TRANSACTION

- The transaction is a set of logically related operation. It contains a group of tasks.
- A transaction is an action or series of actions. It is performed by a single user to perform operations for accessing the contents of the database.

Example: Suppose an employee of bank transfers Rs 800 from X's account to Y's account. This small transaction contains several low-level tasks:

X's Account

1. Open_Account(X)
2. Old_Balance = X.balance
3. New_Balance = Old_Balance - 800
4. X.balance = New_Balance
5. Close_Account(X)

Y's Account

1. Open_Account(Y)
2. Old_Balance = Y.balance
3. New_Balance = Old_Balance + 800
4. Y.balance = New_Balance
5. Close_Account(Y)

Operations of Transaction:

Following are the main operations of transaction:

Read(X): Read operation is used to read the value of X from the database and stores it in a buffer in main memory.

Write(X): Write operation is used to write the value back to the database from the buffer.

Let's take an example to debit transaction from an account which consists of following operations:

1. 1. R(X);
2. 2. X = X - 500;
3. 3. W(X);

Let's assume the value of X before starting of the transaction is 4000.

- The first operation reads X's value from database and stores it in a buffer.
- The second operation will decrease the value of X by 500. So buffer will contain 3500.
- The third operation will write the buffer's value to the database. So X's final value will be 3500.

But it may be possible that because of the failure of hardware, software or power, etc. that transaction may fail before finished all the operations in the set.

For example: If in the above transaction, the debit transaction fails after executing operation 2 then X's value will remain 4000 in the database which is not acceptable by the bank.

To solve this problem, we have two important operations:

Commit: It is used to save the work done permanently.

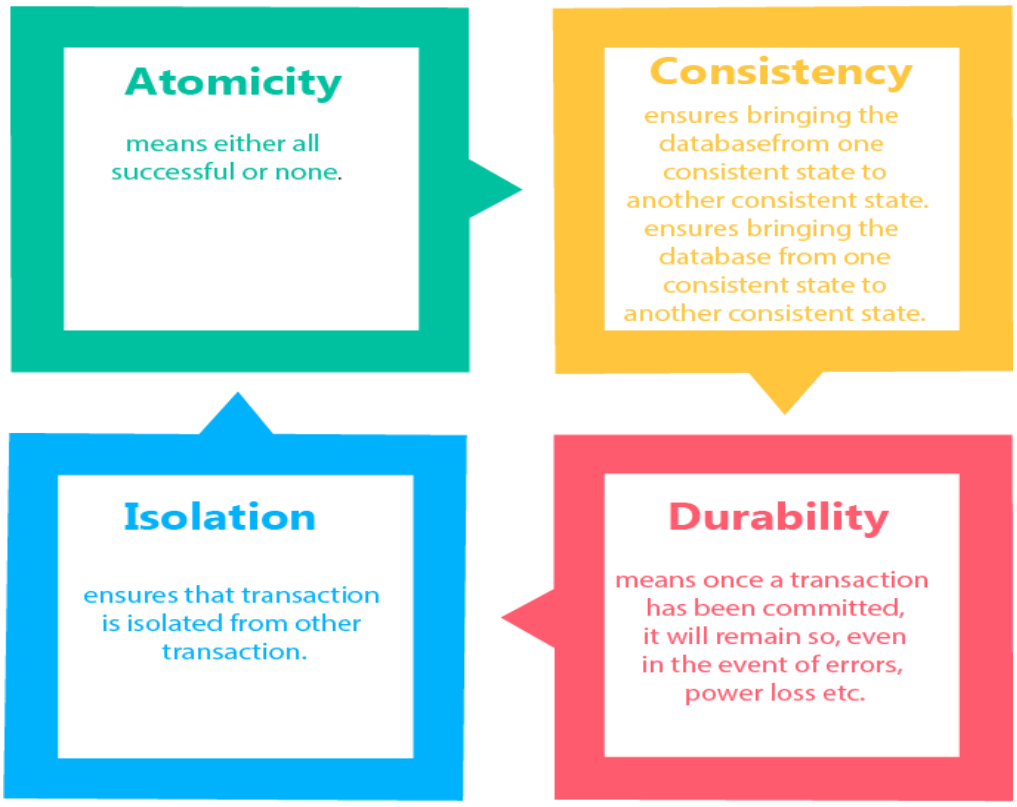
Rollback: It is used to undo the work done.

Transaction property

The transaction has the four properties. These are used to maintain consistency in a database, before and after the transaction.

Property of Transaction

1. Atomicity
2. Consistency
3. Isolation
4. Durability



Atomicity

- It states that all operations of the transaction take place at once if not, the transaction is aborted.
- There is no midway, i.e., the transaction cannot occur partially. Each transaction is treated as one unit and either run to completion or is not executed at all.

Atomicity involves the following two operations:

Abort: If a transaction aborts then all the changes made are not visible.

Commit: If a transaction commits then all the changes made are visible.

Example: Let's assume that following transaction T consisting of T1 and T2. A consists of Rs 600 and B consists of Rs 300. Transfer Rs 100 from account A to account B.

T1	T2
Read(A) A:= A-100 Write(A)	Read(B) Y:= Y+100 Write(B)

After completion of the transaction, A consists of Rs 500 and B consists of Rs 400.

