Chair of Distributed Systems and Security
School of Computation, Information and Technology
Technical University of Munich

Esolution
Place student sticker here

Note:

- During the attendance check a sticker containing a unique code will be put on this exam.
- This code contains a unique number that associates this exam with your registration number.
- This number is printed both next to the code and to the signature field in the attendance check list.

Computer Networking and IT Security

Exam:	INHN0012 / Midterm	**Date:**	Friday 16th December, 2022
Examiner:	Prof. Dr.-Ing. Stephan Günther	**Time:**	13:30 – 14:15

Before we proceed with reading the processing instructions, please answer the following questions. This information helps us to examine learning success depending on participation in individual lecture components. The information is **voluntary** and **not considered for evaluation**, i. e., answers to these questions do not give credits. In order to exclude any influence, this page will not be made accessible during the correction.

a) Did you attend the lecture?

☐ 1 (regularly) ☐ 2 (sometimes) ☐ 3 (never)

b) Did you attend the tutorials?

☐ 1 (regularly) ☐ 2 (sometimes) ☐ 3 (never)

Working instructions

- This exam consists of **8 pages** with a total of **3 problems** and a cheatsheet.
  Please make sure now that you received a complete copy of the exam.
- The total amount of achievable credits in this exam is 45 credits.
- Detaching pages from the exam is prohibited.
- Allowed resources:
  - one **non-programmable pocket calculator**
  - one **analog dictionary** English ↔ native language
- Subproblems marked by * can be solved without results of previous subproblems.
- **Answers are only accepted if the solution approach is documented.** Give a reason for each answer unless explicitly stated otherwise in the respective subproblem.
- Do not write with red or green colors nor use pencils.
- Physically turn off all electronic devices, put them into your bag and close the bag.

Left room from ________ to ________ / Early submission at ________

Problem 1 **Multiple Choice (9 credits)**

The following subproblems are multiple chouce / multiple answer, i. e., at least one answer per subproblem is correct. Subproblems with a single correct answer are graded with 1 credit if correct. Those with more than one correct answers are graded with 0.5 credit per correct answer and −0.5 credit per wrong answer. Missing crosses have no influence. The minimal amount of credits per subproblem is 0 credits.

Mark correct answers with a cross ☒

To undo a cross, completely fill out the answer option ■

To re-mark an option, use a human-readable marking ×■

a) Given the signals shown in Figures 1.1 (a) – (d) below. Which signal properties hold?

☐ (a) time discrete ☒ (b) time discrete ☐ (c) time discrete ☒ (d) time discrete

☒ (a) time cont. ☐ (b) time cont. ☒ (c) time cont. ☐ (d) time cont.

b)* Given the signals shown in Figures 1.1 (a) – (d) below. Which signal properties hold?

☐ (a) value discrete ☐ (b) value discrete ☒ (c) value discrete ☒ (d) value discrete

☒ (a) value cont. ☒ (b) value cont. ☐ (c) value cont. ☐ (d) value cont.

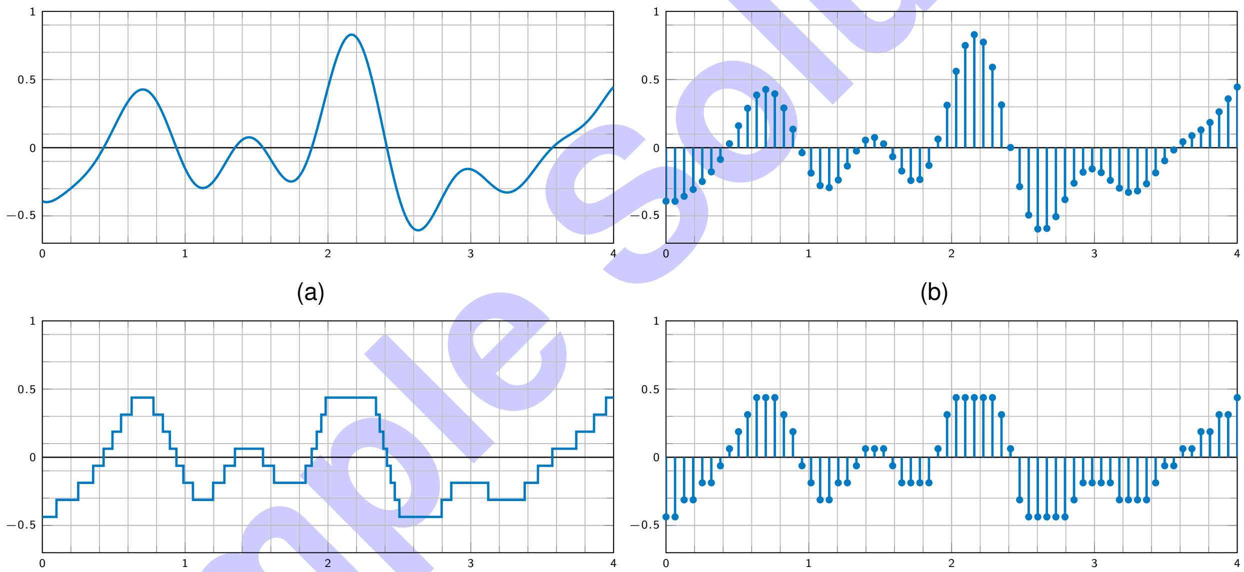
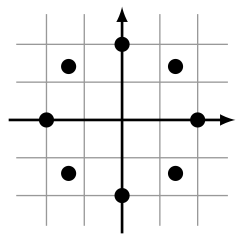


