Frontpage

Department of Computer Science

Examination paper for
TDT4225 Very Large, Distributed Data Volumes

Examination date: 9 Dec 2020
Examination time (from-to): 09.00-13.00 (9am - 1pm)
Permitted examination support material: A / All support material is allowed
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OTHER INFORMATION

In this exam you are allowed to answer in Norwegian: bokmål eller nynorsk da sensor forstår norsk.

Make your own assumptions: If a question is unclear/vague, make your own assumptions and specify them in your answer. Only contact academic contact in case of errors or insufficiencies in the question set.

Saving: Answers written in Inspera Assessment are automatically saved every 15 seconds. If you are working in another program remember to save your answer regularly.

Cheating/Plagiarism: The exam is an individual, independent work. Examination aids are permitted, but make sure you follow any instructions regarding citations. If you copy text from the Internet or books, please show the citation to this. During the exam it is not permitted to communicate with others about the exam questions, or distribute drafts for solutions. Such communication is regarded as cheating. All submitted answers will be subject to plagiarism control. *Read more about cheating and plagiarism here.*

Notifications: If there is a need to send a message to the candidates during the exam (e.g. if there is an error in the question set), this will be done by sending a notification in Inspera. A dialogue box will appear. You can re-read the notification by clicking the bell icon in the top right-hand corner of the screen. All candidates will also receive an SMS to ensure that nobody misses out on important information. Please keep your phone available during the exam.

Weighting: The questions are weighted in their headings.

ABOUT SUBMISSION

There are no questions which need file upload in this exam.

Your answer will be submitted automatically when the examination time expires and the test closes, if you have answered at least one question. This will happen even if you do not click “Submit and return to dashboard” on the last page of the question set. You can reopen and edit your answer as long as the test is open. If no questions are answered by the time the examination time expires, your answer will not be submitted.

Withdrawing from the exam: If you become ill, or wish to submit a blank test/withdraw from the exam for another reason, go to the menu in the top right-hand corner and click “Submit blank”. This cannot be undone, even if the test is still open.

Accessing your answer post-submission: You will find your answer in Archive when the examination time has expired.

1

Problem 1 (15 %)

SQL model vs. document model (15 %)

We have a tracking database where we should store users' gps tracks visiting tourist sites. Thus, we have the enitities Users, Activities and Trackpoints which store where users have been doing visits during their activities. In addition to this, we would like to know which trackpoints are at a *tourist site*, which is a separate entity in the database. Thus, when a trackpoint is as close as 100 meters from a tourist site, we would like to store a connection between the tourist site and the activity of the user.

Thus, the queries we would like issue is who and when did the users visit certain tourist sites. By storing attributes of the different tourist sites, we would like to know which users are likely to visit certain sites. **You should not show the queries in this task.**

a)

Show how you will store this information using SQL tables. Include all entities and their connections: User, Activity, Trackpoint and TouristSite. Assume reasonable attributes of the tables.

b)

Also show how this would be stored using a document model (e.g. MongoDB). You don't need to draw anything here, text is enough.

c)

What are the problems with using the document model for this example?

Please describe any assumptions you make.

Fill in your answer here

Format

Words: 0

Maximum marks: 15

2 Problem 2 (5 %)

Column compression (5 %)

You have the following values for a column:

73 73 87 87 87 63 63 63 31 34 34 34 34 88 88 31 33

a) Create a bitmap for the values.

b) Create a runlength encoding for the values

Fill in your answer here

Format | B I U x_2 x^2 I_x | Ω | ∑ | ABC

Words: 0

Maximum marks: 5

3 Problem 3 (15 %)

Replication (15 %)

a)

Describe what happens when a new, extra replica is created while the databases is online and is in use by concurrent operations.

b)

How could “happens-before” be captured and used in leaderless replication?

c)

Describe how quorums work in replicated systems when doing reads and writes of data.

Fill in your answer here

Format

Words: 0

Maximum marks: 15

4 Problem 4 (5 %)

Coordination of services (5 %)

How should you support coordination of services, so that every participant in the network agrees on which other services are available?

Fill in your answer here

Format

Words: 0

Maximum marks: 5

5

Problem 5 (10 %)

Problems in concurrency control (10 %)

There are several different problem situations which are listed with respect to concurrency control in the curriculum:

1) dirty read
2) dirty write
3) lost update
4) read skew (nonrepeatable read)
5) lost update
6) write skew
7) phantom reads

Which of those problems do you see in the following examples:

a) Two transactions reading and setting two variabels where at least one should be true: r1(A=true); r1(B=true); r2(A=true); r2(B=true); w1(A=false); w2(B=false); c1; c2;

b) w1(A=2); r2(A); c1; w2(A=3); c2;

c) r1(A=8); r2(A=8); w1(A=9); w2(A=9); c1; c2;

d) w1(A=2); w2(A=3); w2(B=3); w1(B=2); c1; c2;

Explain your answers.