If the transaction T fails after the completion of transaction T1 but before completion of transaction T2, then the amount will be deducted from A but not added to B. This shows the inconsistent database state. In order to ensure correctness of database state, the transaction must be executed in entirety.

Consistency

- The integrity constraints are maintained so that the database is consistent before and after the transaction.
- The execution of a transaction will leave a database in either its prior stable state or a new stable state.
- The consistent property of database states that every transaction sees a consistent database instance.
- The transaction is used to transform the database from one consistent state to another consistent state.

For example: The total amount must be maintained before or after the transaction.

1. Total before T occurs = 600+300=900
2. Total after T occurs= 500+400=900

Therefore, the database is consistent. In the case when T1 is completed but T2 fails, then inconsistency will occur.

Isolation

- It shows that the data which is used at the time of execution of a transaction cannot be used by the second transaction until the first one is completed.

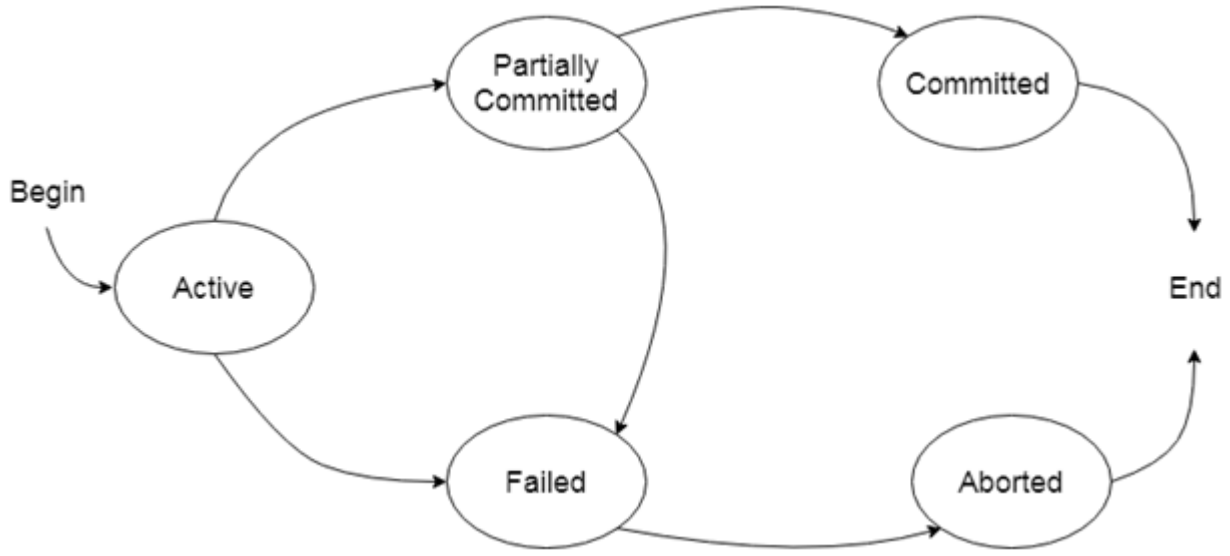
- In isolation, if the transaction T1 is being executed and using the data item X, then that data item can't be accessed by any other transaction T2 until the transaction T1 ends.
- The concurrency control subsystem of the DBMS enforced the isolation property.

Durability

- The durability property is used to indicate the performance of the database's consistent state. It states that the transaction made the permanent changes.
- They cannot be lost by the erroneous operation of a faulty transaction or by the system failure. When a transaction is completed, then the database reaches a state known as the consistent state. That consistent state cannot be lost, even in the event of a system's failure.
- The recovery subsystem of the DBMS has the responsibility of Durability property.

States of Transaction

In a database, the transaction can be in one of the following states -



Active state

- The active state is the first state of every transaction. In this state, the transaction is being executed.
- For example: Insertion or deletion or updating a record is done here. But all the records are still not saved to the database.

Partially committed

- In the partially committed state, a transaction executes its final operation, but the data is still not saved to the database.
- In the total mark calculation example, a final display of the total marks step is executed in this state.

Committed

A transaction is said to be in a committed state if it executes all its operations successfully. In this state, all the effects are now permanently saved on the database system.

Failed state

- If any of the checks made by the database recovery system fails, then the transaction is said to be in the failed state.
- In the example of total mark calculation, if the database is not able to fire a query to fetch the marks, then the transaction will fail to execute.

Aborted

- If any of the checks fail and the transaction has reached a failed state then the database recovery system will make sure that the database is in its previous consistent state. If not then it will abort or roll back the transaction to bring the database into a consistent state.
- If the transaction fails in the middle of the transaction then before executing the transaction, all the executed transactions are rolled back to its consistent state.
- After aborting the transaction, the database recovery module will select one of the two operations:
    1. Re-start the transaction
    2. Kill the transaction

Concurrency Control

- In the concurrency control, the multiple transactions can be executed simultaneously.
- It may affect the transaction result. It is highly important to maintain the order of execution of those transactions.

Problems of concurrency control

Several problems can occur when concurrent transactions are executed in an uncontrolled manner. Following are the three problems in concurrency control.

