CSCI235 Database Systems

Introduction to Transaction Processing (3)

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Introduction to Transaction Processing

Outline

Serialization graph

Serialization graph is constructed in the following way

- If a transaction `T` participates in a concurrent execution then we add a node labeled with `T` to a serialization graph
- If the transactions T_i and T_j process conflicting operations such that T_i processes its operation first then we add an edge directed from T_i to T_j

Sample construction of a serialization graph

Concurrent execution of database transactions

T1	T2	T3
write(x, 10)		

Create a node `T1`

	write(x, 20)	

Create a node `T2` and add an edge from `T1` to `T2`

Serialization graph

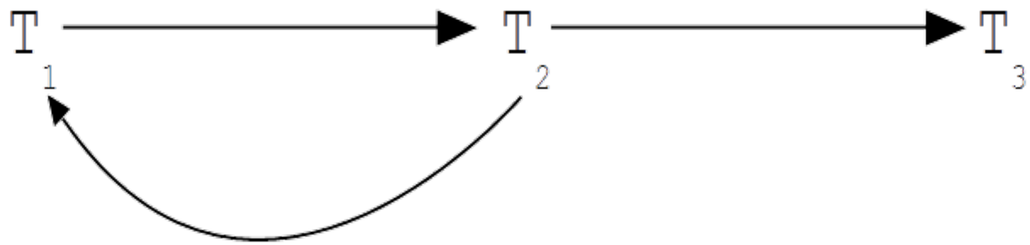
```
                                                       write(x,30)
```

Create a node `T3` and add the edges from `T1` to `T3` and from `T2` to `T3`

```
                              write(y,10)
```

```
a=read(y)
```

Add an edge from `T2` to `T1`



Serialization graph

A serialization graph of not conflict serializable execution of database transactions

Not conflict serializable execution of database transactions

T1	T2
a=read(x)	

Create a node T1

	b=read(x)

Create a node T2

write(x,a-10)	

Add an edge from T2 to T1

	write(x,b+20)

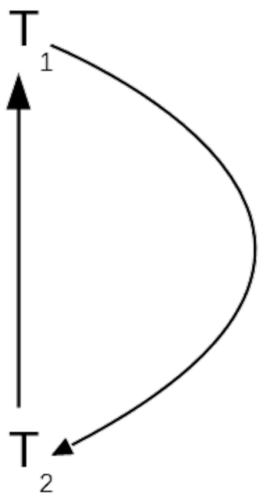
Add an edge from T1 to T2

Serialization graph

A serialization graph for not conflict serializable execution of database transactions

Not conflict serializable execution of database transactions

T1	T2
a=read(x)	
	b=read(x)
write(x,a-10)	
	write(x,b+20)



Introduction to Transaction Processing

Outline

Serialization graph testing protocol (SGT)

Principles

- Scheduler maintains and tests serialization graph
- If an operation issued by a transaction violates conflict serializability, i.e. if it creates a cycle in serialization graph then such transaction is aborted

Problems

- Cascading aborts: if a transaction `T` that created a data item `x` is aborted then all transactions that read a new value of `x` must be aborted
- Performance: testing acyclicity of serialization graph has $O(n^2)$ complexity

Introduction to Transaction Processing

Outline

Two-phase locking (2PL) protocol

Principles

- Access to data items is controlled by shared (read) and exclusive (write) locks
- A transaction can read a data item only if a data item is read or write locked by the same transaction or a data item is read locked by another transaction
- A transaction can write a data item only if a data item is write locked by the same same transaction
- Each transaction must acquire all locks before releasing any lock

Two-phase locking protocol belongs to a class of pessimistic protocols

Problems

- Deadlocks
- Unnecessary locks and delays when an execution is conflict serializable

Two-phase locking (2PL) protocol

A sample execution controlled by two-phase locking protocol

Concurrent execution of database transactions controlled by 2PL protocol

T1	T2
lock(u) a=read(u)	
	lock(v) write(v,10)
write(u,a+2)	
lock(v) wait	
	lock(x) b=read(x)
	unlock(v)
	write(x,b+2)
lock(v)	
	unlock(x)
write(v,a+1)	
unlock(v)	
unlock(u)	

Two-phase locking (2PL) protocol

A sample execution that ends in a deadlock

Concurrent execution of database transactions that ends in a deadlock

T1	T2
lock(u) a=read(u)	
	lock(v) b=read(v)
	lock(v) write(v,b+10)
lock(v) wait	
	lock(u) wait

Both transactions are in a wait state

In a database system deadlock is eliminated through either wait for graph or throught timeout

Two-phase locking (2PL) protocol

A sample execution that unnecessarily delays a transaction

Concurrent execution of database transactions that unnecessarily delays a transaction	
lock(u) a=read(u)	
	lock(u) wait
lock(v) write(v,a+1)	
unlock(v,u)	
	lock(u) b=read(u)
	write(u,b+1)

The transactions `T1` and `T2` never get into not conflict serializable execution

Therefore, there is no need to delay a transaction `T2`

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Outline

Timestamp ordering (TO) protocol

Principles

- Each transaction obtains a timestamp at its start point
- Data items are stamped each time any transaction accesses data items in a read or write mode
- Access to data items is permitted in an increasing order of timestamps

Timestamp ordering protocol belongs to a class of optimistic protocols

Problems

- Cascading aborts
- Unnecessary aborts when execution is conflict serializable

Timestamp ordering (TO) protocol

A sample execution controlled by the timestamp ordering protocol

Concurrent execution of database transactions controlled by TO protocol

T1	T2	x
timestamp(t1)		
a=read(x)		x:t1
write(x,a-10)		
	timestamp(t2)	
	write(x,10)	x:t1:t2
	b=read(y)	y:t2
write(y,a+1)		y:t2:t1
abort		

Timestamp ordering (TO) protocol

A sample excution controlled by the timestamp ordering protocol with cascading abort

Concurrent execution of database transactions controlled by TO protocol with cascading abort

T1	T2	x
timestamp(t1)		
a=read(x)		x:t1
write(x,x-10)		
	timestamp(t2)	
	b=read(x)	x:t1:t2
fail		
	forced abort	

A transaction `T2` is forced to abort because it reads a dirty data item written by a failed transaction `T1`

Timestamp ordering (TO) protocol

A sample excution controlled by the timestamp ordering protocol where a transaction is unnecessarily aborted

Concurrent execution of database transactions controlled by TO protocol with unnecessary abort

T1	T2	x
	timestamp(t2)	
timestamp(t1)		
a=read(x)		x:t1
write(x,a-10)		
	b=read(x) forced abort	x:t1:t2

A transaction T2 is aborted even the execution is conflict serializable

References

T. Connoly, C. Begg, Database Systems, A Practical Approach to Design, Implementation, and Management, Chapter 22.2 Concurrency Control, Pearson Education Ltd, 2015