


Computer Networks

CMSC 417 : Spring 2024

COMPUTER SCIENCE
UNIVERSITY OF MARYLAND

Topic: TCP Flow-control and Congestion-control (Textbook chapter 5 & 6)

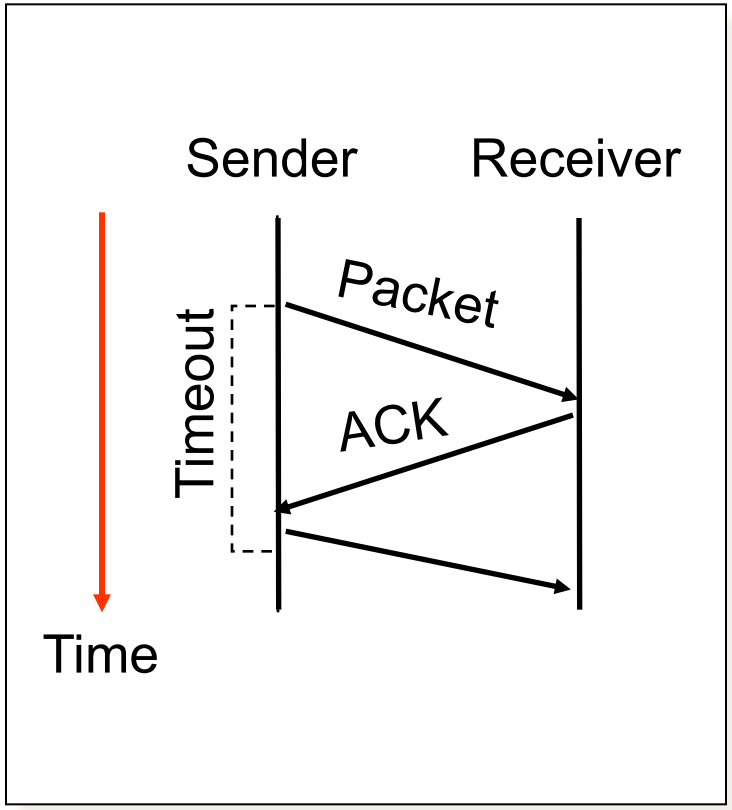
Nirupam Roy

Tu-Th 2:00-3:15pm
CSI 2117

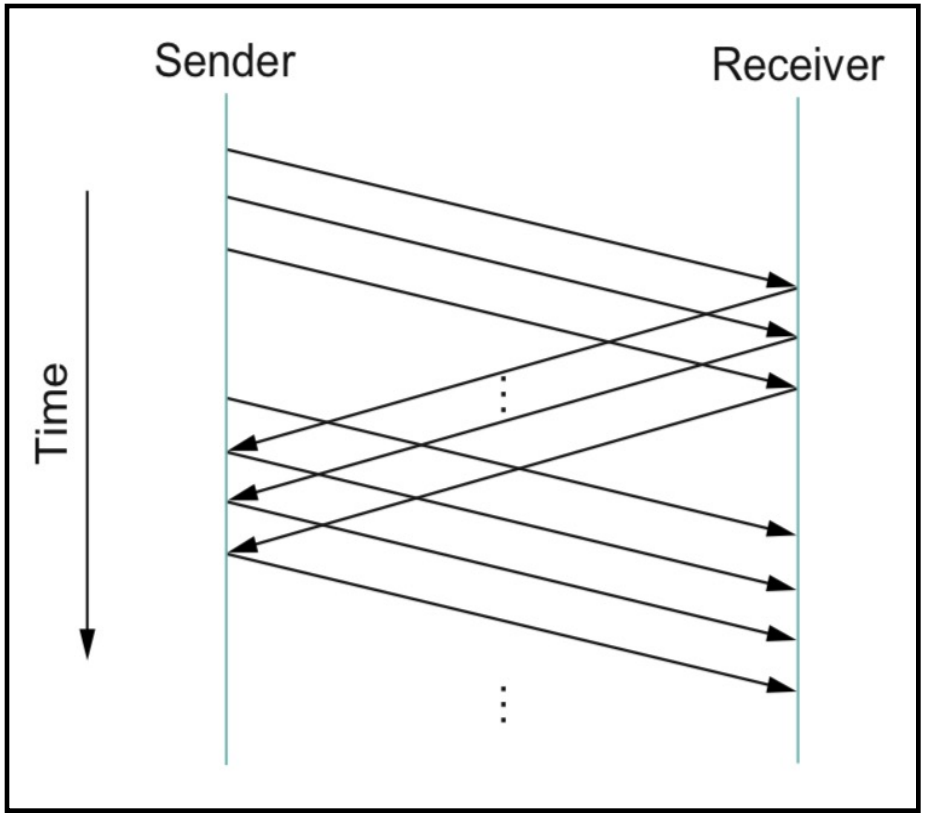
March 14th, 2024




Stop-and-wait

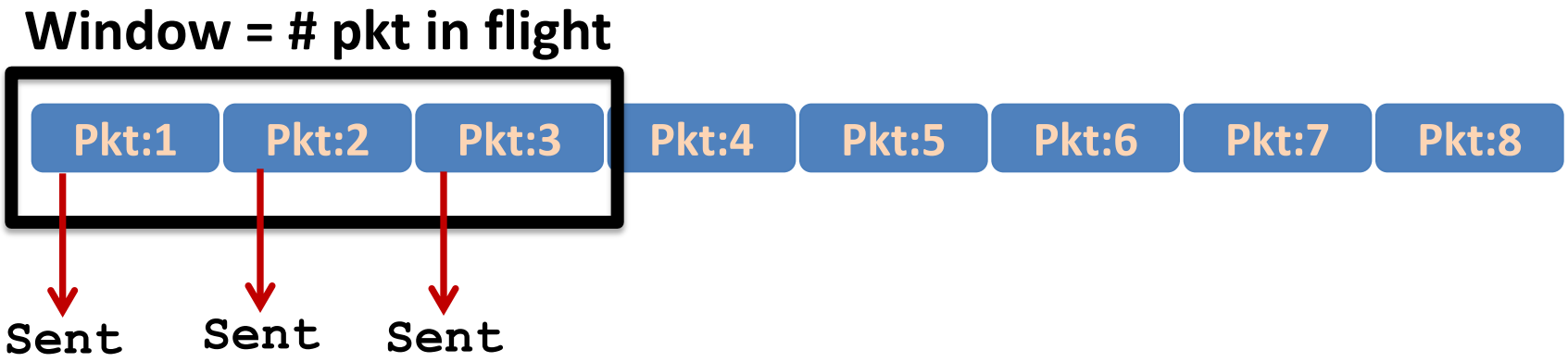


Sliding Window



Sliding Window Protocol (recap)

Sliding Window: A series of packets to be sent reliably



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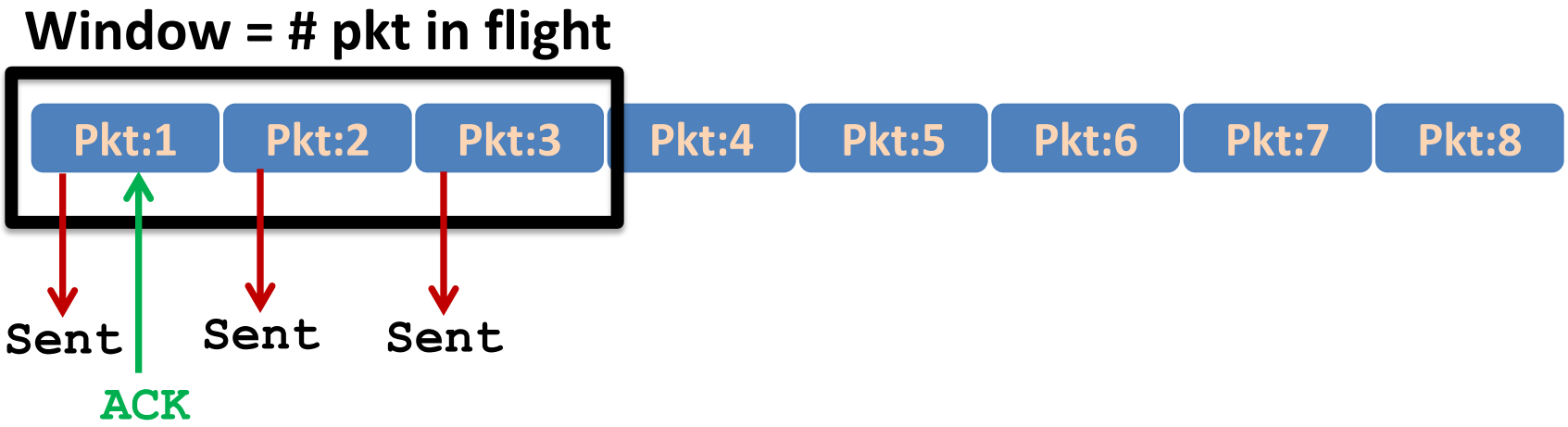

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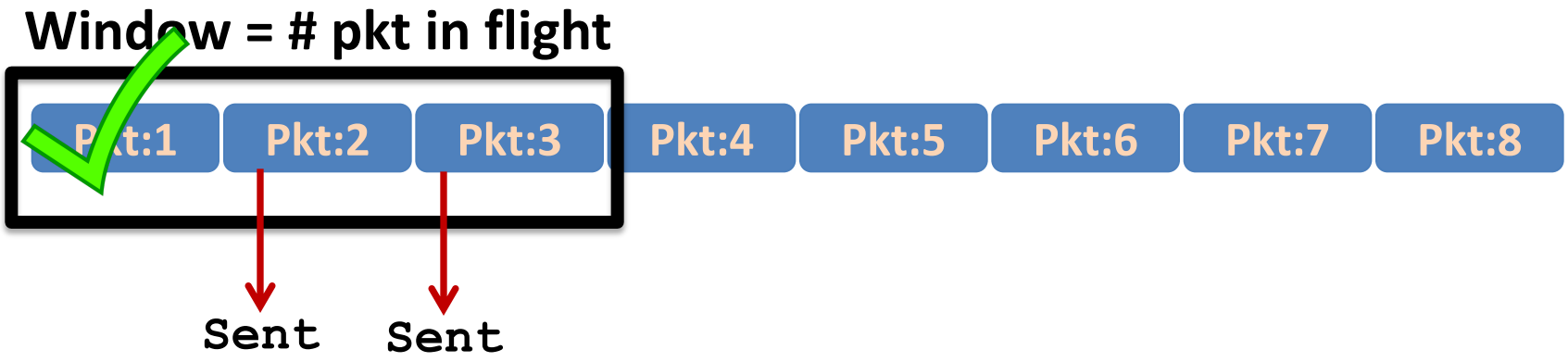
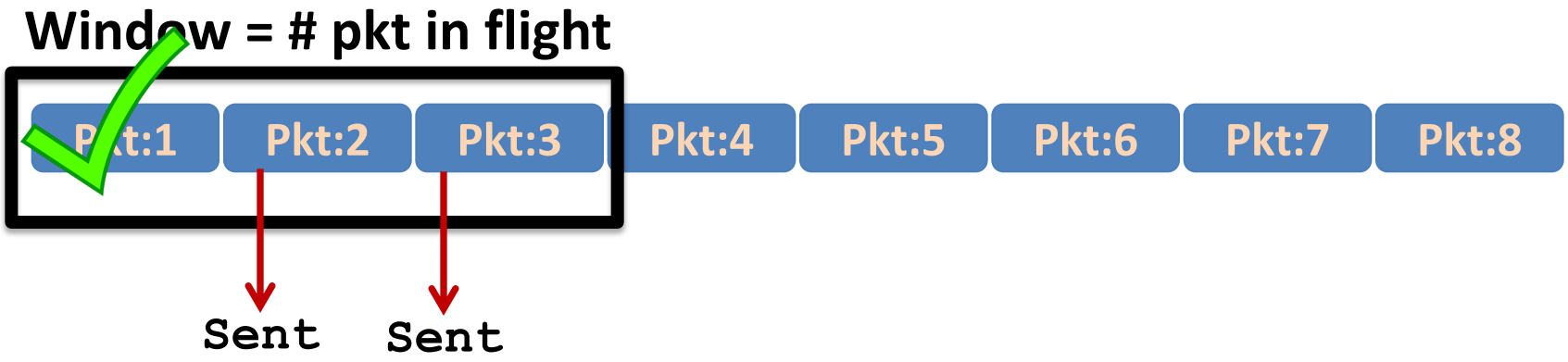


Packet 1 is delivered

Sliding Window: A series of packets to be sent reliably



Packet 1 is delivered. Slide the window.

