



Politecnico di Milano

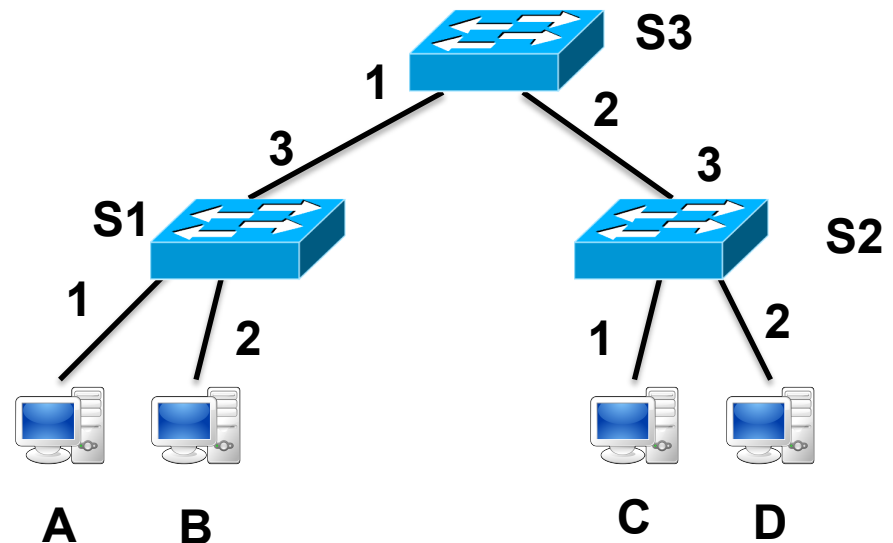
Scuola di Ingegneria Industriale e dell'Informazione

E4

Local Area Networks

Exercise 1

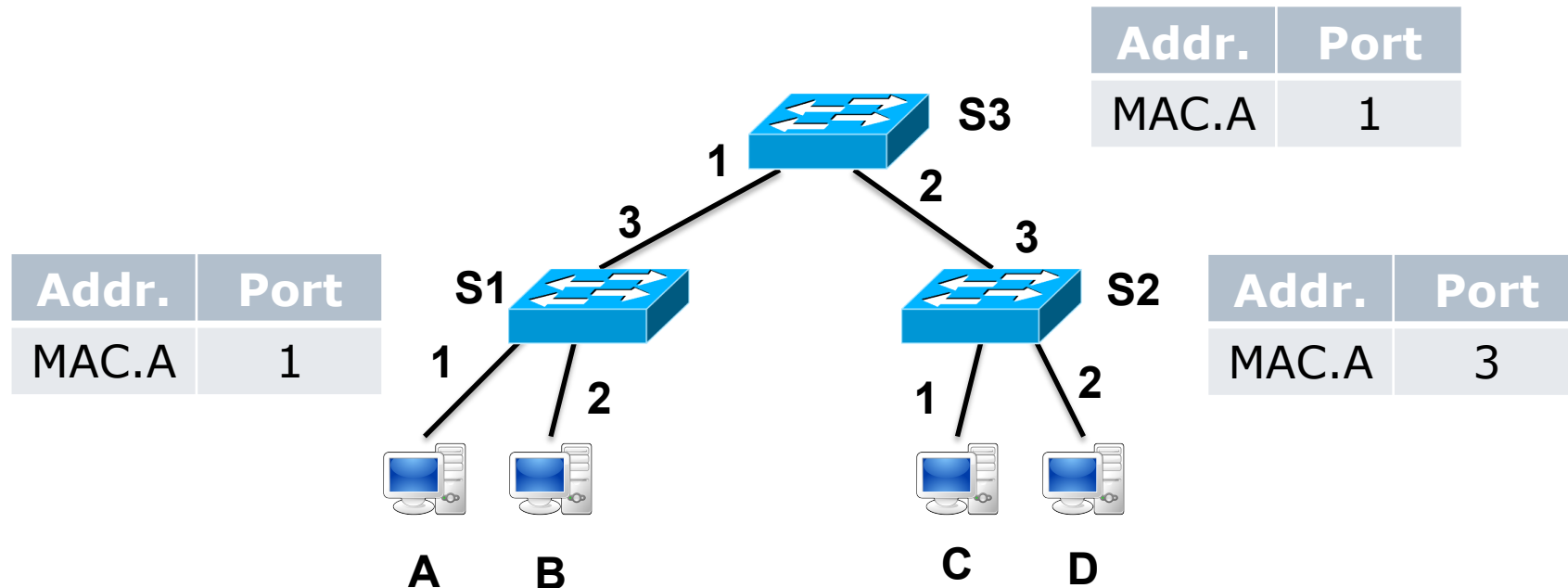
- Consider the LAN in the figure with stations A, B, C, and D (with addresses MAC.A, MAC.B, MAC.C, and MAC.D, respectively) and switches S1, S2, and S3 (port numbers are indicated in the figure).
- Forwarding tables are initially empty. A sequence of 4 frames is exchanged by A and C (F1: A-to-C, F2: C-to-A, F3: A-to-C, F4: C-to-A).
- Indicate the forwarding behavior of all switches for each frame and the content of forwarding tables after each packet processing
- Which frames are received also by B and D? What B and D do with the received frames?



