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Innovation and Creativity

Preventing Orphan Requests by Integrating Replication and Transactions

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Outline

- Motivation
- Integration
- Performance Results
- Summary

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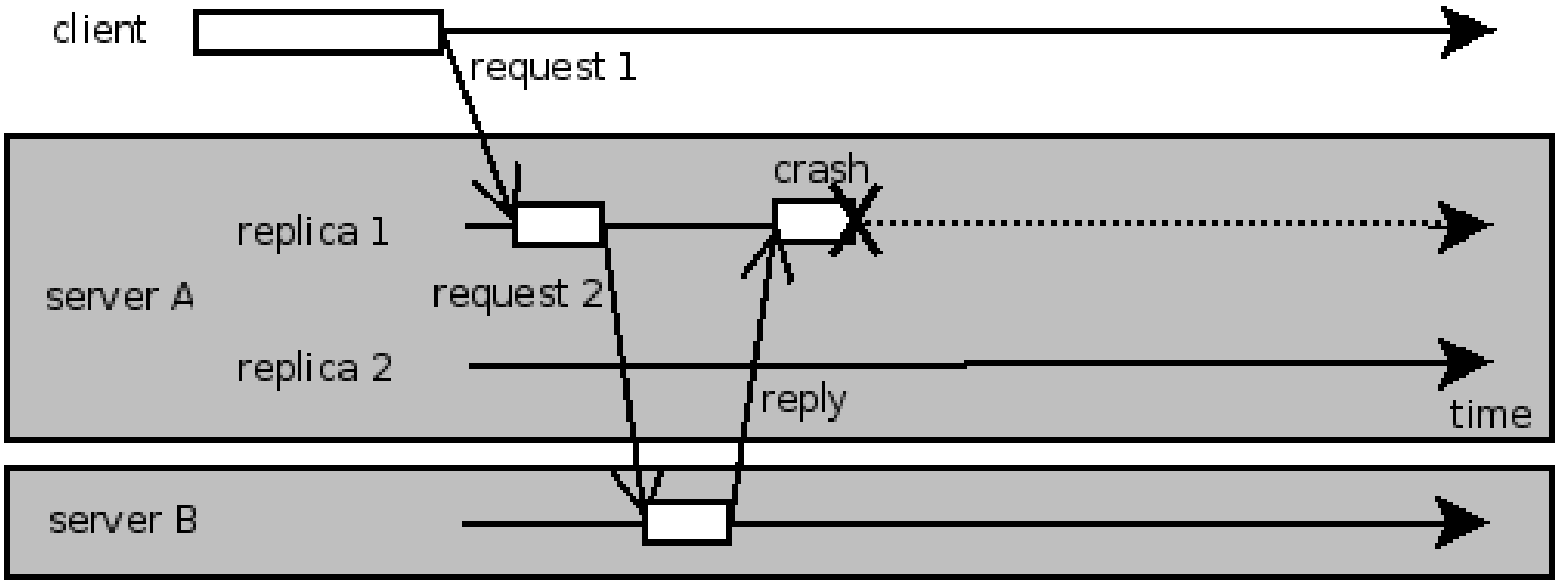
Orphan Request



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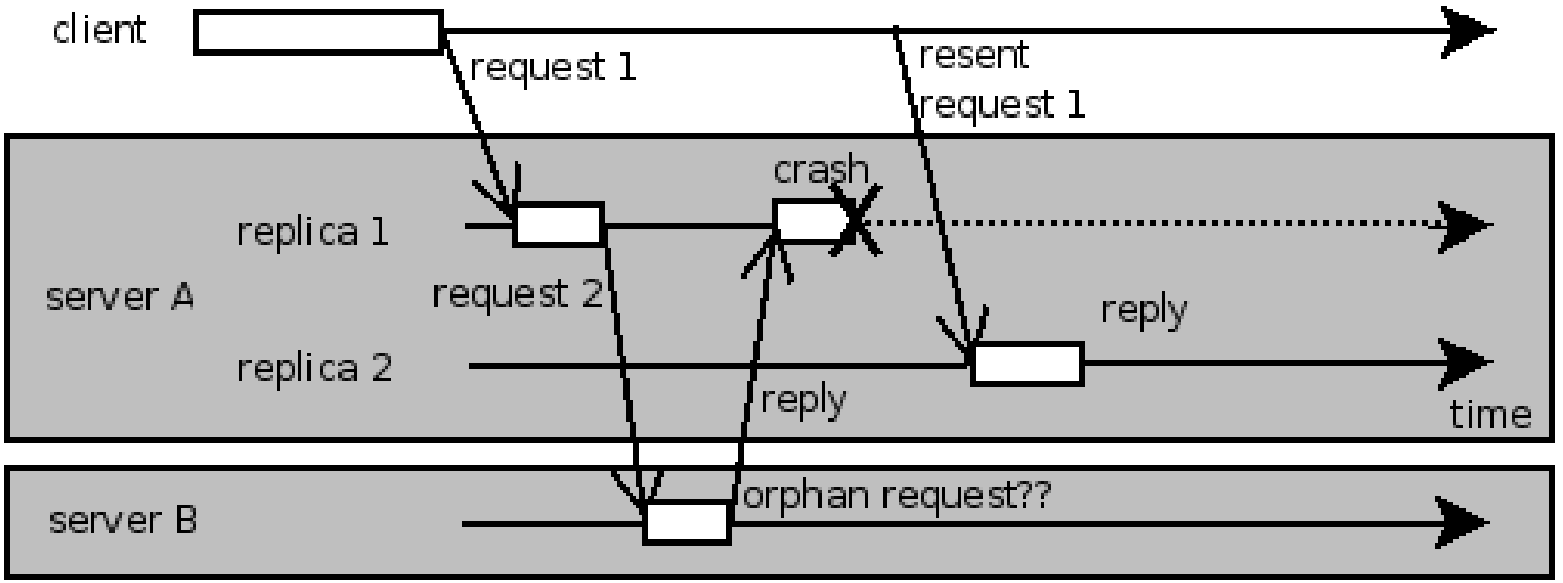
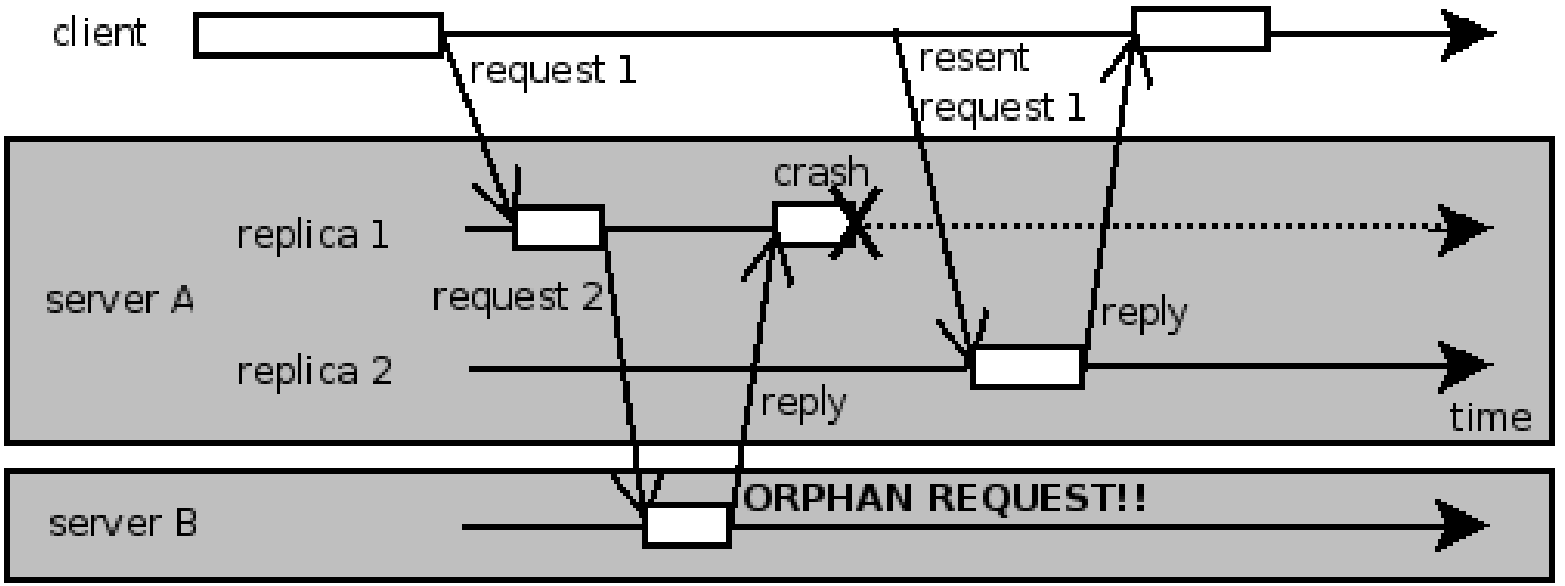
Orphan Request



Orphan Request



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Determinism

- Identical input gives identical output and identical internal state changes.
- Sources of non-determinism [Poledna 1993]:
  - Multi-threading
  - Timeouts
  - Reading analogue sensors
  - Inconsistent order
  - ...

