Distributed ACID Transactions in Apache Ignite

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GridGain

http://ignite.apache.org

#apacheignite

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My Background

- Pre-2000
  - Developer
  - Academic (City University)
  - Consultant
  - Technical Architect
- Post-2000
  - Senior Architect
  - Senior IT Specialist
  - Technical Instructor
  - Solutions Architect
  - Independent Consultant

My Background

- Broad industry experience
- Worked with various technologies
  - Programming languages
  - IDE
  - Database systems
- Client-facing roles
  - Developers
  - Senior executives
  - Journalists
- Publications and presentations


XML Data Management
Native XML and XML-Enabled Database Systems
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First International XML Database Symposium, XSym 2003
Berlin, Germany, September 2003
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NODe 2002 Web- and Database-Related Workshops
Erfurt, Germany, October 2002
Revised Papers
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Mong Li Lee Jeffrey Xu Yu
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VLDB 2002 Workshop EEXTT
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XML-Based Data Management and Multimedia Engineering – EDBT 2002 Workshops
EDBT 2002 Workshops XMLDM, MDDE, and YRWS
Prague, Czech Republic, March 2002
Revised Papers
Springer
XML Data Management
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XML数据管理
纯XML和支持XML的数据库系统
事例で学ぶ
オブジェクトデータベース活用技法

Agenda

- Apache Ignite Transactions Overview
- Concurrency Modes and Isolation Levels
- Two-Phase Commit (2PC) Protocol
- One-Phase Commit (1PC) Optimization
- RAM and Disk Level Consistency
- Deadlock Handling
- Demos
- Q & A

Apache Ignite Transactions Overview

- ACID-compliant
- Distributed
- Integrated with JTA
- Used by Financial Institutions
- Atomicity modes
  - Atomic
  - Transactional

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Atomicity Modes

- Atomic mode
  - Updates are applied right away
  - No locks => better performance
- Transactional mode
  - Operations meets transaction boundaries
  - Fully ACID-compliant

Concurrency Modes and Isolation Levels

- Concurrency modes for transactions
  - Pessimistic
  - Optimistic
- Isolation levels
  - READ_COMMITTED
  - REPEATABLE_READ
  - SERIALIZABLE
- All combinations can be used simultaneously

```
try (Transaction tx = transactions.txStart()) {
    Integer hello = cache.get("Hello");

    if (hello == 1)
        cache.put("Hello", 11);

    cache.put("World", 22);

    tx.commit();
}
```

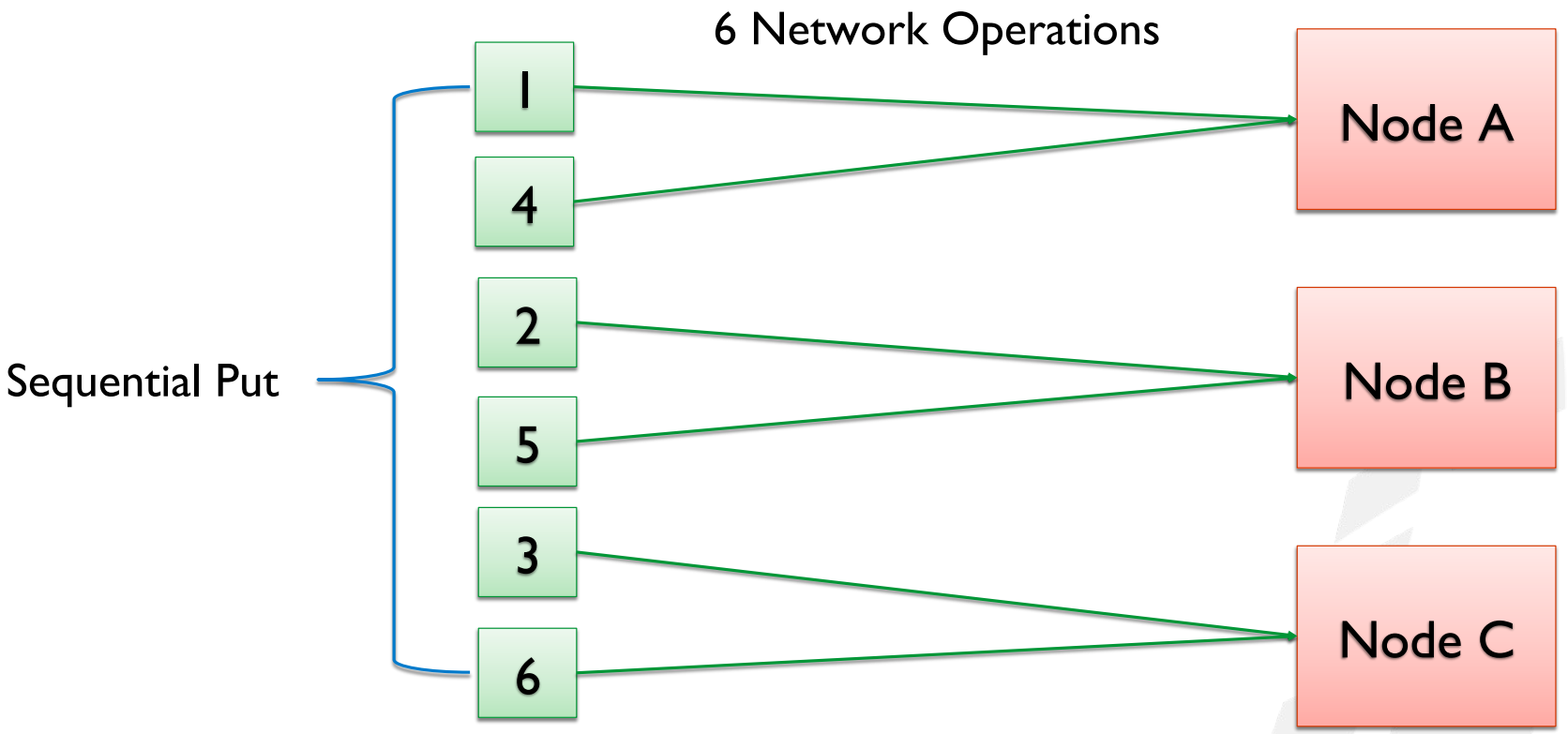
Pessimistic Transactions

```
try (Transaction tx = Ignition.ignite().transactions().txStart(PESSIMISTIC,
    REPEATABLE_READ)) {
    Account acct = cache.get(acctId);

    assert acct != null;

    // Deposit into account.
    acct.update(amount);

    // Store updated account in cache.
    cache.put(acctId, acct);

    tx.commit();
}
```

