KTH ROYAL INSTITUTE
OF TECHNOLOGY

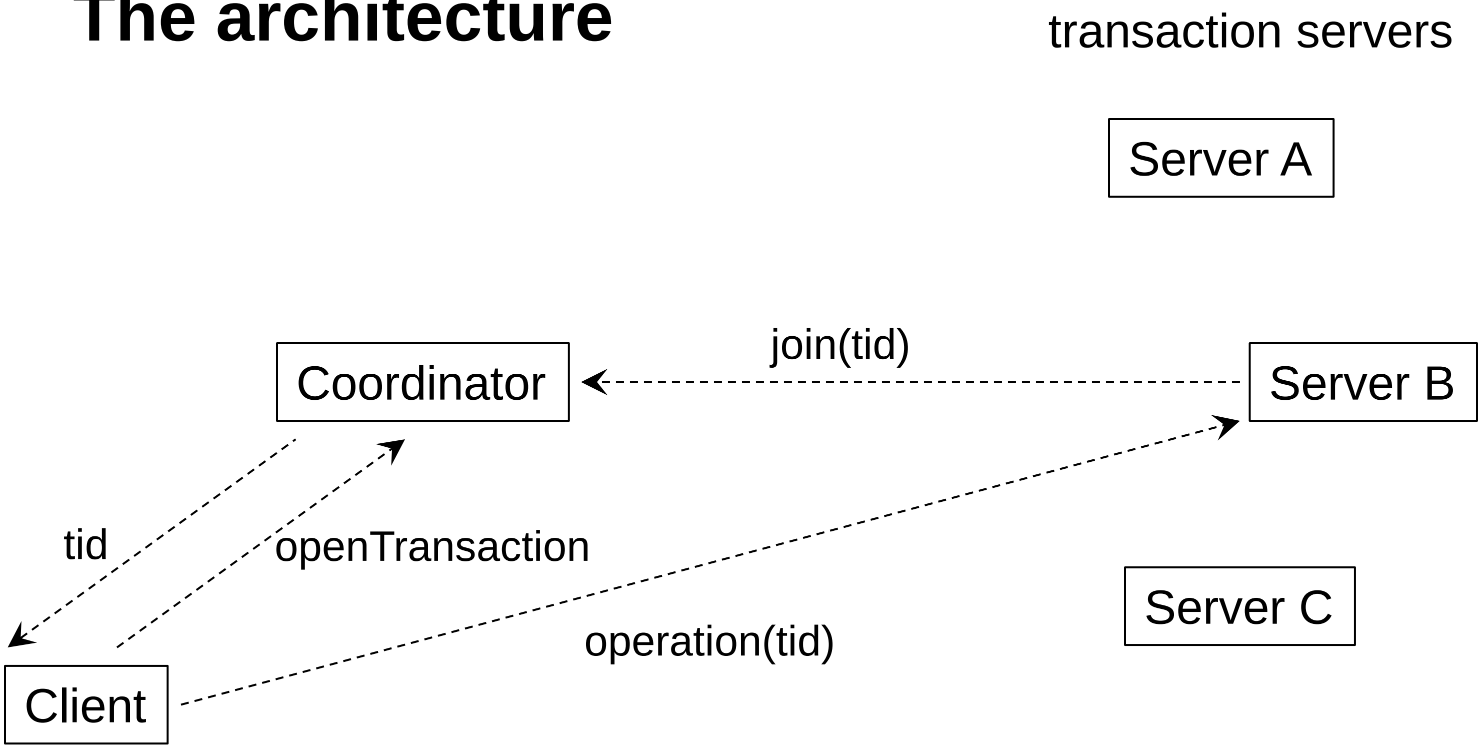
Distributed transactions

Johan Montelius and Vladimir Vlassov

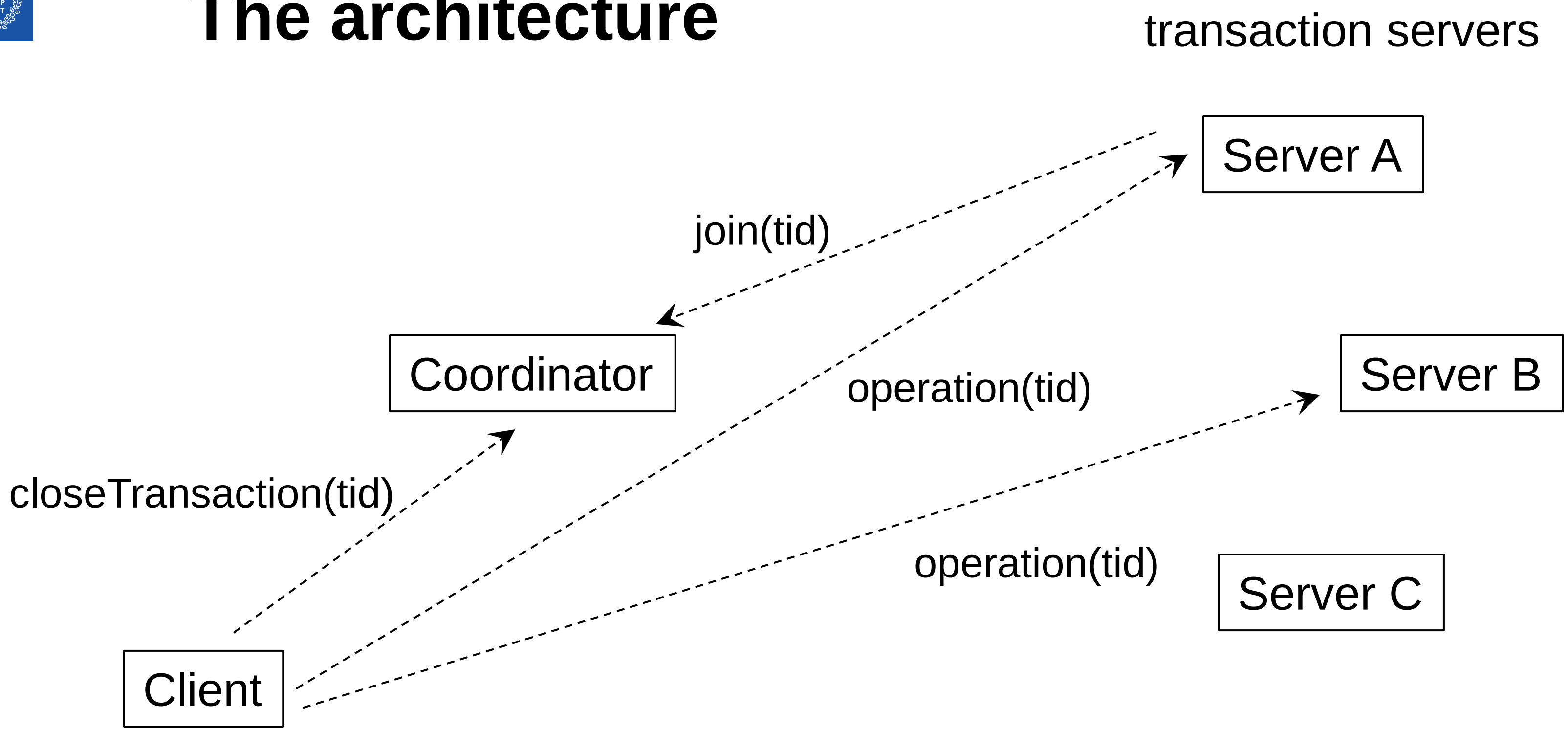
Problem

- Several independent transaction servers should be coordinated in one transaction.
- How do we coordinate operations to guarantee serial equivalence?

The architecture



The architecture



One-phase commit

- Client sends closeTransaction to coordinator.
- Coordinator tells participants to commit the transaction.
- Problem:
  - ?

