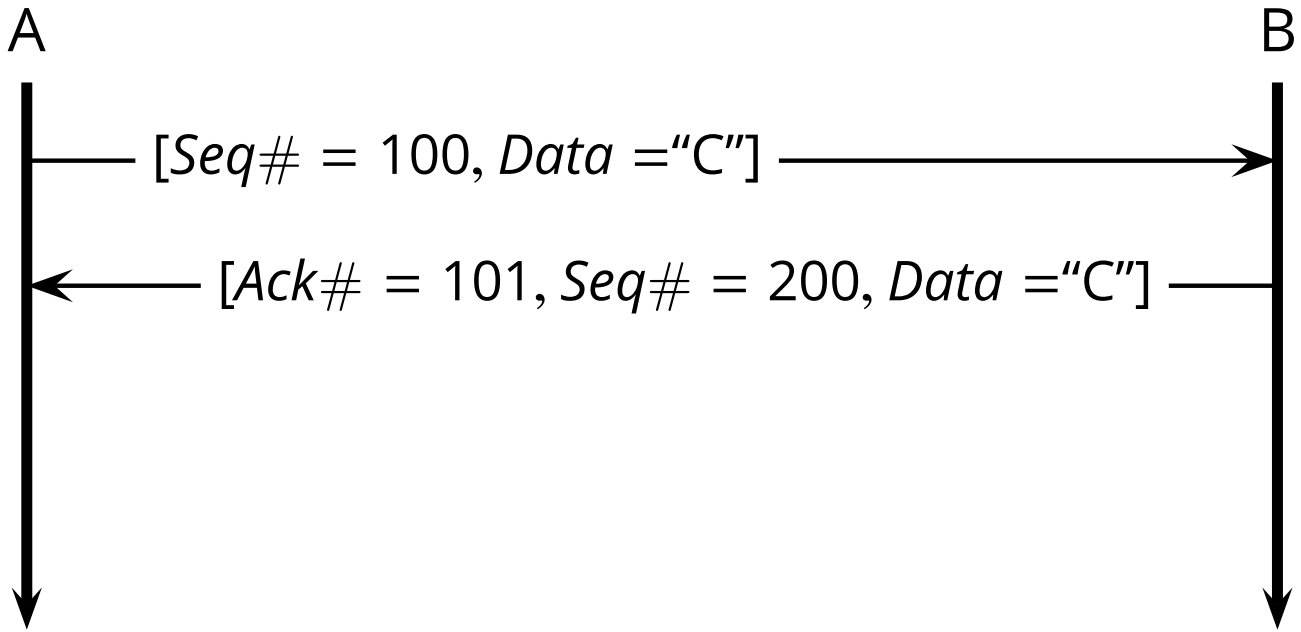

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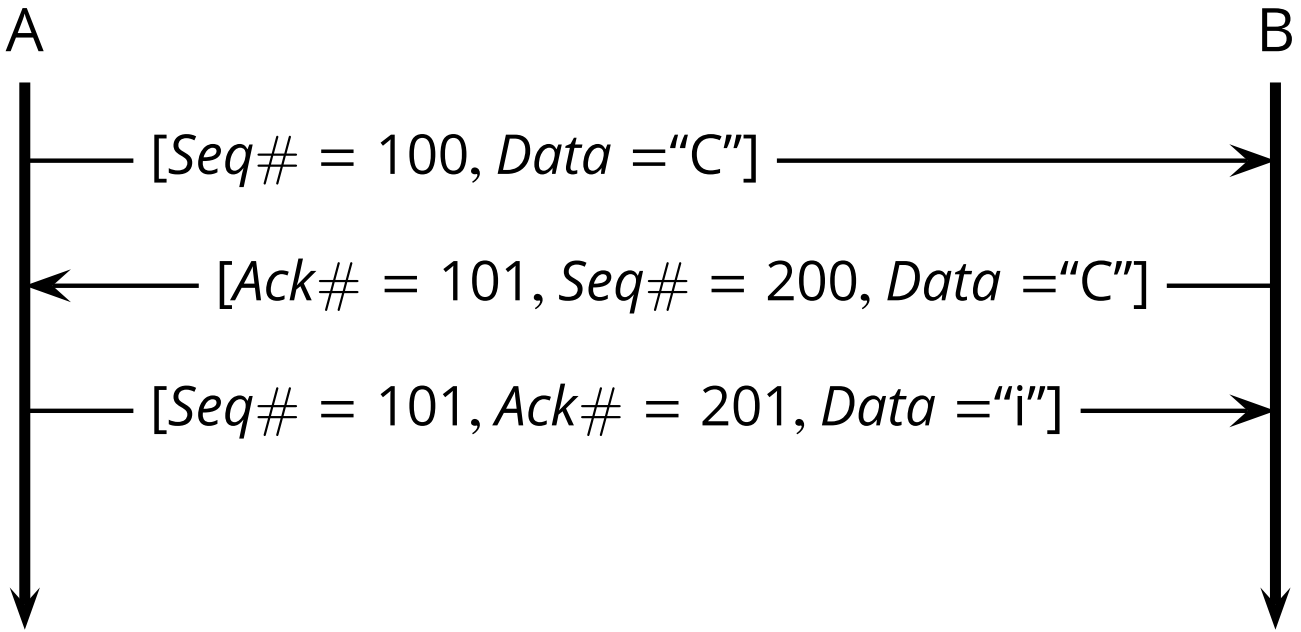

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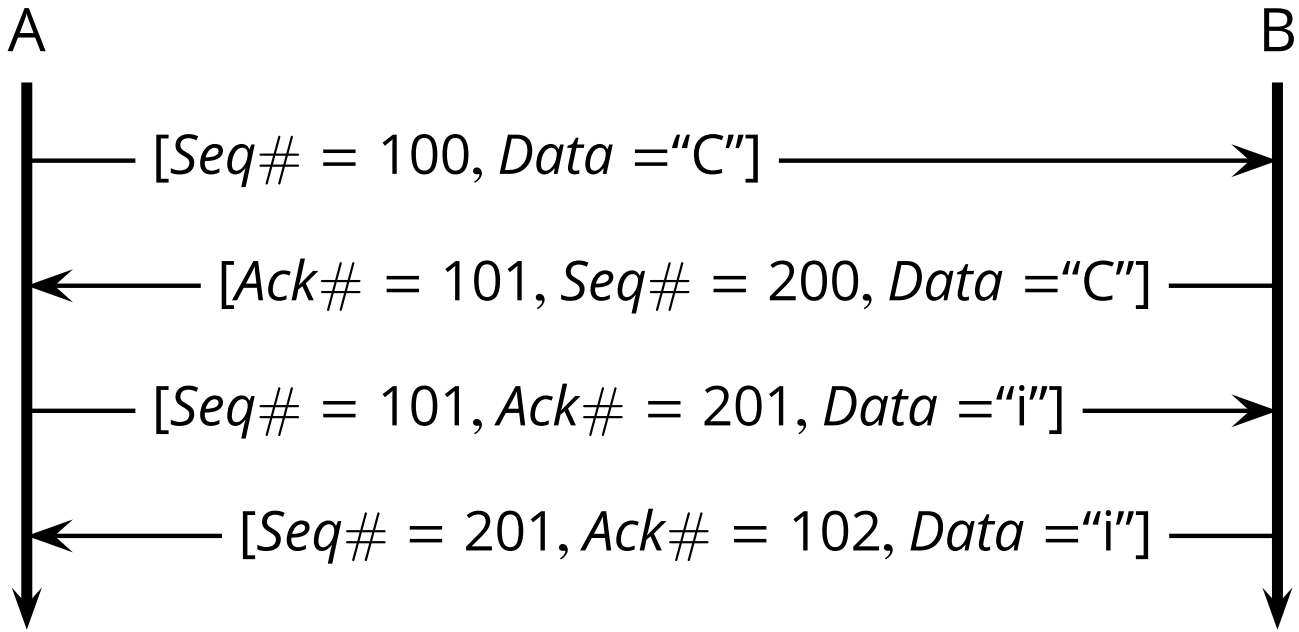

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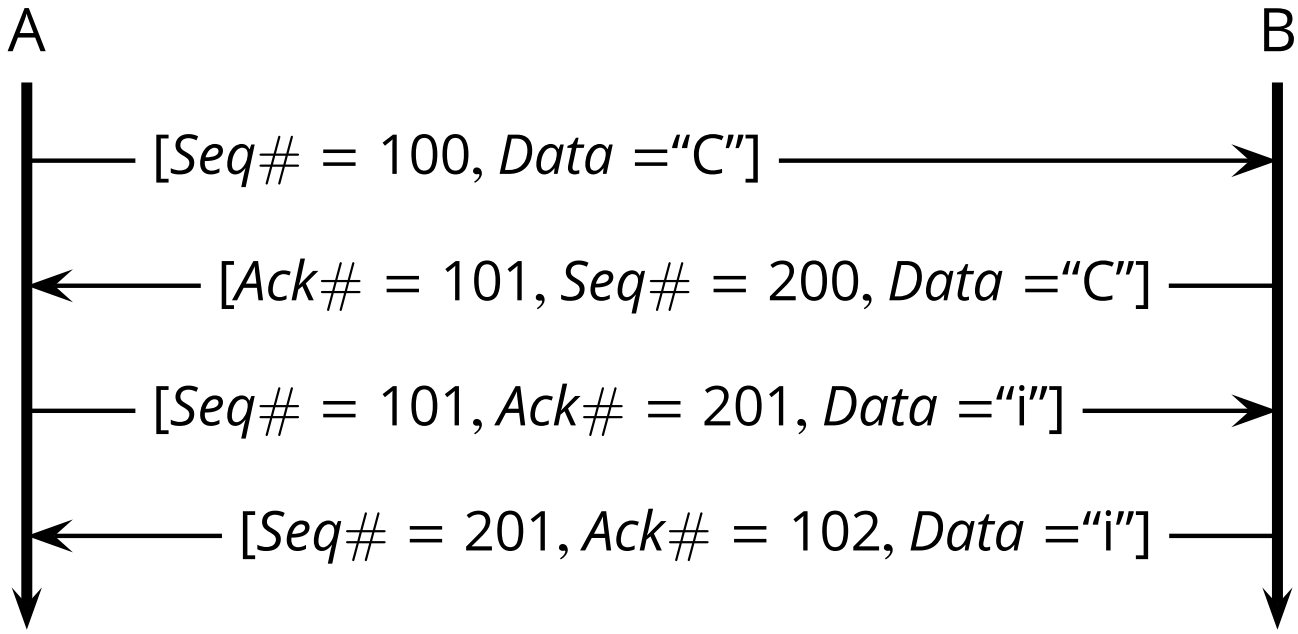

- Acknowledgments are "piggybacked" on data segments

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- TCP controls its timeout by continuously *estimating the current RTT*

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- TCP sets its timeouts using the estimated RTT ($\overline{RTT}$) and the variability estimate $\overline{DevRTT}$:

$$T = \overline{RTT} + 4\overline{DevRTT}$$

Reliable Data Transfer (Sender)

A simplified TCP sender

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  if (timer not running)
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- u_recv([ACK,*y*])

  if (*y* > *base*)
  base ← *y*
  if (there are pending segments)
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  else ...

