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Computer Networking and IT Security (INHN0012)

Tutorial 4

Problem 1 Transmission Channels

A new undersea cable has connected Japan and the USA since 2010. The cable runs from Chikura near Tokyo to Los Angeles in California (approx. 10 000 km) and consists of 8 fiber pairs (in each fiber pair, one fiber is used for one direction and the other fiber for the other direction). The transmission rate amounts to a total of 7.68 Tbit/s per direction.

As a simplifying assumption, we assume that the light only travels the path of the cable and that no signal impairments or delays occur due to signal amplifiers, connectors and the like. The relative propagation speed of light within an optical fiber (as well as in copper cables) is approximately $\nu = 2/3$ in relation to the speed of light in a vacuum $c_0 = 3 \cdot 10^8\,\mathrm{m/s}$.

a)* Determine the propagation delay from Chikura to Los Angeles within the cable.

b)* What does the *bandwidth delay product* mean?

c) Determine the bandwidth delay product.

Laying and maintaining a submarine cable is very complex. The connection between the two cities could also be made via satellite. Take a brief look at the two connection paths in relation to the round trip time (RTT[1]).

Assume that the submarine cable is in direct airline connection between Chikura and Los Angeles. In doing so, neglect the curvature of the earth. A geostationary satellite (36 000 km altitude) is located exactly above the center of the route.

d) Determine the minimum RTT for the submarine cable.
Note: Think about which component of the RTT makes the most significant contribution in this case.

e) Determine the minimum RTT for a corresponding satellite connection.
Note: Consider which sections of the route can be neglected if necessary. The curvature of the earth may be neglected.

[1] RTT is the time it takes for a message to travel from the sender to the recipient and back again

Problem 2 Media Access Control

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

b) How are collisions detected in *ALOHA*?

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

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

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

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

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

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

i)* What is the *Binary Exponential Backoff*?

Problem 3 ALOHA and CSMA/CD

Let there be a network (see figure 3.1) 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 as $c_0 = 3 \cdot 10^8\,\text{m/s}$.

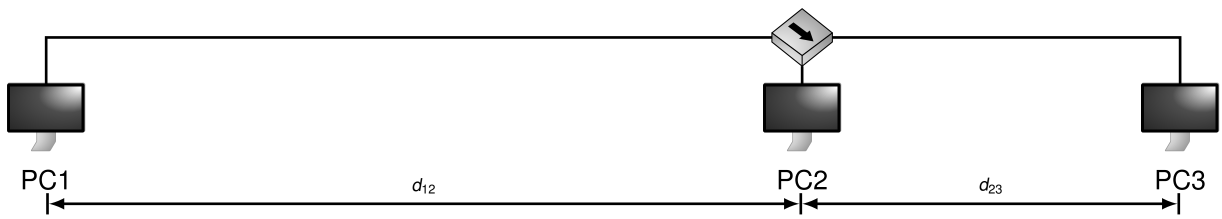


Figure 3.1

At time

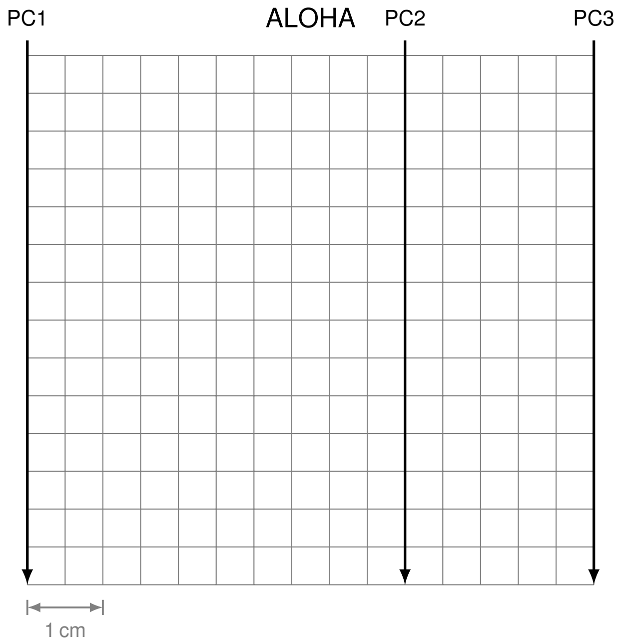
- $t_0 = 0\,\text{s}$ no transmission takes place and none of the computers have data to send,
- $t_1 = 5\,\mu\text{s}$ PC1 begins to send,
- $t_2 = 15\,\mu\text{s}$ PC2 begins to send and
- $t_3 = 10\,\mu\text{s}$ PC3 begins to send

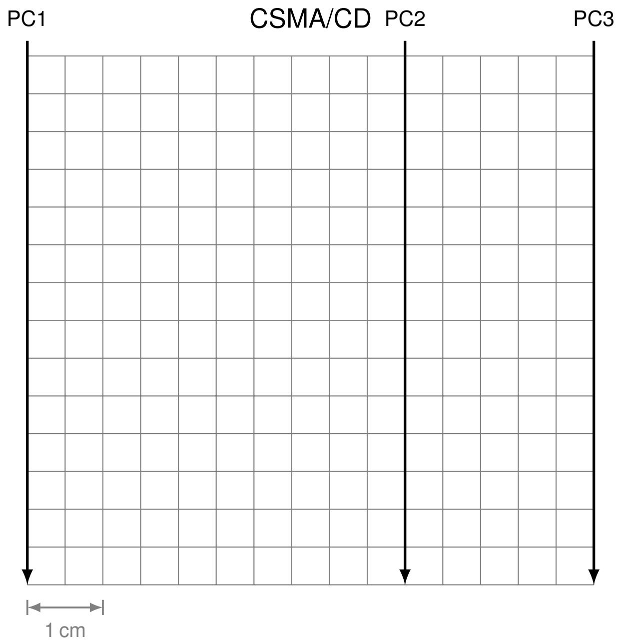
to send a frame of length 94 B each.

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 $t \in [t_0, t_0 + 30\,\mu s)$. Scale: $100\,m \triangleq 5\,mm$ and $2.5\,\mu s \triangleq 5\,mm$, slot time: $\approx 5\,\mu s$





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 ($r = 100\,\text{Mbit/s}$, $l_{min} = 64\,B$).

Problem 4 ALOHA (Homework)

ALOHA (Hawaiian: „Hello“) 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. $n \leq 8$[2].
- 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: $\lim_{n\to\infty} \left(1 + \frac{x}{n}\right)^n = e^x$

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