19th ACM/IFIP International Middleware Conference December 10-14 2018 Rennes, Brittany, France

L-Store Concurrency Control: QueCC

Slides are adopted from Qadah, Sadoghi

QueCC - A Queue-Oriented, Control-Free Concurrency Architecture, ACM Middleware 2018

ECS 165A – Winter 2021

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ExpoLab
Creativity Unfolded

ResilientDB

Hardware Trends

Large core counts

Large main-memory

HPE Superdome Flex for SAP HANA Scale-out configuration

HPE Superdome Server
144 physical cores
6TB of RAM

***Image source: https://www.hpe.com/us/en/servers/superdome.html**

Popularity of Key-value Stores

- No multi-statement transactions
- Weak consistency
- Weak isolation

AEROSPIKE
riakKV
redis
amazon DynamoDB
ORACLE NOSQL DATABASE
Project Voldemort
A distributed database.

High-Contention Workloads

Challenge ???

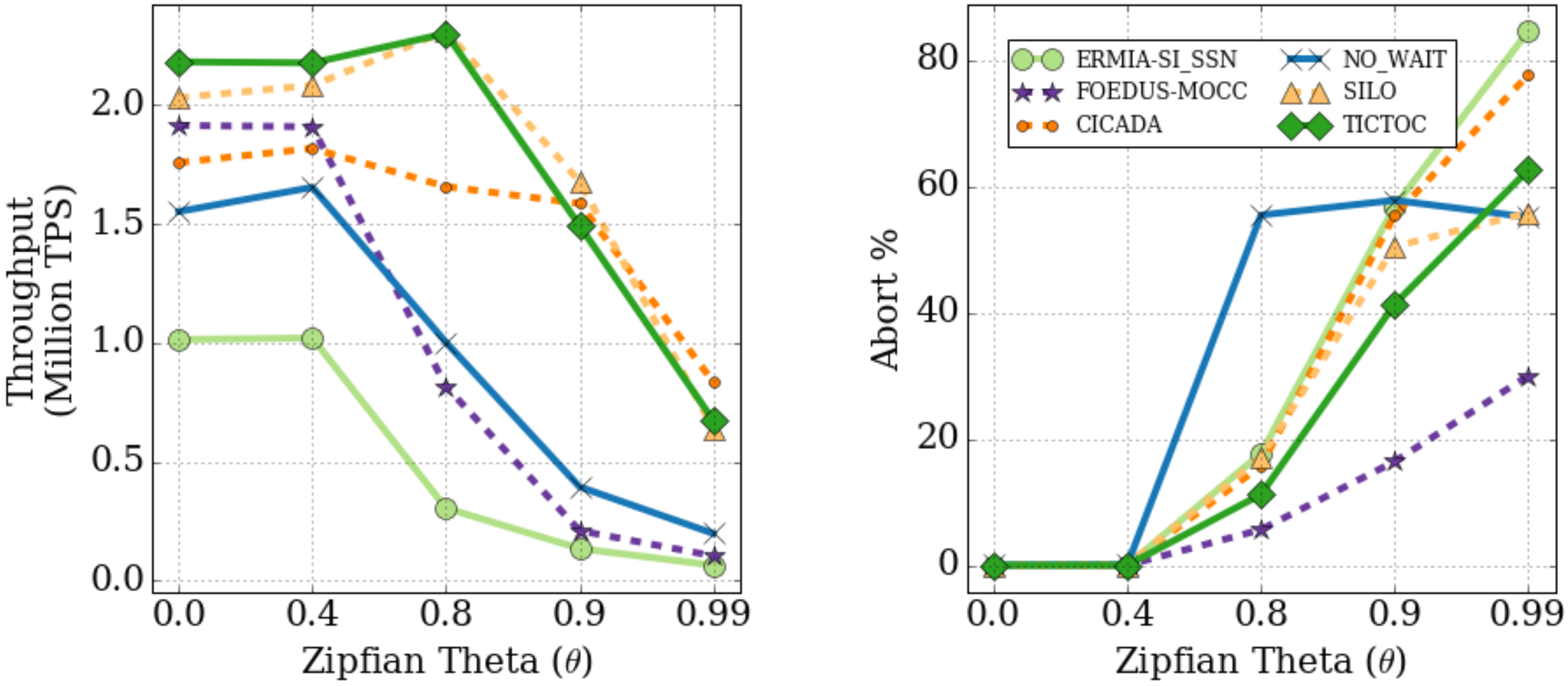
High number of
contented operations

State-of-the-Art Concurrency Control Protocols

- Optimized for multi-core hardware and main-memory databases
- Non-deterministic