Solution 1

F1: A-to-C

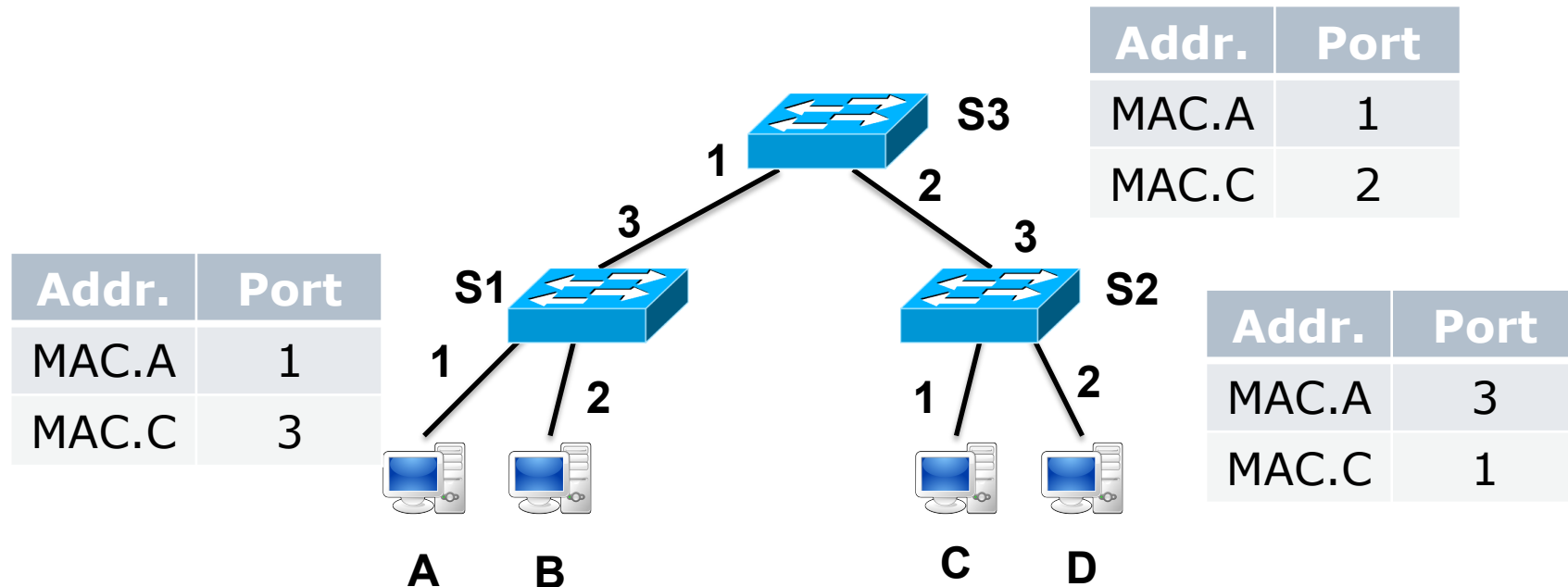
- ❑ Frame is received by S1 on port 1 and forwarded on ports 2 and 3; S1 adds an entry in the forwarding table: (MAC.A, port 1)
- ❑ Frame is received by S3 on port 1 and forwarded on port 2; S3 adds an entry in the forwarding table: (MAC.A, port 1)
- ❑ Frame is received by S2 on port 3 and forwarded on ports 1 and 2; S2 adds an entry in the forwarding table: (MAC.A, port 3)



Solution 1

F2: C-to-A

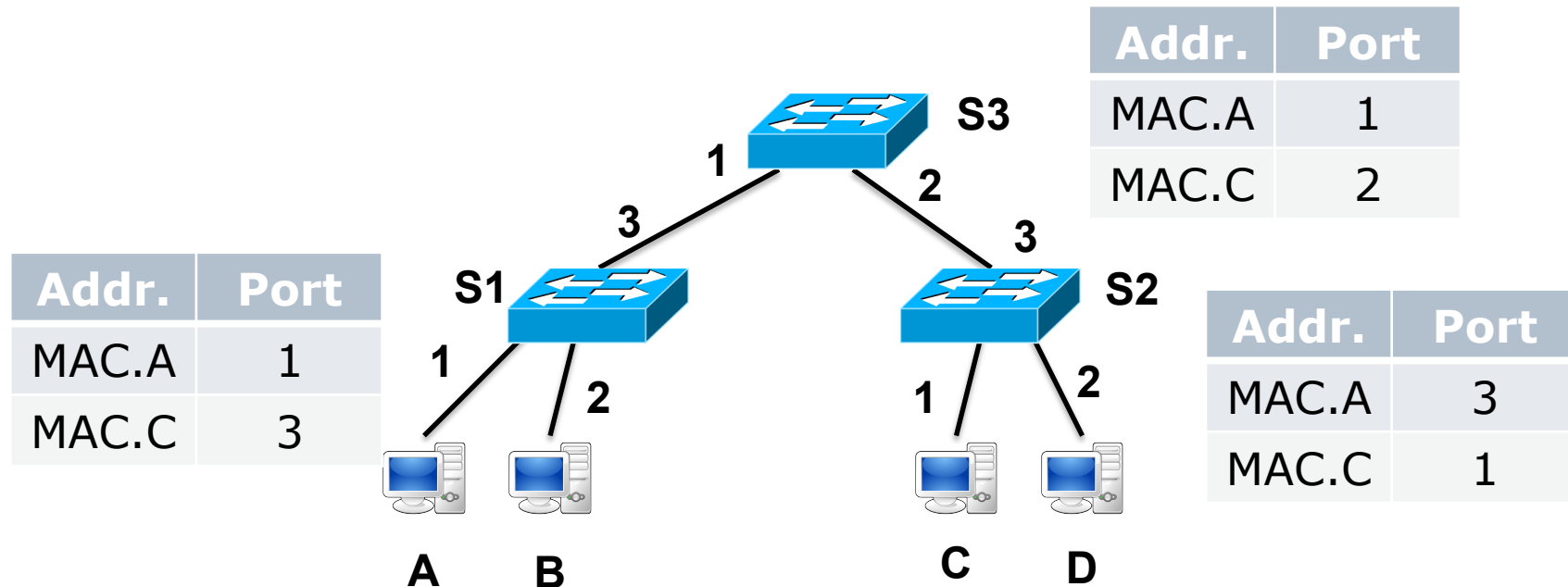
- ❑ Frame is received by S2 on port 1 and forwarded on port 3; S2 adds an entry in the forwarding table: (MAC.C, port 1)
- ❑ Frame is received by S3 on port 2 and forwarded on port 1; S3 adds an entry in the forwarding table: (MAC.C, port 2)
- ❑ Frame is received by S1 on port 3 and forwarded on port 1; S2 adds an entry in the forwarding table: (MAC.C, port 3)