1. Lost updates
2. Dirty read
3. Unrepeatable read

1. Lost update problem

- When two transactions that access the same database items contain their operations in a way that makes the value of some database item incorrect, then the lost update problem occurs.
- If two transactions T1 and T2 read a record and then update it, then the effect of updating of the first record will be overwritten by the second update.

Example:

Transaction-X	Time	Transaction-Y
——	t1	——
Read A	t2	——
——	t3	Read A
Update A	t4	——
——	t5	Update A
——	t6	——

Here,

- At time t2, transaction-X reads A's value.

- At time t3, Transaction-Y reads A's value.
- At time t4, Transactions-X writes A's value on the basis of the value seen at time t2.
- At time t5, Transactions-Y writes A's value on the basis of the value seen at time t3.
- So at time T5, the update of Transaction-X is lost because Transaction y overwrites it without looking at its current value.
- Such type of problem is known as Lost Update Problem as update made by one transaction is lost here.

2. Dirty Read

- The dirty read occurs in the case when one transaction updates an item of the database, and then the transaction fails for some reason. The updated database item is accessed by another transaction before it is changed back to the original value.
- A transaction T1 updates a record which is read by T2. If T1 aborts then T2 now has values which have never formed part of the stable database.

Example:

Transaction-X	Time	Transaction-Y
——	t1	——
——	t2	Update A
Read A	t3	——
——	t4	Rollback
——	t5	——

- At time t2, transaction-Y writes A's value.
- At time t3, Transaction-X reads A's value.
- At time t4, Transactions-Y rollbacks. So, it changes A's value back to that of prior to t1.
- So, Transaction-X now contains a value which has never become part of the stable database.
- Such type of problem is known as Dirty Read Problem, as one transaction reads a dirty value which has not been committed.

3. Inconsistent Retrievals Problem

- Inconsistent Retrievals Problem is also known as unrepeatable read. When a transaction calculates some summary function over a set of data while the other transactions are updating the data, then the Inconsistent Retrievals Problem occurs.
- A transaction T1 reads a record and then does some other processing during which the transaction T2 updates the record. Now when the transaction T1 reads the record, then the new value will be inconsistent with the previous value.

Example:

Suppose two transactions operate on three accounts.

Account-1	Account-2	Account-3
Balance = 200	Balance = 250	Balance = 150

Transaction-X	Time	Transaction-Y
——	t1	——
Read Balance of Acc-1 sum <-- 200 Read Balance of Acc-2	t2	——
Sum <-- Sum + 250 = 450	t3	——
——	t4	Read Balance of Acc-3
——	t5	Update Balance of Acc-3 150 --> 150 - 50 --> 100
——	t6	Read Balance of Acc-1
——	t7	Update Balance of Acc-1 200 --> 200 + 50 --> 250
Read Balance of Acc-3	t8	COMMIT
Sum <-- Sum + 250 = 550	t9	——

- Transaction-X is doing the sum of all balance while transaction-Y is transferring an amount 50 from Account-1 to Account-3.
- Here, transaction-X produces the result of 550 which is incorrect. If we write this produced result in the database, the database will become an inconsistent state because the actual sum is 600.
- Here, transaction-X has seen an inconsistent state of the database.

Concurrency Control Protocol

Concurrency control protocols ensure atomicity, isolation, and serializability of concurrent transactions. The concurrency control protocol can be divided into three categories:

1. Lock based protocol
2. Time-stamp protocol

1. Locking Methods of Concurrency Control :

"A lock is a variable, associated with the data item, which controls the access of that data item."

Locking is the most widely used form of the concurrency control. Locks are further divided into three fields: Lock Granularity,Lock Types,Deadlocks

1. Lock Granularity :

A database is basically represented as a collection of named data items. The size of the data item chosen as the unit of protection by a concurrency control program is called GRANULARITY. Locking can take place at the following level :

- Database level.
- Table level.
- Page level.
- Row (Tuple) level.
- Attributes (fields) level.

i. Database level Locking :

At database level locking, the entire database is locked. Thus, it prevents the use of any tables in the database by transaction T2 while transaction T1 is being executed. Database level of locking is suitable for batch processes. Being very slow, it is unsuitable for on-line multi-user DBMSs.

ii. Table level Locking :

At table level locking, the entire table is locked. Thus, it prevents the access to any row (tuple) by transaction T2 while transaction T1 is using the table. if a transaction requires access to several tables, each table may be locked. However, two transactions can access the same database as long as they access different tables. Table level locking is less restrictive than database level. Table level locks are not suitable for multi-user DBMS

iii. Page level Locking :

At page level locking, the entire disk-page (or disk-block) is locked. A page has a fixed size such as 4 K, 8 K, 16 K, 32 K and so on. A table can span several pages, and a page can contain several rows (tuples) of one or more tables. Page level of locking is most suitable for multi-user DBMSs.

iv. Row (Tuple) level Locking :

At row level locking, particular row (or tuple) is locked. A lock exists for each row in each table of the database. The DBMS allows concurrent transactions to access different rows of the same table, even if the rows are located on the same page. The row level lock is much less restrictive than database level, table level, or page level locks. The row level locking improves the availability of data. However, the management of row level locking requires high overhead cost.

v. Attributes (fields) level Locking :

At attribute level locking, particular attribute (or field) is locked. Attribute level locking allows concurrent transactions to access the same row, as long as they require the use of different attributes within the row. The attribute level lock yields the most flexible multi-user data access. It requires a high level of computer overhead.

