Transaction & Concurrency Control - Part IV

Complete Course on DBMS for GATE

Sanchit Jain • Lesson 6 • Mar 23, 2022

TRANSACTION

- Why we study transaction?
  - According to general computation principle (operating system) we may have partially executed program, as the level of atomicity is instruction i.e. either an instruction is executed completely or not
  - But in DBMS view, user perform a logical work(operation) which is always atomic in nature i.e. either operation is execute or not executed, there is no concept like partial execution. For example, Transaction T_1 which transfer 100 units from account A to B

T_1
Read(A)
A = A-100
Write(A)
Read(B)
B = B+100
Write(B)

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- In this transaction if a failure occurs after Read(B) then the final statue of the system will be inconsistent as 100 units are debited from account A but not credited in account B, this will generate inconsistency.

- Here for 'consistency' before (A + B) == after (A + B)"

T_1
Read(A)
A = A-100
Write(A)
Read(B)
B = B+100
Write(B)

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What is transaction

- To remove this partial execution problem, we increase the level of atomicity and bundle all the instruction of a logical operation into a unit called transaction.

- So formally 'A transaction is a Set of logically related instructions to perform a logical unit of work'.

T_1
Read(A)
A = A-100
Write(A)
Read(B)
B = B+100
Write(B)

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- As here we are only concerned with DBMS so we well only two basic operation on database

- **READ (X)** - Accessing the database item x from disk (where database stored data) to memory variable also name as X.

- **WRITE (X)** - Writing the data item from memory variable X to disk.

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Q A transaction can include following basic database access operations: **(NET-JUNE-2011)**

(A) Read_item(X)

(B) Write_item(X)

(C) Both (A) and (B)

(D) None of these

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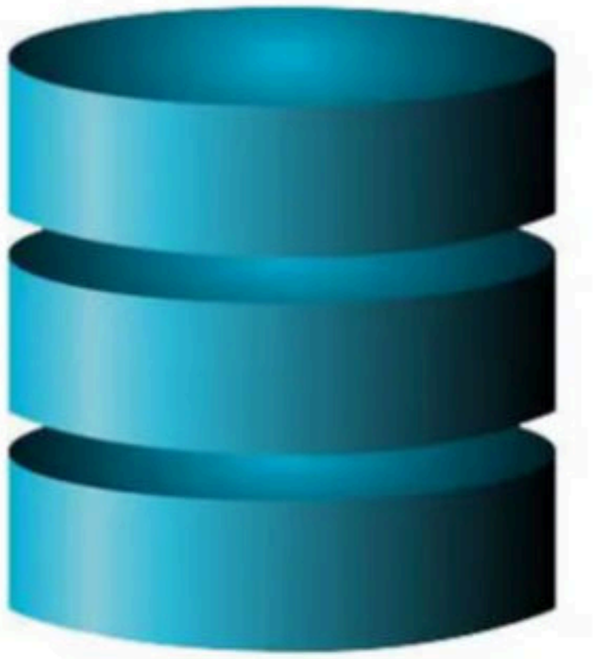
Desirable properties of transaction

- Now as the smallest unit which have atomicity in DBMS view is transaction, so if want that our data should be consistent then instead of concentrating on data base, we must concentrate on the transaction for our data to be consistent.

T_1
Read(A)
A = A-100
Write(A)
Read(B)
B = B+100
Write(B)



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- Transactions should possess several properties, often called the **ACID** properties; to provide integrity and consistency of the data in the database. The following are the ACID properties:

A = Atomicity

C = Consistency

I = Isolation

D = Durability

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- **Atomicity** - A transaction is an atomic unit of processing; it should either be performed in its entirety or not performed at all.

- It is the responsibility of ***recovery control manager / transaction control manager of DBMS*** to ensure atomicity

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- **Consistency** - A transaction should be consistency preserving, meaning that if it is completely executed from beginning to end without interference from other transactions, it should take the database from one consistent state to another.

- The definition of consistency may change from one system to another. The preservation of consistency of database is the responsibility of programmers(users) or the DBMS modules that enforces integrity constraints.

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- **Isolation** - A transaction should appear as though it is being executed in isolation from other transactions, even though many transactions are executing concurrently.

- That is, the execution of a transaction should not be interfered with by any other transactions executing concurrently.

- The isolation property of database is the responsibility of ***concurrency control manager of database***.

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- **Durability** - The changes applied to the database by a committed transaction must persist in the database.

- These changes must not be lost because of any failure. It is the responsibility of ***recovery control manager of DBMS.***

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Q NOT a part of the **ACID** properties of database transactions? **(GATE-2016) (1 Marks)**

(a) Atomicity

(b) Consistency

(c) Isolation

(d) Deadlock-freedom

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Q Consider the following transaction involving two bank accounts x and y. **(GATE - 2015) (1 Marks)**

```
read(x);
x: = x – 50;
write(x);
read(y);
y: = y + 50;
write(y)
```

The constraint that the sum of the accounts x and y should remain constant is that of

(A) Atomicity **(B)** Consistency **(C)** Isolation **(D)** Durability

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Q All Oracle transactions obey the basic properties of a database transaction. What is the name of the following property?
'All tasks of a transaction are performed or none of them are. There are no partial transactions.' **[Asked in Wipro NLTH 2021]**

a) Atomicity

b) Durability

c) Consistency

d) Isolation

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Answer: Option 1

ACID Properties:

A transaction in a database system must maintain Atomicity, Consistency, Isolation, and Durability – commonly known as ACID properties – in order to ensure accuracy, completeness, and data integrity.

Atomicity – This property states that a transaction must be treated as an atomic unit, that is, either all its operations are executed or none. There are no partial transactions

Consistency – The database must remain in a consistent state after any transaction. No transaction should have any adverse effect on the data residing in the database.

Isolation – In a database system where more than one transaction is being executed simultaneously and in parallel, the property of isolation states that all the transactions will be carried out and executed as if it is the only transaction in the system.

Durability – The database should be durable enough to hold all its latest updates even if the system fails or restarts.

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Break

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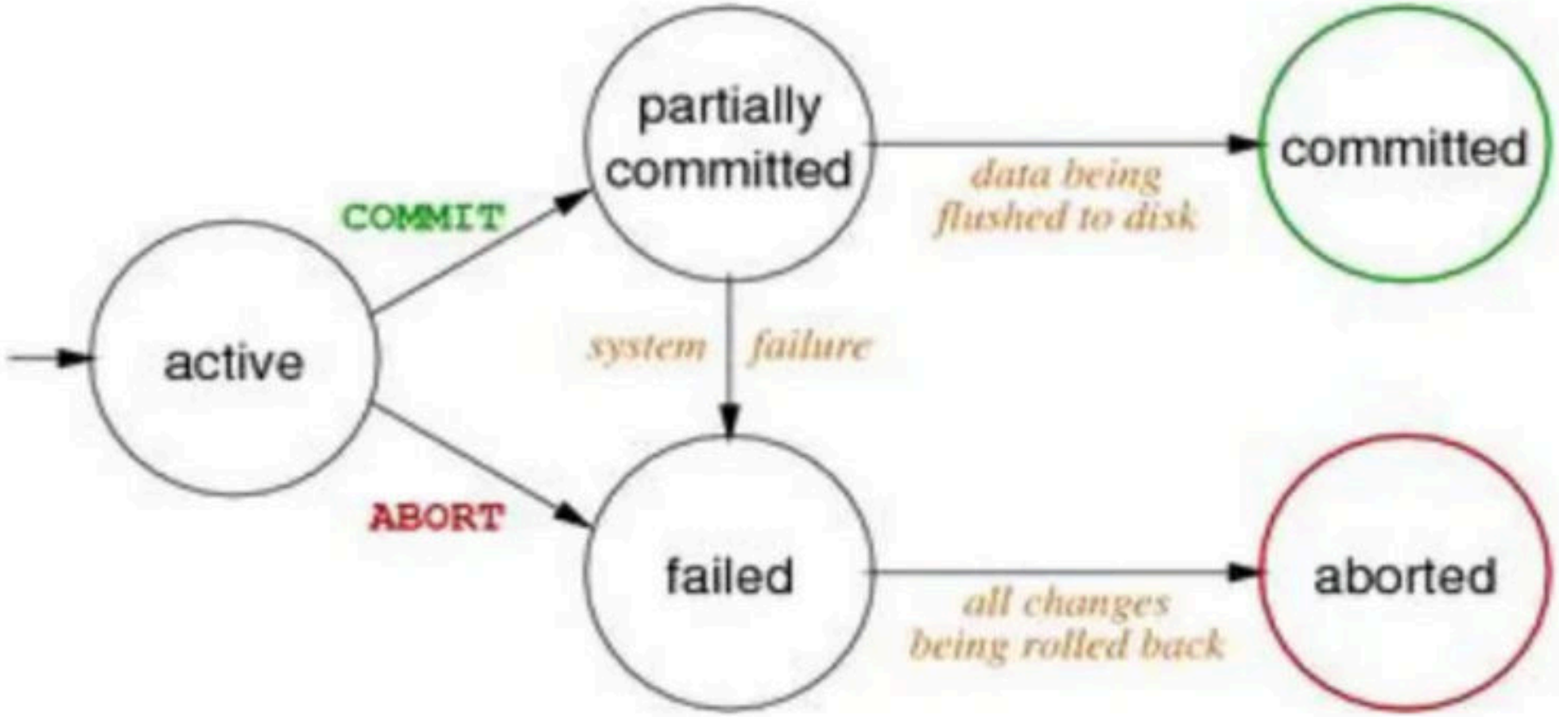
Transaction states

- **ACTIVE** - It is the initial state. Transaction remains in this state while it is executing operations.



