Midterm preparation

Ideally

- Review lectures
- Review exercise sessions
- Do past midterm exams
  - plus a couple of TCP problems from past final exams
- Come to the Q&A session and ask questions

No time for all this

- Try to solve all the past midterm exams
  - plus a couple of TCP problems from past final exams
- When you get stuck, study related lecture+exercise and retry
- Don't look at the solutions without trying (hard) first

What's in the exam

- Problem 1: multiple-choice questions (similar to the quizzes, 10% of the grade)
- Problems 2+3: web+DNS, sockets, flow and congestion control, delay/throughput computation
- One or two small questions related to wireshark or DNS or socket programming (up to 20% of the grade)

What's in the exam

- Mostly in the same spirit as past exams
- But there are always a couple of questions that are a bit different

Taking the exam

- Start from the easier questions
- If a question makes no sense, leave it for the end and ask for clarification
- Do your best (in English or in French). Grading is adjusted to difficulty.

Delay & throughput

Transmission delay

- of N bits over a link =
- amount of time to push all N bits into the link

Propagation delay

- of a link =
  - amount of time to move 1 bit
    from one end of the link to the other

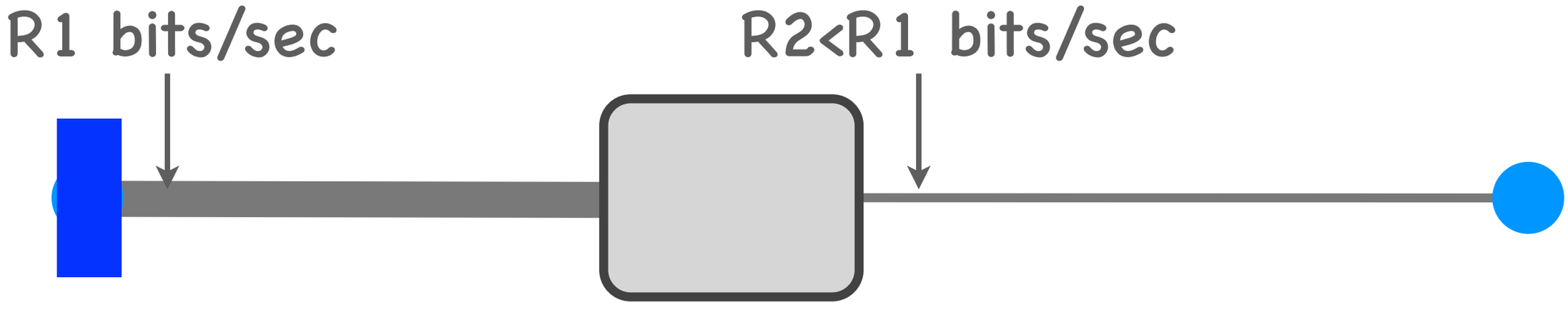
Transfer time = transmission delay of L bits on link
+ propagation delay of link
= L/R
+ propagation delay of link

Transfer time = transmission delay of 2L bits on link
+ propagation delay of link

= 2L/R
+ propagation delay of link

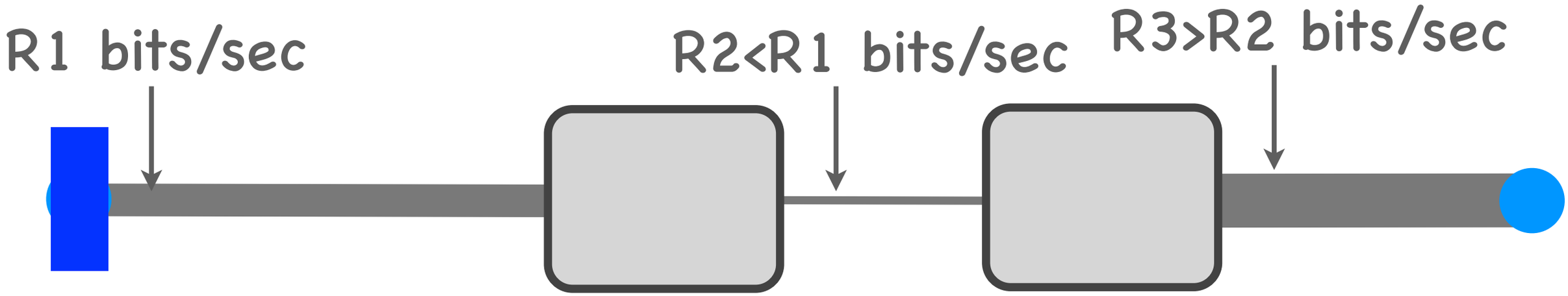
Transfer time = transmission delay of NL bits on link
+ propagation delay of link

= NL/R
+ propagation delay of link



Transfer time = transmission delay of 1st packet on link 1
+ propagation delay for link 1
+ transmission delay of N packets on link 2
+ propagation delay for link 2

= L/R1 + NL/R2 + sum of propagation delays



Transfer time = transmission delay of 1st packet on 1st link
+ propagation delay of 1st link
+ transmission delay of N packets on 2nd link
+ propagation delay of 2nd link
+ transmission delay of last packet on 3rd link
+ propagation delay of 3rd link

= L/R1 + NL/R2 + L/R3 + sum of propagation delays

N packets of size L bits

Transfer time =

time for 1st packet to get to bottleneck

+ time for all packets to cross bottleneck

+ time for last packet to get to final destination

N packets of size L bits

Transfer time =

sum of transmission delays of 1st packet until bottleneck
+ sum of propagation delays of links until bottleneck
+ transmission delay of N packets on bottleneck
+ propagation delay of bottleneck
+ sum of transmission delays of last packet after bottleneck
+ sum of propagation delays of links after bottleneck

$= L/R_1 + \ldots L/R_x + NL/R_b + L/R_{b+1} + \ldots + L/R_{b+y}$
+ sum of propagation delays of all links

N packets of size L bits

N is large

Transfer time =

sum of transmission delays of 1st packet until bottleneck
+ sum of propagation delays of links until bottleneck
+ transmission delay of N packets on bottleneck
+ propagation delay of bottleneck
+ sum of transmission delays of last packet after bottleneck
+ sum of propagation delays of links after bottleneck

$= L/R_1 + \ldots L/R_x + NL/R_b + L/R_{b+1} + \ldots + L/R_{b+y}$
+ sum of propagation delays of all links

Average throughput

- Data size / Transfer time

N packets of size L bits

N is large

Transfer time =

transmission delay of N packets on bottleneck

$= NL/R_b$

$$\text{Average throughput} = \frac{NL}{NL/R_b} = R_b$$

N packets of size L bits

N is not large

Transfer time = ...

$$\text{Average throughput} = \frac{NL}{\text{Transfer time}} < R_b$$

End-systems Alice and Bob are connected over a sequence of N links, each of propagation delay D.

Alice sends a packet of size L bits to Bob. The propagation delay experienced by the packet is:

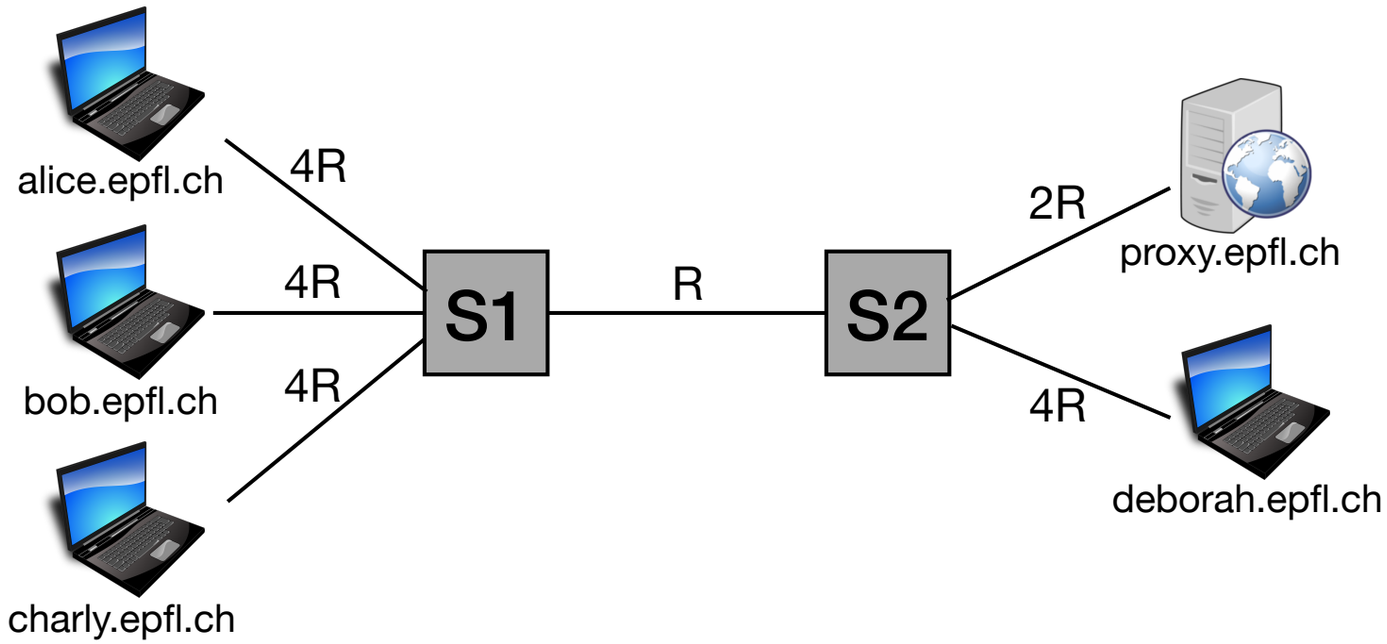
(a) D.