2. Lock Types : The DBMS uses following types of locking techniques.

- Binary Locking
- Shared / Exclusive Locking
- Two - Phase Locking (2PL)

a. Binary Locking :

A binary lock can have two states or values: locked and unlocked (or 1 and 0, for simplicity). A distinct lock is associated with each database item X.

If the value of the lock on X is 1, item X cannot be accessed by a database operation that requests the item. If the value of the lock on X is 0, the item can be accessed when requested. We refer to the current value (or state) of the lock associated with item X as LOCK(X).

Two operations, lock_item and unlock_item, are used with binary locking.

Lock_item(X):

A transaction requests access to an item X by first issuing a lock_item(X) operation. If LOCK(X) = 1, the transaction is forced to wait. If LOCK(X) = 0, it is set to 1 (the transaction locks the item) and the transaction is allowed to access item X.

Unlock_item (X):

When the transaction is through using the item, it issues an unlock_item(X) operation, which sets LOCK(X) to 0 (unlocks the item) so that X may be accessed by other transactions. Hence, a binary lock enforces mutual exclusion on the data item ; i.e., at a time only one transaction can hold a lock.

b. Shared / Exclusive Locking :

Shared lock :

These locks are reffered as read locks, and denoted by 'S'.

If a transaction T has obtained Shared-lock on data item X, then T can read X, but cannot write X. Multiple Shared lock can be placed simultaneously on a data item.

Exclusive lock :

These Locks are referred as Write locks, and denoted by 'X'.

If a transaction T has obtained Exclusive lock on data item X, then T can be read as well as write X. Only one Exclusive lock can be placed on a data item at a time. This means multiple transactions does not modify the same data simultaneously.

Lock Protocols

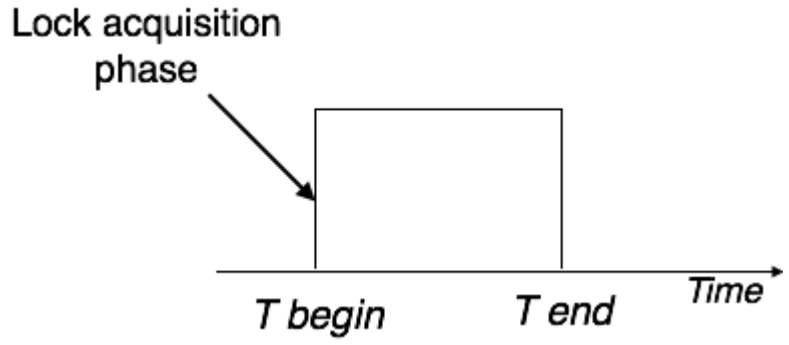
There are four types of lock protocols available −

Simplistic Lock Protocol

Simplistic lock-based protocols allow transactions to obtain a lock on every object before a 'write' operation is performed. Transactions may unlock the data item after completing the ‘write’ operation.

Pre-claiming Lock Protocol

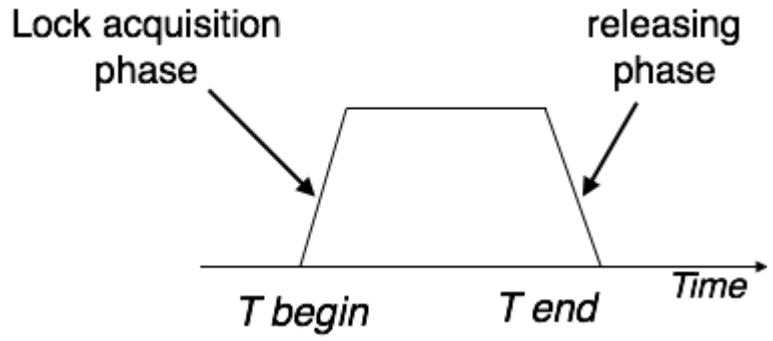
Pre-claiming protocols evaluate their operations and create a list of data items on which they need locks. Before initiating an execution, the transaction requests the system for all the locks it needs beforehand. If all the locks are granted, the transaction executes and releases all the locks when all its operations are over. If all the locks are not granted, the transaction rolls back and waits until all the locks are granted.



Two-Phase Locking 2PL

This locking protocol divides the execution phase of a transaction into three parts. In the first part, when the transaction starts executing, it seeks permission for the locks it requires. The second part is where the transaction acquires all the locks.

As soon as the transaction releases its first lock, the third phase starts. In this phase, the transaction cannot demand any new locks; it only releases the acquired locks.