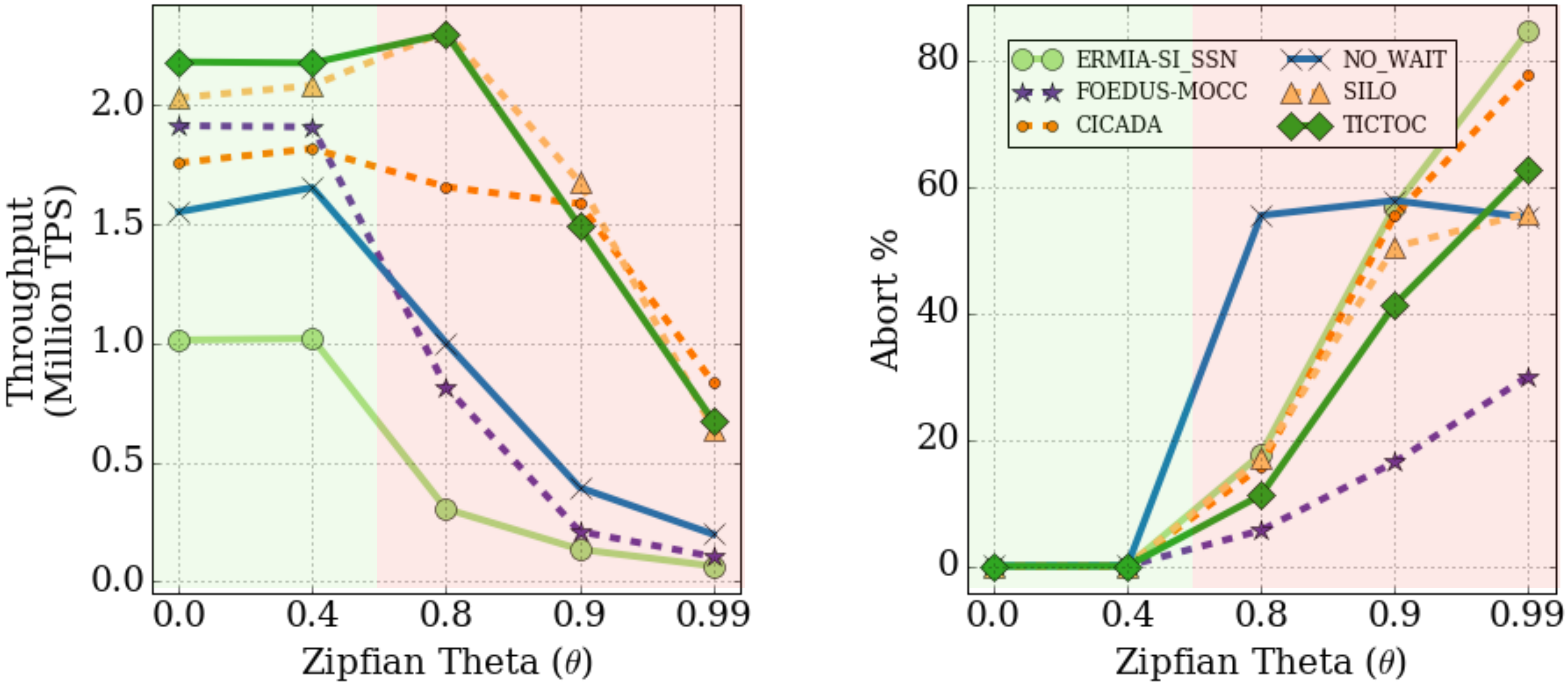
CC	Class	Year
SILO	Optimistic CC	SOSP ‘13
TICTOC	Timestamp Ordering	SIGMOD ‘16
FOEDUS-MOCC	Optimistic CC	VLDB ‘16
ERMIA	MVCC	SIGMOD ‘16
Cicada	MVCC	SIGMOD ‘17