(b) D x N.

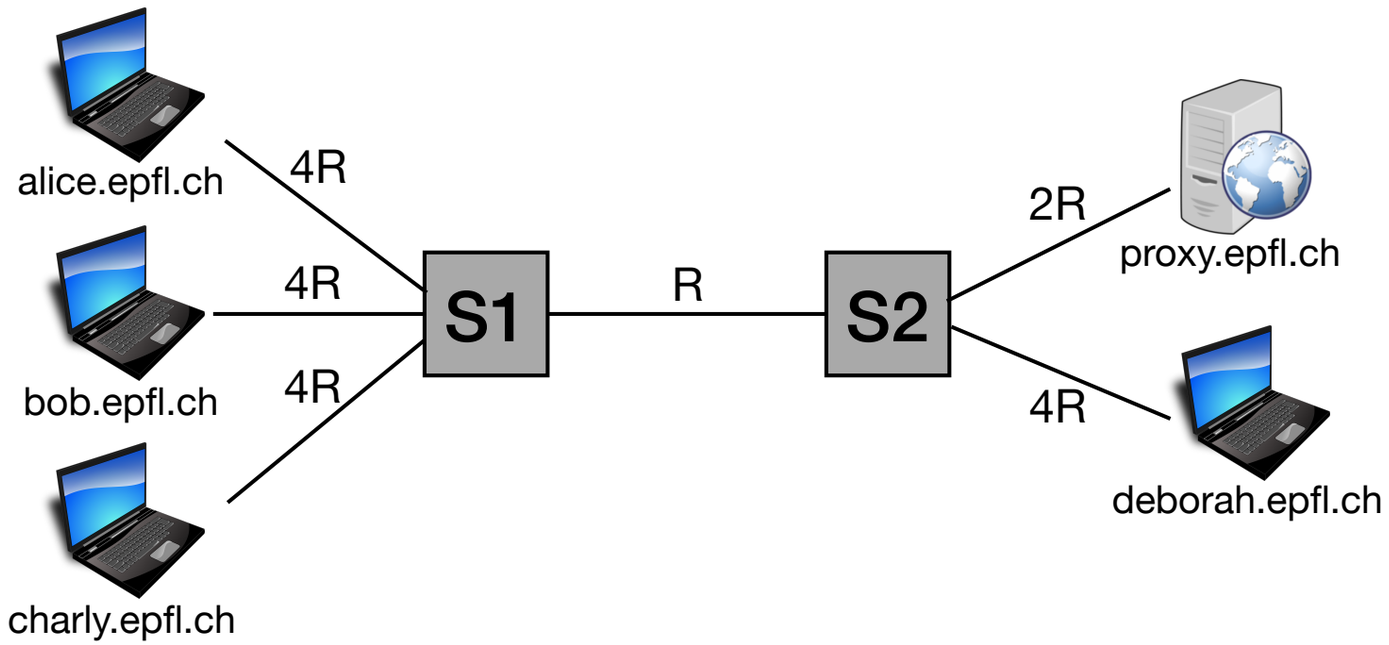
(c) D x N x L.

(d) I don't have enough info to answer.

Midterm 2018, Problem 4



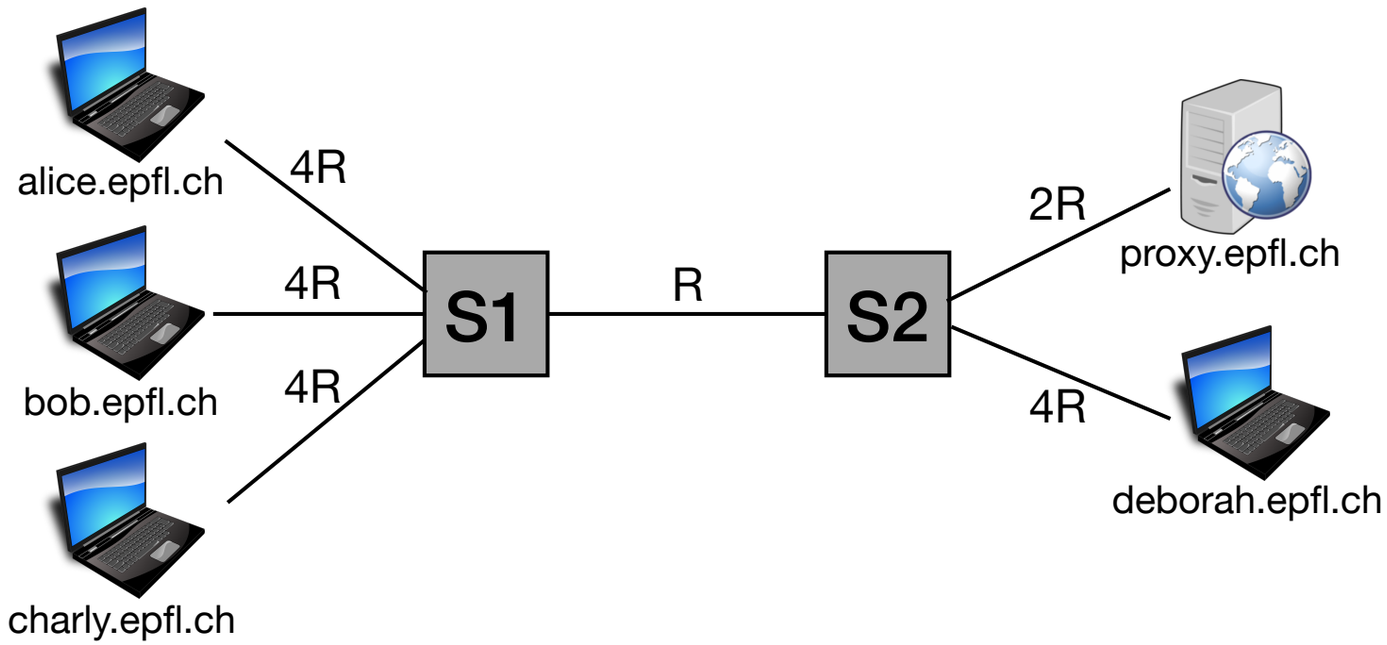
- All links have length l and prop. speed c
- Switches are store & forward, have infinite queues



Alice sends packet of size Q to the proxy.
What is the packet delay?

Q/4R + l/c + Q/R + l/c + Q/2R + l/c

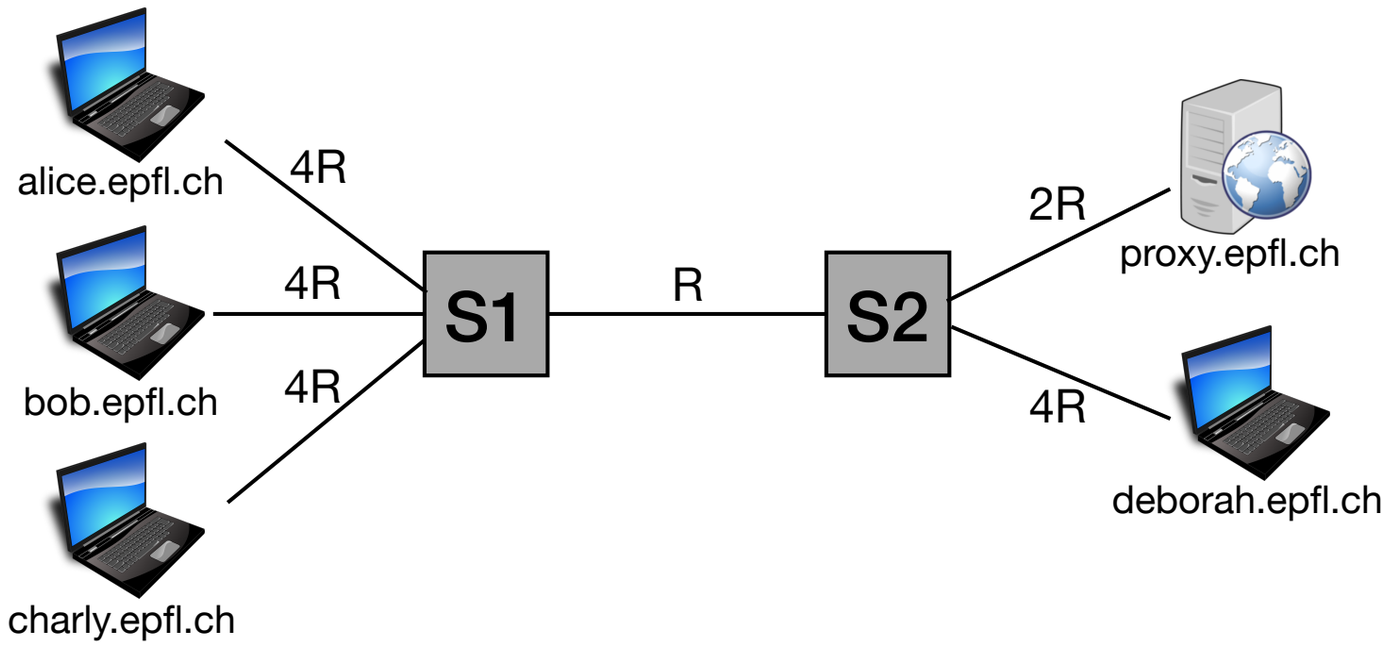
= Q/4R + Q/R + Q/2R + 3l/c



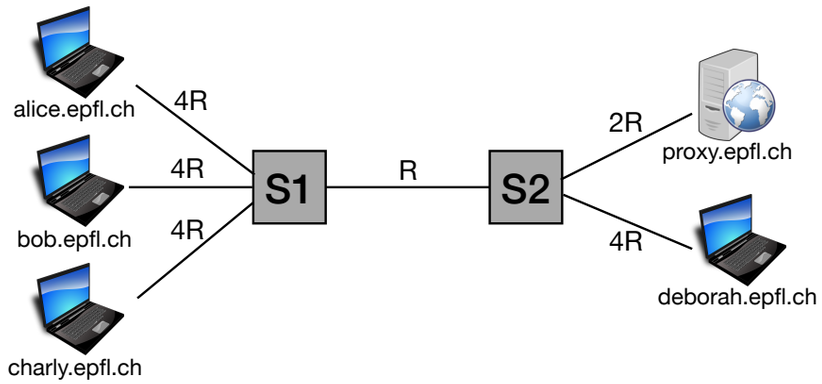
The proxy sends P packets of size L to Alice.
What is the transfer time?

