Distributed Transaction Processing

Roles of Components

- ***Distributed system components involved in transactions can take role of:***
- ***Transactional Client***
- ***Transactional Server***
- ***Coordinator***

Coordinator

- *Coordinator plays key role in managing transaction.*
- *Coordinator is the component that handles begin / commit / abort transaction calls.*
- *Coordinator allocates system-wide unique transaction identifier.*
- *Different transactions may have different coordinators.*

Transactional Server

- *Every component with a resource accessed or modified under transaction control.*
- *Transactional server has to know coordinator.*
- *Transactional server registers its participation in a transaction with the coordinator.*
- *Transactional server has to implement a transaction protocol (two-phase commit).*

Transactional Client

- *Only sees transactions through the transaction coordinator.*
- *Invokes services from the coordinator to begin, commit and abort transactions.*
- *Implementation of transactions are transparent for the client.*
- *Cannot tell difference between server and transactional server.*

Two-Phase Commit

- *Multiple autonomous distributed servers:*
  - *For a commit, all transactional servers have to be able to commit.*
  - *If a single transactional server cannot commit its changes every server has to abort.*
- *Single phase protocol is insufficient.*
- *Two phases are needed:*
  - *Phase one: Voting*
  - *Phase two: Completion.*

Phase One

- *Called the voting phase.*
- *Coordinator asks all servers if they are able (and willing) to commit.*
- *Servers reply:*
  - *Yes: it will commit if asked, but does not yet know if it is actually going to commit.*
  - *No: it immediately aborts its operations.*
- *Hence, servers can unilaterally abort but not unilaterally commit a transaction.*

Phase Two

- *Called the completion phase.*
- *Co-ordinator collates all votes, including its own, and decides to*
  - *commit if everyone voted 'Yes'.*
  - *abort if anyone voted 'No'.*
- *All voters that voted 'Yes' are sent*
  - *'DoCommit' if transaction is to be committed.*
  - *Otherwise 'Abort'.*
- *Servers acknowledge DoCommit once they have committed.*

Server Uncertainty (1)

- *Period when a server must be able to commit, but does not yet know if has to.*
- *This period is known as server uncertainty.*
- *Usually short (time needed for co-ordinator to receive and process votes).*
- *However, failures can lengthen this process, which may cause problems.*

Recovery in Two-Phase Commit

- *Failures prior to start of 2PC results in abort.*
- *Coordinator failure prior to transmitting commit messages results in abort.*
- *After this point, co-ordinator will retransmit all Commit messages on restart.*
- *If server fails prior to voting, it aborts.*
- *If it fails after voting, it sends GetDecision.*
- *If it fails after committing it (re)sends HaveCommitted message.*

Complexity

- *Assuming N participating servers:*
- *(N-1) Voting requests from coordinator to servers.*
- *(N-1) Completion requests from coordinator to servers.*
- *Hence, complexity of requests is linear in the number of participating servers.*

Committing Nested Transactions

- *Cannot use same mechanism to commit nested transactions as:*
  - *subtransactions can abort independently of parent.*
  - *subtransactions must have made decision to commit or abort before parent transaction.*
- *Top level transaction needs to be able to communicate its decision down to all subtransactions so they may react accordingly.*

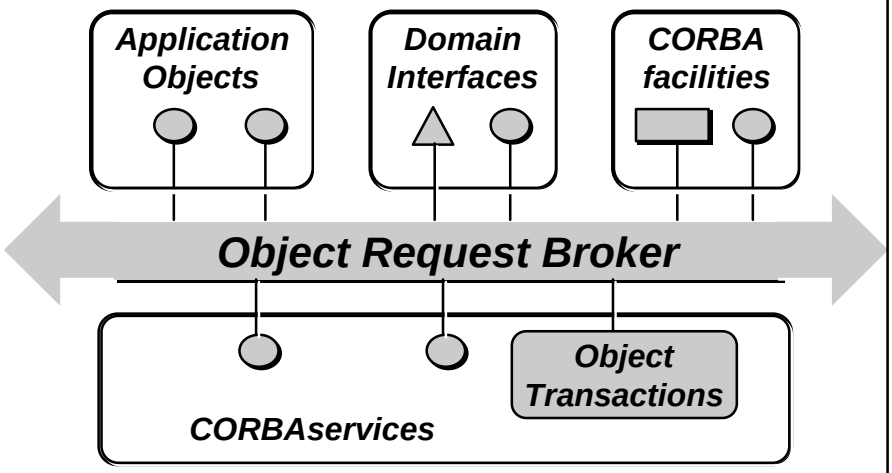
Provisional Commit

- *Subtransactions vote either:*
  - *aborted or*
  - *provisionally committed.*
- *Abort is handled as normal.*
- *Provisional commit means that coordinator and transactional servers are willing to commit subtransaction but have not yet done so.*