Performance Under High-Contention



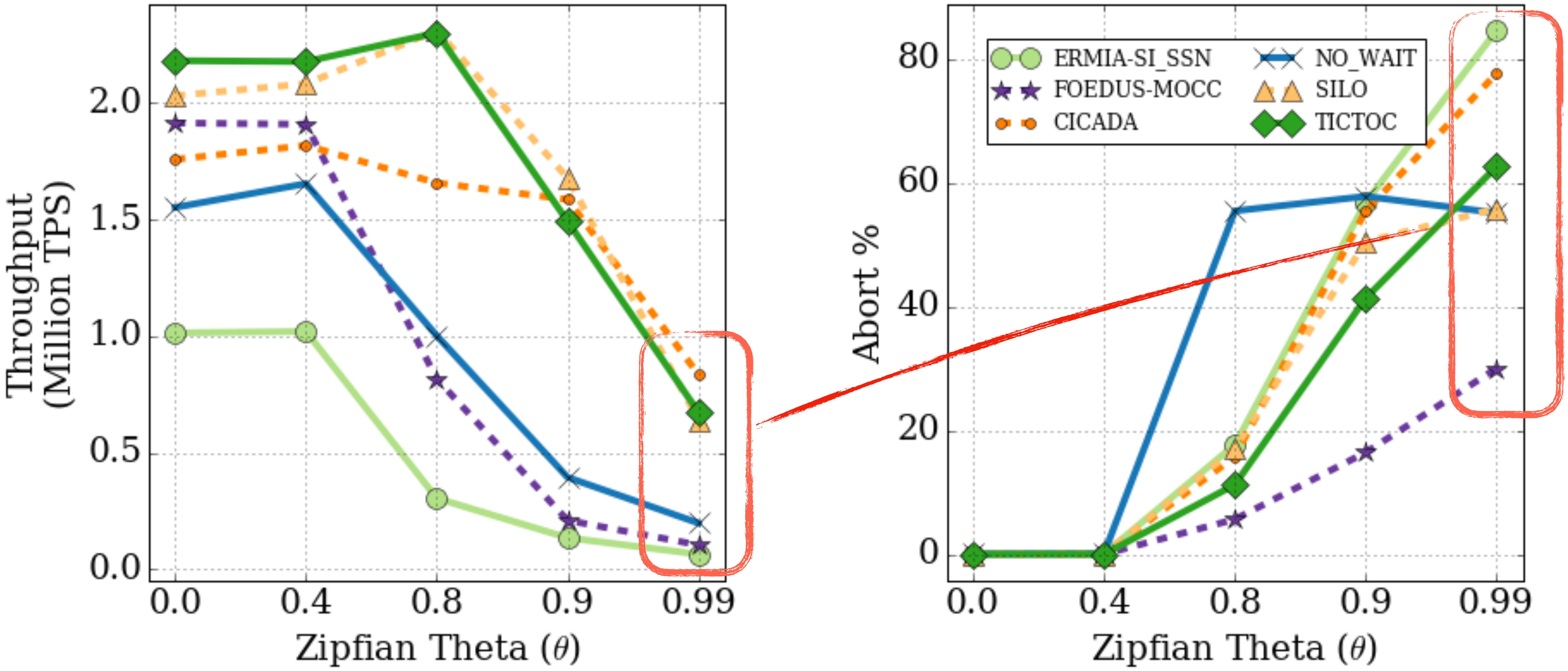
Optimize-for-multi-core concurrency control techniques suffer under high-contention due to increasing abort rate

