Communication Networks

Spring 2021
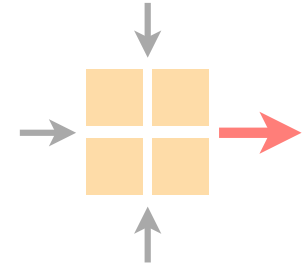
Tobias Bühler

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https://comm-net.ethz.ch/
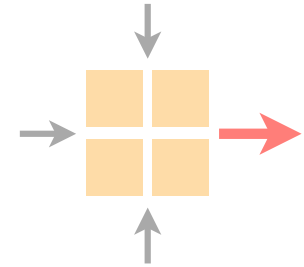
ETH Zürich

May 20 2021

In-person session

We will teach the last exercise session (03.06.2021)
at ETH as well as online via Zoom

In the coming days you will receive a Doodle link via email.
Please register for the in-person session (max 50 students)

The Q&A session before the exam will also be in-person,
more details follow later

Communication Networks

Exercise 10

Transport project (with demo)

Overview current assignment

Solutions will be published next week

Soon the first week is over

| Part 1 | Complete a simple Go-Back-N implementation |
| 21.05.2021 | Retransmit all packets after a timeout |

| Part 2 | Add support for Selective Repeat |
| 28.05.2021 | Fast retransmission after duplicated ACKs |

| Part 3 | Add support for Selective Acknowledgements (SACK) |
| 04.06.2021 | SACK contains blocks of correctly received segments |

| Bonus | Implement your own congestion control algorithm |

Sequence number overflow

NBITS	controls the maximum sequence number
maximum	assuming NBITS=3: $2^{NBITS} - 1 = 7$
overflow	… 5, 6, 7, 0, 1, 2, …
application examples	ACK number, SACK header blocks, retransmission, …

The Go-Back-N sender waits for a timeout before segments are retransmitted

Sent segments: 0   ~~1~~   2   3   4   5

Receiver behavior: 0   -   ~~2~~   ~~3~~   ~~4~~   ~~5~~   Out-of-order segments are **dropped**

Sent ACKs: 1   -   1   1   1   1

Retransmission:

The Go-Back-N sender waits for a timeout before segments are retransmitted

Sent segments: 0   ~~1~~   2   3   4   5

Receiver behavior: 0   -   ~~2~~   ~~3~~   ~~4~~   ~~5~~   Out-of-order segments
                                                                 are **dropped**

Sent ACKs: 1   -   1   1   1   1

Retransmission: |————————————| 1   2   3   4   5

                                               timeout

Selective Repeat can increase the performance

Sent segments: 0   ~~1~~   2   3   4   5

Receiver behavior: 0   -   2   3   4   5   Out-of-order segments
                                                 are **buffered**

Sent ACKs: 1   -   1   1   1   1

Retransmission:

Selective Repeat can increase the performance
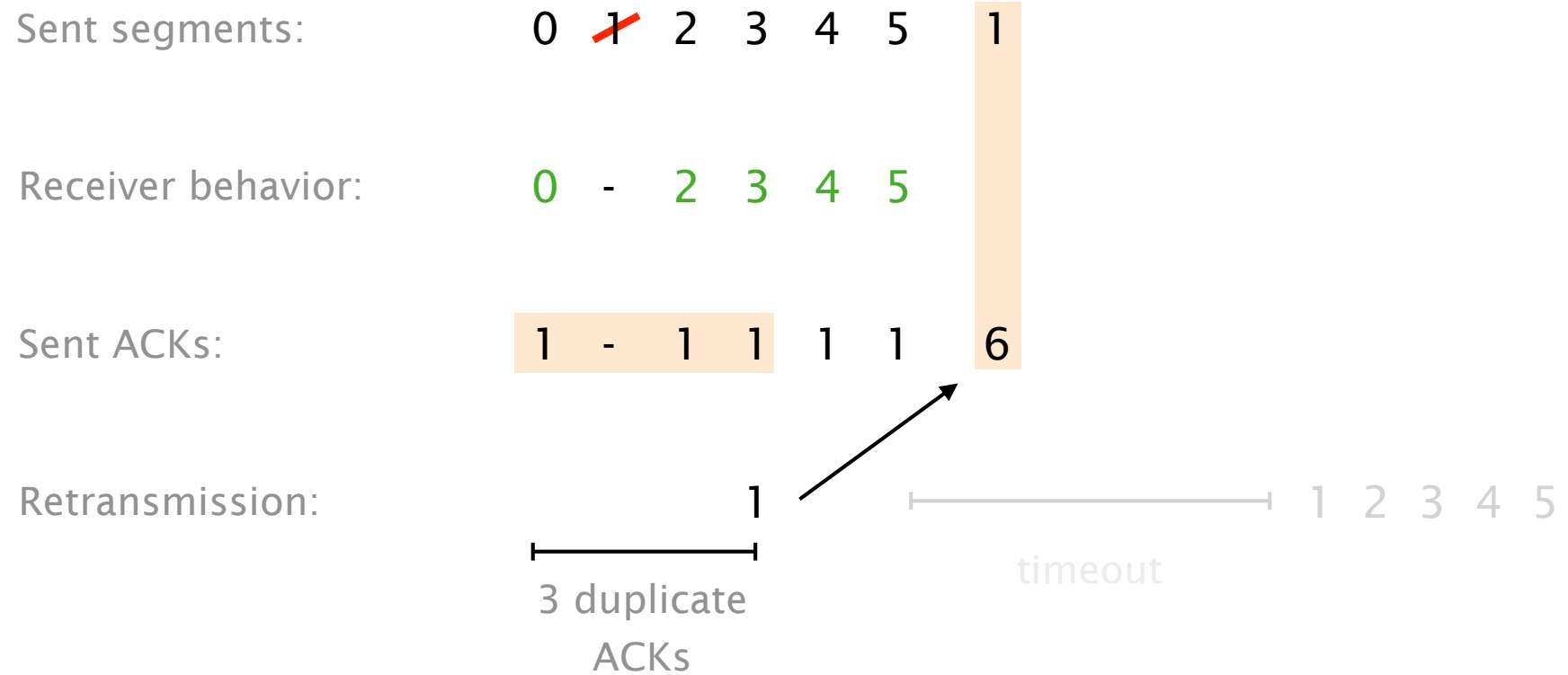
Sent segments: 0   ~~1~~   2   3   4   5

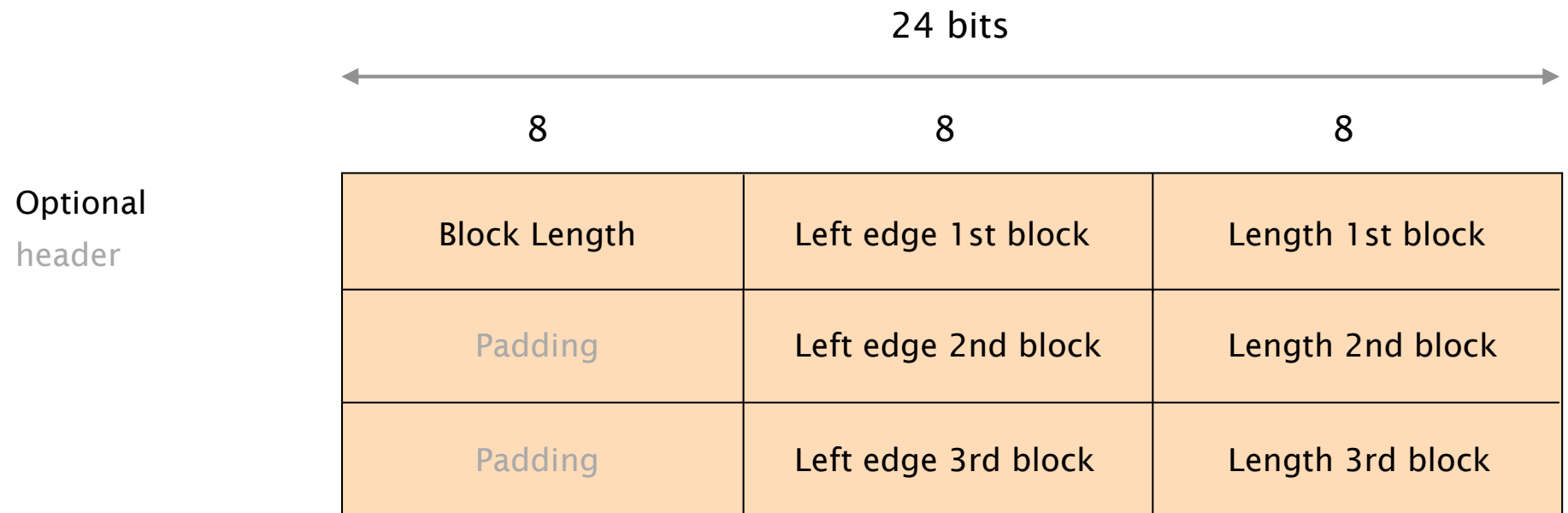Receiver behavior: 0   -   2   3   4   5   Out-of-order segments are **buffered**