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Availability And Consistency

- Replication -> Availability
  - Active
  - Passive
- Transactions -> Consistency
  - ACID properties

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System Model

- Set S of fail-crash processes (nodes)
- Group G implements a service
- Node in G is called a replica
- Group view
- Passive replication
- Two-Phase Commit protocol
- Stateful, but no persistent state
- All replicas are non-deterministic

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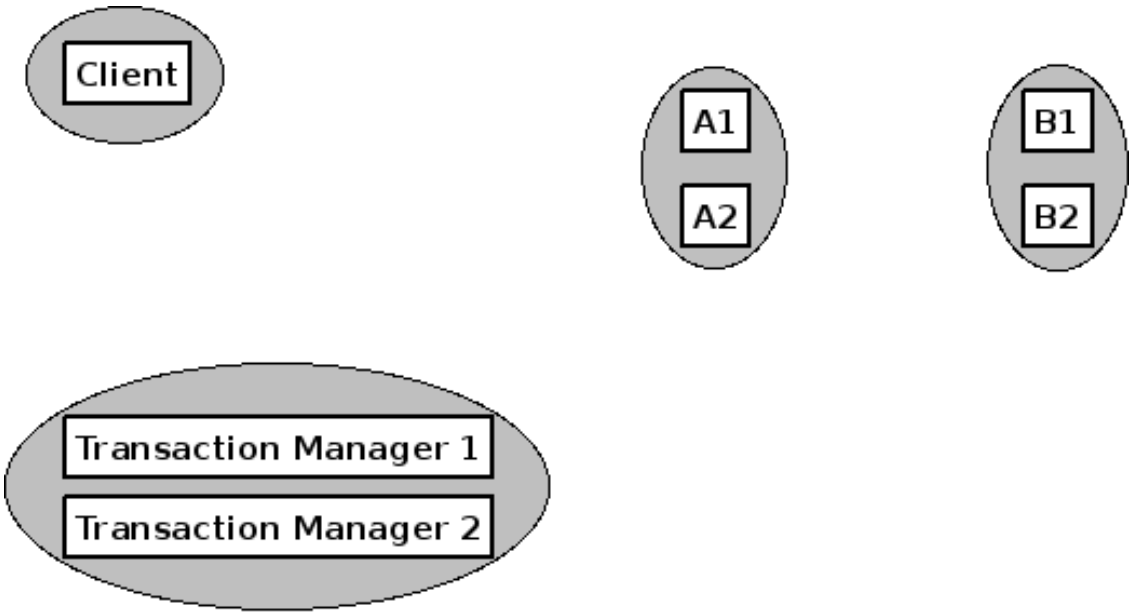
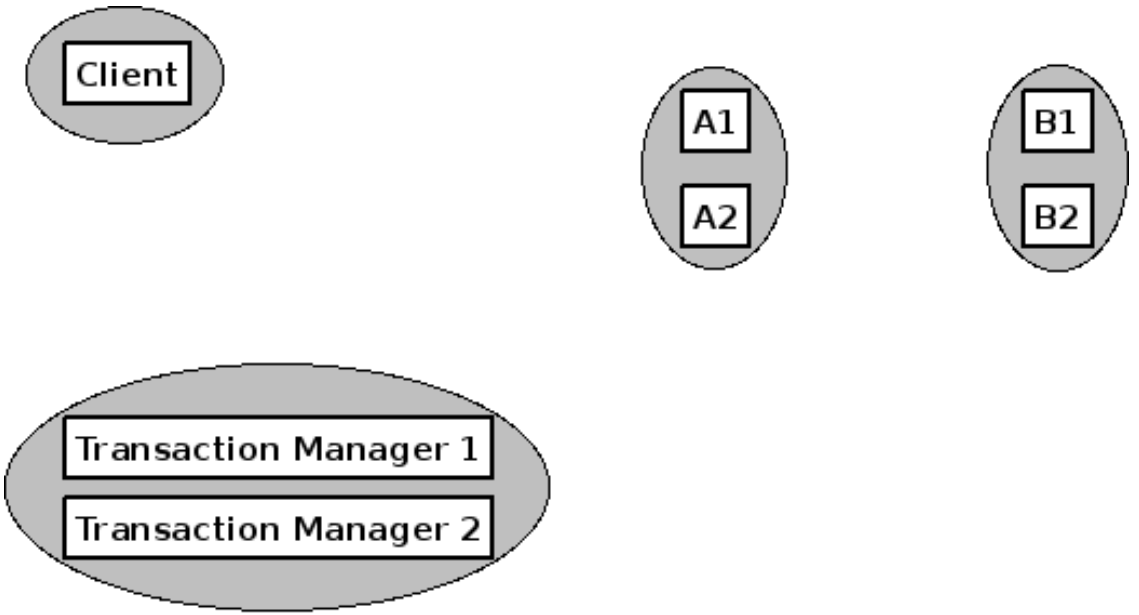
Components

- Client - initiate transaction and commitment processing
- Transaction Manager - creates txn ID and manages commitment
- Transaction Participants - execute requests and vote



Transaction Initiation and Execution



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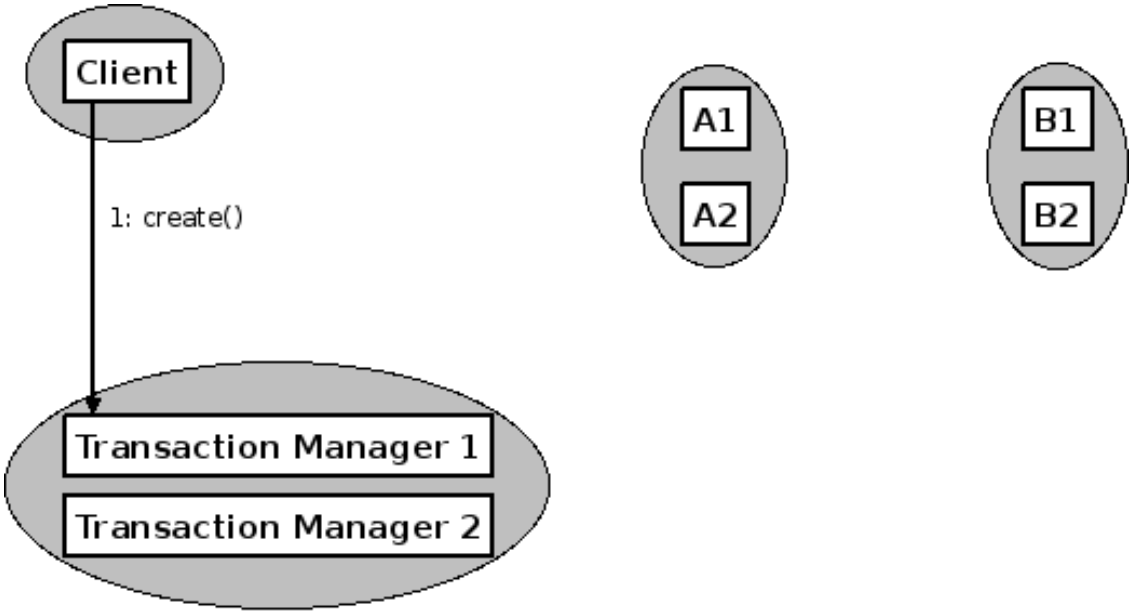

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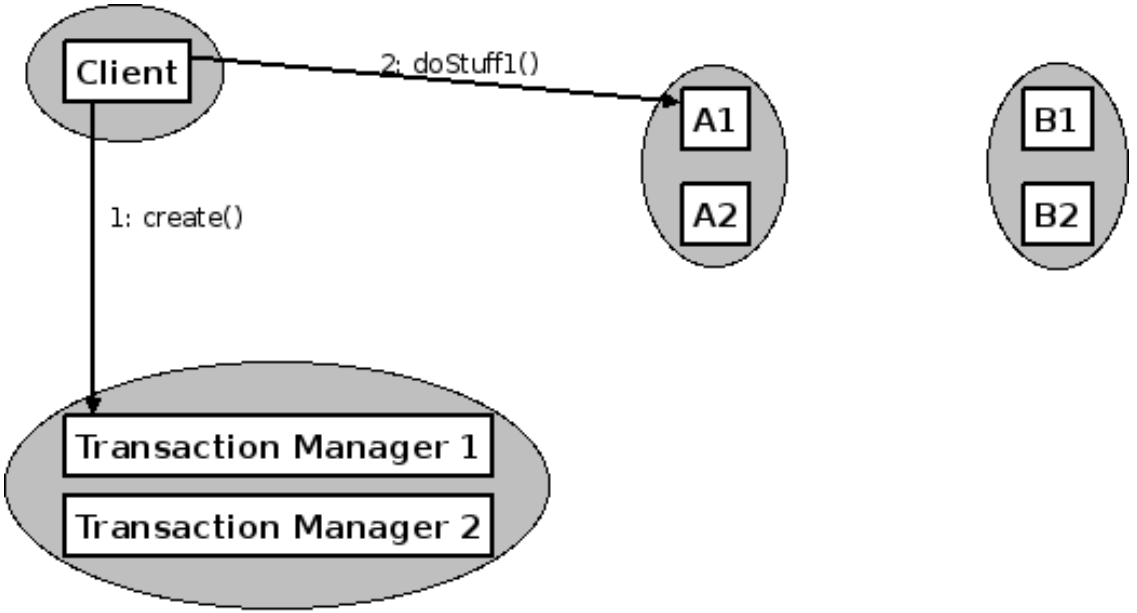

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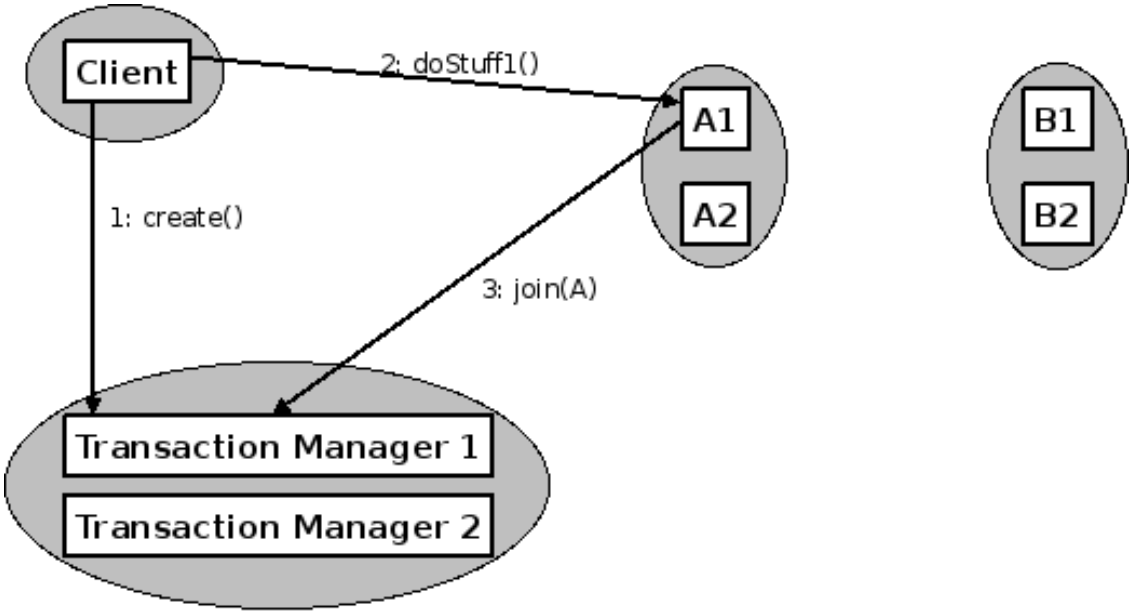