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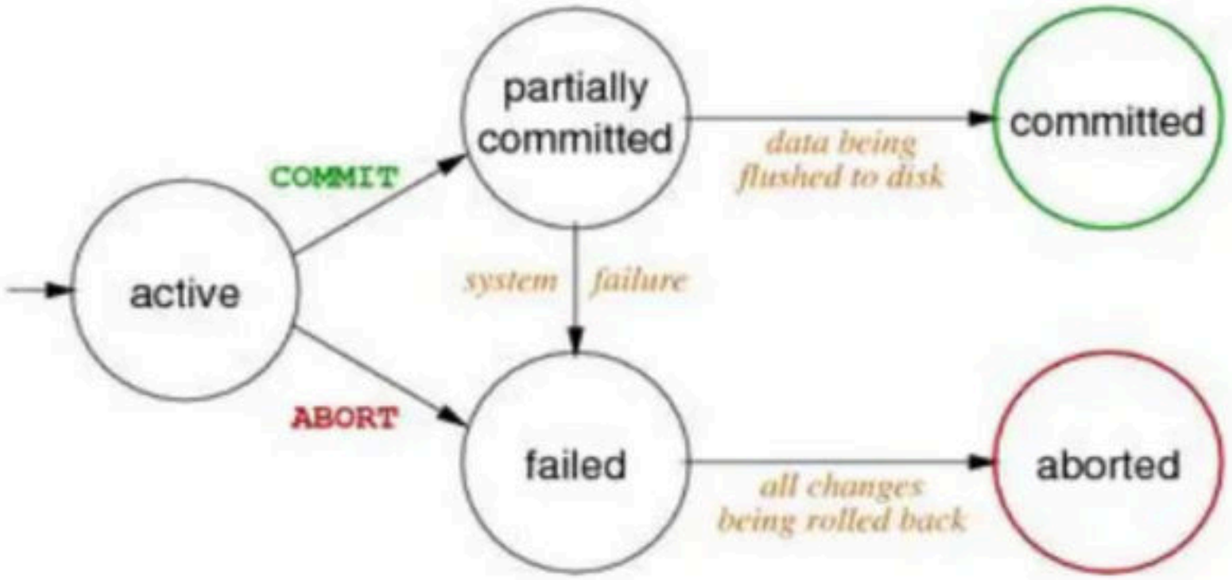
Transaction states

- **PARTIALLY COMMITTED** - After the final statement of a transaction has been executed, the state of transaction is partially committed as it is still possible that it may have to be aborted (due to any failure) since the actual output may still be temporarily residing in main memory and not to disk.



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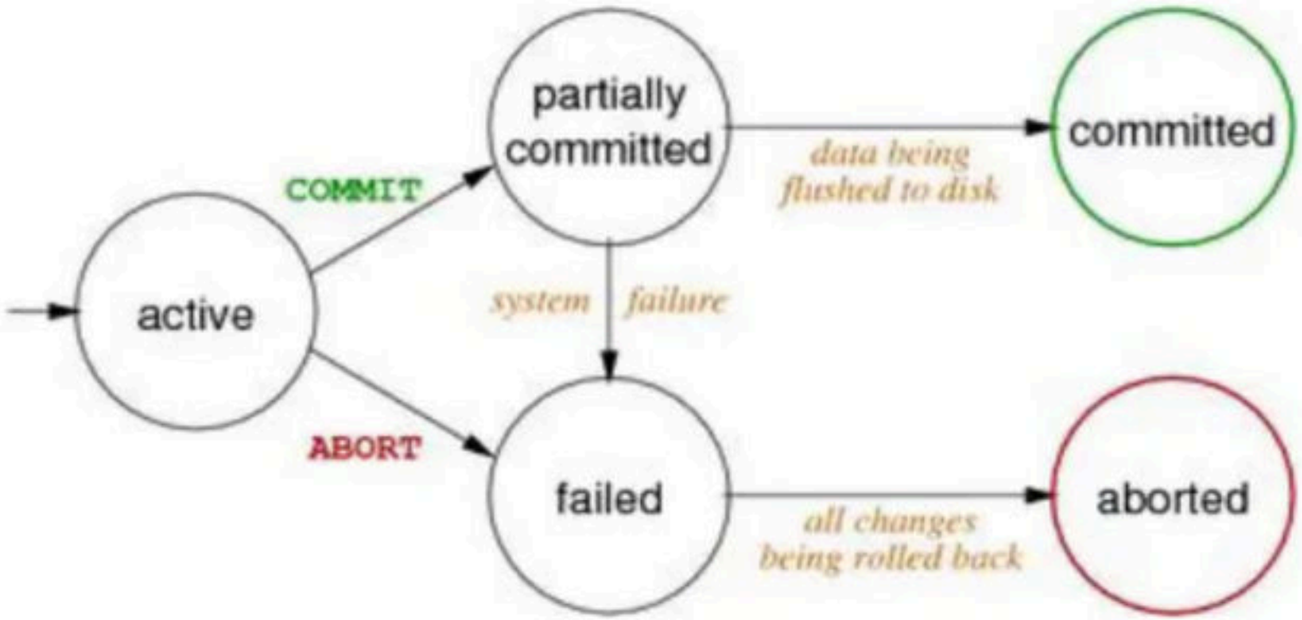
Transaction states

- **FAILED** - After the discovery that the transaction can no longer proceed (because of hardware /logical errors). Such a transaction must be rolled back



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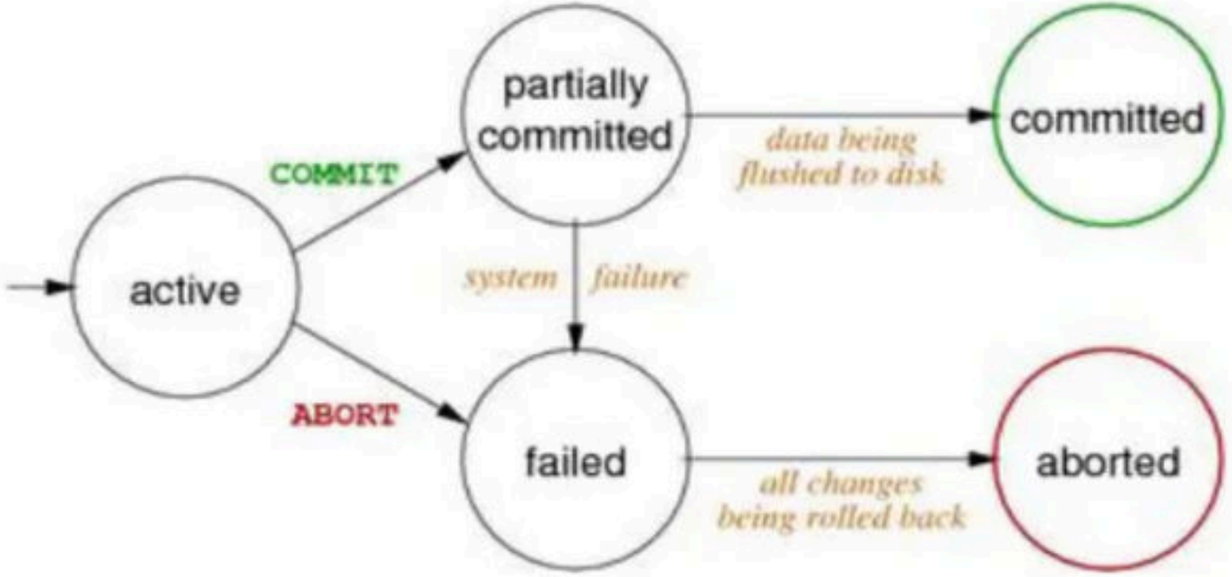
Transaction states

- **ABORTED** - A transaction is said to be in aborted state when the when the transaction has been rolled back and the database has been restored to its state prior to the start of execution.



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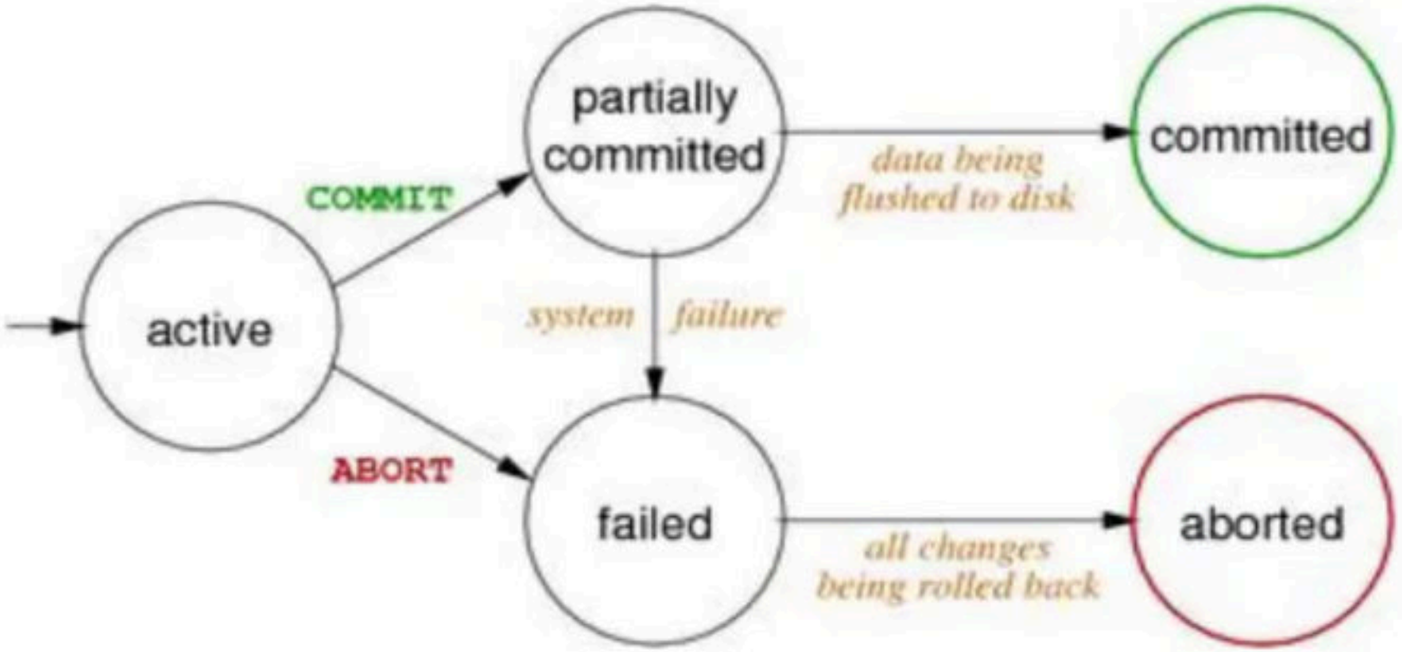
Transaction states

- **COMMITTED** - A transaction enters committed state after successful completion of a transaction and final updation in the database



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Q if the transaction is in which of the state that we can guarantee that data base is in consistent state

a) aborted

b) committed

c) both aborted & committed

d) none

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Q Match:

Column I	Column II
1. Atomicity	A. Recovery Manager
2. Durability	B. Concurrency control manager
3. Isolation	C. Programmer
4. Consistency	

a) 1-a, 2–a, 3-b, 4–c

b) 1-a, 2-b,3-b,4-c

c) 1-a,2-a,3-b,4-b

d) none of these

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Break

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Why we need concurrent execution

- Concurrent execution is necessary because-
  - It leads to good database performance , less weighting time.
  - Overlapping I/O activity with CPU increases throughput and response time.

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PROBLEMS DUE TO CONCURRENT EXECUTION OF TRANSACTION

- But interleaving of instructions between transactions may also lead to many problems that can lead to inconsistent database.

- Sometimes it is possible that even though individual transaction are satisfying the acid properties even though the final statues of the system will be inconsistent.