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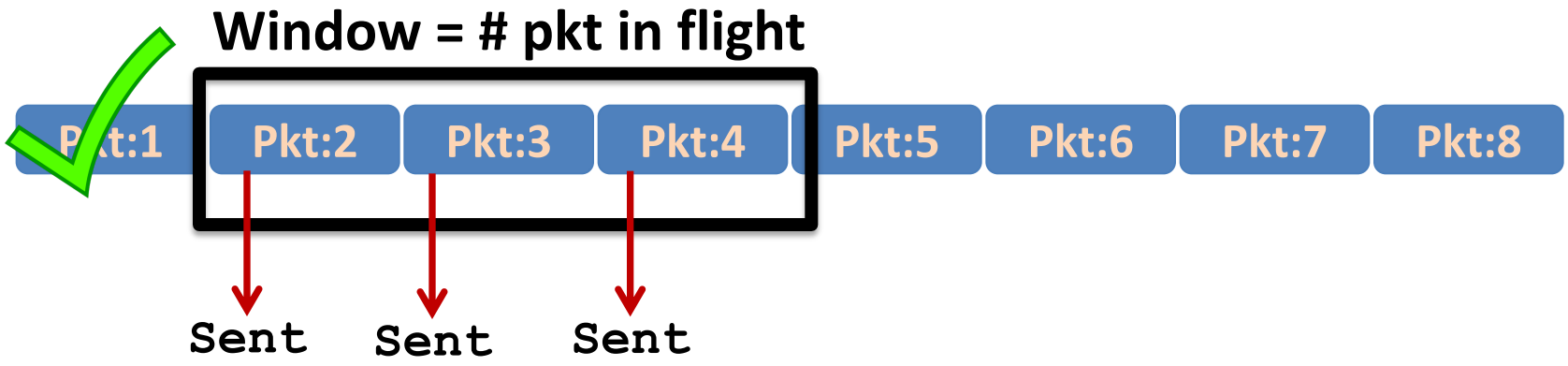

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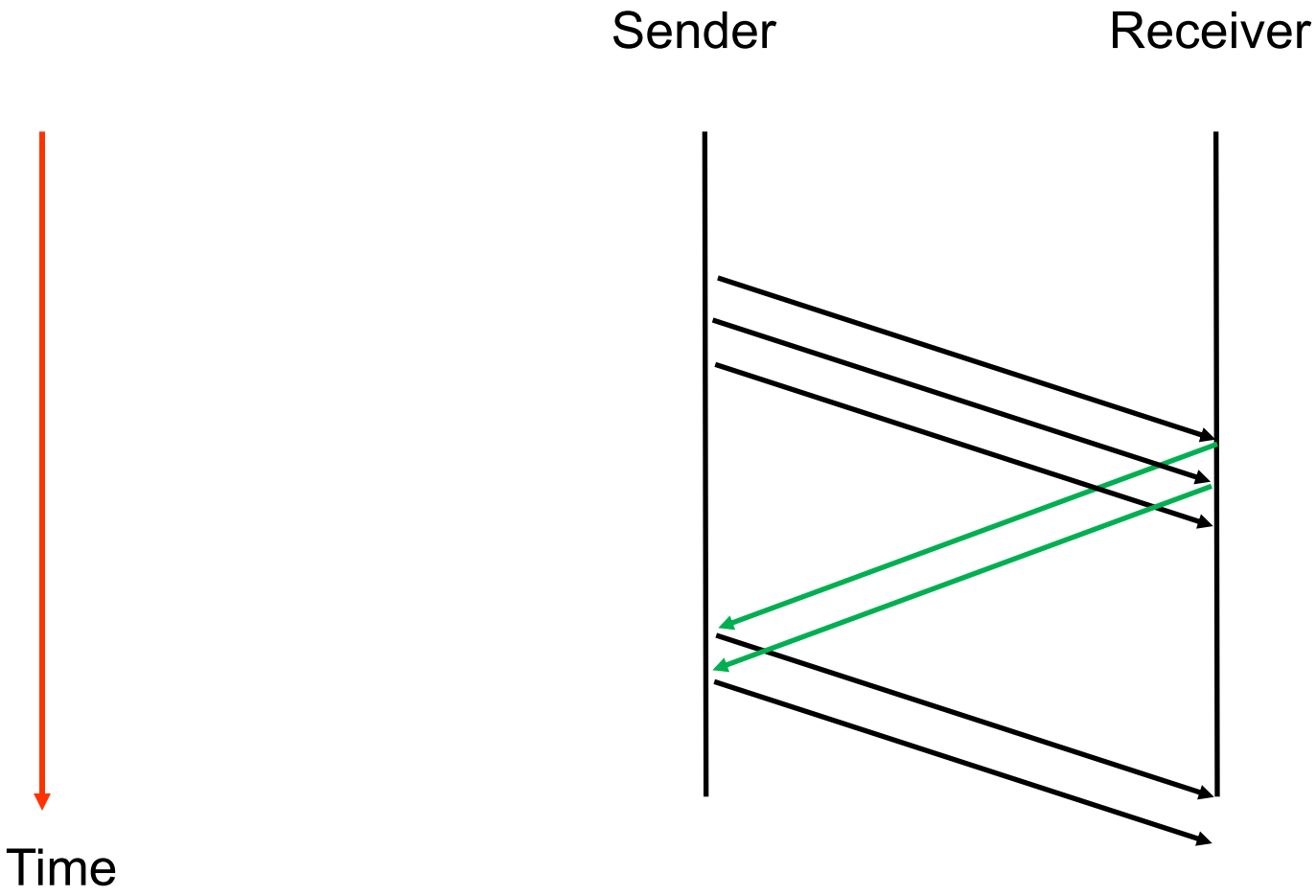

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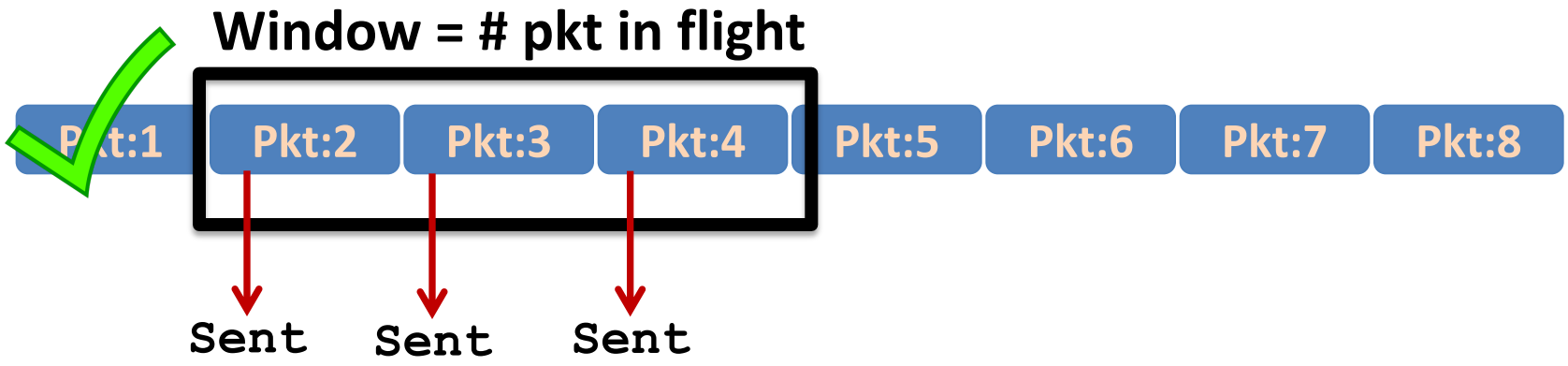
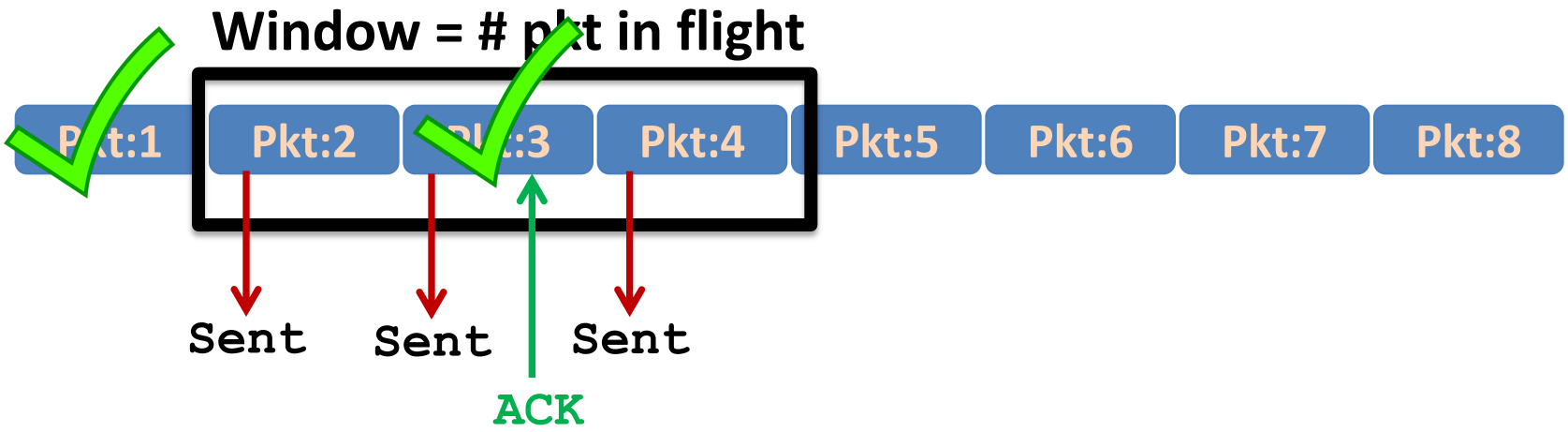


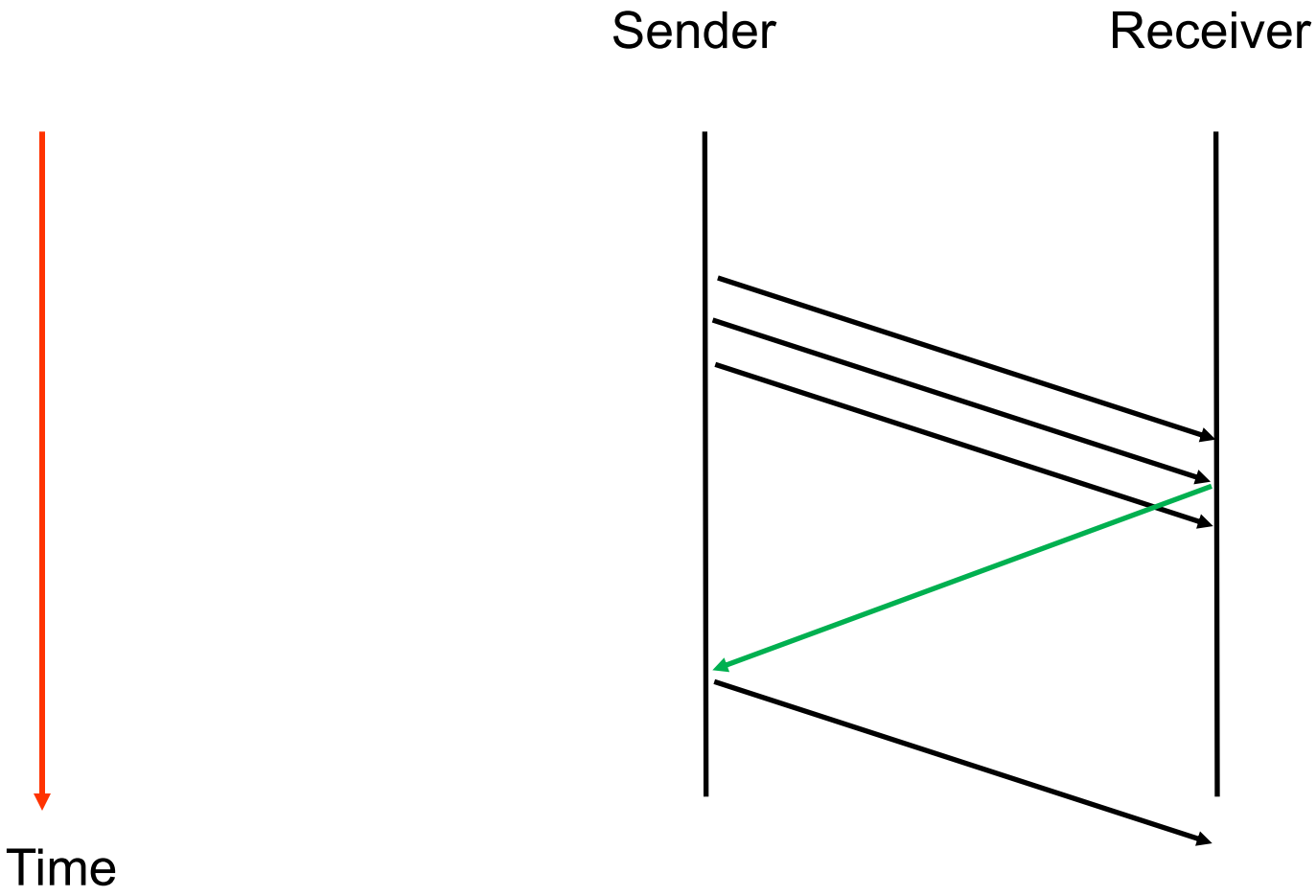
Packet 1 is delivered. Slide the window.

Sliding Window: A series of packets to be sent reliably

Should we advance the window in the following scenario?



Sliding Window: A series of packets to be sent reliably



Sliding Window: A series of packets to be sent reliably

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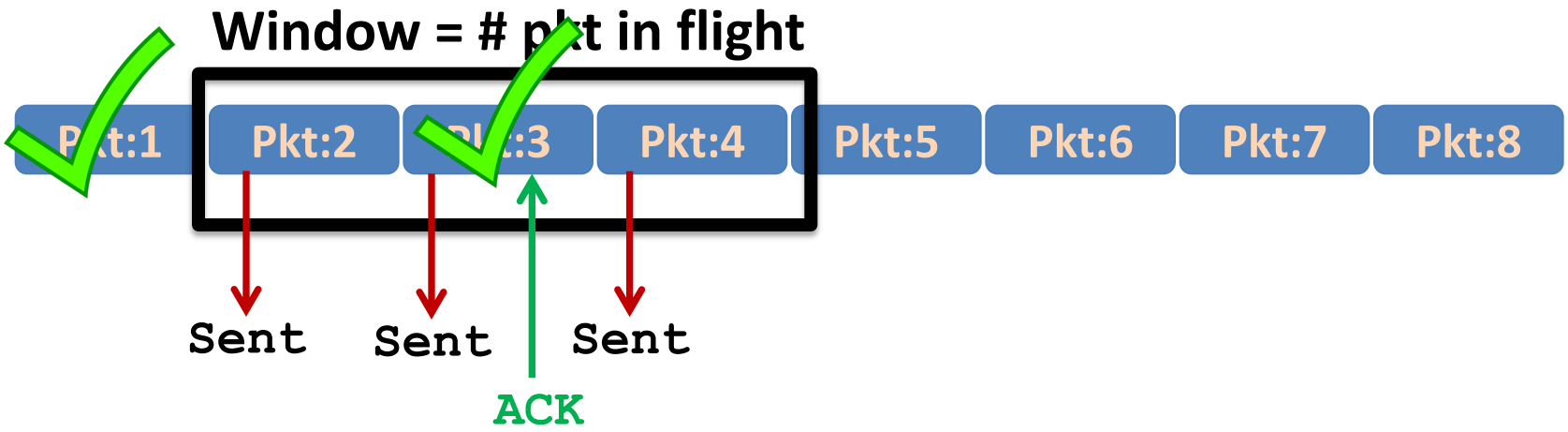
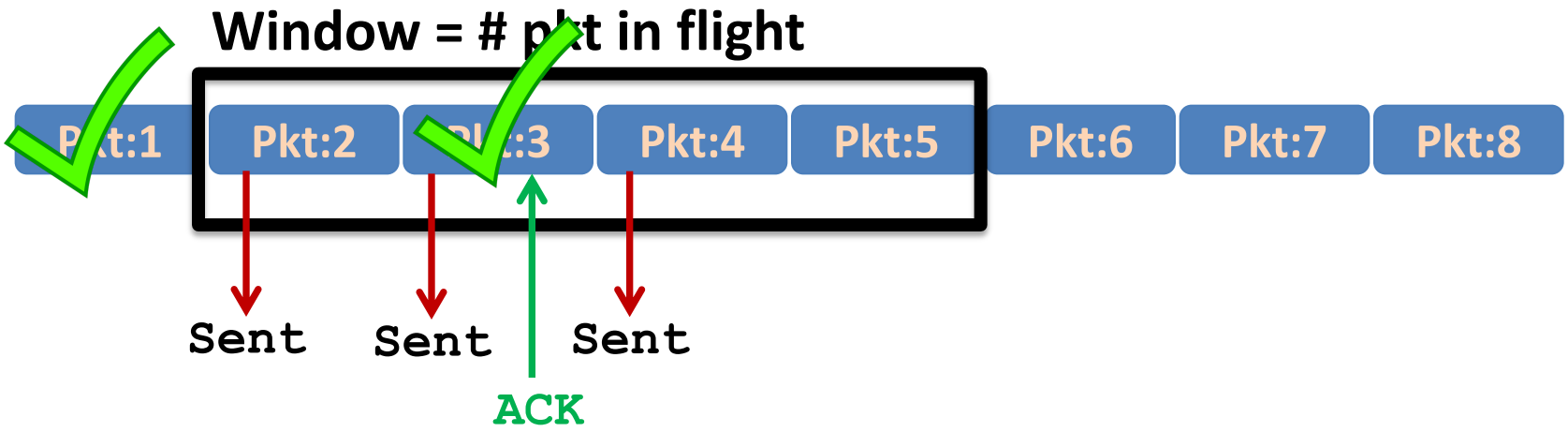