Performance Under High-Contention



Under high-contention: Non-deterministic aborts dominates

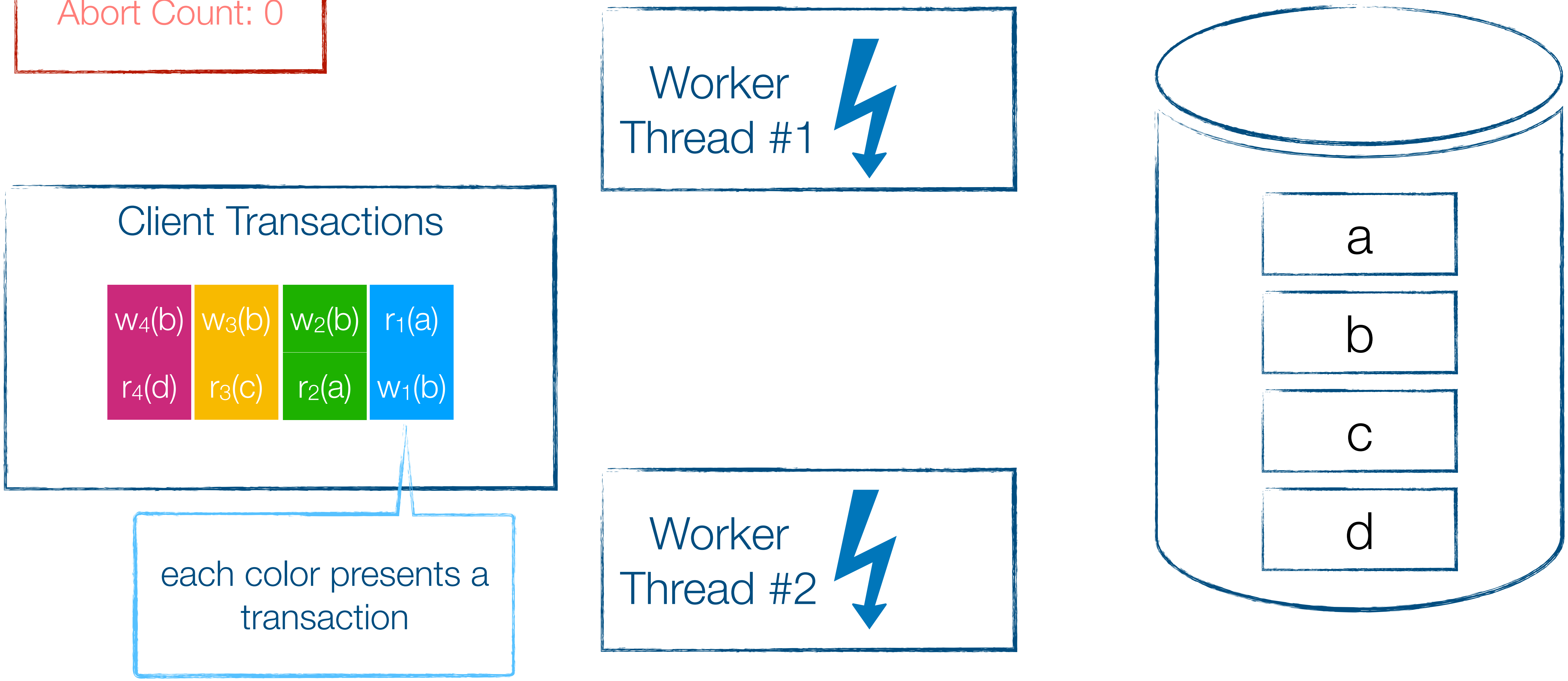
Performance Under High-Contention



Under high-contention: Non-deterministic aborts dominates

2PL - NoWait

Abort Count: 0