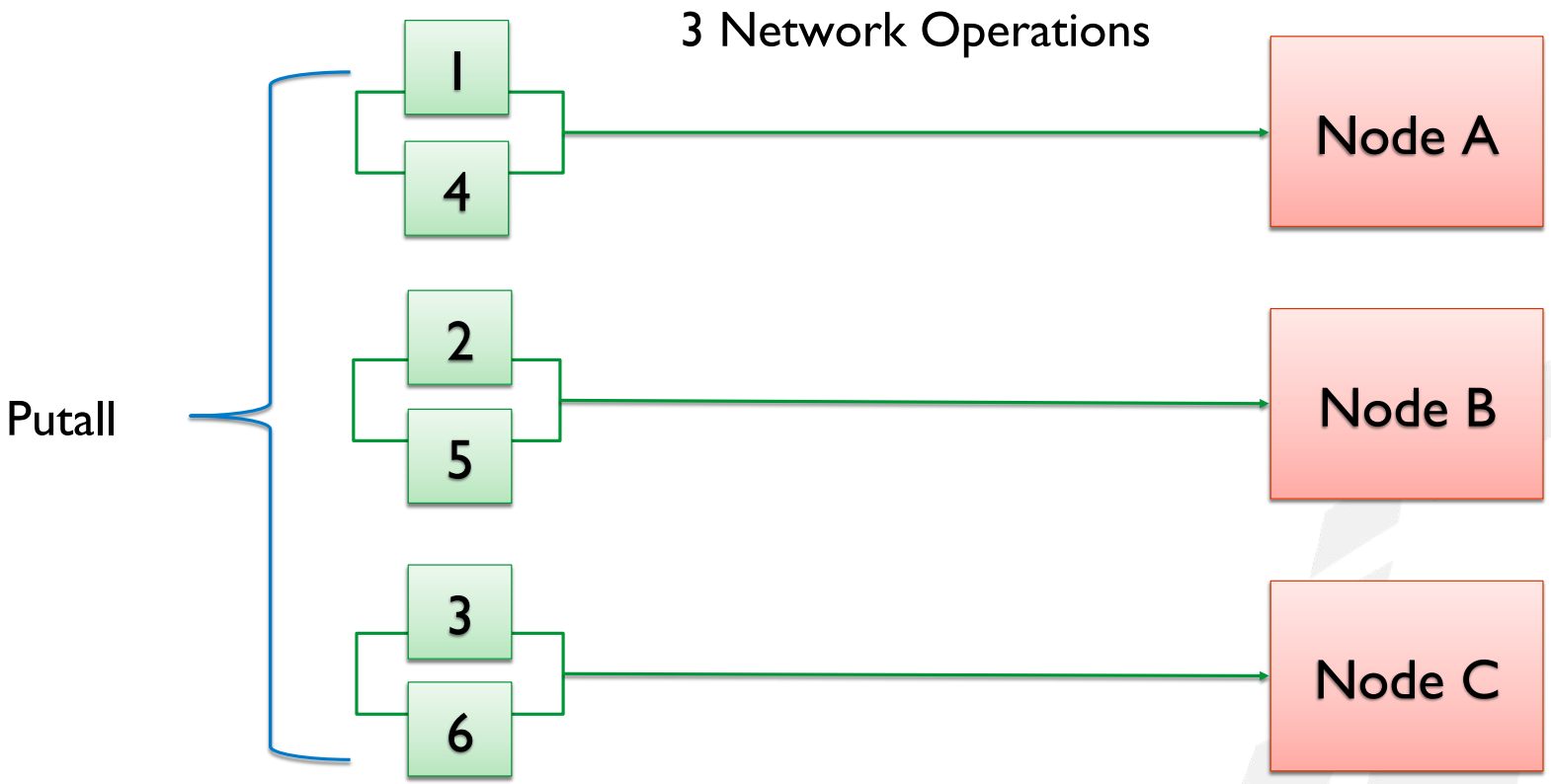
Optimistic Transactions

```
while (true) {
    try (Transaction tx =
        ignite.transactions().txStart(TransactionConcurrency.OPTIMISTIC,
            TransactionIsolation.SERIALIZABLE)) {
        Account acct = cache.get(acctId);

        assert acct != null;

        // Deposit into account.
        acct.update(amount);

        // Store updated account in cache.
        cache.put(acctId, acct);

        tx.commit();
        break;
    } catch (TransactionOptimisticException e) {
        // Transaction has failed. Retry.
    }
}
```

