Concurrency Control

Motivation

- *Components of distributed systems use shared resources concurrently:*
  - *Hardware Components*
  - *Operating system resources*
  - *Databases*
  - *Objects*
- *Resources may have to be accessed in mutual exclusion.*

Motivation

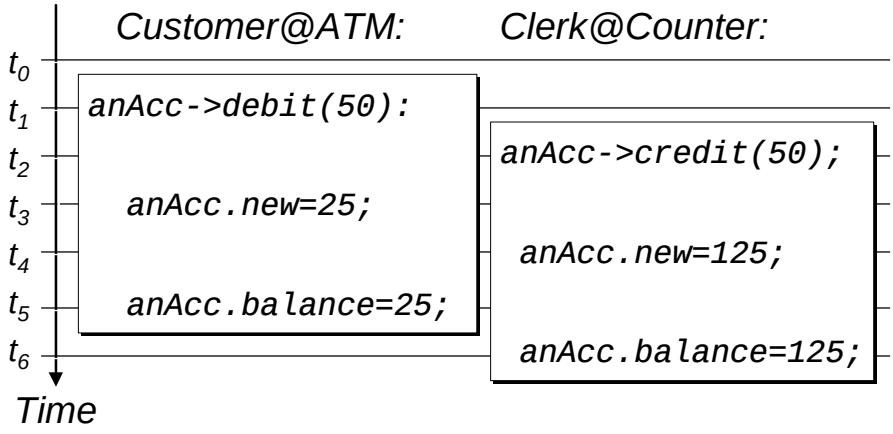
- **Concurrent access and updates of resources may lead to:**
  - **lost updates**
  - **inconsistent analysis.**
- **Example for lost updates:**
  - **Cash withdrawal from ATM and concurrent**
  - **Credit of cheque.**
- **Example for inconsistent analysis:**
  - **Funds transfer between accounts of a customer**
  - **Sum of account balances (Report for Inland Revenue).**

Motivating Examples

```
class Account {
  protected:
    float balance;
  public:
    float get_balance() {return balance;};
    void debit(float amount){
        float new=balance-amount;
        balance=new;
    };
    void credit(float amount) {
      float new=balance+amount;
      balance=new;
    };
};
```

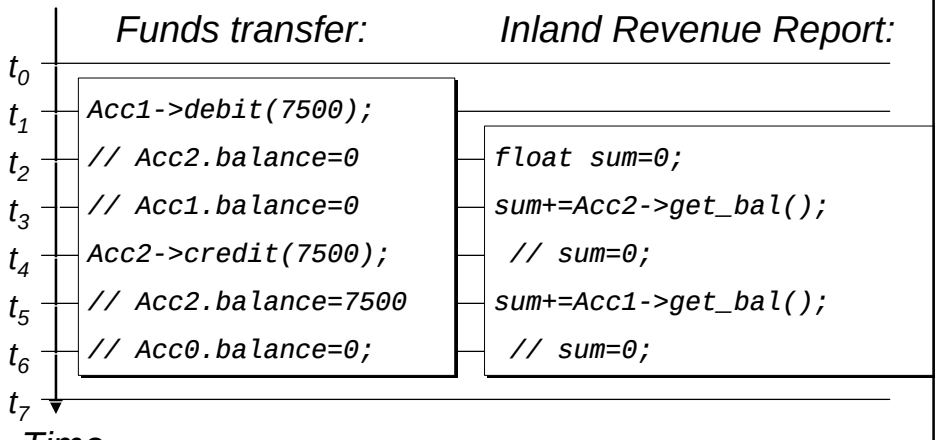
Lost Updates

Balance of account anAcc at t_0 is 75



Inconsistent Analysis

Balances at t_0 Acc1: 7500, Acc2: 0



Two Phase Locking (2PL)

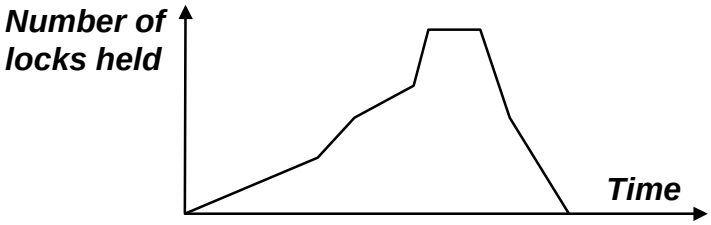
- *The most popular concurrency control technique. Used in:*
  - *RDBMSs (Oracle, Ingres, Sybase, DB/2, etc.)*
  - *ODBMSs (O2, ObjectStore, Versant, etc.)*
  - *Transaction Monitors (CICS, etc)*
- *Concurrent processes acquire locks on shared resources from lock manager.*
- *Lock manager grants lock if request does not conflict with already granted locks.*
- *Guarantees serialisability.*

Locks

- *A lock is a token that indicates that a process accesses a resource in a particular mode.*
- *Minimal lock modes: read and write.*
- *Locks are used to indicate to concurrent processes the current use of that resource.*

Locking

- *Processes acquire locks before they access shared resources and release locks afterwards.*
- *2PL: Processes do not acquire locks once they have released a lock.*
- *Typical 2PL locking profile of a process:*



Lock Compatibility

- *Lock manager grants locks.*
- *Grant depends on compatibility of acquisition request with modes of already granted locks.*
- *Compatibility defined in lock compatibility matrix.*
- *Minimal lock compatibility matrix:*