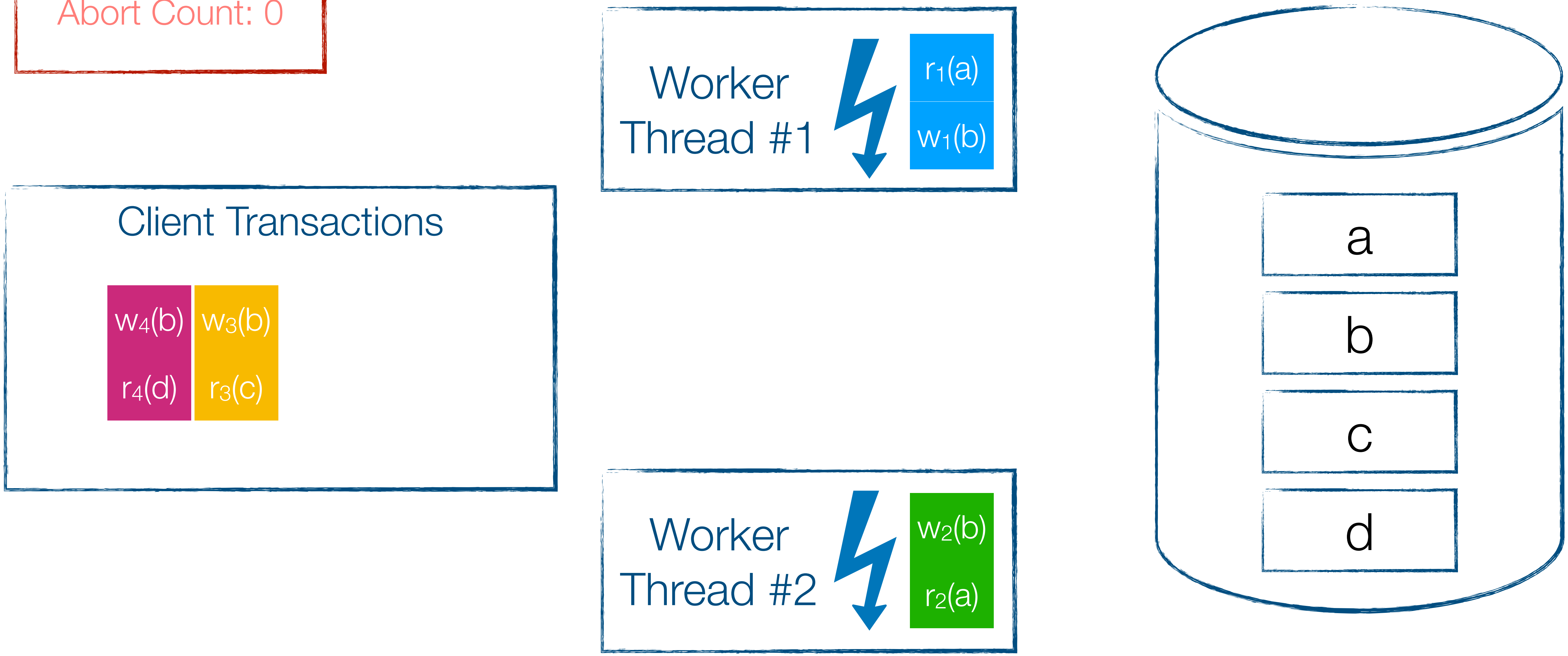
Client Transactions

$w_4(b)$	$w_3(b)$	$w_2(b)$	$r_1(a)$
$r_4(d)$	$r_3(c)$	$r_2(a)$	$w_1(b)$

each color presents a transaction

2PL - NoWait

Abort Count: 0



Client Transactions

$w_4(b)$ $r_4(d)$

$w_3(b)$ $r_3(c)$