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Lost update problem / Write - Write problem-

- If there is any two write operation of different transaction on same data value, and between them there is no read operations, then the second write over writes the first write.

T_1	T_2
Read(A)	
Write(A)	
	Write(A)
	Commit
Commit	

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Dirty read problem/ Read -Write problem

- In this problem, the transaction reads a data item updated by another uncommitted transaction, this transaction may in future be aborted or failed.
- The reading transactions end with incorrect results.

T_1	T_2
Read(A)	
Write(A)	
	Read(A)
	Commit
Abort	

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Q The problem that occurs when one transaction updates a database item and then the transaction fails for some reason is _____. **(NET-JUNE-2012)**

(A) Temporary Select Problem

(B) Temporary Modify Problem

(C) Dirty Read Problem

(D) None

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Unrepeatable read problem

- When a transaction tries to read a value of a data item twice, and another transaction updates the data item in between, then the result of the two read operation of the first transaction will differ, this problem is called, Non-repeatable read problem

T_1	T_2
Read(A)	
	Read(A)
	Write(A)
Read(A)	

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Phantom read problem

T_1	T_2
Read(A)	
	Delete(A)
Read(A)	

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Q The following schedule is suffering from

T_1	T_2
R(y)	
	R(x) R(y) y = x + y w(y)
R(y)	

a) Lost update problem

b) Unrepeatable read problem

c) Both A and B

d) Neither A and B

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Q Which of the following scenarios may lead to an irrecoverable error in a database system? **(GATE – 2008) (1 Marks)**

(A) A transaction writes a data item after it is read by an uncommitted transaction

(B) A transaction reads a data item after it is read by an uncommitted transaction

(C) A transaction reads a data item after it is written by a committed transaction

(D) A transaction reads a data item after it is written by an uncommitted transaction

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Break

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Solution is Schedule

- When two or more transaction executed together or one after another then they can be bundled up into a higher unit of execution called schedule.

- A **schedule** of n transactions $T_1, T_2, ..., T_n$ is an ordering of the operations of the transactions. Operations from different transactions can be interleaved in the schedule S.

- However, schedule for a set of transaction must contain all the instruction of those transaction, and for each transaction T_i that participates in the schedule S, the operations of T_i in S must appear in the same order in which they occur in T_i.

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- **Serial schedule** - A serial schedule consists of sequence of instruction belonging to different transactions, where instructions belonging to one single transaction appear together. Before complete execution of one transaction another transaction cannot be started.

T_0	T_1
read(A)	
write(A)	
read(B)	
write(B)	
	read(A)
	write(A)
	read(B)
	write(B)

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- For a set of n transactions, there exist **n!** different valid serial schedules. Every serial schedule lead database into consistent state. Throughput of system is less.

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- **Non-serial schedule** - A schedule in which sequence of instructions of a transaction appear in the same order as they appear in individual transaction but the instructions may be interleaved with the instructions of different transactions i.e. concurrent execution of transactions takes place.

T_2	T_3
read(B)	
	read(B)
	write(B)
read(A)	
	read(A)
	write(A)

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- So the number of schedules for n different transaction T_1, T_2, T_3,---------T_N where each transaction conations n_1, n_2, n_3, ----------,n_4 respectively will be.

- $\{(n_1 + n_2 + n_3 + \text{----------} + n_n)!\} / (n_1!\ n_2!\ n_3!\ \text{----------} n_n!)\}$

- $\{(n_1 + n_2 + n_3 + \text{----------} + n_n)!\} / (n_1!\ n_2!\ n_3!\ \text{----------} n_n!)\} - n!$

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- **Conclusion of schedules**
  - We do not have any method to proof that a schedule is consistent, but from the above discussion we understand that a serial schedule will always be consistent, so if somehow we proof that a non-serial schedule will also have same effects as of a serial schedule that we get a proof that, this particular non-serial schedule will also be consistent "find those schedules that are logically equal to serial schedules".

  - For a concurrent schedule to result in consistent state, it should be equivalent to a serial schedule. i.e. it must be serializable.

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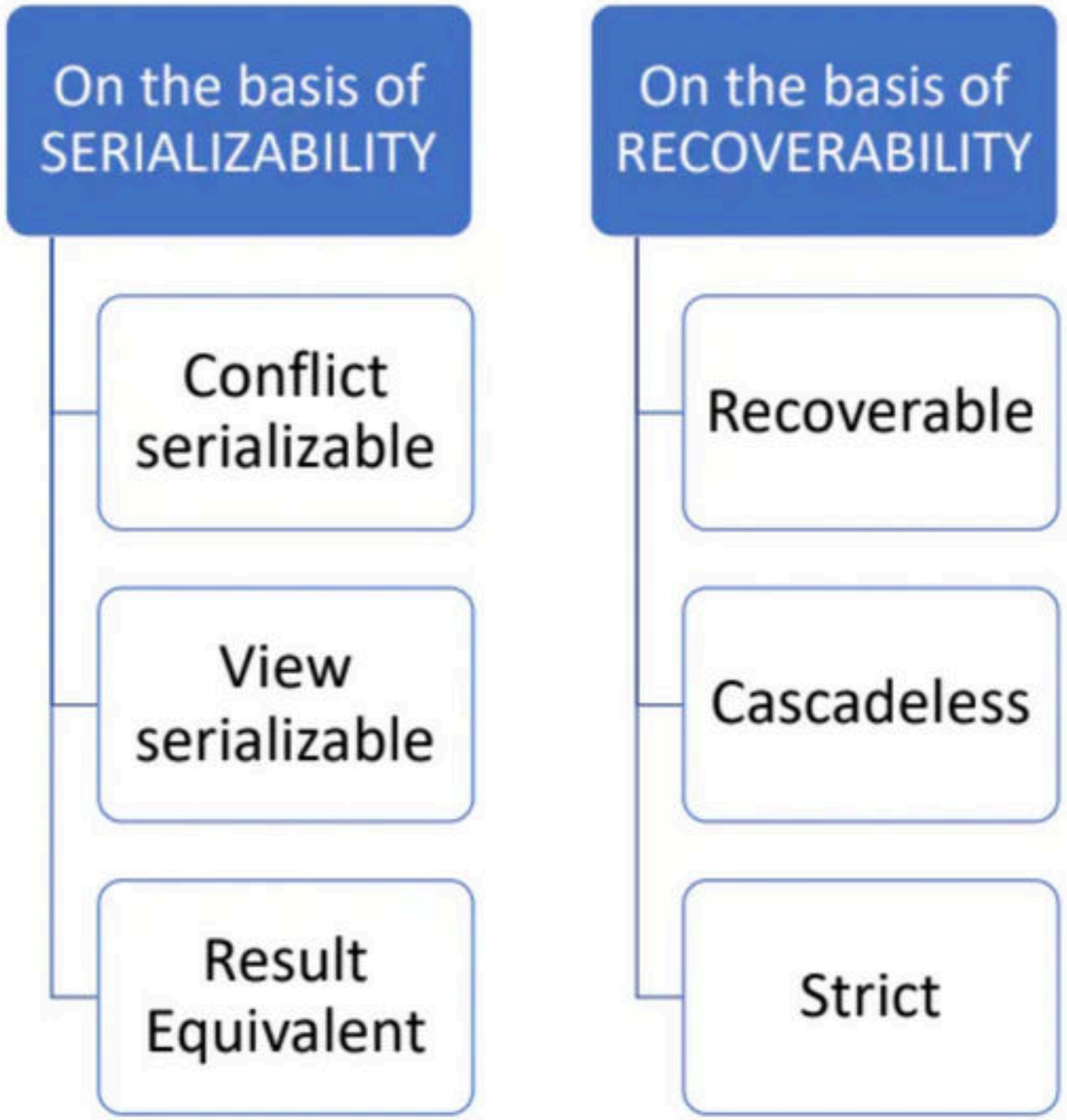

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T_1	T_2
R(A)	
	R(B)

T_1	T_2
	R(B)
R(A)	

T_1	T_2
R(A)	
	W(A)

T_1	T_2
	W(A)
R(A)	

T_1	T_2
R(A)	
	W(B)

T_1	T_2
R(A)	
	W(B)

T_1	T_2
	R(A)
W(A)	

T_1	T_2
W(A)	
	R(A)

T_1	T_2
R(A)	
	R(A)

T_1	T_2
R(A)	
	R(A)

T_1	T_2
	W(A)
W(A)	

T_1	T_2
W(A)	
	W(A)

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SERIALIZABILITY

- ***Conflicting instructions*** - Let I and J be two consecutive instructions belonging to two different transactions T_i and T_j in a schedule S, the possible I and J instruction can be as-
  - I= READ(Q), J=READ(Q) ->*Non-conflicting*
  - I= READ(Q), J=WRITE(Q) ->*Conflicting*
  - I= WRITE(Q), J=READ(Q) ->*Conflicting*
  - I= WRITE(Q), J=WRITE(Q) ->*Conflicting*

- So, the instructions I and J are said to be conflicting, if they are operations by different transactions on the same data item, and at least one of these instructions is a write operation.

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Conflict equivalent – if one schedule can be converted to another schedule by swapping of non-conflicting instruction then they are called conflict equivalent schedule.

T_1	T_2
R(A)	
A=A-50	
	R(B)
	B=B+50
R(B)	
B=B+50	
	R(A)
	A=A+10

T_1	T_2
	R(B)
	B=B+50
R(A)	
A=A-50	
R(B)	
B=B+50	
	R(A)
	A=A+10

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Q Consider a schedule of transactions T_1 and T_2:
Here, RX stands for "Read(X)" and WX stands for "Write(X)". Which one of the following schedules is conflict equivalent to the above schedule?**(Gate-2020) (2 Marks)**

S	
T_1	T_2
RA	
	RB
	WB
RC	
	RD
WD	
	WC
WB	
Commit	
	Commit

a)

S	
T_1	T_2
	RB
	WB
	RD
RA	
RC	
WD	
WB	
	WC
Commit	
	Commit

b)

S	
T_1	T_2
RA	
RC	
WD	
WB	
	RB
	WB
	RD
	WC
Commit	
	Commit

c)

S	
T_1	T_2
RA	
RC	
WD	
	RB
	WB
	RD
WB	
	WC
Commit	
	Commit

d)

S	
T_1	T_2
	RB
	WB
	RD
	WC
RA	
RC	
WD	
WB	
Commit	
	Commit

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CONFLICT SERIALIZABLE

- The schedules which are conflict equivalent to a serial schedule are called conflict serializable schedule.

- If a schedule S can be transformed into a schedule S' by a series of swaps of non- conflicting instructions, we say that S and S' are ***conflict equivalent.***

- A schedule S is ***conflict serializable***, if it is conflict equivalent to a serial schedule.