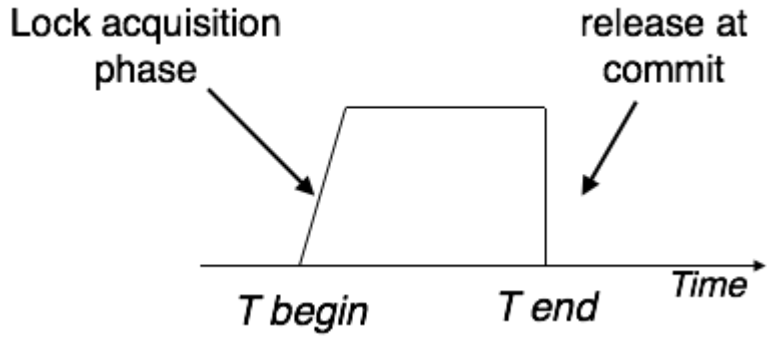


Two-phase locking has two phases, one is **growing**, where all the locks are being acquired by the transaction; and the second phase is shrinking, where the locks held by the transaction are being released.

To claim an exclusive (write) lock, a transaction must first acquire a shared (read) lock and then upgrade it to an exclusive lock.

Strict Two-Phase Locking

The first phase of Strict-2PL is same as 2PL. After acquiring all the locks in the first phase, the transaction continues to execute normally. But in contrast to 2PL, Strict-2PL does not release a lock after using it. Strict-2PL holds all the locks until the commit point and releases all the locks at a time.



Strict-2PL does not have cascading abort as 2PL does.

2. Time-Stamp Methods for Concurrency control :

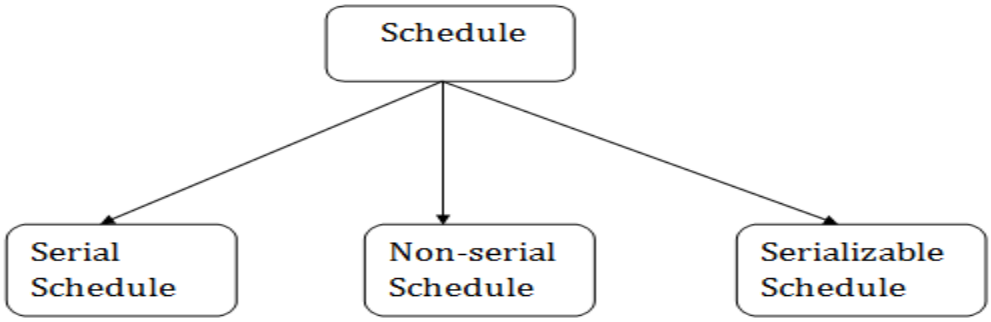
Timestamp is a unique identifier created by the DBMS to identify the relative starting time of a transaction.

Typically, timestamp values are assigned in the order in which the transactions are submitted to the system. So, a timestamp can be thought of as the transaction start time. Therefore, time stamping is a method of concurrency control in which each transaction is assigned a transaction timestamp. Timestamps must have two properties namely

- Uniqueness : The uniqueness property assures that no equal timestamp values can exist.
- monotonicity : monotonicity assures that timestamp values always increase.

SCHEDULE

A series of operation from one transaction to another transaction is known as schedule. It is used to preserve the order of the operation in each of the individual transaction.



1. Serial Schedule

The serial schedule is a type of schedule where one transaction is executed completely before starting another transaction. In the serial schedule, when the first transaction completes its cycle, then the next transaction is executed.

For example: Suppose there are two transactions T1 and T2 which have some operations. If it has no interleaving of operations, then there are the following two possible outcomes:

1. Execute all the operations of T1 which was followed by all the operations of T2.
2. Execute all the operations of T1 which was followed by all the operations of T2.

- In the given (a) figure, Schedule A shows the serial schedule where T1 followed by T2.
- In the given (b) figure, Schedule B shows the serial schedule where T2 followed by T1.

(a)

Time

T1	T2

read(A);
A := A – N;
write(A);
read(B);
B := B + N;
write(B);
	read(A);
	A := A + M;
	write(A);

Schedule A

(b)

Time

T1	T2

read(A);
A:= A - N;
write(A);
read(B);
B:= B +N;
write(B);
	read(A);
	A := A + M;
	write(A);

Schedule B

Table: Schedule A and Schedule B are serial schedule.

2. Non-serial Schedule

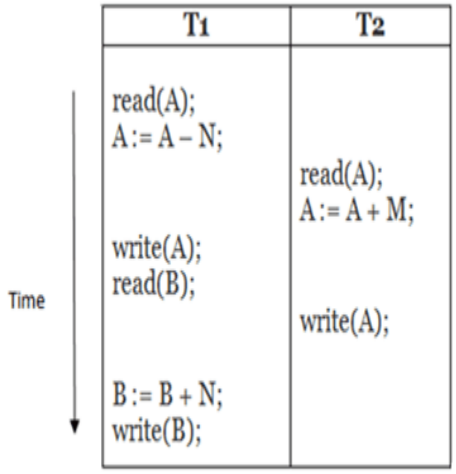
- If interleaving of operations is allowed, then there will be non-serial schedule.
- It contains many possible orders in which the system can execute the individual operations of the transactions.
- In the given figure (c) and (d), Schedule C and Schedule D are the non-serial schedules. It has interleaving of operations.

3. Serializable schedule

- The serializability of schedules is used to find non-serial schedules that allow the transaction to execute concurrently without interfering with one another.