Worker Thread #1

$r_1(a)$ $w_1(b)$

Worker Thread #2

$w_2(b)$ $r_2(a)$

a

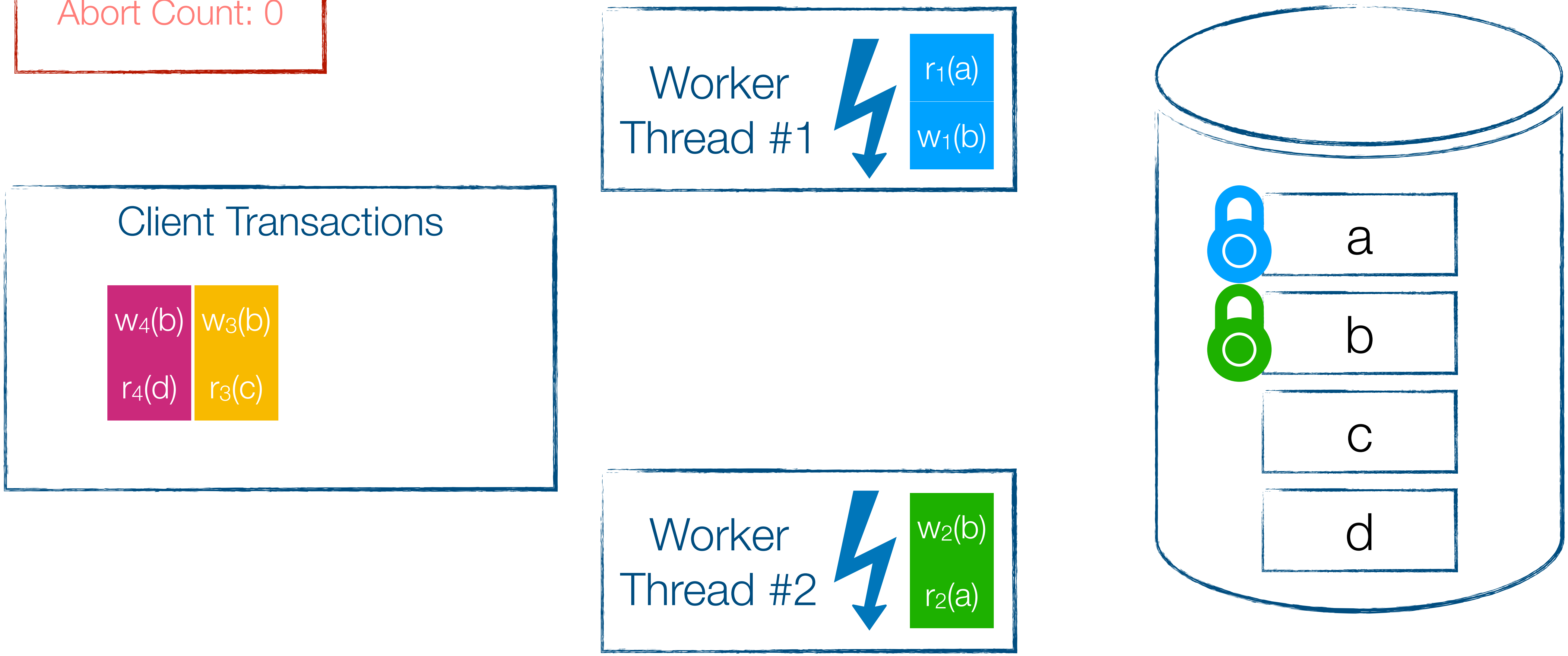
b

c

d

2PL - NoWait

Abort Count: 0



Client Transactions

$w_4(b)$ $r_4(d)$

$w_3(b)$ $r_3(c)$

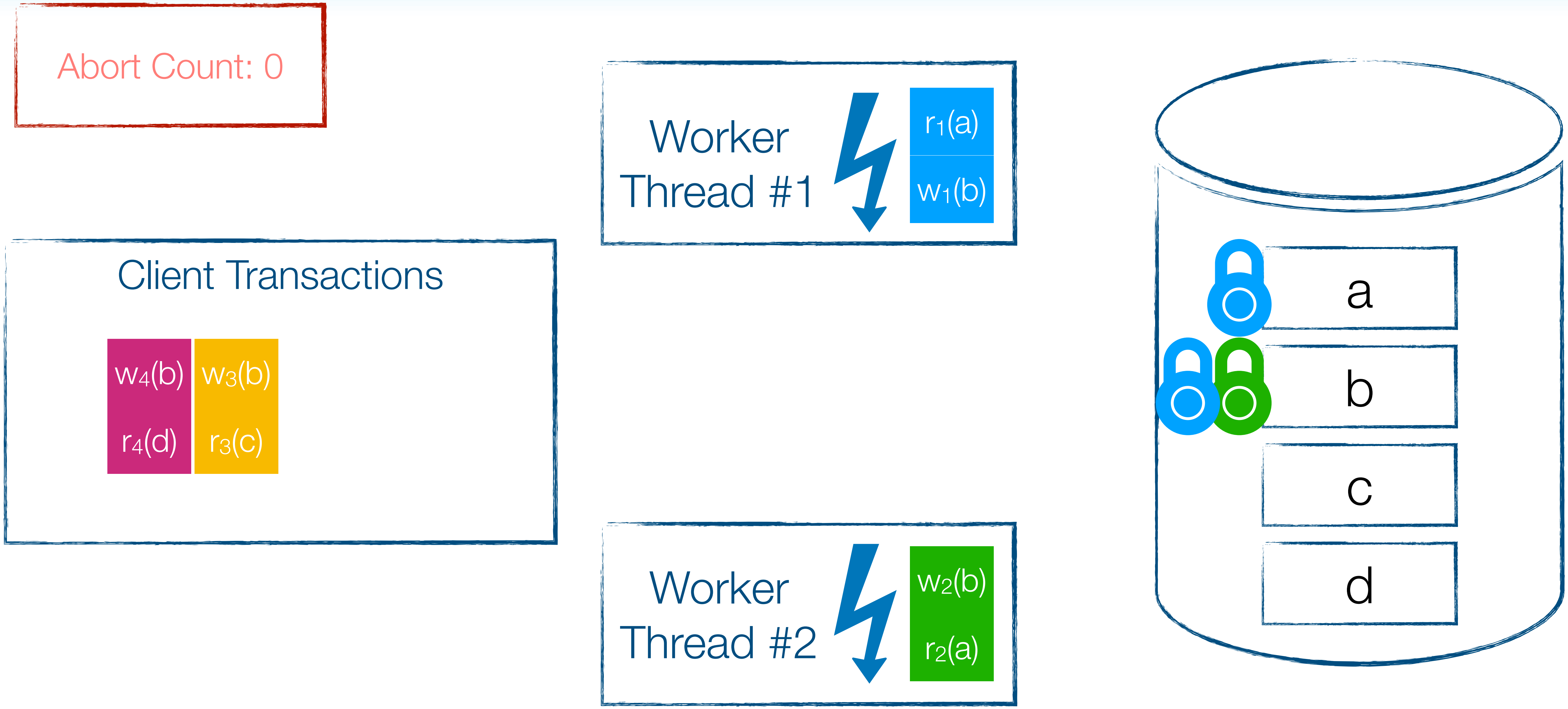