Sent ACKs: 1   -   1   1   1   1

Retransmission: 1   ⊢————————⊣   1 2 3 4 5
                            ⊢—————⊣   timeout
                            3 duplicate
                               ACKs

Selective Repeat can increase the performance

Sent segments: 0 ~~1~~ 2 3 4 5   1

Receiver behavior: 0 - 2 3 4 5

Sent ACKs: 1 - 1 1 1 1   6

Retransmission: 1   1 2 3 4 5

3 duplicate
ACKs

timeout

For SACK we need an optional header

24 bits

8	8	8
Block Length	Left edge 1st block	Length 1st block
Padding	Left edge 2nd block	Length 2nd block
Padding	Left edge 3rd block	Length 3rd block

Optional
header

Maximal 3 SACK blocks in the optional header

SACK example - Receiver

Correctly received segments: 0, 1, 2

Buffered out-of-order segments: 4, 5, 8, 10, 11, 12, 13, 15, 16, 17

Mandatory header:

SACK header:

SACK example - Receiver

Correctly received segments: 0, 1, 2

Buffered out-of-order segments: 4, 5, 8, 10, 11, 12, 13, 15, 16, 17

Mandatory header: ACK number: 3

SACK header:

SACK example - Receiver

Correctly received segments: 0, 1, 2

Buffered out-of-order segments: 4, 5, 8, 10, 11, 12, 13, 15, 16, 17

Mandatory header: ACK number: 3

SACK header:

#blocks	start b1	size b1
Padding	start b2	size b2
Padding	start b3	size b3

SACK example - Receiver

Correctly received segments: 0, 1, 2

Buffered out-of-order segments: 4, 5, 8, 10, 11, 12, 13, 15, 16, 17

Mandatory header: ACK number: 3

SACK header:

#blocks	4	2
Padding	start b2	size b2
Padding	start b3	size b3

SACK example - Receiver

Correctly received segments: 0, 1, 2

Buffered out-of-order segments: 4, 5, 8, 10, 11, 12, 13, 15, 16, 17

Mandatory header: ACK number: 3

SACK header:

#blocks	4	2
Padding	8	1
Padding	start b3	size b3

SACK example - Receiver

Correctly received segments: 0, 1, 2

Buffered out-of-order segments: 4, 5, 8, 10, 11, 12, 13, 15, 16, 17

Mandatory header: ACK number: 3

SACK header:

#blocks	4	2
Padding	8	1
Padding	10	4

SACK example - Receiver

Correctly received segments: 0, 1, 2

                                                                no space

Buffered out-of-order segments: 4, 5, 8, 10, 11, 12, 13, ~~15, 16, 17~~

Mandatory header: ACK number: 3

SACK header:

#blocks	4	2
Padding	8	1
Padding	10	4

SACK example - Receiver

Correctly received segments: 0, 1, 2

Buffered out-of-order segments: 4, 5, 8, 10, 11, 12, 13, 15, 16, 17

Mandatory header: ACK number: 3

SACK header:

3	4	2
Padding	8	1
Padding	10	4

SACK example - Sender

Receiver SACK header:

3	4	2
Padding	8	1
Padding	10	4

ACK number: 3

ACK - block 1:

block 1 - block 2:

block 2 - block 3:

after block 3:

SACK example - Sender

Receiver SACK header:

3	4	2
Padding	8	1
Padding	10	4

ACK number: 3

ACK - block 1:　3

block 1 - block 2:

block 2 - block 3:

after block 3:

SACK example - Sender

Receiver SACK header:

3	4	2
Padding	8	1
Padding	10	4

ACK number: 3

ACK - block 1: 3

block 1 - block 2: 6, 7

block 2 - block 3:

after block 3:

SACK example - Sender

Receiver SACK header:

3	4	2
Padding	8	1
Padding	10	4

ACK number: 3

ACK - block 1:   3

block 1 - block 2:   6, 7

block 2 - block 3:   9

after block 3:

SACK example - Sender

Receiver SACK header:

3	4	2
Padding	8	1
Padding	10	4

ACK number: 3

ACK - block 1:   3

block 1 - block 2:   6, 7

block 2 - block 3:   9

after block 3:   no retransmission

Let's see how we can use Git to collaborate
and remotely edit your files on the VM

Watch the live session or the recorded video!

Communication Networks
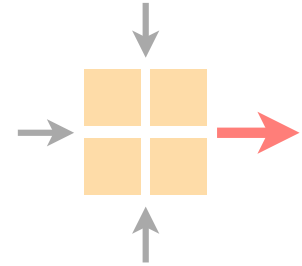
Exercise 10

Transport project (with demo)

Overview current assignment

Solutions will be published next week

Task 1: TCP Warm-up

True/false question from the 2019 exam
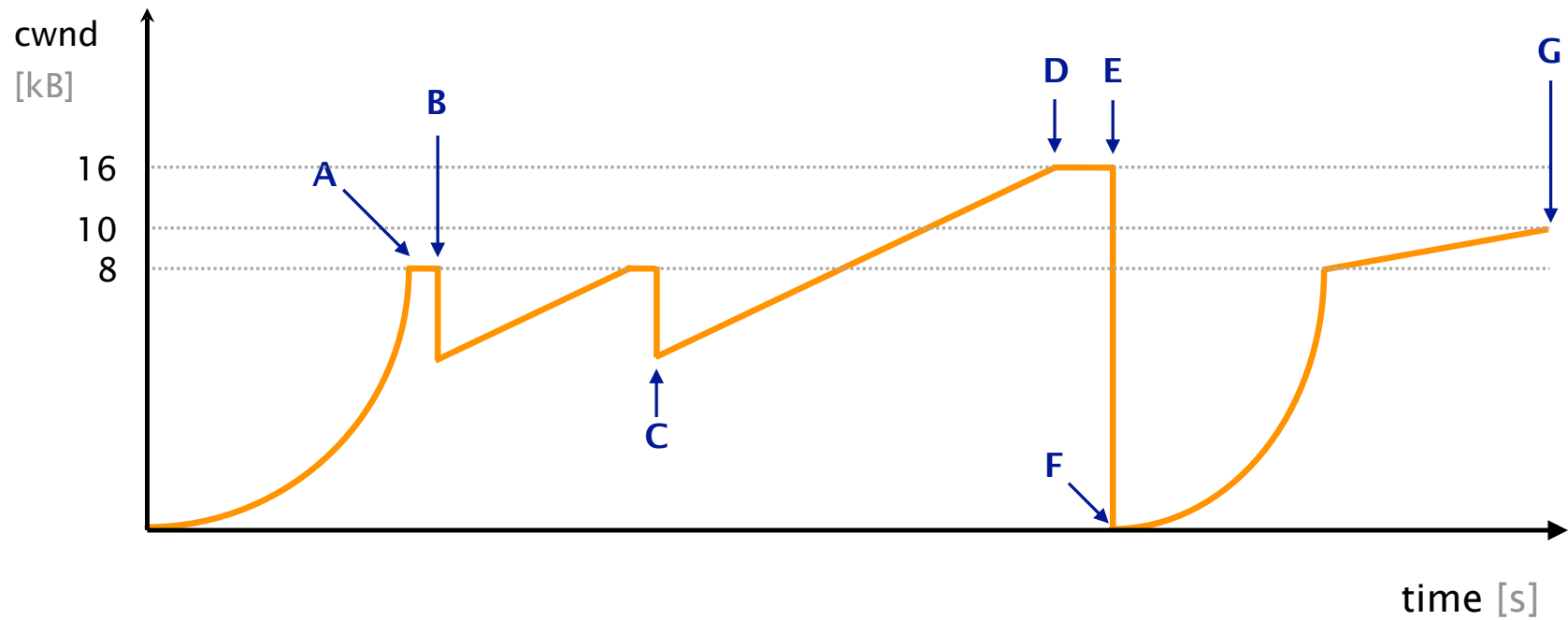
In the exam, you cannot give an explanation

