# CONCURRENCY AND REPLICA CONTROL :-

→ Handling large clients
→ Handling multiple servers

## CONCURRENCY CONTROL :-

RPC → Remote Procedure call. → Abstraction for processes to call functions in other processes.

Ⓐ Code reuse

For object based settings
↳ RMI (Remote method invocation)

LOCAL PROCEDURE CALL → Call from one function to another within the same process.

Ⓐ Stack usage to pass arguments and return values.

⇒ Object access via pointers. (because same address space)

→ Follows Exactly-once symantics.

RPC :→ Caller and callee are in different processes

Ⓐ Object references via global pointers.

Ex. obj. Address = IP + Port + obj. Number

⇓ Basically crosses process boundaries.

FAILED CALL :-

→ Request message dropped
→ Reply message dropped
→ Called process fails → before execution / → after execution

Ⓐ These cases are hard to distinguish

MULTIPLE CALL :-

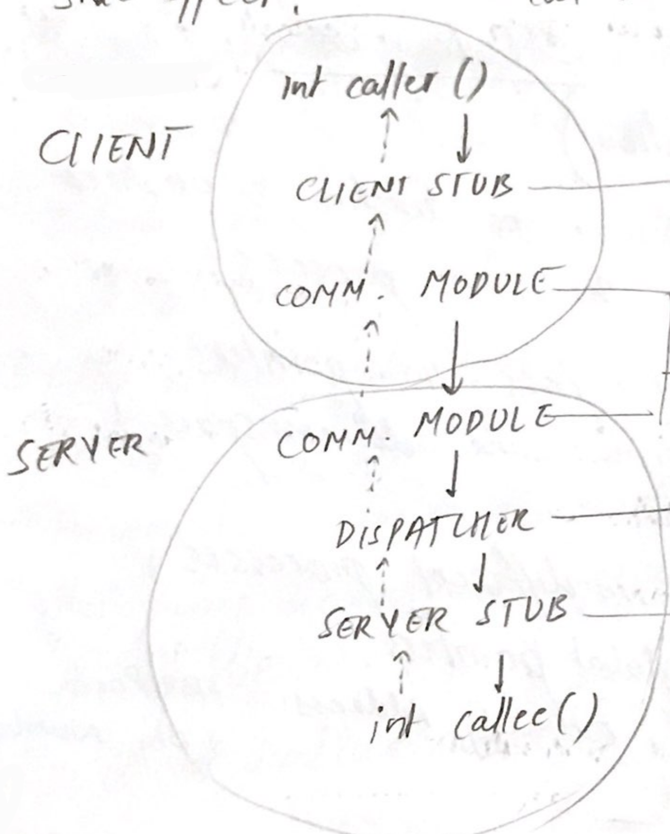
→ Request message duplicated by the network

Possible Symantics

- AT MOST ONCE → JAVA RMI
- AT LEAST ONCE → Sun RPC
- MAYBE → CORBA

| | RETRANSMIT | FILTER DUPLICATES | RE-EXCUTE OR RETRANSMIT REPLY |
|---|---|---|---|
| AT LEAST ONCE | Yes | NO | Re-execute |
| AT MOST ONCE | Yes | Yes | Retransmit |
| MAYBE | NO | N/A | N/A |

(*) Idempotent Operations can be repeated without any side effect. → can be used with AT LEAST ONCE




Has same function signature a callee. (Allows caller code to be used as RPC & LPC)

Forwards requests/replies

Selects server stub

because of multiple client requests

calls callee and allow to return a value

All part of Middleware System.

MARSHALLING → Caller converts arguments from platform dependent format to COMMON DATA REPESENTATI (CDR)

(*) CDR is used by Middleware to become platform independent

REVERSE PROCESS. → Unmarshalling.

## TRANSACTIONS :

→ Series of operations executed by client
→ Each operation is an RPC to a server

Either commits all operations at server

Or Aborts all operations and has no effect

### REQUIREMENTS :—

→ Atomicity
→ Isolation → Indivisible from point of view of other transaction (Basically free from interference)
→ Consistency
→ Durability

## PROBLEMS :—

① Lost update Problem (solved by Isolation)

② Inconsistent Retrieval

## SERIAL EQUIVALENCE :—

An interleaving O of transactions is serially equivalent iff there exists ordering O' of those transactions one at a time which gives same end-result (for all the objects and transactions)

Read → Affects client

Write → Affects server.