Solution 1

F3: A-to-C

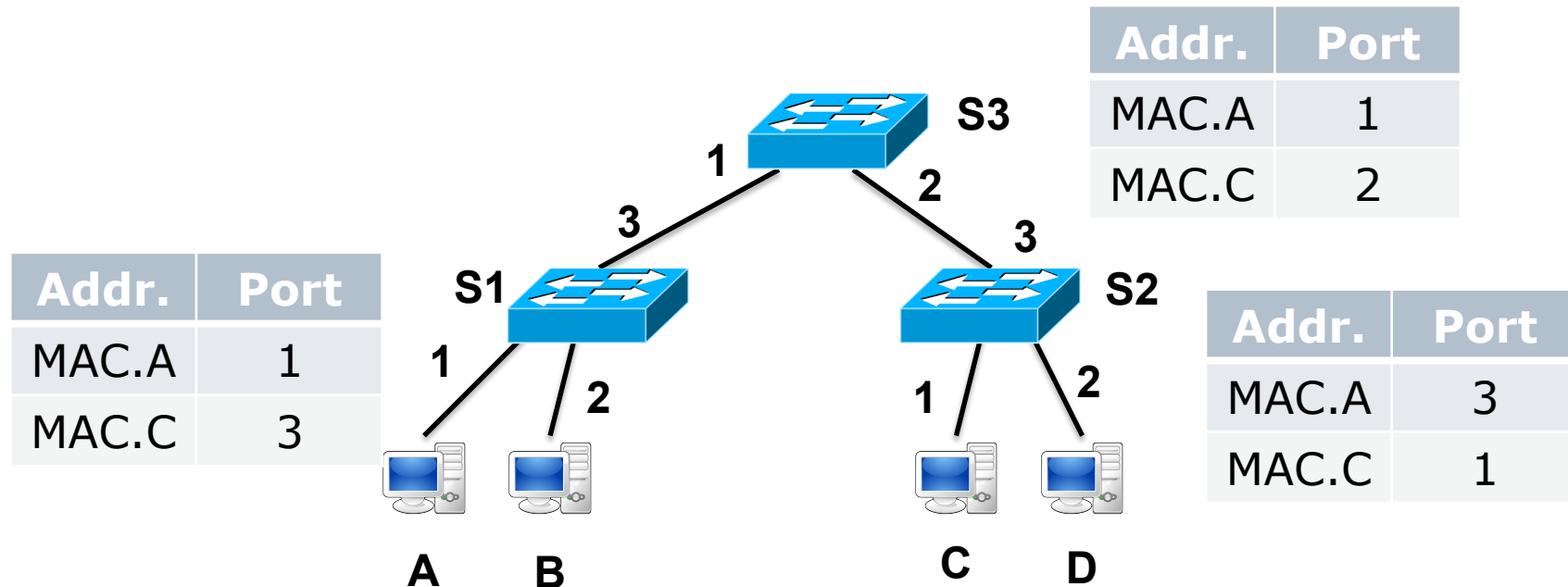
- ❑ Frame is received by S1 on port 1 and forwarded on port 3
- ❑ Frame is received by S3 on port 1 and forwarded on port 2
- ❑ Frame is received by S2 on port 3 and forwarded on port 1



