Theory Exercise 8

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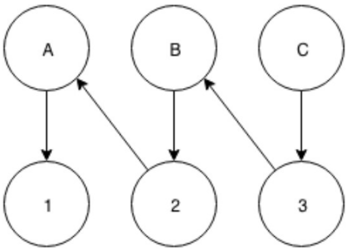
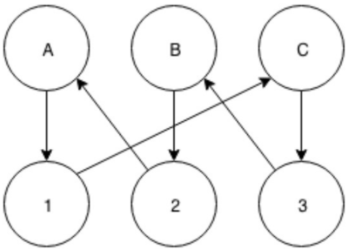
Task 1: Correctness in distributed Systems

Safety Property Safety properties describe predicates that are *always* true throughout computation in distributed systems. It can be paraphrased as trying to make sure that *bad things* cannot happen or that they are at least identified within a finite number of steps.

A typical example is deadlock freedom. This property ensures that there is always at least one process that can execute the next instruction. The following pictures shows three processes (1, 2, 3) and three resources (A, B, C). An arrow from a resource to a process does mean that this resource is assigned to the process. An arrow from a process to a resource does mean that the process requested the resource and it does wait for it. Even though 2 and 3 are blocked, 1 can execute, because it does not wait for a resource. The system is deadlock free and safety property is hold.



The next pictures shows a circular wait situation. 1 waits for C, 2 for A and 3 for B. There is no process in the system that can do any progress. The deadlock property is violated.



Liveness Property The liveness property guarantees the progress of a computation in a distributed system. However, it does not state *when* the computation terminates but rather guarantees the termination in a *finite number* of steps.

Task 2: Time synchronization using the algorithm by Christian

a) Which entry in the depicted table should C select to set its local clock?
In order to get the best accuracy, C should choose the second entry, with a round-trip time of 18ms.

b) How accurate is the time estimate of C in relation to S?
The time estimate of C (see next lines) has an accuracy of `±RTT/2 = ±18/2 = ±9ms` ,

c) Which time should C set to its local clock?
In order to set the local clock according to christians algorithm, the table is missing a column of when the packages were received, because the client needs to calculate the time that has past since the arrival of the response of S. Assuming that this time is given, the local time can be set by calculating the time-difference `td_i` , where i corresponds to the table entry (i = 1,2,3). The local clock can be set to the time that C received from S, increased by the time difference `td_2` and half of the duration of the RTT: `newtime = 15:38:36.580 + 0.009 + td_2 = 15:38:36.589 + td_2`

d) The transmission of a message between C and S takes at least 4ms (for each direction). How does this change the answers for a-c?

A minimum transmission delay of 4ms implies...:

- ... no change of the answer in a)
- ... a smaller error (=> higher accuracy): `accuracy = ±0.5 × (RTT - 2 × min_trans_delay) = ±0.5 × (18 - 8) = ±5ms`
- ... no change of the answer in c)

Task 3: Time synchronization using NTP

Note: We assume that the timestamps given in the task, correspond to the local time of server A and B respectively. Using the formula on the slides, this translates into the following values:

- T_{i-3} = 15.32.56.210
- T_{i-2} = 15.32.56.400
- T_{i-1} = 15.32.56.690
- T_i = 15.32.56.960

The estimated offset is given by $\mathbf{o_i}$ = 0.5 × (T_{i-2} - T_{i-3} + T_{i-1} - T_i) = 0.5 × (15.32.56.400 - 15.32.56.310 + 15.32.56.690 - 15.32.56.960) = 0.5 × (-180) = **-90ms**.

In order to calculate the accuracy (according to the true clock offset `o`), we need to first calculate the transmission delay d_i:
$\mathbf{d_i}$ = T_{i-2} - T_{i-3} + T_i - T_{i-1} = 15.32.56.400 - 15.32.56.210 + 15.32.56.960 - 15.32.56.690 = **460ms**.
The accuracy according to the real offset `o` is given by $o_i - d_i/2 \le o \le o_i + d_i/2$ ⇒ -90ms - 230ms ≤ o ≤ -90ms + 230ms ⇒
-320ms ≤ o ≤ 140ms