Worker Thread #1

$r_1(a)$ $w_1(b)$

Worker Thread #2

$w_2(b)$ $r_2(a)$

2PL - NoWait



Abort Count: 0

Client Transactions

$w_4(b)$ $r_4(d)$

$w_3(b)$ $r_3(c)$

Worker Thread #1

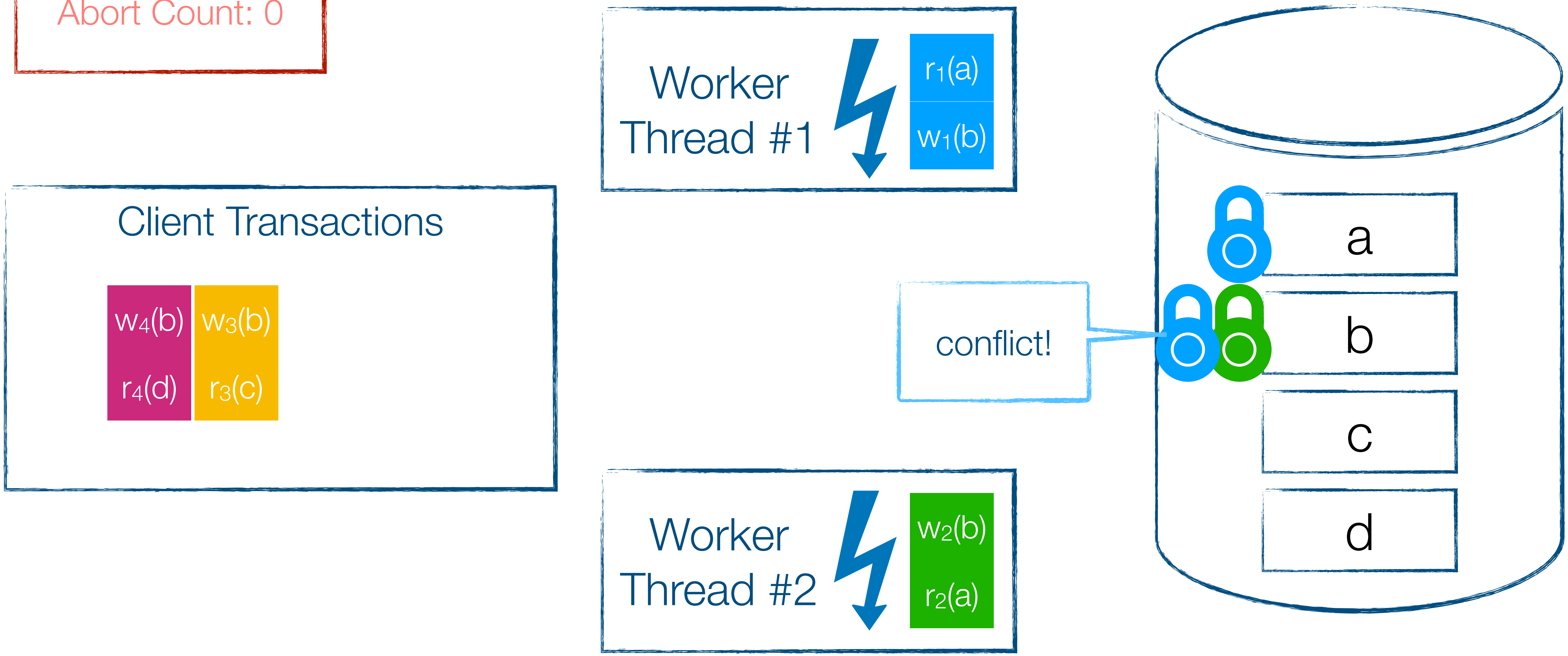
$r_1(a)$ $w_1(b)$