Every wrong answer results in a point deduction!

Task 2: Fairness
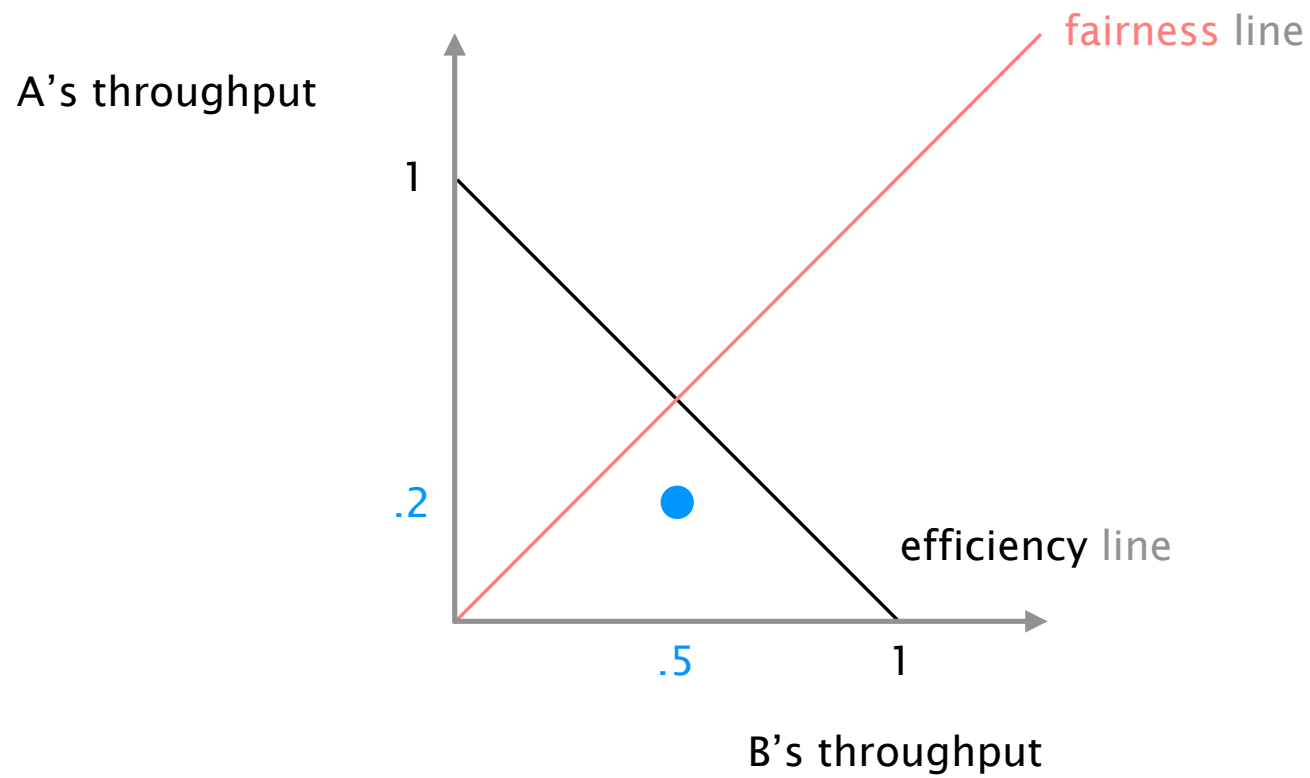
