Database Management System 20

Concurrent Execution

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Concurrent Execution

Concurrent Execution

Concurrent execution of transactions means executing more than one transaction at the same time

In the serial execution, one transaction can start executing only after the completion of the previous

The advantages of using concurrent execution of transactions are:

- Improved throughput and resource utilization
- Reduced waiting time

The database system must control the interaction among the concurrent transactions to prevent them from destroying the consistency of the database. It does this through a variety of mechanisms called concurrency control schemes

Concurrent Execution...

T_1 transfers Dollar \$100 from account A to account B

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

T_2 transfers 20% of balance from account A to account B

T_2
Read(A);
Temp=0.2*A;
A:=A-Temp;
Write(A);
Read(B);
B:=B+Temp;
Write(B);

Schedules

Schedules

A schedule is a sequence that indicates the chronological order in which instructions of concurrent transactions are executed

A schedule for a set of transactions must consist of all instructions of those transactions

We must preserve the order in which the instructions appear in each individual transaction

Serial Schedule

Serial Schedule

A serial schedule is a schedule where all the instructions belonging to each transaction appear together

There is no interleaving of transaction operations. A serial schedule has no concurrency and therefore it does not interleave the actions of different transactions

For n transactions, there are exactly n! different serial schedules possible

Serial Schedule...

Schedule1 (T_1 followed by T_2)

T_1	T_2
Read(A); A:=A-100; Write(A); Read(B); B:=B+100; Write(B);	Read(A); Temp=0.2*A; A:=A-Temp; Write(A); Read(B); B:=B+Temp; Write(B);

Schedule2 (T_2 followed by T_1)

T_1	T_2
Read(A); A:=A-100; Write(A); Read(B); B:=B+100; Write(B);	Read(A); Temp=0.2*A; A:=A-Temp; Write(A); Read(B); B:=B+Temp; Write(B);

Concurrent Schedule

Concurrent Schedule

In concurrent schedule, operations from different concurrent transactions are interleaved

The number of possible schedules for a set of n transactions is much larger than n!

Schedule3

T_1	T_2
Read(A);	
A:=A-100;	
Write(A);	
	Read(A);
	Temp=0.2*A;
	A:=A-Temp;
	Write(A);
Read(B);	
B:=B+100;	
Write(B);	
	Read(B);
	B:=B+Temp;
	Write(B);

Concurrent Schedule...

Schedule4

T_1	T_2
Read(A);	
A:=A-100;	
	Read(A);
	Temp=0.2*A;
	A:=A-Temp;
	Write(A);
	Read(B);
Write(A);	
Read(B);	
B:=B+100;	
Write(B);	
	B:=B+Temp;
	Write(B);

Schedule5

T_1	T_2
Read(A);	
A:=A-100;	
Write(A);	
	Read(A);
	Temp=0.2*A;
	A:=A-Temp;
Read(B);	
B:=B+100;	
	Write(A);
	Read(B);
	B:=B+Temp;
	Write(B);
Write(B);	

Serializability

Serializability

A concurrent schedule is serializable if it is equivalent to a serial schedule

Serial schedules preserve consistency as we assume each transaction individually preserves consistency

The database system must control concurrent execution of transactions to ensure that the database state remains consistent

Since the modifications are done in the local buffer, we can ignore the operations other than Read and Write instructions for easier understanding of the serializability

Serializability...

T_1	T_2
Read(A);	
Write(A);	
Read(B);	
Write(B);	
	Read(A);
	Write(A);
	Read(B);
	Write(B);
Schedule1	

T_1	T_2
	Read(A);
	Write(A);
	Read(B);
	Write(B);
Read(A);	
Write(A);	
Read(B);	
Write(B);	
Schedule2	

T_1	T_2
Read(A);	
Write(A);	
	Read(A);
	Write(A);
Read(B);	
Write(B);	
	Read(B);
	Write(B);
Schedule3	

T_1	T_2
Read(A);	
	Read(A);
	Write(A);
	Read(B);
Write(A);	
Read(B);	
Write(B)	
	Write(B);
Schedule4	

T_1	T_2
Read(A);	
Write(A);	
	Read(A);
Read(B);	
	Write(A);
	Read(B);
	Write(B);
Write(B);	
Schedule5	

Conflict Serializability

Conflict Serializability

Conflict Serializability consists of conflicting operations
Let us consider a schedule S in which there are two consecutive instructions, I_i and I_j of transactions T_i and T_j respectively (i≠j)

If I_i and I_j access different data items, then we can swap I_i and I_j without affecting the results of any transactions in the schedule. However, if I_i and I_j access the same data item Q, then the order of the two instructions may matter:

- **Case-1: I_i=Read(Q) and I_j=Read(Q)**:
  - Order of I_i and I_j does not matter
- **Case-2: I_i=Read(Q) and I_j=Write(Q)**:
  - Order of I_i and I_j matters in a schedule
- **Case-3: I_i=Write(Q) and I_j=Read(Q)**:
  - Order of I_i and I_j matters in a schedule
- **Case-1: I_i=Write(Q) and I_j=Write(Q)**:
  - Order of I_i and I_j matters in a schedule

Conflict Serializability...

Conflict Serializability...

Thus, I_i and I_j conflict if they are the instructions by different transactions on the same data item, and at least one of these instructions is a write operation

Let I_i and I_j be consecutive instructions of a schedule S. If I_i and I_j are instructions of different transactions and they do not conflict, then we can swap the order of I_i and I_j to produce a new schedule S'. Here, we expect S to be equivalent to S'

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 concurrent schedule S is conflict serializable if it is conflict equivalent to a serial schedule

Conflict Serializability...

