4. Exercise sheet: Refresh Concurrency Control and Recovery

Exercise 1
Consider the following schedules.

\[ S_1: R_3 X R_2 Y W_2 Y R_1 Y W_1 Y R_2 X W_2 X R_1 X W_1 X W_3 Z. \]
\[ S_2: R_1 X R_2 Y W_2 Y R_1 Y W_1 Y R_2 X W_2 X R_1 X W_1 X W_3 Y. \]
\[ S_3: R_1 Y W_1 Y R_2 Y W_2 Y R_2 X W_2 X R_1 Z W_3 X R_1 X W_1 X. \]

For each schedule give its conflict graph. Which schedules are serializable, which are not?

Exercise 2
Assume on a database three transactions are being executed.

a) The transactions are of the form:
\[ T_1 : RA \ W A \]
\[ T_2 : RA \ W A \]
\[ T_3 : RA \ W A \]

(i) How many serial schedules do exist for \( T_1, T_2, T_3 \)? Give the reasons!

(ii) How many serializable schedules do exist for \( T_1, T_2, T_3 \), which are not serial ones? Give the reasons!

b) The transactions are of the form:
\[ T_1 : RA \ W C \]
\[ T_2 : RB \ W A \]
\[ T_3 : RC \ W D \]

(i) How many schedules do exist for \( T_1, T_2, T_3 \), which are not serializable? Give the reasons!

(ii) Applying 2-phase-locking, is it possible that all serializable schedules of \( T_1, T_2, T_3 \) may occur? Give the reasons!

Exercise 3
Consider the schedule \( S \):
\[ T_1 : \quad R(X) \quad W(Y) \]
\[ T_2 : \quad R(Y) \quad W(Y) \]
\[ T_3 : \quad R(Z) \quad W(Y) \]

(a) Demonstrate that \( S \) is not (conflict-) serializable.

(b) We call two schedules equivalent, whenever (i) they are built out of the same transactions, (ii) in both schedules the transactions read the same values, and (iii) both schedules produce the same final state of the database. Demonstrate that the serial schedule \( T_1 T_3 T_2 \) and schedule \( S \) are equivalent.
Exercise 4
(a) Give an example of three transactions, which obey 2PL and have the following properties: (i) When being executed a deadlock may occur. (ii) For each pair of the three transactions and for any execution of such a pair, no deadlock can occur.
(b) Make suggestions for deadlock-free variants of the 2PL-protocol.

Exercise 5
Assume the granularity of objects used by a concurrency control are tuples and and the granularity of objects used by a recovery component are pages. Describe a scenario in which the restart algorithm will produce a state in the database which contradicts serializability of the corresponding transactions.

Exercise 6
Consider the following schedule.

<table>
<thead>
<tr>
<th></th>
<th>LA</th>
<th>RA</th>
<th>WA</th>
<th>System-failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Assume that actions $W_1A, W_2B$ are not materialized in the database, however action $W_3$ is.

(i) Give the state of the database, the systembuffer and the log file when the system failure occurs.
(ii) Describe the operations done when executing the restart algorithm and give the resulting state of the database.