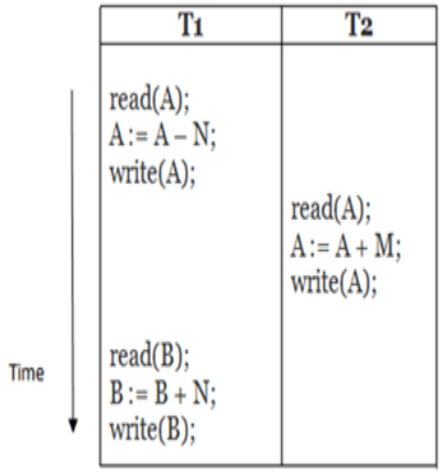
- It identifies which schedules are correct when executions of the transaction have interleaving of their operations.
- A non-serial schedule will be serializable if its result is equal to the result of its transactions executed serially.

(c)



Schedule C

(d)



Schedule D

Schedule C and Schedule D are Non-serial schedule.

Testing of Serializability

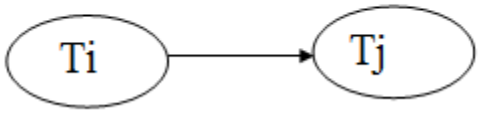
Serialization Graph is used to test the Serializability of a schedule.

Assume a schedule S. For S, we construct a graph known as precedence graph. This graph has a pair G = (V, E), where V consists a set of vertices, and E consists a set of edges. The set of vertices is used to contain all the transactions participating in the schedule. The set of edges is used to contain all edges Ti ->Tj for which one of the three conditions holds:

1. Create a node Ti → Tj if Ti executes write (Q) before Tj executes read (Q).

2. Create a node Ti → Tj if Ti executes read (Q) before Tj executes write (Q).
3. Create a node Ti → Tj if Ti executes write (Q) before Tj executes write (Q).

Precedence graph for Schedule S



- If a precedence graph contains a single edge Ti → Tj, then all the instructions of Ti are executed before the first instruction of Tj is executed.
- If a precedence graph for schedule S contains a cycle, then S is non-serializable. If the precedence graph has no cycle, then S is known as serializable.

Equivalence Schedules

An equivalence schedule can be of the following types −

Result Equivalence

If two schedules produce the same result after execution, they are said to be result equivalent. They may yield the same result for some value and different results for another set of values. That's why this equivalence is not generally considered significant.

View Equivalence

Two schedules would be view equivalence if the transactions in both the schedules perform similar actions in a similar manner.

For example −

- If T reads the initial data in S1, then it also reads the initial data in S2.
- If T reads the value written by J in S1, then it also reads the value written by J in S2.

- If T performs the final write on the data value in S1, then it also performs the final write on the data value in S2.

Conflict Equivalence

Two schedules would be conflicting if they have the following properties −

- Both belong to separate transactions.
- Both accesses the same data item.
- At least one of them is "write" operation.

Two schedules having multiple transactions with conflicting operations are said to be conflict equivalent if and only if −

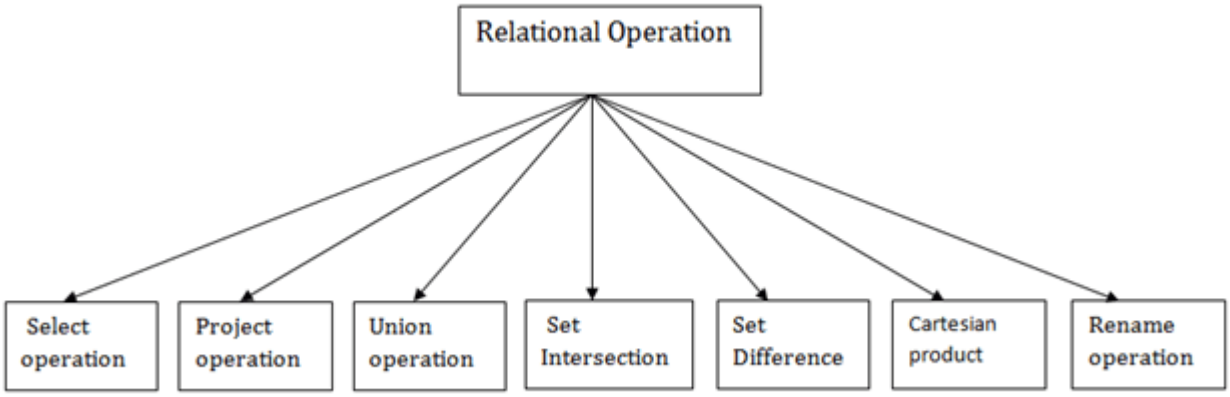
- Both the schedules contain the same set of Transactions.
- The order of conflicting pairs of operation is maintained in both the schedules.

Note − View equivalent schedules are view serializable and conflict equivalent schedules are conflict serializable. All conflict serializable schedules are view serializable too.

Relational Algebra

Relational algebra is a procedural query language. It gives a step by step process to obtain the result of the query. It uses operators to perform queries.

Types of Relational operation



1. Select Operation:

- The select operation selects tuples that satisfy a given predicate.
- It is denoted by sigma (σ).
- Select operation creates vertical partition of the relation

Notation: σ p(r)

Where:

σ is used for selection prediction
r is used for relation
p is used as a propositional logic formula which may use connectors like: AND OR and NOT. These relational can use as relational operators like =, ≠, ≥, <, >, ≤.