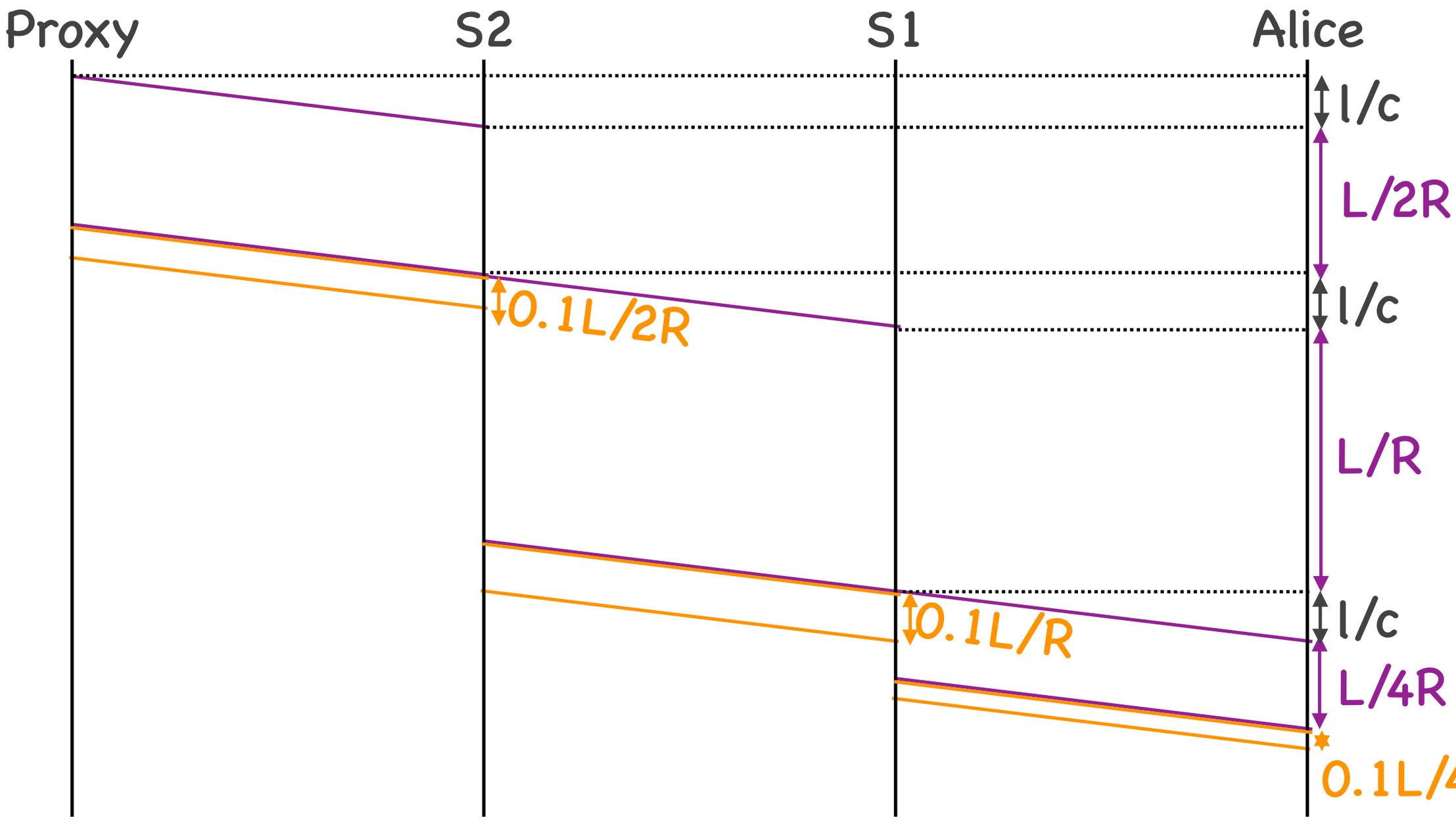
$$L/2R + l/c + PL/R + l/c + L/4R + l/c$$

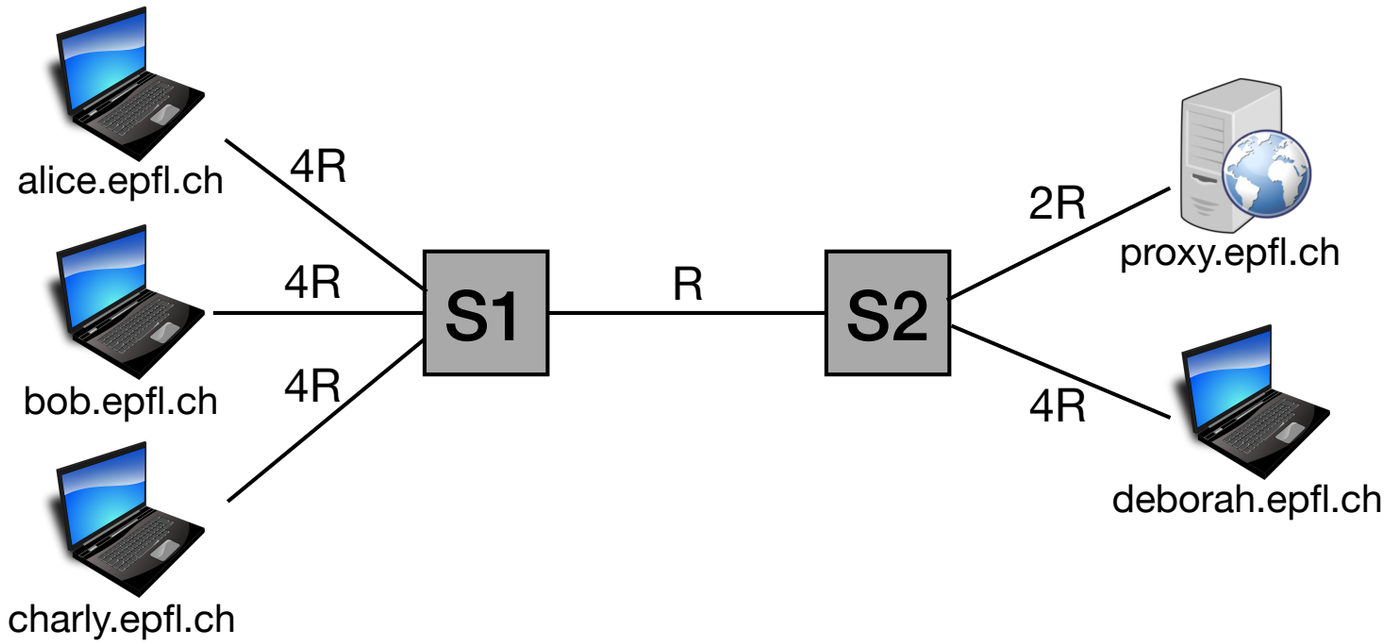
$$= L/2R + PL/R + L/4R + 3l/c$$



The proxy sends 2 packets, of sizes L and 0.1L, to Alice.
What is the transfer time?


alice.epfl.ch
bob.epfl.ch
charly.epfl.ch
4R
4R
4R
S1
R
S2
2R
4R
proxy.epfl.ch
deborah.epfl.ch