Figure 1.1: Signals

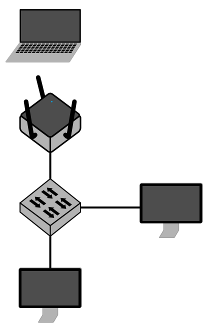
c)* The constellation diagram adjacent shows which digital modulation scheme?



☐ 8-ASK ☒ 8-PSK ☐ 8-QAM

☐ 8-PAM ☐ 8-RSK ☐ 8-CSK

d)* If the notebook (NB) in the adjacent figure wants to send a frame to one of the PCs, whose MAC address(es) are used to specify the destination?



☒ PC ☒ AP ☐ Switch ☐ NB

e)* If the notebook (NB) in the adjacent figure wants to send a frame to one of the PCs, whose IP address(es) are used to specify the destination?

☒ PC ☐ NB ☐ Switch ☐ AP

Assume the topology given in Figure 1.2.

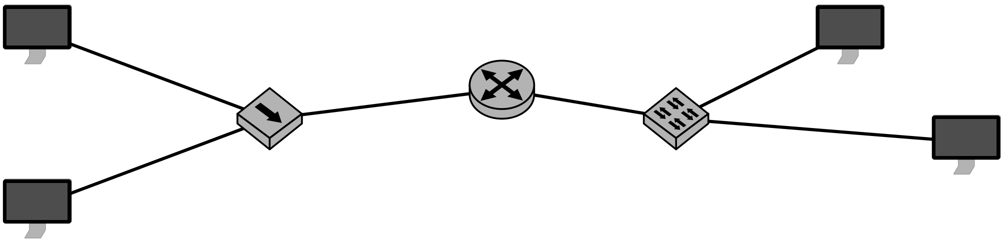


Figure 1.2: Network topology

f)* How many **collision** domains are contained?

☐ 1 ☐ 2 ☐ 3 ☒ 4 ☐ 5

g)* How many **broadcast** domains are contained?

☐ 1 ☒ 2 ☐ 3 ☐ 4 ☐ 5

Problem 2 Short Questions (22 credits)

The following problems can be solved independently of each other.

a)* A binary message source emits the string `001101101000`. Based on that message, Calculate the information content for the characters `0` and `1` and determine the entropy of the source.

$\Pr[X=0] = \frac{7}{12}$ and $\Pr[X=1] = \frac{5}{12}$

therefore $I(0) = -\log_2(\frac{7}{12}) = 0.78$ and $I(1) = -\log_2(\frac{5}{12}) = 1.26$

and finally $H(X) = -\log_2(\frac{7}{12})\frac{7}{12} - \log_2(\frac{5}{12})\frac{5}{12} = 0.98$

b)* Typically, we try to avoid redundancy. What is the purpose of adding redundancy on layer 1?

Purposefully added redundancy allows to detect and correct errors within a certain margin.

c)* An IPv6 packet carrying 1800 B of payload is sent over a link with an MTU of 1280 B. Calculate the size of the payload for each of the two fragments.

We have to subtract the IPv6 header and the IPv6 fragmentation header. Fragment 1: 1280 B − 40 B − 8 B = 1232 B
Fragment 2: 1800 B − 1232 B = 568 B

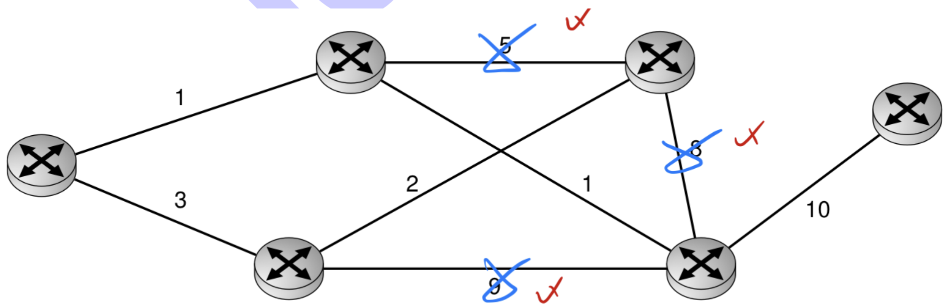
d)* How do split horizon, triggered updates, and path vector work, and how do they try to solve *count to infinity* occurring with distance vector protocols?