Query to select all employee details staying in paris location

Example : σ city="paris" (EMPLOYEE)

2. Project Operation:

- This operation shows the list of those attributes that we wish to appear in the result. Rest of the attributes are eliminated from the table.
- It is denoted by ∏.
- Project operation creates vertical partition of the relation

Notation: ∏ A1, A2, An (r)

Where A1, **A2**, **A3** is used as an attribute name of relation **r**.

Example: ∏ FNAME, LNAME, HIRE_DATE, CITY (EMPLOYEE)

3. Rename Operation:

The rename operation is used to rename the output relation. It is denoted by **rho** (ρ).

Example: We can use the rename operator to rename STUDENT relation to STUD_DETAILS.

Example ρ(STUD_DETAILS, STUDENT)

DEPOSITOR RELATION

CUSTOMER_NAME	ACCOUNT_NO
Johnson	A-101
Smith	A-121
Mayes	A-321
Turner	A-176
Johnson	A-273
Jones	A-472
Lindsay	A-284

BORROW RELATION

CUSTOMER_NAME	LOAN_NO
Jones	L-17
Smith	L-23
Hayes	L-15
Jackson	L-14
Curry	L-93
Smith	L-11
Williams	L-17

CONSIDER ABOVE TWO TABLES FOR EXAMPLE

4. Union Operation:

- Suppose there are two tuples R and S. The union operation contains all the tuples that are either in R or S or both in R & S.
- It eliminates the duplicate tuples. It is denoted by ∪.

Notation: R ∪ S

A union operation must hold the following condition:

- R and S must have the attribute of the same number.
- Duplicate tuples are eliminated automatically.

∏ CUSTOMER_NAME (BORROW) ∪ ∏ CUSTOMER_NAME (DEPOSITOR)

CUSTOMER_NAME
Johnson
Smith
Hayes
Turner
Jones
Lindsay
Jackson
Curry
Williams
Mayes

5. Set Intersection:

- Suppose there are two tuples R and S. The set intersection operation contains all tuples that are in both R & S.
- It is denoted by intersection ∩.

Notation: R ∩ S

Example: Using the above DEPOSITOR table and BORROW table

Input:

∏ CUSTOMER_NAME (BORROW) ∩ ∏ CUSTOMER_NAME (DEPOSITOR)

Output:

CUSTOMER_NAME
Smith
Jones

6. Set Difference:

- Suppose there are two tuples R and S. The set intersection operation contains all tuples that are in R but not in S.
- It is denoted by intersection minus (-).

Notation: R - S

Example: Using the above DEPOSITOR table and BORROW table

Input:

∏ CUSTOMER_NAME (BORROW) - ∏ CUSTOMER_NAME (DEPOSITOR)

Output:

CUSTOMER_NAME
Jackson
Hayes
Willians
Curry

6. Cartesian product

- The Cartesian product is used to combine each row in one table with each row in the other table. It is also known as a cross product.
- It is denoted by X.

Notation: E X D

Example:

EMPLOYEE

EMP_ID	EMP_NAME	EMP_DEPT
1	Smith	A
2	Harry	C
3	John	B

DEPARTMENT

DEPT_NO	DEPT_NAME
A	Marketing
B	Sales
C	Legal

Input: EMPLOYEE X DEPARTMENT

Output:

EMP_ID	EMP_NAME	EMP_DEPT	DEPT_NO	DEPT_NAME
1	Smith	A	A	Marketing
1	Smith	A	B	Sales
1	Smith	A	C	Legal
2	Harry	C	A	Marketing
2	Harry	C	B	Sales
2	Harry	C	C	Legal
3	John	B	A	Marketing
3	John	B	B	Sales
3	John	B	C	Legal

JOIN OPERATIONS:

A Join operation combines related tuples from different relations, if and only if a given join condition is satisfied. It is denoted by ⋈.

Example:

EMPLOYEE

EMP_CODE	EMP_NAME
101	Stephan
102	Jack
103	Harry

SALARY

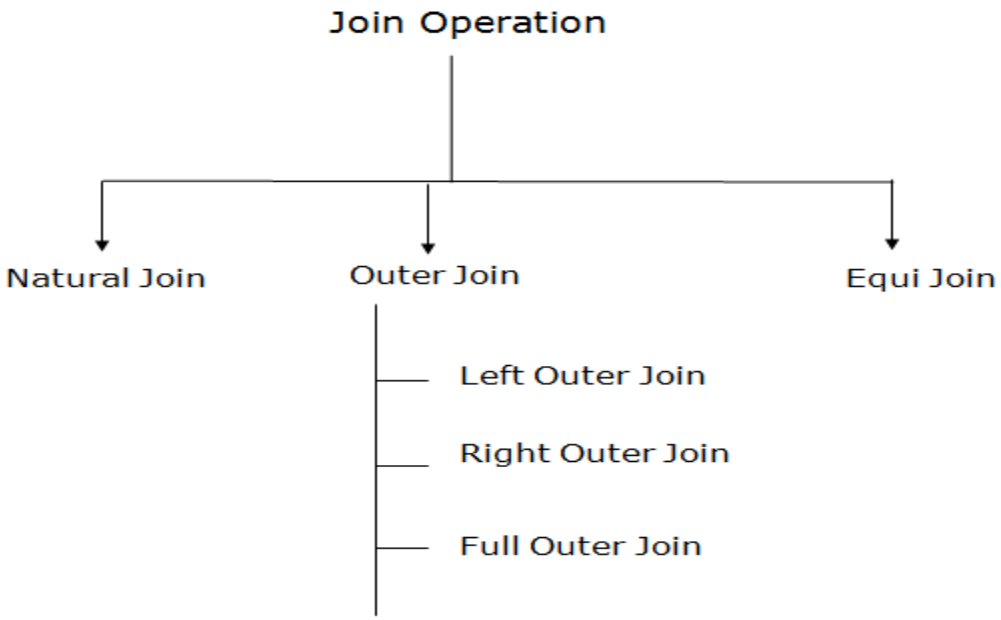
EMP_CODE	SALARY
101	50000
102	30000
103	25000