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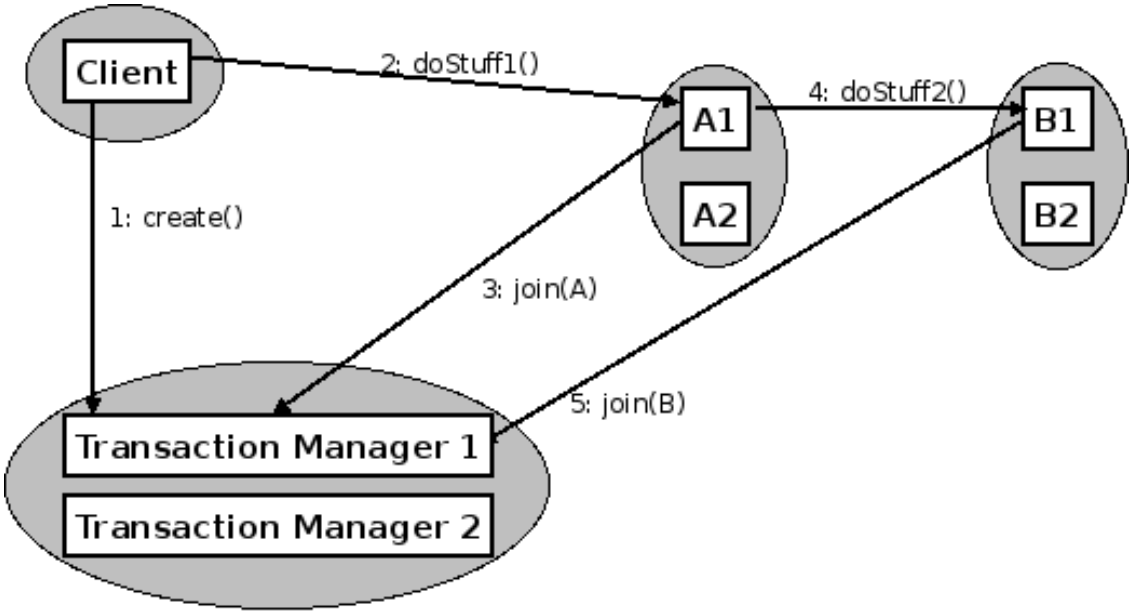

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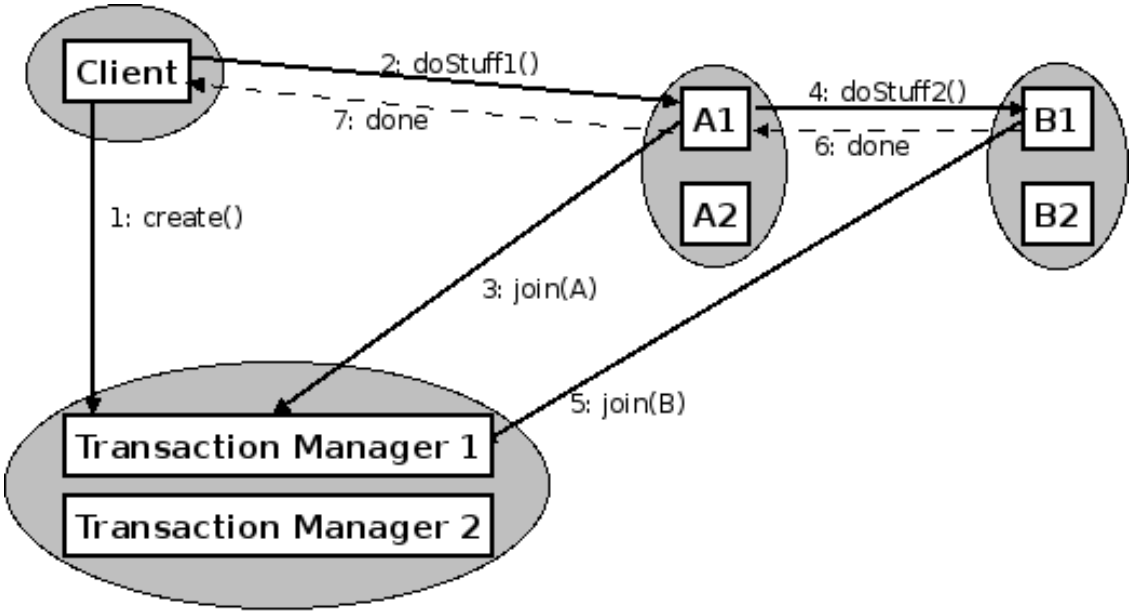
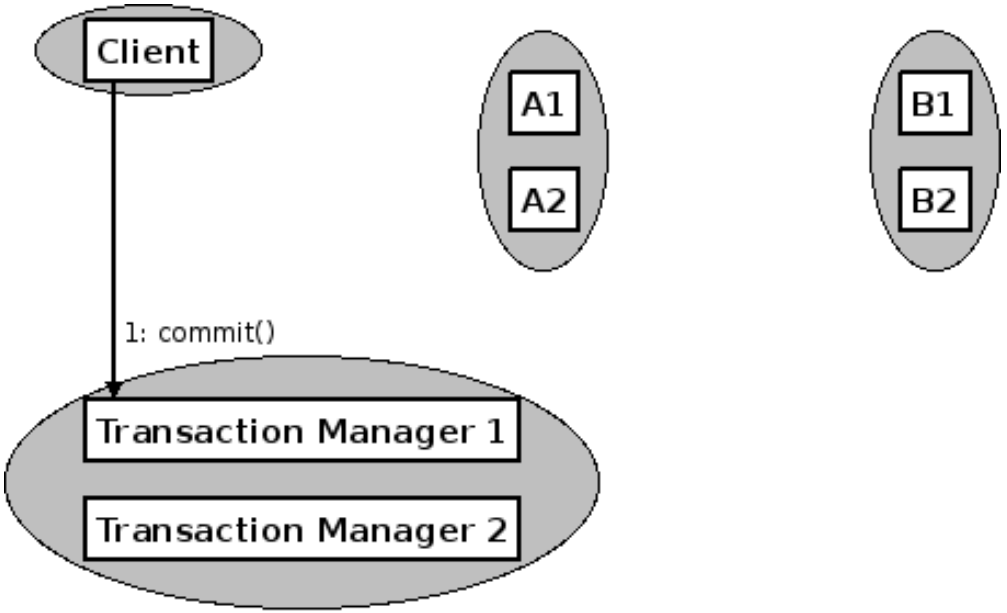
Transaction Initiation and Execution



Transaction Termination



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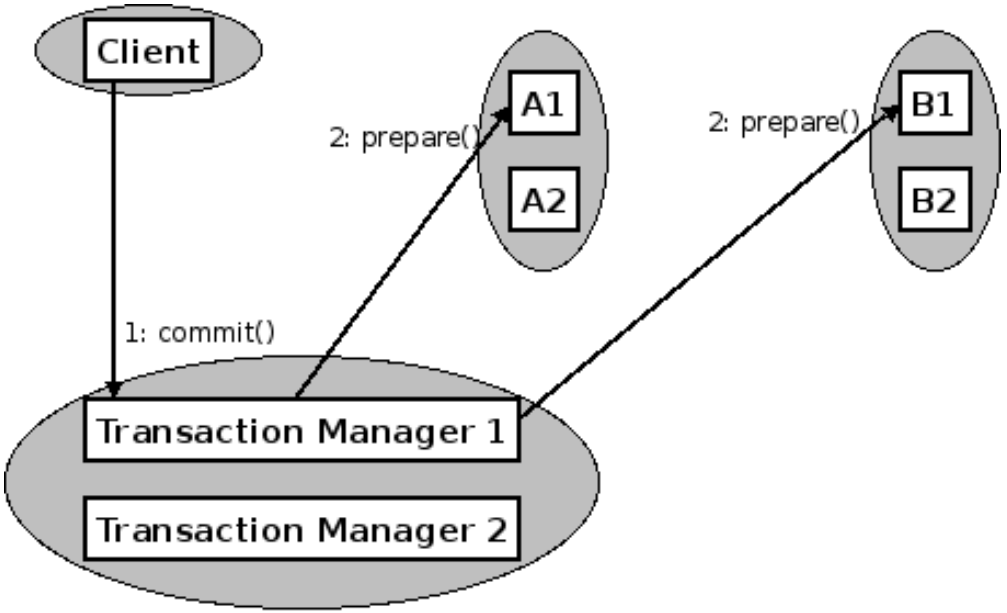

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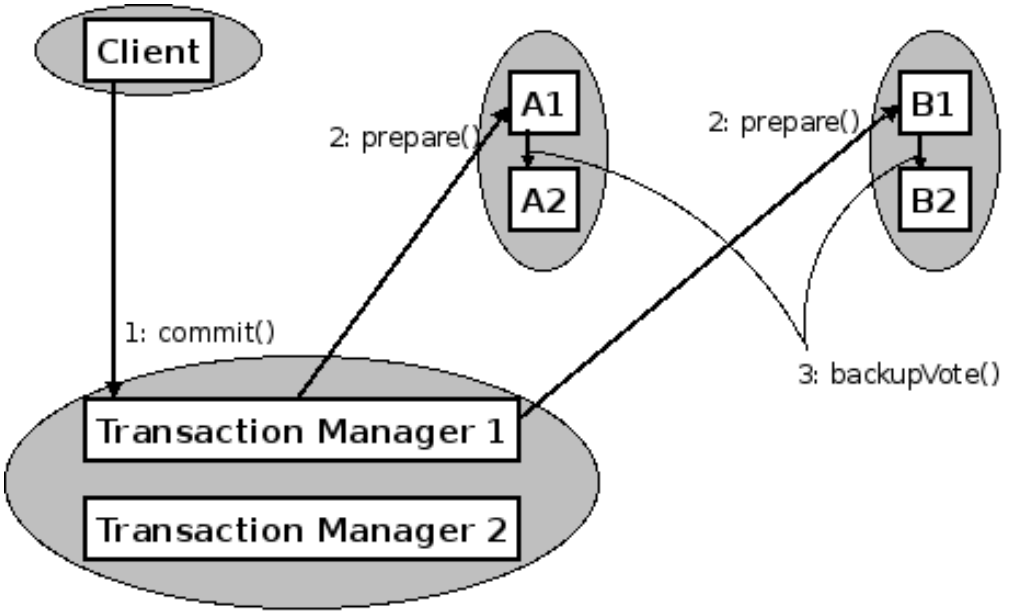

