Introduction to Distributed Systems
WT 20/21

Assignment 4 – Part I

Submission Deadline: Monday, 25.01.2021, 10:00

- *Submit the solution in PDF via Ilias (only one solution per group).*
- *Respect the submission guidelines (see Ilias).*

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1 Global State [8 points]

Figure 1 shows a distributed system consisting of two processes P_1 and P_2. P_1 has the events e_1^1 through e_1^5 and P_2 has the events e_2^1 through e_2^3. Each event in P_1 and P_2 changes the value of local variables x_1 and x_2, respectively. Figure 2 depicts the corresponding lattice of global states for the distributed system shown in Figure 1.

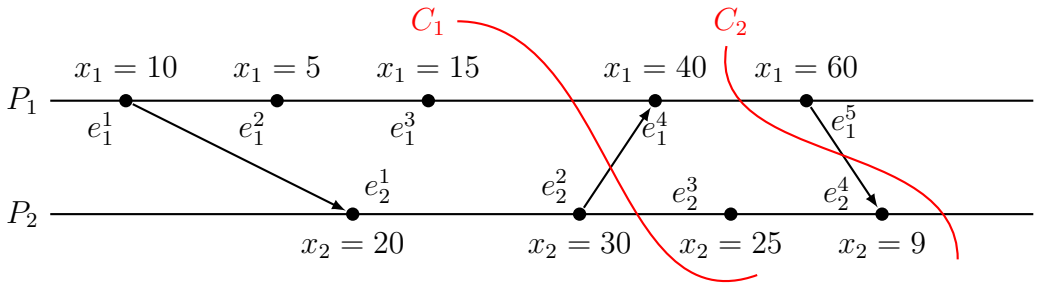

Figure 1: Distributed System with Processes P_1 and P_2

a) [2 points] C_1 and C_2 represent two cuts of the system history. Mention all events that belong to C_1 and C_2. Are C_1 and C_2 consistent cuts? Justify your answer.

b) [2 points] Complete Figure 2 by adding the values of local variables x1 and x2 for all states.

c) Consider the following two predicates,

- $\phi_1 = \left(x_1 - x_2\right) = 10$
- $\phi_2 = \left(x_2 + x_1\right) \geq 65$ *and* $\left(x_1 - x_2\right) < 50$

i. [2 points] Is the condition $\neg$ *possibly* ϕ_1 fulfilled? Justify.

ii. [2 points] Is the condition *definitely* ϕ_2 fulfilled? Justify.