T_1	T_2
read(A)	
write(A)	
	read(A)
	write(A)
read(B)	
write(B)	
	read(B)
	write(B)

T_1	T_2
read(A)	
write(A)	
read(B)	
write(B)	
	read(A)
	write(A)
	read(B)
	write(B)

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Procedure for determining conflict serializability of a schedule

- It can be determined using PRECEDENCE GRAPH method:
- A precedence graph consists of a pair G (V, E)
- V= set of vertices consisting of all the transactions participating in the schedule.
- E= set of edges consists of all edges $T_i \rightarrow T_j$, for which one of the following conditions holds:
  - T_i executes write(Q) before T_j executes read(Q)
  - T_i executes read(Q) before T_j executes write(Q)
  - T_i executes write(Q) before T_j executes write(Q)

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- If an edge $T_i \rightarrow T_j$ exists in the precedence graph, then in any serial schedule S' equivalent to S, Ti must appear before T_j.

- **If the precedence graph for S has no cycle, then schedule S is conflict serializable, else it is not.** This cycle detection can be done by cycle detection algorithms, one of them based on depth first search takes **$O(n^2)$** time.

- The serialializibility order of transactions of equivalent serial schedule can be determined using **topological order** in a precedence graph.

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Break

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Q Let $r_i(z)$ and $w_i(z)$ denote read and write operations respectively on a data item z by a transaction T_i. Consider the following two schedules.

- $S_1: r_1(x) r_1(y) r_2(x) r_2(y) w_2(y) w_1(x)$
- $S_2: r_1(x) r_2(x) r_2(y) w_2(y) r_1(y) w_1(x)$

Which one of the following options is correct? **(GATE - 2021) (2 Marks)**

a) S_1 is conflict serializable, and S_2 is not conflict serializable

b) S_1 is not conflict serializable, and S_2 is conflict serializable

c) Both S_1 and S_2 are conflict serializable

d) Neither S_1 nor S_2 is conflict serializable

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Q Let $r_i(z)$ and $w_i(z)$ denote read and write operations respectively on a data item z by a transaction T_i. Consider the following two schedules.

- $S_1: r_1(x) r_1(y) r_2(x) r_2(y) w_2(y) w_1(x)$
- $S_2: r_1(x) r_2(x) r_2(y) w_2(y) r_1(y) w_1(x)$

Which one of the following options is correct? **(GATE - 2021) (2 Marks)**

a) S_1 is conflict serializable, and S_2 is not conflict serializable

b) S_1 is not conflict serializable, and S_2 is conflict serializable

c) Both S_1 and S_2 are conflict serializable

d) Neither S_1 nor S_2 is conflict serializable

S_1	
T_1	T_2
R(X)	
R(Y)	
	R(X)
	R(Y)
	W(Y)
W(X)	

S_2	
T_1	T_2
R(X)	
	R(X)
	R(Y)
	W(Y)
R(Y)	
W(X)	

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Q Consider the following four schedules due to three transactions (indicated by the subscript) using read and write on a data item X, denoted by r(X) and w(X) respectively. Which one of them is conflict serializable? **(NET-NOV-2018)** **(GATE - 2014) (2 Marks)**

S_1: $r_1(X); r_2(X); w_1(X); r_3(X); w_2(X)$

S_2: $r_2(X); r_1(X); w_2(X); r_3(X); w_1(X)$

S_3: $r_3(X); r_2(X); r_1(X); w_2(X); w_1(X)$

S_4: $r_2(X); w_2(X); r_3(X); r_1(X); w_1(X)$

(a) S_1 **(b)** S_2 **(c)** S_3 **(d)** S_4

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Q Consider the following four schedules due to three transactions (indicated by the subscript) using read and write on a data item X, denoted by r(X) and w(X) respectively. Which one of them is conflict serializable? **(NET-NOV-2018)** **(GATE - 2014) (2 Marks)**

S_1: $r_1(X); r_2(X); w_1(X); r_3(X); w_2(X)$

	S_1	
T_1	T_2	T_3
R(X)		
	R(X)	
W(X)		
		R(X)
	W(X)	

S_2: $r_2(X); r_1(X); w_2(X); r_3(X); w_1(X)$

	S_2	
T_1	T_2	T_3
	R(X)	
R(X)		
	W(X)	
		R(X)
W(X)		

S_3: $r_3(X); r_2(X); r_1(X); w_2(X); w_1(X)$

	S_3	
T_1	T_2	T_3
		R(X)
	R(X)	
R(X)		
	W(X)	
W(X)		

S_4: $r_2(X); w_2(X); r_3(X); r_1(X); w_1(X)$

	S_4	
T_1	T_2	T_3
	R(X)	
	W(X)	
		R(X)
R(X)		
W(X)		

(a) S_1 **(b)** S_2 **(c)** S_3 **(d)** S_4

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Q Consider following schedules involving two transactions :

S_1 : $r_1(X); r_1(Y); r_2(X); r_2(Y); w_2(Y); w_1(X)$

S_2 : $r_1(X); r_2(X); r_2(Y); w_2(Y); r_1(Y); w_1(X)$

Which of the following statement is true ? **(NET-JAN-2017)** **(GATE - 2007) (2 Marks)**

(a) Both S_1 and S_2 are conflict serializable.

(b) S_1 is conflict serializable and S_2 is not conflict serializable.

(c) S_1 is not conflict serializable and S_2 is conflict serializable.

(d) Both S_1 and S_2 are not conflict serializable.

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Q Consider following schedules involving two transactions :

S_1 : $r_1(X); r_1(Y); r_2(X); r_2(Y); w_2(Y); w_1(X)$

T_1	T_2
r(x)	
r(y)	
	r(x)
	r(y)
	w(y)
w(x)	

S_2 : $r_1(X); r_2(X); r_2(Y); w_2(Y); r_1(Y); w_1(X)$

T_1	T_2
r(x)	
	r(x)
	r(y)
	w(y)
r(y)	
w(x)	

Which of the following statement is true ? **(NET-JAN-2017)** **(GATE - 2007) (2 Marks)**

(a) Both S_1 and S_2 are conflict serializable.

(b) S_1 is conflict serializable and S_2 is not conflict serializable.

(c) S_1 is not conflict serializable and S_2 is conflict serializable.

(d) Both S_1 and S_2 are not conflict serializable.

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Q Consider the following transactions with data items P and Q initialized to zero: **(GATE-2012) (2 Marks)**

T_1: read (P);
read (Q);
if P = 0 then Q: = Q + 1;
write (Q);

T_2: read (Q);
read (P);
if Q = 0 then P: = P + 1;
write (P);

Any non-serial interleaving of T_1 and T_2 for concurrent execution leads to

(A) A serializable schedule
(B) A schedule that is not conflict serializable
(C) A conflict serializable schedule
(D) A schedule for which a precedence graph cannot be drawn

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Q Consider the following transactions with data items P and Q initialized to zero: **(GATE-2012) (2 Marks)**

T_1: read (P);
read (Q);
~~if P = 0 then Q := Q + 1;~~
write (Q);

T_2: read (Q);
read (P);
~~if Q = 0 then P := P + 1;~~
write (P);

T_1	T_2
r(P)	r(Q)
r(Q)	r(P)
w(Q)	w(P)

Any non-serial interleaving of T1 and T2 for concurrent execution leads to

(A) ~~A serializable schedule~~ — 16

(B) A schedule that is not conflict serializable — 61

(C) A conflict serializable schedule — 22

(D) ~~A schedule for which a precedence graph cannot be drawn~~ — 6

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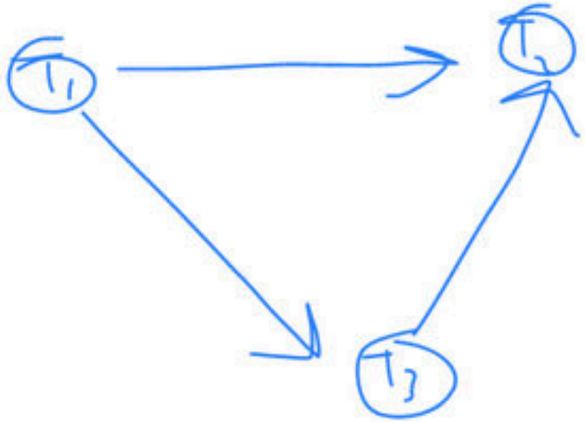
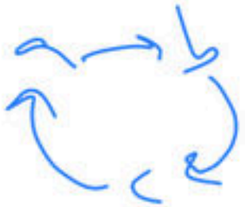
Q Consider the following schedule for transactions T_1, T_2 and T_3: **(GATE – 2010) (2 Marks)**
Which one of the schedules below is the correct serialization of the above?

T1	T2	T3
Read (X)		
	Read (Y)	
		Read (Y)
	Write (Y)	
Write (X)		
		Write (X)
	Read (X)	
	Write (X)	

$T_i \longrightarrow T_j$





$T_1 \longrightarrow T_3 \longrightarrow T_2$

1) $T_3 \rightarrow T_1 \rightarrow T_2$ – 5

(A) T_1->>T_3->>T_2 → 10

(B) T_2->>T_1->>T_3 – 7

(C) T_2->>T_3->>T_1 – 8

(D) T_3->>T_1->>T_2

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Q Consider two transactions T_1 and T_2 which form schedules S_1, S_2, S_3 and S_4 as follows: -

T_1: R_1 [A], W_1 [A], W_1 [B]

T_2: R_2 [A], R_2 [B], W_2 [B]

S_1: R_1[A], R_2 [A], R_2[B], W_1[A], W_2[B], W_1[B]

S_2: R_1[A], R_2 [A], R_2[B], W_1[A], W_1[B], W_2 [B]

S_3: R_2[A], R_1 [A], R_2[B], W_1[A], W_1[B], W_2[B]

S_4: R_1[A], R_2 [A], R_2[B], W_1[B], R_2[B], W_2[B]

A) S_3 & S_4

Which of the above schedules is conflicts serializable? **(GATE - 2009) (2 Marks)**

a) Only S_1 **b)** Both S_1 and S_2 **c)** Both S_1 and S_4 **d)** Both S_3 and S_4

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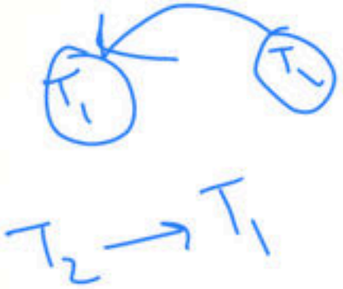
Q Consider two transactions T_1 and T_2 which form schedules S_1, S_2, S_3 and S_4 as follows: -

T_1: R_1 [A], W_1 [A], W_1 [B]

T_2: R_2 [A], R_2 [B], W_2 [B]

S_1: R_1[A], R_2 [A], R_2[B], W_1[A], W_2[B], W_1[B]

