Chair of Distributed Systems and Security
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Computer Networking and IT Security (INHN0012)

Tutorial 5

Problem 1 ALOHA

ALOHA (Hawaiian: „Hallo“) is one of the oldest media access methods and was developed in 1971 at the University of Hawaii to connect the Hawaiian Islands to a central switching station via a radio link. The two communication directions from the islands to the switching station and back were separated by frequency division duplex (FDD). Controlling media access was extremely simple: as soon as a transmitter received data, it was allowed to start transmitting. However, as no directional antennas were used and all transmitters on the islands used the same frequency, collisions could occur if two transmissions overlapped in time.

Two years later, slotted ALOHA was introduced, in which the transmitters were only allowed to start transmitting at the beginning of fixed time slots. The switching station transmitted a clock signal on the return channel for synchronization.

We now want to define our own strategy, which we call p-persistent Slotted ALOHA. If data is available, a station transmits with probability p in the next slot or delays the transmission by one slot with probability $1 - p$. The following initial situation is given:

- Initially, only some of the main islands are connected to the network, i. h. $n \leq 8$[1].
- All n users are saturated, i. e. there is always data to send.
- Each user starts sending with probability p in the next possible time slot.
- The duration of a send process corresponds to the length of a time slot.

a)* What is the probability that a collision-free transmission takes place in a time slot?

b) Determine p^* such that the probability of a collision-free transmission is maximized.

c) Now determine the maximum channel utilization for n users.

d) Now determine the maximum channel utilization for a very large number of users.
Hint: $\lim_{n\to\infty} \left(1 + \frac{x}{n}\right)^n = e^x$

[1] For large n (approx. $n > 15$) and small send probabilities, the Poisson distribution could also be used here

Problem 2 ALOHA and CSMA/CD

Let there be a network (see figure 2.1) consisting of three computers which are connected to each other via a hub. The distances between the computers are approximately $d_{12} = 1\,\text{km}$ and $d_{23} = 500\,\text{m}$. Any indirect cable routing may be neglected. The transmission rate shall be $r = 100\,\text{Mbit/s}$. The relative propagation speed is $\nu = 2/3$ as usual. The speed of light is given by $c_0 = 3 \cdot 10^8\,\text{m/s}$.

