Chapter Two

Transaction

What is a Transaction?

- **A Transaction:**
  - Logical unit of database processing that includes one or more access operations (read -retrieval, write - insert or update, delete).
- A transaction (set of operations) may be stand-alone specified in a high level language like SQL submitted interactively, or may be embedded within an application program.
- **Transaction boundaries**:
  - Any single transaction in an application program is bounded with Begin and End statements.
- An **application program** may contain several transactions separated by the Begin and End transaction boundaries

Transaction operations

- the basic database access operations that a transaction can include are as follows:

■ read_item(*X*)*.*

✓ Reads a database item named X into a program variable

■ write_item(*X*)*.*

✓ Writes the value of program variable X into the database item named *X.*

- The basic access is one disk block from disk to memory

read_item(*X)*

- Executing a read_item(*X) command includes* the following steps:

1. Find the address of the disk block that contains x
2. Copy the disk block to memory buffer(if not in memory)
3. Copy the item from the buffer to program variable x

write_item(*X)*

- Executing a write_item(*X) command includes the following steps:*

1. Find the address of the disk block that contains x
2. Copy the disk block to memory buffer (if not in memory)
3. Copy the program variable x into buffer
4. Store the updated buffer to disk

A Transaction: An Informal Example

- E.g. Transfer transaction to transfer 500 birr from account A to account B: For a user it is one activity
- To database:
  - Read balance of A : read(A)
  - Read balance of B : read (B)
  - Subtract 500 birr from A
  - Add 500 birr to B
  - Write new value of A back to disk
  - Write new value of B back to disk

Cont'd

- Transaction to transfer 500 birr from account A to account B:
  1. **read**(*A*)
  2. *A* := *A* – 500
  3. **write**(*A*)
  4. **read**(*B*)
  5. *B* := *B* + 500
  6. **write**(*B)*

Transaction states and additional operations

- For recovery purposes, it keeps track of start, terminate and commits or aborts
- the recovery manager of the DBMS needs to keep track of the following operations :
  - ✓BEGIN_TRANSACTION
  - ✓ READ OR WRITE
  - ✓ END_TXN
  - ✓ COMMIT_TXN
  - ✓ ROLLBACK or ABORT
- Failed state need rollback operation

Transaction States

- transaction must be in one of several states:
  - **Active :** A transaction that has executed at least one action, but has not completed.
  - **Partially committed :** A transaction that has completed all actions, but has not been confirmed as completed.
  - **Failed :** A transaction that fails completion checks, or is aborted during the active state.
  - **Committed :** A completed and checked transaction
  - **Aborted :** A transaction that has failed and has had no effect on the database system