Solution 1

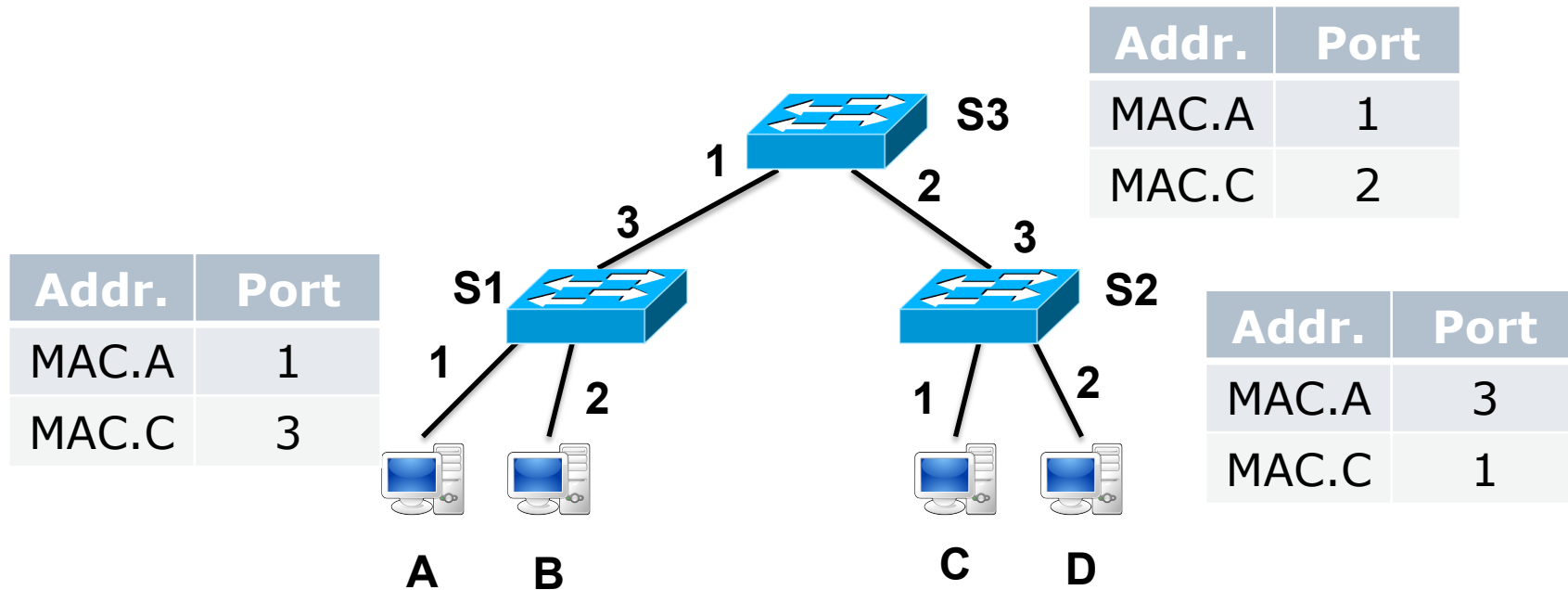
F4: C-to-A

- ❑ Frame is received by S2 on port 1 and forwarded on port 3
- ❑ Frame is received by S3 on port 2 and forwarded on port 1
- ❑ Frame is received by S1 on port 3 and forwarded on port 1



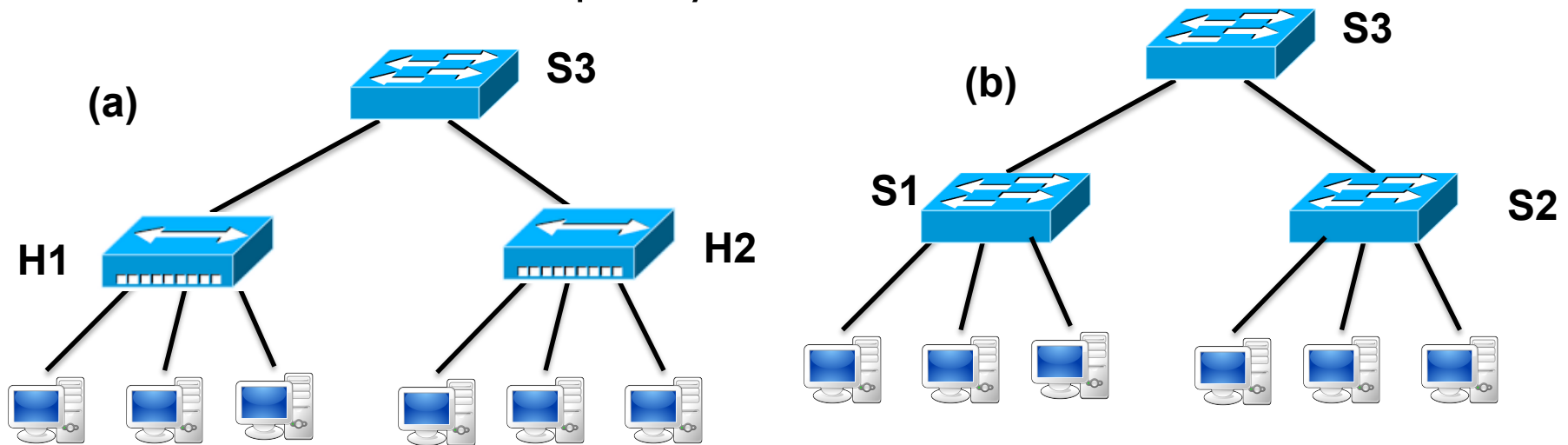
Solution 1

- ❑ Station B receives a copy of F1 and discards it
- ❑ Station D receives a copy of F1 and discards it



Exercise 2

- ❑ Consider the LAN in figures (a) and (b) with switches (indicated with S) and hubs (indicated with H).
- ❑ Assume that each station generates traffic uniformly towards the other stations and that the traffic of all stations is the same
- ❑ Access links connecting stations have a rate of 10 Mb/s and trunk links connecting network nodes (S1-S3 and S2-S3, H1-S3, H2-S3) have a rate of 100 Mb/s. Multiple access efficiency is 0.90
- ❑ Calculate the total capacity of the network.



Solution 2

- Let us denote with S_M the efficiency of each LAN segment. S_M is equal to 0.90 if the segment is shared through multiple access, while it is equal to 1 otherwise
- Let us denote with X the traffic capacity of each segment.
- We have

$$S_M = \underbrace{X(1 - \alpha)}_{\text{Internal traffic}} + \underbrace{X\alpha}_{\text{Outgoing traffic}} + \underbrace{X\alpha}_{\text{Ingoing traffic}} = X(1 + \alpha)$$

$$X = \frac{S_M}{1 + \alpha}$$

Solution 2

- In network (a) the access capacity is much smaller than trunk link capacity, so we can consider only the access part.
- We have:

$$\alpha = 5 / 6$$

$$S_M = 0.9$$

$$X = \frac{0.9}{(1 + 5 / 6)} = 0.49$$

- And therefore with two access segments we have that the network total traffic capacity is

$$X_N = 2X = 0.98$$

$$C_N = X_N \cdot R = 9.8 \text{ Mb/s}$$

Solution 2

- In network (b) the access capacity is also much smaller than trunk link capacity, so we can consider only the access part.
- In this network also access link are switched and therefore full-duplex, and therefore there is no loss of efficiency due to multiple access
- We have:

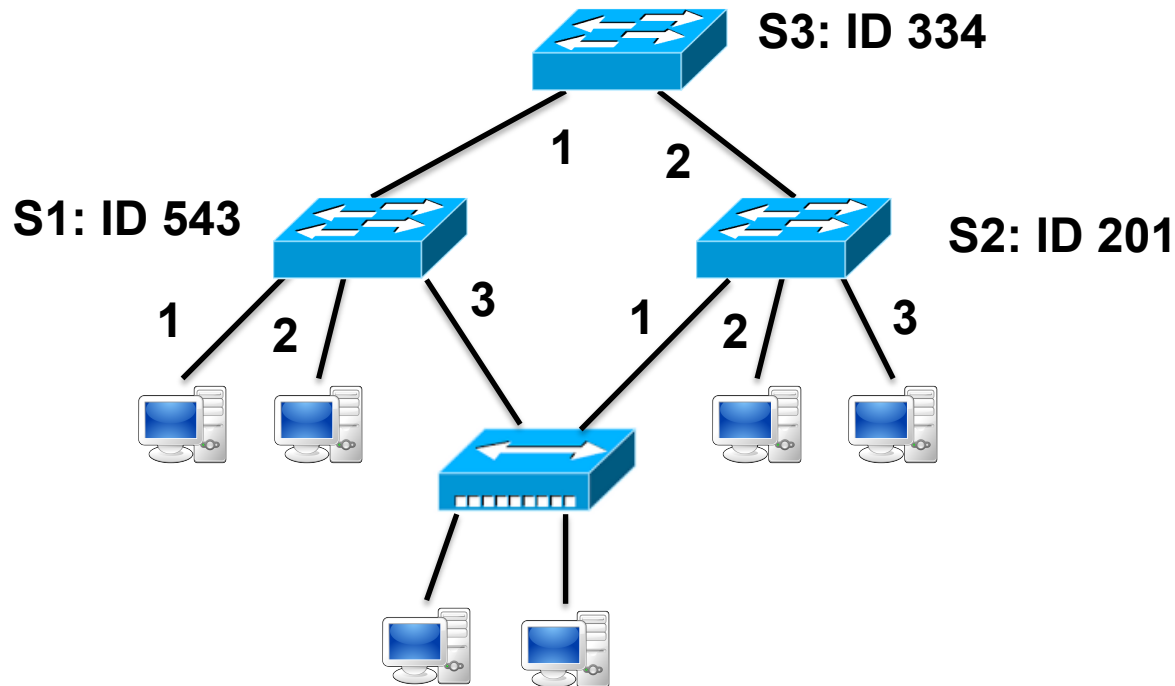
$$X = 1$$

$$X_N = 6X = 6$$

$$C_N = X_N \cdot R = 60 \text{ Mb/s}$$

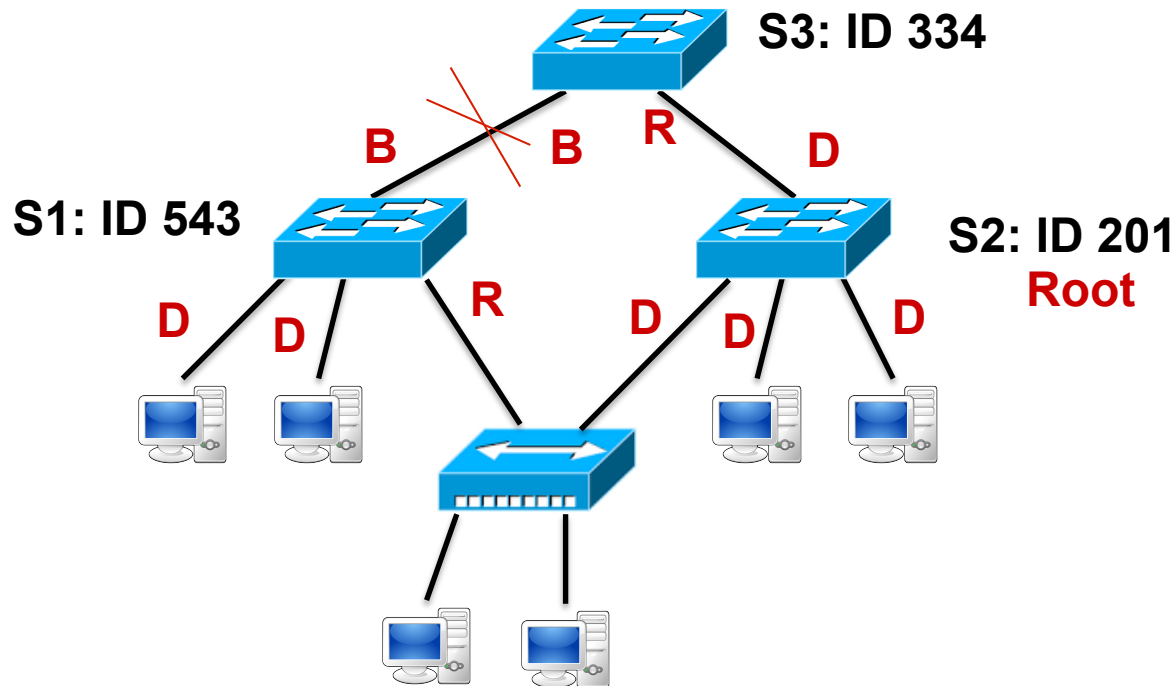
Exercise 3

- ❑ Consider the LAN in the figure.
- ❑ The STP is active on switches. Metric for Root Path Cost is the same for all ports.
- ❑ Indicate which switch is elected as root, which ports are blocked, which are root ports, and which are designed.