Two-phase commit

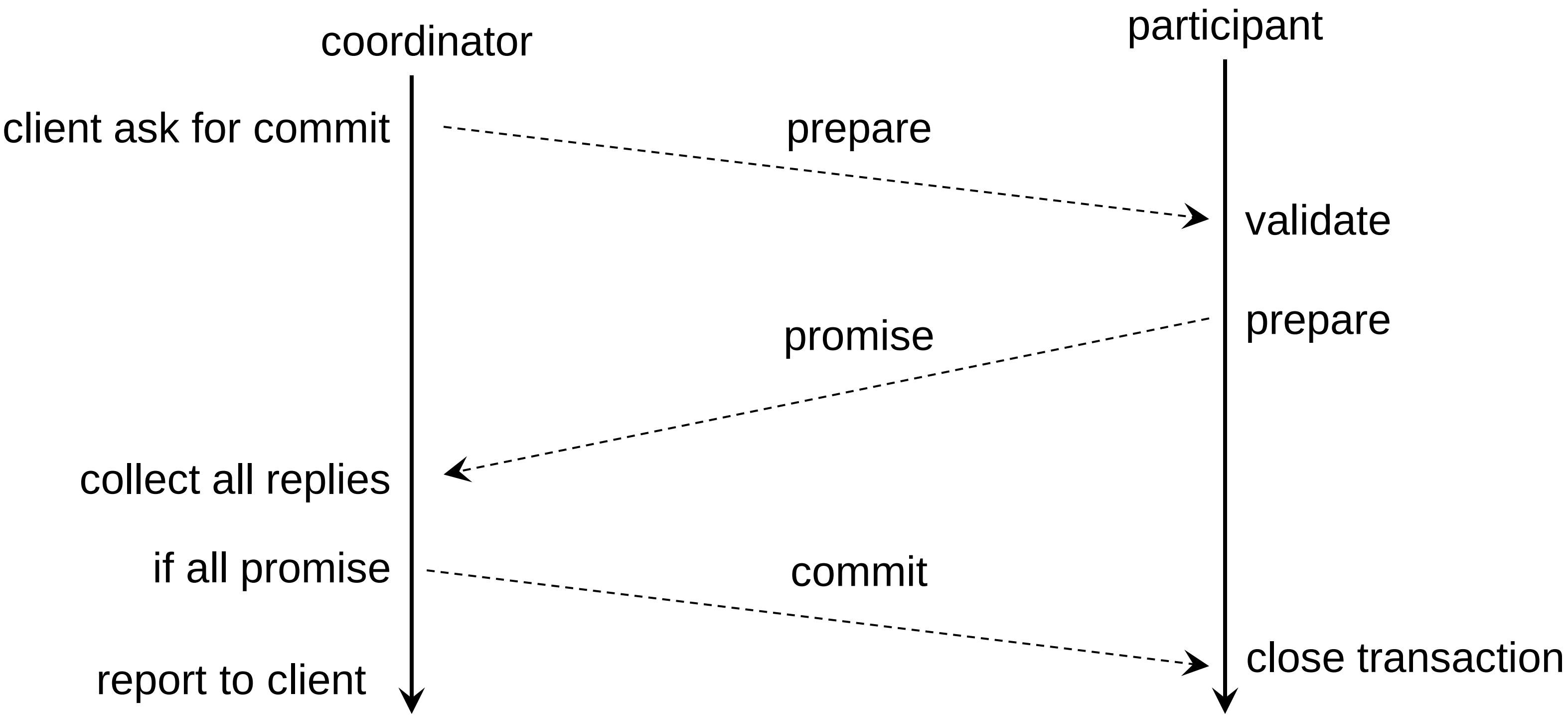
- phase one (voting): ask participants to vote for commit or abort
  - if voting for commit, one has to be able to commit even after a node crash
  - if anyone aborts all must abort
- phase two (completion): inform all participants of the result