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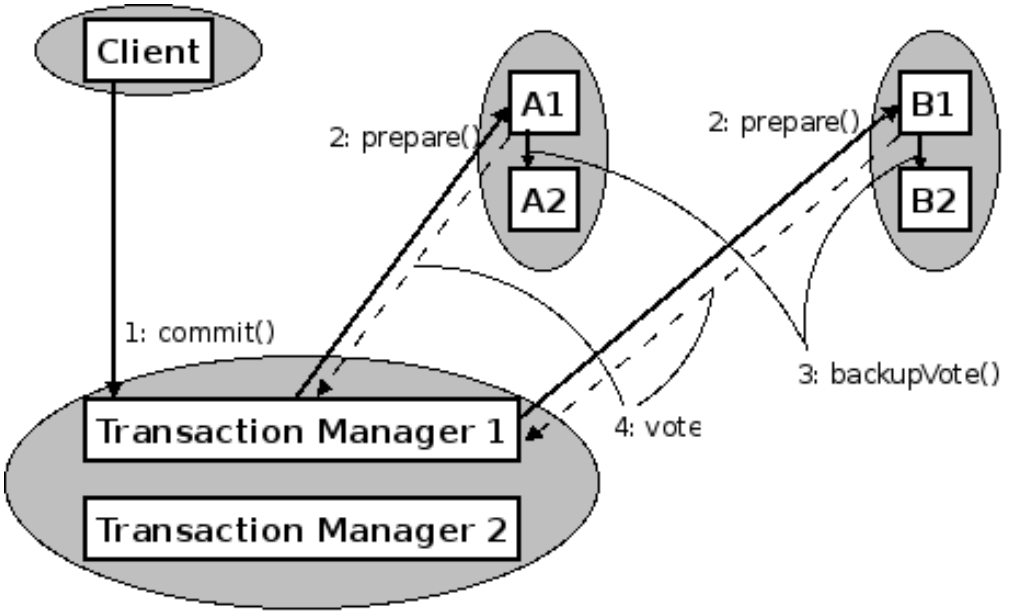

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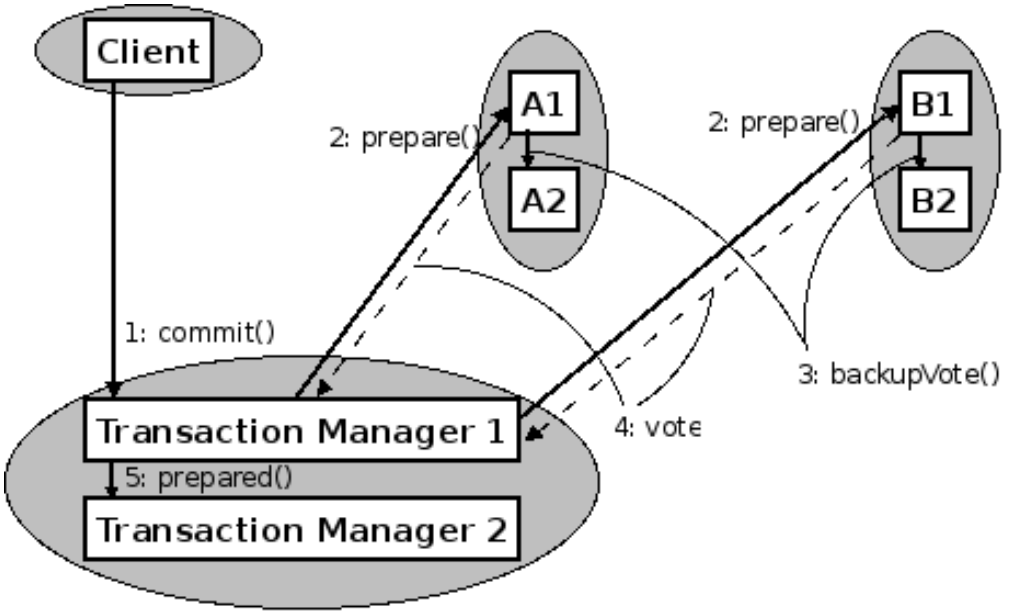

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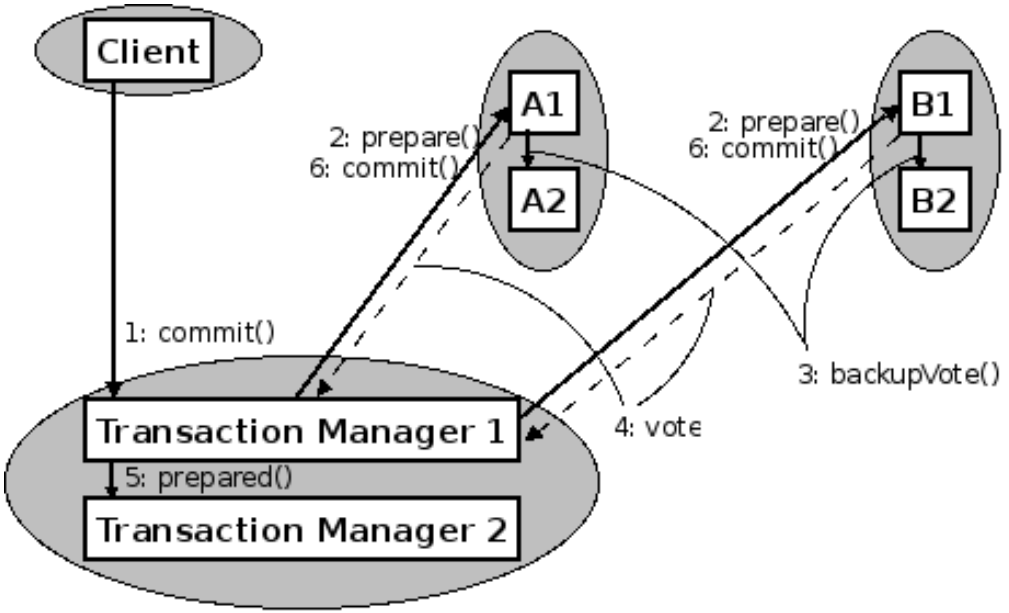

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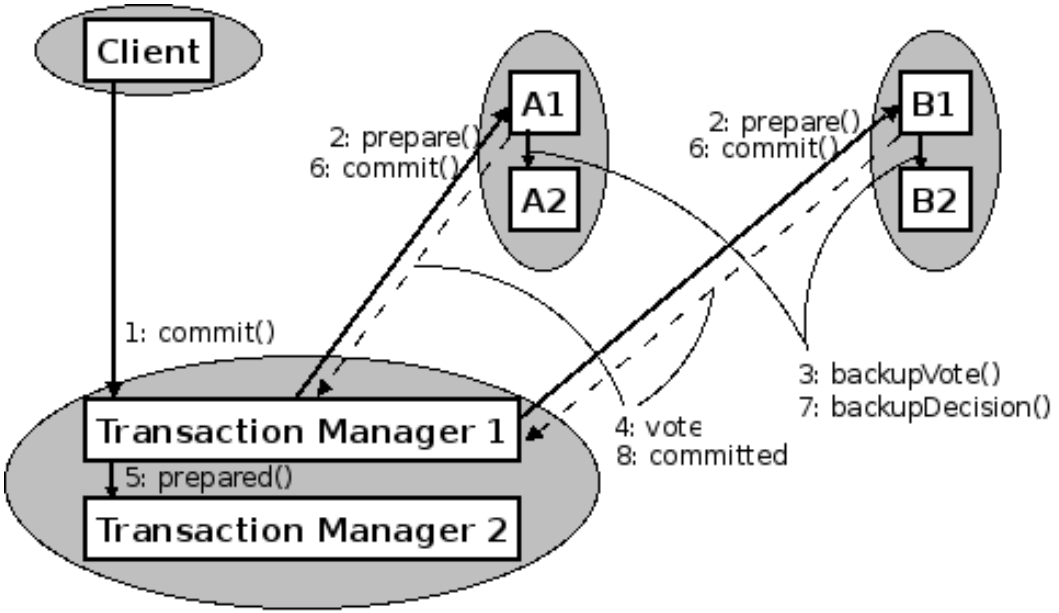

