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Advanced Information Systems
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2. Exercise Sheet: Time

Submission: 19.05.2011
Discussion: 19.05.2011

Submission Guidlines: We will discuss the solutions to the exercise sheet on 19.05.2011. If you want to have comments on your solutions you can submit them after the lesson.

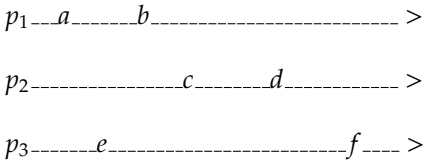
Exercise 1 (Network Time Protocol NTP)
A client attempts to synchronize with a time server. It records the round-trip times and timestamps returned by the server as given:

Round-trip in msec	Time (hr:min:sec)
22	10:54:23.674
25	10:54:25.450
20	10:54:28.342

a) Which of these times should it use to set its clock? To what time should it set it? Estimate the accuracy of the setting with respect to the server's clock.
b) If it is known that the time between sending and receiving a message in the system concerned is at least 8 ms, do your answers change?
c) Assume it is required to synchronize a file server's clock to within +/-1 millisecond. Discuss this in relation to Cristian's algorithm.

Exercise 2 (Lamport-Clock)
Show that for a Lamport-Clock and events e, e' it holds: $e \rightarrow e' \Rightarrow C(e) < C(e')$.

Exercise 3 (Lamport's and Mattern's algorithm)
Consider processes p_1, p_2, and p_3 with associated events $a, \ldots, f$ as shown in the figure:



Processes interchange messages m_1 and m_2, where $send(m_1) = b$ and $receive(m_1) = c$, respectively, $send(m_2) = d$ and $receive(m_2) = f$.

a) Which events are related by the happened-before relation and which are not, i.e. are concurrent?

b) Assume each process maintains a local logical clock. Assign to each event a timestamp according to Lamport's algorithm. Fill in the following table.

a	b	c	d	e	f

c) Assign to each event a vector timestamp according to Mattern's algorithm. Fill in the following table.

a	b	c	d	e	f

d) Consider three processes p, q, r with n, m, k events, respectively. Processes may interchange messages. Does there exist a sequence of events, such that when applying Mattern's algorithm, the following vector timestamps are derived? Give an example or explain why such a sequence does not exist.

$$\begin{pmatrix} n \\ m \\ 0 \end{pmatrix} \quad \text{and} \quad \begin{pmatrix} 0 \\ m \\ k \end{pmatrix}$$

Exercise 4 (Mattern's algorithm)
Assume logical time is based on Mattern's vector timestamps. During execution of a set of processes some events happen which imply the following set of vector timestamps:

$$\left\{ e_1 : \begin{pmatrix} 0 \\ 1 \\ 1 \end{pmatrix}, e_2 : \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix}, e_3 : \begin{pmatrix} 0 \\ 3 \\ 1 \end{pmatrix}, e_4 : \begin{pmatrix} 0 \\ 2 \\ 2 \end{pmatrix}, e_5 : \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix}, e_6 : \begin{pmatrix} 2 \\ 3 \\ 1 \end{pmatrix}, e_7 : \begin{pmatrix} 0 \\ 2 \\ 1 \end{pmatrix} \right\}$$

a) Which events are related by the happened-before relation and which are not, i.e. are concurrent?

b) Have there any messages been sent between the processes? Give the involved processes and the respective send- and receive-events.

c) Complete the following figure by assigning events e_1 ... e_7 and possible messages between processes. Physical time goes from left to right.

p_1----------->

p_2----------->

p_3----------->