The deadline to upload your solution to iCorsi is on the 22 of May, at 23:59. Late submission policy will apply; see the Intro slides for details. Upload a PDF file with your solutions. Write your name on the PDF and name the file using the "HW6_FirstName_LastName" convention.

Description

This homework will give you experience in database transaction processing. Refer to the lecture slides "Transaction processing recovery" and "Transaction processing concurrency".
The text in the solution **must not be handwritten** (e.g., you can use Word, LaTeX). Diagrams or small examples **can** be handwritten, photographed and pasted into the document. Consider also using drawing tools (e.g. diagram.net, LibreOffice draw).

Exercises

Make suitable assumptions where necessary and state them explicitly in your answers.

A. Transaction crash recovery
A database system uses the write-ahead-log protocol to manage recovery.

1. To remind you, if a log contains a tuple "T1, a,0,1", this means that transaction T1 read the value of a as 0 and wrote the value of a as 1. Assume that the log of the system is as follows after the system crashes:

```
T1 starts
T1, a, 1, 12
T1, b, -1, 0
T1 commits
T2 starts
T3 starts
T2, c, 2, 3
system checkpoints
T2, a, 12, 4
T3, b, 0, 15
T2 commits
T4 starts
T4, b, 15, 3
system checkpoints
T4, b, 3, -1
T4 commits
T5 starts
T5 a, 4, 1
T6 start
T5 b, 3, 9
```

   (a) Which transactions need to be redone?

   (b) Which transactions need to be undone?

   (c) Which transactions are not affected by the failure?

   Note: For each item, explain your reasons.

2. Given the database initially contains 3 items: a = b = c = 0. The system crashed. After examining the log, you see that it is the sequence of the following tuples:

```
T1, started
T1, a,0,1
T1, b,0,1
T2, started
T3, started
T1, committed
T2, b,1,2
system checkpoints
T2, a,1,2
T2, committed
T3, b,2,3
T3, c,0,1
T4, started
```

   (a) You now proceed to look at the database itself (on the disk). What are all the possible values of the items a, b, c on the database disk?

   (b) The database recovers. What will be the values of a, b, c on the database disk?

B. Properties of transaction history

1. Explain the following properties for the database history (schedule):

   (a) Recoverable

   (b) Cascadeless (no cascading aborts)

   (c) Strict

2. For the both following schedules, identify whether they are **recoverable, cascadeless (no cascading aborts) and strict**. Add a short motivation for each property.

   (a)
```
T5: Read x;
T1: Read x;
T2: Write x;
T1: Read y;
T3: Read y;
T3: Write z;
T4: Read x;
T3: Commits;
T4: Write y;
T5: Read z;
T5: Write z;
T5: Commits;
```

   (b)
```
T2: Read a;
T1: Read a;
T2: Write b;
T1: Write b;
T1: Write c;
```

```
T2: Write c;
T2: Commits;
T3: Read a;
T3: Commits:
T4: Read b;
T4: Write c;
T4: Write d;
T4: Commits:
T5: Write e;
```

C. Serializability of concurrent transactions

Produce a conflict graph for both of the schedules above. From the graph, determinate if the schedule (S) is serializable or not. Show an example that backs up your answer by moving around transaction executions in the schedule: for serializable schedule show the serial equivalent, else show a sequnce that breaks serializability. Serial schedules can be represented as [T1, T2, T3], [T2, T1, T3], etc., instead of having to specify all operations in each of the transaction.