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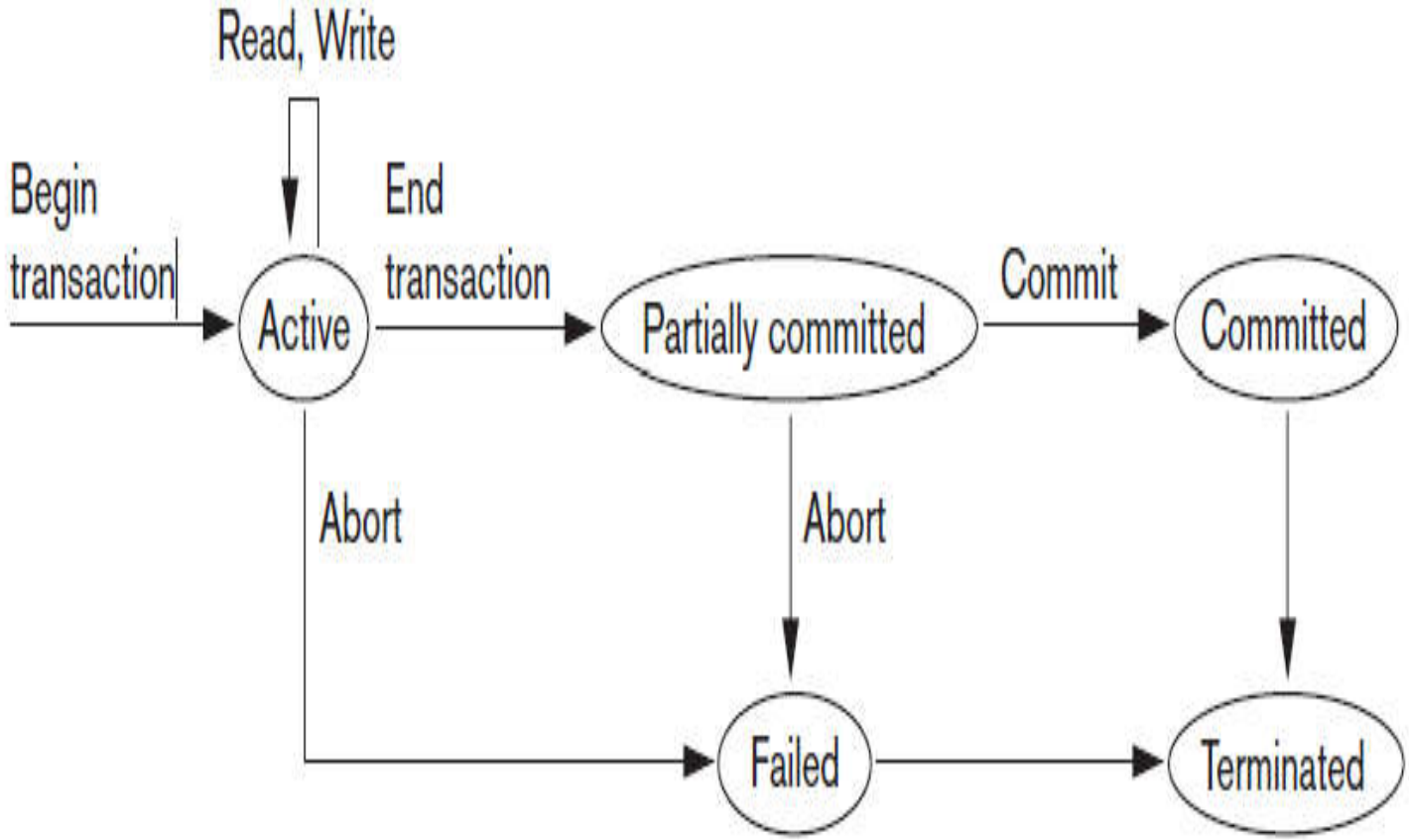

Read, Write
Begin transaction
Active
End transaction
Partially committed
Commit
Committed
Abort
Abort
Failed
Terminated

Desirable Properties of Transactions

- Transactions should possess several properties, often called the **ACID properties;**
- The following are the ACID properties
  - ✓**Atomicity**
  - ✓**Consistency preservation**
  - ✓**Isolation**
  - ✓**Durability or permanency**

Cont’d

- **Atomicity**

✓ A transaction is an atomic unit of processing;

✓ it should either be performed in its entirety or not performed at all

- **Consistency preservation.**

✓ A transaction should be consistency preserving,

✓ it is completely executed from beginning to end without interference from other transactions,

Cont’d

- **Isolation**

✓ A transaction should appear as though it is being executed in isolation from other transactions,

✓ even though many transactions are executing concurrently

- **Durability or permanency.**

✓ 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.

Schedules

- Multiple transactions can be executed concurrently by interleaving their operations
- **Schedule S** – a sequences of instructions that specify the **chronological order** in which instructions of concurrent transactions T_1, T_2, … , T_n are executed
  - A schedule for a set of transactions **must consist** of all instructions of those transactions.
  - Must **preserve** the order in which the instructions appear in each individual transaction.