Consensus

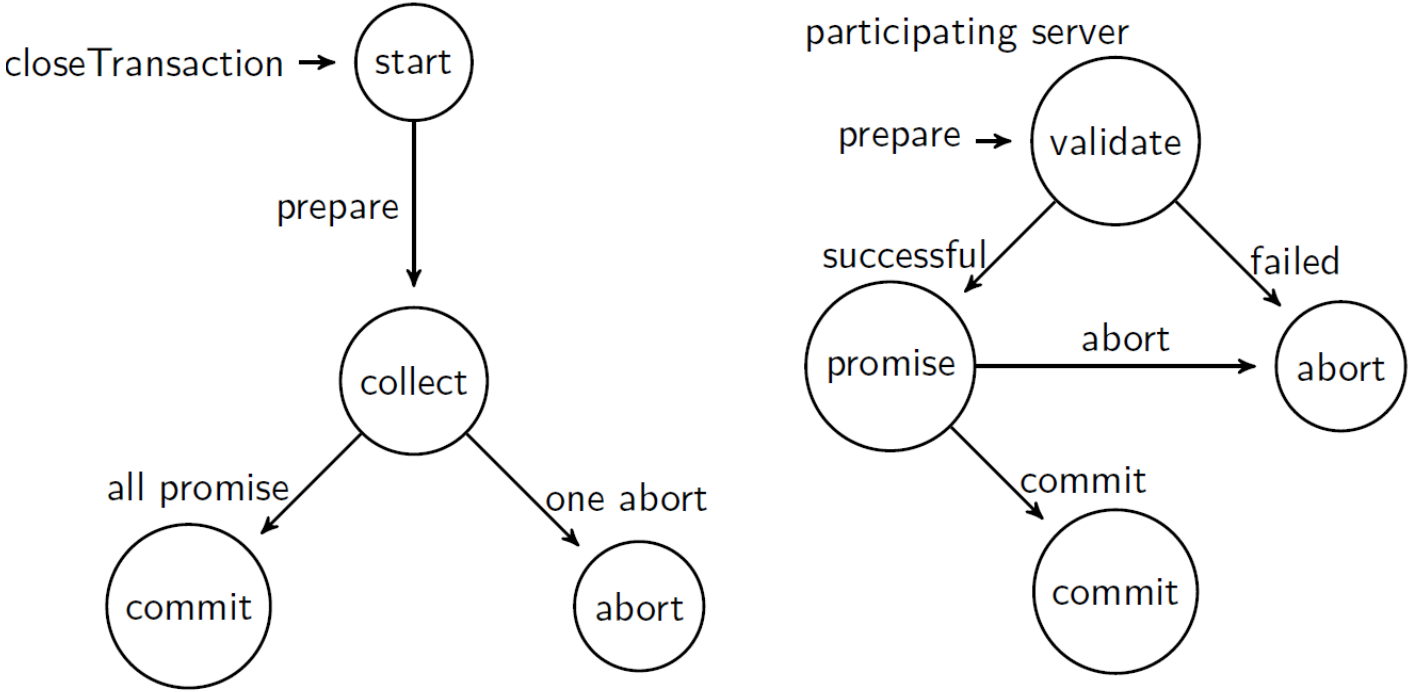
Two-phase commit is a consensus protocol but:

- all servers must vote
- if any server wants to abort then we abort

Two-phase commit



Two-phase commit



What if ..

- A participating server crashes before making a promise
- A participating server crashes after having promised
- The coordinator crashes before asking for a promise
- The coordinator crashes but you have made a promise

Two-phase commit can be suspended waiting for a crashed coordinator

If we know our peers

Assume that the participants know each other.

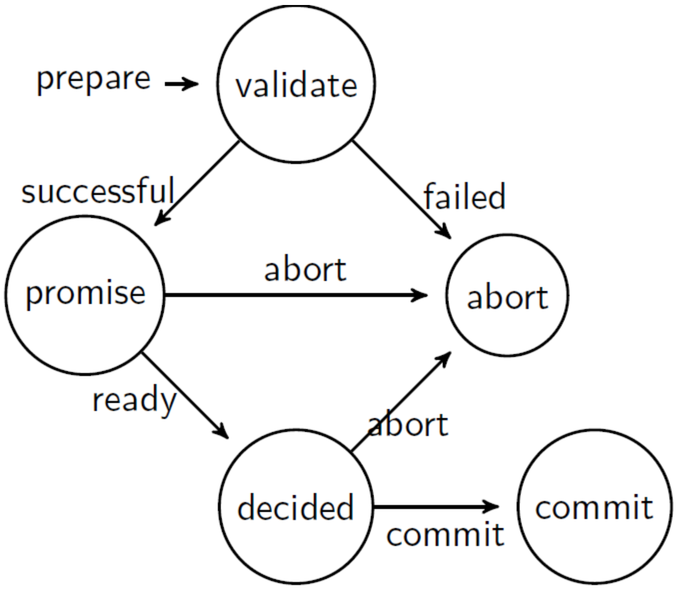
If the coordinator crashes:

- and no participant was told to commit, then it is safe to abort
- if one participant was told to commit, then we should all commit

What if the coordinator and one participant has crashed and none of the surviving participants have received a commit message?