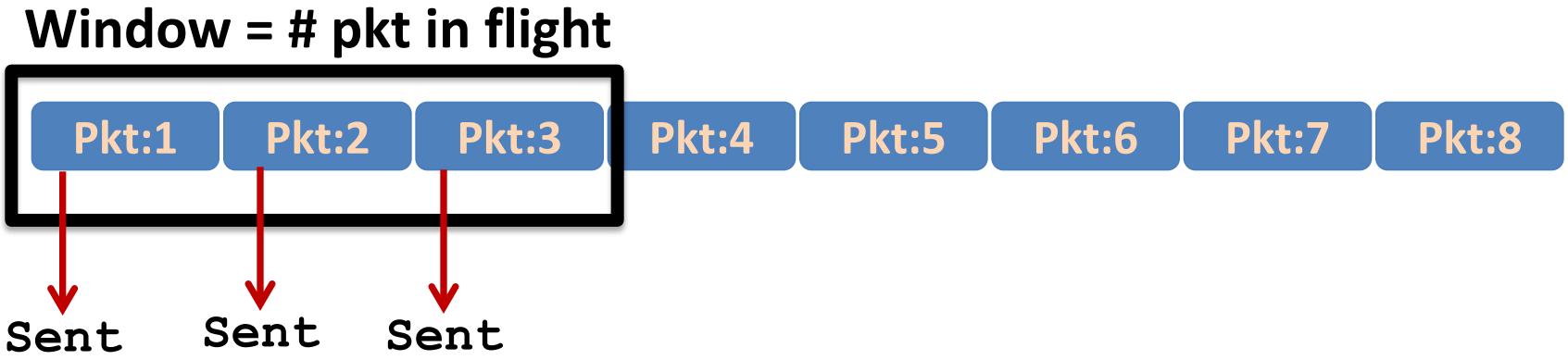
Sliding Window: A series of packets to be sent reliably

Should we advance the window in the following scenario?



Note that the window size is not changed!

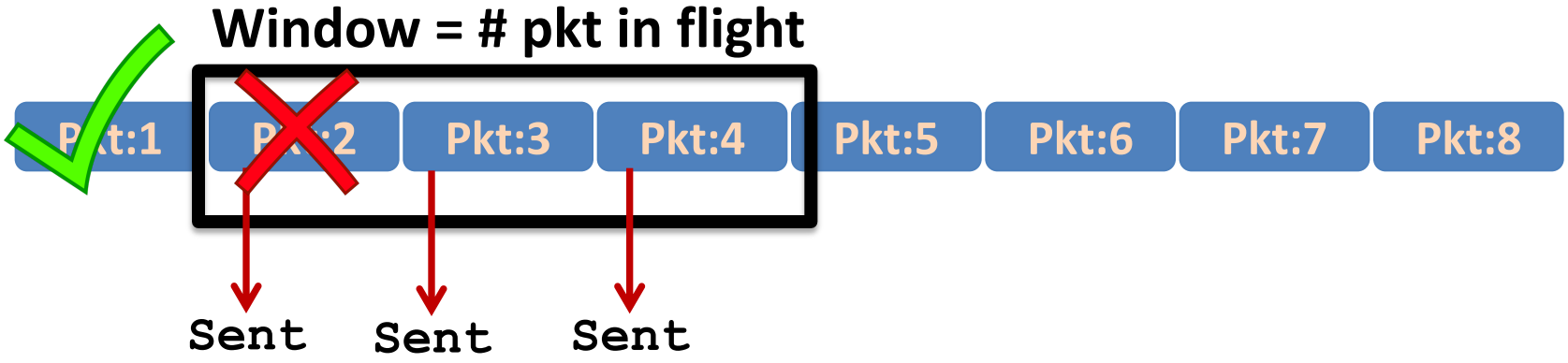
Sliding Window: A series of packets to be sent reliably



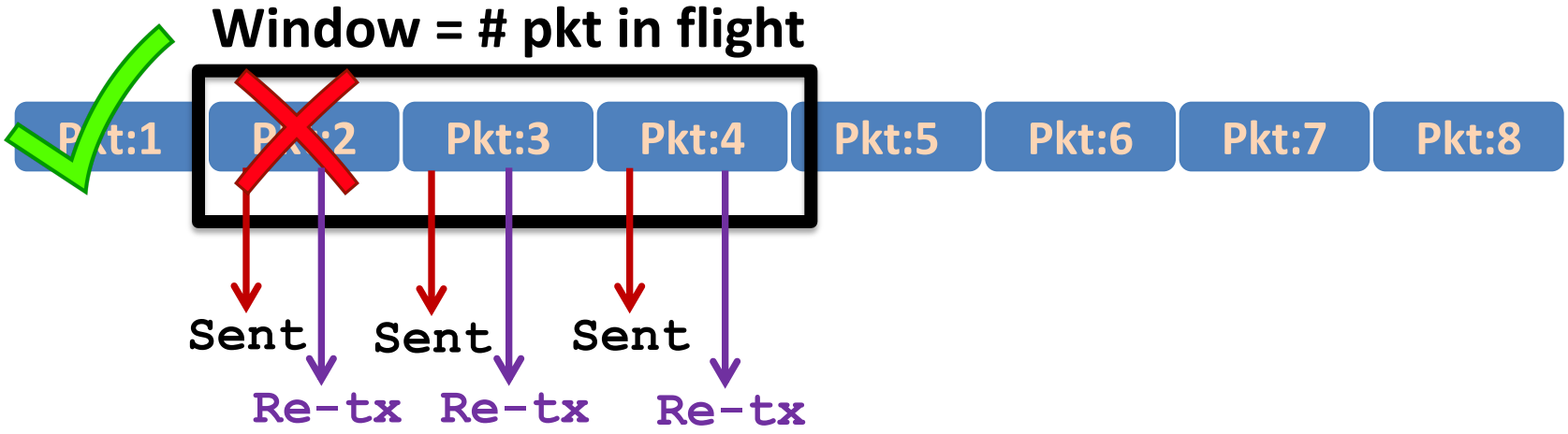
Can you make sliding window behave like stop-and-wait?

Sliding Window Protocol (dealing packet loss)

Sliding Window: A series of packets to be sent reliably



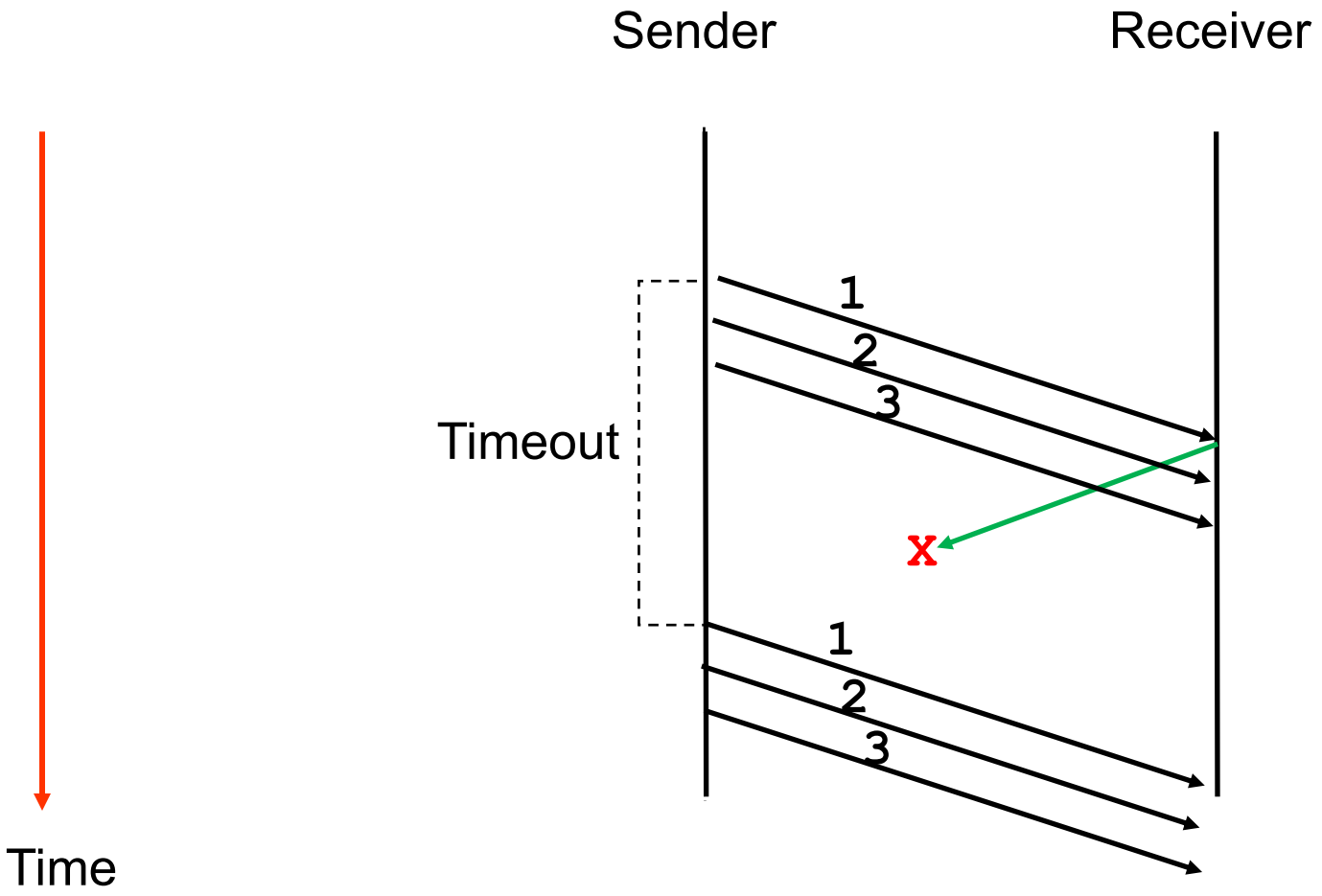
Sliding Window: A series of packets to be sent reliably



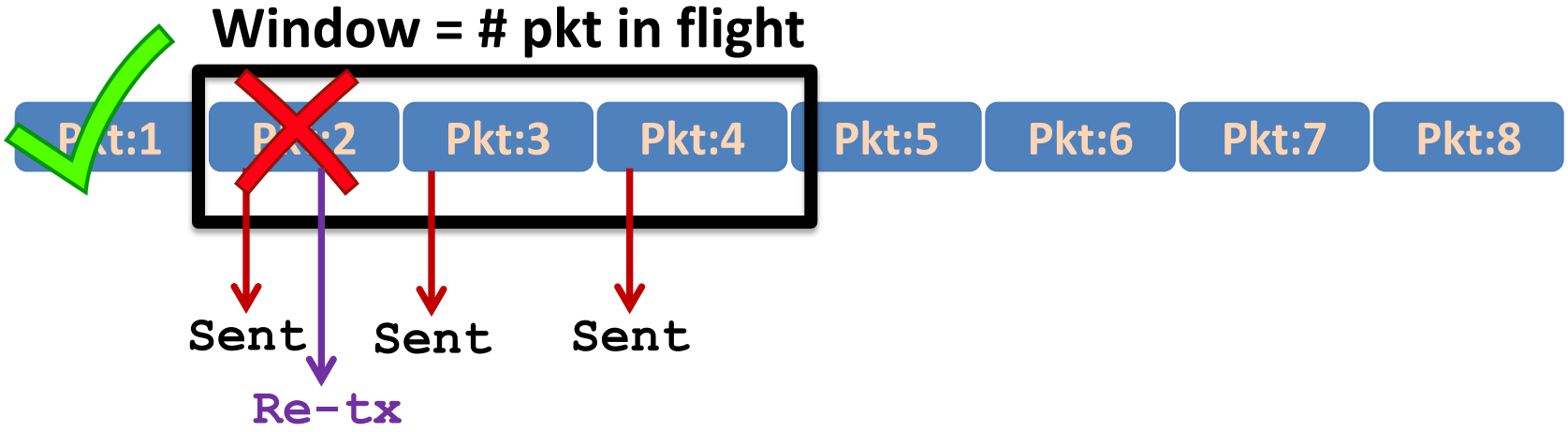
(1) ARQ strategy 1: Retransmit all un-ACKed packets

Sliding Window: A series of packets to be sent reliably

(1) Go-back-N (Sender side)