Operation: (EMPLOYEE ⋈ SALARY)

Result:

EMP_CODE	EMP_NAME	SALARY
101	Stephan	50000
102	Jack	30000
103	Harry	25000

Types of Join operations:



1. Natural Join:

- A natural join is the set of tuples of all combinations in R and S that are equal on their common attribute names.
- It is denoted by ⋈.

Example: Let's use the above EMPLOYEE table and SALARY table:

Input:

1. ∏EMP_NAME, SALARY (EMPLOYEE ⋈ SALARY)

Output:

EMP_NAME	SALARY
Stephan	50000
Jack	30000
Harry	25000

2. Outer Join:

The outer join operation is an extension of the join operation. It is used to deal with missing information.

Example:

EMPLOYEE

EMP_NAME	STREET	CITY
Ram	Civil line	Mumbai
Shyam	Park street	Kolkata
Ravi	M.G. Street	Delhi
Hari	Nehru nagar	Hyderabad

FACT_WORKERS

EMP_NAME	BRANCH	SALARY
Ram	Infosys	10000
Shyam	Wipro	20000
Kuber	HCL	30000
Hari	TCS	50000

Input:

1. (EMPLOYEE ⋈ FACT_WORKERS)

Output:

EMP_NAME	STREET	CITY	BRANCH	SALARY
Ram	Civil line	Mumbai	Infosys	10000
Shyam	Park street	Kolkata	Wipro	20000
Hari	Nehru nagar	Hyderabad	TCS	50000

An outer join is basically of three types:

a. Left outer join
b. Right outer join

c. Full outer join

a. Left outer join:

- Left outer join contains the set of tuples of all combinations in R and S that are equal on their common attribute names.
- In the left outer join, tuples in R have no matching tuples in S.
- It is denoted by ⟕.

Example: Using the above EMPLOYEE table and FACT_WORKERS table

Input:

1. EMPLOYEE ⟕ FACT_WORKERS

EMP_NAME	STREET	CITY	BRANCH	SALARY
Ram	Civil line	Mumbai	Infosys	10000
Shyam	Park street	Kolkata	Wipro	20000
Hari	Nehru street	Hyderabad	TCS	50000
Ravi	M.G. Street	Delhi	NULL	NULL

b. Right outer join:

- Right outer join contains the set of tuples of all combinations in R and S that are equal on their common attribute names.
- In right outer join, tuples in S have no matching tuples in R.
- It is denoted by ⟖.

Example: Using the above EMPLOYEE table and FACT_WORKERS Relation

Input:

1. EMPLOYEE ⋈ FACT_WORKERS

Output:

EMP_NAME	BRANCH	SALARY	STREET	CITY
Ram	Infosys	10000	Civil line	Mumbai
Shyam	Wipro	20000	Park street	Kolkata
Hari	TCS	50000	Nehru street	Hyderabad
Kuber	HCL	30000	NULL	NULL

c. Full outer join:

- Full outer join is like a left or right join except that it contains all rows from both tables.
- In full outer join, tuples in R that have no matching tuples in S and tuples in S that have no matching tuples in R in their common attribute name.
- It is denoted by ⟗.

Example: Using the above EMPLOYEE table and FACT_WORKERS table

Input:

1. EMPLOYEE ⟗ FACT_WORKERS

Output:

EMP_NAME	STREET	CITY	BRANCH	SALARY
Ram	Civil line	Mumbai	Infosys	10000
Shyam	Park street	Kolkata	Wipro	20000
Hari	Nehru street	Hyderabad	TCS	50000
Ravi	M.G. Street	Delhi	NULL	NULL
Kuber	NULL	NULL	HCL	30000

3. Equi join:

It is also known as an inner join. It is the most common join. It is based on matched data as per the equality condition. The equi join uses the comparison operator(=).

Example:

CUSTOMER RELATION

CLASS_ID	NAME
1	John
2	Harry

3	Jackson

PRODUCT

PRODUCT_ID	CITY
1	Delhi
2	Mumbai
3	Noida

Input:

1. CUSTOMER ⋈ PRODUCT

Output:

CLASS_ID	NAME	PRODUCT_ID	CITY
1	John	1	Delhi
2	Harry	2	Mumbai
3	Harry	3	Noida