Performance Considerations: Put vs PutAll

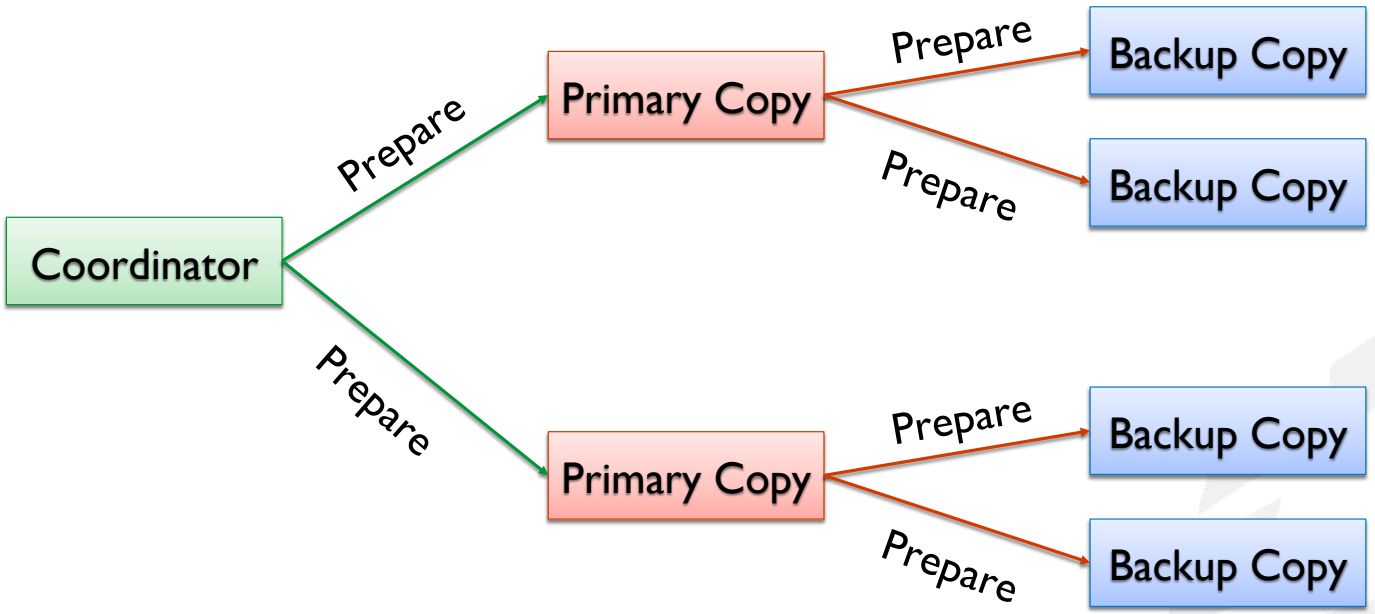


Performance Considerations: Put vs PutAll



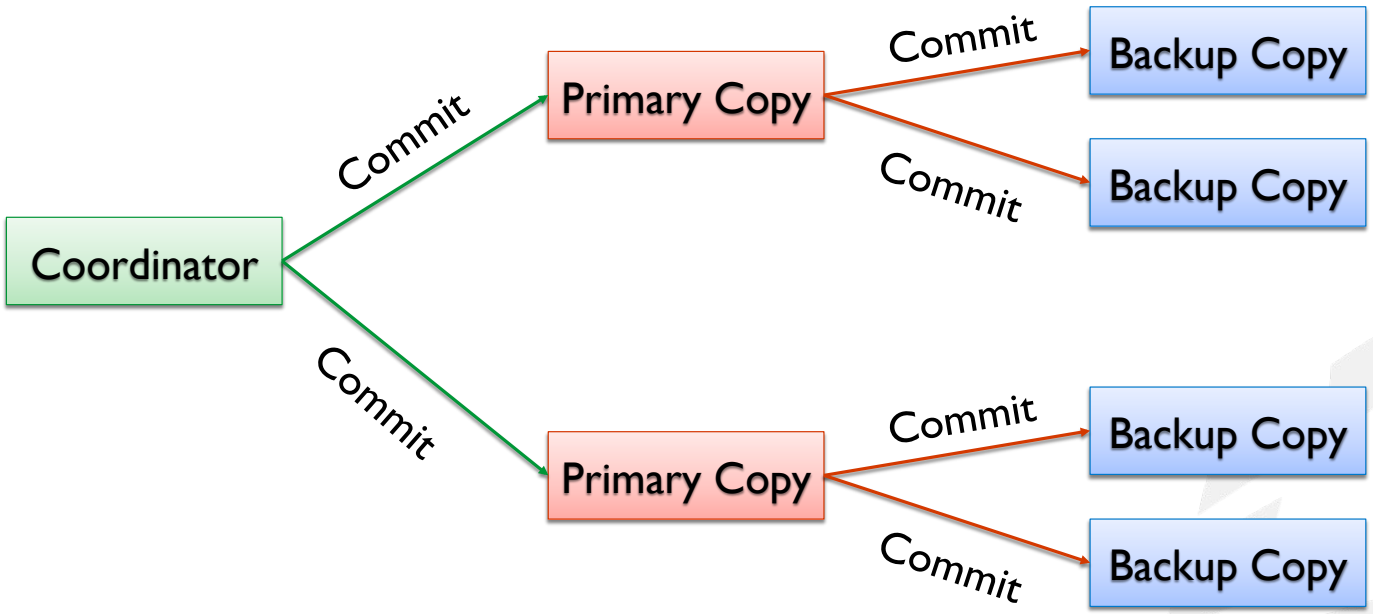
Two-Phase Commit protocol

Phase 1 - Prepare



Two-Phase Commit protocol

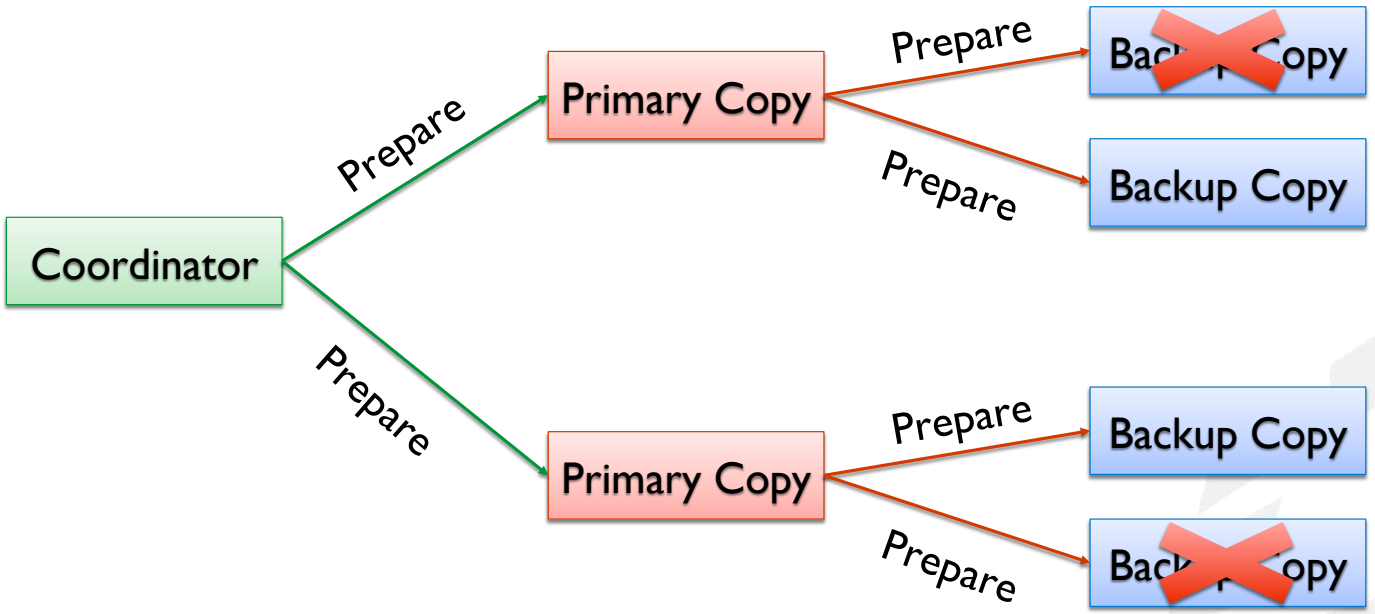
Phase 2 - Commit



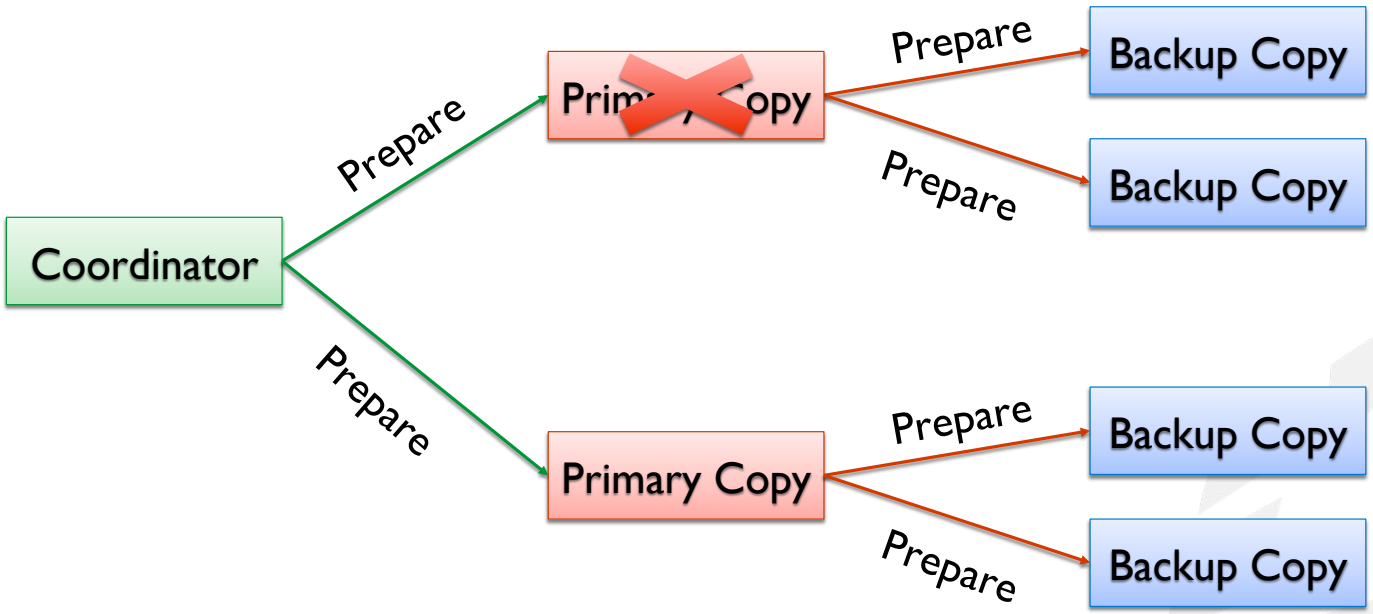
Two-Phase Commit: Benefits

- Advantages of in-memory
  - In-memory cache is volatile
  - The only reply for the "Prepare" is "Yes"
- Expands to the disk level
  - Ignite Persistent Store
  - 3rd party Persistence