- Split Horizon: don't communicate routes back to the neighbor they were learned from. Does not work for topologies with loops.
- Triggered updates: send an update as soon as the routing table changes. Allows the process to terminate faster.
- Path vector: include a vector of hops for each route, thereby allowing to detect loops and evict the problem.

e)* Why is there a limit to the physical extent of an Ethernet connection? Assume that a minimum frame size is always enforced.

Edge case: The host with the largest physical distance from the transmitting host notices a collision and sends a jam signal. The jam signal has to be able to reach the transmitting host before it finishes to send the frame.

f)* Given the following topology with assigned link costs, cross out all links that would **not** be in use after a link-state routing protocol has fully converged. **Hint:** Choose and mark a specific root node!



g)* Convert `0xadfe1723` from big endian to network byte order.

`0xadfe1723` as network byte order is big endian.

h)* Why does the IPv6 header not require a header length field?

The IPv6 header is not of variable length as it has no options. It rather chains additional headers via the next header field.

i)* IEEE 802.11 data frames typically contain three layer 2 addresses. Depending on the direction of the frame, these three addresses have four different meanings. Briefly describe those four different meanings.

0 1 2

- source address: equivalent to 802.3 source
- destination address: equivalent to 802.3 destination
- transmitter address: station that is transmitting the frame within the wireless subsystem
- receiver address: next station to receive the frame within the wireless subsystem

j)* An interface has been assigned the address `10.42.28.6/20`. What is the IPv4 network and broadcast address for the network?

0 1 2

⇒ 10.42.0001|1100.6/20
⇒ Network address:10.42.0001|0000.0/20 = 10.42.16.0/20
⇒ Broadcast address:10.42.0001|1111.255/20 = 10.42.31.255/20

Zero points if approach not understandable.

k)* Show whether the networks of the addresses `192.168.12.1/24` and `192.168.12.2/24` can be combined into a `/23` network.

0 1 2

Network address for network 1: `192.168.12.0/24`
Network address for network 2: `192.168.12.0/24`
Therefore both addresses are in the same network
⇒ No, we cannot combine the networks as they are already the same network
for showing that the networks are the same.

l)* Generate the IPv6 link-local address for the interface with layer 2 address `04:7b:cb:b9:17:ac`. Give the address in its shortened form.

0 1 2 3

1. Flip the 7th bit: `06:7b:cb:b9:17:ac`
2. Add prefix and padding: `fe80::067b:cbff:feb9:17ac`
3. Shorten the address: `fe80::67b:cbff:feb9:17ac`

Problem 3 Packet Pair Probing (14 credits)

Let us assume the simplified network topology from Figure 3.1. Nodes 1 and 4 are connected to their routers via a full-duplex local network. All links are assumed to be full duplex and symmetric. The two distances d_{12} and d_{34} are negligibly small. The connection between routers 2 and 3 is significantly slower. It therefore holds that $r_{23} < r_{12}$ and $r_{23} < r_{34}$. The distance d_{23} is **not** to be neglected.

The transmission rate r_{23} is to be determined by Node 1 by generating as little load as possible on the already slow link. The method should work with all nodes that have a common IP stack.