Cont'd

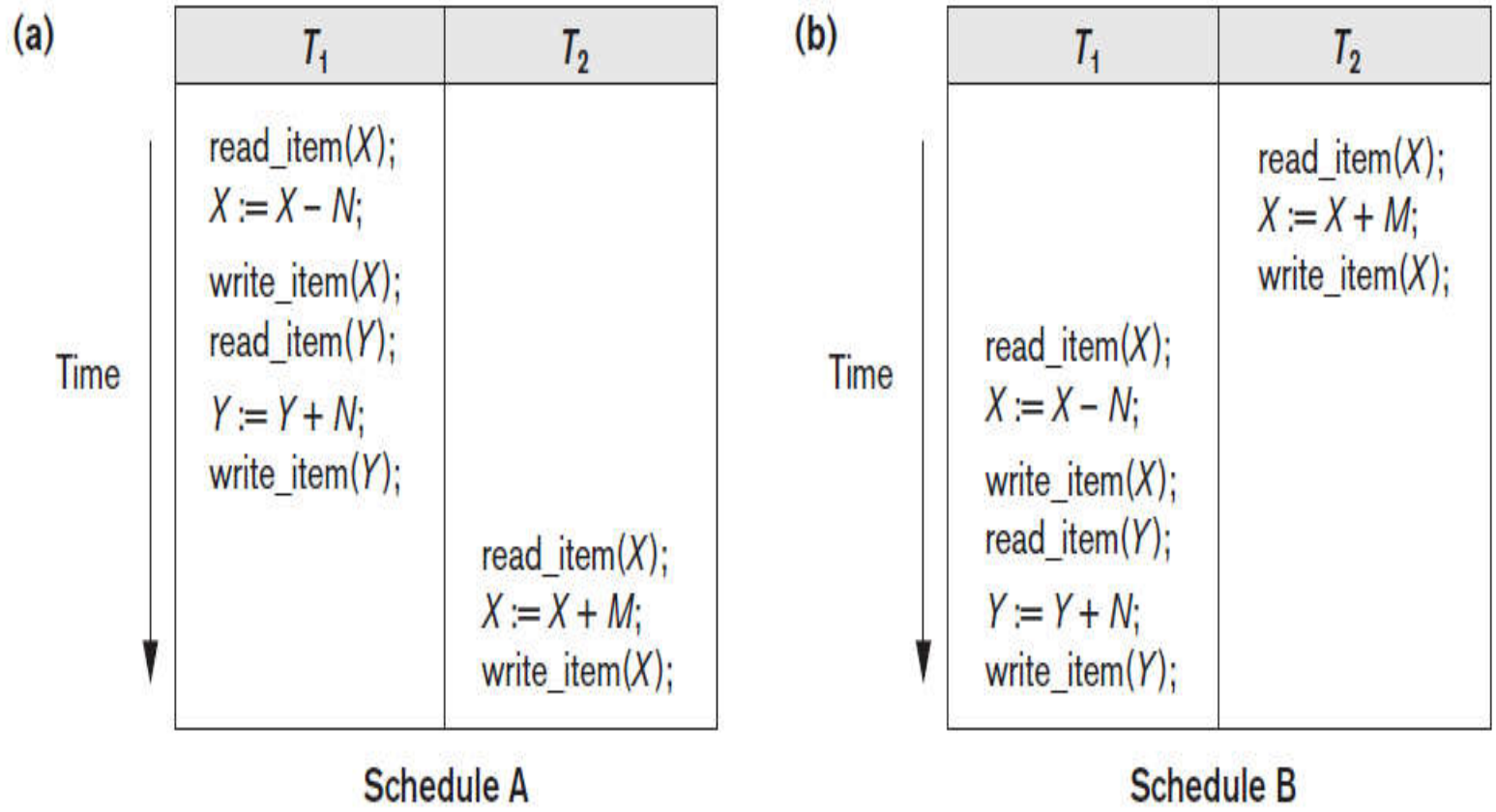
Serial schedule

- ✓ S is a schedule that executes all of the operations from one transaction T1, before moving on to the operations of another transaction T2.