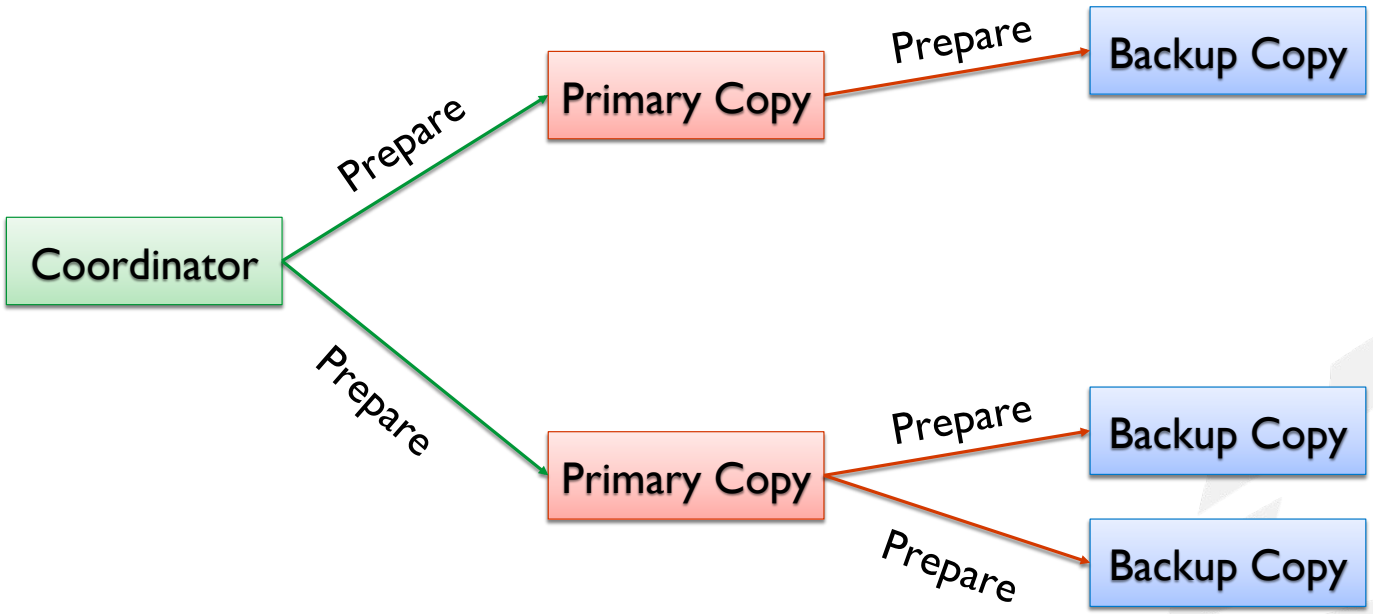
Two-Phase Commit: Backup Node Failures



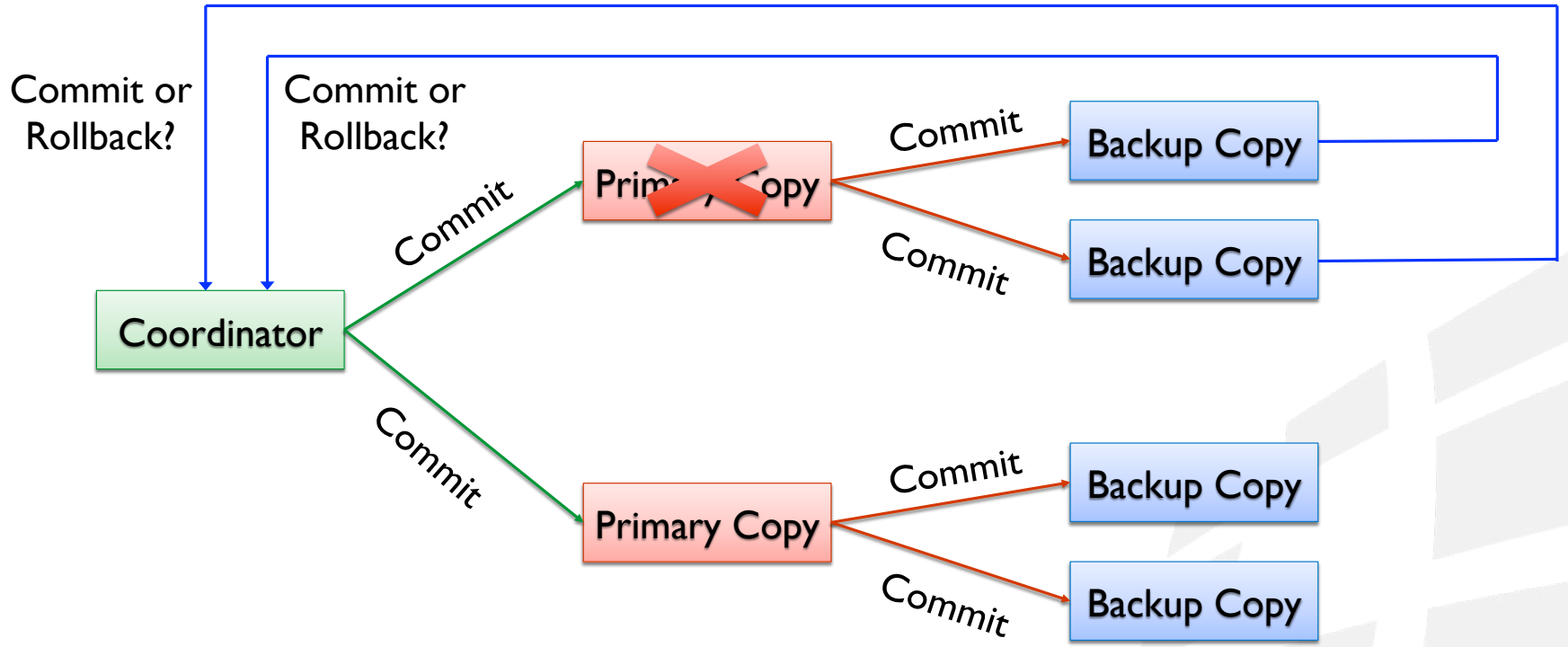
Two-Phase Commit: Primary Node Failures



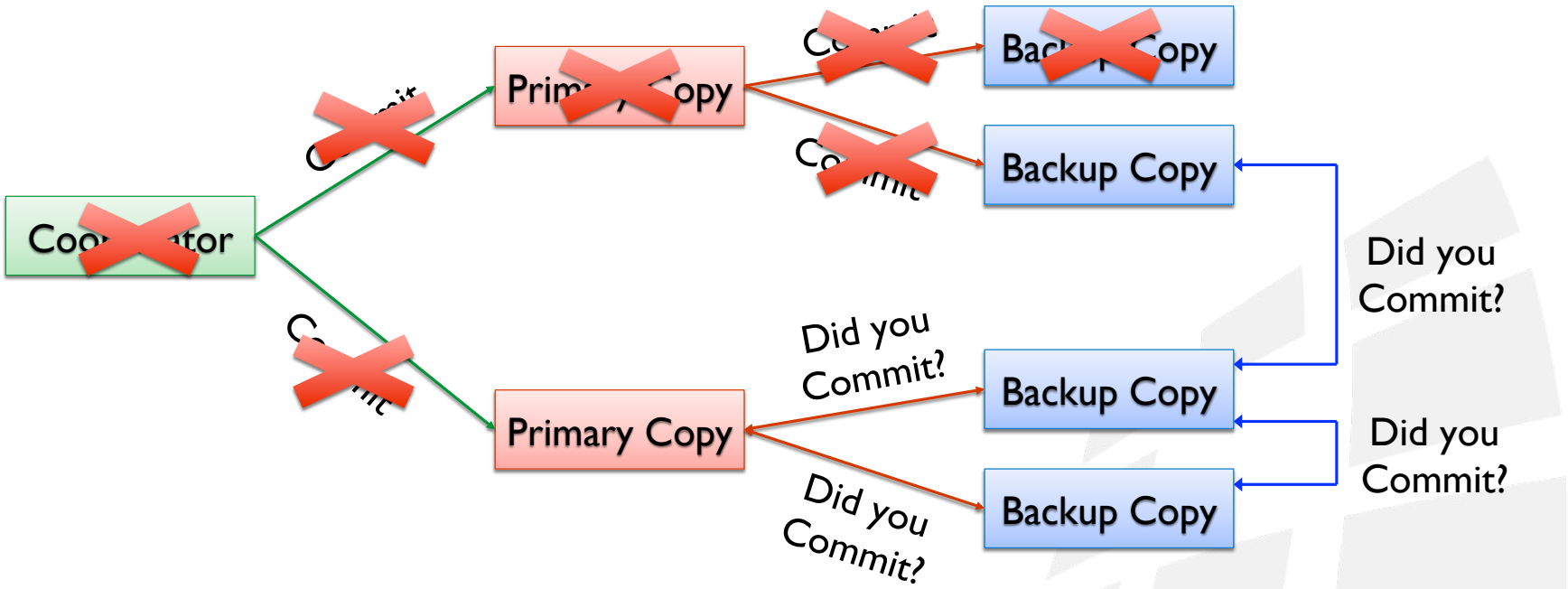
Two-Phase Commit: Primary Node Failures



Two-Phase Commit: Primary Node Failures



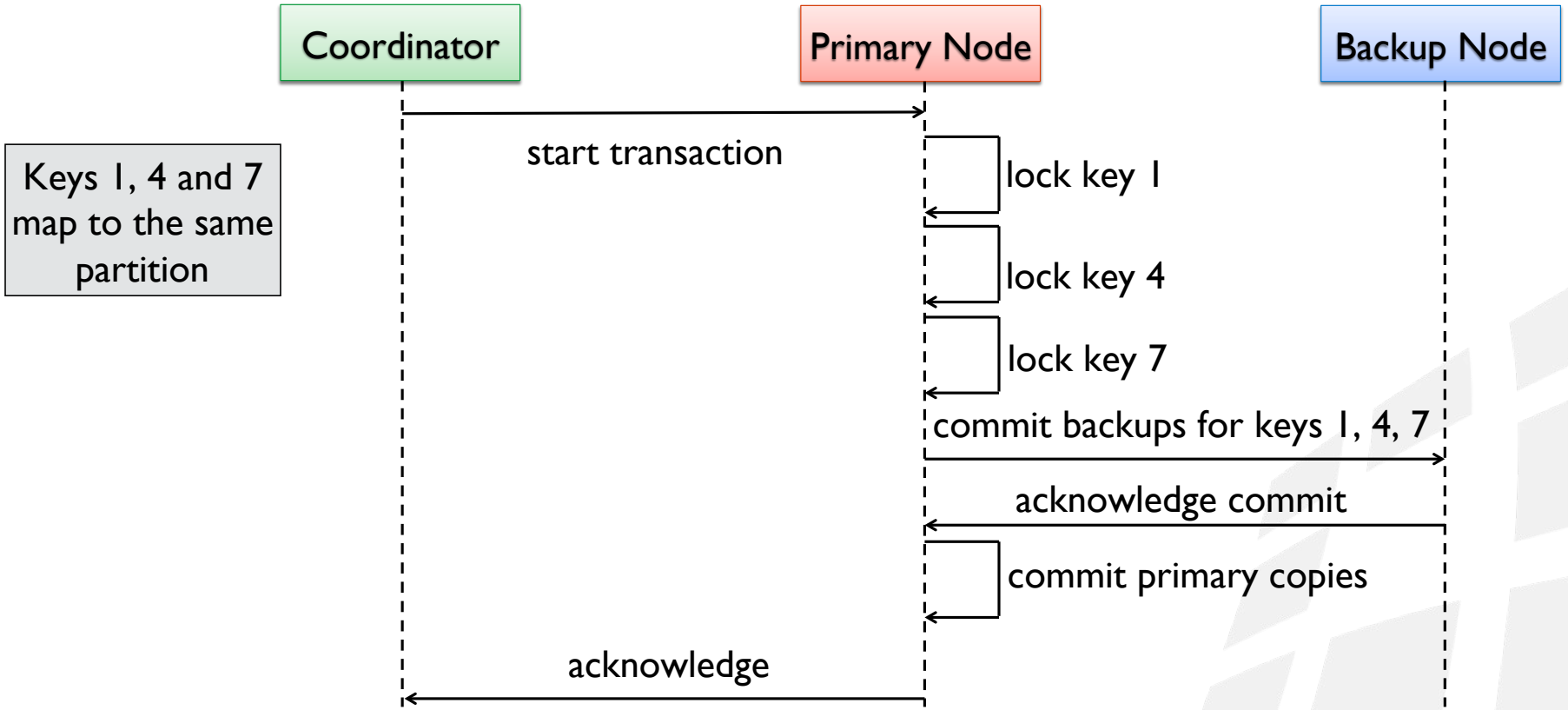
Two-Phase Commit: Coordinator Failure Recovery Protocol



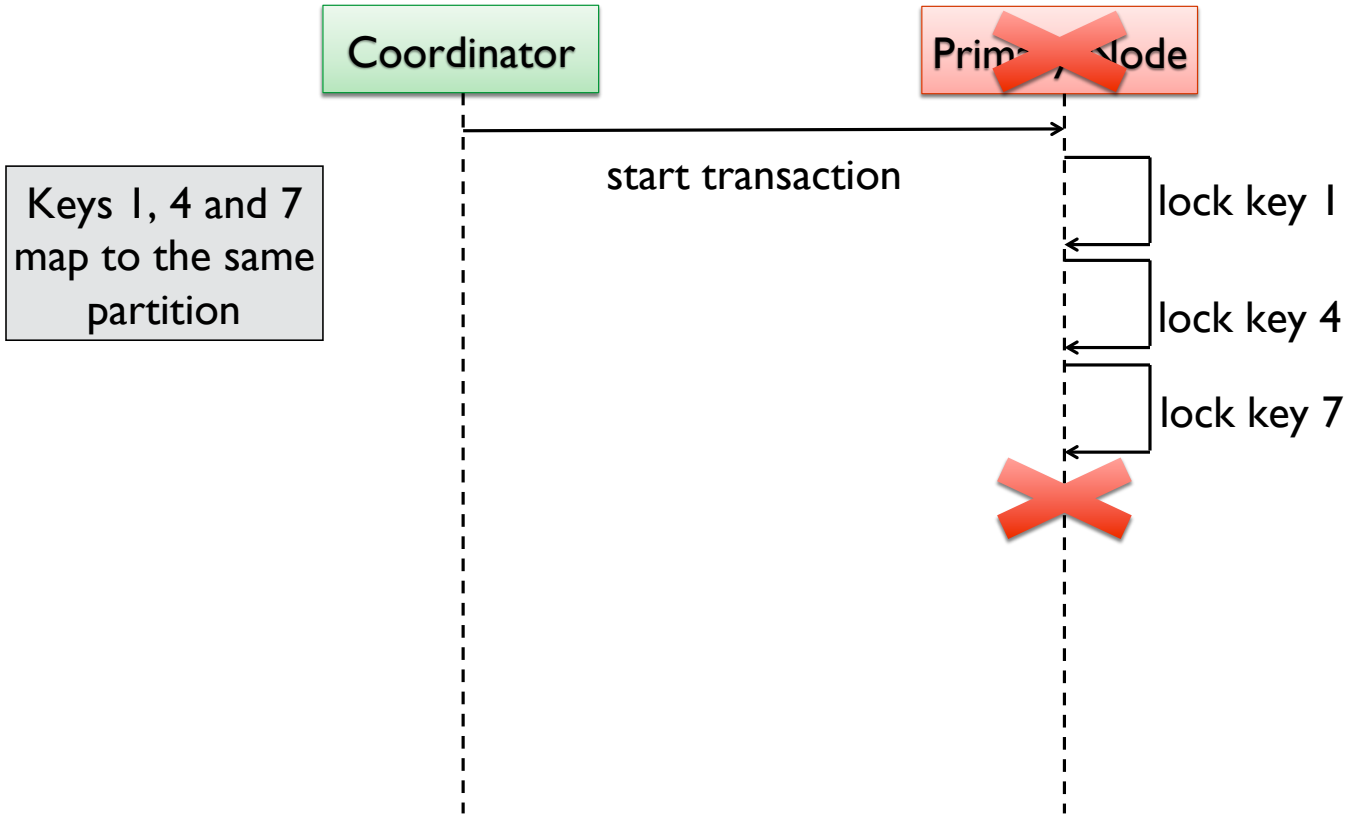