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if (y > base)
    base ← y
    if (there are pending segments)
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else
    ack_counter[y] ← ack_counter[y] + 1
    if (ack_counter[y] = 3)
        u_send(segment with sequence number y)
```

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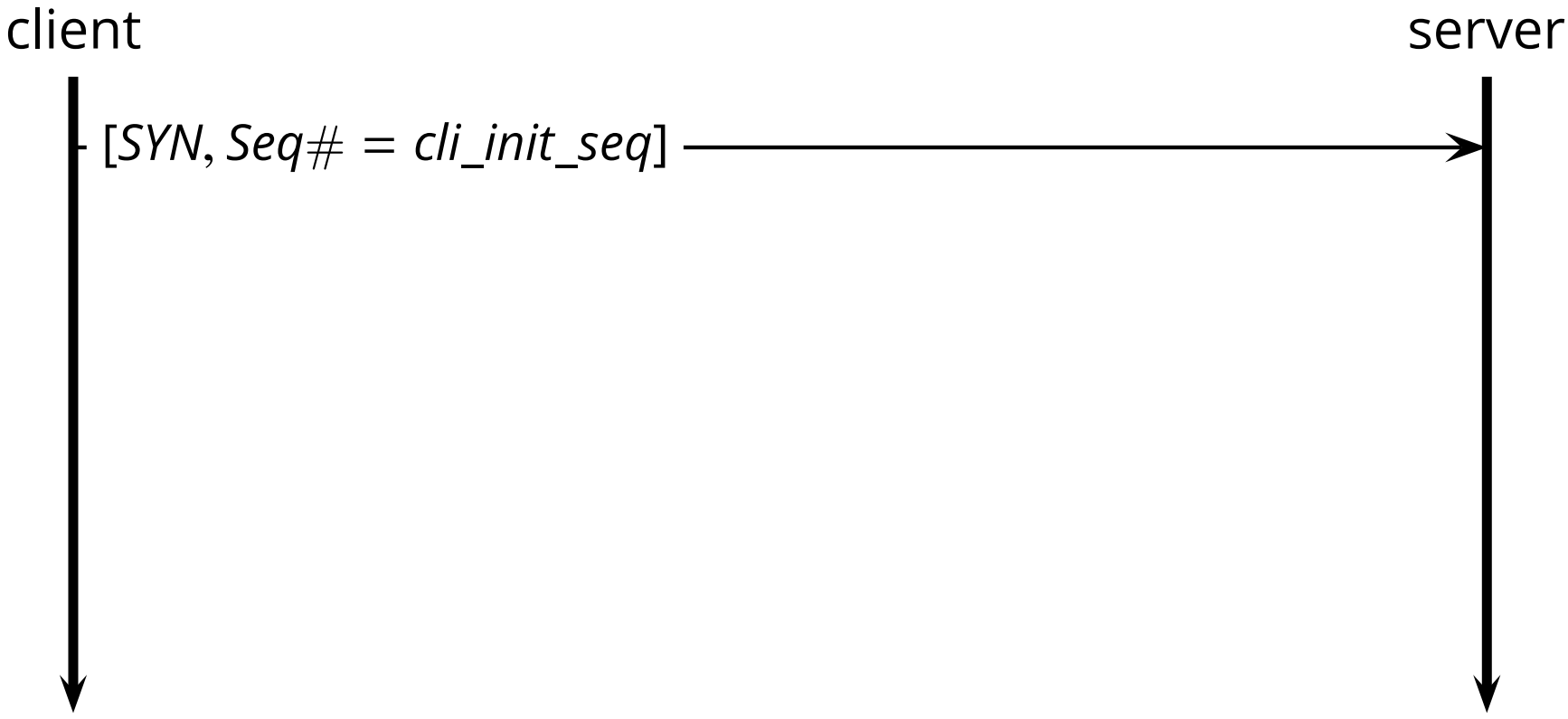