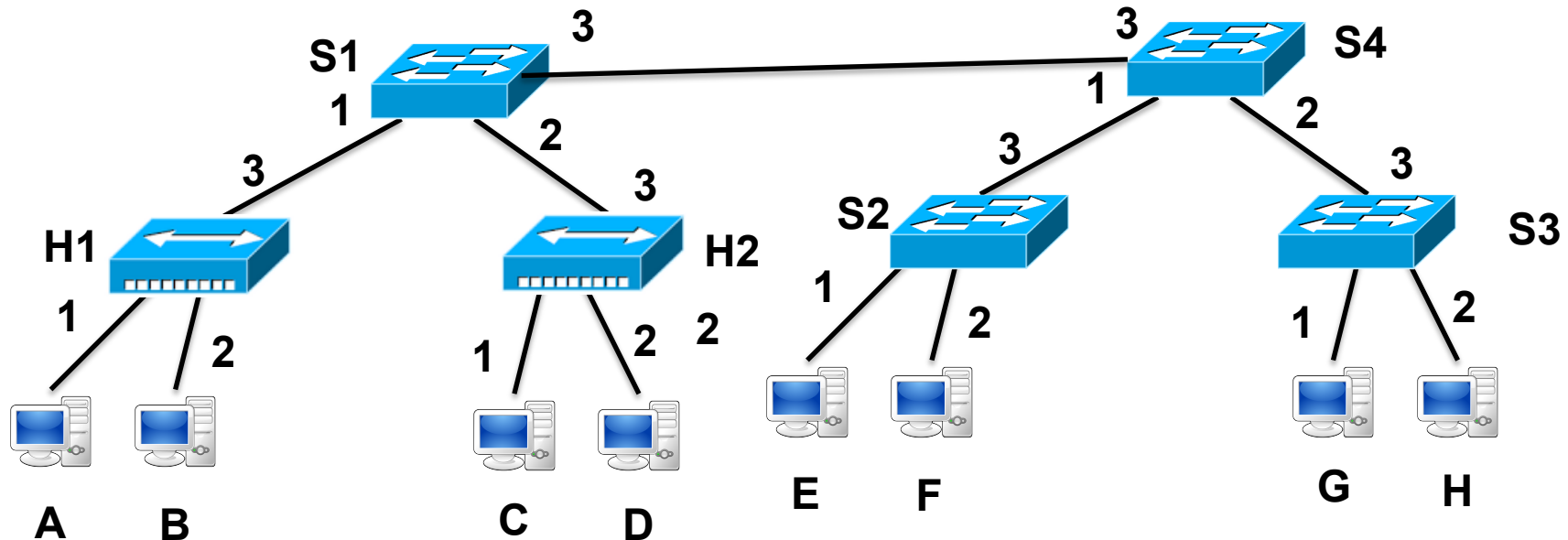
Solution 3

- ❑ S2 is elected as root bridge
- ❑ Root ports are indicated with "R"
- ❑ Designated ports are indicated with "D"
- ❑ Blocked ports are indicated with "B"



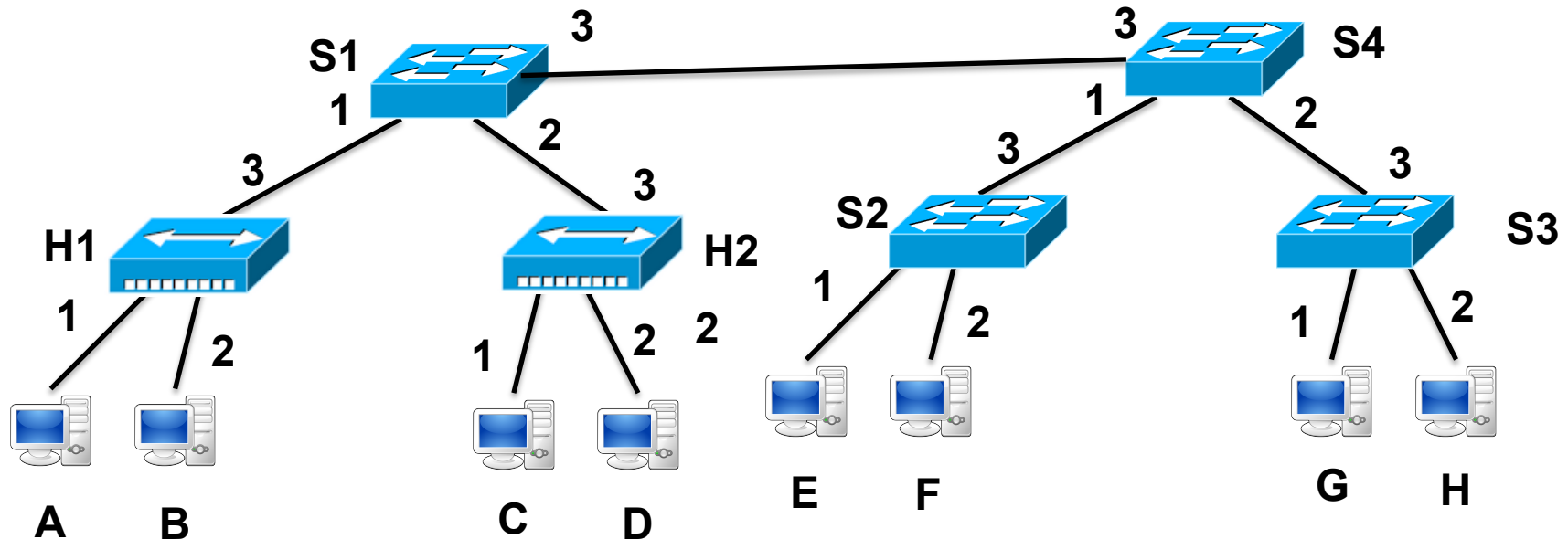
Exercise 4

- Consider the LAN in the figure with stations A-H (with addresses MAC.x, x=A,B, ..., H, respectively), switches S1, S2, S3 and S4, and hubs H1 and H2 (port numbers for switches and hubs are indicated in the figure).
- Forwarding tables are initially complete will all entries corresponding to the stations of the network.
- A sequence of 3 frames is exchanged in the network (F1: A-to-Broadcast; F2: H-to-A, F3: A-to-H).