S_1	
T_1	T_2
R(A)	
	R(A)
	R(B)
W(A)	
	W(B)
W(B)	

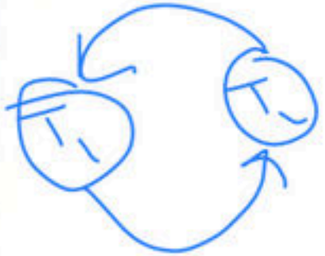


S_2: R_1[A], R_2 [A], R_2[B], W_1[A], W_1[B], W_2 [B]

S_2	
T_1	T_2
~~R(A)~~	
	~~R(A)~~
	~~R(B)~~
~~W(A)~~	
~~W(B)~~	
	W(B)

S_3: R_2[A], R_1 [A], R_2[B], W_1[A], W_1[B], W_2[B]

S_3	
T_1	T_2
	R(A)
R(A)	
	R(B)
W(A)	
W(B)	
	W(B)



S_4: R_1[A], R_2 [A], R_2[B], W_1[B], R_2[B], W_2[B]

S_4	
T_1	T_2
R(A)	
	R(A)
	R(B)
W(A)	
	R(B)
	W(B)

Which of the above schedules is conflicts serializable? **(GATE - 2009) (2 Marks)**

a) Only S_1 **b)** Both S_1 and S_2 **c)** Both S_1 and S_4 **d)** Both S_3 and S_4

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Q Consider the transactions T_1, T_2, and T_3 and the schedules S_1 and S_2 given below. **(GATE - 2006) (2 Marks)**

T_1: $r_1(X)$; $r_1(Z)$; $w_1(X)$; $w_1(Z)$

T_2: $r_2(Y)$; $r_2(Z)$; $w_2(Z)$

T_3: $r_3(Y)$; $r_3(X)$; $w_3(Y)$

S_1: $r_1(X)$; $r_3(Y)$; $r_3(X)$; $r_2(Y)$; $r_2(Z)$;$w_3(Y)$; $w_2(Z)$; $r_1(Z)$; $w_1(X)$; $w_1(Z)$

S_2: $r_1(X)$; $r_3(Y)$; $r_2(Y)$; $r_3(X)$; $r_1(Z)$;$r_2(Z)$; $w_3(Y)$; $w_1(X)$; $w_2(Z)$; $w_1(Z)$

Which one of the following statements about the schedules is TRUE?

(A) Only S_1 is conflict-serializable.

(B) Only S_2 is conflict-serializable.

(C) Both S_1 and S_2 are conflict-serializable.

(D) Neither S_1 nor S_2 is conflict-serializable.

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Q Consider the transactions T_1, T_2, and T_3 and the schedules S_1 and S_2 given below. **(GATE - 2006) (2 Marks)**

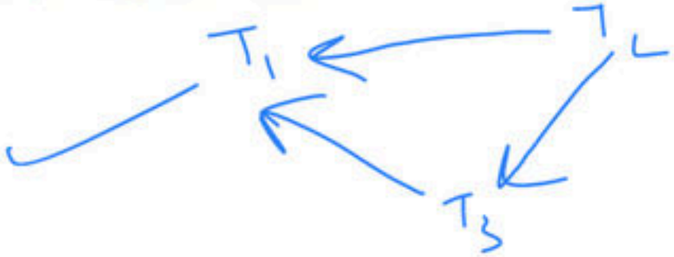
T_1: $r_1(X)$; $r_1(Z)$; $w_1(X)$; $w_1(Z)$

T_2: $r_2(Y)$; $r_2(Z)$; $w_2(Z)$

T_3: $r_3(Y)$; $r_3(X)$; $w_3(Y)$

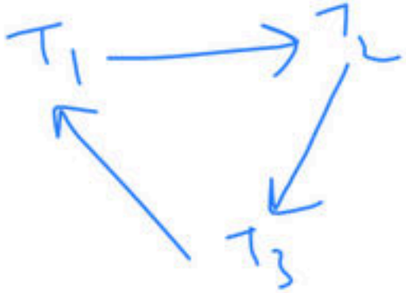
S_1: $r_1(X)$; $r_3(Y)$; $r_3(X)$; $r_2(Y)$; $r_2(Z)$;$w_3(Y)$; $w_2(Z)$; $r_1(Z)$; $w_1(X)$; $w_1(Z)$

$T_2 \rightarrow T_3 \rightarrow T_1$



	S_1	
T_1	T_2	T_3
~~R(X)~~		
		~~R(Y)~~
		~~R(X)~~
	~~R(Y)~~	
	~~R(Z)~~	
		~~W(Y)~~
	~~W(Z)~~	
R(Z)		
W(X)		
W(Z)		

S_2: $r_1(X)$; $r_3(Y)$; $r_2(Y)$; $r_3(X)$; $r_1(Z)$;$r_2(Z)$; $w_3(Y)$; $w_1(X)$; $w_2(Z)$; $w_1(Z)$



	S_2	
T_1	T_2	T_3
~~R(X)~~		
		~~R(Y)~~
	~~R(Y)~~	
		~~R(X)~~
R(Z)		
	R(Z)	
		W(Y)
W(X)		
	W(Z)	
W(Z)		

Which one of the following statements about the schedules is TRUE?

(A) Only S_1 is conflict-serializable.

(B) Only S_2 is conflict-serializable.

(C) Both S_1 and S_2 are conflict-serializable.

(D) Neither S_1 nor S_2 is conflict-serializable.

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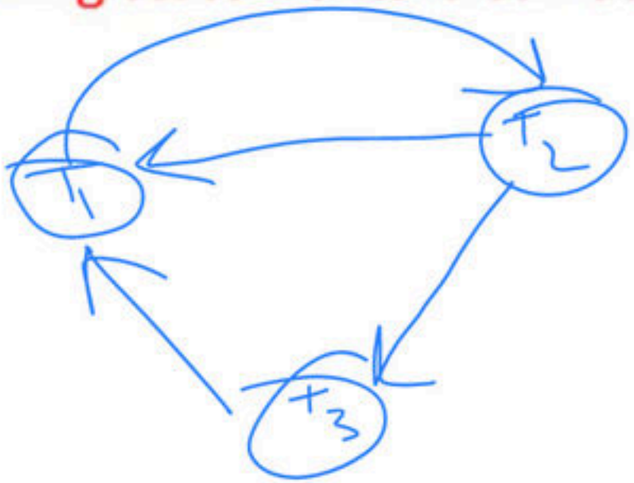
Q Consider three data items D_1, D_2 and D_3 and the following execution schedule of transactions T_1, T_2 and T_3. In the diagram, R(D) and W(D) denote the actions reading and writing the data item D respectively. **(GATE – 2003) (2 Marks)**

Which of the following statements is correct?



	T1	T2	T3
time ↓		~~R(D3);~~	
		~~R(D2);~~	
		~~W(D2);~~	
			~~R(D2);~~
			~~R(D3);~~
	~~R(D1);~~		
	W(D1);		
			W(D2);
			W(D3);
		R(D1);	
	R(D2);		
	W(D2);		
		~~W(D1);~~	

(A) The schedule is serializable as T_2; T_3; T_1 18

(B) The schedule is serializable as T_2; T_1; T_3 2

(C) The schedule is serializable as T_3; T_2; T_1 5

(D) The schedule is not serializable 7(

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Break

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Q Suppose a database schedule S involves transactions T_1, T_2, ...,T_n. Consider the precedence graph of S with vertices representing the transactions and edges representing the conflicts. If S is serializable, which one of the following orderings of the vertices of the precedence graph is guaranteed to yield a serial schedule?

(NET-NOV-2017) (GATE- 2016) (1 Marks)

(a) Topological order

(b) Depth - first order

(c) Breadth - first order

(d) Ascending order of transaction indices

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Q Consider a simple checkpointing protocol and the following set of operations in the log.

(start, T_4);
(write, T_4, y, 2, 3);
(start, T_1);
(commit, T_4);
(write, T_1, z, 5, 7);
(checkpoint);
(start, T_2);
(write, T_2, x, 1, 9);
(commit, T_2);
(start, T_3);
(write, T_3, z, 7, 2);

If a crash happens now and the system tries to recover using both undo and redo operations, what are the contents of the undo list and the redo list **(GATE - 2015) (2 Marks)**

(A) Undo: T_3, T_1; Redo: T_2

(B) Undo: T_3, T_1; Redo: T_2, T_4

(C) Undo: none; Redo: T_2, T_4, T_3; T_1

(D) Undo: T_3, T_1, T_4; Redo: T_2

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Q Consider a simple checkpointing protocol and the following set of operations in the log.

(start, T_4);
(write, T_4, y, 2, 3);
(start, T_1);
(commit, T_4);
(write, T_1, z, 5, 7);
(checkpoint);
(start, T_2);
(write, T_2, x, 1, 9);
(commit, T_2);
(start, T_3);
(write, T_3, z, 7, 2);

S			
T_1	T_2	T_3	T_4
			START
			(write, y, 2, 3)
START			
			COMMIT
(write, z, 5, 7)			
(checkpoint)	(checkpoint)	(checkpoint)	(checkpoint)
	START		
	(write, x, 1, 9)		
	COMMIT		
		START	
		(write, z, 7, 2)	

If a crash happens now and the system tries to recover using both undo and redo operations, what are the contents of the undo list and the redo list **(GATE - 2015) (2 Marks)**

(A) Undo: T_3, T_1; Redo: T_2
(B) Undo: T_3, T_1; Redo: T_2, T_4
(C) Undo: none; Redo: T_2, T_4, T_3; T_1
(D) Undo: T_3, T_1, T_4; Redo: T_2

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Q.18 Suppose a database system crashes again while recovering from a previous crash. Assume checkpointing is not done by the database either during the transactions or during recovery.

(Gate-2021) (1 Marks)

Which of the following statements is/are correct?

(a) The same undo and redo list will be used while recovering again.

(b) The system cannot recover any further.

(c) The database will become inconsistent.

(d) All the transactions that are already undone and redone will not be recovered again.

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Q.24 Let S be the following schedule of operations of three transactions T_1, T_2 and T_3 in a relational database system:

(GATE-2021)

$$R_2(Y),\ R_1(X),\ R_3(Z),\ R_1(Y),\ W_1(X),\ R_2(Z),\ W_2(Y),\ R_3(X),\ W_3(Z)$$

Consider the statements P and Q below:

P : S is conflict-serializable.

Q : If T_3 commits before T_1 finishes, then S is recoverable.

Which one of the following choices is correct?

(a) P is true and Q is false.

(b) Both P and Q are false.

(c) Both P and Q are true.

(d) P is false and Q is true.