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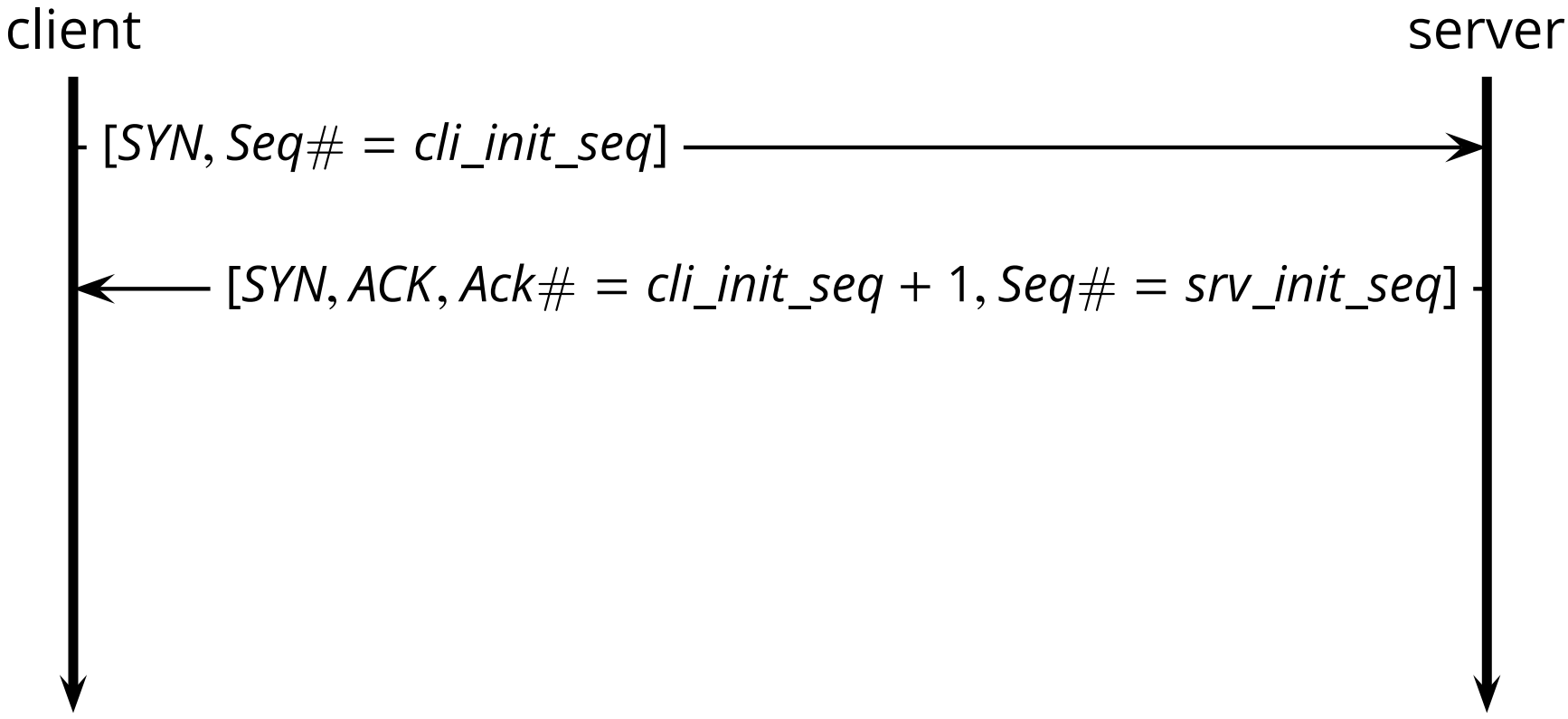

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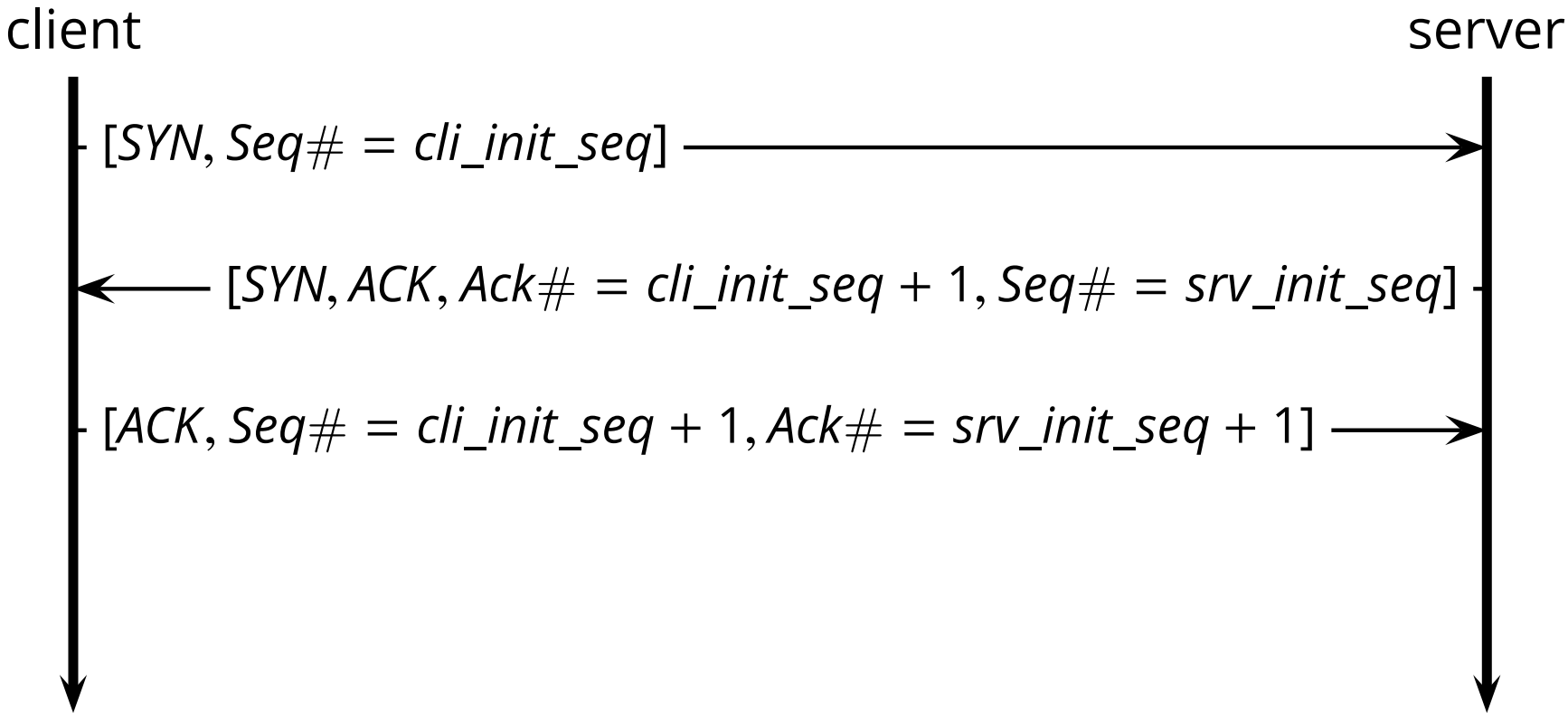

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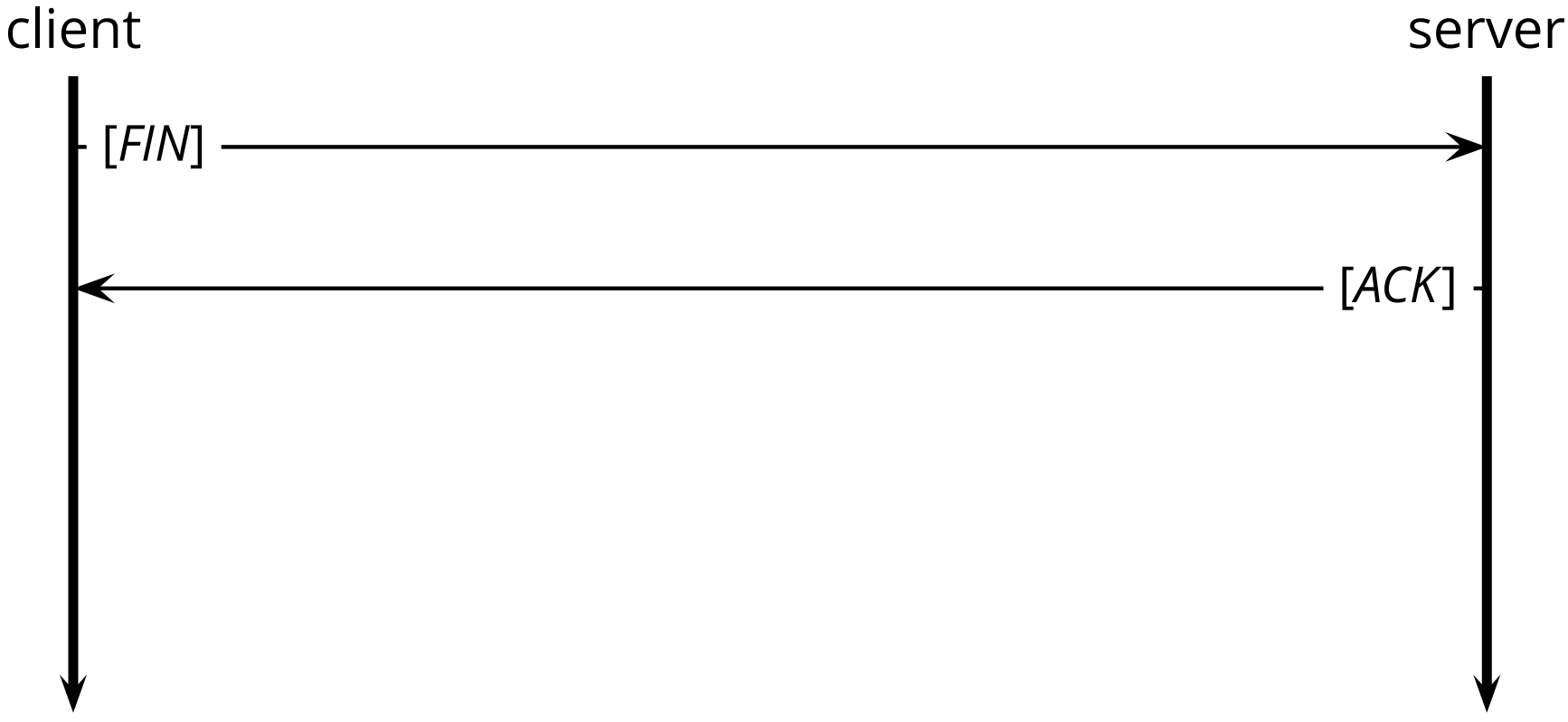
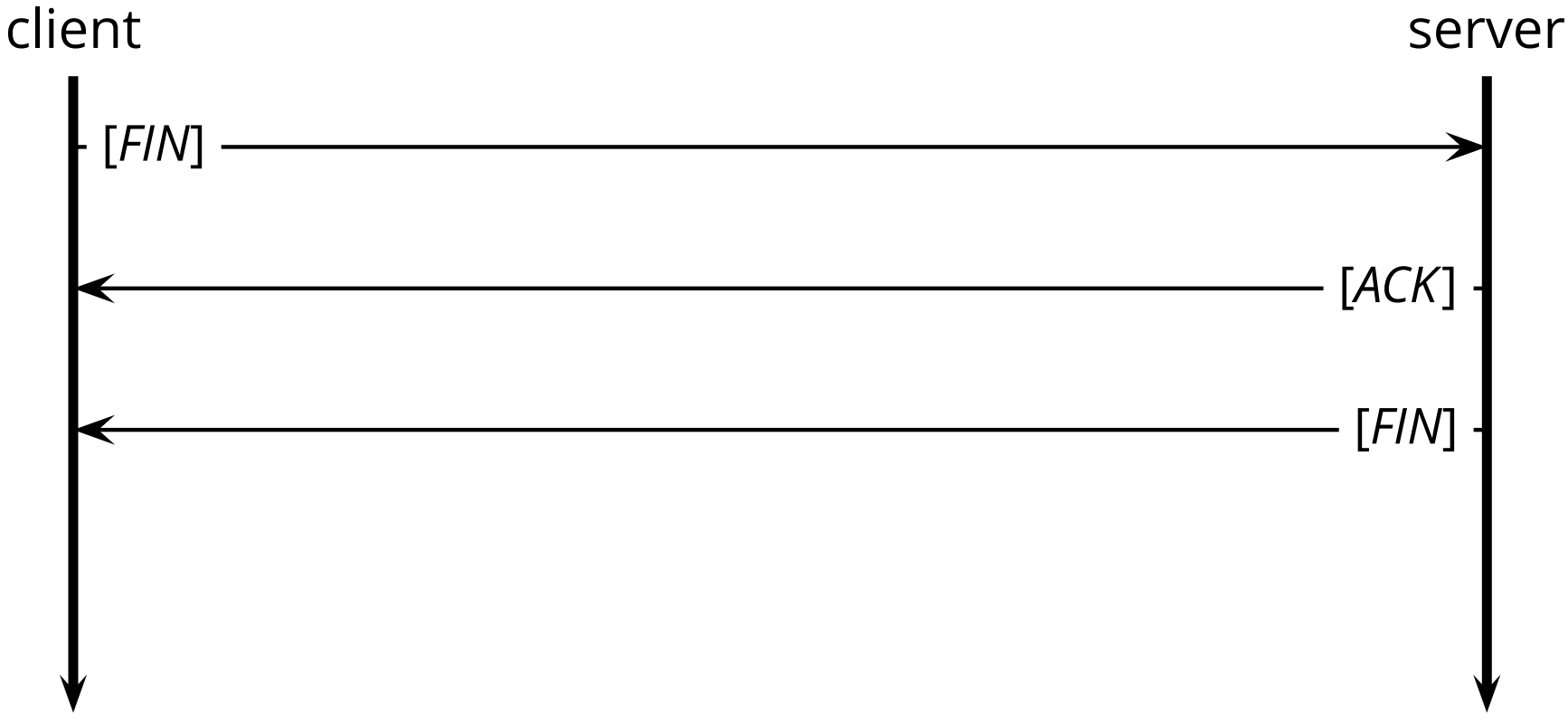


Connection Shutdown

“This is it.”