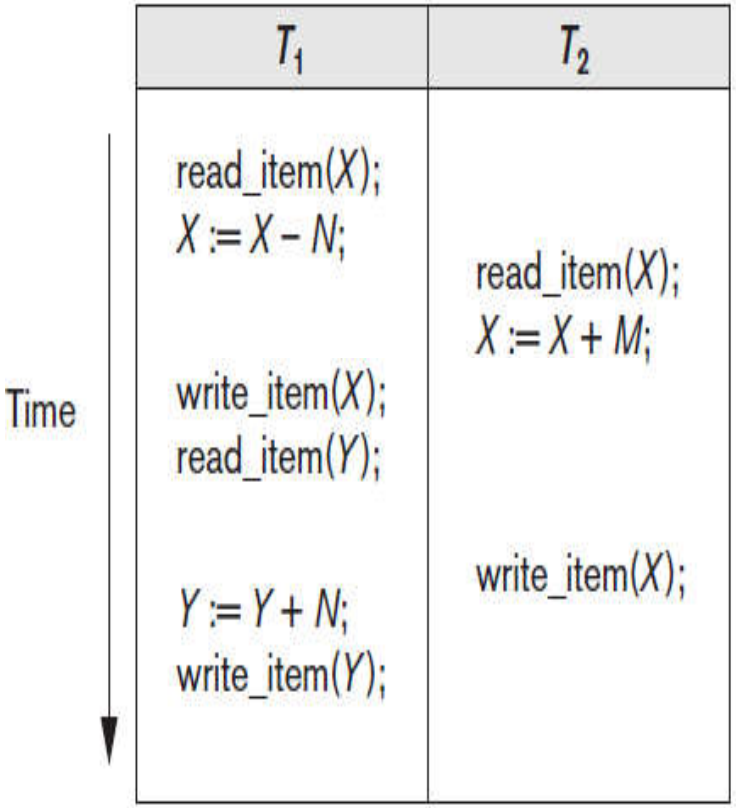
Non-serial schedule(*interleaved* schedule)

- ✓ An is a schedule in which the operations of an individual transaction are executed in order with respect to the same transaction,
- ✓ This is a type of Scheduling where the operations of multiple transactions are interleaved.
- ✓ This might lead to a rise in the concurrency problem

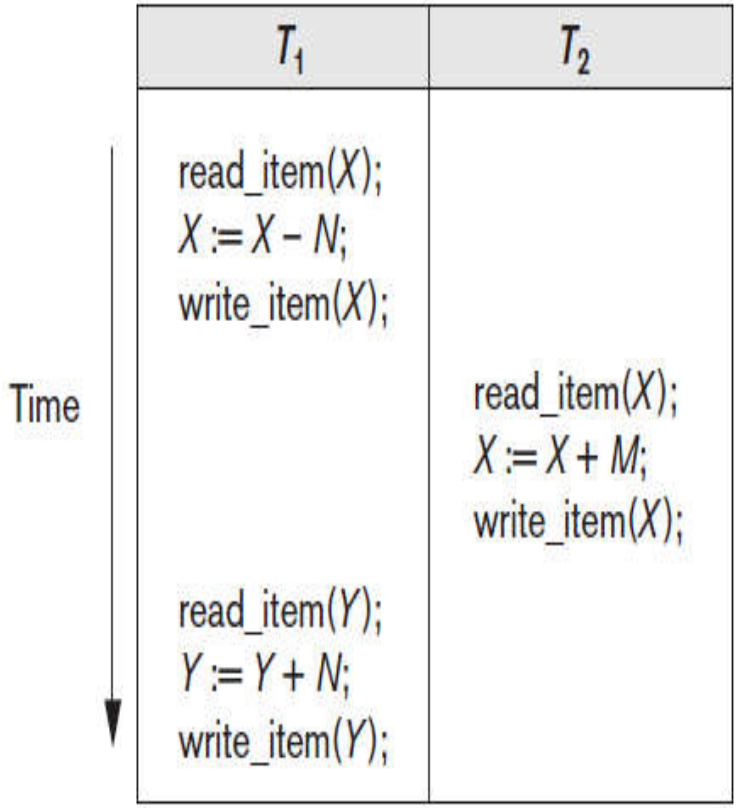
Serial schedule



Non-serial schedules



Schedule C



Schedule D

Result Equivalent Schedules

- Two schedules are result equivalent if they produce the same final state of the database
- Problem: May produce same result by accident!