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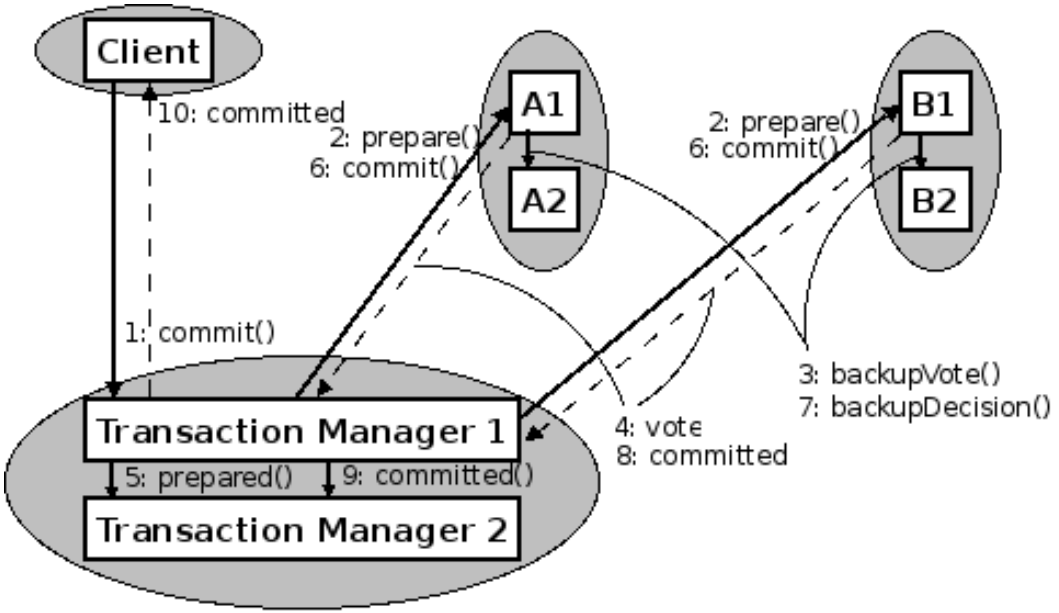
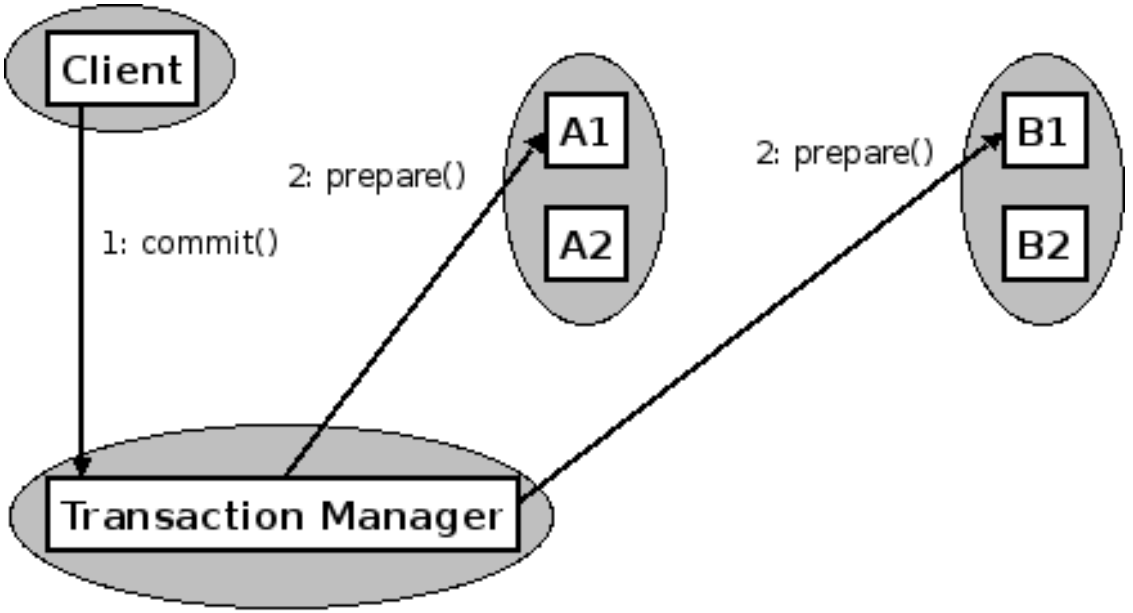


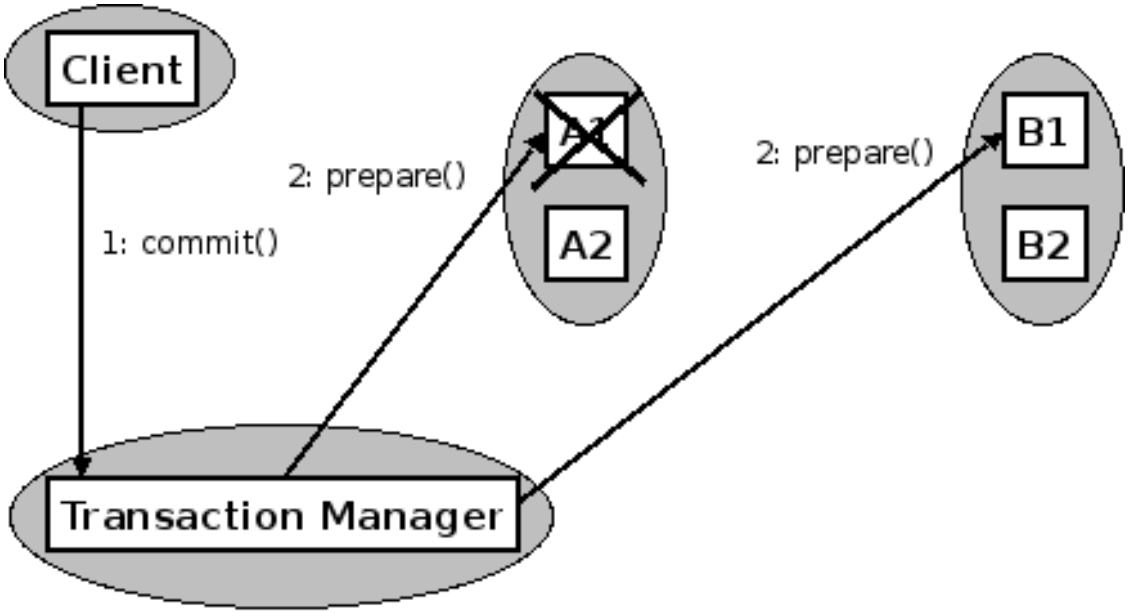
Replication Transparency

- The replication of the server is hidden from the client
- Server-side proxy sends message to primary replica
- Group communication mechanisms keeps the proxy up to date
- Failovers are handled by proxy, server does not know

