CSCI235 Database Systems

Introduction to Transaction Processing (1)

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Introduction to Transaction Processing

Outline

An interesting experiment

Use SQLcl to create two simultaneous connections to the same user account

```
$sqlcl jrg
```
SQLcl

```
$sqlcl jrg
```
SQLcl

Next, process the same `SELECT` statement in both connections

```
SQL> SELECT COUNT(*) FROM SKILL;

COUNT(*)
----------
19
```
SQL

```
SQL> SELECT COUNT(*) FROM SKILL;

COUNT(*)
----------
19
```
SQL

Obviously, the results are the same

An interesting experiment

Now, `INSERT` a row into a relational table `SKILLS` through one of the connections

```sql
SQL> INSERT INTO SKILL VALUES('singing');
1 row created.
```

And now repeat the same `SELECT` statements

```sql
SQL> SELECT COUNT(*)FROM SKILL;

COUNT(*)
----------
20
```

```sql
SQL> SELECT COUNT(*) FROM SKILL;

COUNT(*)
----------
19
```

Surprise, surprise, the results are different ! Why ?

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Outline

Where is a problem ?

Why a modification performed by the first user is not visible to the second user ?

Is it correct that the second user must see all modifications performed by the first user ?

What if a modification performed by the first user is immediately visible to the second user and after that the first user rolls back the modification ?

Then, the second user is left with incorrect data !

Hence, only committed data can be revealed to the other users

Is such conclusion always true ?

Problem statement

- Given a multiuser database system
- Find the most efficient synchronisation method for a set of concurrent processes accessing the shared database resources

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Principles of transaction processing

A partially ordered set of read, write operations on the database items is called as a transaction

Users interact with a database by executing programs

Execution of a program is equivalent to execution of a partially ordered set of read, write operations

A database is visible to transactions as a collection of data items

Concurrently running transactions interleave their operations

Transactions have no impact on execution of their operations

Each transaction terminates by either commit or abort operation

Each transaction arrives at a consistent database state and must leave a database in a consistent state as well

Principles of transaction processing

A sample concurrent processing of database transcations

Concurrent processing of database transactions

T1	T2	
		x: $100
a=read(x)		x: $100 a: $100
	b=read(x)	x: $100 b: $100
write(x,a-10)		x: $90 a: $100
	write(x,b+20)	x: $120 b: $100
	commit	x: $120
commit		x: $120

If a state of a bank account is $100 then withdrawal of $10 and deposit of $20 cannot change a state of bank account to $120

Uncontrolled concurrent processing of database transactions may corrupt a database

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Update synchronisation

Database transaction can perform update in two different ways:

- A transaction immediately writes uncommitted values into a database - update-in-place
- A transaction does not modify a database until the time it commits itself - deferred-update

In the last example the transactions applied update-in-place to modify a database

A way how the transactions perform an update has no impact on the final outcomes, e.g. when deferred-update is applied a database maybe still corrupted (see the next example)

Principles of transaction processing

A sample concurrent processing of database transactions when deferred-update is applied

Concurrent processing of database transactions

T1	T2	x: $100
a=read(x)		x: $100 a: $100
	b=read(x)	x: $100 b: $100
write(x,a-10)		x: $100 log T1:$90
	write(x,b+20)	x: $100 log T2:$120
	commit	x: $120
commit		x: $90

If a state of a bank account is $100 then withdrawal of $10 and deposit of $20 cannot change a state of bank account to $90

Deferred-update does not solve the problem

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ACID properties

Processing of database transactions must satisfy ACID properties

Atomicity

- Each database operation is treated as a single unit (all-or-nothing)

Consistency

- A transaction takes a database from one consistent state to another

Isolation

- Transactions do not directly communicate one with each other and they do not read the intermediate results of the other transactions

Durability

- The results of committed transactions must be permanent in a database in spite of failures

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Protocols

An execution atomicity protocol ensures Consistency property

A failure atomicity protocol ensures Atomicity, Isolation and Durability properties

A sample incorrect execution atomicity protocol

Concurrent processing of database transactions

T1	T2	x: $100
a=read(x)		x: $100 a: $100
	b=read(x)	x: $100 b: $100
write(x,a-10)		x: $90 a: $100
	write(x,b+20)	x: $120 b: $100
	commit	x: $120
commit		x: $120

Protocols

A sample incorrect failure atomicity protocol

Concurrent processing of database transactions

T1	T2	
T1	T2	x: $100
a=read(x)		x: $100 a: $100
write(x,a-10)		x: $90 a: $100
	b=read(x)	x: $90 b: $90
	write(x,b+20)	x: $110 b: $90
	commit	x: $110
abort		x: $100

If a state of a bank account is $100 then withdrawal of $10 and deposit of $20 cannot change a state of bank account to $100

Protocols

Execution atomicity protocol = Concurrency control protocol

Failure atomicity protocol = Recovery protocol

Lost update problem

Concurrent processing of database transactions

T1	T2	
		x: $100
a=read(x)		x: $100 a: $100
	b=read(x)	x: $100 b: $100
write(x,a-10)		x: $90 a: $100
	write(x,b+20)	x: $120 b: $100
	commit	x: $120
commit		x: $120

Protocols

Inconsistent retrieval problem

T1	T2	x	y	a	b	c
		Concurrent processing of database transactions				
a=read(x)		100	50	100		
	b=read(y)	100	50	100	50	
write(x,a-10)		90	50	100	50	
	c=read(x)	90	50	100	50	90
write(y,a-30)		90	70	100	50	90
	print(b+c)140	90	70	100	50	90

References

T. Connoly, C. Begg, Database Systems, A Practical Approach to Design, Implementation, and Management, Chapter 22.1 Transaction Support, Chapter 22.2 Concurrency Control, Pearson Education Ltd, 2015