### CONFLICTING OPERATIONS

→ Combined effect depends on order of execution

Ex. Read(x), write(x)

① Serial Equivalence achieved when pairs of conflicting operations are in same order for all the objects

② Must abort one of the transactions when conflict in 2 transactions detected.

## 2 APPROACHES : ① PESSIMISTIC ② OPTIMISTIC

① PESSIMISTIC → Prevent access → Use exclusive locks (Read-write locks)

PROBLEM: Reduces concurrency.

② OPTIMISTIC → check at commit time

## TWO PHASE LOCKS :- (PESSIMISTIC CONCURRENCY CONTROL)

→ Transaction cannot acquire any locks after it has started releasing locks.

PHASE ①: Growing Phase ] → Guarantees serial equivalence
PHASE ②: Shrinking phase

**DISADVANTAGE: Deadlocks**

**FIX:** ① Timeout: Abort transaction
* Expensive
* Might not even be a deadlock
* Wasted work

② Deadlock Detection:
* Keeping track of weight graph
* Find cycles
* Abort one or more transactions to break cycle

③ Deadlock Prevention:
1. Allow read-only access to objects
2. Allow pre-emption of some transactions
3. Compound locks → Lock all objects at the beginning

## ② OPTIMISTIC CONCURRENCY CONTROL

**1. BASIC APPROACH:** Check for serial equivalence, abort if not satisfied → Leads to cascading abort
↓
Transactions who read dirty data of aborted transaction needs to be aborted

**2. TIME STAMP ORDERING:**
↓
Transaction id determines its position in serialization order (Abort if rule violated)
* Read only if write by lower id in past
* Write only if read/write by lower ids in past.

## ③ MULTI - VERSION CONCURRENCY :—

→ Per-transaction version of object is maintained and marked as tentative versions (alongside committed version at server).

Has timestamp

→ On read-write, mark correct version to read or write from
based on transaction id

Eventual consistency → Similar to Optimistic concurrency

RIAK KEY-VALUE STORE → Vector clock implements Causal ordering

* Sibling value resolved by user or application.

## REPLICATION CONTROL :—
→ Fault tolerance
→ Load balancing

Higher availability? $1-f$ per server ⇒ $1-f^k$ any 1 server is working

CHALLENGE : → Transparency (replication must be invisible) ⇒ Frontend → provides replication transparency
→ Consistency (Sees single consistent copy)

*. Concept of Replicated State Machines

### ① PASSIVE REPLICATION

→ Elected master in the system ⇒ Determines total ordering of all updates.
(On leader failure, run election)

### ② ACTIVE REPLICATION :
Frontend multicasts the request to read/write to entire replica group
→ can use any ordering

Total order on Multicast ⇒ Same inputs to replicas.

(*) Failures in active replication dealt by Virtual Synchrony

## ONE-COPY SERIALIZABILITY :-

A concurrent execution of transaction in a replicated database is one-copy-serializable if it is equivalent to serial execution of these transactions on a single logi. copy of database

FINAL OBJECTIVE = Serial equivalence + One-copy Serializability

(*) A transaction may touch different servers for different objects. Commit must commit to all or no servers (Atomic commit).

## (*) ONE-PHASE COMMIT

⇒ special server Coordinator initiates atomic commit

PROBLEM :- ① Problems at a single server like corrupted object
② Server may crash before receiving commit mes.

## (*) TWO-PHASE COMMIT

retrievable after crash.

① Coordinator sends PREPARE message to servers.
② Server saves updates to disk and reply YES or NO
③ If all votes received are YES within the timeout, it sends commit message. Otherwise abort.
④ On commit, server commits and sends ACK.

server can poll if no decision received

To deal with COORDINATOR crash, it logs all messages, decisions on disk. After recovery, new election.