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Computer Networking and IT Security (INHN0012)

Tutorial 6

Problem 1 Media Access Control

a)* Briefly explain the principle of *ALOHA*.

A station transmits as soon as data is received.Transmissions are confirmed out-of-band (other frequency).

b) How collisions are detected in *ALOHA*?

Not directly, but via the lack of out-of-band confirmation.

c) Briefly explain the principle of ***Slotted*** *ALOHA*.

Station starts transmitting in the next time slot, regardless of whether a transmission is already taking place.

d) What is the advantage of *Slotted ALOHA* over normal *ALOHA*?

The division into time slots reduces the probability of collisions,as stations can no longer start a transmission at any time.
If the time slots correspond to the transmission duration of a complete message and the nodes are sufficiently synchronized with each other (which is possible with such long time slots), a collision either occurs at the beginning of a time slot or it is guaranteed that at most one station transmits. (see lecture)

e)* Briefly explain the principle of *CSMA*.

Medium is monitored before sending.If the medium is free in the current time slot,can start sending in the next one.

f) Briefly explain which additions *CSMA/**CD*** has compared to pure *CSMA*.

Collisions are detectedand affected frames are transferred again.

g) How are successful transmissions recognized for *CSMA/CD* with Ethernet?

A transmission is assumed to be successful if no collision was detected during the transmission or no JAM signal was received.

h) Briefly explain which additions *CSMA/**CA*** has compared to pure *CSMA*.

Collisions can generally not be detected.Instead, their probability of occurrence is reduced by randomizing the start of transmission.
(Contention window with a minimum size of several slot times)

i)* What is meant by *Binary Exponential Backoff*?

CSMA (both CD and CA) wait a random number of slot times after a collision or unsuccessful transmission.This number is drawn randomly and evenly from the backoff window. With each collision or unsuccessful transfer, this window is doubled (binary exponential) until a certain maximum value is reached.After a successful transfer, the window is reset.

Problem 2 Packet Pair Probing – Old Exam Problem

Packet Pair Probing is a method to determine the bandwidth of a link section by cleverly exploiting serialization and delay times. We will demonstrate this using the example network shown in Figure 2.1.
Nodes 1 and 4 are each connected to their routers via Ethernet with a data rate of 1 Gbit/s. However, the connection between routers 2 and 3 is significantly slower. This transmission rate r_{23} is to be determined by 1 and 4 by generating as little load as possible on the already slow connection.

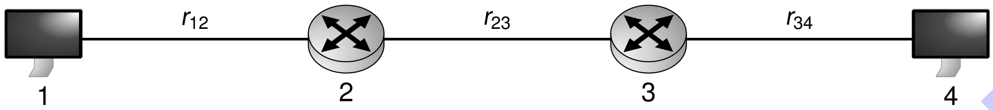


Figure 2.1: Network topology

In this task, we first derive a general procedure by means of which nodes 1 and 4 can determine the required transmission rate. We then evaluate the procedure for given numerical values and discuss possible problems that will occur in practice.

a)* Specify the serialization time $t_s(i, j)$ between two neighboring nodes i and j as a function of packet size p and transmission rate r_{ij}.

$$t_s(i, j) = \frac{p}{r_{ij}}$$

b)* Give the propagation delay $t_p(i, j)$ between two adjacent nodes i and j as a function of distance d_{ij}.

With the relative propagation velocity ν (which depends on the medium) and the speed of light c_0 we get:

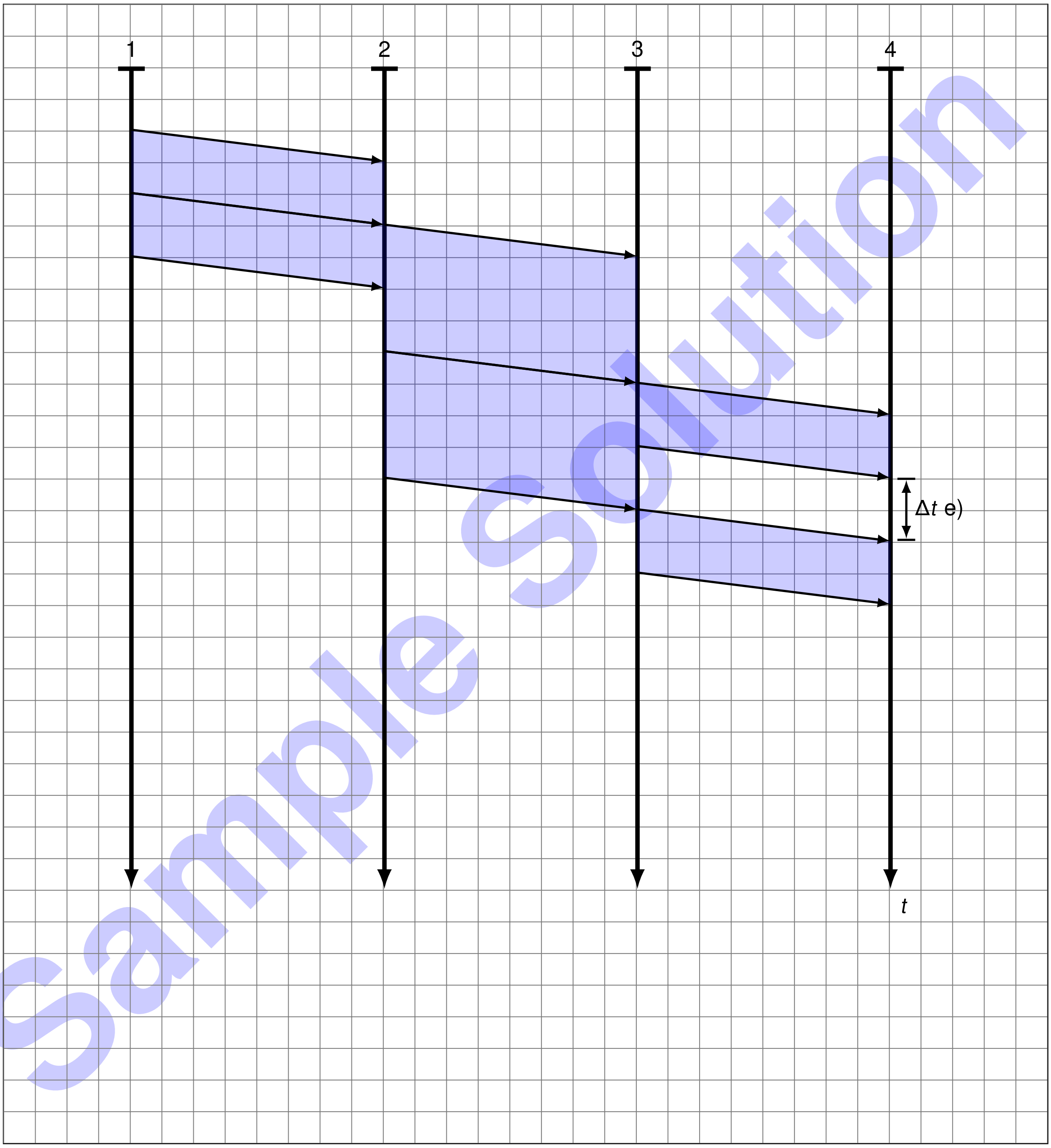
$$t_p(i, j) = \frac{d_{ij}}{\nu c_0}$$

c)* Briefly explain how 1 can determine the maximum MTU on the path to 4 when using IPv4.

1 sends a packet with the MTU_{12} of the local segment and sets the DF bit (do not fragment) in the IP header. If MTU_{12} is greater than MTU_{23}, 2 will drop the packet and return a corresponding ICMP message type 3 code 4 (Destination Unreachable Fragmentation Needed, DF set to 1). This message contains the maximum MTU_{23} for the section from 2 to 3.

1 now sends two packets of length p to 4 in immediate succession. You can assume that no other traffic will affect the transmission. Let the length p be such that no fragmentation is necessary. You can neglect any processing times at the nodes.

d) Draw a path-time diagram that correctly represents the transmission of the two packets qualitatively. In particular, consider $r_{23} < r_{12} = r_{34}$ as mentioned at the beginning.



Due to the low transmission rate between 2 and 3, a transmission pause Δt occurs at node 3 between the two forwarded packets. This can be measured by 4 and used to determine the transmission rate between 2 and 3.

e) Mark Δt in your solution of subtask d). On which factors does Δt depend?

Only of r_{23}, r_{34} and p, but not of the propagation delays.

f) Specify an expression for Δt. Simplify the expression as much as possible.

$$\Delta t = t_s(2,3) - t_s(3,4) = \frac{p}{r_{23}} - \frac{p}{r_{34}} \tag{2.1}$$

g) Give an expression for the data rate r_{23} you are looking for. Simplify the expression as much as possible.