T_1	T_2
Read(A);	
Write(A);	
Read(B);	
Write(B);	
	Read(A);
	Write(A);
	Read(B);
	Write(B);
Schedule3	

T_1	T_2
Read(A);	
	Read(A);
	Write(A);
Write(A);	
	Read(B);
Read(B);	
Write(B)	
	Write(B);
Schedule4	

T_1	T_2
Read(A);	
Write(A);	
Read(B);	
	Read(A);
	Write(A);
	Read(B);
	Write(B);
Write(B);	
Schedule5	

Conflict Serializability...

It is possible to have two schedules that produce the same outcome, but that are not conflict equivalent

T_1	T_5
Read(A); A:=A-100; Write(A); Read(B); B:=B+100; Write(B);	 Read(B); B:=B-200; Write(B); Read(A); A:=A+200; Write(A);
Schedule6	

T_1	T_5
Read(A); Write(A); Read(B); Write(B);	 Read(B); Write(B); Read(A); Write(A);
Schedule6	

Testing for Conflict Serializability

Testing for Conflict Serializability

Construct a directed graph, called a precedence graph from S. This graph consists of a pair G = (V, E), where V is a set of vertices and E is a set of edges

The set of vertices consists of all the transactions participating in the schedule

The set of edges consists of all edges $T_i \rightarrow T_j$ for which one of three conditions holds:

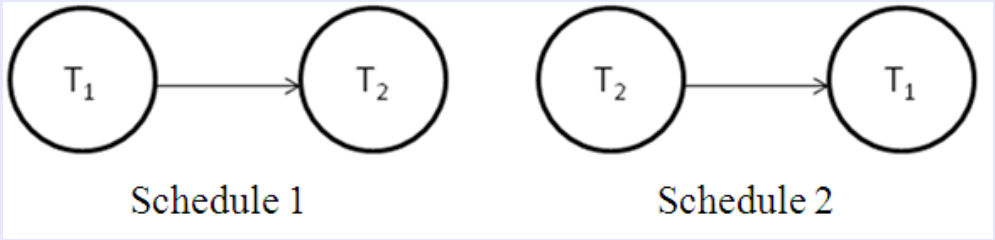
- T_i executes write(Q) before T_j executes read(Q)
- T_i executes read(Q) before T_j executes write(Q)
- T_i executes write(Q) before T_j executes write(Q)

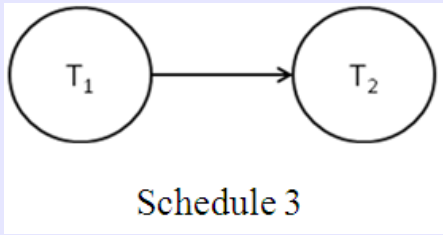
If an edge $T_i \rightarrow T_j$ exists in the precedence graph, then in any serial schedule S' equivalent to S, T_i must appear before T_j

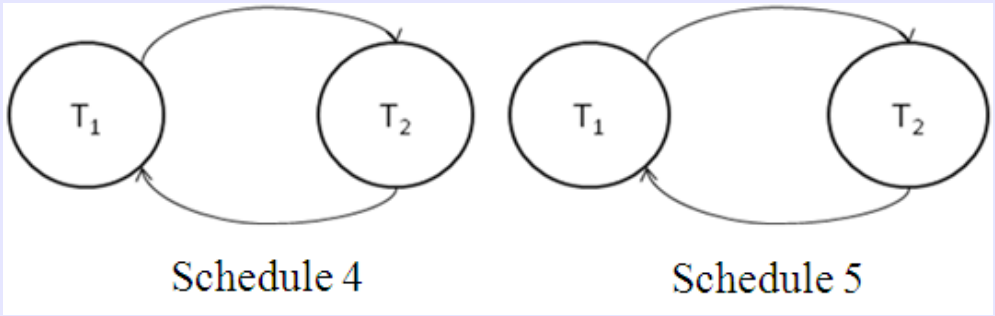
Testing for Conflict Serializability...

Testing for Conflict Serializability...

If the precedence graph for a concurrent schedule S has a cycle, then that schedule is not conflict serializable. If the graph contains no cycles, then the schedule S is conflict serializable







View Serializability

View Serializability

The schedules S and S_1 are said to be view equivalent if the following three conditions are met:

- For each data item Q, if transaction T_i reads the initial value of Q in schedule S, then it must also read the initial value of Q in schedule S_1
- For each data item Q, the transaction that performs the final Write(Q) operation in schedule S must also perform the final Write(Q) operation in schedule S_1
- For each data item Q, if transaction T_i executes Read(Q) in schedule S, and if that value was produced by a Write(Q) operation executed by transaction T_j; then in schedule S_1, the Read(Q) operation of T_i must also read the value of Q that was produced by the same Write(Q) operation of transaction T_j

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

View Serializability...

View Serializability...

Schedule7

T_1	T_2	T_3
Read(Q);		
	Write(Q);	
Write(Q);		
		Write(Q);

- This schedule is view serializable
- This schedule is not conflict serializable
- *Every conflict serializable schedule is also view serializable, whereas all view serializable schedules are not conflict serializable*
- Every view serializable schedule, which is not conflict serializable, has blind writes

Testing for View Serializability

Testing for View Serializability

It can be tested using poly graph

- If the given schedule is conflict serializable, then it is also view serializable
- If the given schedule isn't conflict serializable and contains no blind writes, it is not view serializable
- If the given schedule isn't conflict serializable and contains blind writes, poly graph can be used to test