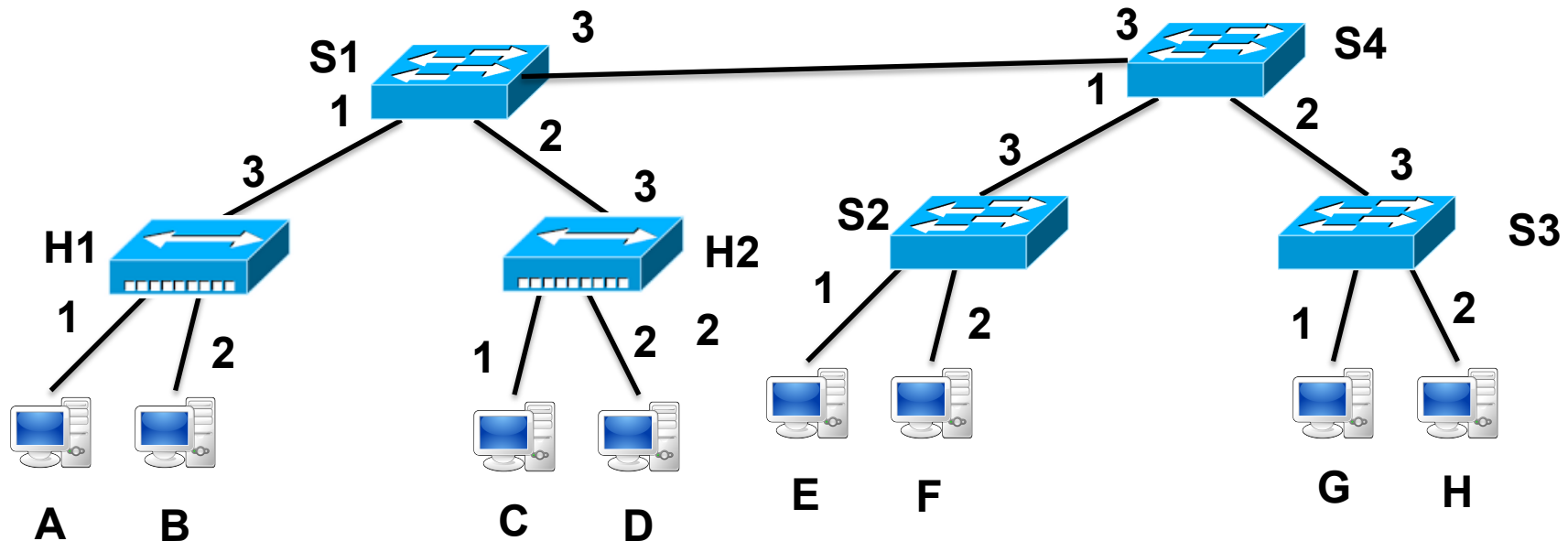
Exercise 4

- Indicate the forwarding behavior of all switches for each frame and the content of forwarding tables after each packet processing
- Indicate the destination address and source address of packets travelling between S1 and S4
- Indicate which packets are received by station B and by station G



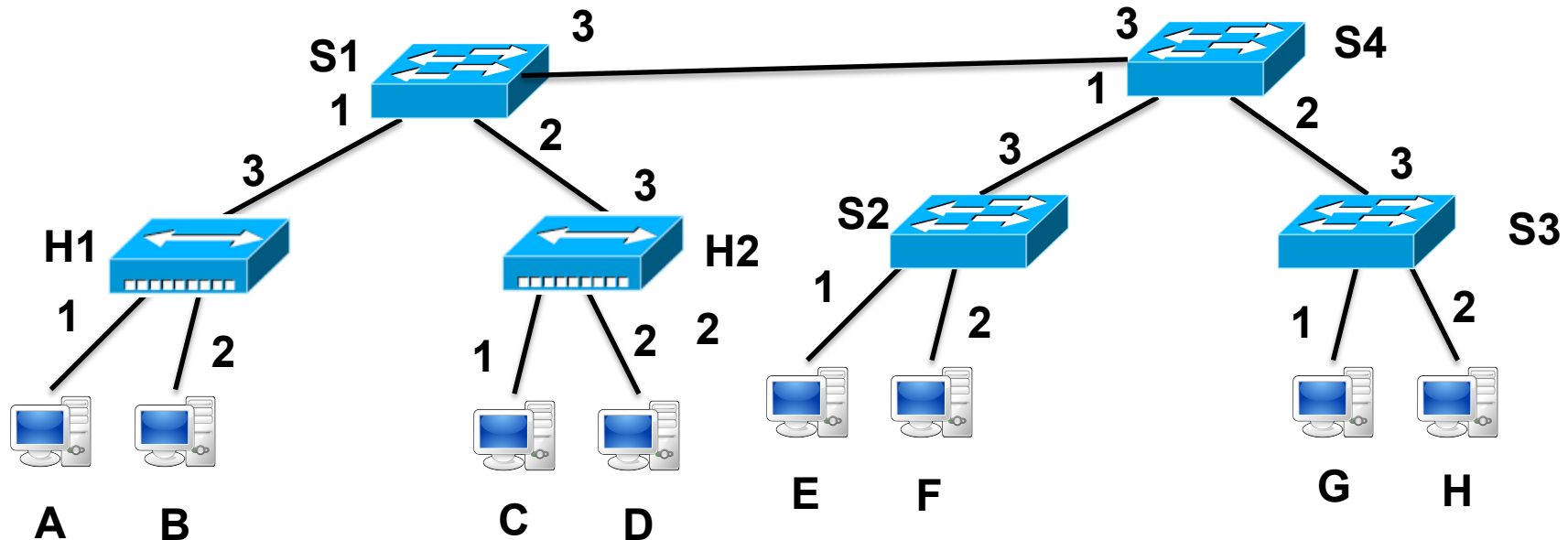
Solution 4

- F1: received by S1 on port 1 and forwarded on ports 2 and 3; received by S4 on port 3 and forwarded on ports 1 and 2; received by S2 on port 3 and forwarded on ports 1 and 2; received by S3 on port 3 and forwarded on ports 1 and 2;