One-Phase Commit Protocol

- 1PC is 2PC optimization
- For best performance
  - Minimize cluster nodes in a transaction
  - All transaction entries belong to same partition
  - Backup copies will also be grouped together
  - Custom affinity mapping
- Example
  - All employees working for the same company will be mapped to the same partition using companyId

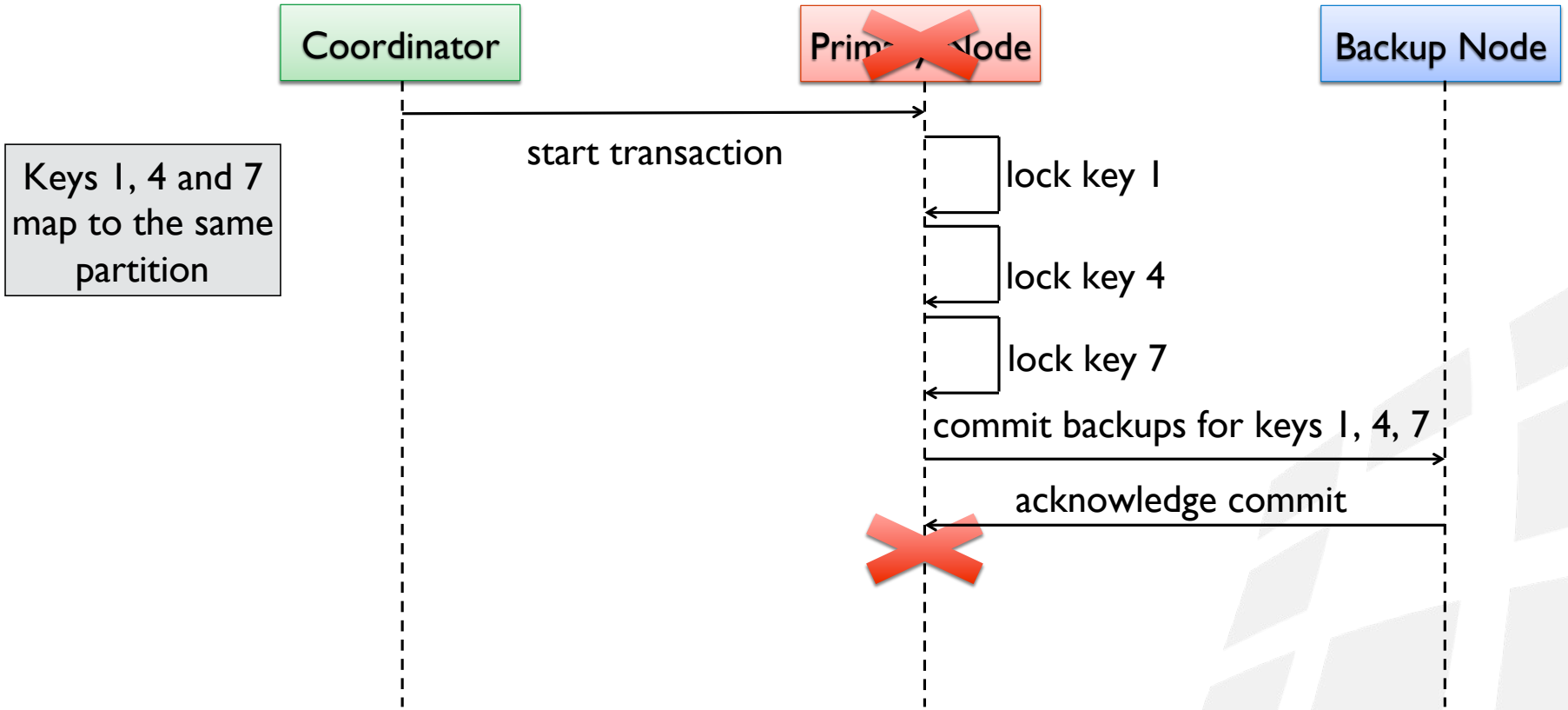
One-Phase Commit (1PC)