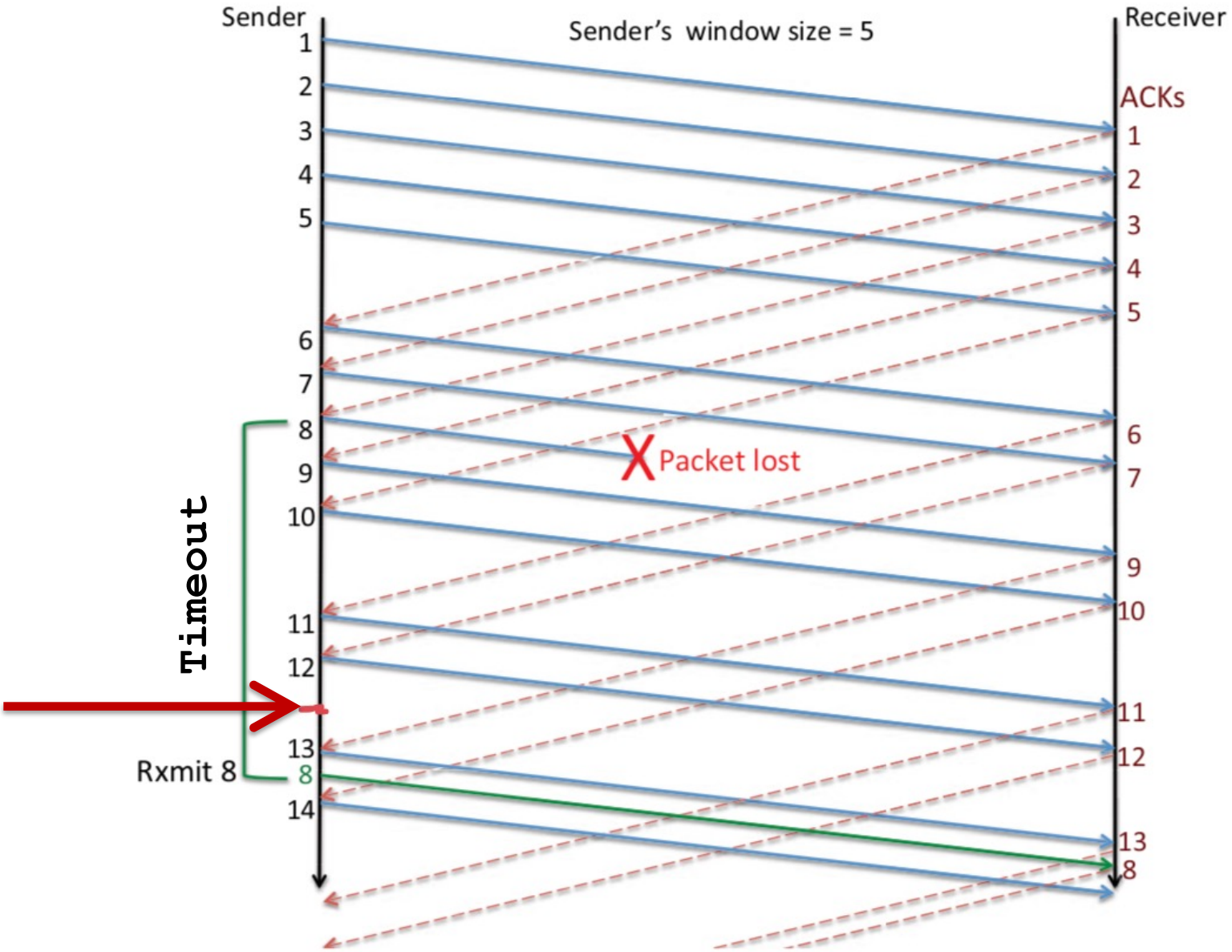
Sliding Window: A series of packets to be sent reliably



(2) ARQ strategy 2: Retransmit only the lost packet

(2) Selective retransmit (Sender side)

Sliding Window: Lost Packet/ACK



TCP Cumulative ACK strategy (receiver side)

Cumulative ACK:

ACK the largest in-sequence packet received.

What will be ACK sequence if the receive sequence is: 5, 7, 8, 6 ?

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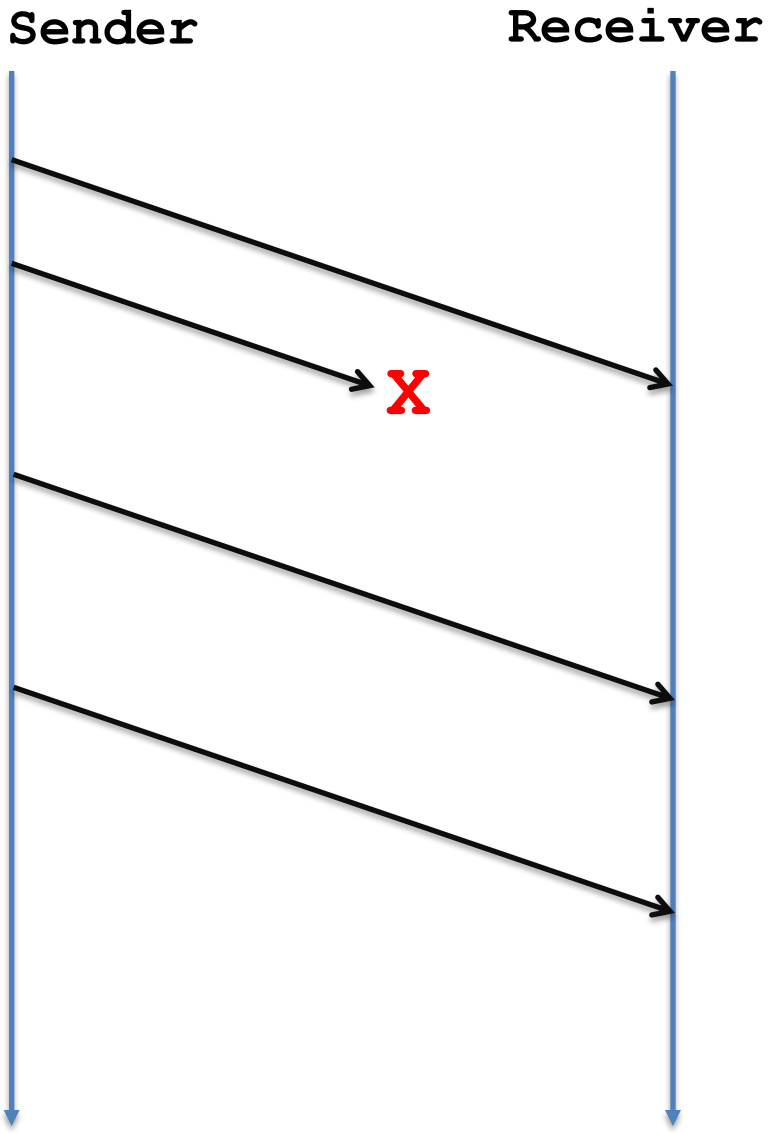
What will be ACK sequence if the receive sequence is: 5, 7, 8, 6 ?

ACK: 6, 6, 6, 9

TCP Cumulative ACK strategy (receiver side)

(A more precise example)



TCP Cumulative ACK strategy (receiver side)

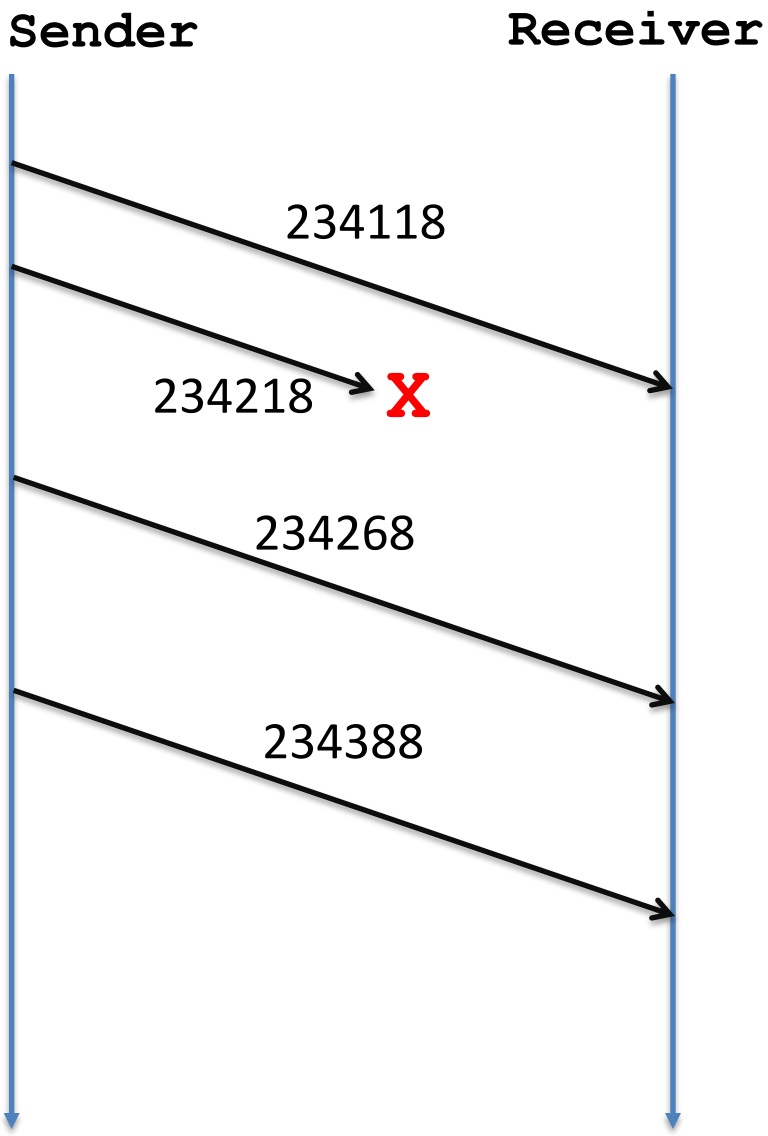
(A more specific example)

Seq. #	234118
ACK flag	N/A
ACK #	N/A
Data Len	100 bytes

Seq. #	234218
ACK flag	N/A
ACK #	N/A
Data Len	50 bytes

Seq. #	234268
ACK flag	N/A
ACK #	N/A
Data Len	120 bytes

Seq. #	234388
ACK flag	N/A
ACK #	N/A
Data Len	100 bytes



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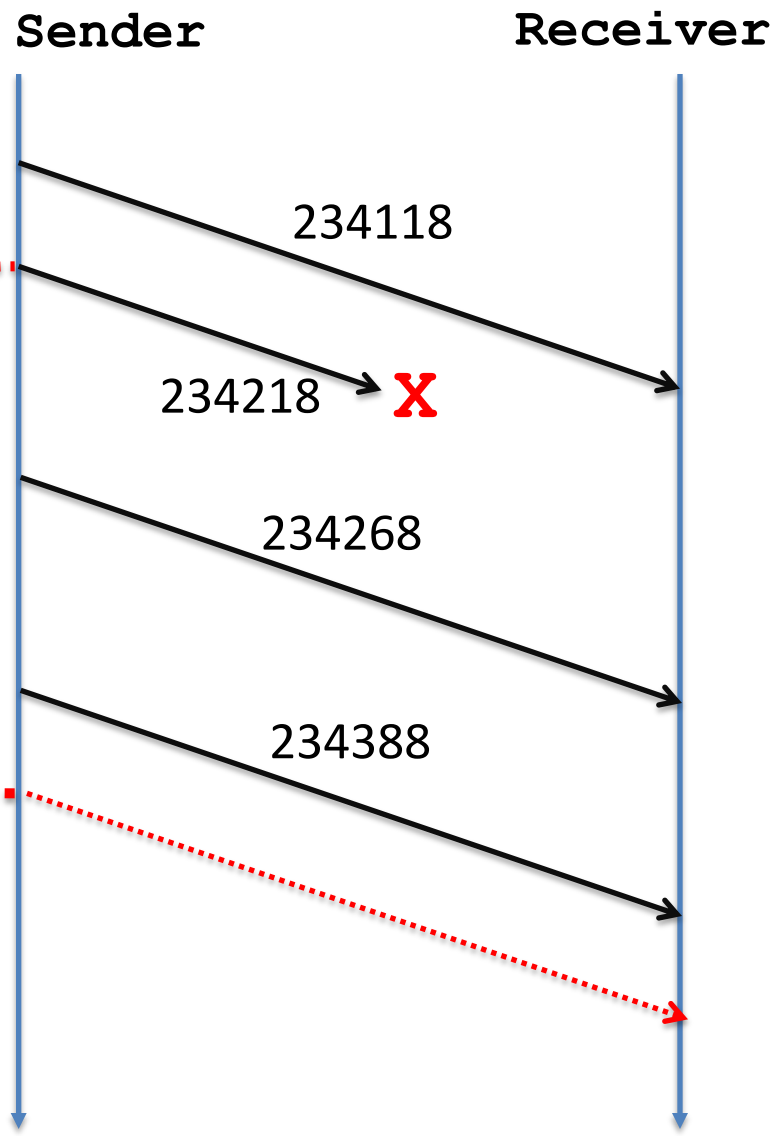