“Okay, Bye now.”
“Bye.”



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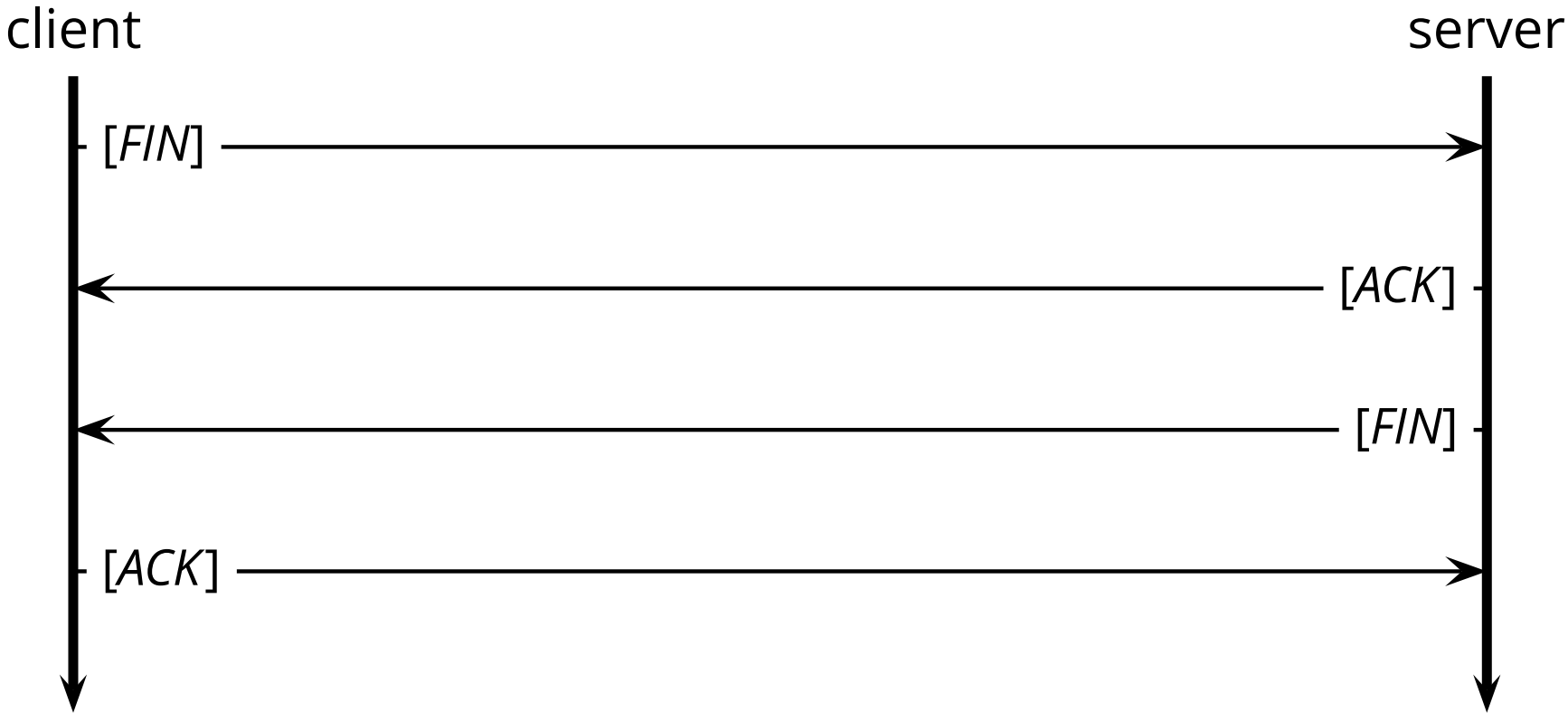

The TCP State Machine (Client)

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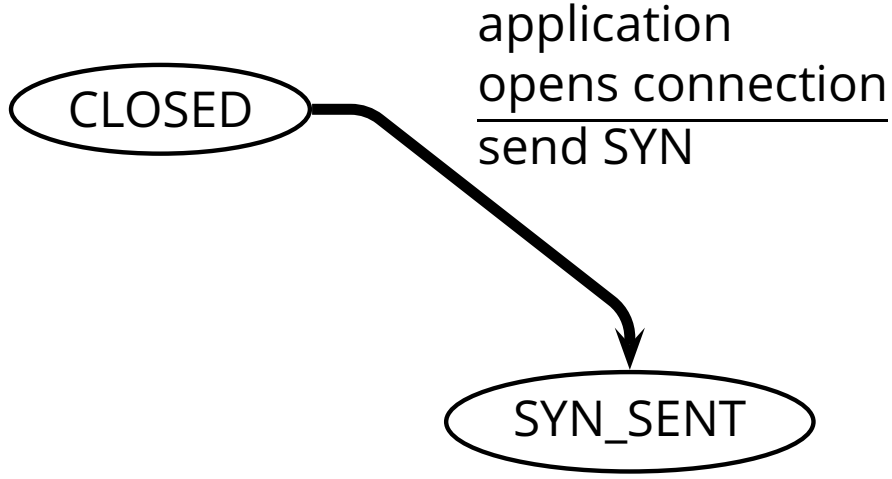