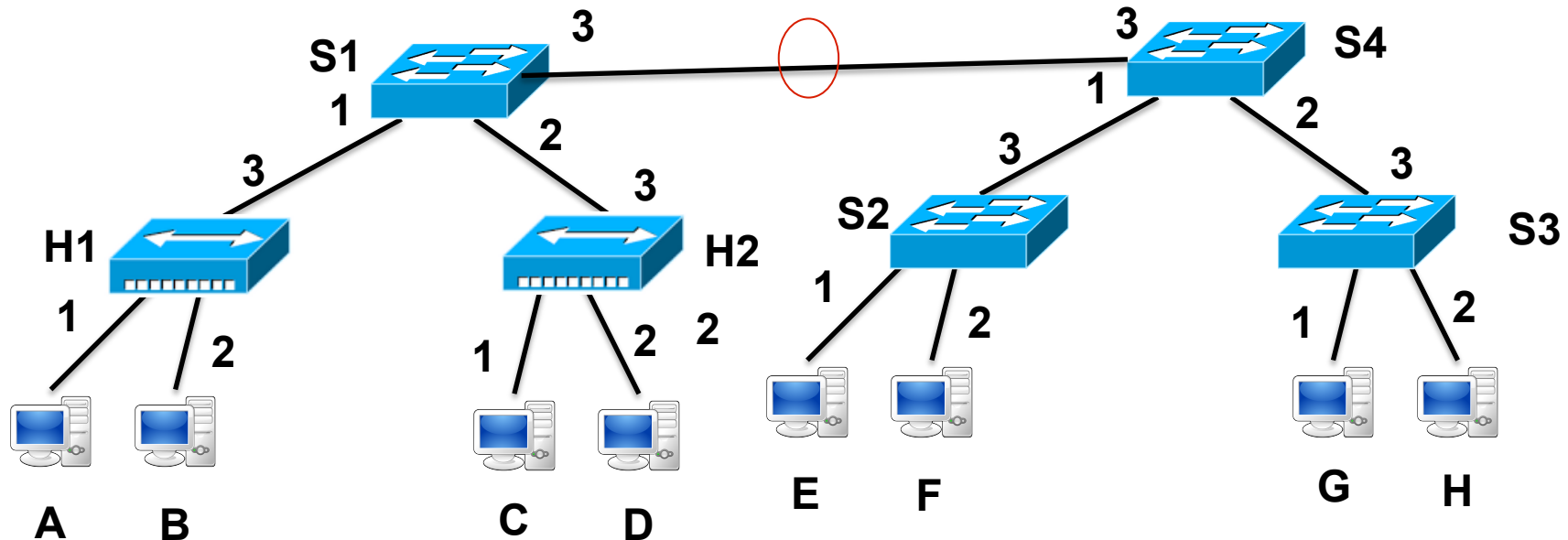
Solution 4

- F2: received by S3 on port 2 and forwarded on port 3, received by S4 on port 2 and forwarded on port 3; received by S1 on port 3 and forwarded on port 1
- F3: received by S1 on port 1 and forwarded on port 3; received by S4 on port 3 and forwarded on port 2; received by S3 on port 3 and forwarded on port 2.



Solution 4

- On the link S1-S4:
 - F1: SA=MAC.A; DA=Broadcast
 - F2: SA=MAC.H; DA=MAC.A
 - F3: SA=MAC.A; DA= MAC.H
- Station B receives frames F1 (broadcast) and F3 (same collision domain of transmitter)
- Station G receives frame F1 only (broadcast)



Exercise 5

- Consider a network based on ALOHA multiple access. Packet duration is T .
- Assume that traffic on the channel (average number of transmission in time T) is $1.649 = \sqrt{e}$ times the number of successfully transmitted frames.
- Calculate the network throughput

Solution 5

- For ALOHA we have:
 - $S = G e^{-2G}$
 - And then: $G / S = e^{2G}$
- Since we know from given data $G / S = 1.649$, we can calculate
 - $G = 1/4$
 - $S = 1.649/4 = 0.125$

Exercise 6

- A LAN technology is based on CSMA-CD
- The transmission rate on the channel is R and the minimum packet length is L
- Propagation speed τ equal to $2/3$ of light speed ($5 \mu\text{s}$ per km).
- Assuming the ratio a between τ and transmission time must be equal or smaller 1 for system efficiency, calculate the maximum distance between stations in the following cases:
 - $R=10 \text{ Mb/s}$, $L=1000 \text{ bits}$
 - $R=100 \text{ Mb/s}$, $L=1000 \text{ bits}$
 - $R=1 \text{ Gb/s}$, $L=1000 \text{ bits}$
 - $R=1 \text{ Gb/s}$, $L=1000 \text{ bytes}$

Solution 6

- $R=10 \text{ Mb/s}$, $L=1000 \text{ bits}$
 $T=100 \text{ } \mu\text{s}$
 $D=20 \text{ km}$
- $R=100 \text{ Mb/s}$, $L=1000 \text{ bits}$
 $T=10 \text{ } \mu\text{s}$
 $D=2 \text{ km}$
- $R=1 \text{ Gb/s}$, $L=1000 \text{ bits}$
 $T=1 \text{ } \mu\text{s}$
 $D=200 \text{ m}$
- $R=1 \text{ Gb/s}$, $L=1000 \text{ bytes}$
 $T=8 \text{ } \mu\text{s}$
 $D=1600 \text{ m}$