Compare slides 04b page 52+
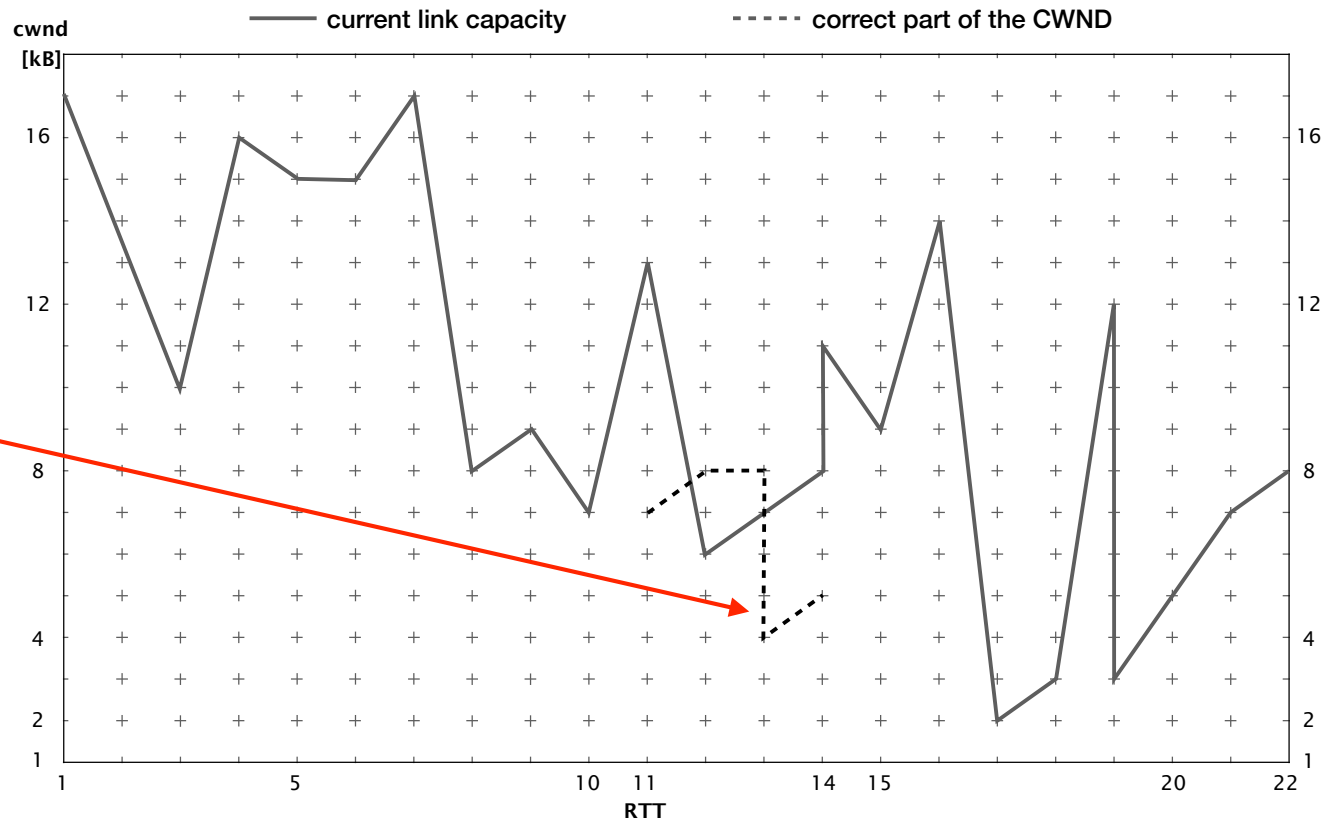
Task 3: Congestion Window