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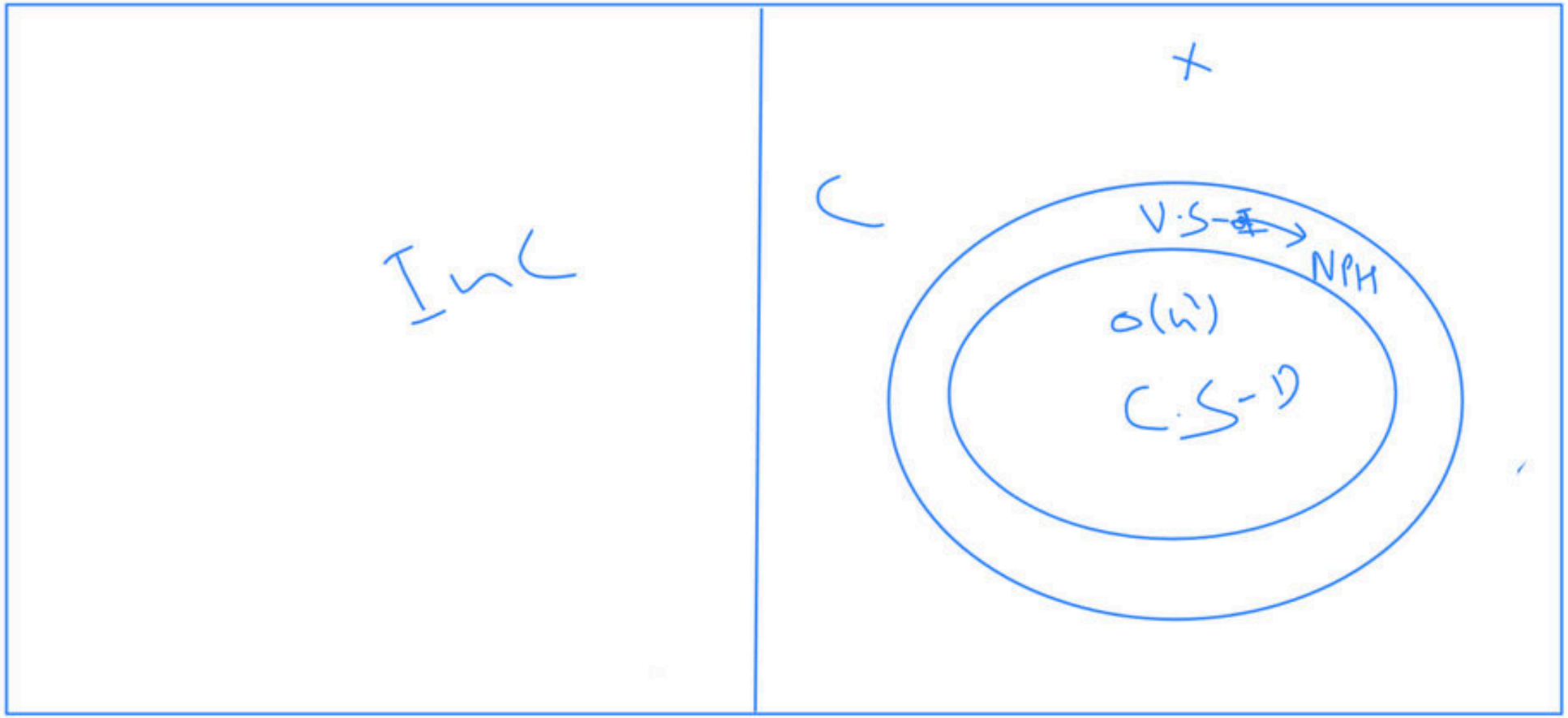
N.S →

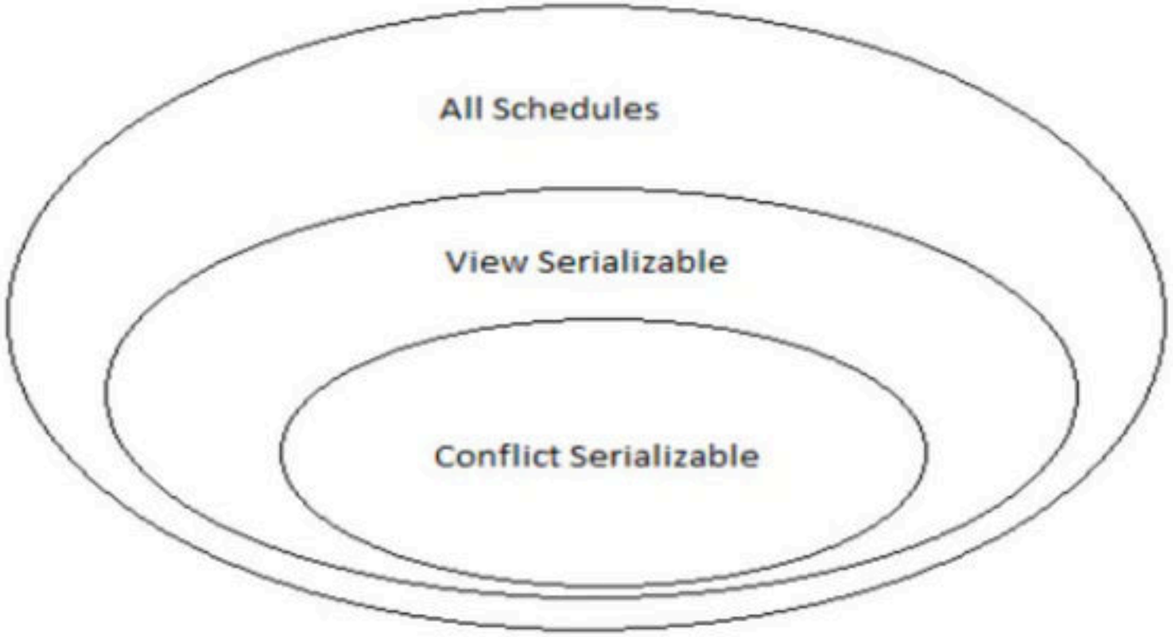
N.S



VIEW SERIALIZABLE

- If a schedule is not conflict serializable, still it can be consistent, so let us study a weaker form of serializability called View serializability, and even if a schedule is view serializable still it can be consistent.

- If a schedule is conflict serializable then it will also be view serializable, so we must check view serializability only if a schedule is not conflict serializable.



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- If a schedule is not conflict serializable then it must have at least one blind write to be eligible for view serializable.

- i.e. if a schedule is not conflict serializable and it does not contain any blind write then it can never be view serializable, but if not conflict serializable and have blind write then may or may not be view serializable.

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- If a schedule is not conflict serializable and if there exist a blind write.
- First tabulate all serial schedules possible. Then check one by one whether given schedule is view equivalent to any of the serial schedule.
- If yes then schedule is view serializable otherwise not.

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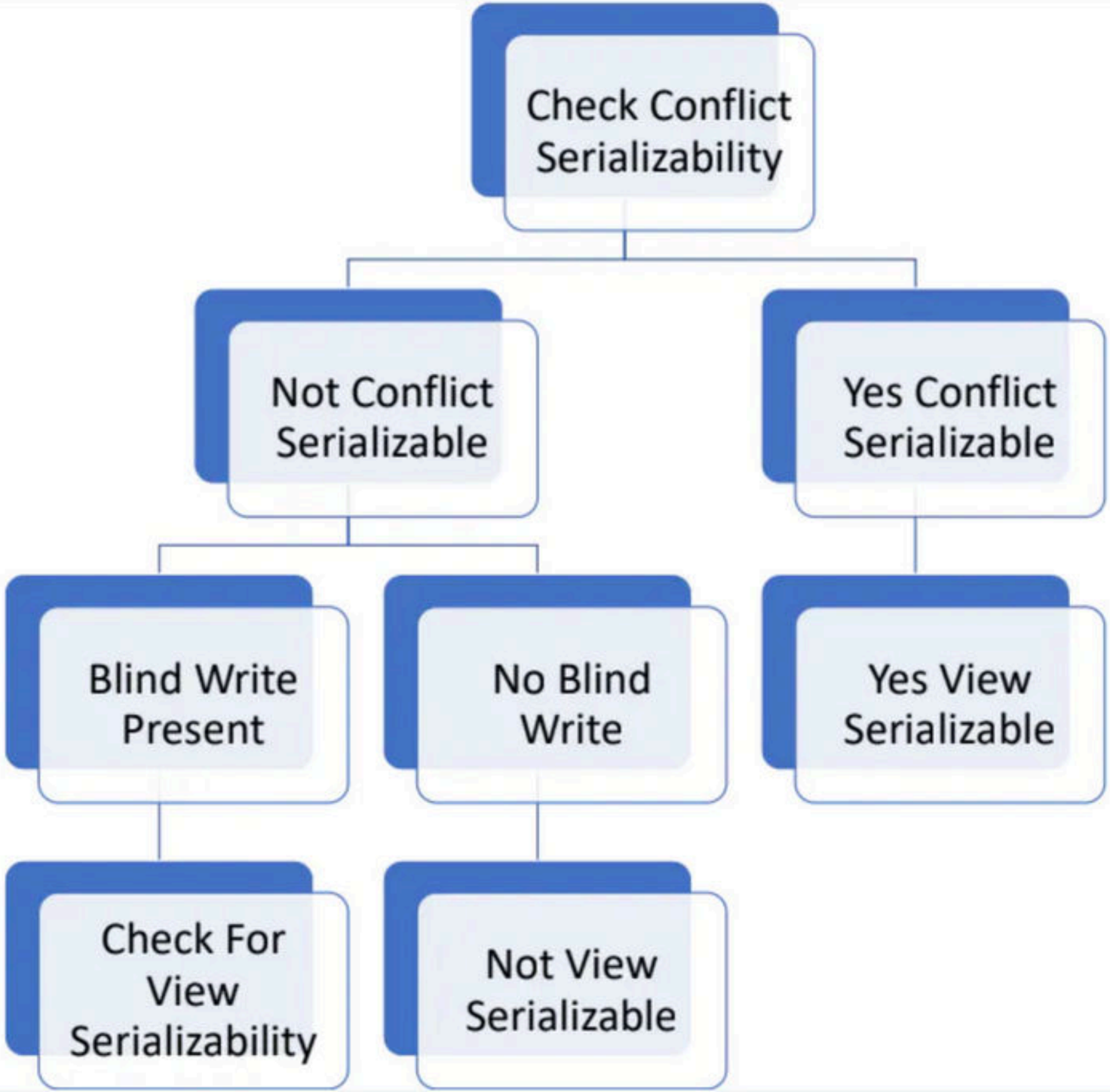
Check Conflict Serializability
Not Conflict Serializable
Yes Conflict Serializable
Blind Write Present
No Blind Write
Yes View Serializable
Check For View Serializability
Not View Serializable

- Two schedules S and S' are view equivalent, if they satisfy following conditions –
  - For each data item Q, if the transaction T_i reads the initial value of Q in schedule S , then then the transaction T_i must, in schedule S' ,also read the initial value of Q.
  - If a transaction T_i in schedule S reads any data item Q, which is updated by transaction T_j, then a transaction T_i must in schedule S' also read data item Q updated by transaction T_j in schedule S'.
  - For each data item Q, the transaction (if any) that performs the final write(Q) operation in schedule S, then the same transaction must also perform final write(Q) in schedule S'.