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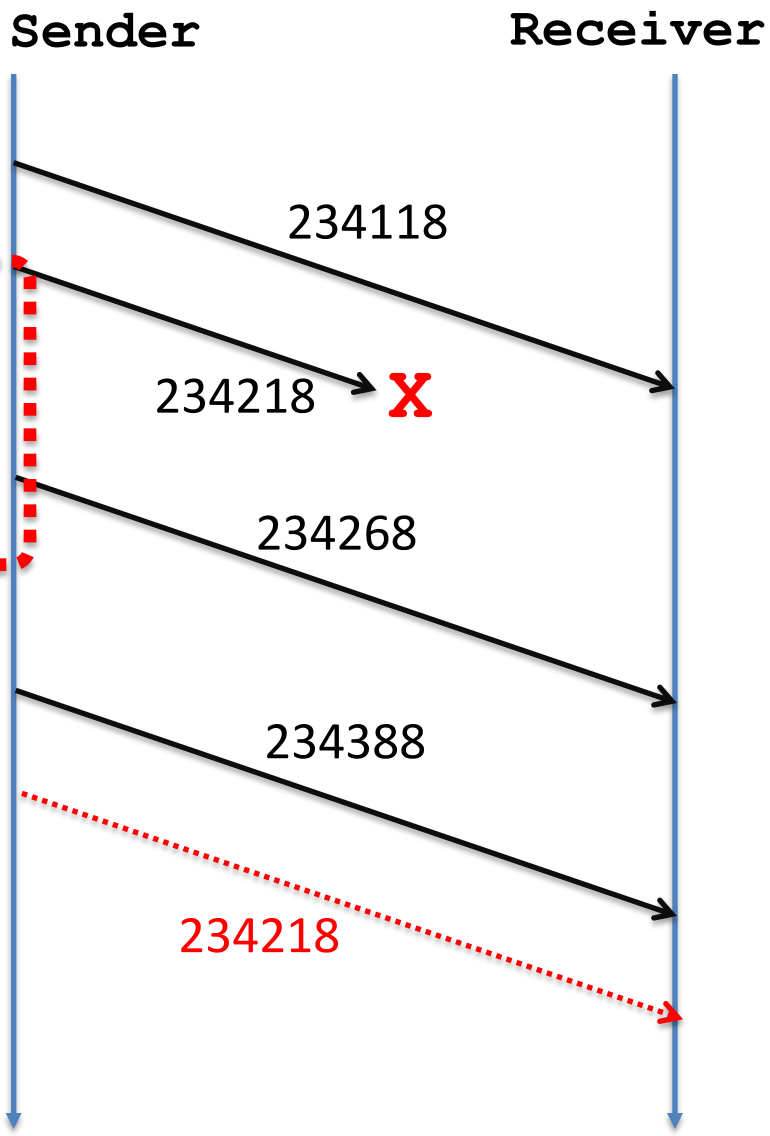

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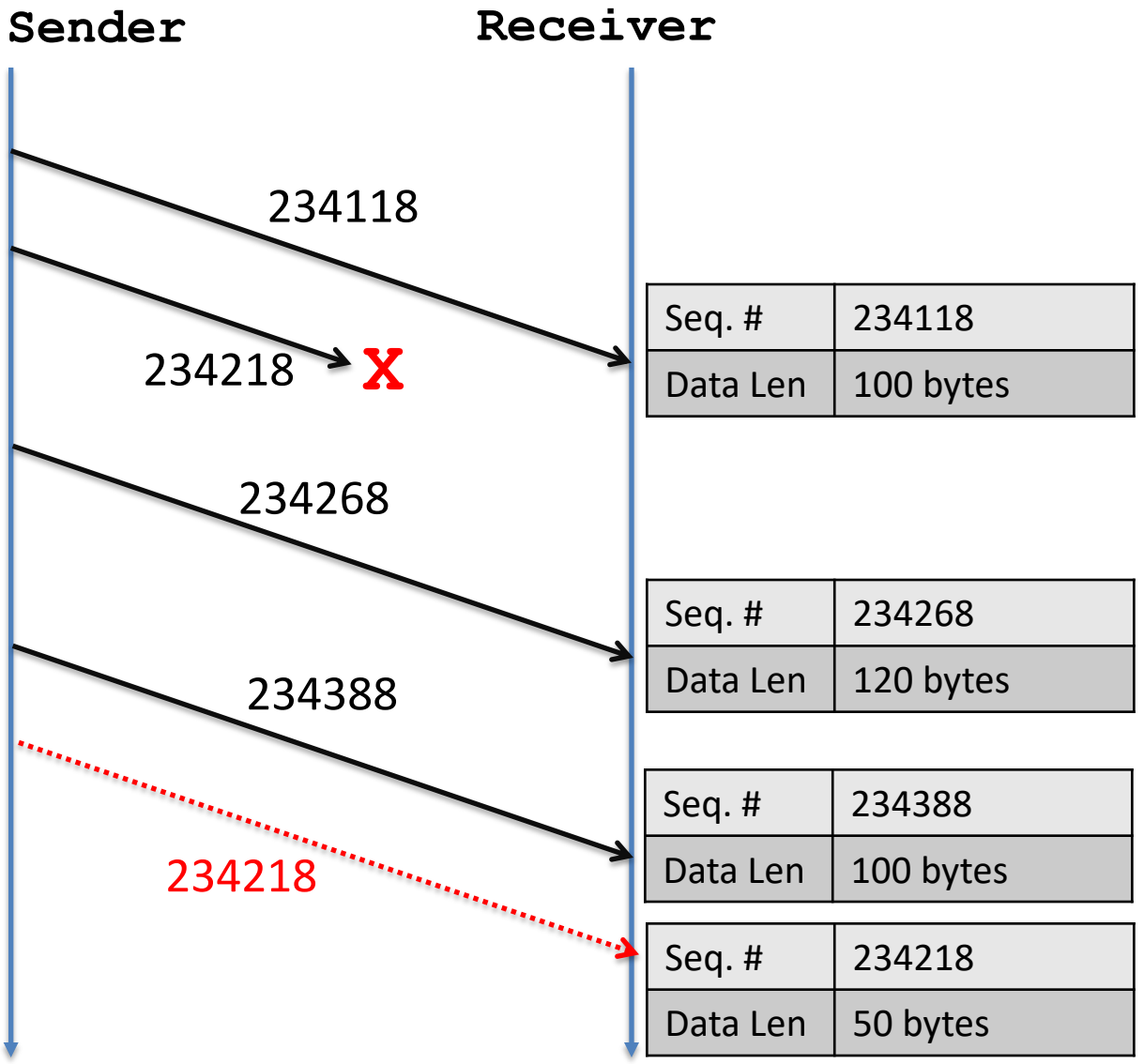

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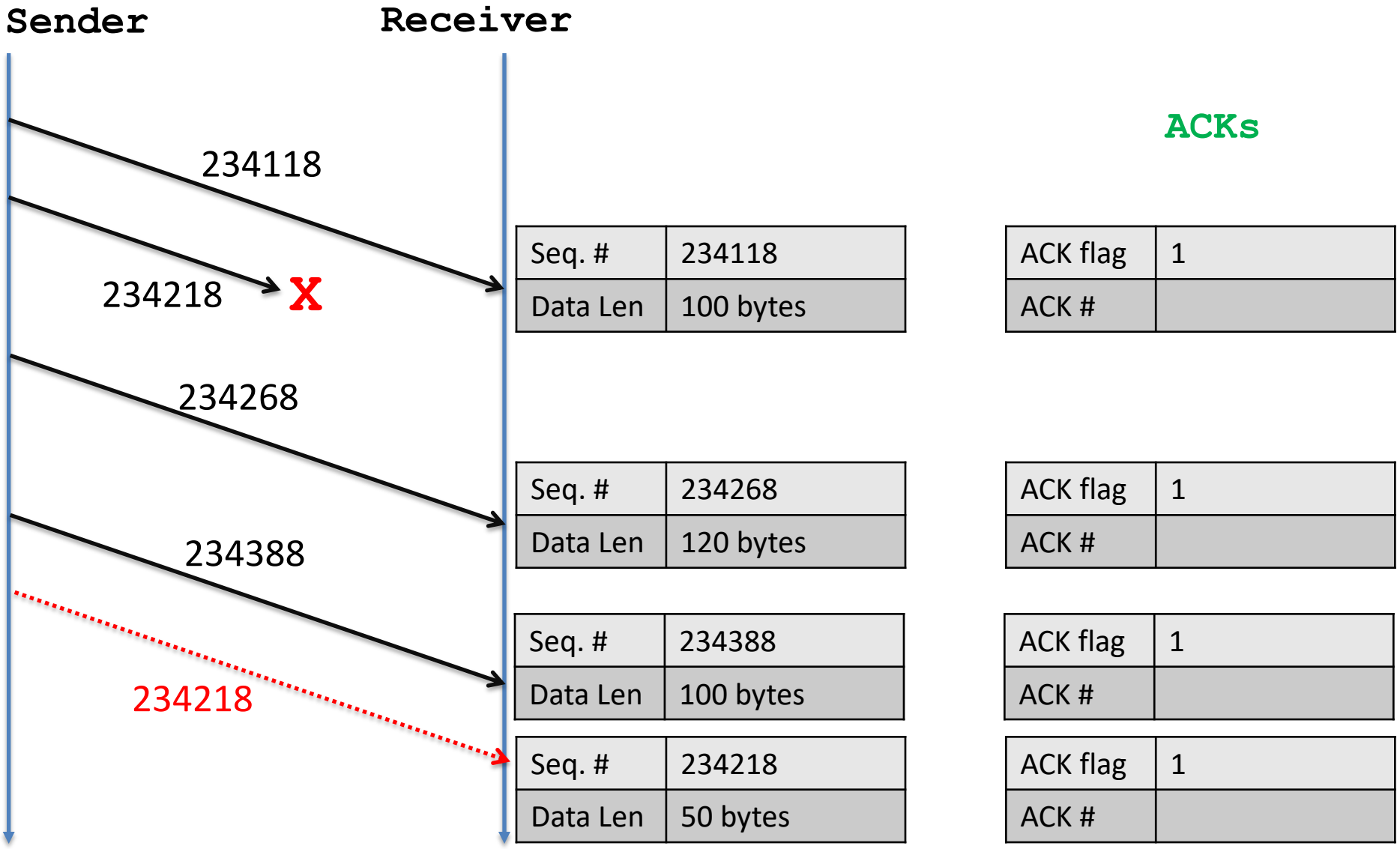
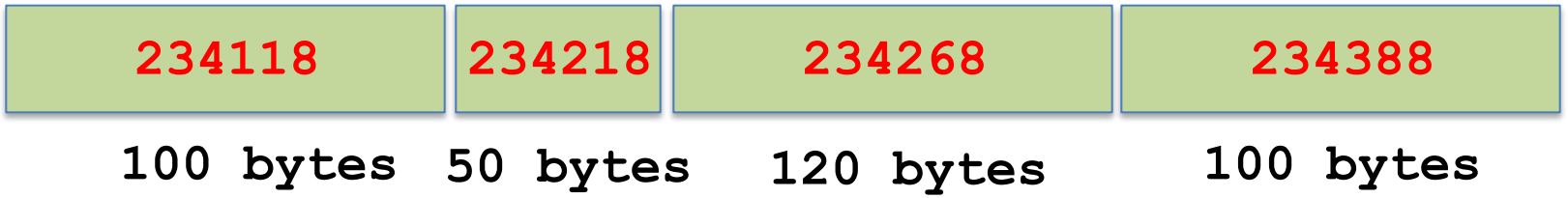


TCP Cumulative ACK strategy (receiver side)

Sender buffer:



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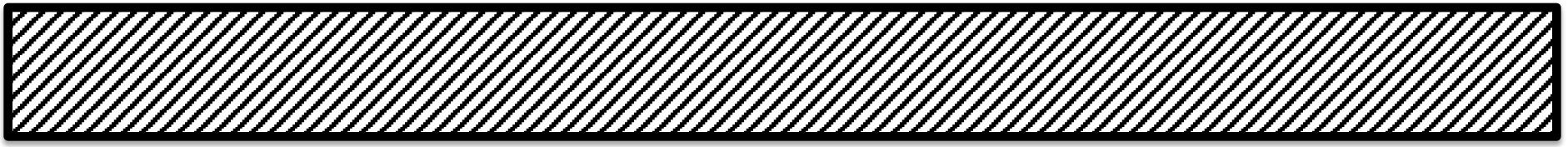

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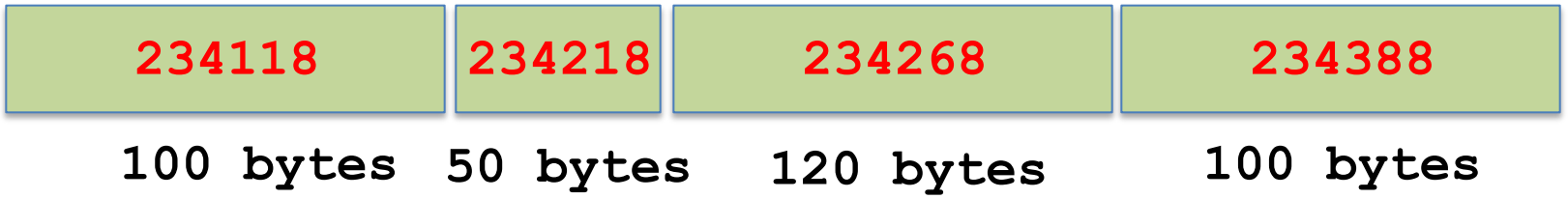

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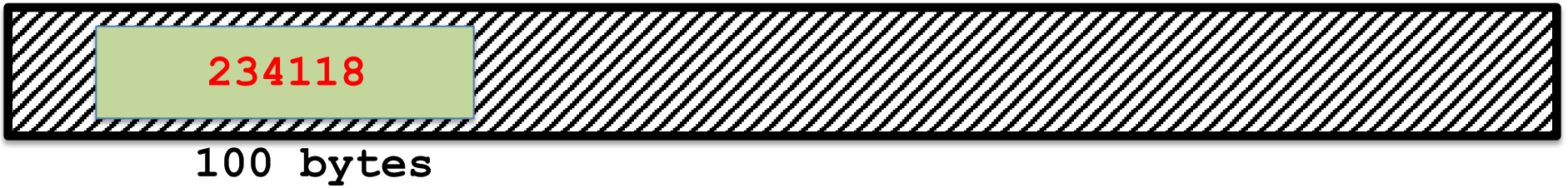