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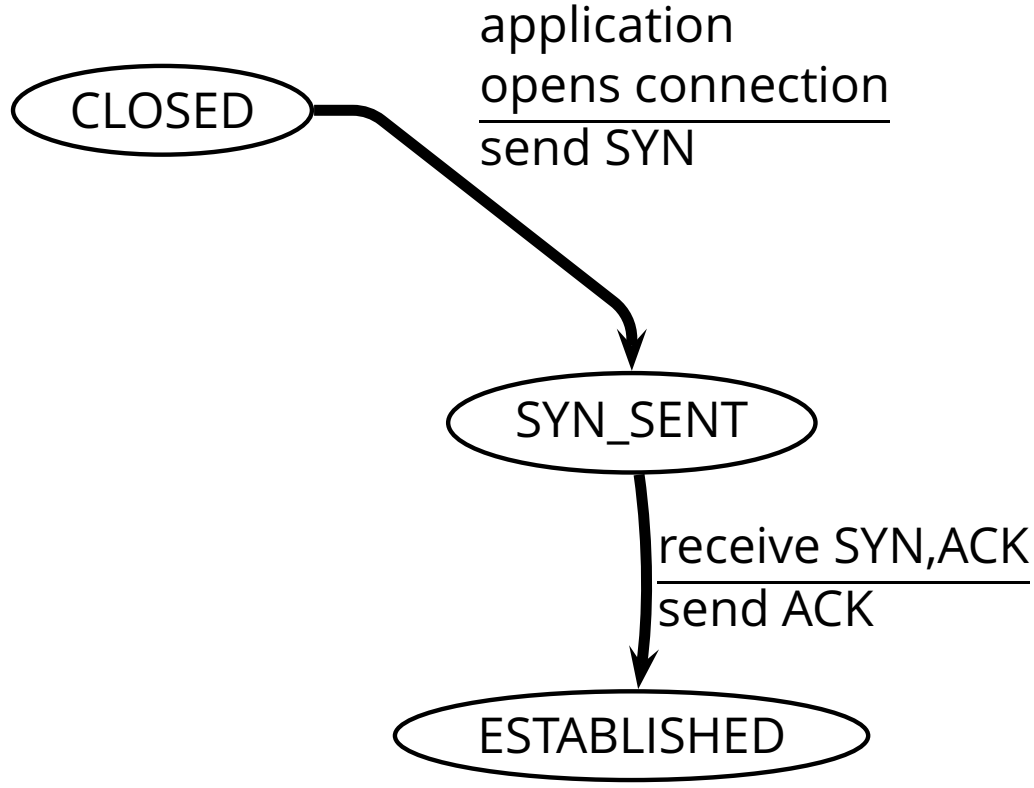

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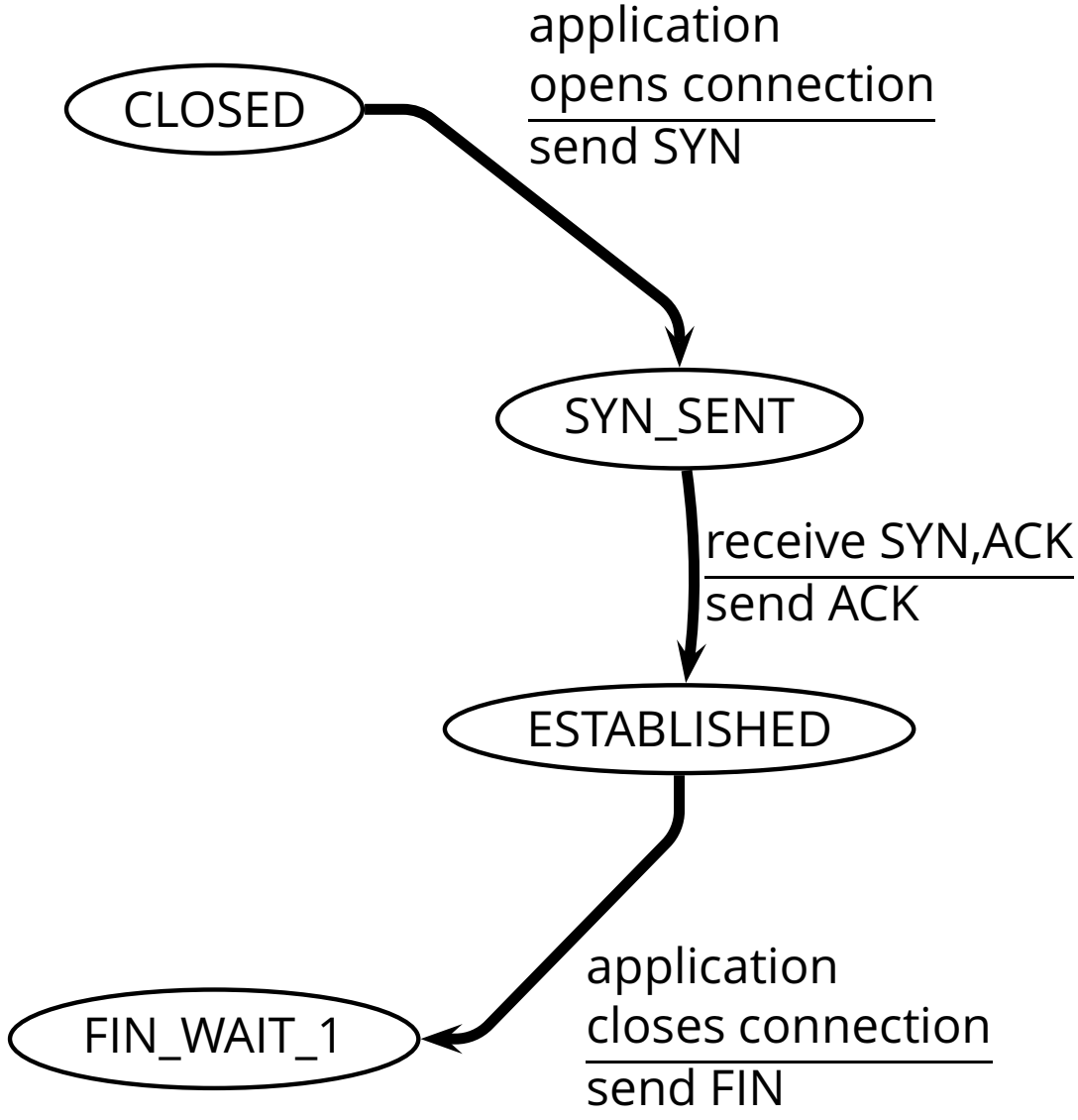

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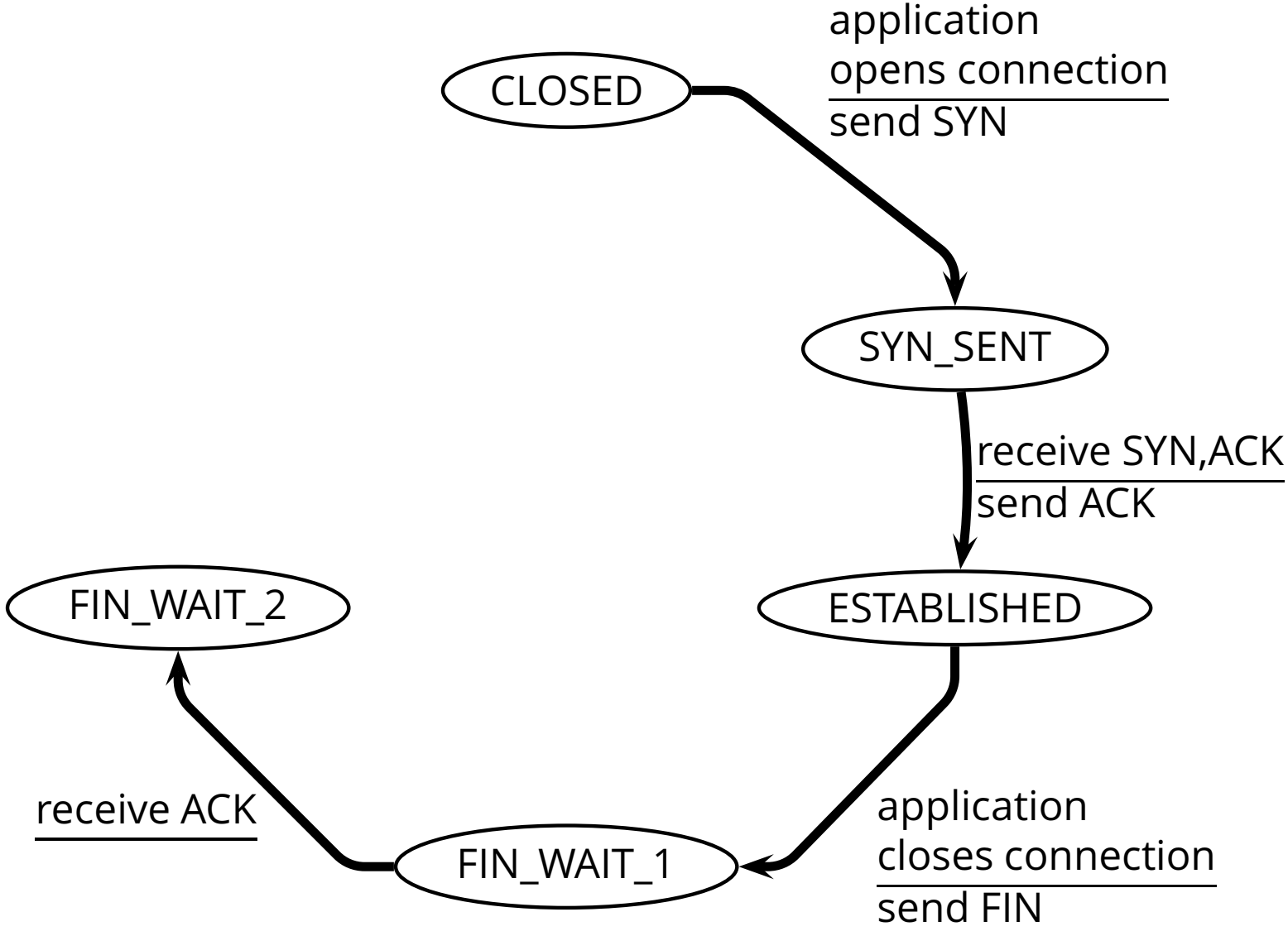