T_1	T_2
read(A)	
write(A)	
	read(A)
	write(A)
read(B)	
write(B)	
	read(B)
	write(B)

T_1	T_2
read(A)	
write(A)	
read(B)	
write(B)	
	read(A)
	write(A)
	read(B)
	write(B)

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- Complexity wise finding the schedule is view serializable or not is a **NP- complete** problem.

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View Serializable

- A schedule S is view serializable, if it is view equivalent to a serial schedule.

Schedule A		
T3	T4	T6
read(Q)		
	write(Q)	
write(Q)		
		write(Q)

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View Serializable

A schedule S is view serializable, if it is view equivalent to a serial schedule.

Schedule A				Serial schedule <T3,T4,T6>		
T3	T4	T6		T3	T4	T6
read(Q)				read(Q)		
	write(Q)			write(Q)		
write(Q)					write(Q)	
		write(Q)				write(Q)

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- ***BLIND WRITES***- In the above example, transaction T_4 and T_6 perform write operation on data item Q without accessing (reading the data item), such updation without knowing/accessing previous value of data item, are called Blind updation or **BLIND WRITE.**

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Break

Q A Schedule that is not conflict serializable and contains at least one blind write then the schedule is

a) Always view serializable

b) Always non-serializable

c) May be View serializable

d) None of the above

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Q Which of the following statements (s) is/are TRUE?

S_1: All view serializable schedules are also conflict serializable.

S_2: All conflict serializable schedules are also view serializable.

S_3: If a schedule is not conflict serializable then it is not view serializable

S_4: If a schedule is not view serializable then it is not conflict serializable.

a) S_1 and S_2 only

b) S_2 and S_3 only

c) S_2 and S_4 only

d) S_1 and S_3 only

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Q Consider the following schedule 'S' with three transactions.

S: $R_1(B); R_3(C); R_1(A); W_2(A); W_1(A), W_2(B); W_3(A); W_1(B); W_3(B), W_3(C)$

Which of the following is TRUE with respect to the above schedule?

a) It is conflict serializable with sequence $[T_1, T_2\ T_3]$

b) It is conflict serializable with sequence $[T_2, T_1\ T_3]$

c) It is view serializable but not conflict serializable

d) It is neither conflict serializable nor view serializable

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Q Consider the following schedule 'S' with three transactions.

S: $R_1(B); R_3(C); R_1(A); W_2(A); W_1(A), W_2(B); W_3(A); W_1(B); W_3(B), W_3(C)$

Which of the following is TRUE with respect to the above schedule?

a) It is conflict serializable with sequence $[T_1, T_2\ T_3]$

b) It is conflict serializable with sequence $[T_2, T_1\ T_3]$

c) It is view serializable but not conflict serializable

d) It is neither conflict serializable nor view serializable

S		
T_1	T_2	T_3
R(B)		
		R(C)
R(A)		
	W(A)	
W(A)		
	W(B)	
		W(A)
W(B)		
		W(B)
		W(C)

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Q The following schedule S is having 4 transactions and is executed concurrently. The order of their operations is given below.

S: R_1 (x); R_2 (y); W_2 (x); W_3 (z); R_4 (z); R_3 (x); W_3 (y); W_1 (x); W_2 (y) W_3 (x); R_4(x); W_4 (y); $commit_1$; $commit_2$; $commit_3$; $commit_4$;

The schedule is

a) Conflict serializable with sequence [T_1 T_2 T_3 T_4]

b) Conflict serializable with sequence [T_2 T_1 T_3 T_4]

c) View serializable but not conflict serializable

d) Neither conflict serializable nor view serializable

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Q The following schedule S is having 4 transactions and is executed concurrently. The order of their operations is given below.

S: R_1 (x); R_2 (y); W_2 (x); W_3 (z); R_4 (z); R_3 (x); W_3 (y); W_1 (x); W_2 (y) W_3 (x); R_4(x); W_4 (y); $commit_1$; $commit_2$; $commit_3$; $commit_4$;

The schedule is

a) Conflict serializable with sequence [T_1 T_2 T_3 T_4]

b) Conflict serializable with sequence [T_2 T_1 T_3 T_4]

c) View serializable but not conflict serializable

d) Neither conflict serializable nor view serializable

S			
T_1	T_2	T_3	T_4
R(X)			
	R(Y)		
	W(X)		
		W(Z)	
			R(Z)
		R(X)	
		W(Y)	
W(X)			
	W(Y)		
		W(X)	
			R(X)
			W(Y)
C			
	C		
		C	
			C

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Break

NON- RECOVERABLE SCHEDULE

- A schedule in which for each pair of transaction T_i and T_j, such that if T_j reads a data item previously written by T_i, then the commit or abort operation of T_i appears before T_j. Such a schedule is called Non- Recoverable schedule.

S	
T_1	T_2
R(X)	
W(X)	
	R(X)
	C
C	

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RECOVERABLE SCHEDULE

- A schedule in which for each pair of transaction T_i and T_j, such that if T_j reads a data item previously written by T_i, then the commit or abort of T_i must appear before T_j. Such a schedule is called Recoverable schedule.

S	
T_1	T_2
R(X)	
W(X)	
	R(X)
C	
	C

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Q Consider the following schedule S of transactions T_1, T_2, T_3, T_4 **(GATE - 2014) (2 Marks)**
Which one of the following statements is CORRECT?

(A) S is conflict-serializable but not recoverable
(B) S is not conflict-serializable but is recoverable
(C) S is both conflict-serializable and recoverable
(D) S is neither conflict-serializable nor is it recoverable

T1	T2	T3	T4
	Reads(X)		
		Writes(X) Commit	
Writes(X) Commit			
	Writes(Y) Reads(Z) Commit		
			Reads(X) Reads(Y) Commit

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Break

CASCADING ROLLBACK

- It is a phenomenon, in which a single transaction failure leads to a series of transaction rollbacks, is called cascading rollback. Even if the schedule is recoverable the, the commit of transaction may lead lot of transaction to rollback.

- Cascading rollback is undesirable, since it leads to undoing of a significant amount of work. Uncommitted reads are not allowed in cascade less schedule.

S		
T_1	T_2	T_3
R(X)		
W(X)		
	R(X)	
	W(X)	
		R(X)
C		
	C	
		C

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CASCADELESS SCHEDULE

- To avoid cascading rollback, cascade less schedule are used.

- A schedule in which for each pair of transactions T_i and T_j, such that if T_j reads a data item previously written by T_i then the commit or abort of T_i must appear before read operation of T_j. Such a schedule is called cascade less schedule.

S		
T_1	T_2	T_3
R(X)		
W(X)		
C		
	R(X)	
	W(X)	
	C	
		R(X)
		C

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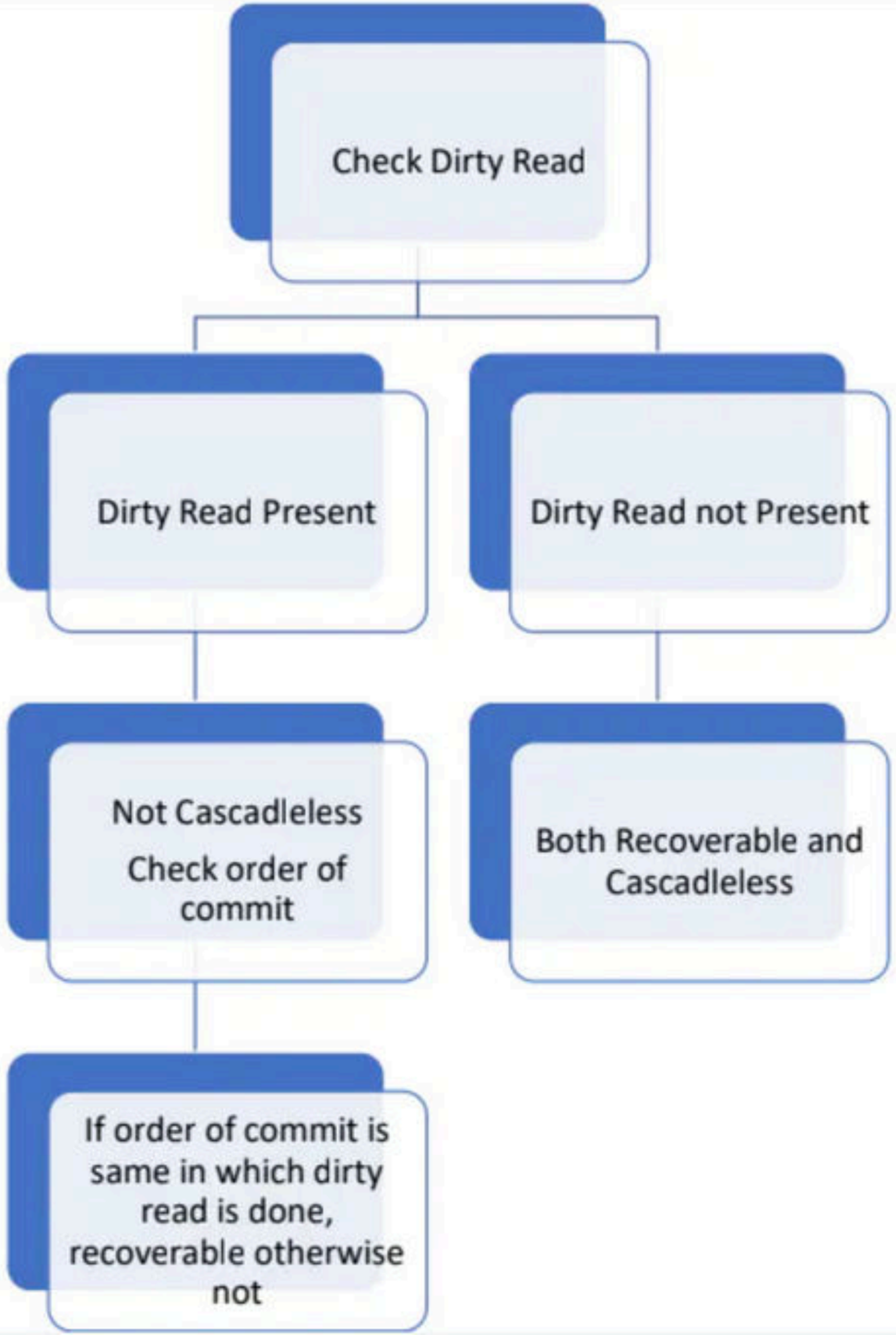
Check Dirty Read
Dirty Read Present
Dirty Read not Present
Not Cascadleless
Check order of commit
Both Recoverable and Cascadleless
If order of commit is same in which dirty read is done, recoverable otherwise not

Q Consider the following partial Schedule S involving two transactions T_1 and T_2. Only the read and the write operations have been shown. The read operation on data item P is denoted by read(P) and the write operation on data item P is denoted by write(P).