S1	S2
read_item(X);	read_item(X);
X:=X+10;	X:=X*1.1;
write_item(X);	write_item(X);

Schedules S1 and S2 are result equivalent for X=100 but not in general

Characterizing Schedules based on Serializability

- The concept of Serializable of schedule is used to identify which schedules are correct when concurrent transactions executions have interleaving of their operations in the schedule
- Serial schedule:
  - A schedule S is serial if, for every transaction T participating in the schedule, all the operations of T are executed consecutively in the schedule.
    - Otherwise, the schedule is called nonserial schedule.
- Serializable schedule:
  - a schedule whose effect on any consistent database instance is identical to that of some complete serial schedule over the set of *committed* transactions in *S*.
  - A nonserial schedule S is serializable is equivalent to say that it is correct to the result of one of the serial schedule

Serializability of Schedules

Serializability

- A schedule *S* of *n* transactions is **serializable** if it is *equivalent to some serial schedule* of the same *n* transactions
- **Kinds** of **serializability**
  - Conflict-serializable schedule
  - View-serializable schedule

Result Equivalent Schedules

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Two types of equivalent schedule:

- Two schedules are said to be conflict equivalent if the order of any two conflicting operations is the same in both schedules.
- Eg
  - S1: r1(x); w2(x) & S2: w2(x); r1(x)
  - S1: w1(x); w2(x); & S2: w2(x); w1(x);

Not conflict equivalent

- Conflict serializable:
  - A schedule S is said to be conflict serializable if it is conflict equivalent to some serial schedule S'.
  - Every conflict serializable schedule is serializable .

Conflict Serializable

- Schedule S is conflict serializable if it is conflict equivalent to some *serial* schedule S'
  - We can reorder the *non-conflicting* operations to improve efficiency
- Non-conflicting operations:
  - Reads and writes from same transaction
  - Reads from different transactions
  - Reads and writes from different transactions on different data items
- Conflicting operations:
  - Reads and writes from different transactions on same data item

- Two operations in a schedule are side to be conflict if they satisfy all the three of the following conditions.
  - They belongs to different transaction
  - They access the same data item X
  - At least one of the operation is a write_Item(X)

Eg. Sa: r1(X); r2(x); w1(X); r1(Y); W2(X); W1(Y);

- r1(X) and w2(X)
- r2(X) and w1(X);
- W1(X) and w2(X)

} Conflict operations

- r1(X) and r2(X)
- W2(X) and w1(Y)

} No Conflict

Cont'd

Testing for conflict serializability: Algorithm

- Looks at only read_Item (X) & write_Item (X) operations
- Constructs a precedence graph (serialization graph) - a graph with directed edges
- An edge is created from Ti to Tj if one of the operations in Ti appears before a conflicting operation in Tj
- The schedule is serializable if and only if the precedence graph has no cycles.