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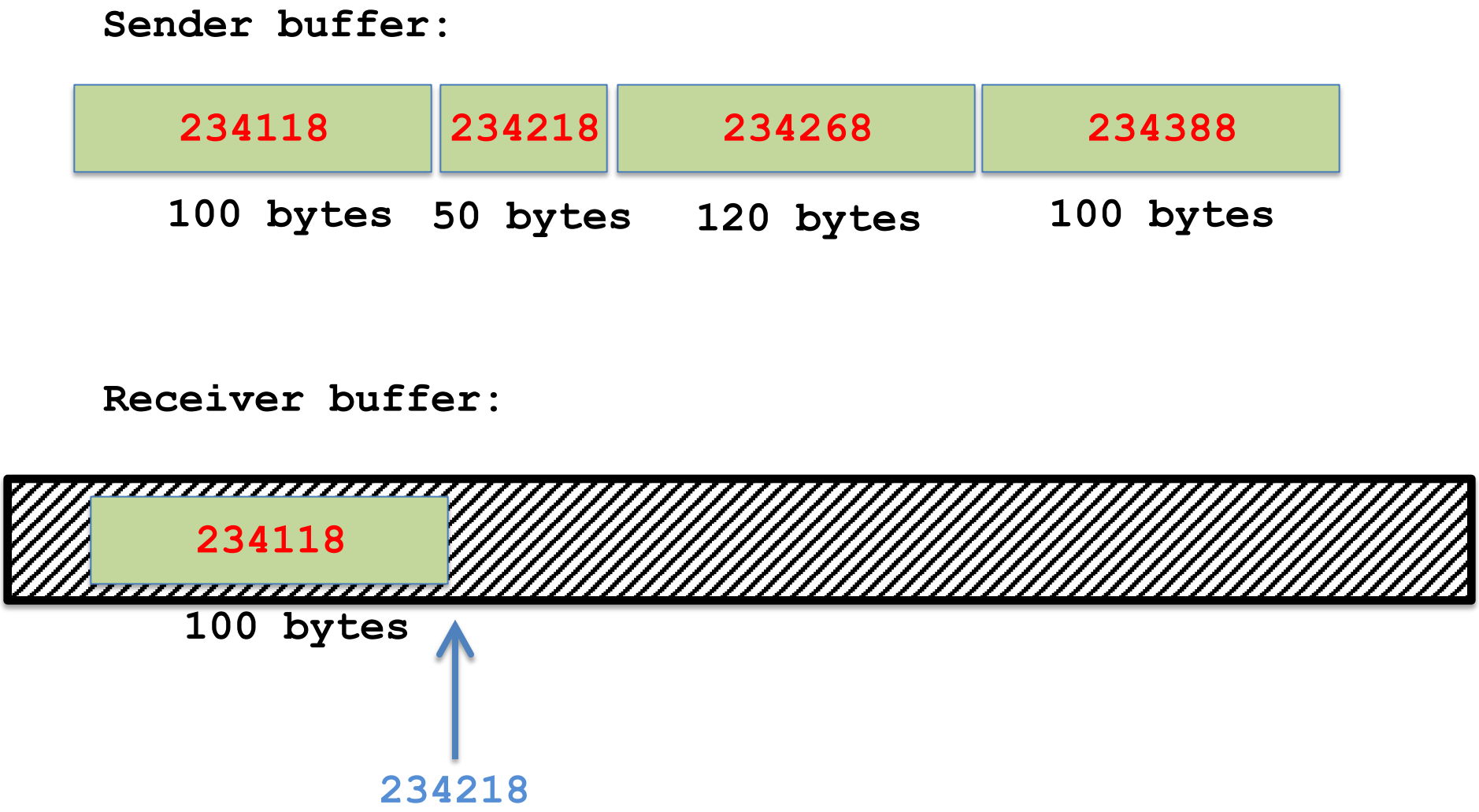

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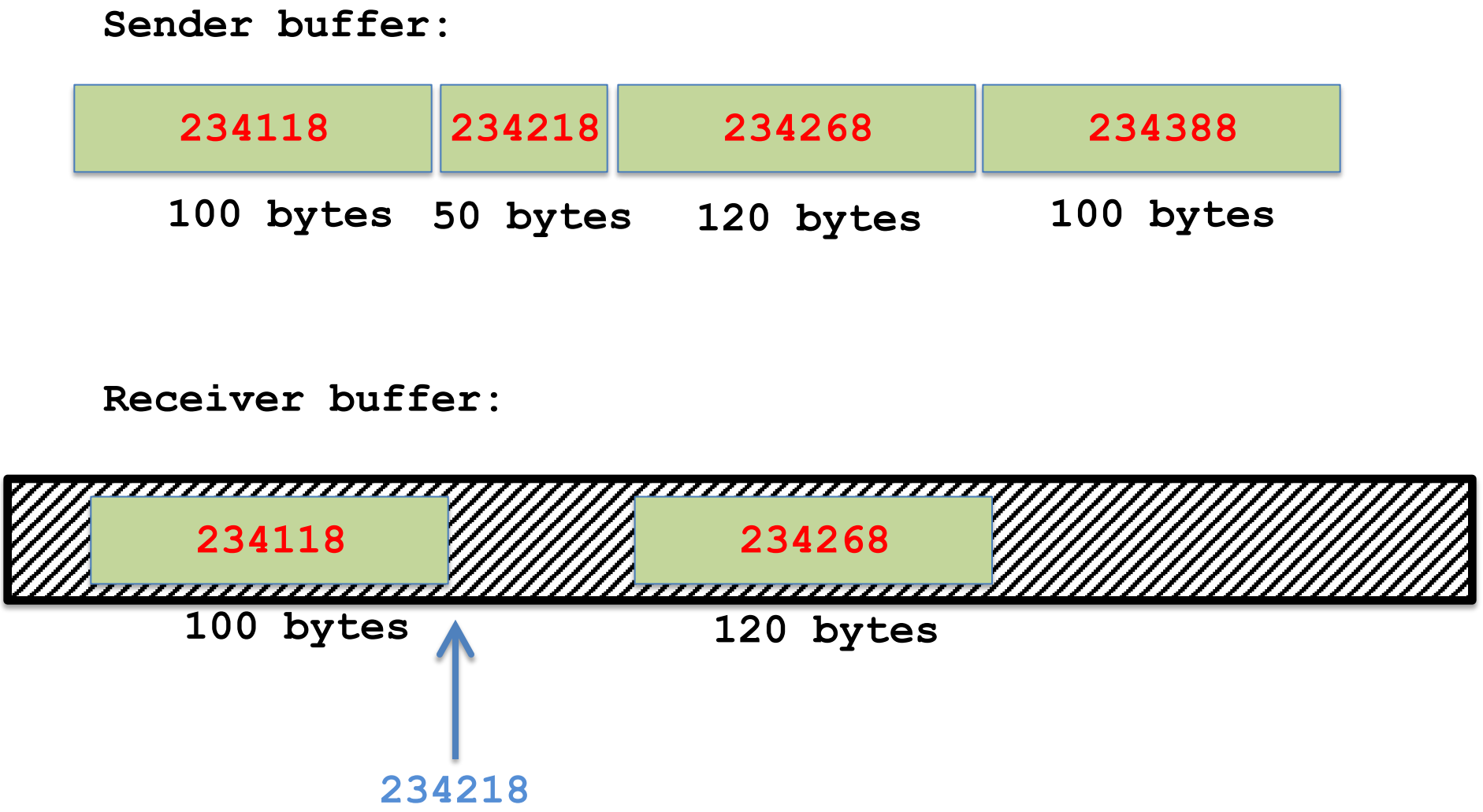

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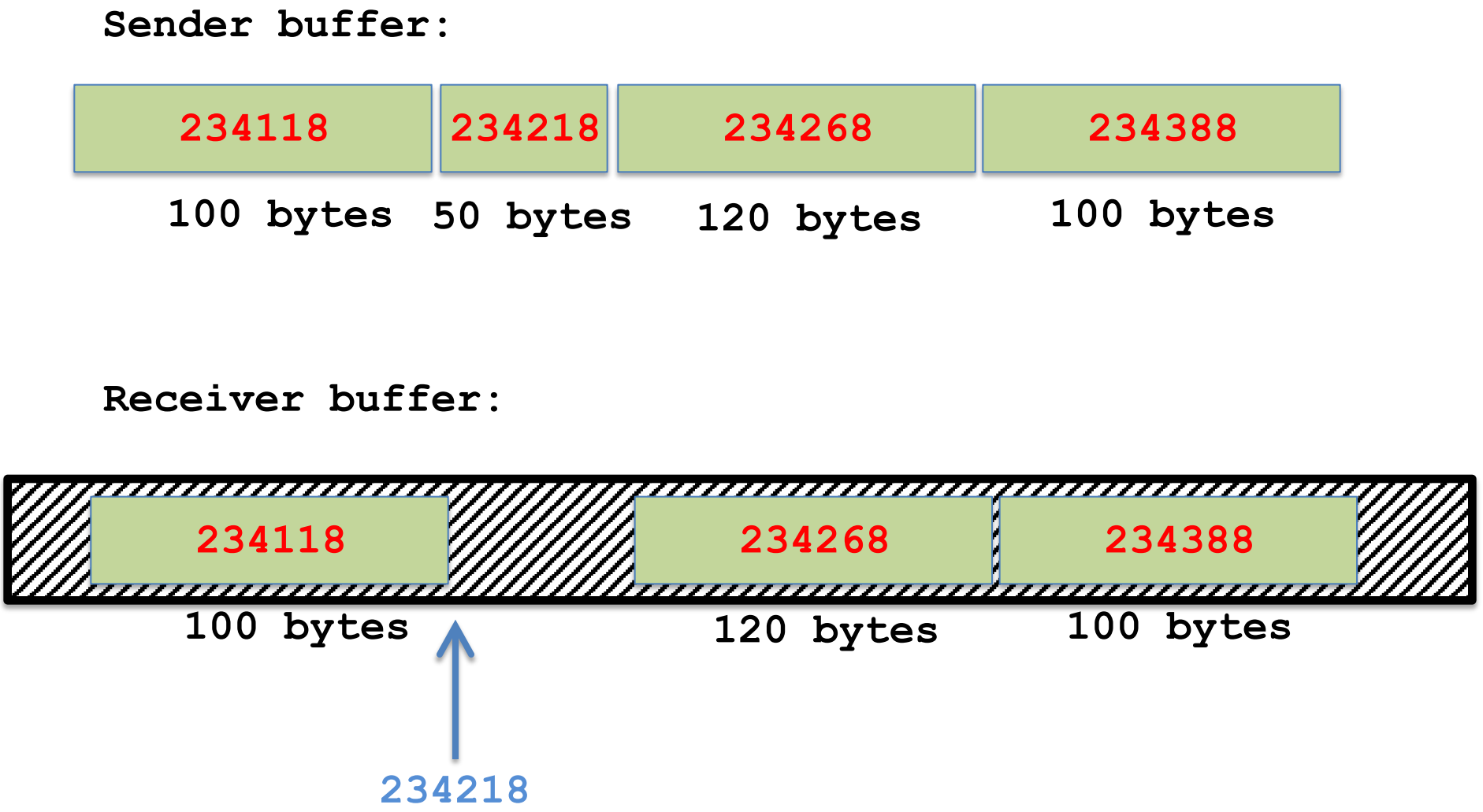
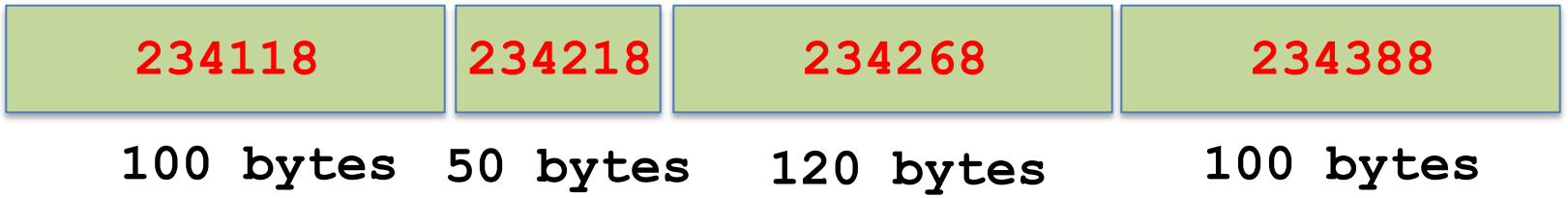


TCP Cumulative ACK strategy (receiver side)

Sender buffer:



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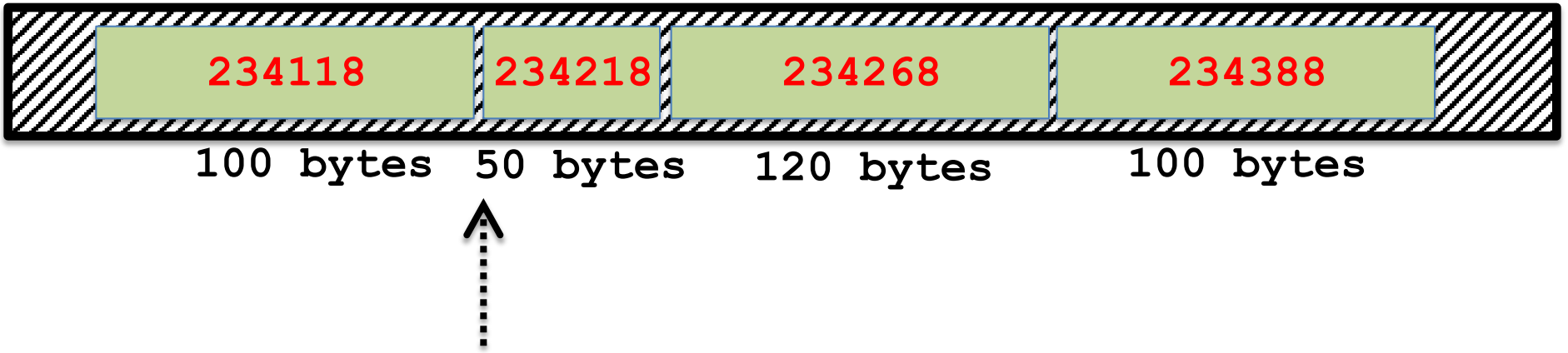

TCP Cumulative ACK strategy (receiver side)