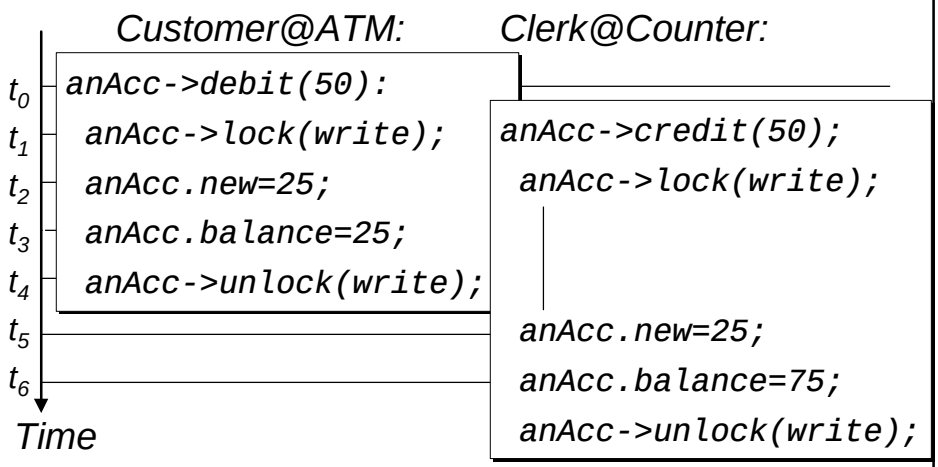
	Read	Write
Read	+	-
Write	-	-

Locking Conflicts

- **Lock requests cannot be granted if incompatible locks are held by concurrent processes.**
- **This is referred to as a locking conflict.**
- **Approaches to handle conflicts:**
  - **Force requesting process to wait until conflicting locks are released.**
  - **Tell process or thread that lock cannot be granted.**

Example (Avoiding Lost Updates)

Balance of account anAcc at t_0 is 75



Deadlocks

- *2PL may lead to processes waiting for each other to release locks.*
- *These situations are called deadlocks.*
- *Deadlocks have to be detected by the lock manager.*
- *Deadlocks have to be resolved by aborting one or several of the processes involved.*
- *This requires to undo all the actions that these processes have done.*

Locking Granularity

- *2PL applicable to resources of any granularity.*
- *High degree of concurrency with small locking granularity.*
- *For small granules large number of locks required.*
- *May involve significant locking overhead.*
- *Trade-off between degree of concurrency and locking overhead.*
- *Hierarchical locking as a compromise.*

Hierarchical Locking

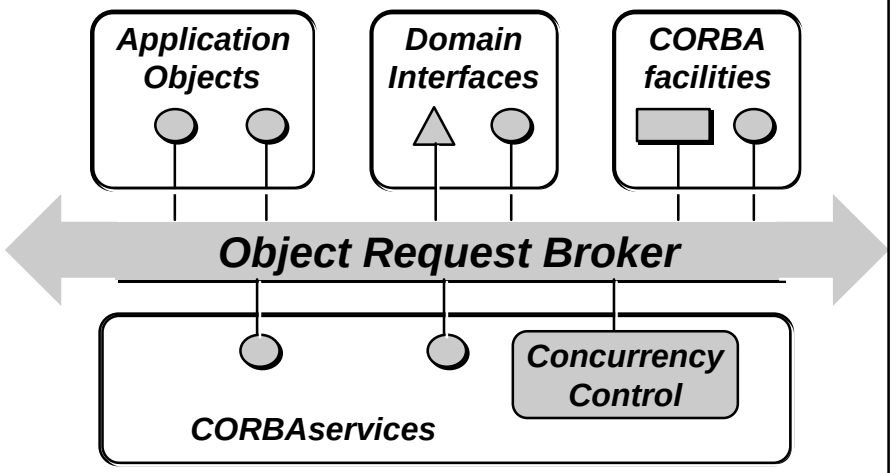
- *Used with container resources, e.g.*
  - *file (containing records)*
  - *set or sequence (containing objects)*
- *Lock modes intention read (IR) and intention write (IW).*
- *Lock compatibility:*

	IR	R	IW	W
IR	+	+	+	-
R	+	+	-	-
IW	+	-	+	-
W	-	-	-	-

Transparency of Locking

- *Who is acquiring locks?*
  - *Concurrency control infrastructure*
  - *Implementation of components*
  - *Clients of components*
- *First option desireable but not always possible:*
  - *Infrastructure must manage all resources*
  - *Infrastructure must know all resource accesses.*
- *Last option is undesirable and avoidable!*

CORBA Concurrency Control Service



Lock Compatibility Matrix

- *CORBA concurrency control service supports hierarchical locking.*
- *Upgrade locks for decreasing probability of deadlocks.*
- *Compatibility matrix:*

	IR	R	U	IW	W
IR	+	+	+	+	-
R	+	+	+	-	-
U	+	+	-	-	-
IW	+	-	-	+	-
W	-	-	-	-	-

Locksets

- *A lockset is associated to a resource (usually in the implementation of that resource).*
- *Each shared resource has a lockset.*
- *Operations of that resource acquire locks before they access or modify the resource.*

The IDL Interfaces

```
interface LocksetFactory {
  LockSet create();
};
interface Lockset {
  void lock(in lock_mode mode);
  boolean try_lock(in lock_mode mode);
  void unlock(in lock_mode mode);
  void change_mode(in lock_mode held,
                   in lock_mode new);
};
```