



Multimedia Systems

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Packet Switching

In a packet switching network, packets are buffered in each node they pass between their source and destination node, before they are transmitted to the next node (store-and-forward). A message (total length: $L = n \cdot k$) consists of n packets with a length of k bit. The transfer rate of the connection is v bit. There are z sections between source and destination node.

1. How long is the transmission time t for the complete message? (The transmission delay, the time needed to process the packets and the access delay can be ignored.)

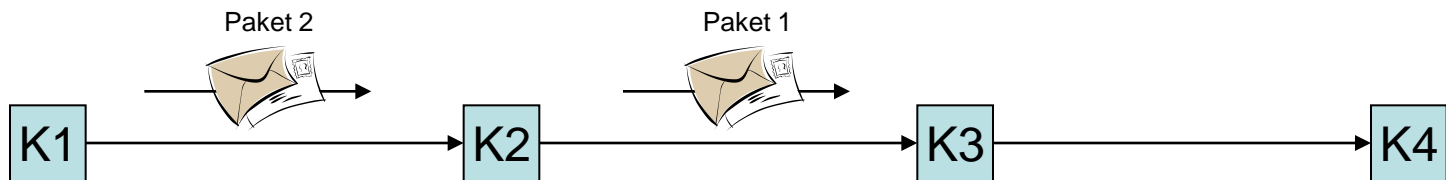


Exercise 4.1



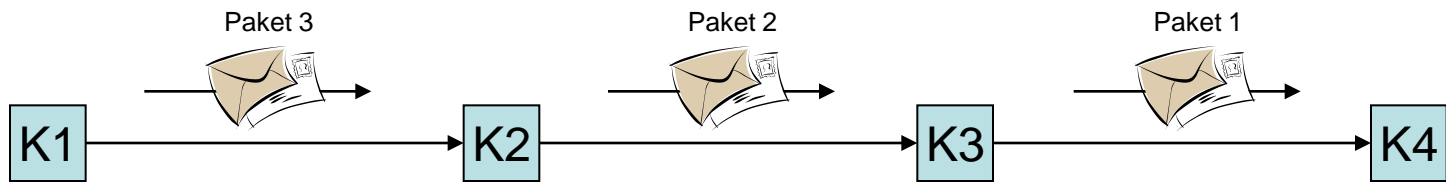


Exercise 4.1



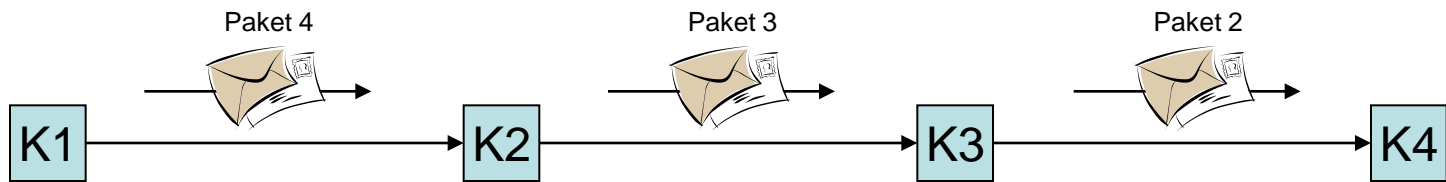


Exercise 4.1



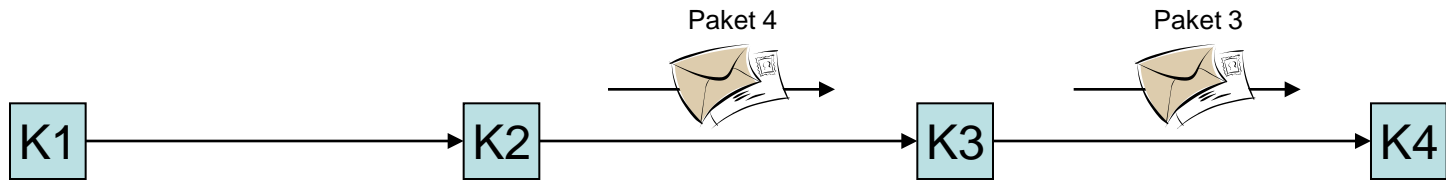


Exercise 4.1



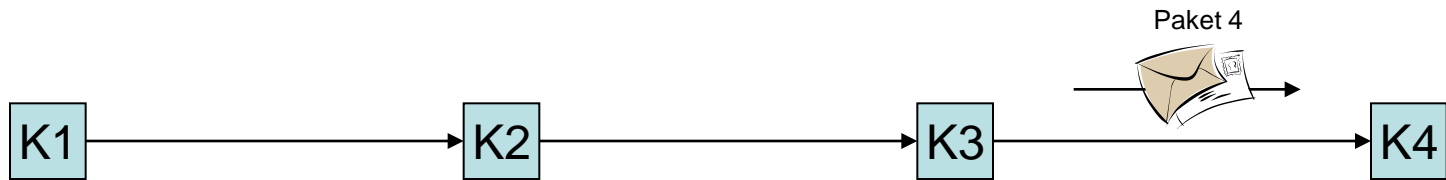


Exercise 4.1





Exercise 4.1



Exercise 4.1

1. How long is the transmission time t for the complete message? (The transmission delay, the time needed to process the packets and the access delay can be ignored.)