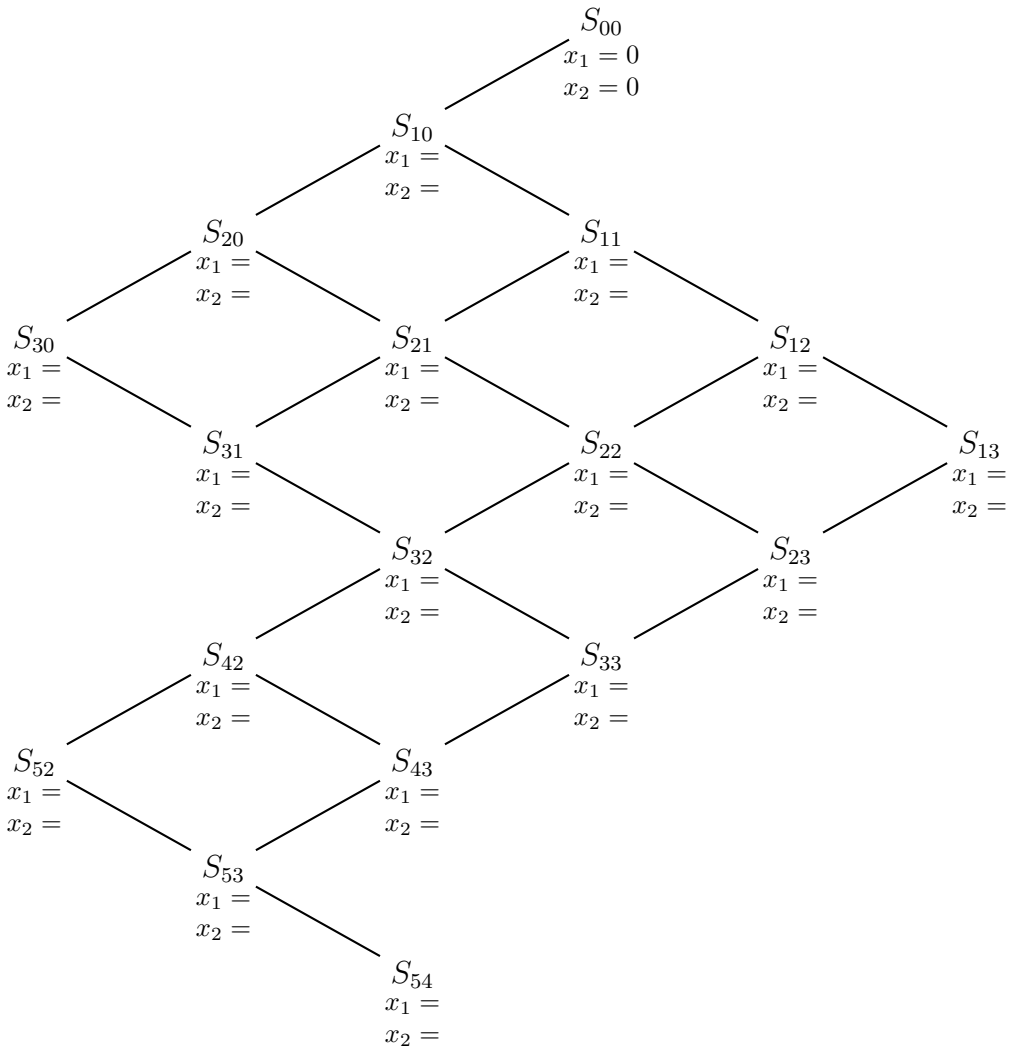

Figure 2: Lattice of global states

2 Transaction Processing [7 points]

a) [3 points] Assume three transactions T1, T2 and T3 as shown in Figure 3. Find all pairs of conflicting operations between these transactions.

$$r_1[y] \longrightarrow r_1[z] \longrightarrow r_1[u] \longrightarrow c_1$$

$$r_2[x] \longrightarrow r_2[z] \longrightarrow w_2[y] \longrightarrow c_2$$

$$r_3[x] \longrightarrow w_3[x] \longrightarrow r_3[y] \longrightarrow w_3[u] \longrightarrow c_3$$

Figure 3: Transactions T1, T2 and T3

b) [4 points] For each of the following histories (Figure 4 and Figure 5) construct a serialization graph and determine whether the history is serializeable.

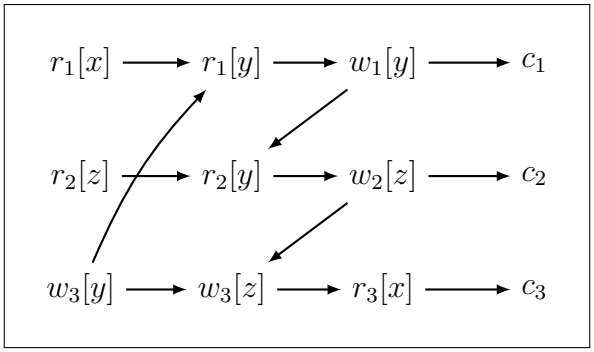

Figure 4: History H_1

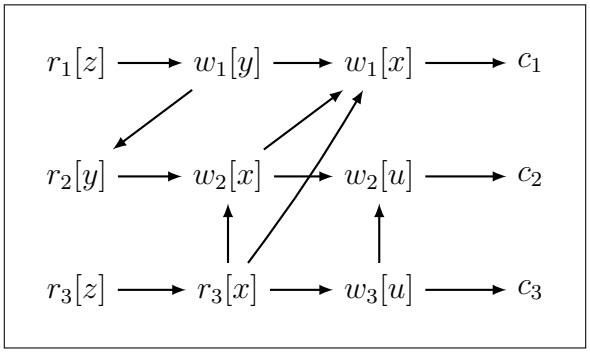

Figure 5: History H_2

3 Two-Phase Locking [6 points]

Figures 6 to 8 show the total order of operations that occurred during a concurrent execution of three transactions. Determine whether each of these executions could have been generated by 2-phase-locking. Assume that locks are requested as late as possible, i.e. on the first use of the respective variable. Justify your answer.

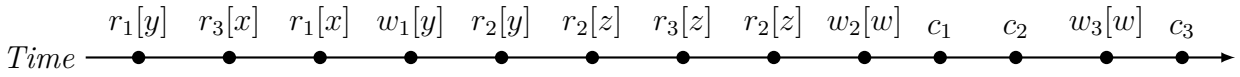

Figure 6: Execution of History H_1

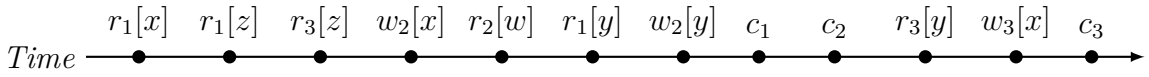

Figure 7: Execution of History H_2

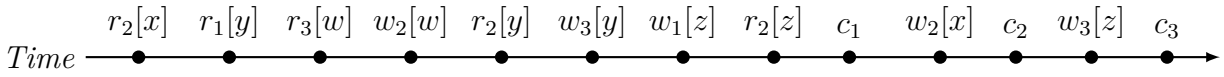

Figure 8: Execution of History H_3