Hint: TCP performs a Three-Way-Handshake at the beginning
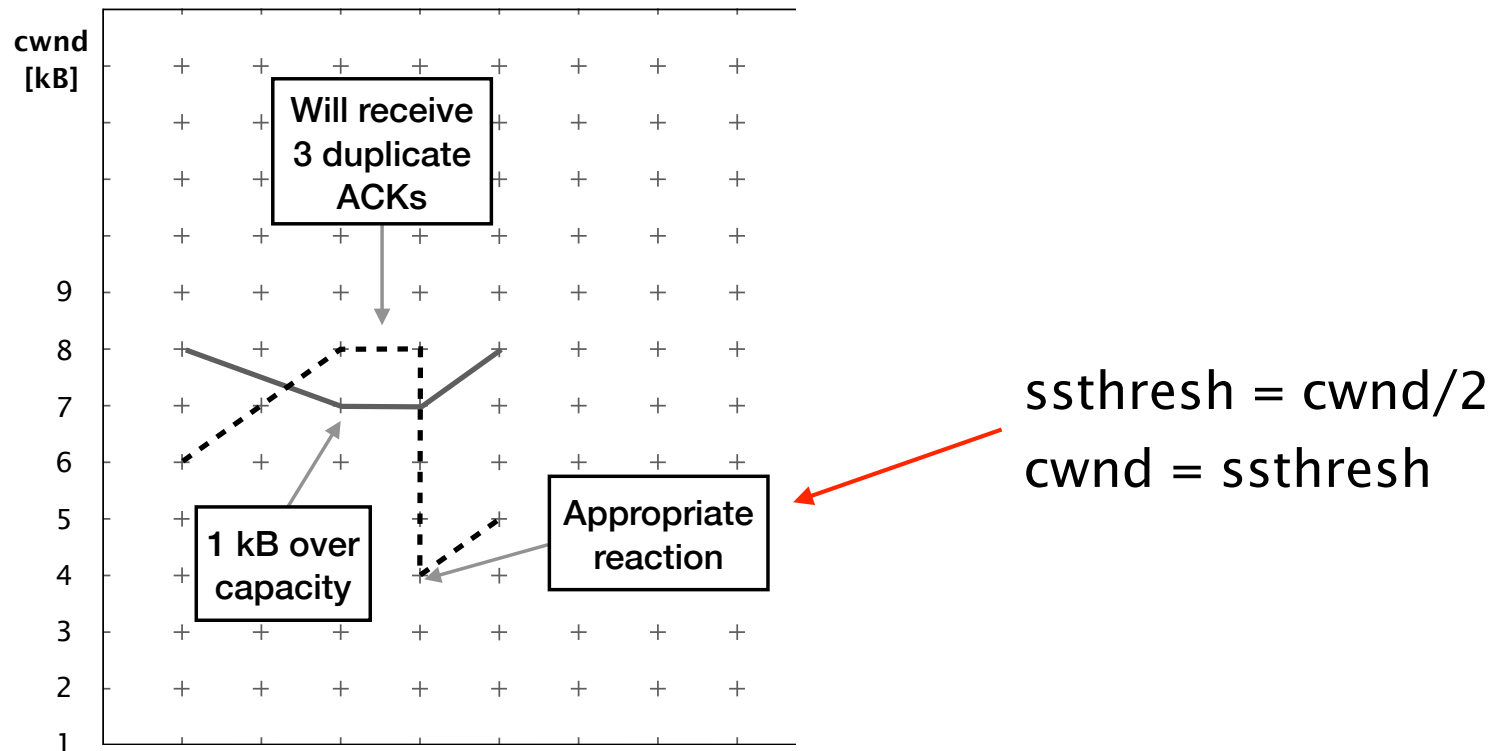
Task 4: Drawing practice (Exam 2018)
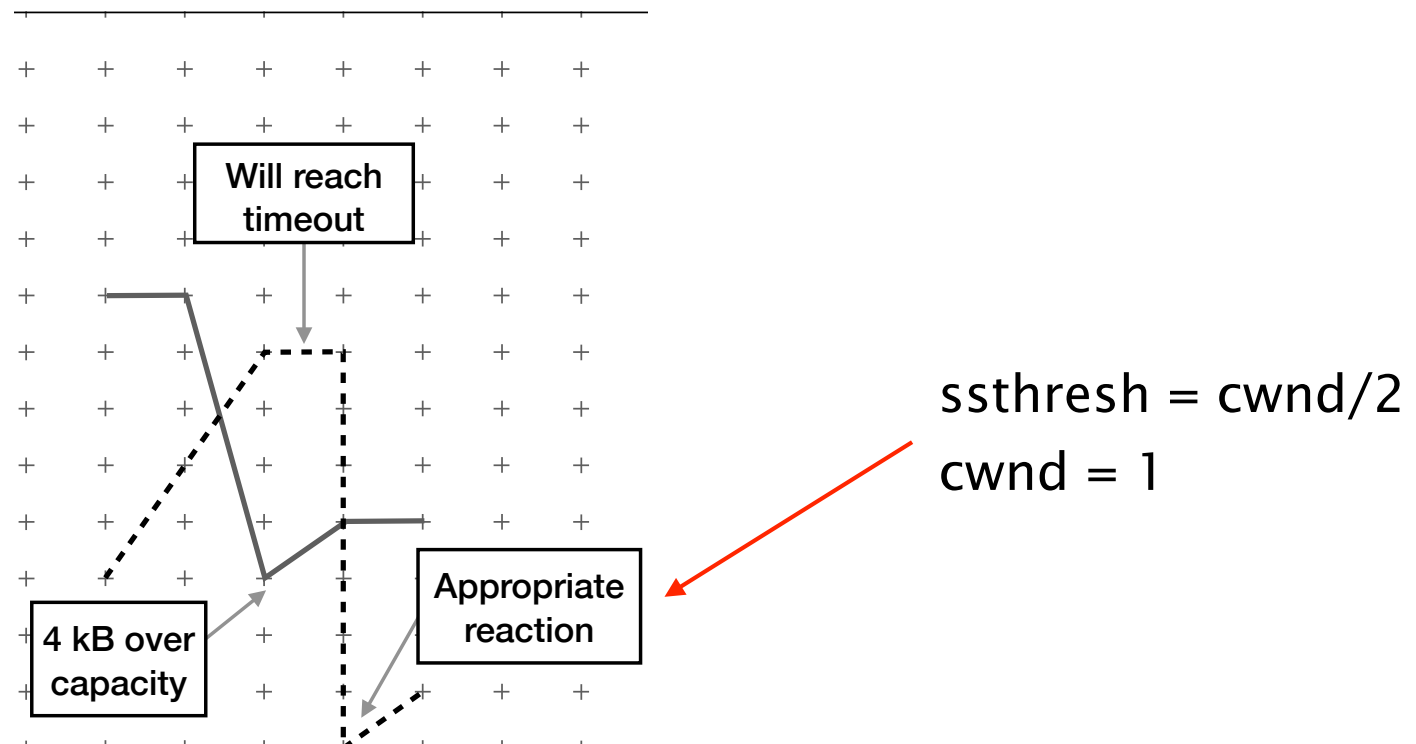
Goal: Draw the CWND given a changing link capacity

Task 4: Reaction if link capacity is exceed by at most 2kB

We assume that we would receive 3 duplicates in this case

cwnd [kB]

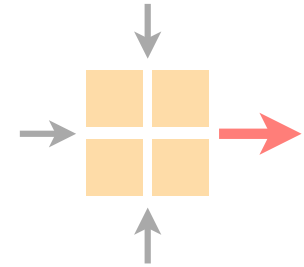Will receive 3 duplicate ACKs

Will reach timeout

1 kB over capacity

Appropriate reaction

ssthresh = cwnd/2
cwnd = ssthresh

4 kB over capacity

Appropriate reaction

Task 4: Reaction if link capacity is exceed by more than 2kB

We assume that we reach a timeout

ill receive
duplicate
ACKs

Will reach
timeout

Appropriate
reaction

4 kB over
capacity

Appropriate
reaction

ssthresh = cwnd/2
cwnd = 1

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Exercise 10

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Overview current assignment

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