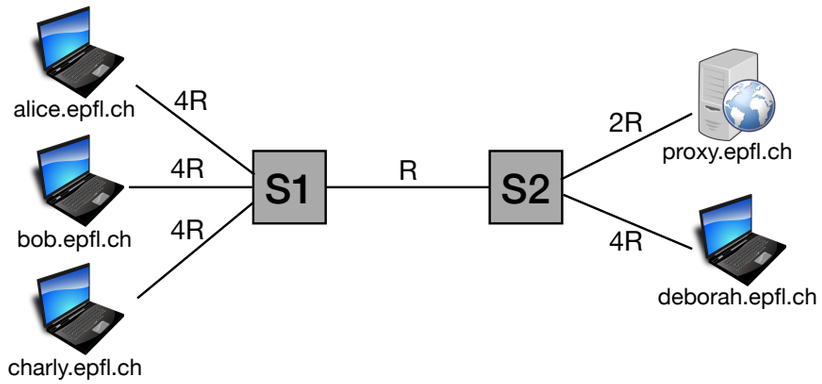

Proxy
S2
S1
Alice
l/c
L/2R
l/c
L/R
0.1L/2R
l/c
L/4R
0.1L/R
0.1L/4R

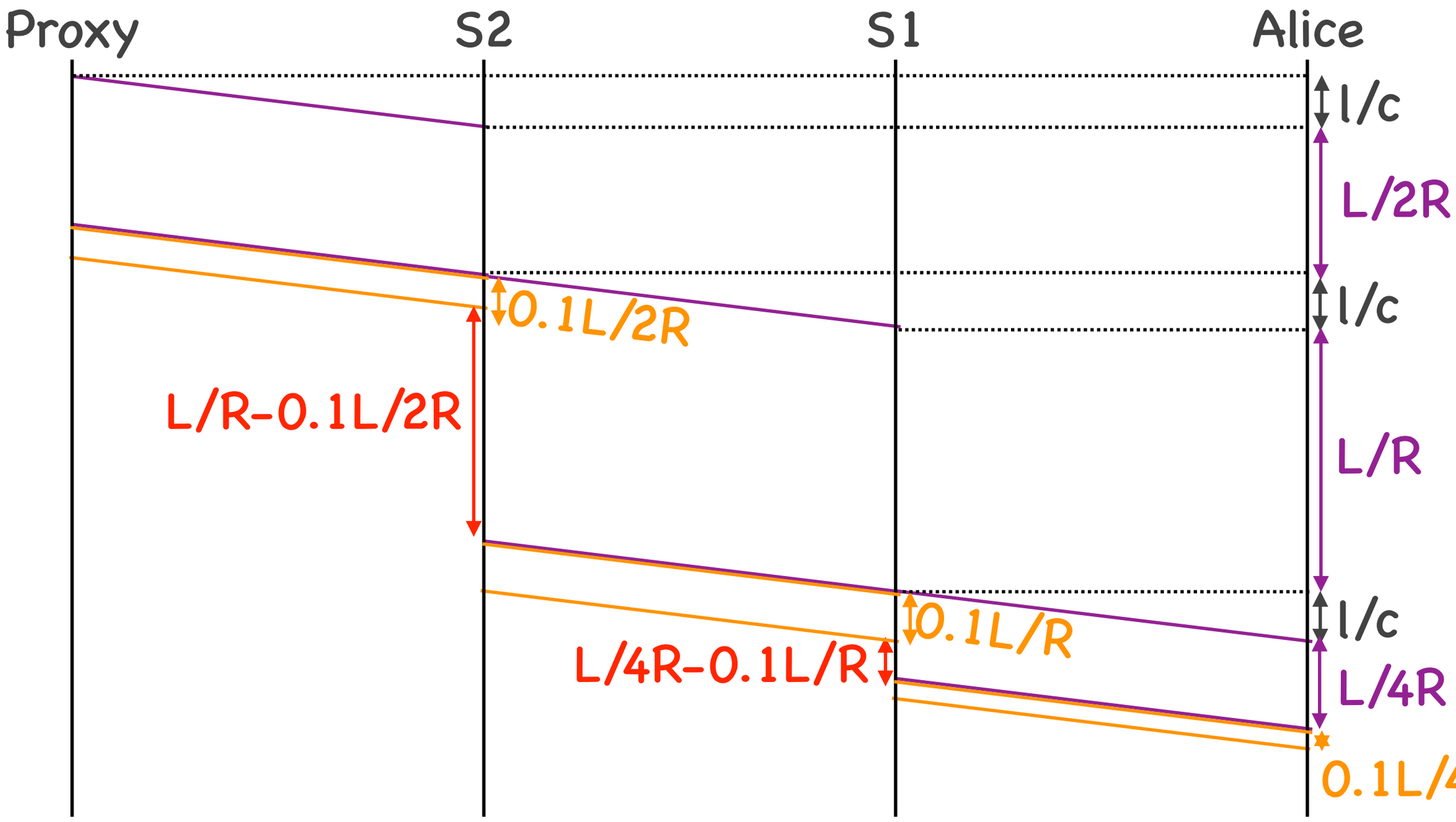


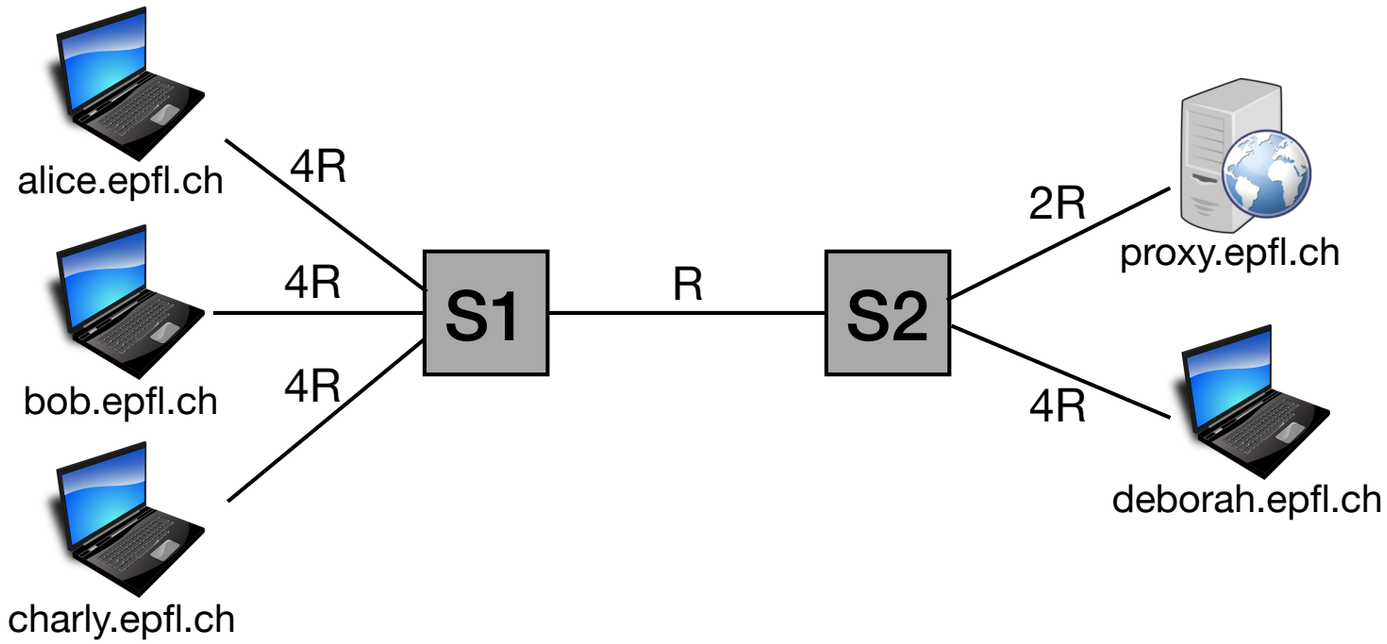
The proxy sends 2 packets, of sizes L and 0.1L, to Alice.
What is the transfer time?

$$L/2R + L/R + L/4R + 0.1L/4R + 3l/c$$

What is the queuing delay experienced by the 2nd packet?


alice.epfl.ch
bob.epfl.ch
charly.epfl.ch
4R
4R
4R
S1
R
S2
2R
4R
proxy.epfl.ch
deborah.epfl.ch


Proxy
S2
S1
Alice
l/c
L/2R
l/c
L/R
l/c
L/4R
0.1L/4R
0.1L/2R
L/R-0.1L/2R
0.1L/R
L/4R-0.1L/R

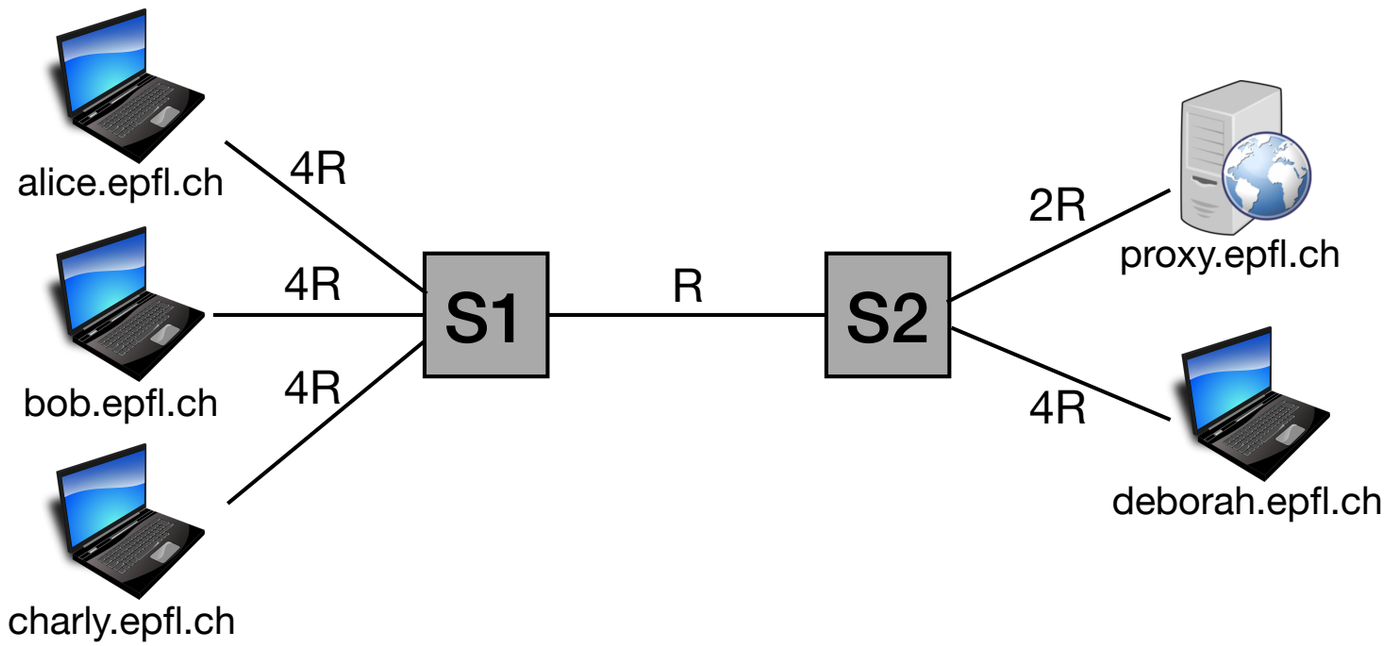


The proxy sends 2 packets, of sizes L and 0.1L, to Alice.
What is the transfer time?