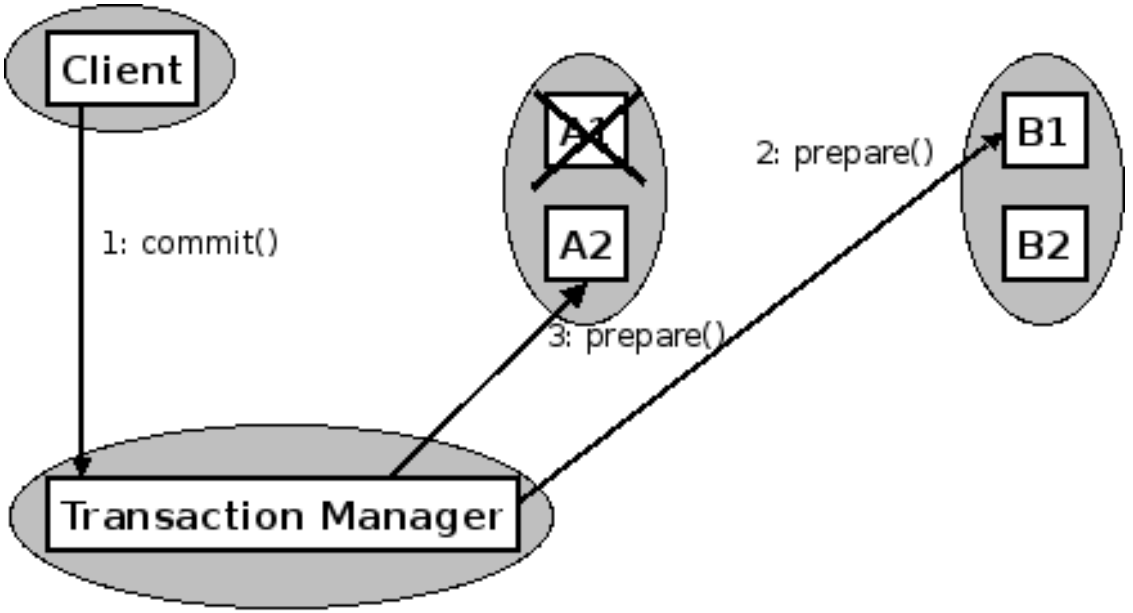
Failover


Client
1: commit()
2: prepare()
A1
A2
2: prepare()
B1
B2
Transaction Manager

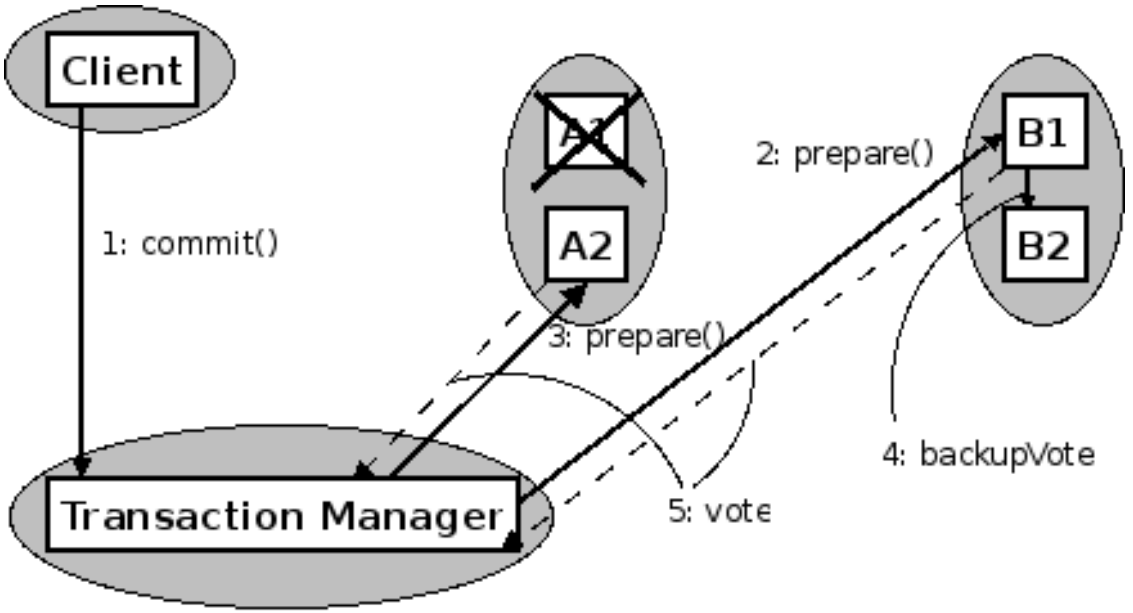
Failover


Client
2: prepare()
1: commit()
A2
2: prepare()
B1
B2
Transaction Manager

Failover

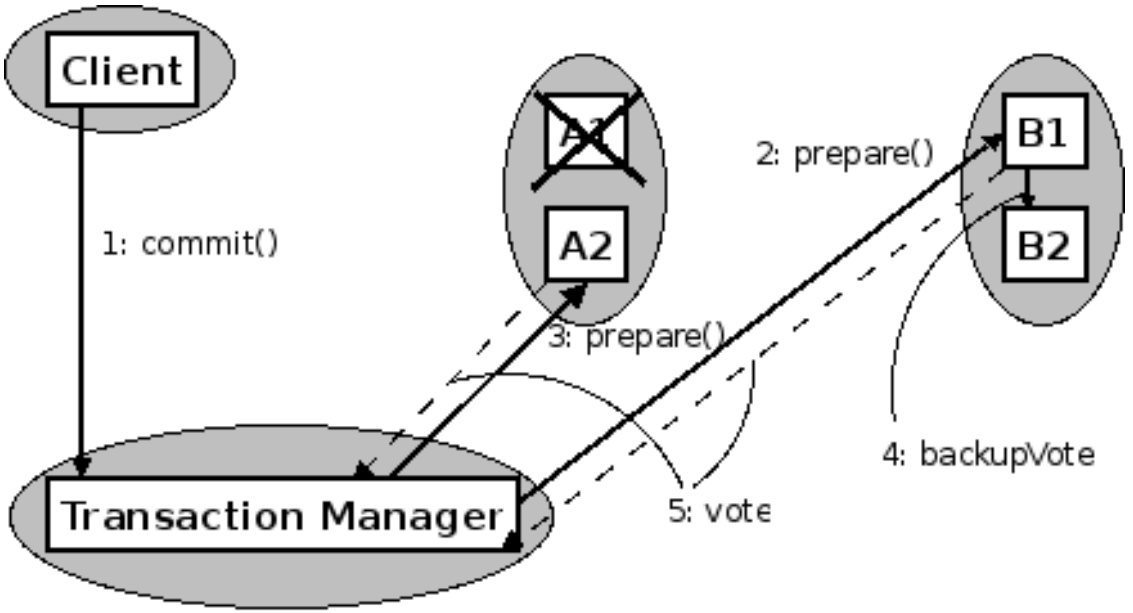

Client
A1
A2
B1
B2
1: commit()
2: prepare()
3: prepare()
Transaction Manager

Failover



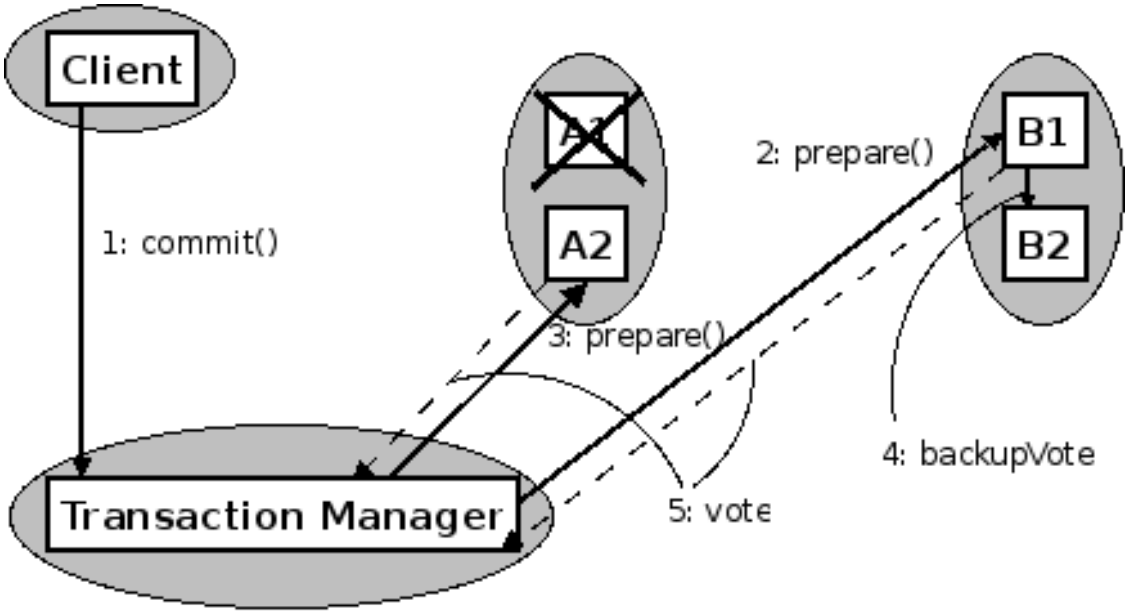
— Server B is in an inconsistent state

Failover



- Server B is in an inconsistent state
- Solution: Abort all transactions interacting with a replica that fails

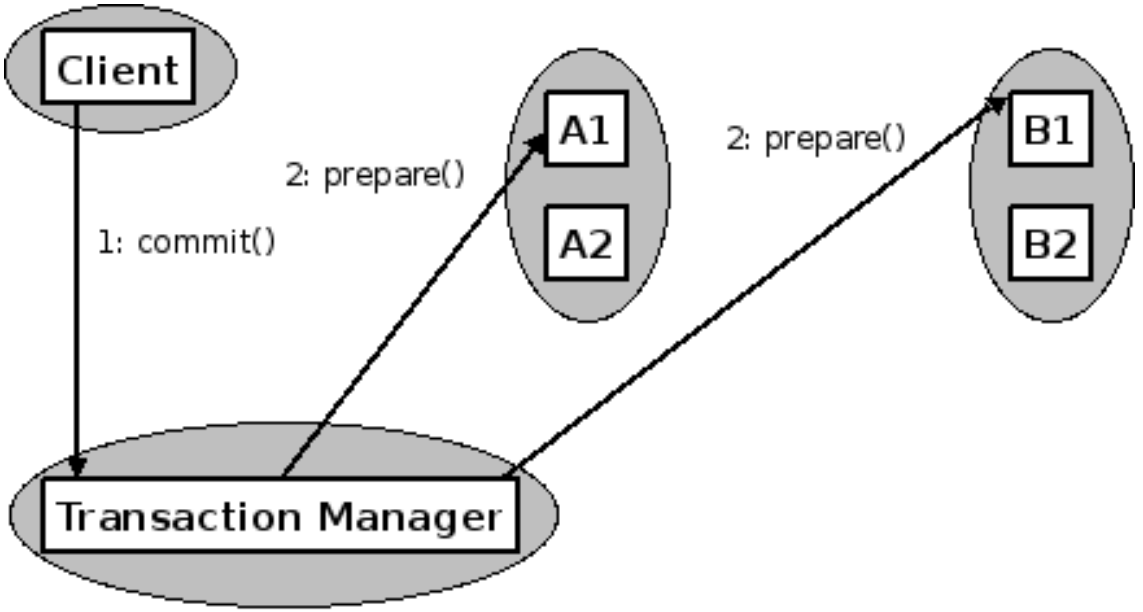
Failover



- Server B is in an inconsistent state
- Solution: Abort all transactions interacting with a replica that fails
- => Which transactions are caught in a failover

Solution

- Avoid failover of prepare messages
- Special proxies for the TM
- TM informed about failovers



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Solution

- Avoid failover of prepare messages
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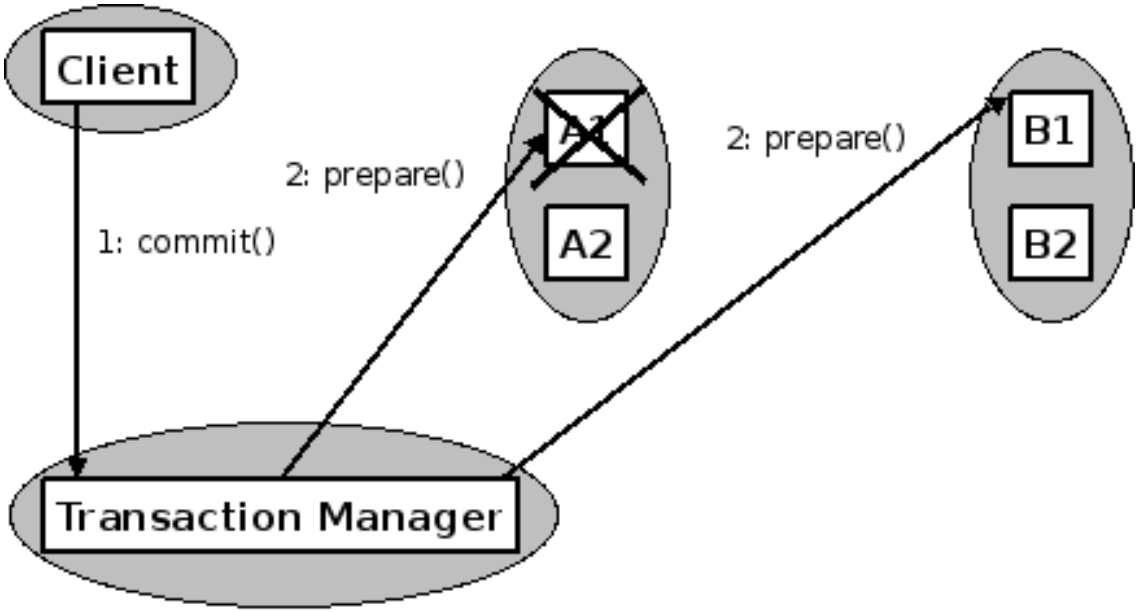

