Victoria University of Wellington

DEGREE EXAMINATIONS — 1996

COMP 302

(MID-YEAR)

COMP 302

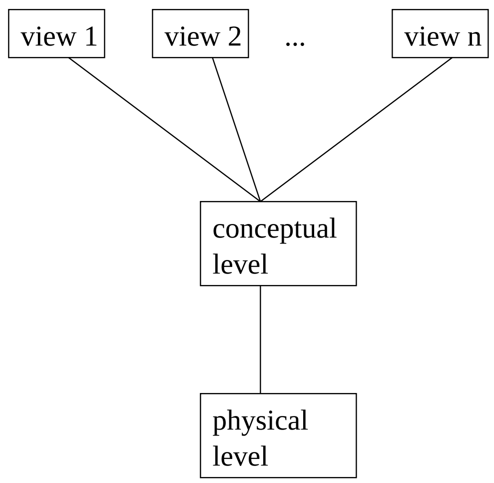
Database Systems

Time Allowed: 3 hours.

Instructions: Answer all questions.
Make sure your answers are clear and to the point.
No reference material is allowed.
There are 180 possible marks on the exam.

1. **Basic concepts**

   (a) The three schema architecture has been proposed to help describe important characteristics of the database approach. Using the diagram below, in half a page, discuss the characteristics that are evident in this architecture.



The three-schema architecture

[8 marks]

 continued...

(b) An entity type that has a primary key is termed a strong entity type. Every weak entity type can be converted to a strong entity type by simply adding appropriate attributes.

i. Use an ER diagram to give an example of a weak entity type.

[3 marks]

ii. Use an ER diagram to give an example of a strong entity type.

[3 marks]

iii. Why do we have weak entity types?

[2 marks]

iv. What structural constraints exist on a relationship between a strong entity type and a weak entity type?

[4 marks]

v. Illustrate how the relationship between a weak entity and a strong entity can be modelled in the relational model.

[4 marks]

vi. Illustrate how the relationship between a weak entity and a strong entity can be modelled in the object-oriented model.

[4 marks]

(c) i. Give 3 meanings for the **NULL** value as it is used in databases.

[3 marks]

ii. Give an example of each meaning.

[3 marks]

iii. Why should one avoid using the **NULL** value in a database?

[2 marks]

2. **Relational model**
Consider the following relations:

Student

Name	Id	Address	Major	Date_of_birth
Plato	123456789	111 First St.	Philosophy	26/6/71
Shakespeare	789789789	222 Second St.	English	2/20/73
Dunn	987654321	333 Third St.	English	28/10/73
Newton	123123123	444 Fourth St.	Physics	3/3/77
Williams	111111111	123 First St.	English	2/10/74
Archimedes	222222222	100 Broad St.	Physics	6/15/76
Browning	333333333	10 Main St.	English	25/7/74
Bolger	444444444	333 Main St.	Political Science	2/9/74

Sport

S_Id	Name	Position
789789789	Netball	centre
123456789	Squash	NULL
222222222	Rugby	fullback
789789789	Baseball	shortstop

Student_Course

S_Id	C_Id
123456789	PHIL 104
123456789	PHIL 105
789789789	ENGL 208
789789789	ENGL 209
789789789	ENGL 210
789789789	ENGL 214
111111111	ENGL 223
111111111	ENGL 224
111111111	ENGL 245
333333333	ENGL 308

For each of the following SQL clauses: [12 marks for each clause]

i. Explain in English what the clause does.
[1 mark]

ii. Write an equivalent clause in relational algebra.
[3 marks]

iii. Write an equivalent clause in domain relational calculus.
[3 marks]

iv. Write an equivalent clause in tuple relational calculus.
[2 marks]

v. Draw the resulting relation.
[3 marks]

The SQL queries are:

(a) **select** S.Id, S.Name, U.C_Id, T.Name
from Student S, Sport T, Student_Course U
where (S.Id = U.S_Id) **and** (S.Id = T.S_Id)

(b) **select** S.Name
from Student S
where exists (**select** *
from Sport T
where S.Id = T.Id **and** T.Name = "Squash")

(c) **select** S.Name
from Student S
where not exists ((**select** U.Id
from Student_Course U)
minus (**select** T.Id
from Sport T
where T.Name = "Squash"))

3. **Normalisation**

(a) Suppose we decompose the scheme $R = (A, B, C, D, E)$ into:
(A,B,C)
(A,D,E).
Show that this is a lossless join decomposition if the following set F of functional dependencies hold:
$A \rightarrow BC$
$CD \rightarrow E$
$B \rightarrow D$
$E \rightarrow A$

[8 marks]

(b) Show that the above decomposition is not a dependency-preserving decomposition.