$$L/2R + L/R + L/4R + 0.1L/4R + 3l/c$$

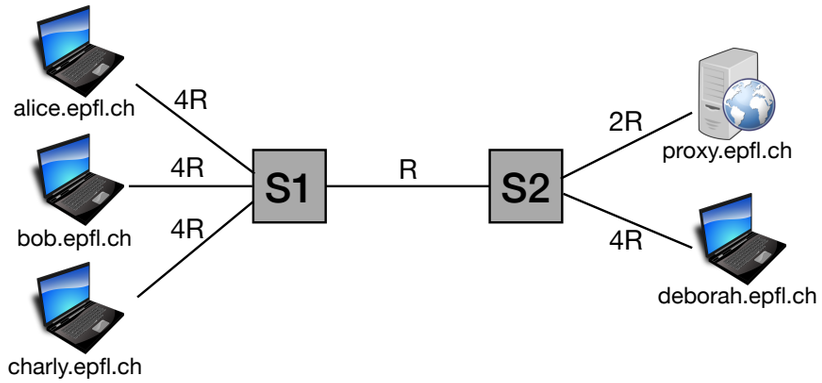
What is the queuing delay experienced by the 2nd packet?

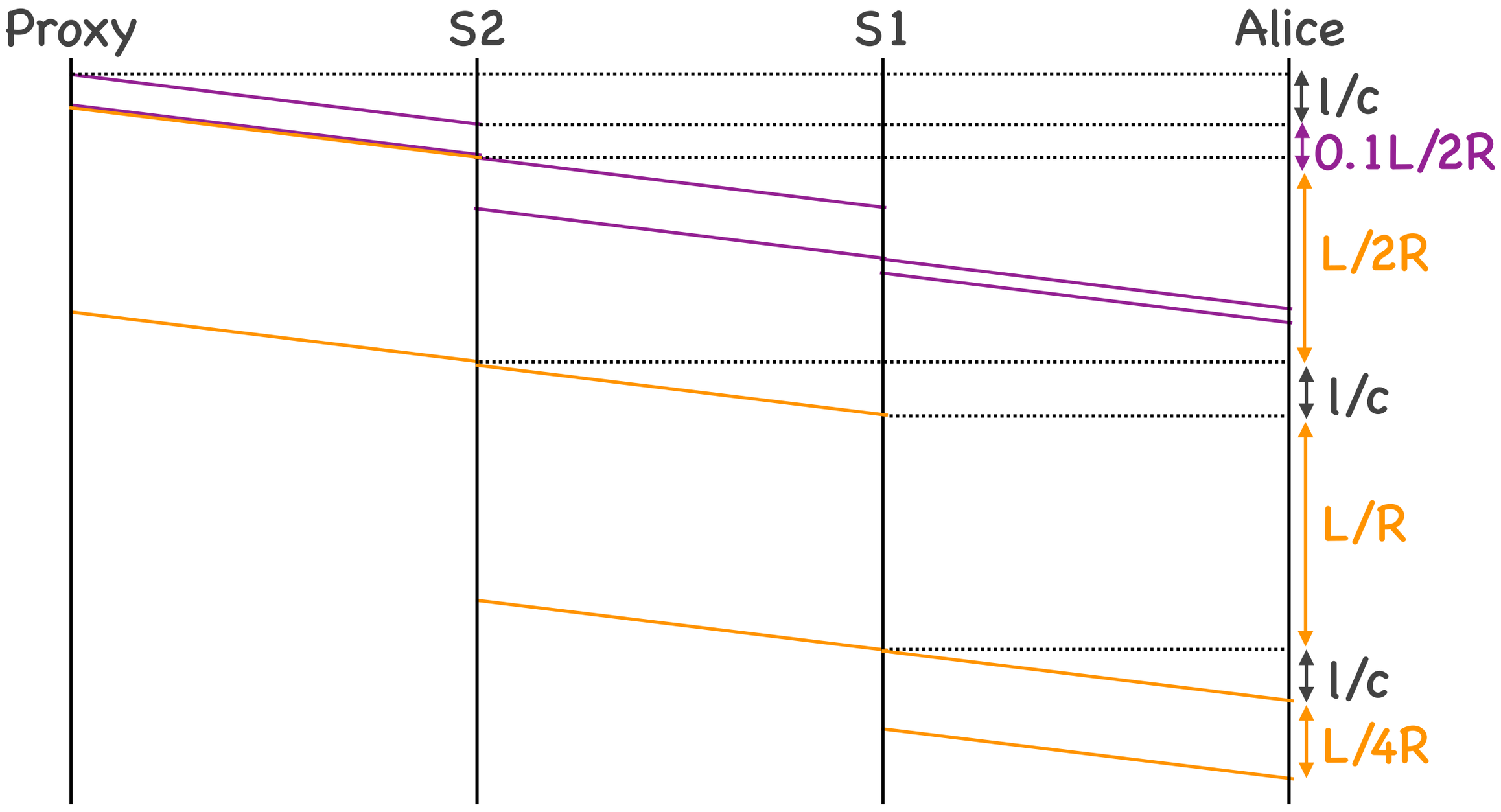
$$L/R - 0.1L/2R + L/4R - 0.1L/R$$

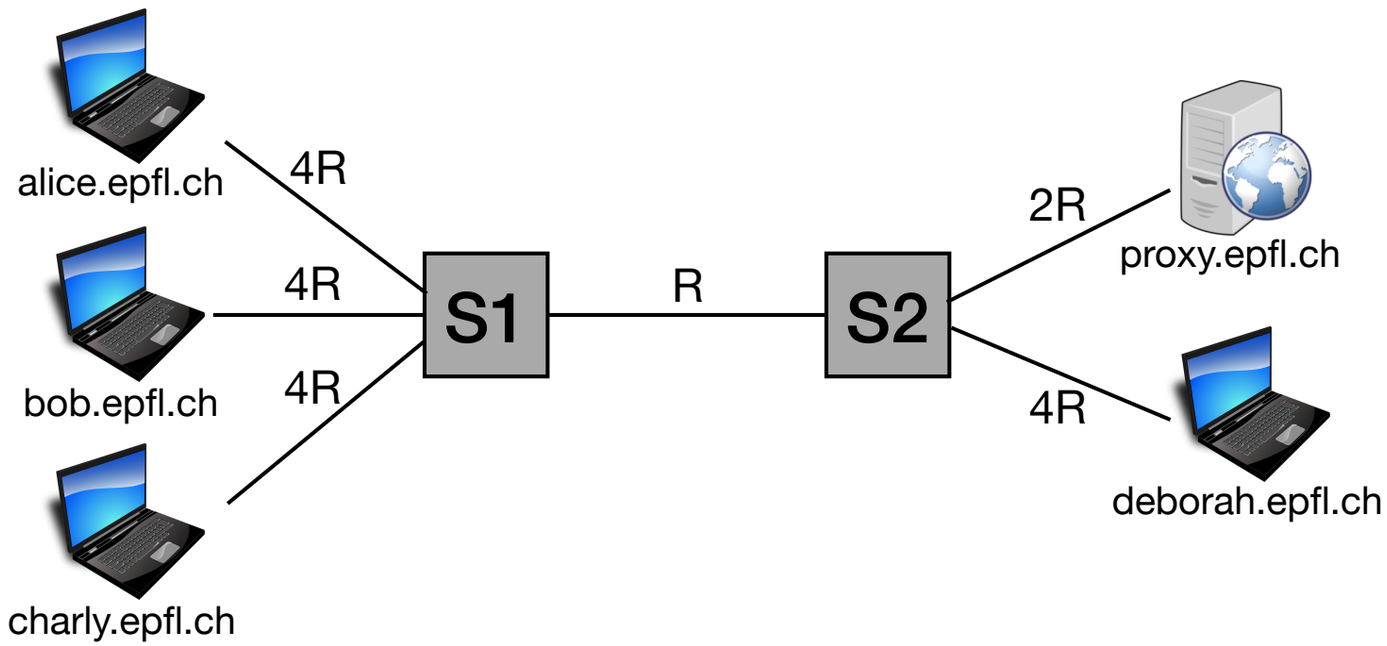


What if the proxy had sent the smaller packet first?