Locking and Provisional Commits

- *Locks cannot be released after provisional commit.*
- *Data items remain 'protected' until top-level transaction commits.*
- *This may reduce concurrency.*
- *Interactions between sibling subtransactions:*
  - *should they be prevented (different)?*
  - *allowed (part of the same transaction)?*
- *Generally they are prevented.*

CORBA Transaction Service



IDL Interfaces

- Object Transaction Service defined through three IDL interfaces:
- Current
- Coordinator
- Resource

Current

```
interface Current {
  void begin() raises (...);
  void commit (in boolean report_heuristics)
       raises (NoTransaction, HeuristicMixed,
               HeuristicHazard);
  void rollback() raises(NoTransaction);
  Status get_status();
  string get_transaction_name();
  Coordinator get_control();
  Coordinator suspend();
  void resume(in Coordinator which)
       raises(InvalidControl);
};
```

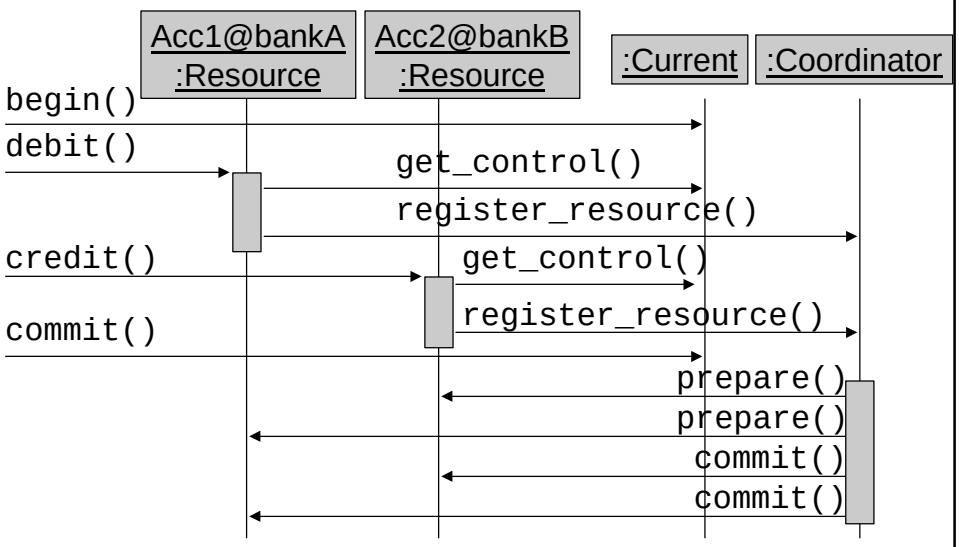

Coordinator

```
interface Coordinator {
 Status get_status();
 Status get_parent_status();
 Status get_top_level_status();
 boolean is_same_transaction(in Coordinator tr);
 boolean is_related_transaction(in Coordinator tr)
 RecoveryCoordinator register_resource(
         in Resource r) raises(Inactive);
 void register_subtran_aware(
         in SubtransactionAwareResource r)
         raises(Inactive, NotSubtransaction);
  …
};
```

Resource

```
interface Resource {
  Vote prepare();
  void rollback() raises(...);
  void commit() raises(...);
  void commit_one_phase raises(...);
  void forget();
};
interface SubtransactionAwareResource:Resource
  {
  void commit_subtransaction(in Coordinator p);
  void rollback_subtransaction();
};
```


Example: Funds Transfer



Summary

- *Two-phase commit*
  - *phase one: voting*
  - *phase two: completion*
- *CORBA Transaction Service*
  - *implements two-phase commit*
  - *needs resources that are transaction aware*