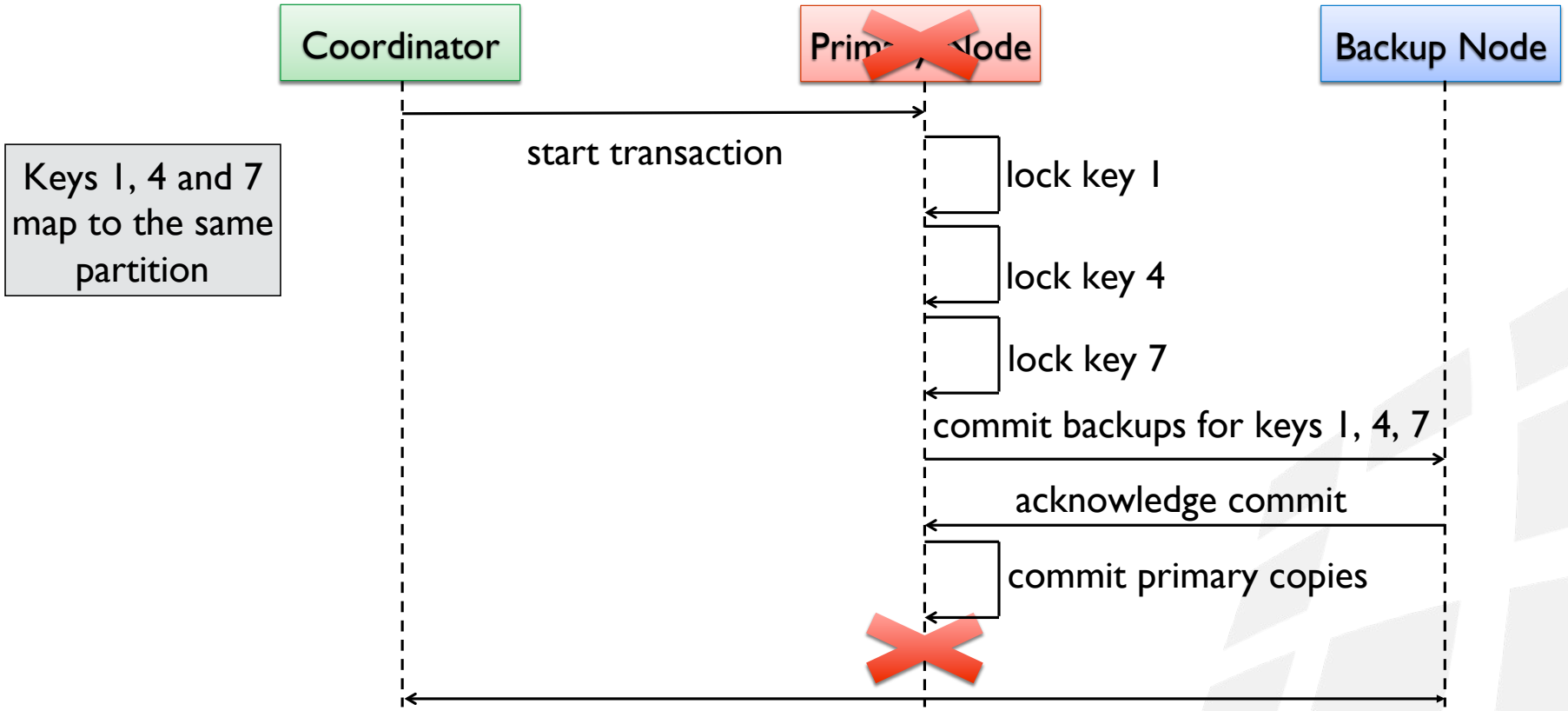
One-Phase Commit: Primary Node Failure



One-Phase Commit: Primary Node Failure

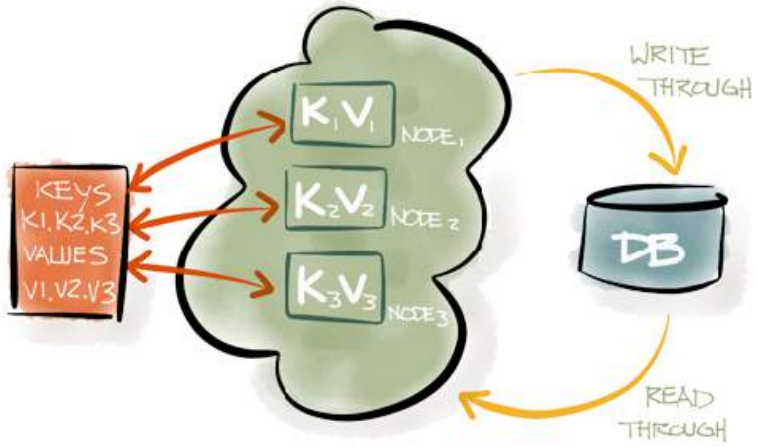


One-Phase Commit: Primary Node Failure Recovery Protocol



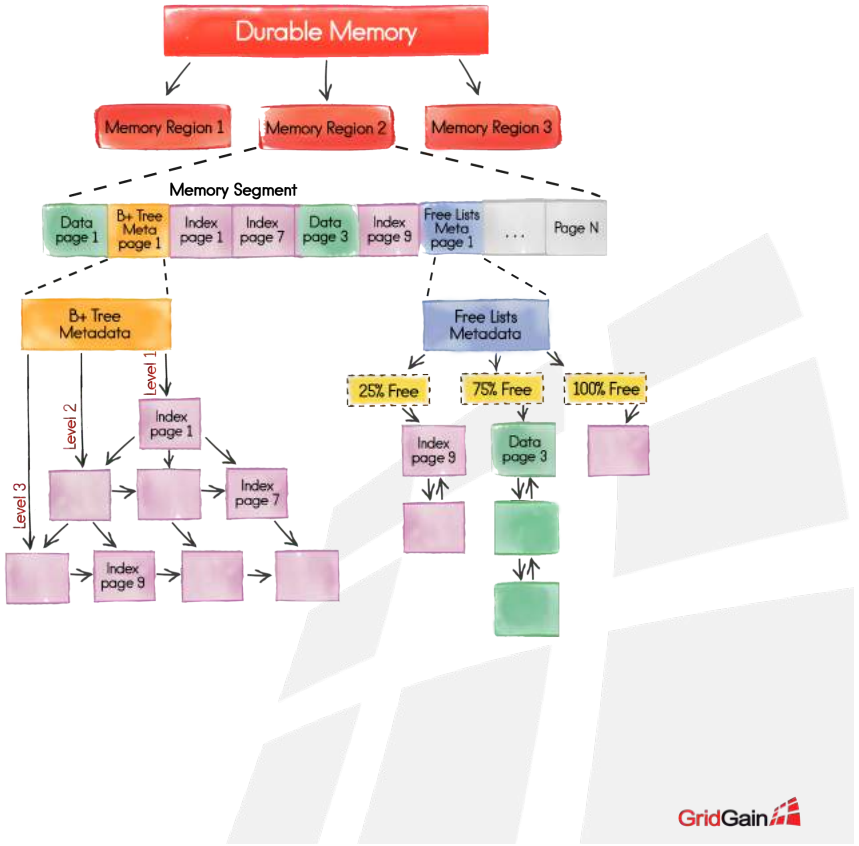
RAM and Disk Level Consistency

- Data are stored both in RAM and on disk
- ACID-compliant on all the levels
- 2PC Protocol is expanded to disk
  - Ignite Persistent Store
  - 3rd Party Stores