What is the transfer time?


alice.epfl.ch
bob.epfl.ch
charly.epfl.ch
4R
4R
4R
S1
R
S2
2R
4R
proxy.epfl.ch
deborah.epfl.ch


Proxy
S2
S1
Alice
l/c
0.1L/2R
L/2R
l/c
L/R
l/c
L/4R

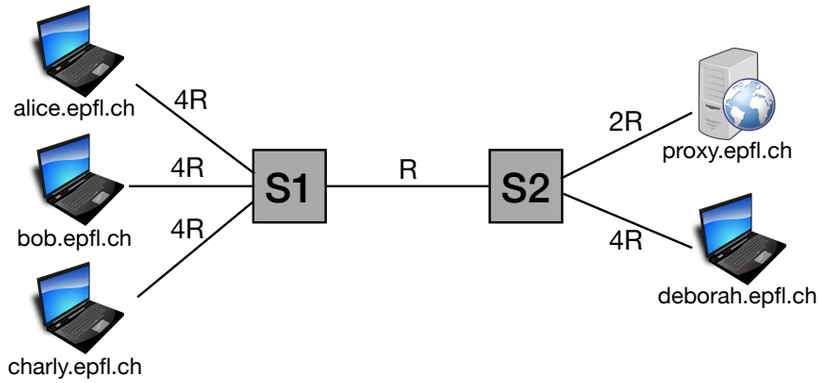


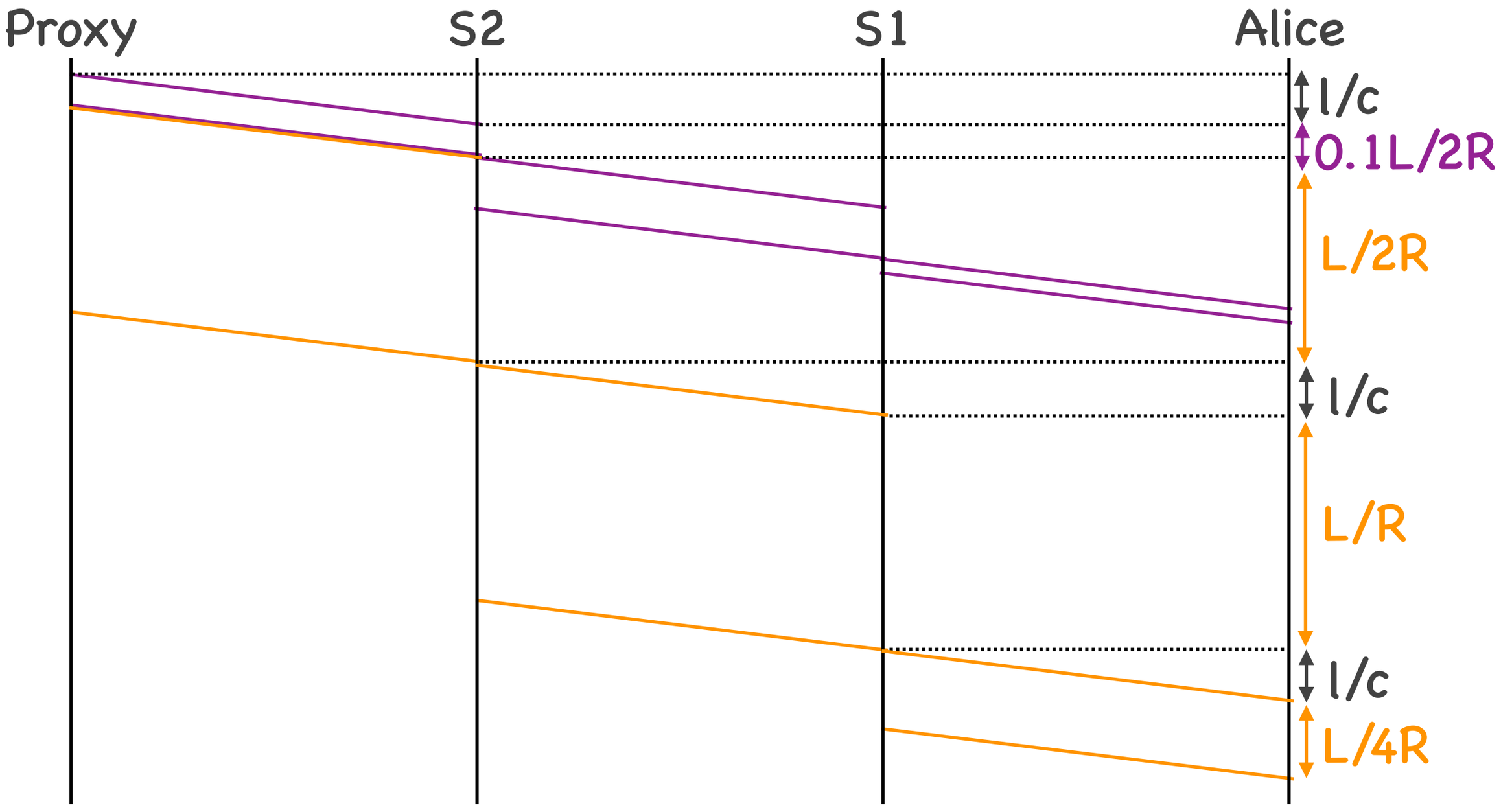
What if the proxy had sent the smaller packet first?

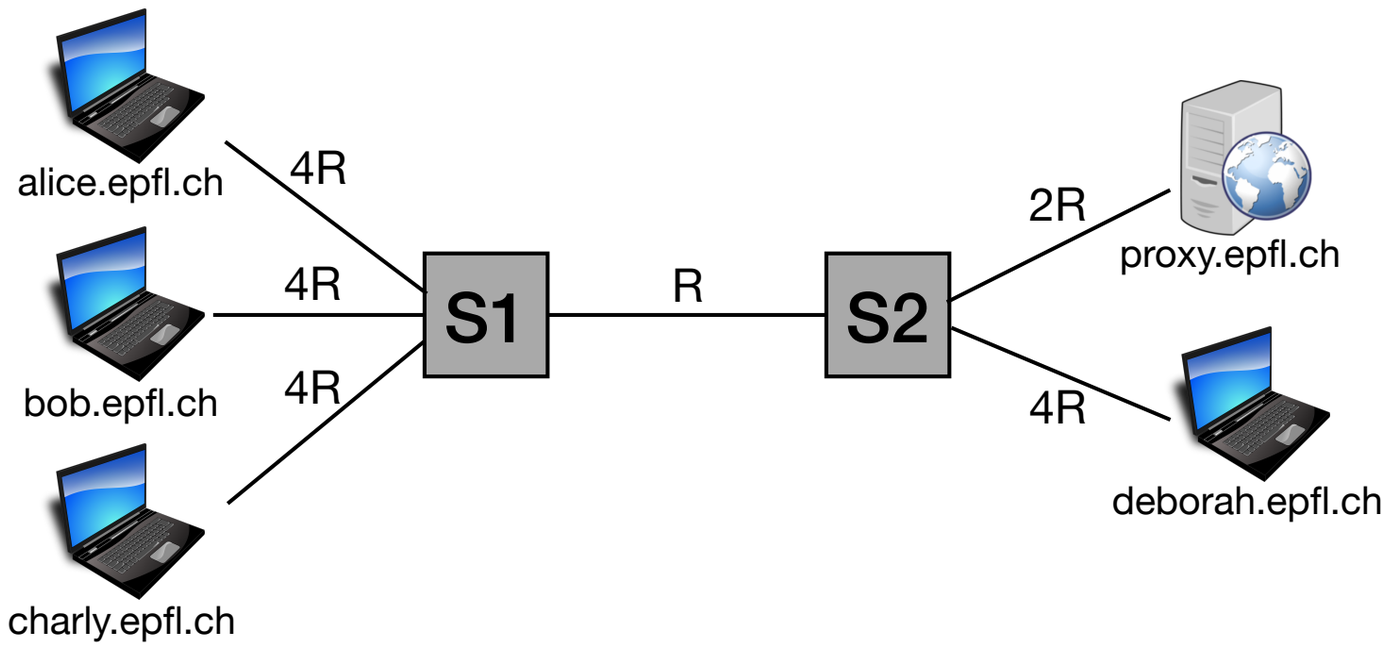
What is the transfer time?

$$L/2R + L/R + L/4R + 0.1L/2R + 3l/c$$

What is the queuing delay experienced by the 2nd packet?


alice.epfl.ch
bob.epfl.ch
charly.epfl.ch
4R
4R
4R
S1
R
S2
2R
4R
proxy.epfl.ch
deborah.epfl.ch