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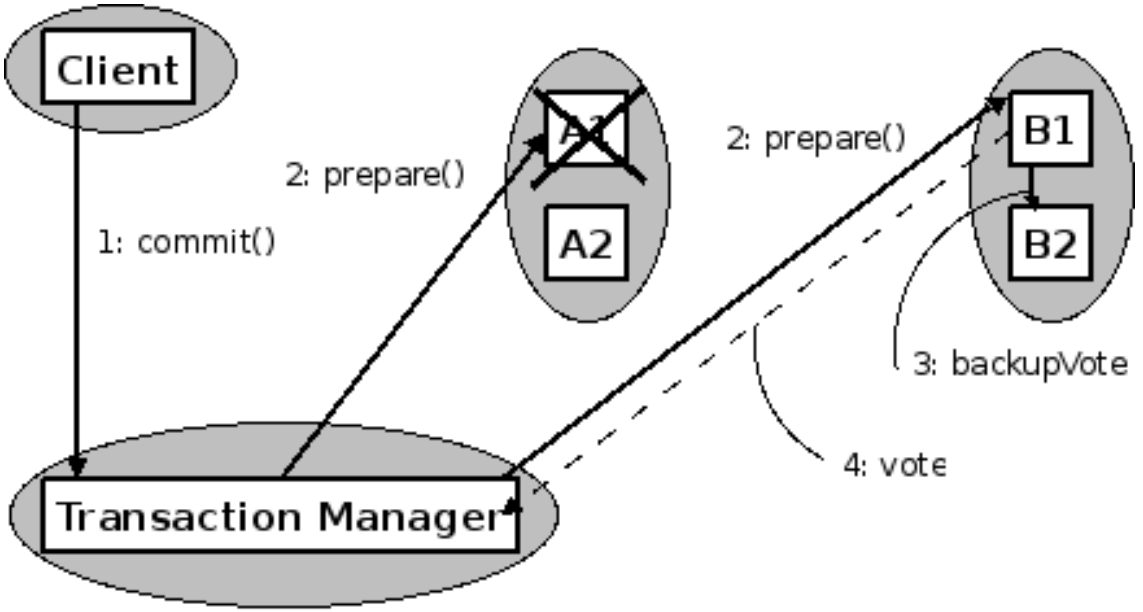

Solution

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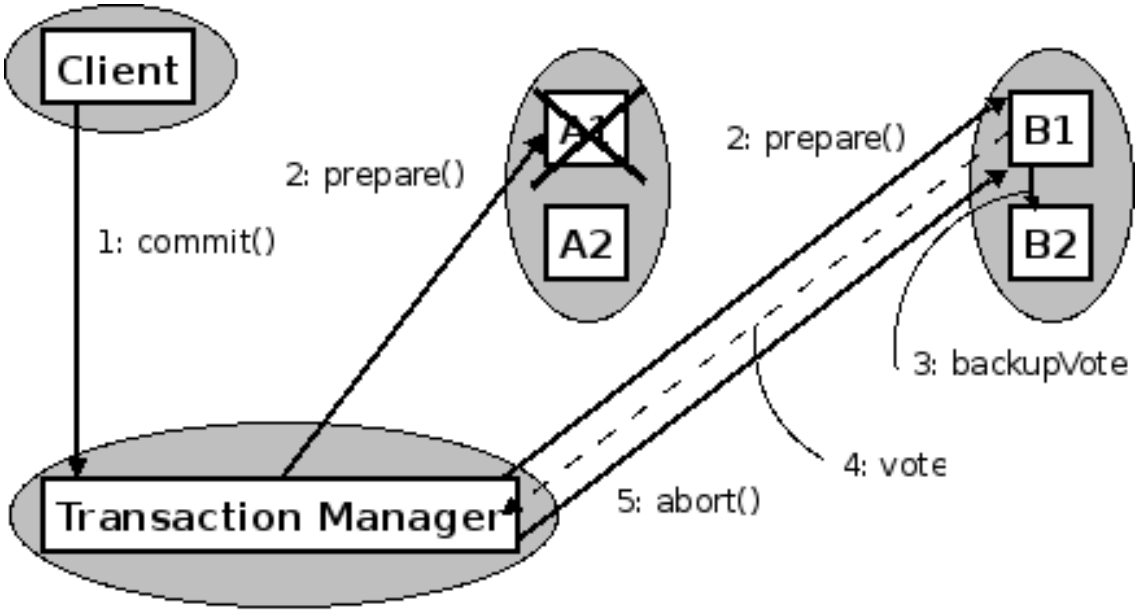
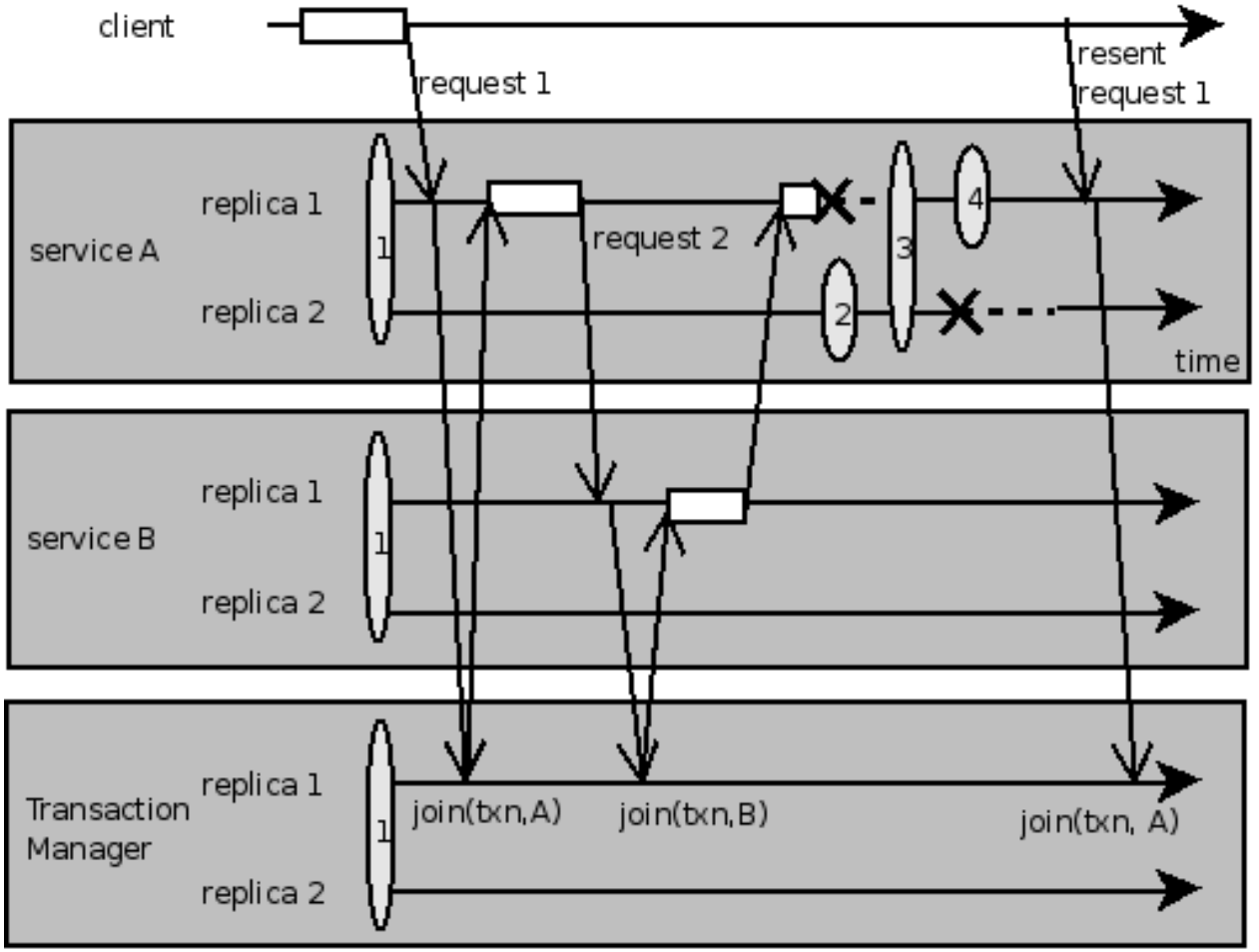
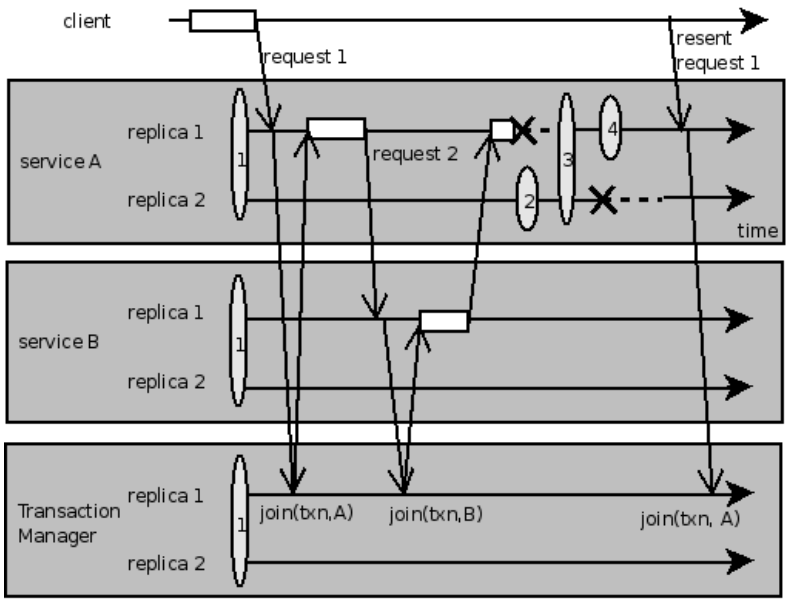