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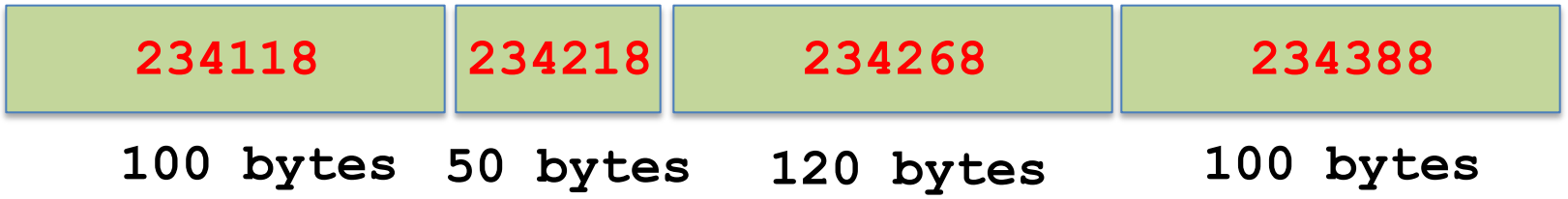
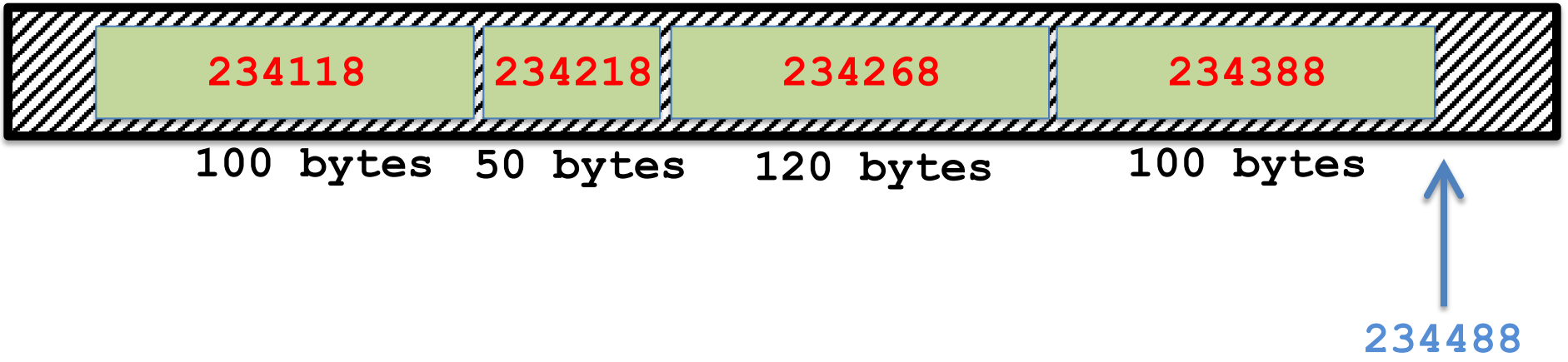
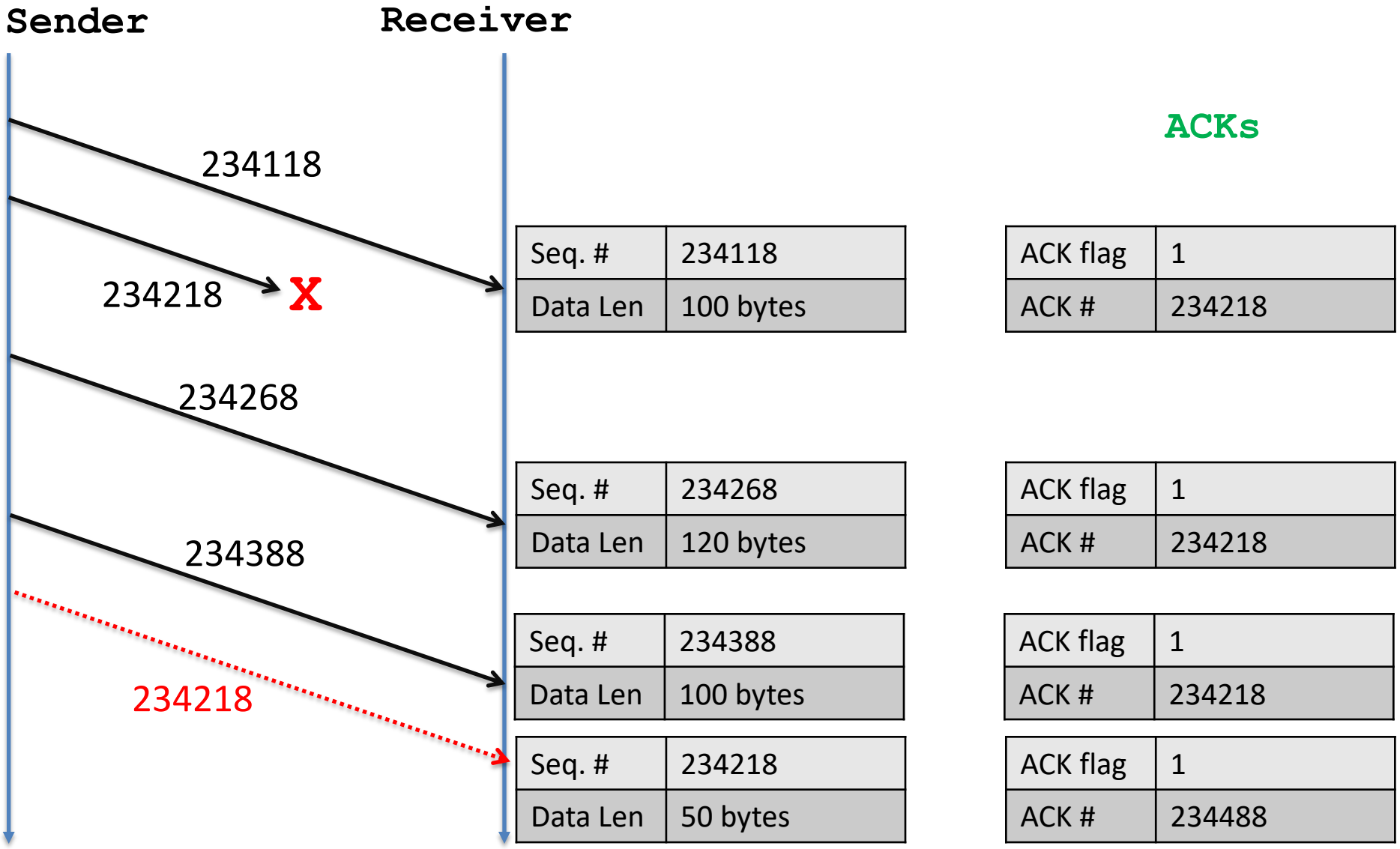


Receiver buffer:



TCP Cumulative ACK strategy (receiver side)

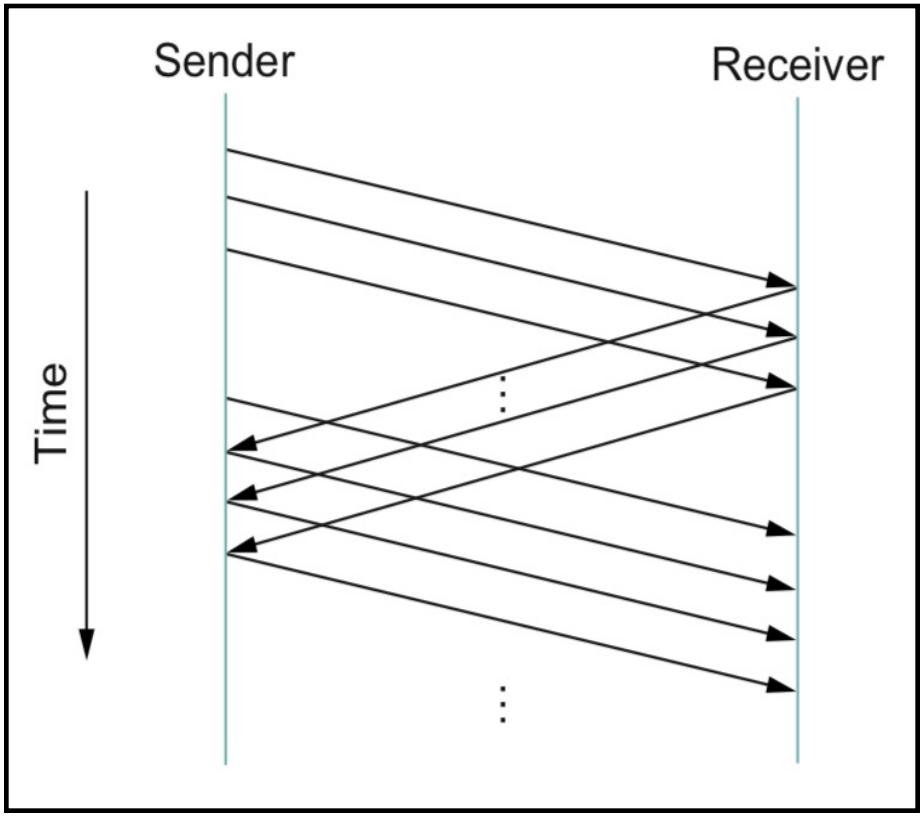
(A more specific example)



Flow Control:
TCP Sliding Window

Motivation: Maximum utilization of the resources without overwhelming the receiver.

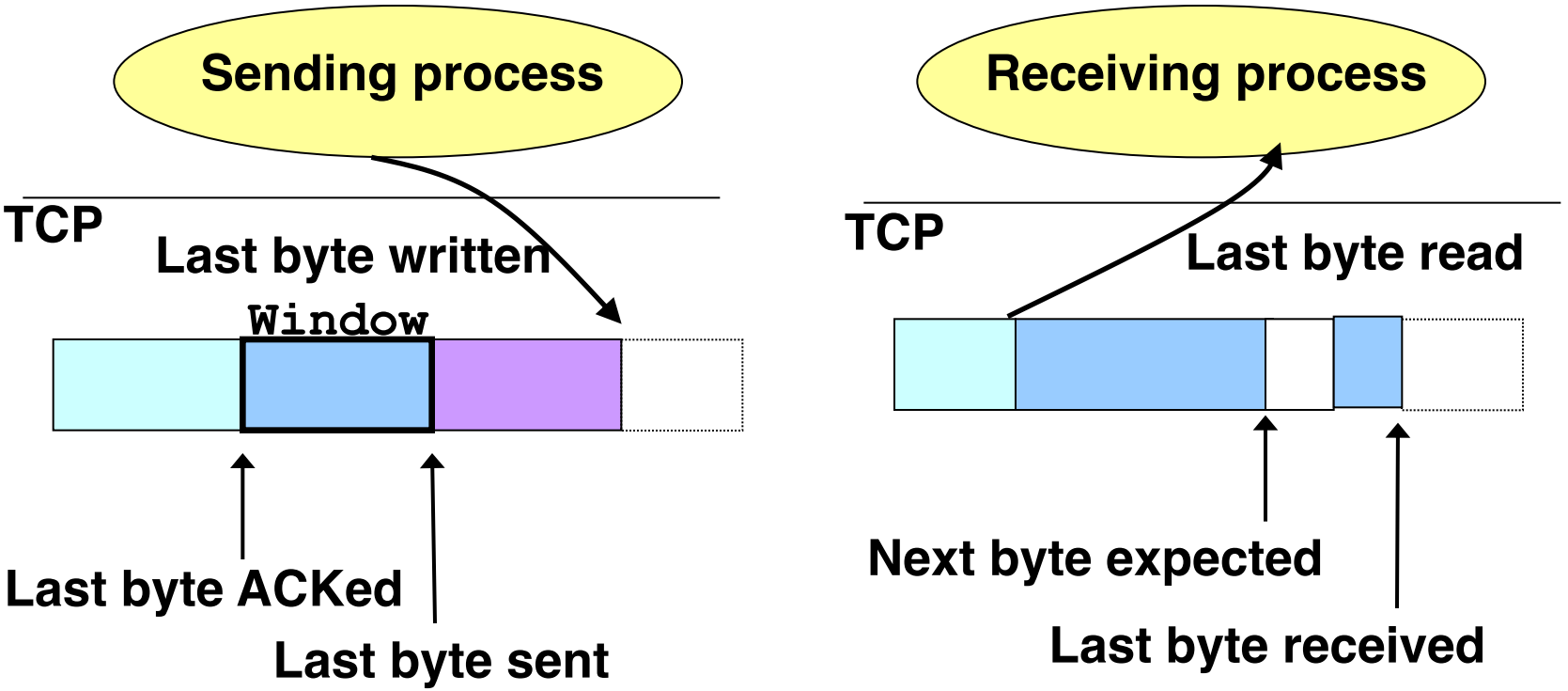
Sliding Window



Receiver should have enough space to buffer/save the received data !!

Sliding Window: Implementation

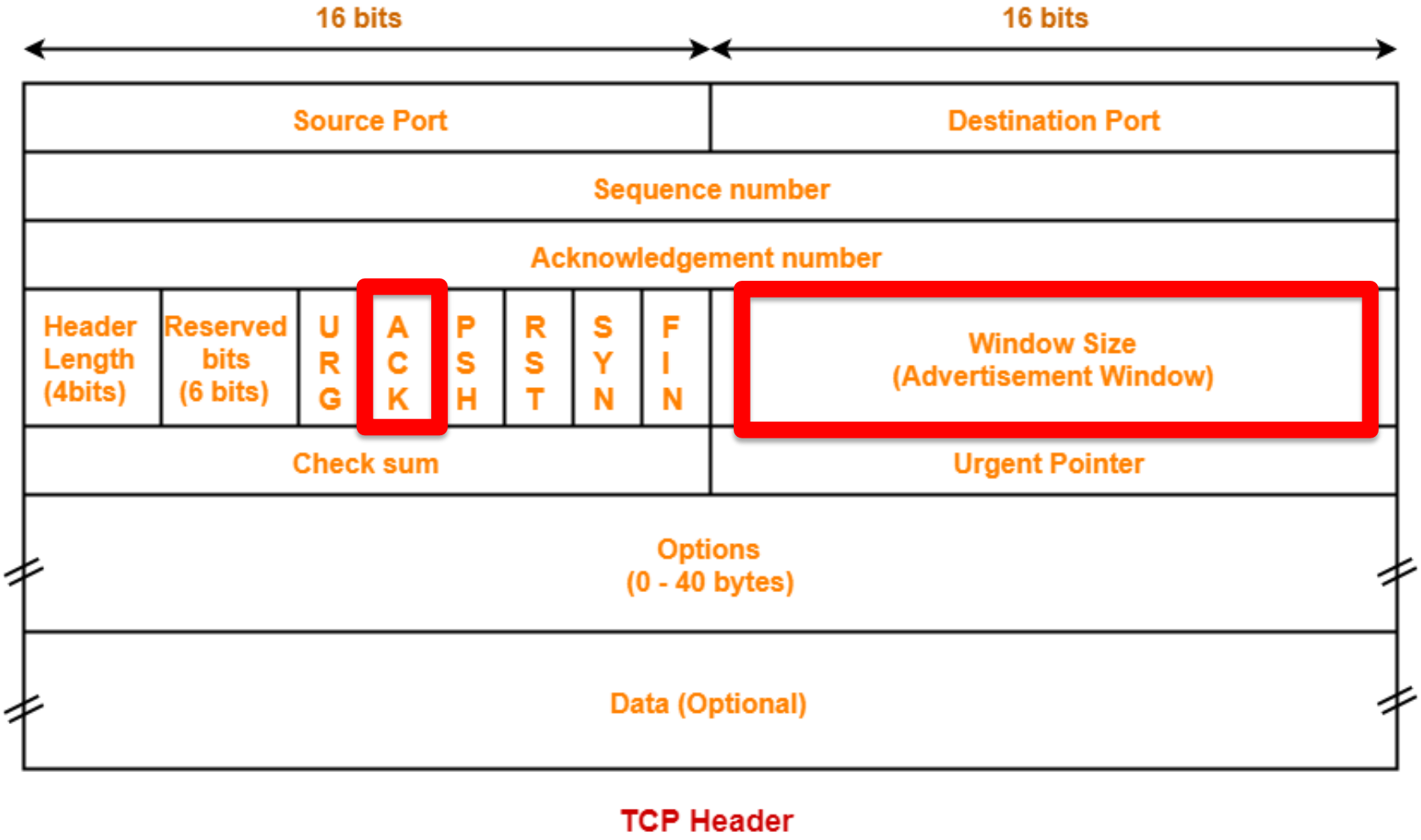
- Allow a larger amount of data "in flight" for better channel utilization, but should not exceed receiver's capacity.