Proxy
S2
S1
Alice
l/c
0.1L/2R
L/2R
l/c
L/R
l/c
L/4R



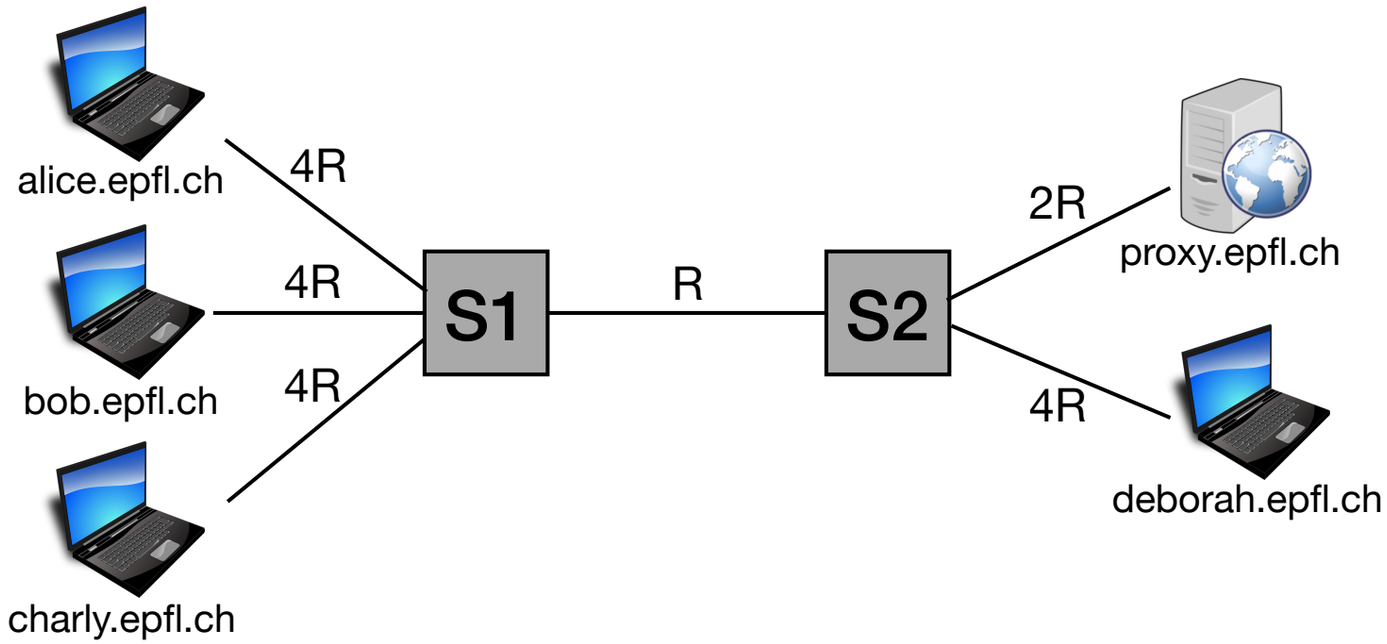
What if the proxy had sent the smaller packet first?

What is the transfer time?

L/2R + L/R + L/4R + 0.1L/2R + 3l/c

What is the queuing delay experienced by the 2nd packet?

0



S1 has 4 queues:

- 1 for all packets going toward S2
- 1 each for Alice, Bob, Charly

S2 has 3 queues:

- 1 for all packets going toward S1
- 1 each for proxy, Deborah

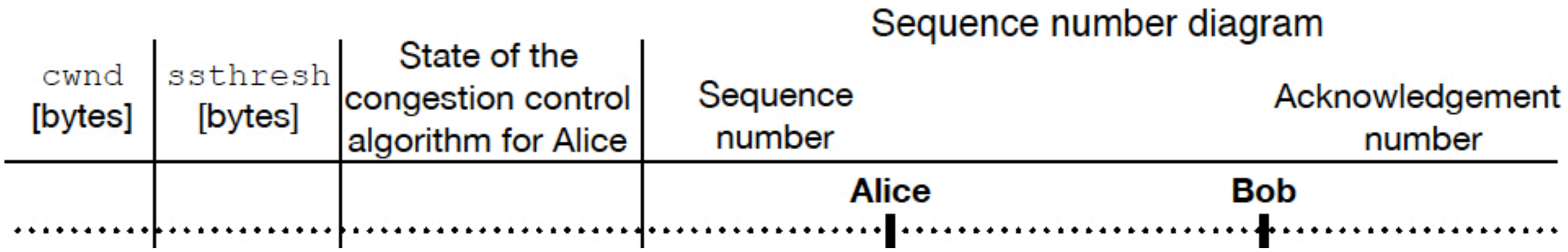
Solving delay problems

- The key is figuring out where packets are queued
- Often determined by the slowest link and/or the largest packet
- …but there is no general formula for all scenarios

Solving delay problems

- Use a timing diagram
- Mark all the relevant transmission and prop. delay components
- Identify which components you need to combine to answer each question

Final 2018, Problem 4, Q1

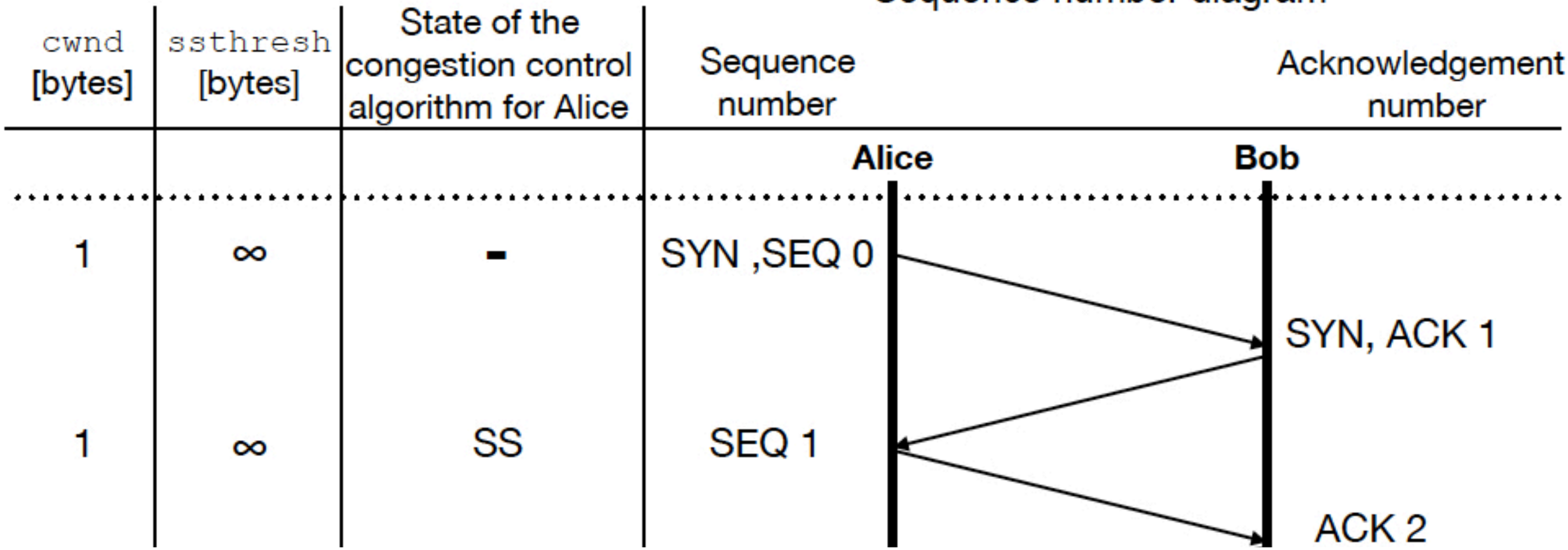


Alice sends 12 bytes of data

Bob's 3,5,6,8,9,10th segment lost

cwnd [bytes]	ssthresh [bytes]	State of the congestion control algorithm for Alice
1	∞	-
1	∞	SS

Sequence number diagram

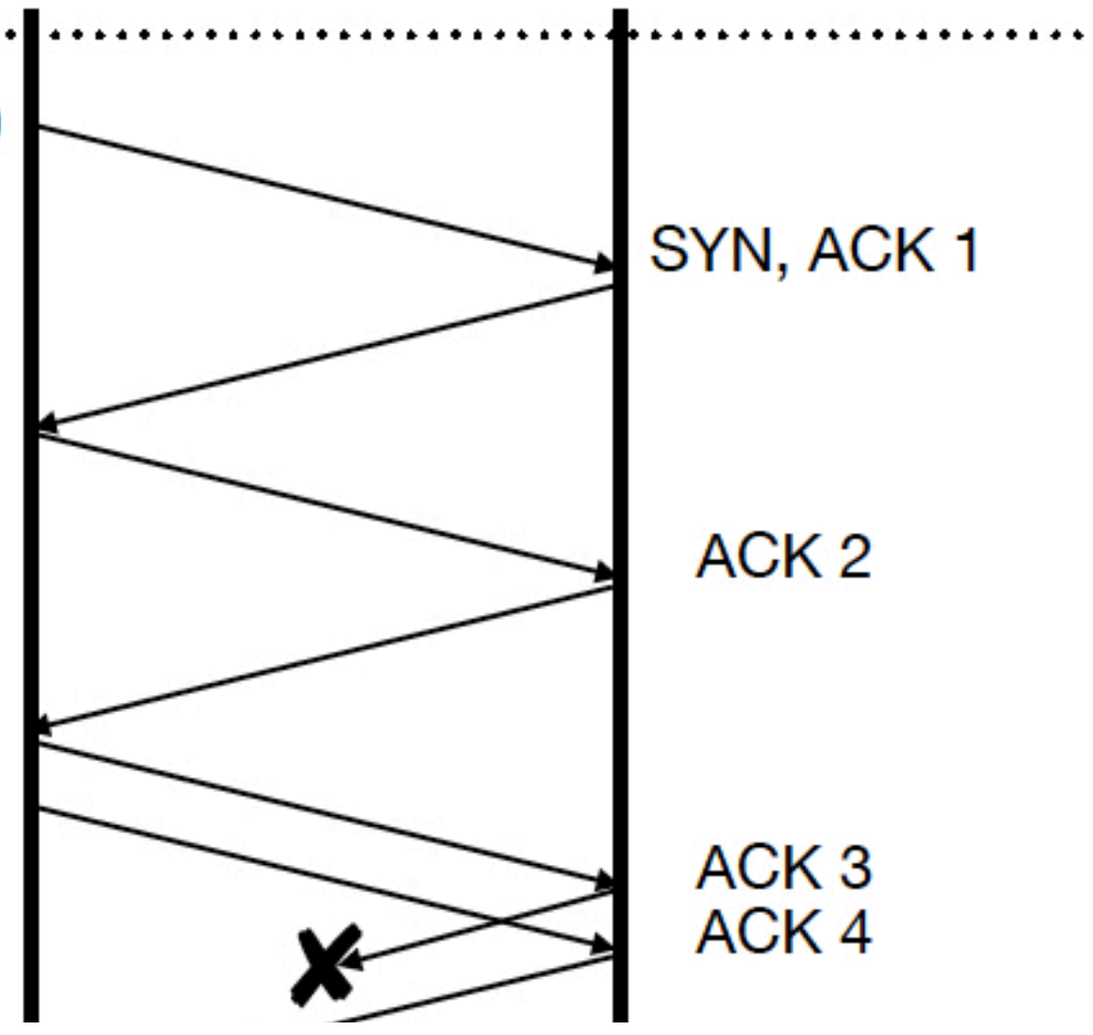


Alice sends 12 bytes of data

Bob's 3,5,6,8,9,10th segment lost

cwnd [bytes]	ssthresh [bytes]	State of the congestion control algorithm for Alice	Sequence number
1	∞	-	SYN ,SEQ 0
1	∞	SS	SEQ 1
2	∞	SS	SEQ 2 SEQ 3