– n packets of size k , transmission rate t , z sections to pass

– Transmission of a packet over one section:

$$t_{1,1} = \frac{k}{v}$$

– Transmission of a packet over z sections:

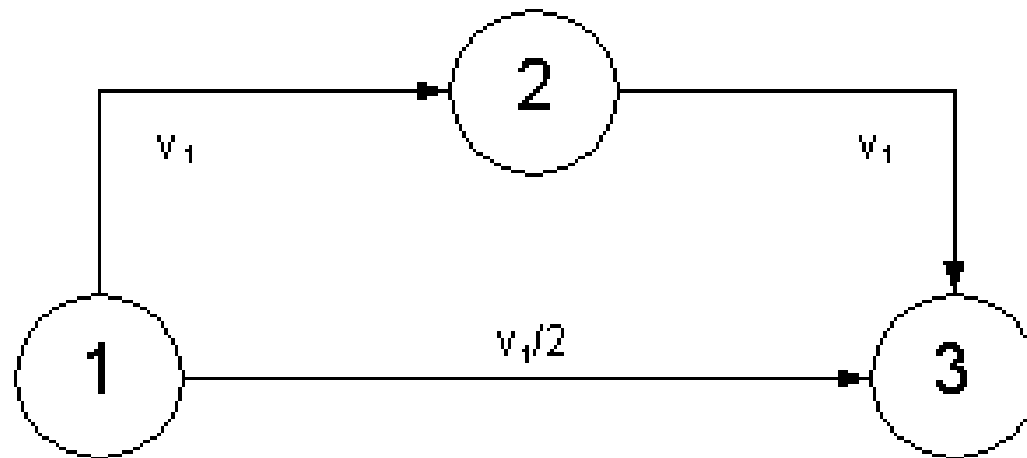
$$t_{1,z} = z * \frac{k}{v}$$

– Transmission of n packets over z sections:

$$t_{n,z} = (n + z - 1) * \frac{k}{v}$$

Exercise 4.2

- Given is the following network topology, which allows two paths for a transmission from node 1 to node 3. The direct path has a transfer rate of $v_2 = v_1/2$. Another path exists over an intermediate node 2, whereas both sections have a transfer rate of v_1 .



Exercise 4.2

- a) Compare the time needed for a transmission of a message between nodes 1 and 3
- i. over intermediate node (t_1)

$$t_1 = (n + 2 - 1) * \frac{k}{v_1} = (n + 1) * \frac{k}{v_1}$$

- ii. on the direct path (t_2)

$$t_2 = (n + 1 - 1) * \frac{k}{\frac{v_1}{2}} = (2 * n) * \frac{k}{v_1}$$

→ For $n > 1$ it is more effective to transmit the data over more, but faster, sections.



Exercise 4.2

b) What is more convenient for a given path: The transfer of a message in form of a few big packets, or in form of plenty small packets?

(Suppose there is no overhead for packet headers and the entire message is available for sending.)

- $L = n * k = const$

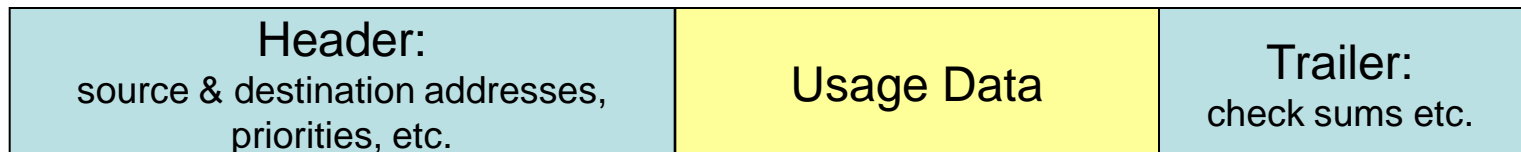
- $$t = (n + z - 1) * \frac{k}{v} = \left(\frac{L}{k} + z - 1\right) * \frac{k}{v} = \frac{L}{v} + \frac{(z - 1)}{v} * k$$

→ The transmission time decreases with a growing amount of packages. (Remember: The packet overhead is ignored.)



Exercise 4.3

2. Each packet (length k) has K bit usage data and O bits overhead for header and trailer. The smaller the packets are, the larger the ratio of the overhead will be.
 - a) What information is placed in headers, what information in trailers?
 - Header (early recognition for “cut-through”): addresses, priority information
 - Trailer (usage data sent/received): check sums
 - Today: most information in header



Exercise 4.3

- b) Calculate the optimal packet length to minimize the transmission time of the entire message considering the overhead O , the transfer rate v and the number of sections z .

We have: $t = (n + z - 1) * \frac{K + O}{v}$ $L = n * K = const$

Condition for minimum: $f'_{K}(t) = \frac{\partial t}{\partial K} = 0$ $f''_{K}(t) = \frac{\partial^2 t}{\partial K^2} > 0$

Calculation:

$$\frac{\partial t}{\partial K} = \frac{\partial \left[\left(\frac{L}{K} + z - 1 \right) * \left(\frac{K + O}{v} \right) \right]}{\partial K} = -\frac{L}{K^2} * \left(\frac{K + O}{v} \right) + \left(\frac{L}{K} + z - 1 \right) * \frac{1}{v} = -\frac{L}{vK} - \frac{LO}{vK^2} + \frac{L}{vK} + \frac{(z-1)}{v} = -\frac{LO}{vK^2} + \frac{(z-1)}{v}$$

$$\frac{\partial t}{\partial K} = -\frac{LO}{vK^2} + \frac{(z-1)}{v} = 0 \Leftrightarrow -LO + K^2(z-1) = 0 \Leftrightarrow K = \sqrt{\frac{LO}{z-1}}$$

$$\frac{\partial^2 t}{\partial K^2} = \frac{\partial \left[-\frac{LO}{vK^2} + \frac{(z-1)}{v} \right]}{\partial K} = 2 \frac{LO}{vK^3} > 0$$