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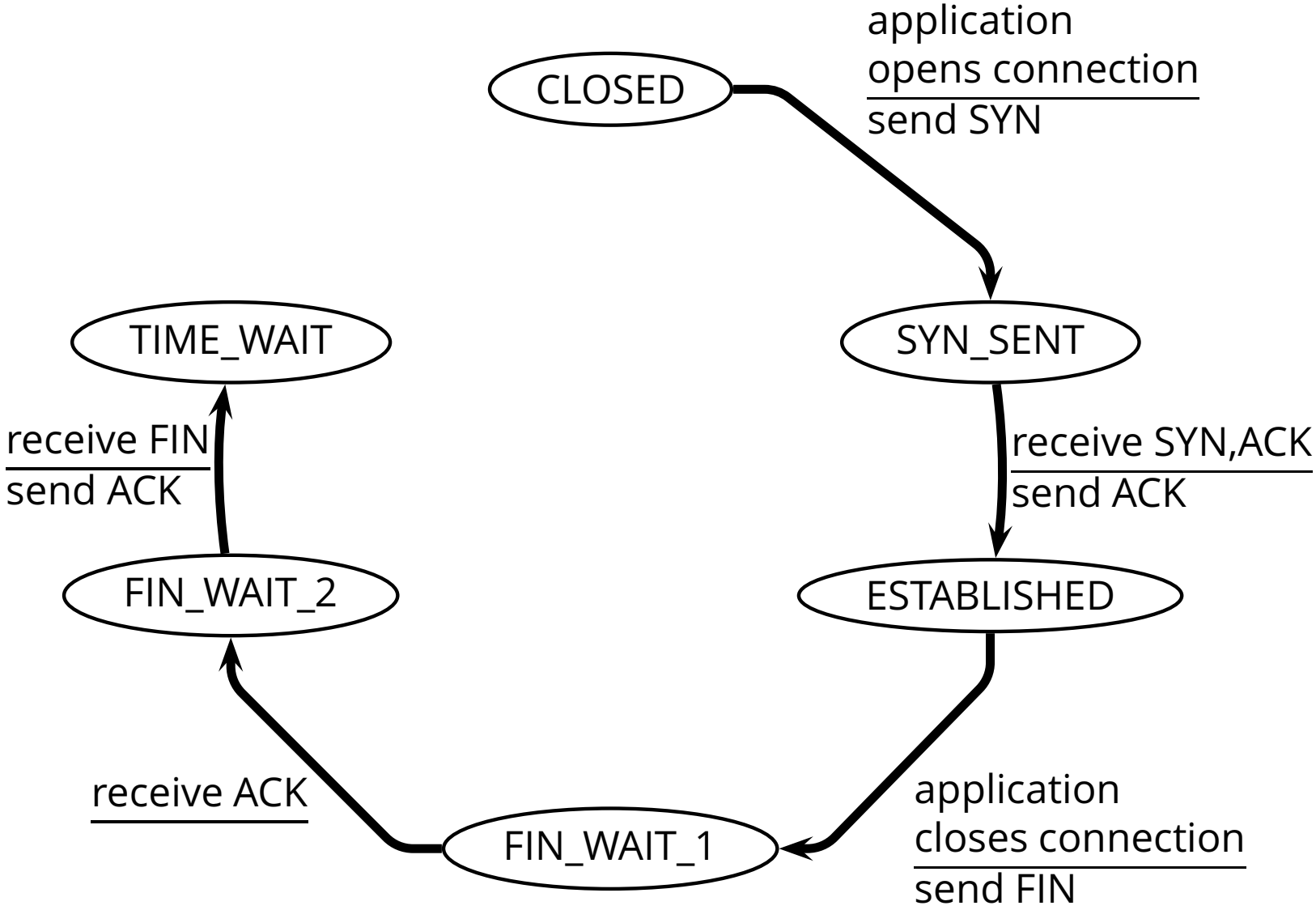

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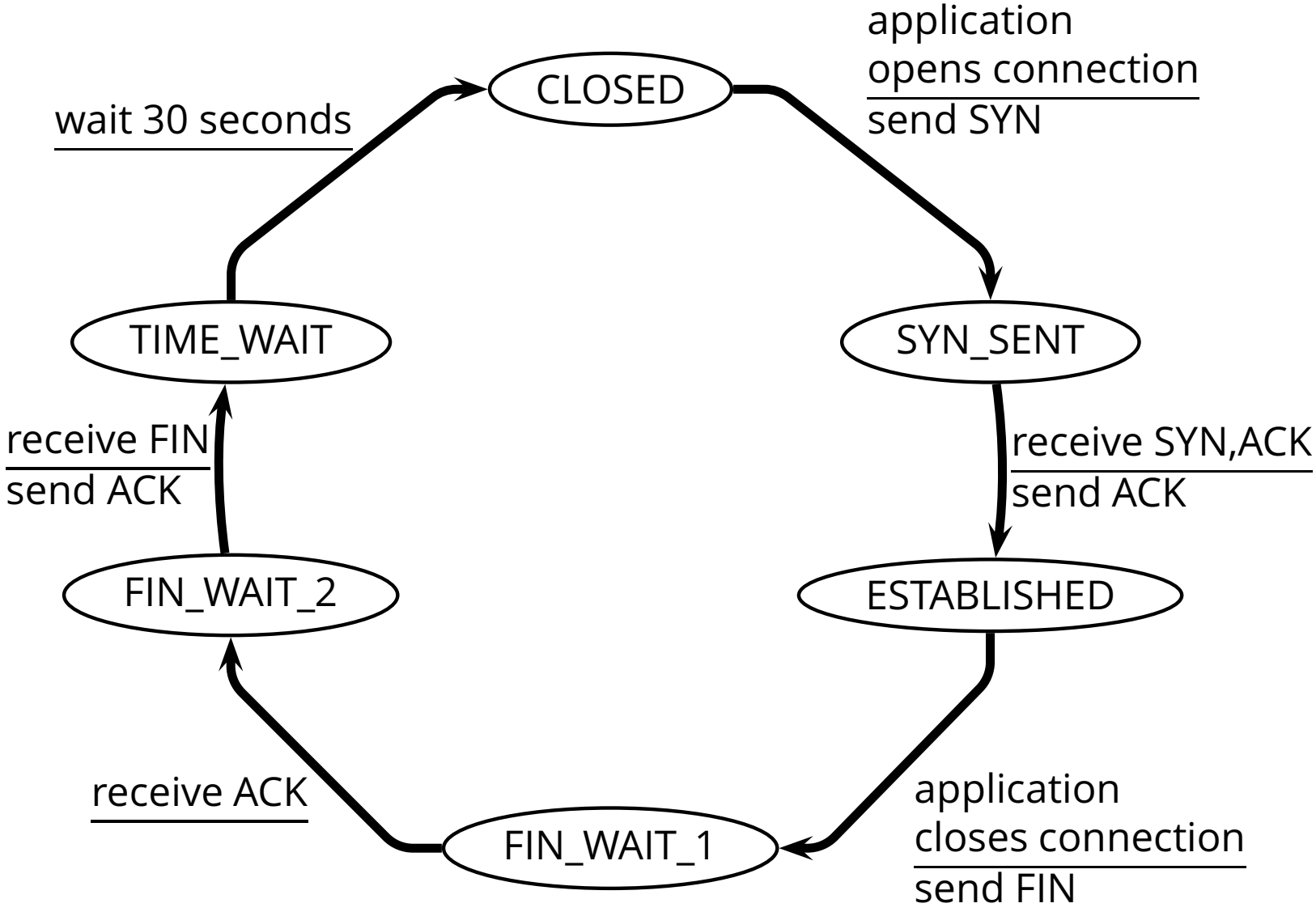

The TCP State Machine (Server)