Suppose that the transaction T_1 fails immediately after time instance 9. Which one of the following statements is correct? **(GATE-2015) (2 Marks)**

(A) T_2 must be aborted and then both T_1 and T_2 must be re-started to ensure transaction atomicity

(B) Schedule S is non-recoverable and cannot ensure transaction atomicity

(C) Only T_2 must be aborted and then re-started to ensure transaction atomicity

(D) Schedule S is recoverable and can ensure atomicity and nothing else needs to be done

Time	Transaction-id	
	T1	*T2*
1	*read(A)*	
2	*write(A)*	
3		*read(C)*
4		*write(C)*
5		*read(B)*
6		*write(B)*
7		*read(A)*
8		*commit*
9	*read(B)*	

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Break

Strict Schedule

- A schedule in which for each pair of transactions T_i and T_j, such that if T_j reads a data item previously written by T_i then the commit or abort of T_i must appear before read and write operation of T_j.

S_1	
T_1	T_2
R(a)	
W(a)	
	W(a)
C	
	R(a)
	C

S_2	
T_1	T_2
R(a)	
W(a)	
C	
	W(a)
	R(a)
	C

S_3	
T_1	T_2
R(a)	
	R(b)
W(a)	
	W(b)
C	
	R(a)
	C

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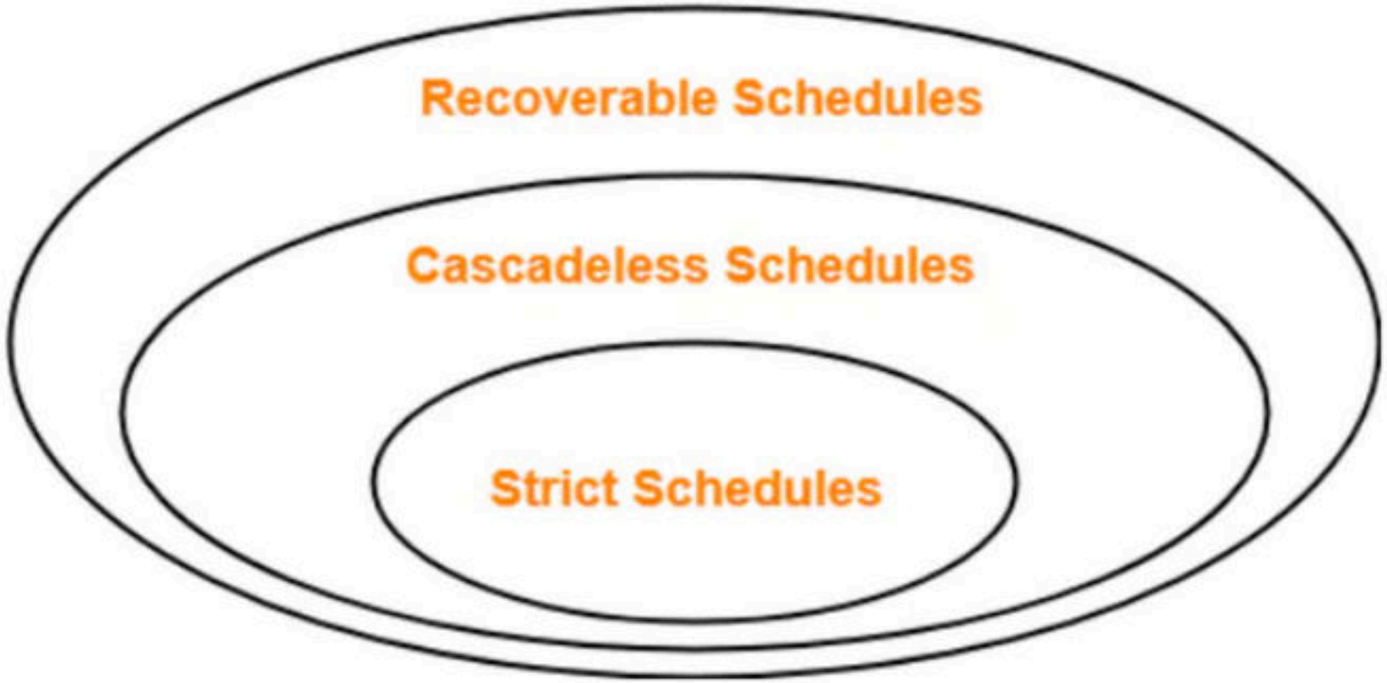

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Q Consider the following database schedule with two transactions, T_1 and T_2. $S = r_2(X); r_1(X); r_2(Y); w_1(X); r_1(Y); w_2(X); a_1; a_2$. where $r_i(Z)$ denotes a read operation by transaction T_i on a variable Z, $w_i(Z)$ denotes a write operation by T_i on a variable Z and a_i denotes an abort by transaction T_i. Which one of the following statements about the above schedule is **TRUE**? **(GATE-2016) (1 Marks)**

(a) S is non-recoverable

(b) S is recoverable, but has a cascading abort

(c) S does not have a cascading abort

(d) S is strict

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Q Consider the following database schedule with two transactions, T_1 and T_2. $S = r_2(X); r_1(X); r_2(Y); w_1(X); r_1(Y); w_2(X); a_1; a_2$. where $r_i(Z)$ denotes a read operation by transaction T_i on a variable Z, $w_i(Z)$ denotes a write operation by T_i on a variable Z and a_i denotes an abort by transaction T_i. Which one of the following statements about the above schedule is **TRUE**? **(GATE-2016) (1 Marks)**

(a) S is non-recoverable

(b) S is recoverable, but has a cascading abort

(c) S does not have a cascading abort

(d) S is strict

S	
T_1	T_2
	R(x)
R(X)	
	R(Y)
W(X)	
R(Y)	
	W(X)
a_1	
	a_2

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Q Consider the following schedules:

S_1: $R_1(x)$ $W_1(x)$ $R_1(y)$ $R_2(x)$ $W_2(x)$ C_2, C_1;

S_2: $R_2(x)$ $W_2(x)$ $R_1(y)$ $R_1(x)$ $W_2(x)$ C_2, C_1;

Which of the following is true?

a) Both S_1 and S_2 are recoverable

b) S_1 is recoverable but S_2 is not

c) S_2 is recoverable but S_1 is not

d) Both schedule are not Recoverable

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Q Consider the following schedules:

S_1: $R_1(x)\ W_1(x)\ R_1(y)\ R_2(x)\ W_2(x)\ C_2,\ C_1;$

S_1	
T_1	T_2
R(x)	
W(x)	
R(y)	
	R(x)
	W(x)
	C
C	

S_2: $R_2(x)\ W_2(x)\ R_1(y)\ R_1(x)\ W_2(x)\ C_2,\ C_1;$

S_2	
T_1	T_2
	R(x)
	W(x)
R(y)	
R(x)	
	W(x)
	C
C	

Which of the following is true?

a) Both S_1 and S_2 are recoverable

b) S_1 is recoverable but S_2 is not

c) S_2 is recoverable but S_1 is not

d) Both schedule are not Recoverable

Q Consider the following schedule 'S'.

S: $r_1(X)$; $r_2(Z)$; $r_3(X)$; $r_1(Z)$; $r_2(Y)$; $r_3(Y)$; $w_1(X)$; c_1; $w_2(Z)$; $w_3(Y)$; $w_2(Y)$; c_3; c_2;

The schedule 'S' is

a) Recoverable

b) Cascade less

c) recoverable and cascade-less

d) None

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Q Consider the following schedule 'S'.

S: $r_1(X); r_2(Z); r_3(X); r_1(Z); r_2(Y); r_3(Y); w_1(X); c_1; w_2(Z); w_3(Y); w_2(Y); c_3; c_2;$

The schedule 'S' is

a) Recoverable

b) Cascade less

c) recoverable and cascade-less

d) None

S		
T_1	T_2	T_3
R(X)		
	R(Z)	
		R(X)
R(Z)		
	R(Y)	
		R(Y)
W(X)		
C		
	W(Z)	
		W(Y)
	W(Y)	
		C
	C	

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Q Consider the given schedule

$R_1(X)$, $R_2(Z)$, $R_1(Z)$, $R_3(X)$, $R_3(Y)$, $W_1(X)$, $Commit_1$, $W_3(Y)$, $Commit_3$, $R_2(Y)$, $W_2(Z)$, $W_2(Y)$, $Commit_2$. The given schedule is

a) Recoverable only

b) Cascade less only

c) recoverable and cascade-less

d) None

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Q Consider the given schedule

$R_1(X)$, $R_2(Z)$, $R_1(Z)$, $R_3(X)$, $R_3(Y)$, $W_1(X)$, $Commit_1$, $W_3(Y)$, $Commit_3$, $R_2(Y)$, $W_2(Z)$, $W_2(Y)$, $Commit_2$. The given schedule is

a) Recoverable only

b) Cascade less only

c) recoverable and cascade-less

d) None

S		
T_1	T_2	T_3
R(X)		
	R(Z)	
R(Z)		
		R(X)
		R(Y)
W(X)		
C		
		W(Y)
		C
	R(Y)	
	W(Z)	
	W(Y)	
	C	

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Q Consider the following schedule

S; $R_2(x)$, $w_2(x)$, $R_3(y)$, $R_1(x)$, $R_1(y)$, $w_1(x)$, $w_3(y)$, $R_3(x)$, $R_1(y)$, C_3, C_2, C_1;

The above schedule is

a) Recoverable but not cascade less

b) Recoverable and cascade less but not strict

c) Recoverable, cascade less and also strict

d) Not recoverable

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Q Consider the following schedule

S: $R_2(x)$, $w_2(x)$, $R_3(y)$, $R_1(x)$, $R_1(y)$, $w_1(x)$, $w_3(y)$, $R_3(x)$, $R_1(y)$, C_3, C_2, C_1;

The above schedule is

a) Recoverable but not cascade less

b) Recoverable and cascade less but not strict

c) Recoverable, cascade less and also strict

d) Not recoverable

S		
T_1	T_2	T_3
	R(X)	
	W(X)	
		R(Y)
R(X)		
R(Y)		
W(X)		
		W(Y)
		R(X)
R(Y)		
		C
	C	
C		

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Q Which of the following statement is/are correct

a) Every view serializable schedule is conflict serializable

b) Every strict schedule is conflict serializable

c) Every conflict serializable schedule is cascade less

d) None of the above

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