Three-phase commit

- If the coordinator crashes and one node is still in the promised state we know that the coordinator has not ordered a commit - we can thus abort.
- If the coordinator crashes and all nodes are in the decided state they agree to commit.



Relies on perfect failure detectors - and that we know who is in the group.

Concurrency control

- locking
- optimistic
- timestamp

The danger of locking

Assume we implement *strict two-phase locking* and need to take the locks for *foo*, *bar* and *zot*.

What does it mean and what should we do?

Avoid or handle

You can either avoid deadlocks or detect them.

We are in a deadlock if T is waiting for S that is waiting for... that is waiting for T.

- *A set of processes is deadlocked when each process in the set is waiting for an event which can only be caused by another process in that set*

Examine the state and look for circular dependencies.

Wait-for graph

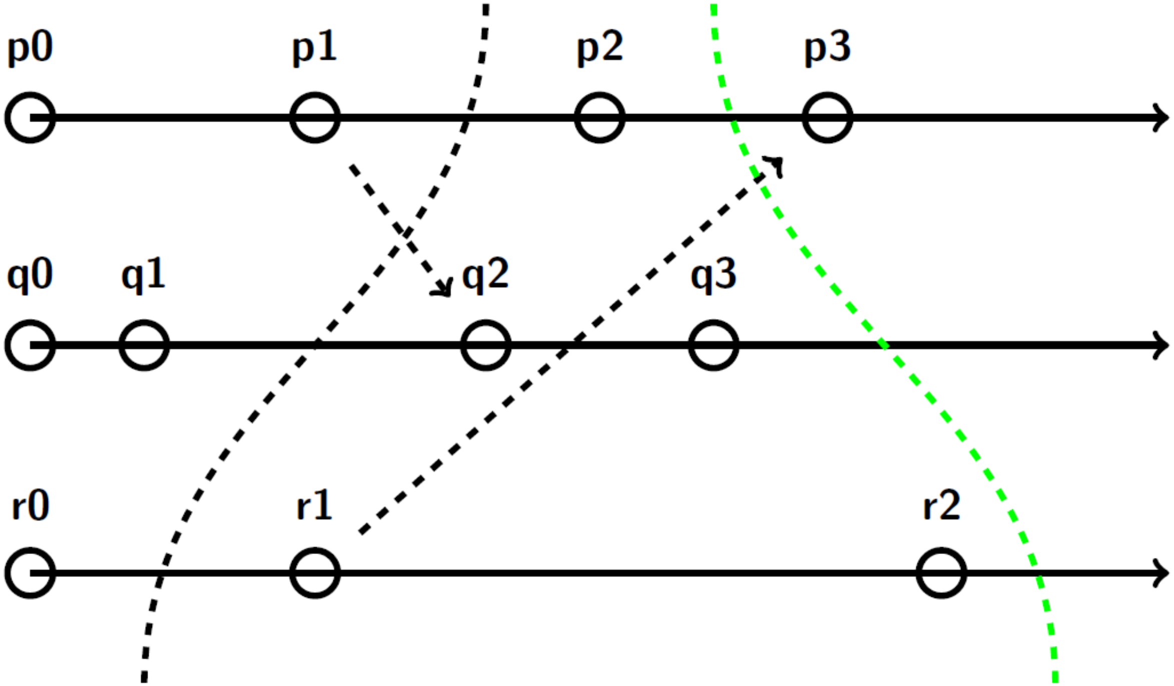
- Nodes are transactions and objects
  - Edge (object ➔ transaction) represents object held by transaction;
  - Edge (transaction ➔ object) represents transaction waiting for object.

There is a deadlock if there is a cycle in the wait-for graph.

- In a distributed system, a global wait-for graph can be constructed from the local ones.