Double Failovers

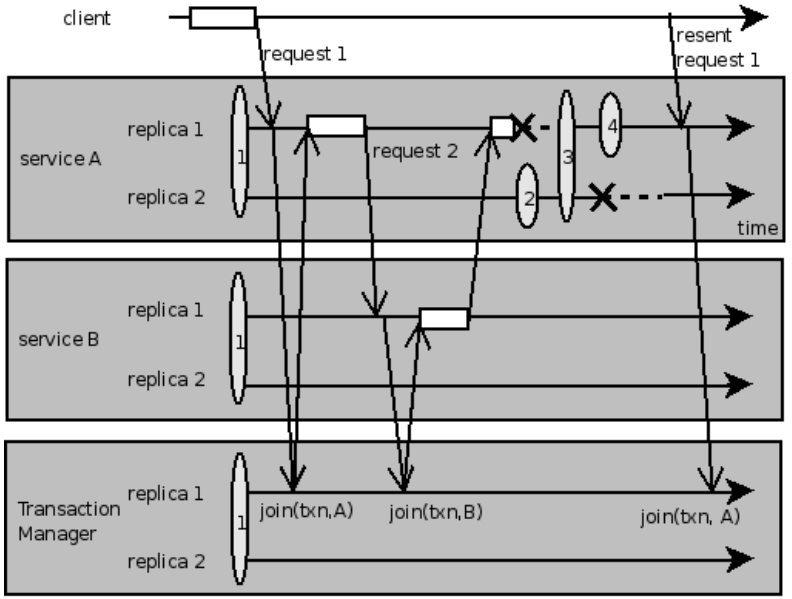


Double Failovers



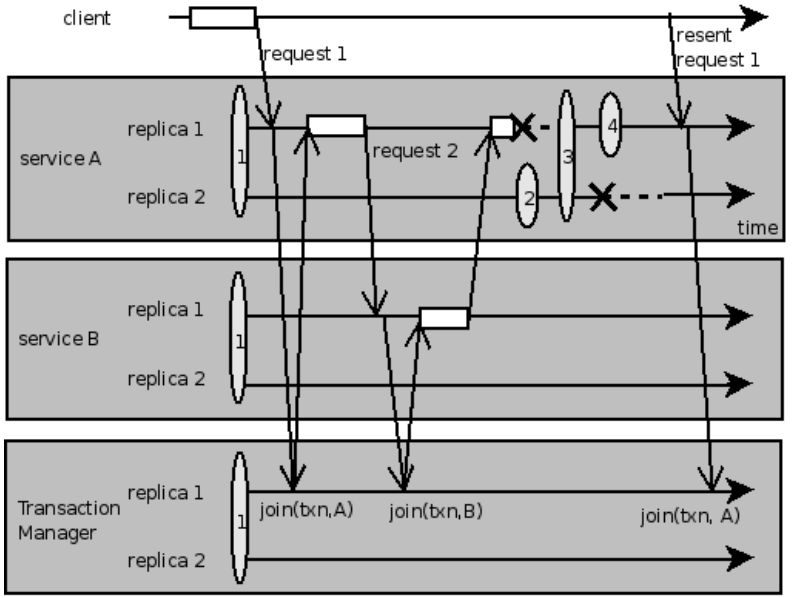
— Second join message from A looks like a resend of first

Double Failovers



- Second join message from A looks like a resend of first
- Solution: join(txnid, group) -> join(txnid, group, viewid)

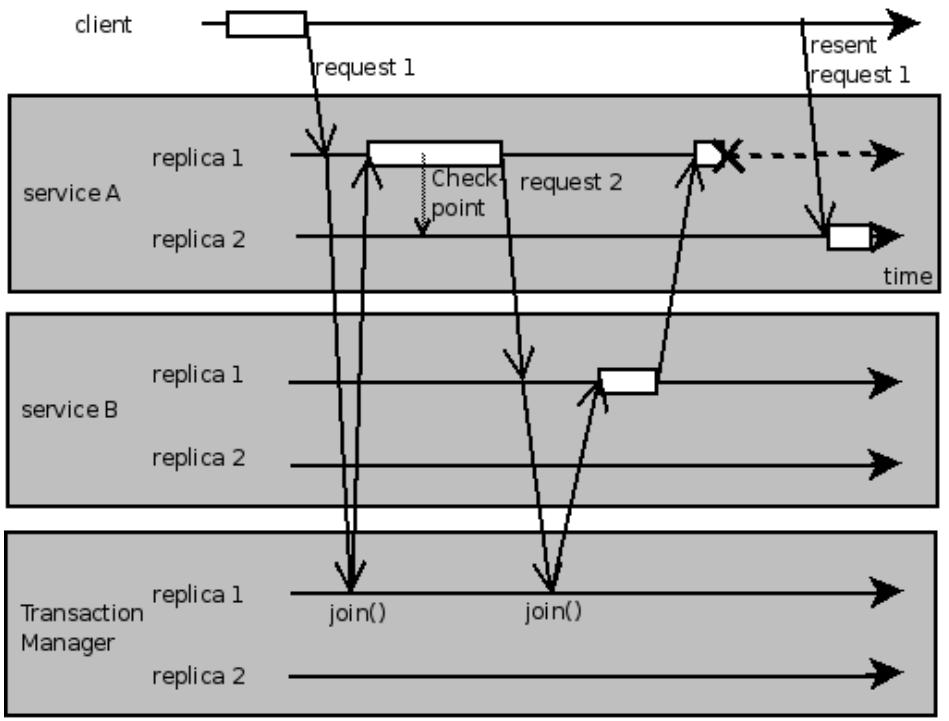
Double Failovers



- Second join message from A looks like a resend of first
- Still need to break replication transparency

Checkpoints

— Can be taken anytime



Checkpoints

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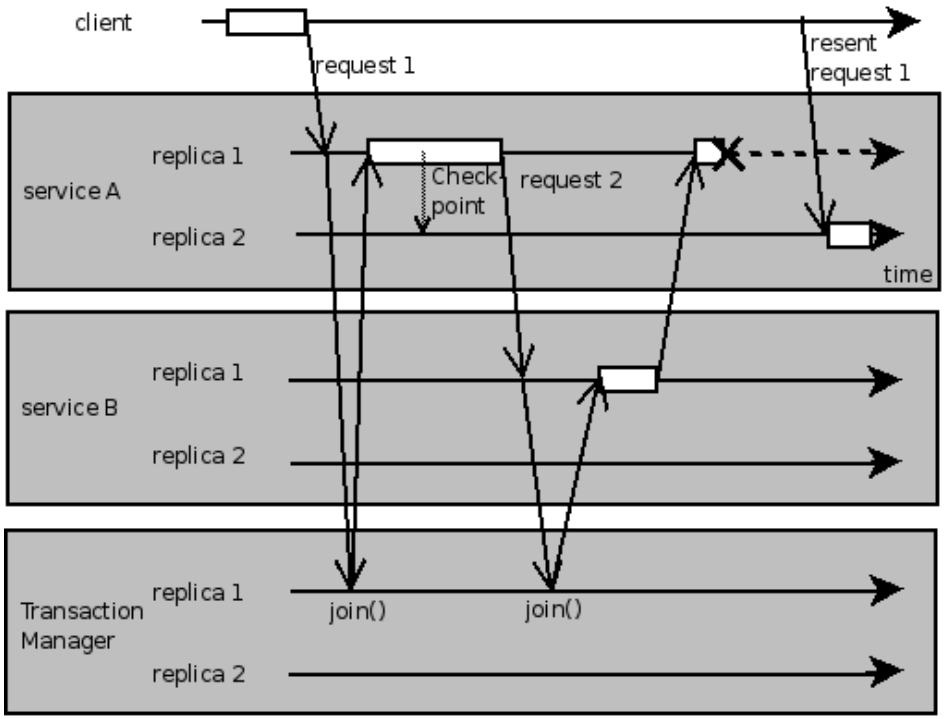
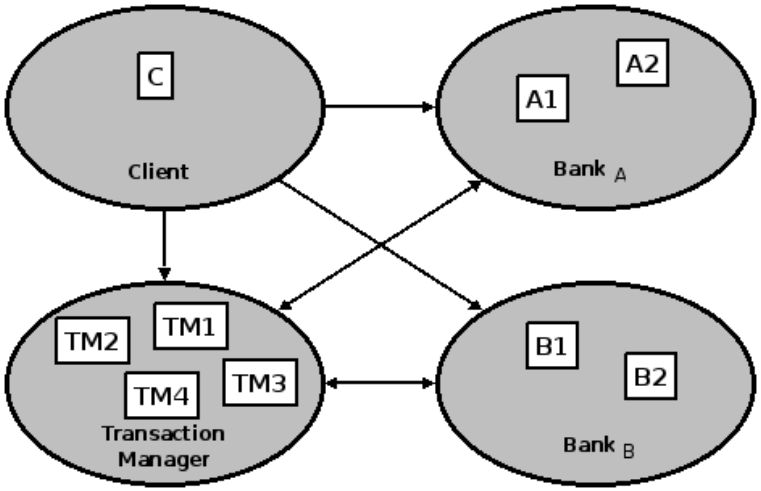


- Prepare message sent to new primary A2 -> request 2 is not aborted
- Break replication transparency

Test Environment



- Hardware: 5 nodes, 100Mbit Ethernet, Dual AMD MP 1600+ 1,4GHz CPUs, 1024 MB RAM
- Software: Linux kernel 2.6, Java version 1.5.0, Jgroup/ARM GMS, Jini Transaction Service
- 500 transactions, measured client side response time

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Test Results

Test run	Description	Average (ms)
Nonreplicated system		
1	1 TM and 2 banks	47

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Nonreplicated system		
1	1 TM and 2 banks	47
Passive replication of the TM		
2	2 passive TMs and 2 banks	77
3	3 passive TMs and 2 banks	92
4	4 passive TMs and 2 banks	106

Test Results

Test run	Description	Average (ms)
Nonreplicated system		
1	1 TM and 2 banks	47
Passive replication of the TM		
2	2 passive TMs and 2 banks	77
3	3 passive TMs and 2 banks	92
4	4 passive TMs and 2 banks	106
Fully replicated system		
5	1 TM and 2x2 banks	75
6	2 passive TMs and 2x2 banks	148
7	3 passive TMs and 2x2 banks	164

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Test Results

Test run	Description	Average (ms)	Delay (%)
Nonreplicated system			
1	1 TM and 2 banks	47	0
Passive replication of the TM			
2	2 passive TMs and 2 banks	77	64
3	3 passive TMs and 2 banks	92	96
4	4 passive TMs and 2 banks	106	126
Fully replicated system			
5	1 TM and 2x2 banks	75	60
6	2 passive TMs and 2x2 banks	148	215
7	3 passive TMs and 2x2 banks	164	249

Conclusions

- Replication - High availability
- Transactions - Consistency
- Integrated without enforcing replica determinism
- Break replication transparency -> no orphan requests
- Open-source prototype:
  - Implementation too slow for RT systems
  - Jini and Jgroup are not tuned for performance

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Further Work

- Implement in a tuned environment
- Other transaction models
- Handle all failure scenarios of 2PC
- Replica management (create, restart, update)

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