[8 marks]

(c) Show that the following decomposition of the scheme R is not a lossless join decomposition.

(A,B,C)
(C,D,E).

Hint: Give an example of a relation r on scheme R such that

$$\pi_{A,B,C}(r) \bowtie \pi_{C,D,E}(r) \neq r.$$

[8 marks]

(d) Give a lossless join decomposition of the scheme R into BCNF.

[8 marks]

4. **Query processing and optimisation**

(a) Draw the canonical query tree for query (b) in question 2 above.

[5 marks]

(b) Describe how this tree can be converted using heuristic optimisation. Show the query trees that are produced in each step of the conversion.

[20 marks]

(c) Let relations $r_1(A, B, C)$ and $r_2(C, D, E)$ have the following properties:

- r_1 has 20,000 tuples.
- r_2 has 45,000 tuples.
- 25 tuples of r_1 fit on one block.
- 30 tuples of r_2 fit on one block.

Estimate the number of block accesses required, using each of the following join strategies for $r_1 \bowtie r_2$:

i. nested loop join

[3 marks]

ii. where there is primary index on C in r_1

[4 marks]

iii. sort-merge join

[4 marks]

5. **Transactions, concurrency control and recovery**

(a) What does it mean to say that a schedule is conflict serializable?

[2 marks]

(b) Consider the following schedule for transactions $T2$, $T3$ and $T5$:

T2	T3	T5
read(Q)		
	write(Q)	
write(Q)		
		write(Q)

Is this schedule conflict serializable? Explain how you know.

[3 marks]

(c) Does the above schedule produce the same result as the following serial schedule? Why or why not?

[5 marks]

T2	T3	T5
read(Q)		
write(Q)		
	write(Q)	
		write(Q)

(d) Consider transactions $T7$, $T8$ and $T9$:

T7	T8	T9
write_lock(B)	read_lock(A)	write_lock(B)
read(B)	read(A)	read(B)
B := B - 50	read_lock(B)	B := B - 50
write(B)	read(B)	write(B)
write_lock(A)	display(A,B)	unlock(B)
read(A)	unlock(A)	write_lock(A)
A := A + 50	unlock(B)	read(A)
write(A)		A := A + 50
unlock(B)		write(A)
unlock(A)		unlock(A)

i. For each transaction, state whether it obeys two-phase locking or not? How do you know?

[5 marks]

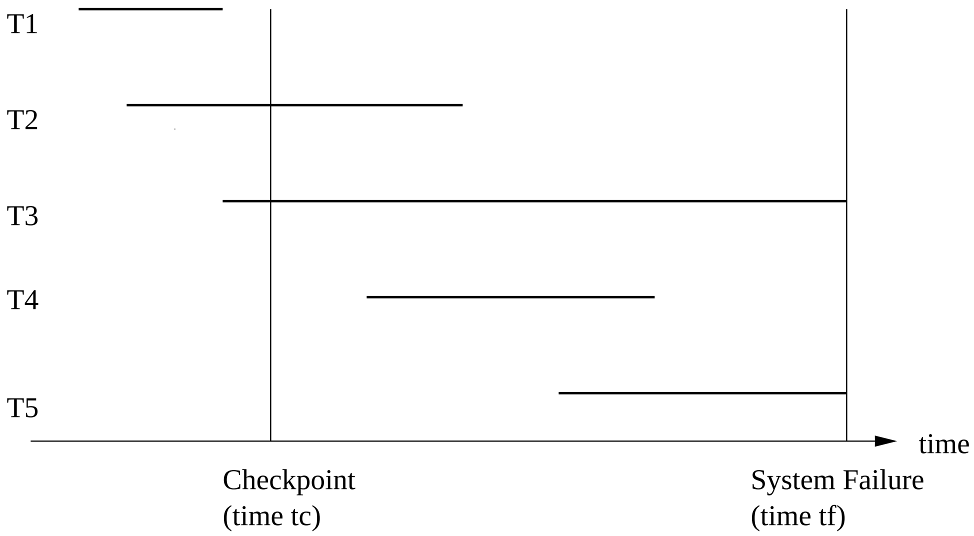
ii. Does the basic two-phase locking protocol ensure conflict serializability? If it does, describe how it does this. If it does not, demonstrate a schedule that is not conflict serializable using the transactions above.

[8 marks]

iii. Does the basic two-phase locking protocol ensure freedom from deadlock? If it does, describe how it does this. If it does not, demonstrate a schedule in which deadlocks may occur using the transactions above.

[8 marks]

(e) Consider the following situation:



Describe which transactions would be undone and which would be redone when the system, which uses a deferred update technique, is recovering from the system failure.

[5 marks]

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