There is a distributed deadlock if there is a cycle in the global wait-for graph

A distributed state



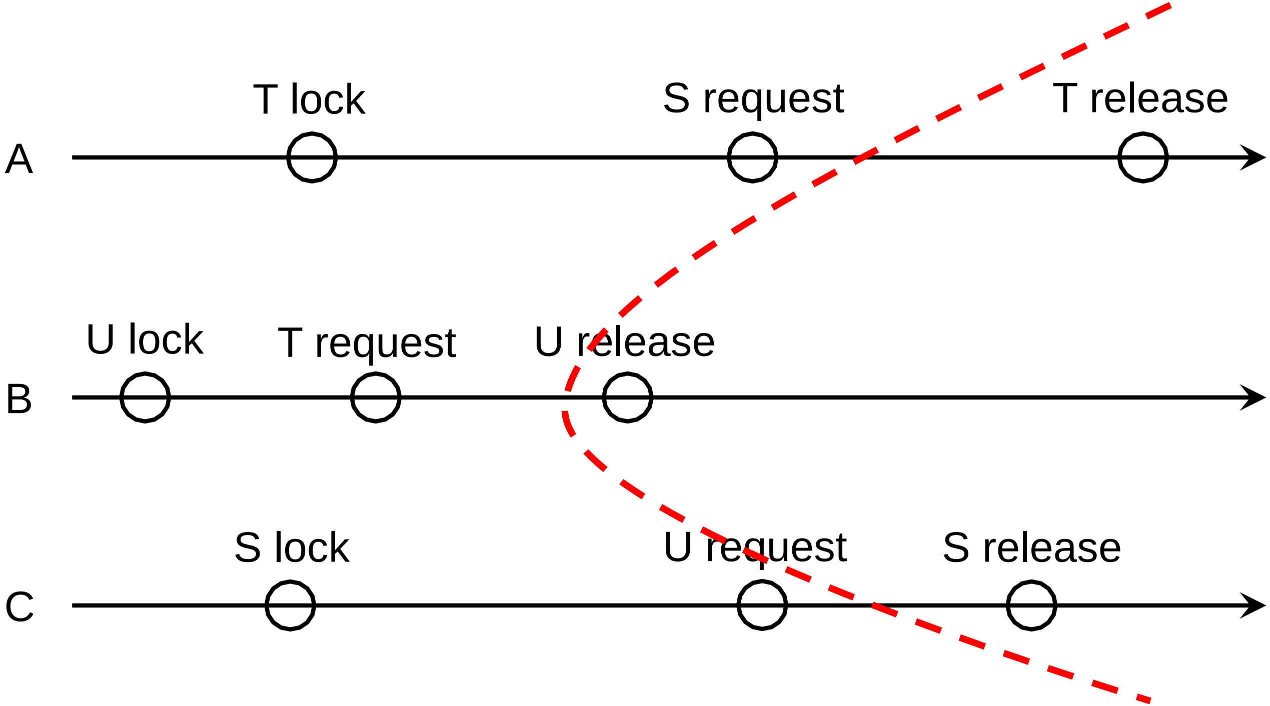
Deadlock detection

What if:

- server A reports: S is waiting for T
- server B reports: T is waiting for U
- server C reports: U is waiting for S

Deadlock detected, let's do something

Phantom deadlock



Detection

How do we detect deadlocks?

Centralized deadlock detection

- one server takes on the role of global deadlock detector.
- Collects local wait-for graphs and constructs a global wait-for graph.
- When finds a cycle, tells the servers which transaction to abort in order to resolve the deadlock.

Distributed deadlock detection

- Uses a technique called edge chasing or path pushing
- Servers forward probes along the edges in the global wait-for graph.
- In this way, paths through the global wait-for graph are built one edge at a time.

Optimistic concurrency control

Transactions should be validated in a total order.

What if transaction T is validated at A and transaction S at B?

A distributed transaction is validated by involved servers, each of which validates transactions that access its own objects.

- This validation takes place during the first phase of the two-phase commit protocol.
- All of the servers of a particular transaction use the same globally unique transaction number (generator by coordinator) at the start of the validation.

Timestamp order

A global timestamp that all transaction servers agree to.

Summary

Distributed transactions

- a global total order of transactions
- if one server needs to abort, then all should abort

Two-phase commit

- coordinator asks participants to prepare
- participants promise to commit (or aborts)
- coordinator directs participants to commit

Distributed deadlock

- hard to prevent
- simpler to detect

Concurrency control

- locks
- optimistic
- timestamp