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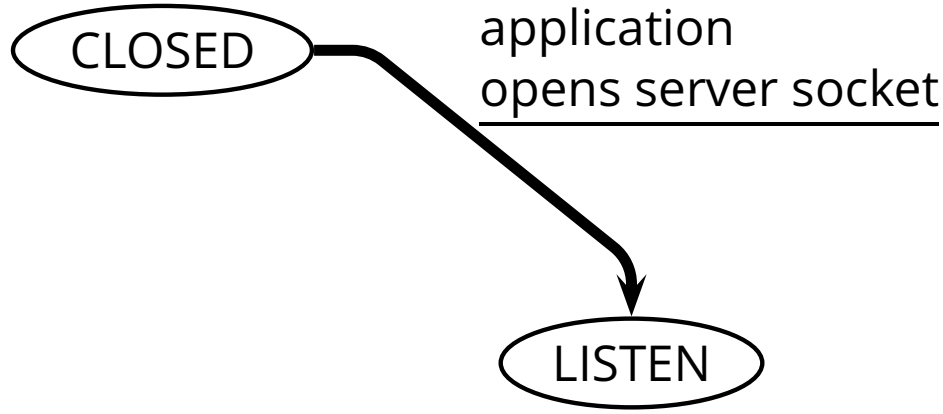

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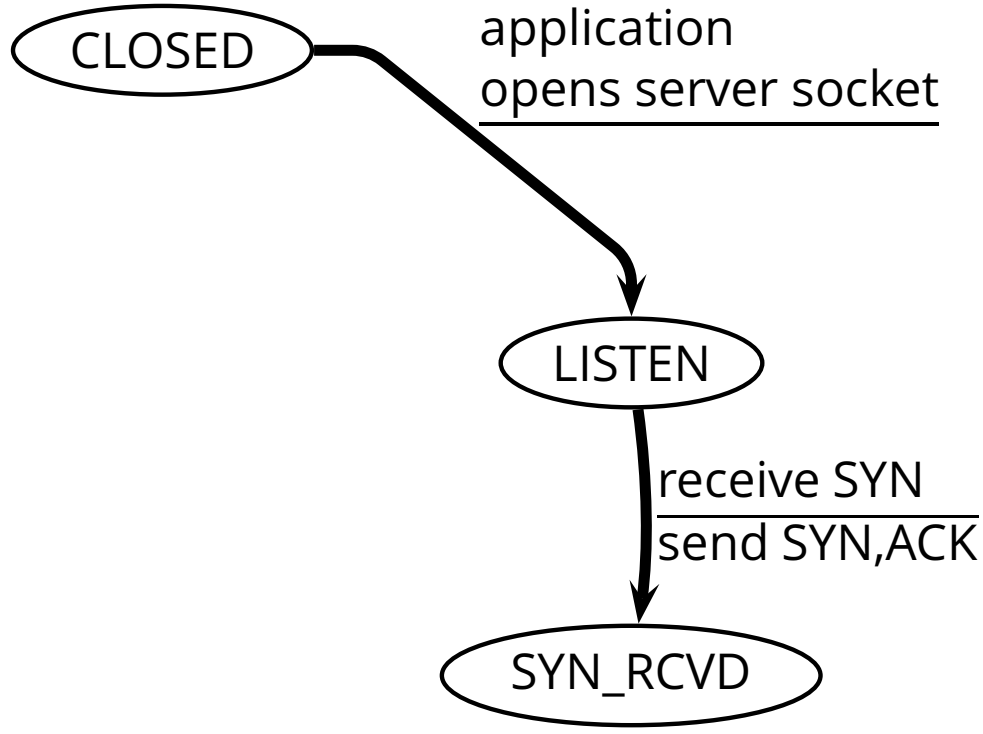

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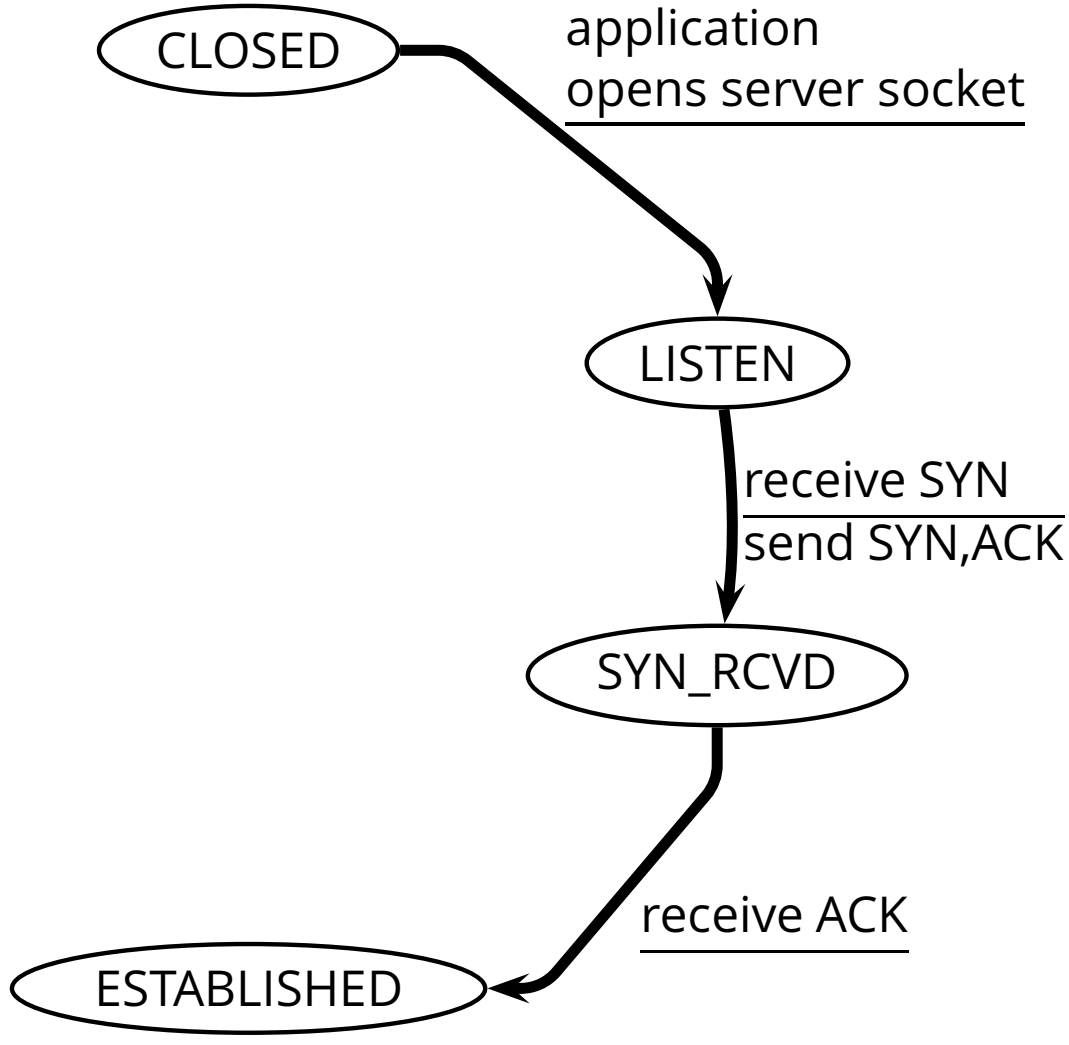