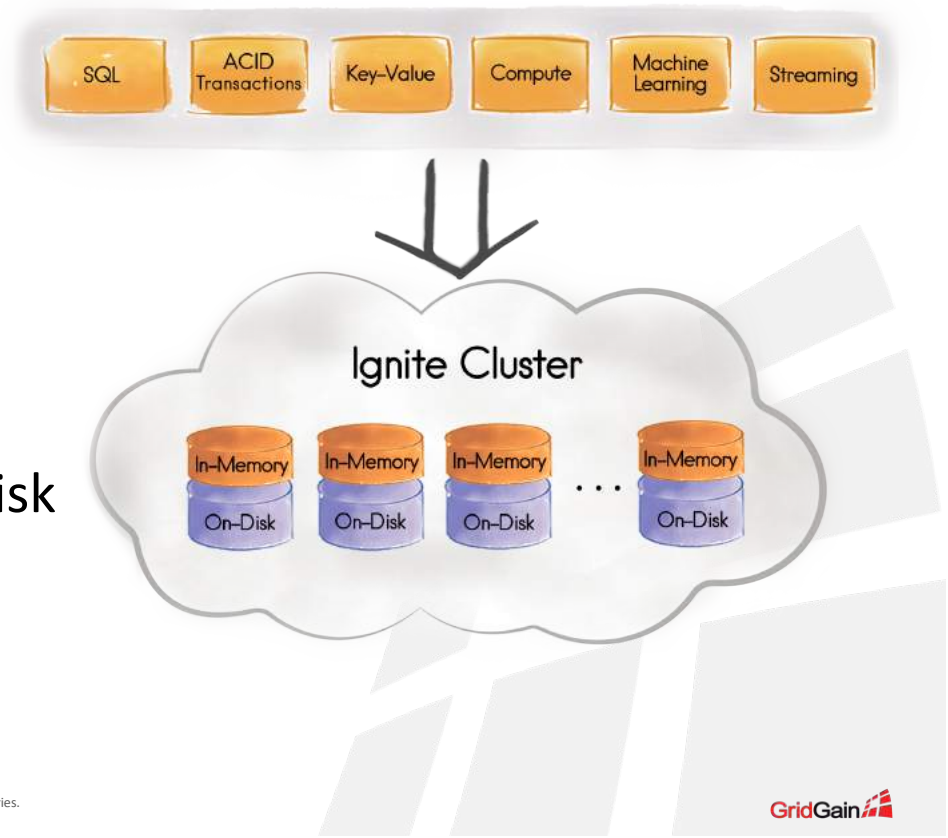
Durable Memory Architecture

- Memory split into *regions*
- Regions split into *segments*
- Segments split into *pages*
- Free-Lists track free space
- Pages can store:
  - Data
  - Indexes
  - Metadata



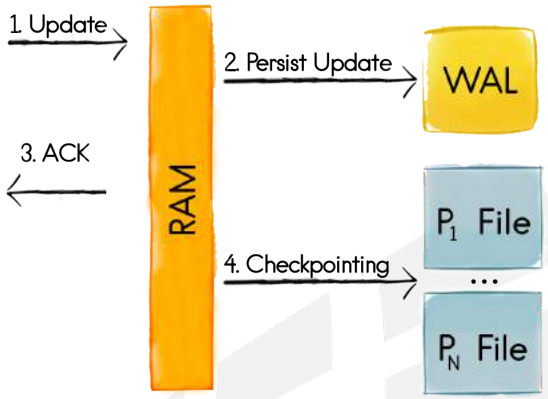
Ignite Persistent Store

- Expands Virtual Memory to Disk
  - Flash, SSD, Intel 3D Xpoint
- ANSI-99 SQL-Compliant
  - Join RAM and disk datasets
- ACID-Compliant
  - Write-ahead logs
- Stores superset of data
  - If a page is in RAM, it is always on disk
  - Same format
- Instantaneous Restarts



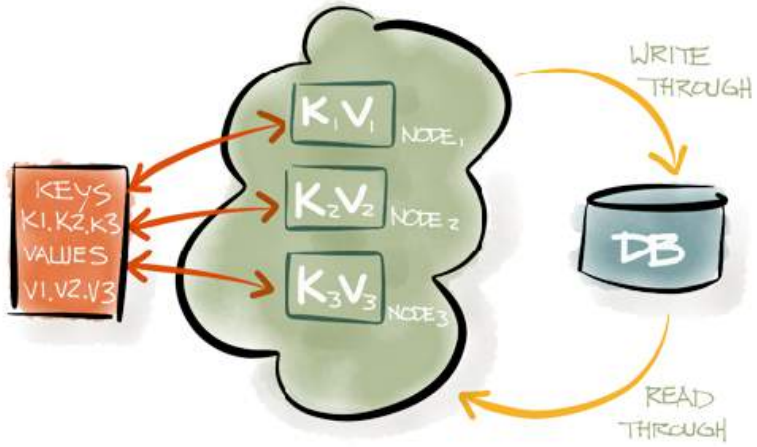
Durability and Consistency

- Write-Ahead Log (WAL)
  - Updates appended to node's WAL
  - WAL propagates updates to disk
  - Provides recovery mechanism
- Checkpointing
  - Triggered periodically based upon config
  - Copy dirty pages from RAM to disk
  - Reduces WAL size



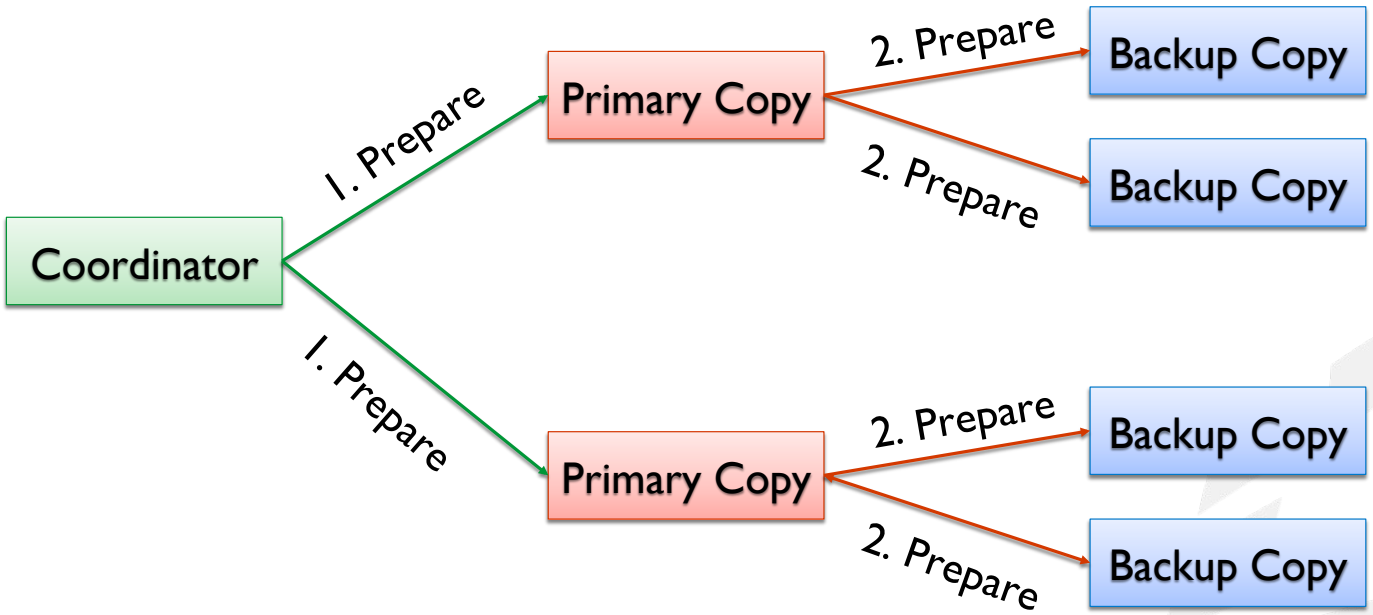
3rd Party Stores: Consistency

- Coordinator writes to the database first
- Commits in the cluster afterwards
- The database must be transactional
  - RDBMS