Resolving (2.1) to r_{23} gives:

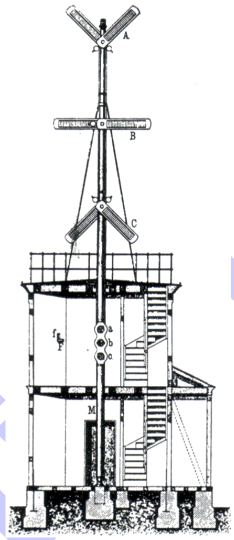
$$r_{23} = \frac{p}{\Delta t + \frac{p}{r_{34}}} \tag{2.2}$$

Repeated measurements on 4 give an average value of $\overline{\Delta t} = 1.2\,\text{ms}$ for a packet size of $p = 1500\,\text{B}$.

h) Determine r_{23} as a numerical value in Mbit/s.

$$r_{23} = \frac{p}{\overline{\Delta t} + \frac{p}{r_{34}}} = 9.90\,\text{Mbit/s} \tag{2.3}$$

Problem 3 Homework: Optical Telegraph – Old Exam Problem



In this task we consider optical telegraphs. The distance between two neighboring telegraph stations is 15 km. The mast of such a station (see adjacent figure) has three wings (indicators) on the left and right, each of which can take up four different positions (|, ╲, — and ╱).
A *symbol* is the configuration of all indicators.
To set a symbol, 10 s is required. The reading at the receiver takes place in parallel and therefore requires no additional time.

a)* How many bits can be transferred with each symbol?

Symbols: $4^6 = 4096$, Bits: $N = \log_2 4096 = 12$

b) Determine the data rate achieved in B/s.

$$r = \frac{N}{8 \cdot 10}\,\mathrm{B/s} = 0.15\,\mathrm{B/s}$$

c)* The available (gross) data rate is usually not fully used for user data. Name two other useful tasks that take up part of the data rate in common systems.

- Control Characters (Start of Frame, End of Frame)
- 4B5B Code: Clock recovery
- Error detection (checksum) / error correction
- Header information (addressing)
- Padding

A message of length 72 B is now to be transmitted.

d) Calculate the serialization time required for this message.

$$t_s = \frac{72\,\mathrm{B}}{r} = \frac{72\,\mathrm{B}}{0.15\,\mathrm{B/s}} = 480\,\mathrm{s}$$

e)* Calculate the propagation delay of this message between two stations. The reduction in the speed of light due to the air can be neglected here.

$$t_p = \frac{d}{vc} = \frac{15\,000\,\text{m}}{300\,000\,000\,\text{m/s}} = 0.05\,\text{ms}$$

We now consider a chain of a total of 4 telegraph stations, which are each 15 km apart. This message of length 72 B is now to be transmitted using packet switching. The protocol used on layer 2 can only transfer frames up to a size of 36 B.

f)* How many packets must the message be divided into if a header of 4 B must be added to each packet?

$$p_{max} = 36\,\text{B} - 4\,\text{B} = 32\,\text{B}$$

$$N = \left\lceil \frac{L}{p_{max}} \right\rceil = \left\lceil \frac{72\,\text{B}}{32\,\text{B}} \right\rceil = 3$$

g) Calculate the duration of a completely packet-based transmission of the message over the entire telegraph chain. Assume that the transmissions are always successful and therefore no confirmations are required.

$$T_{PV} = \frac{1}{r}\left(\left\lceil \frac{L}{p_{\text{max}}} \right\rceil \cdot L_h + L\right) + \frac{d}{\nu c} + n \cdot \frac{L_h + p_{\text{max}}}{r}$$

$$|\text{Number of intermediate stations}| = n = 2$$

$$T_{PV} = \frac{1}{0.15\,\text{B/s}}(3 \cdot 4 + 72) + \frac{45\,\text{km}}{c} + 2 \cdot \frac{4 + 32}{0.15\,\text{B/s}}$$

$$= 560\,\text{s} + 0.15\,\text{ms} + 480\,\text{s} \approx 1040\,\text{s}$$

h) How much does the duration deviate with continuous message switching? Assume that no header is used for message transfer.

Each station must receive the message in full before the message can be forwarded.

$$\text{Total distance} d = 3 \cdot 15\,\text{km} = 45\,\text{km}$$

$$T_{NV} = (n + 1) \cdot t_s + t_{p,gesamt}$$

$$= (2 + 1) \cdot 480\,\text{s} + 0.15\,\text{ms} = 1440\,\text{s}$$

A message switching would be approx. $1440\,\text{s} - 1040\,\text{s} = 400\,\text{s}$ slower.