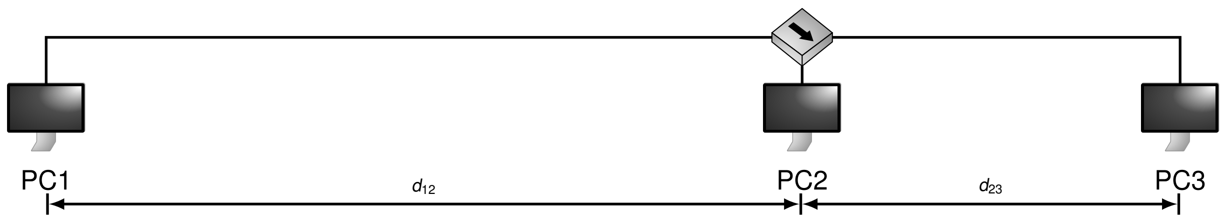


Figure 2.1

At time

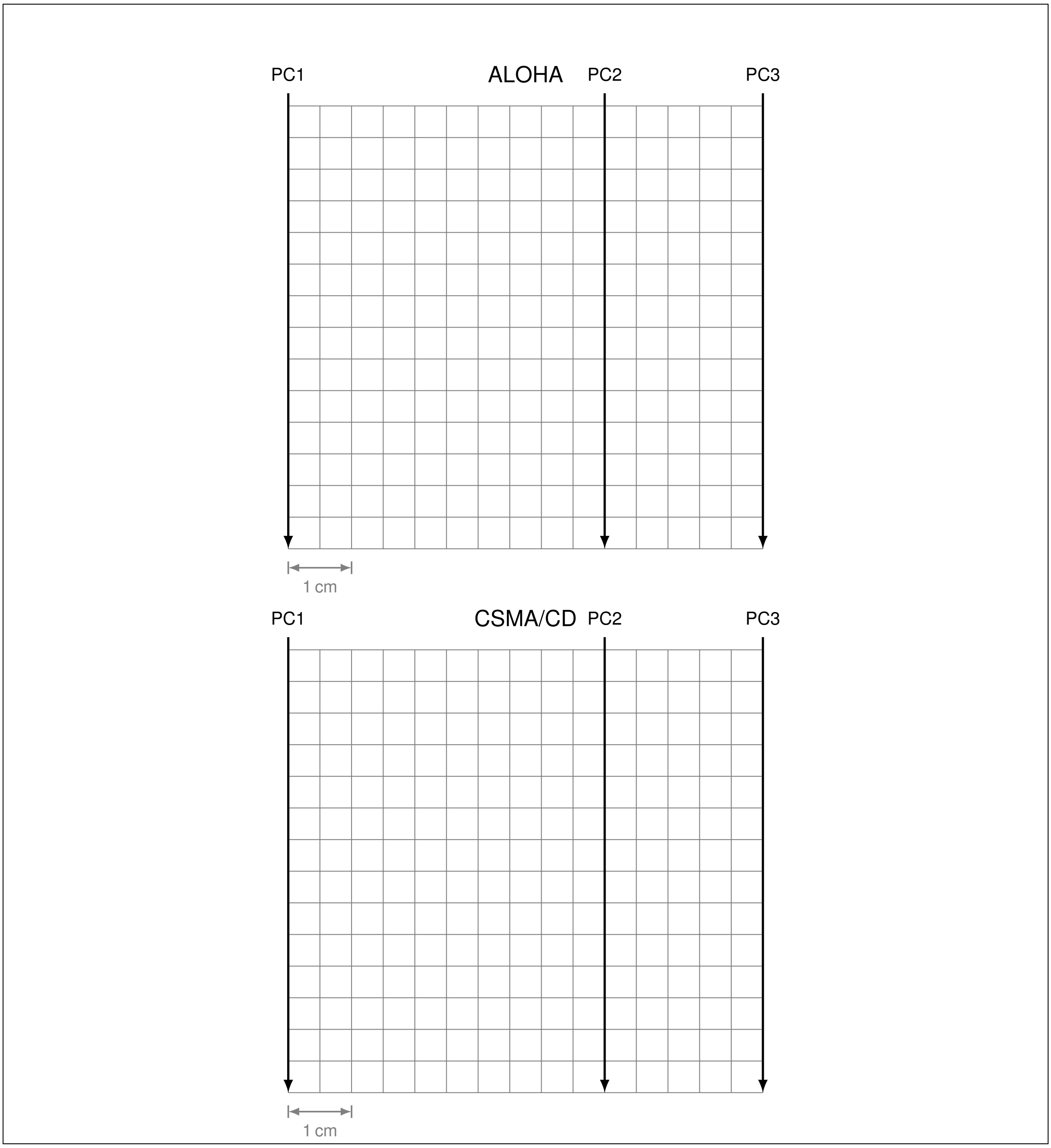
- $t_0 = 0\,\text{s}$ no transmission takes place and none of the computers has data to send,
- $t_1 = 5\,\mu\text{s}$ PC1 begins to send,
- $t_2 = 15\,\mu\text{s}$ PC2 begins to send and
- $t_3 = 10\,\mu\text{s}$ PC3 begins to send

to send a frame of length 94 B each.

a)* Calculate the serialisation time t_s for a message.

b)* Calculate the propagation delays $t_p(1,2)$ and $t_p(2,3)$ on the two sections.

c) For ALOHA and 1-persistent CSMA/CD respectively, draw a path-time diagram representing the transmission process in the time interval $t \in [t_0, t_0 + 30\,\mu\text{s})$. Scale: $100\,\text{m} \triangleq 5\,\text{mm}$ and $2.5\,\mu\text{s} \triangleq 5\,\text{mm}$, slot time: $\approx 5\,\mu\text{s}$



d) From the previous subtask it can be seen that collisions occur with both methods. In contrast to ALOHA, however, CSMA/CD does not work under the given circumstances. Why?

e) What is the condition for CSMA/CD that a node can detect a collision in time?

f) For CSMA/CD, calculate the maximum distance between two computers within a collision domain as a function of the minimum frame length. Insert the values for FastEthernet (r = 100 Mbit/s, l_{min} = 64 B).

Problem 3 Cyclic Redundancy Check (CRC)

The message `10101100` is secured using CRC as introduced in the lecture. The reduction polynomial $r(x) = x^3 + 1$ is given.

a)* What is the checksum length?

b) Determine the checksum for the given message.

c)* Specify the transmitted bit sequence.

The error pattern `00100000000` now occurs during the transfer.

d)* What is the received bit sequence?

e) Show that the transmission error is detected.

f)* Specify an error pattern that cannot be detected.

g) CRC was explicitly introduced in the lecture as an error-detecting, but not as an error-correcting code. Show that by means of CRC even 1 bit errors are not correctable in the concrete example of this task.