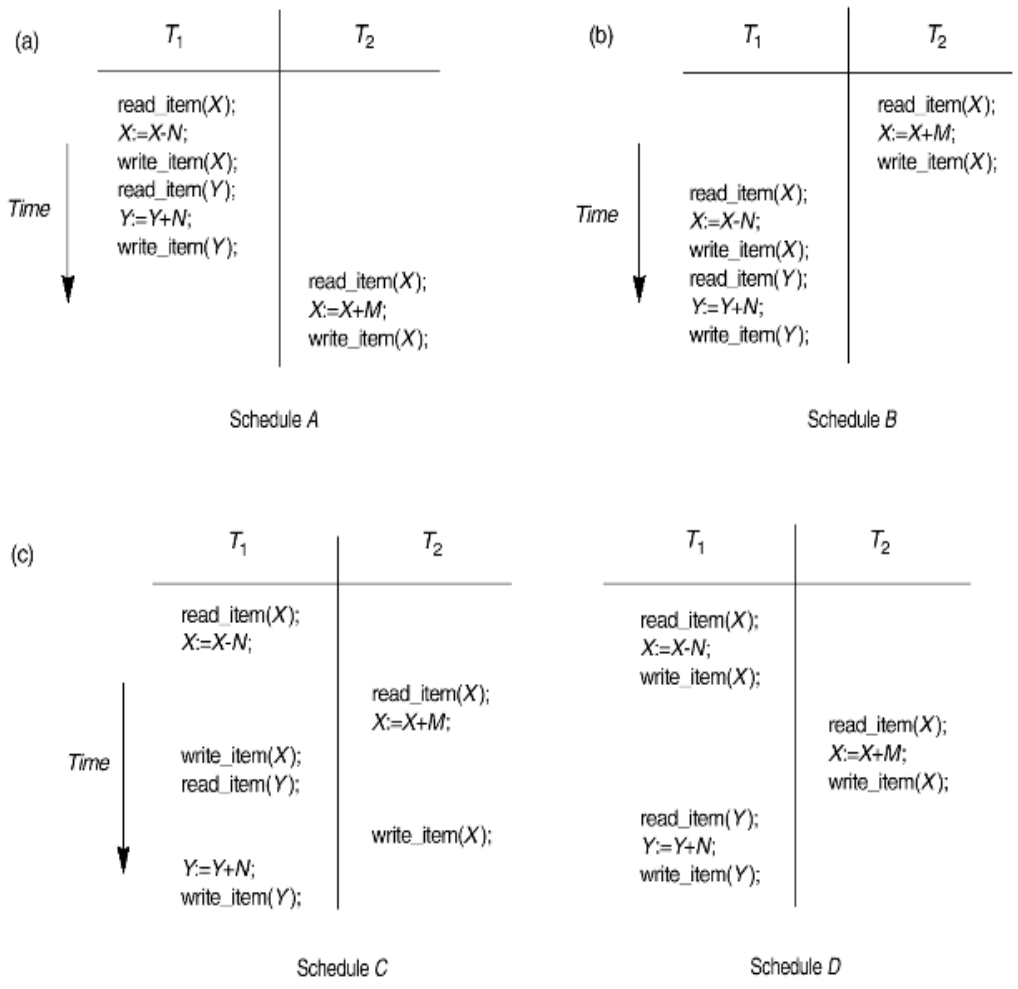
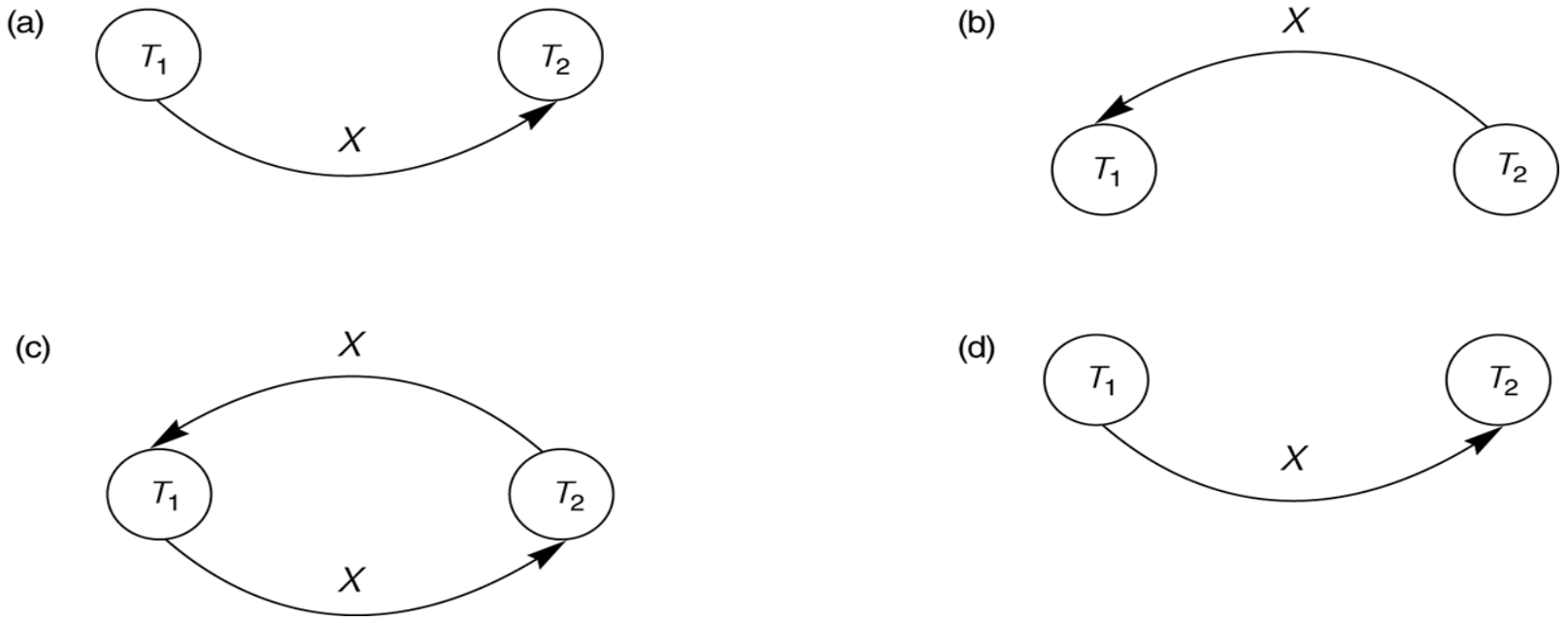