Receiver Buffering: Flow control

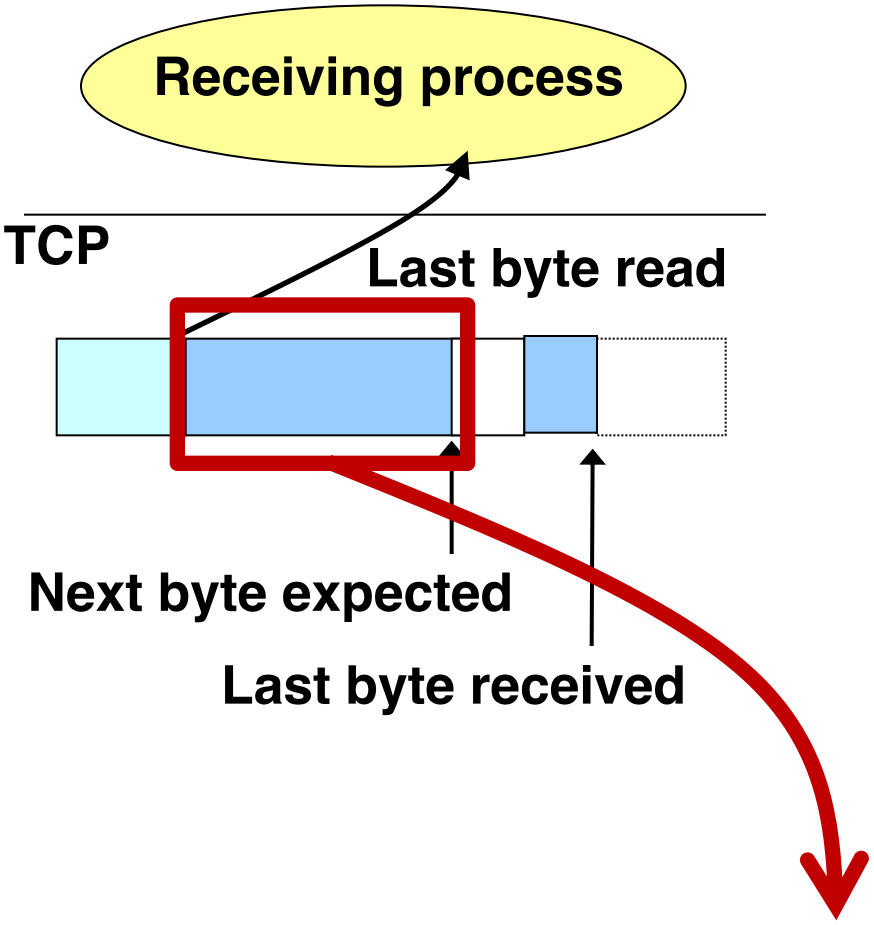
- Receive window size
  - Amount that can be sent without acknowledgment
  - Receiver must be able to store this amount of data
- Receiver tells the sender the window
  - Tells the sender the amount of free space left (i.e. sends an Advertised_Window size to the sender)

How to send the Advertised_Window size



TCP Header

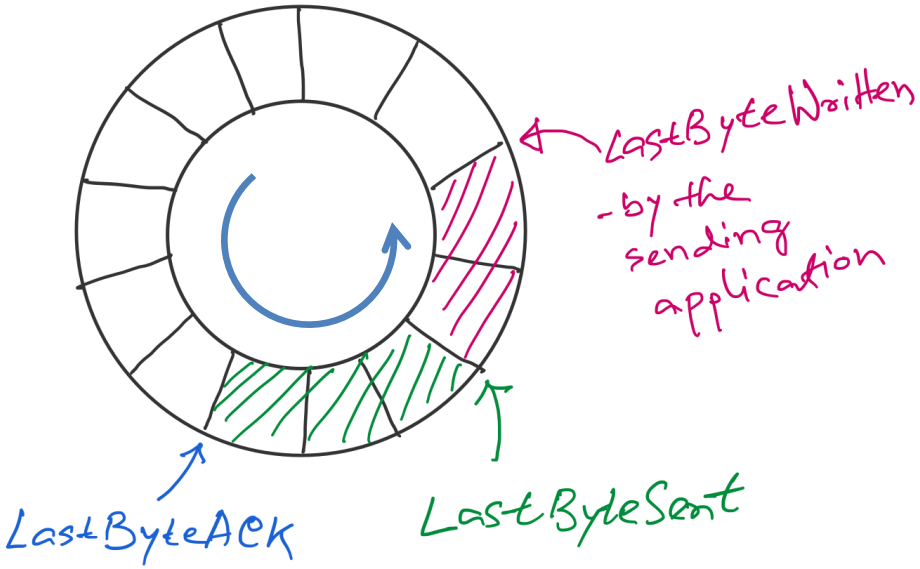
Calculate Advertised_Window (Receiver side)



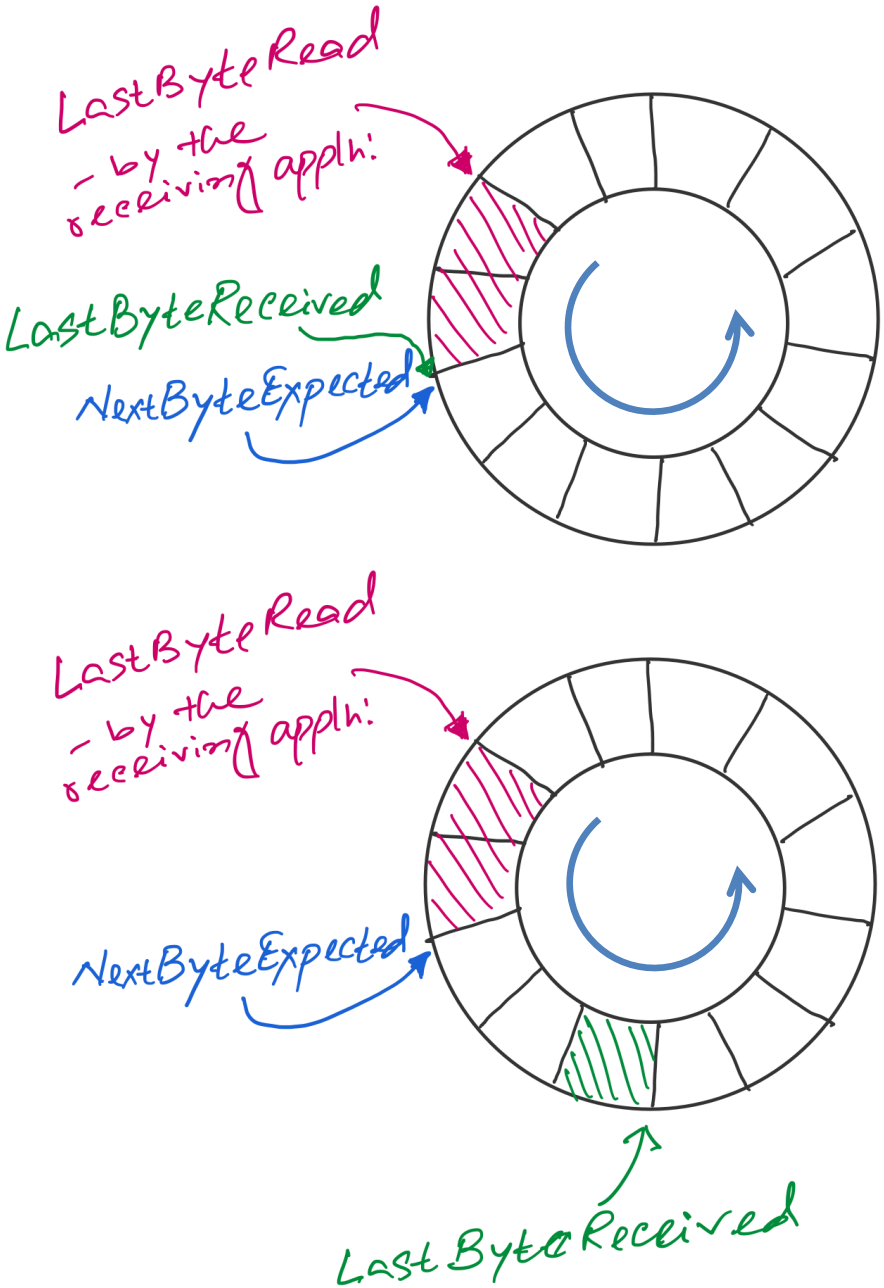

```
AdvertisedWindow = MaxRcvBuffer - (bytes used)

AdvertisedWindow = MaxRcvBuffer -
                        ((NextByteExpected-1) - LastByteRead)
```

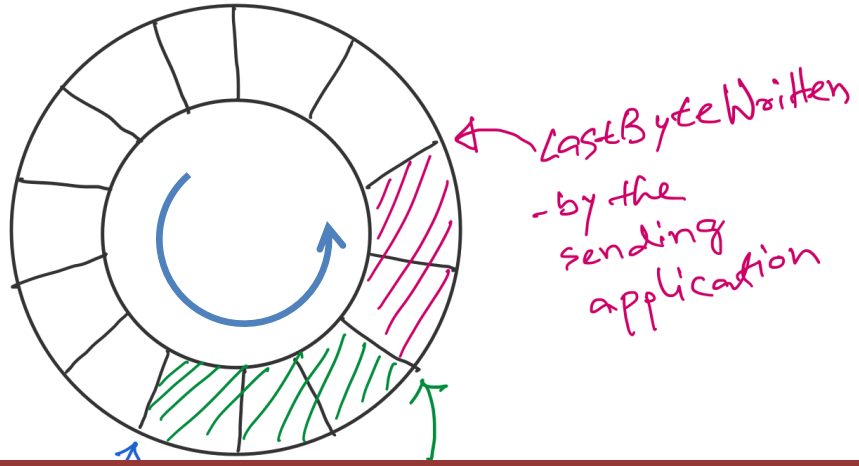
Sender buffer



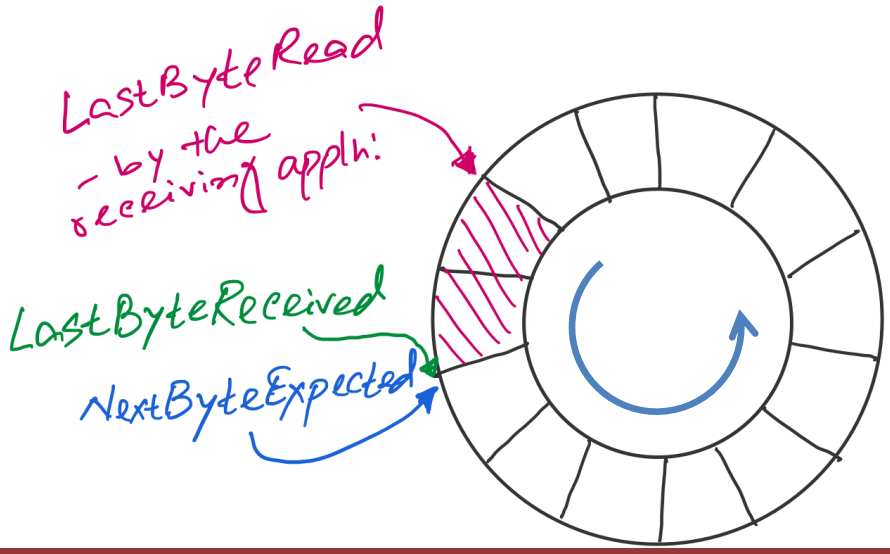
Receiver buffer



Sender buffer



Receiver buffer

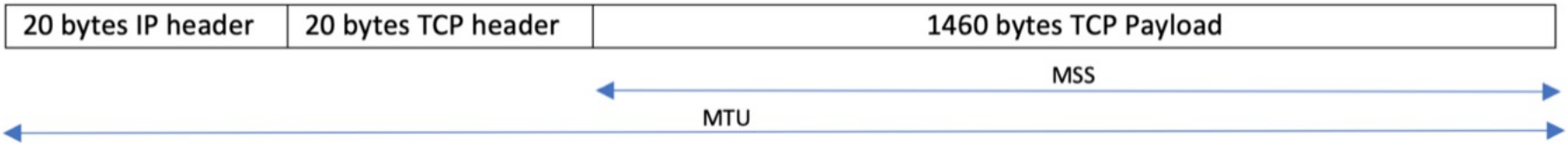


What if the AdvertisedWindow is zero?

>> Periodically send 1byte packets to break the deadlock. (uses the persist timer)

```
EffectiveWindow (calculated at the sender side)
= AdvertisedWindow - (LastByteSent - LastByteACKed)
```

Considering Maximum Segment Size (MSS)



What if…

(1) Adv_window > MSS

(2) Adv_window < MSS