Fill in your answer here

Format

Words: 0

Maximum marks: 10

6 # Problem 6 (10 %)

Read committed vs. snapshot isolation (10 %)

We want to compare *read committed* with *snapshot isolation*. We assume the traditional way of implementing read committed, where write locks are held to the end of the transaction, while read locks are set and released when doing the read itself. Show how the following schedule is executed using these two approaches:

r1(A); r1(B); w2(A); r2(B); w2(B); r1(B); c1; c2;

a) Read-commited

b) Snapshot isolation

Fill in your answer here

Format

Words: 0

Maximum marks: 10

7

Problem 7 (10 %)

Causality vs. linearizability (10 %)

a)

What is the difference between causality and linearizability in distributed systems?

b)

Give some examples of applications which would need linearizability.

Fill in your answer here

Format | B I U x_2 x^2 I_x | ABC | Words: 0

Maximum marks: 10

8

Problem 8 (10 %)

Lsm trees (10 %)

a)

How does the compaction process function in RocksDB / LevelDB.

b)

One of the problems of LSM trees is read and write activity from the compaction process which interacts / disturbs the lookup activities of the LSM trees. How could this problem be solved / releaved?

Fill in your answer here

Format | B I U x_2 x^2 I_x | Ω | ∑ | ABC

Words: 0

Maximum marks: 10

9 Problem 9 (5 %)

Dynamo (5 %)

How does Dynamo handle the problem that some nodes may be temporarily unavailable?

Fill in your answer here

Format

Words: 0

Maximum marks: 5

10

Problem 10 (5 %)

Timing in distributed systems (5 %)

Should we use physical clocks for synchronization in distributed systems? Why or why not?

Fill in your answer here

Format

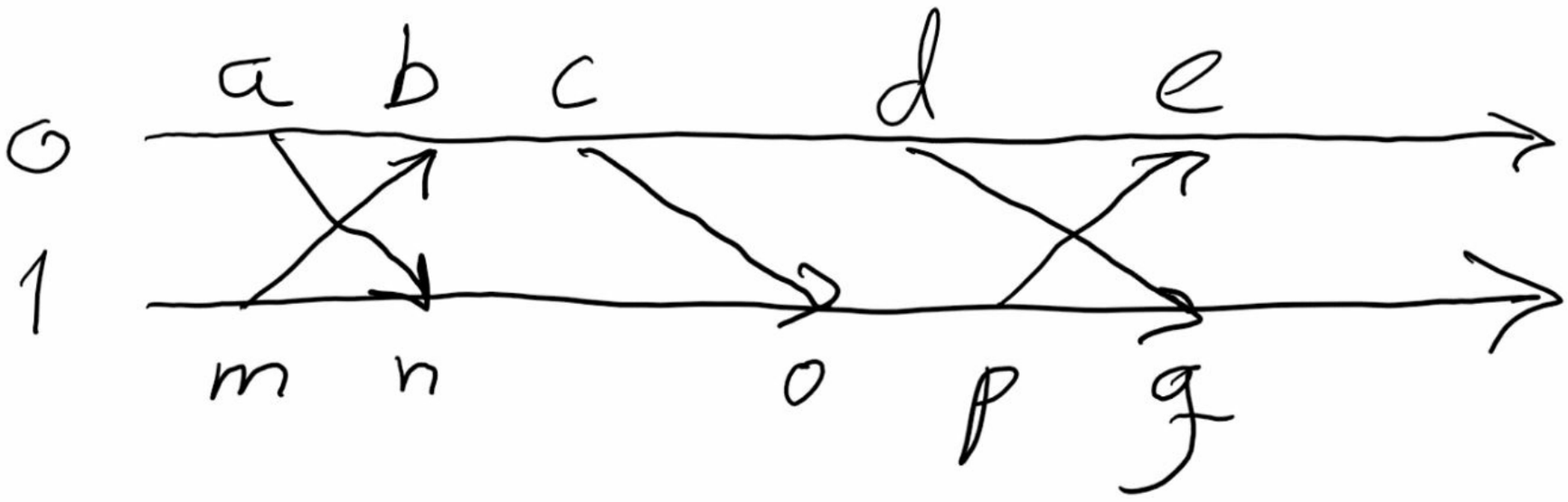
Words: 0

Maximum marks: 5

11 Problem 11 (5 %)

Events in distributed systems (5 %)

The figure below shows two distributed processes, 0 and 1, which exchange messages.
There are 10 events in this system, numbered **a-e** and **m-q**. Which pairs of events are “concurrent” in the sense that they are not involved in a “happens before” relation?



Fill in your answer here

Format

Words: 0

Maximum marks: 5

12

Problem 12 (5 %)

Multi-leader replication (5 %)

We have a company residing in multiple geographical regions. This company decides to have a multi-leader replicated database. Describe how this could be feasible even if a multi-leader database may have conflicts with respect to updates.

Fill in your answer here

Format | B I U x_2 x^2 I_x | ABC

Words: 0

Maximum marks: 5