Sequence number diagram

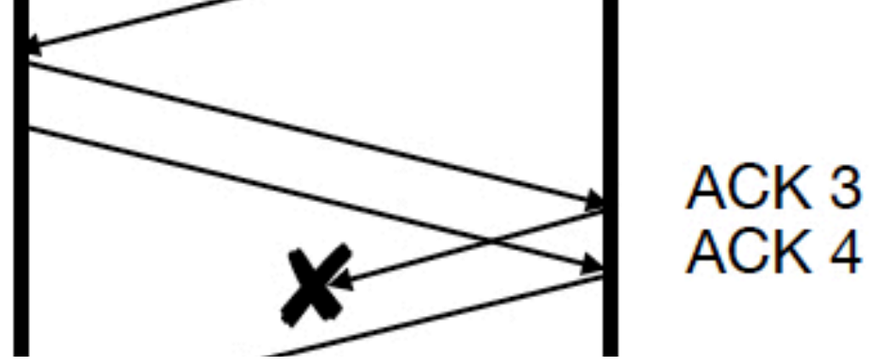


Acknowledgement number

Alice sends 12 bytes of data

Bob's 3,5,6,8,9,10th segment lost

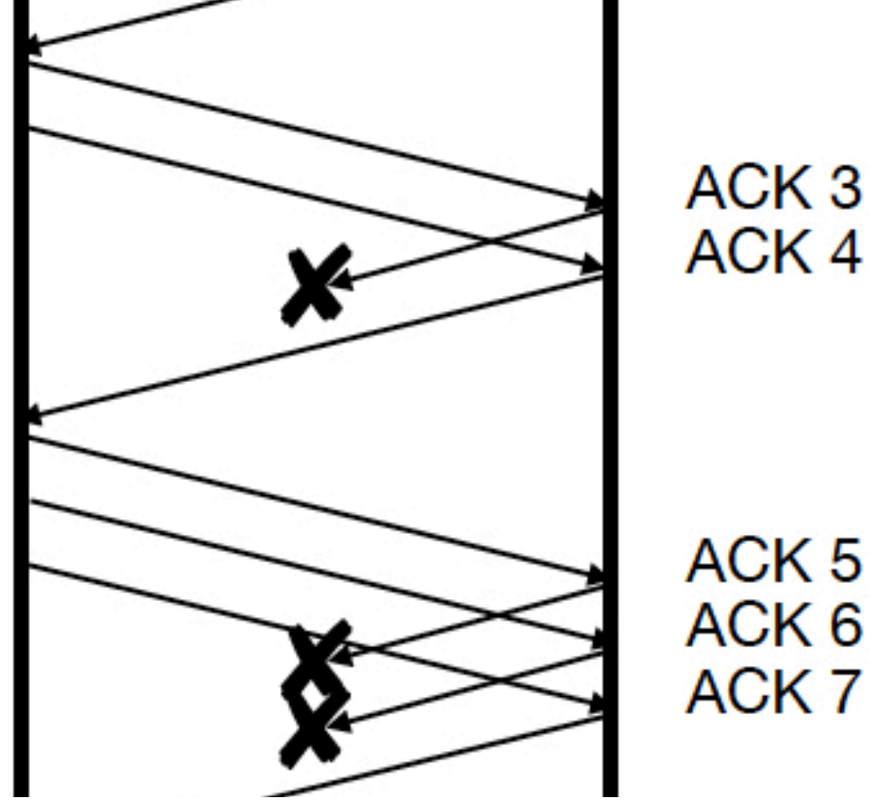
2	∞	SS	SEQ 2 SEQ 3	ACK 3 ACK 4



Alice sends 12 bytes of data

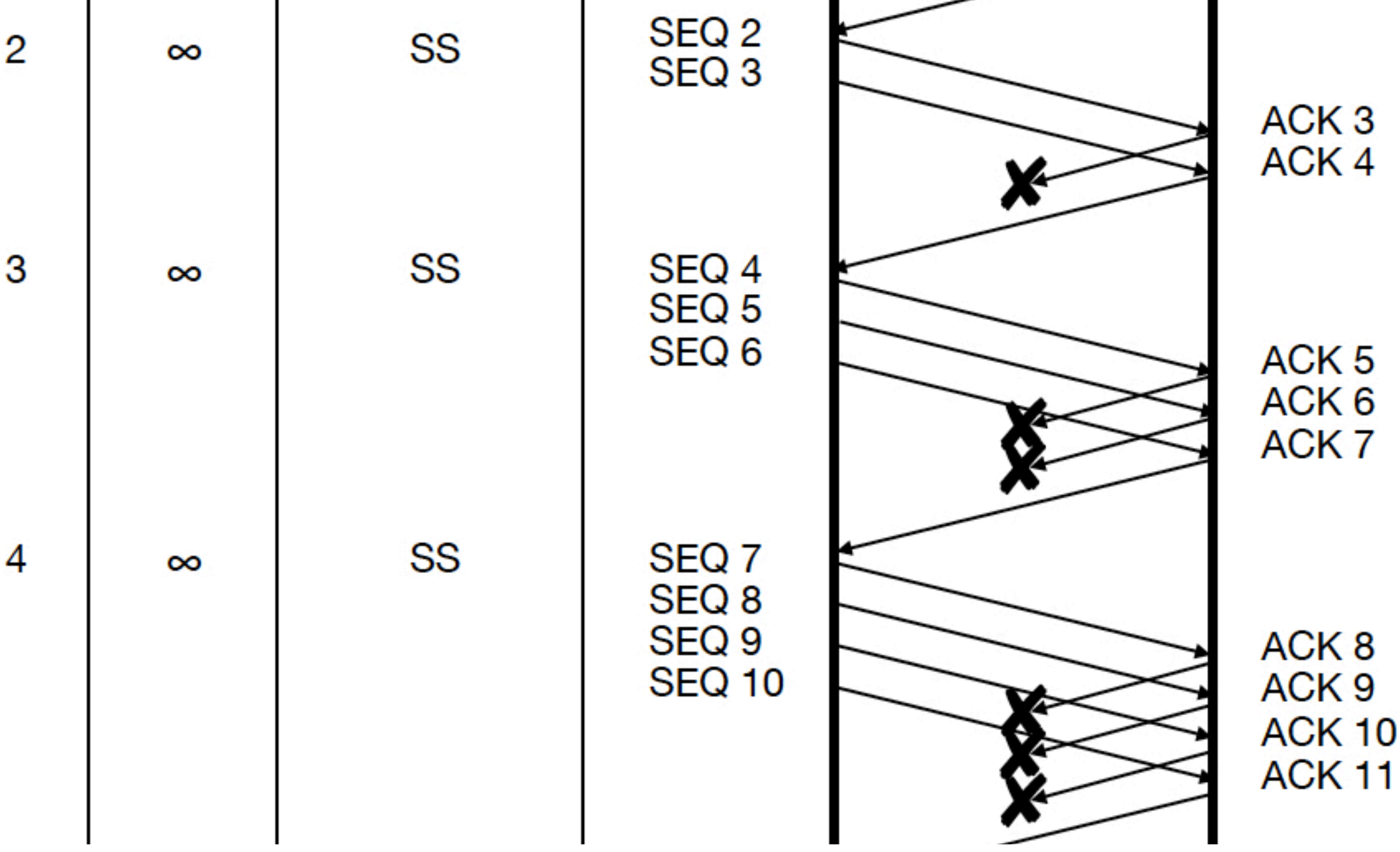
Bob's 3,5,6,8,9,10th segment lost

2	∞	SS	SEQ 2 SEQ 3	ACK 3 ACK 4
3	∞	SS	SEQ 4 SEQ 5 SEQ 6	ACK 5 ACK 6 ACK 7



Alice sends 12 bytes of data

Bob's 3,5,6,8,9,10th segment lost



Alice sends 12 bytes of data

Bob's 3,5,6,8,9,10th segment lost

2	∞	SS	SEQ 2 SEQ 3	ACK 3 ACK 4
3	∞	SS	SEQ 4 SEQ 5 SEQ 6	ACK 5 ACK 6 ACK 7
4	∞	SS	SEQ 7 SEQ 8 SEQ 9 SEQ 10	ACK 8 ACK 9 ACK 10 ACK 11
5	∞	SS	SEQ 11 SEQ 12	ACK 12 ACK 13
6 7	∞	SS