Fig 1: Examples of serial and nonserial schedules involving transactions T_1 and T_2.

Constructing the Precedence Graphs

- FIGURE 2: Constructing the precedence graphs for schedules A and D from Figure 1 to test for conflict serializability.
  (a) Precedence graph for serial schedule A.
  (b) Precedence graph for serial schedule B.
  (c) Precedence graph for schedule C (not serializable).
  (d) Precedence graph for schedule D (serializable, equivalent to schedule A).



View Equivalence and View Serializability

- **View Serializability** is a process to find out that a given **schedule** is view serializable or not.
- To check whether a given schedule is view serializable,
- we need to check whether the given schedule is **View Equivalent** to its serial schedule.
  - **Definition of serializability based on view equivalence.**

  A schedule is *view serializable* if it is *view equivalent* to a serial schedule
- A schedule is *view serializable* if it is *view equivalent* to a serial schedule

view equivalence:

- As long as each read operation of a transaction reads the result of *the same write operation* in both schedules,
- the write operations of each transaction must produce the same results.
- **“The view”**: the read operations are said to see the *same view* in both schedules.

- Two schedules are said to be view equivalent if the following three conditions hold:
  1. The same set of transactions participates in S and S', and S and S' include the same operations of those transactions.
  2. If Ti reads a value **A** written by Tj in S1 , it must also read the value of **A** written by Tj in S2
  3. for each data object A, the transaction that perform the final write on x in S1 must also perform the final write on **A** in S2

S'

T1: R(A)	W(A)	
T2:	W(A)	
T3:		W(A)

view

S

T1: R(A),W(A)		
T2:	W(A)	
T3:		W(A)

- **Relationship between view and conflict equivalence**:
  - The two are same under **constrained write assumption** which assumes that if T writes X, it is constrained by the value of X it read;

    i.e., new X = f(old X)
  - Conflict serializability is **stricter** than view serializability.
  - a schedule that is view serializable is not necessarily conflict serializable.
  - Any conflict serializable schedule is also view serializable, but not vice versa.

Reading Assignment

Strict schedule