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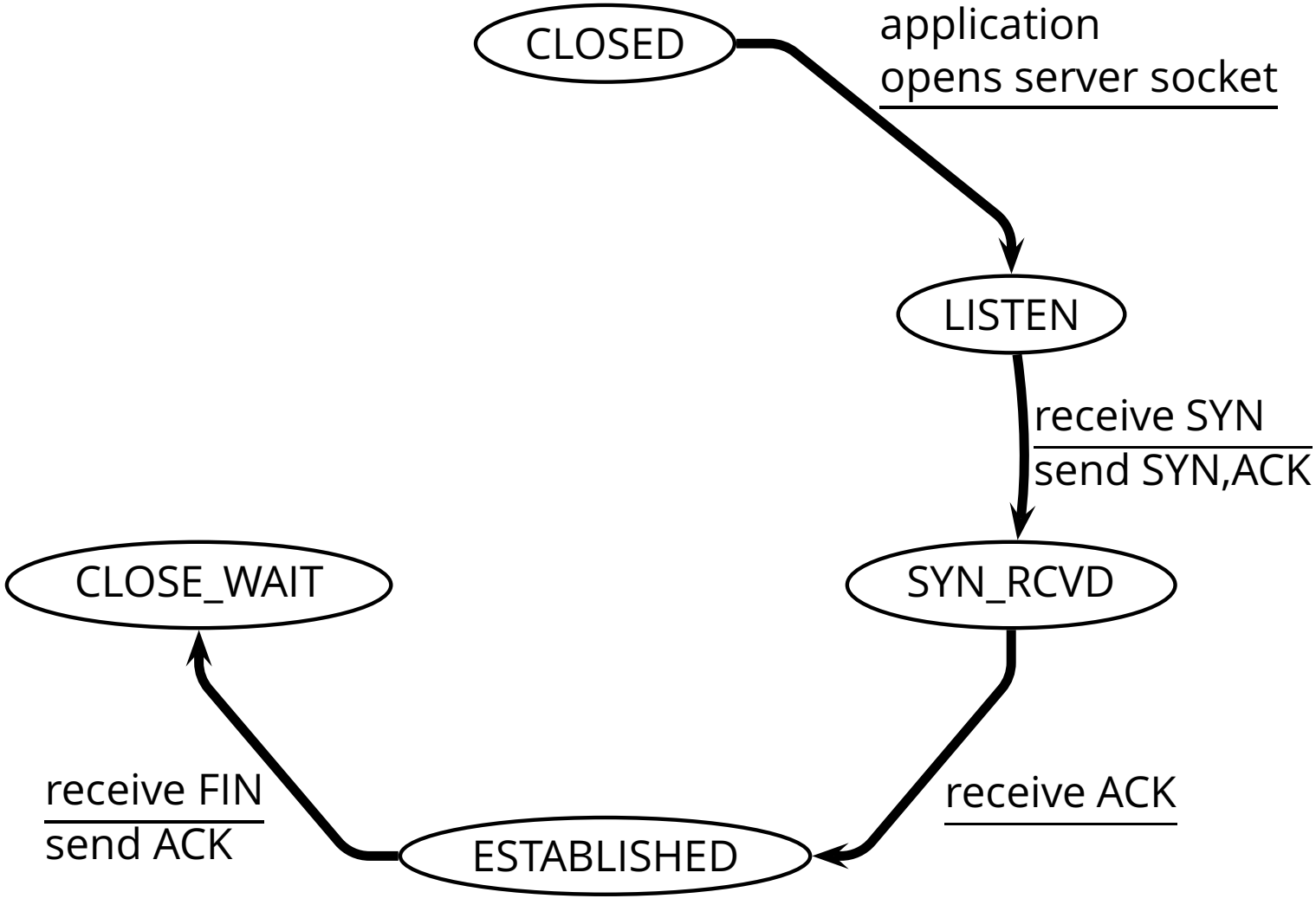

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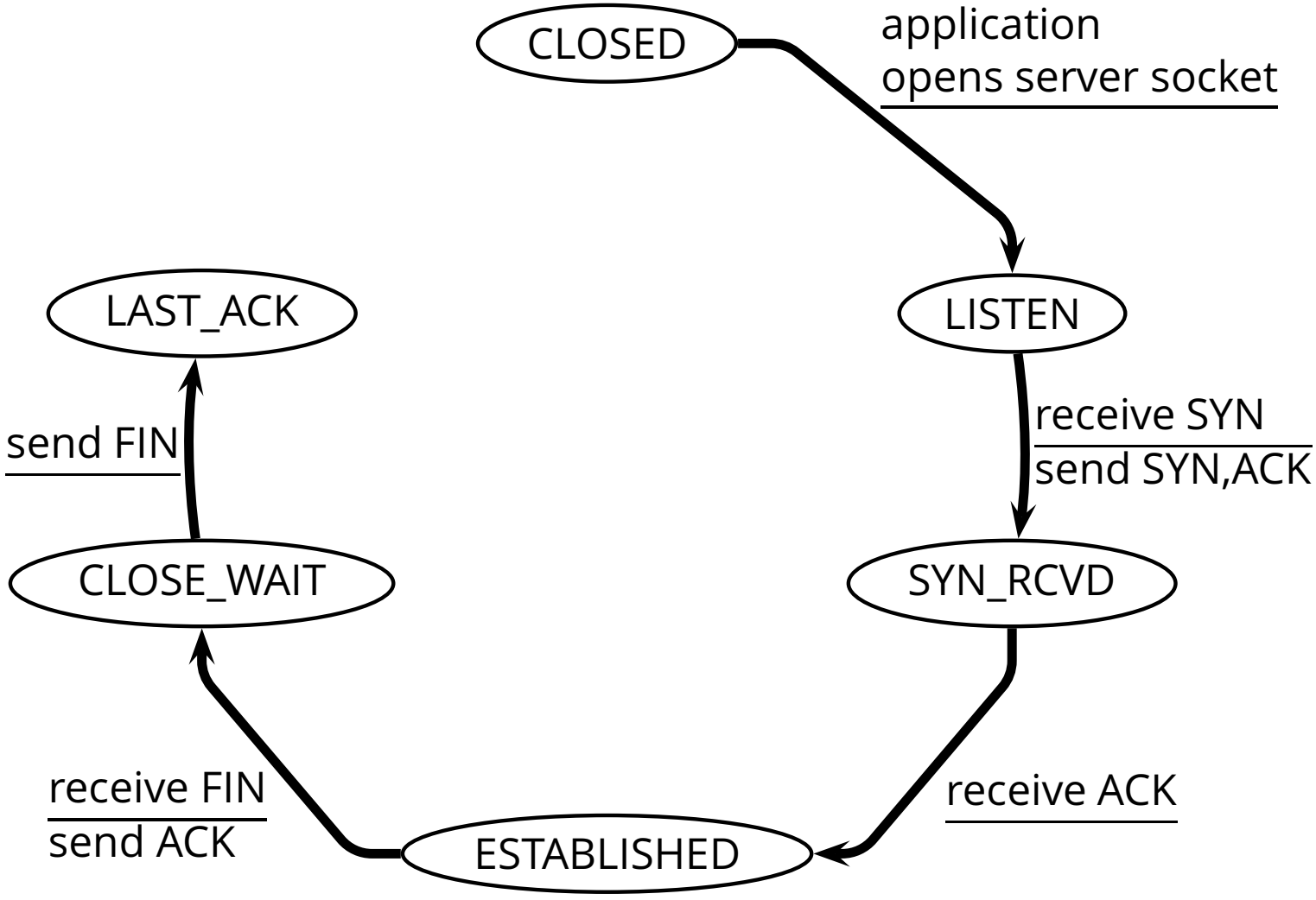
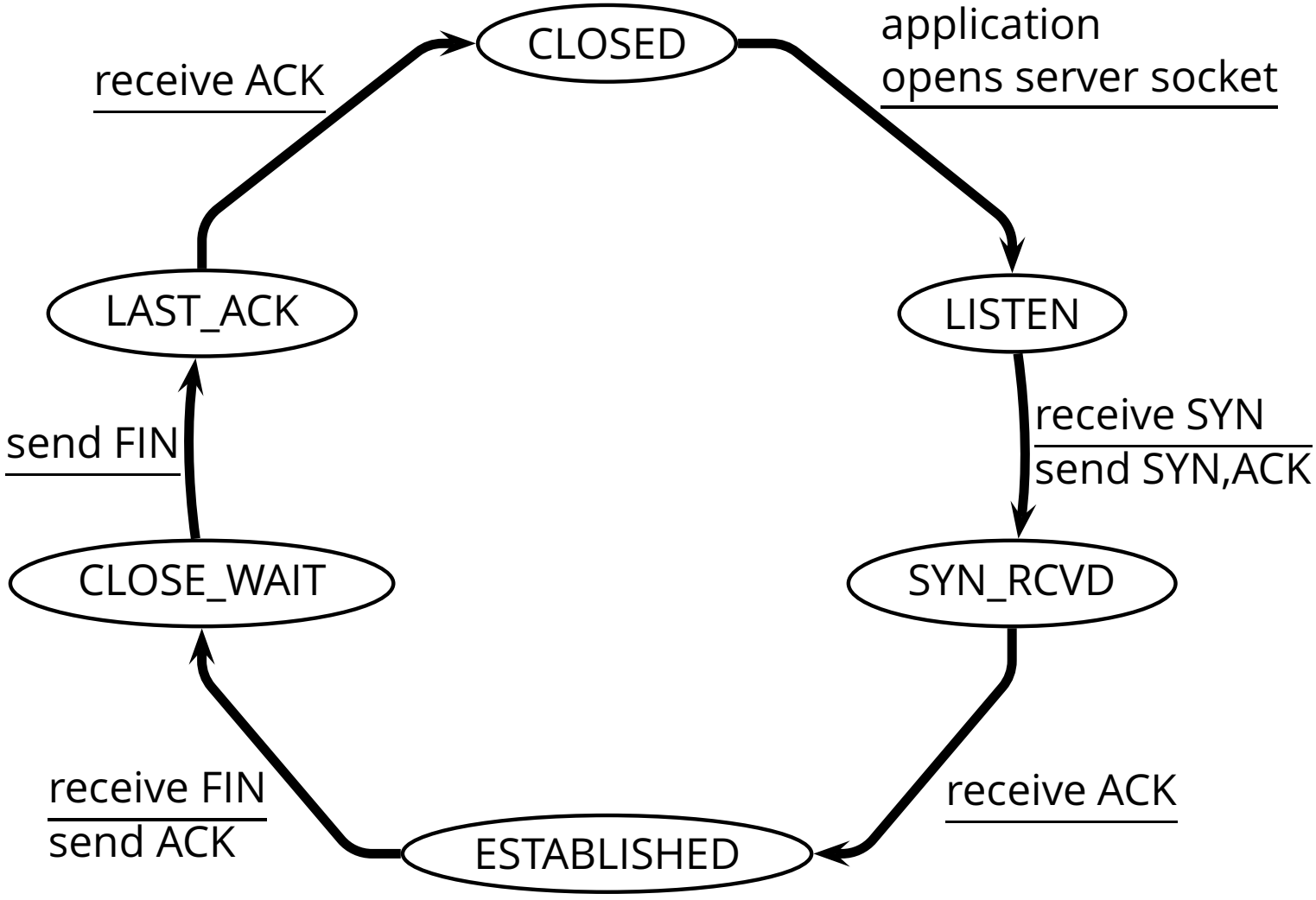
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