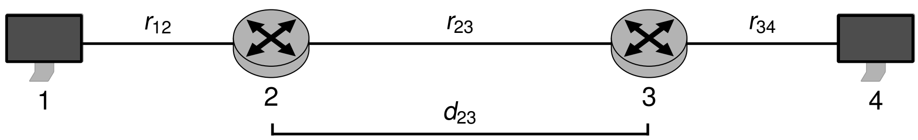


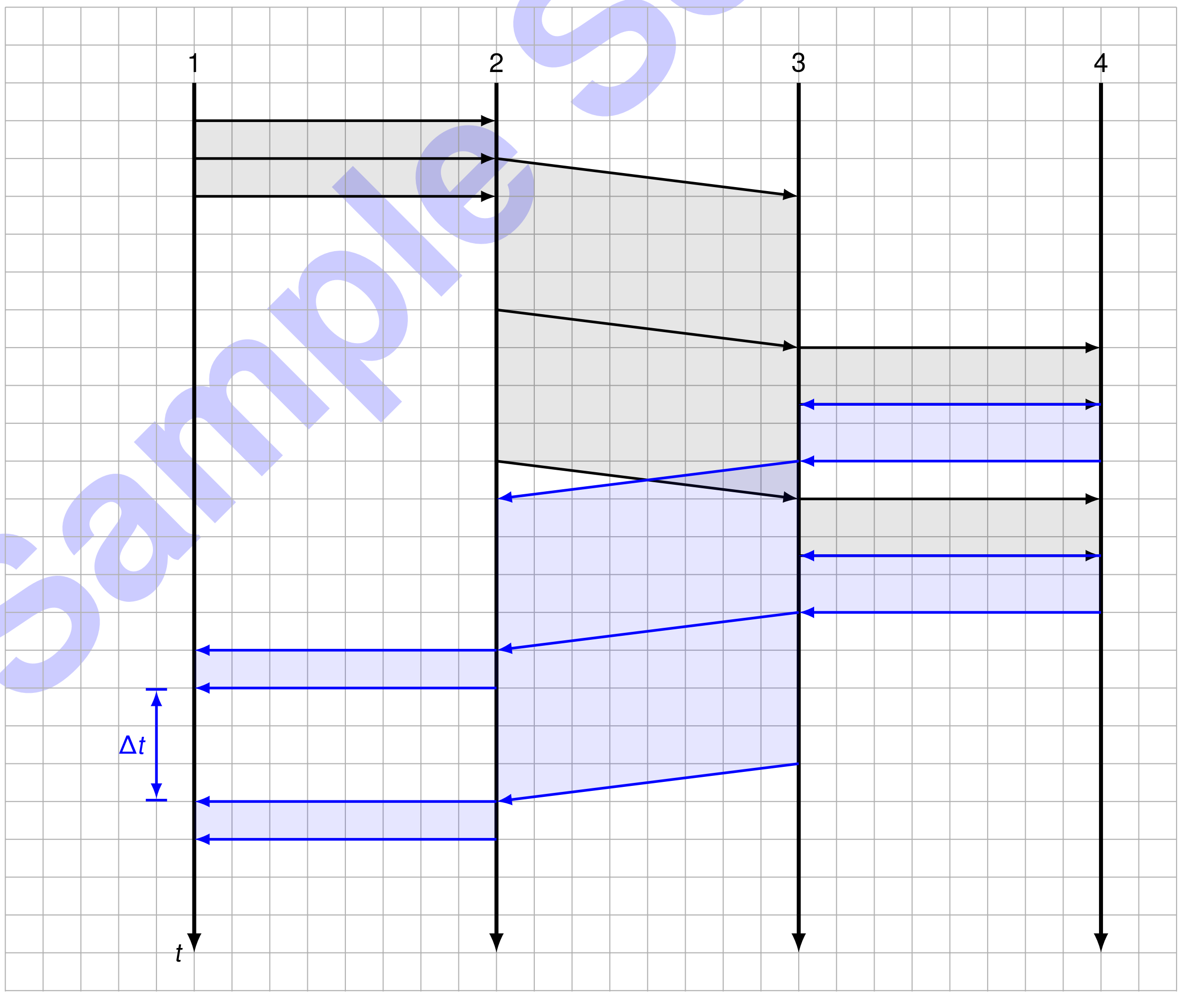
Figure 3.1: Simplified network topology

In this problem, we first derive a general method for node 1 to determine the transmission rate in question. Then we evaluate the method for concrete numerical values.

a)* How will node 4 react when it receives the ICMP echo requests from node 1?

It will respond with an ICMP echo reply of the same size for each request.

b)* Complete the path-time diagram shown in the solution box.



Due to the low transmission rate between nodes 2 and 3, a reception pause Δt occurs at node 1. This can be measured by node 1 and used to determine the "transmission rate between nodes 2 and 3.

c) Mark Δt in your solution of Subproblem b).

d) Describe in words the general influence of d_{23} on the reception pause Δt.

There is no influence since it is the same for both replies.

e) Describe in words the general influence of r_{34} on the reception pause Δt.

As long as r_{34} is larger than $r23$, thre is no idle period between the two packets between router 3 and 2 on the return path.

f) What condition must r_{34} thus satisfy exactly such that the procedure works?

$$r_{34} > r_{23}$$

g) Derive an expression for Δt. Simplify it as much as possible.

$$\Delta t = t_s(2,3) - t_s(1,2) = \frac{p}{r_{23}} - \frac{p}{r_{12}}$$

h) Derive an expression for the data rate r_{23} we are looking for. Simplify it as much as possible.

Solving the solution of Subproblem g) by r_{23} yields:

$$r_{23} = \frac{p}{\Delta t + \frac{p}{r_{12}}}$$

Repeated measurements of node 1 result in an average value $\overline{\Delta t} = 108\,\mu s$ with a packet size of $p = 1500\,B$. The transmission rate r_{12} is $1\,\text{Gbit/s}$.

i) Determine r_{23} in that case.

$$r_{23} = \frac{p}{\Delta t + \frac{p}{r_{12}}} = 100\,\text{Mbit/s}$$

Additional space for solutions–clearly mark the (sub)problem your answers are related to and strike out invalid solutions.