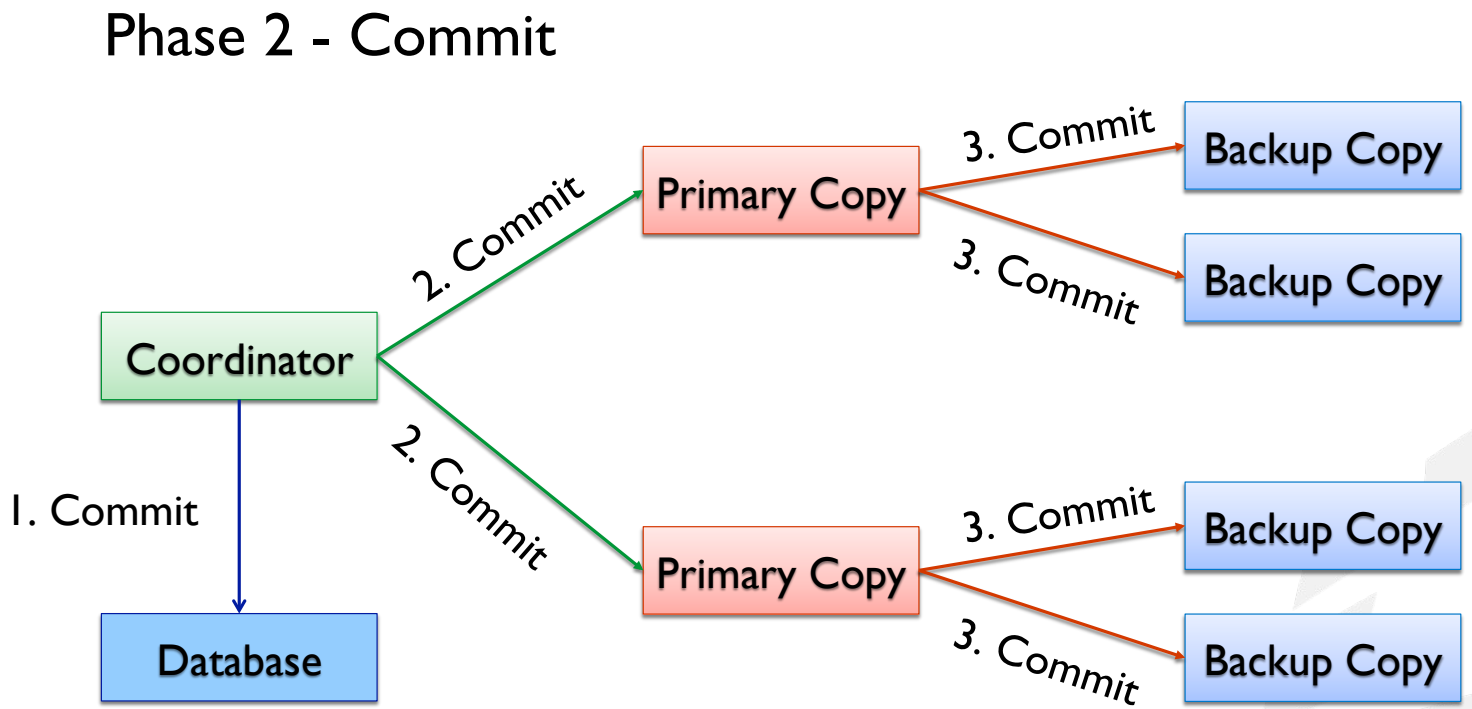


3rd Party Stores: 2PC Protocol

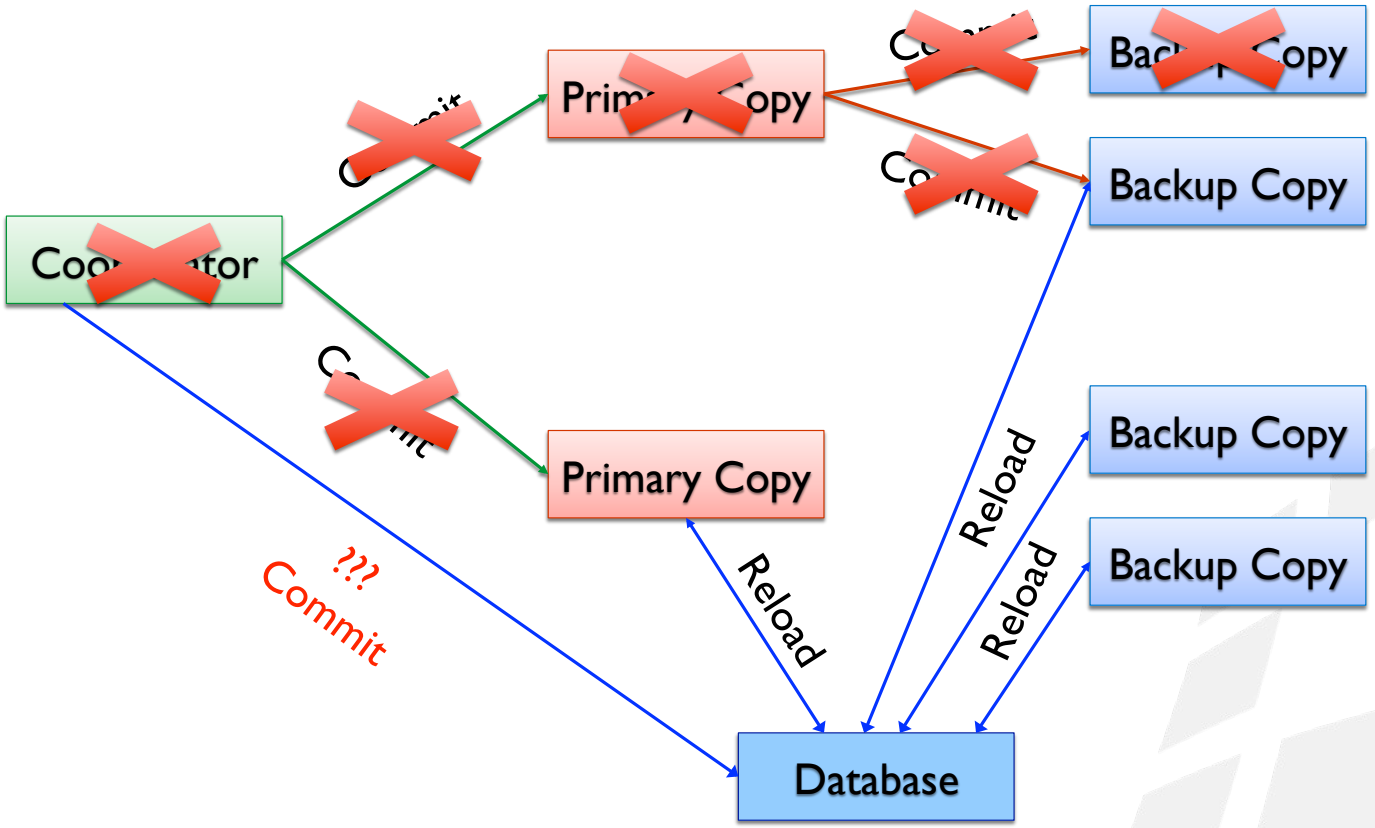
Phase 1 - Prepare



3rd Party Stores: 2PC Protocol



3rd Party Stores: Failures



Deadlock Handling

- Deadlock Detection
  - Helps prevent distributed deadlocks
  - Facilitates deadlock debugging and avoidance
- Deadlock-free Transactions
  - Optimistic and Serializable mode
  - Avoids possibility of deadlock
  - One of the transactions always fails
  - Failed transaction can be retried

Demos

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ANY QUESTIONS?

Thank you for joining us. Follow the conversation.

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Resources

- Two-Phase-Commit for Distributed In-Memory Caches
  - http://gridgain.blogspot.co.uk/2014/09/two-phase-commit-for-distributed-in.html
- Two-Phase-Commit for In-Memory Caches - Part II
  - http://gridgain.blogspot.co.uk/2014/09/two-phase-commit-for-in-memory-caches.html
- One-Phase-Commit - Fast Transactions For In-Memory Caches
  - http://gridgain.blogspot.co.uk/2014/09/one-phase-commit-fast-transactions-for.html