Worker Thread #2

$w_2(b)$ $r_2(a)$

2PL - NoWait

Abort Count: 0



Client Transactions

$w_4(b)$ $r_4(d)$

$w_3(b)$ $r_3(c)$

Worker Thread #1

$r_1(a)$ $w_1(b)$

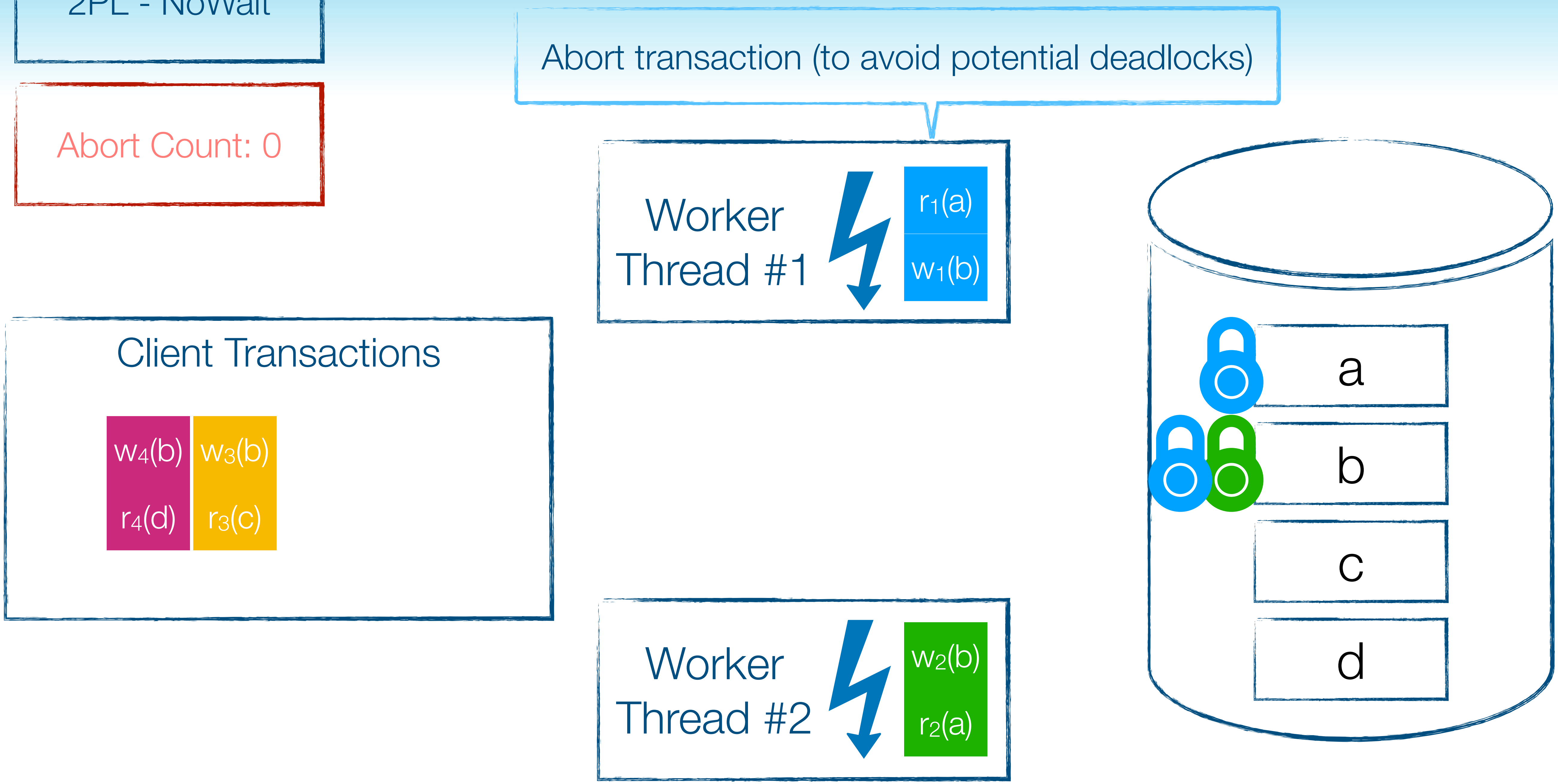
Worker Thread #2

$w_2(b)$ $r_2(a)$

conflict!

2PL - NoWait

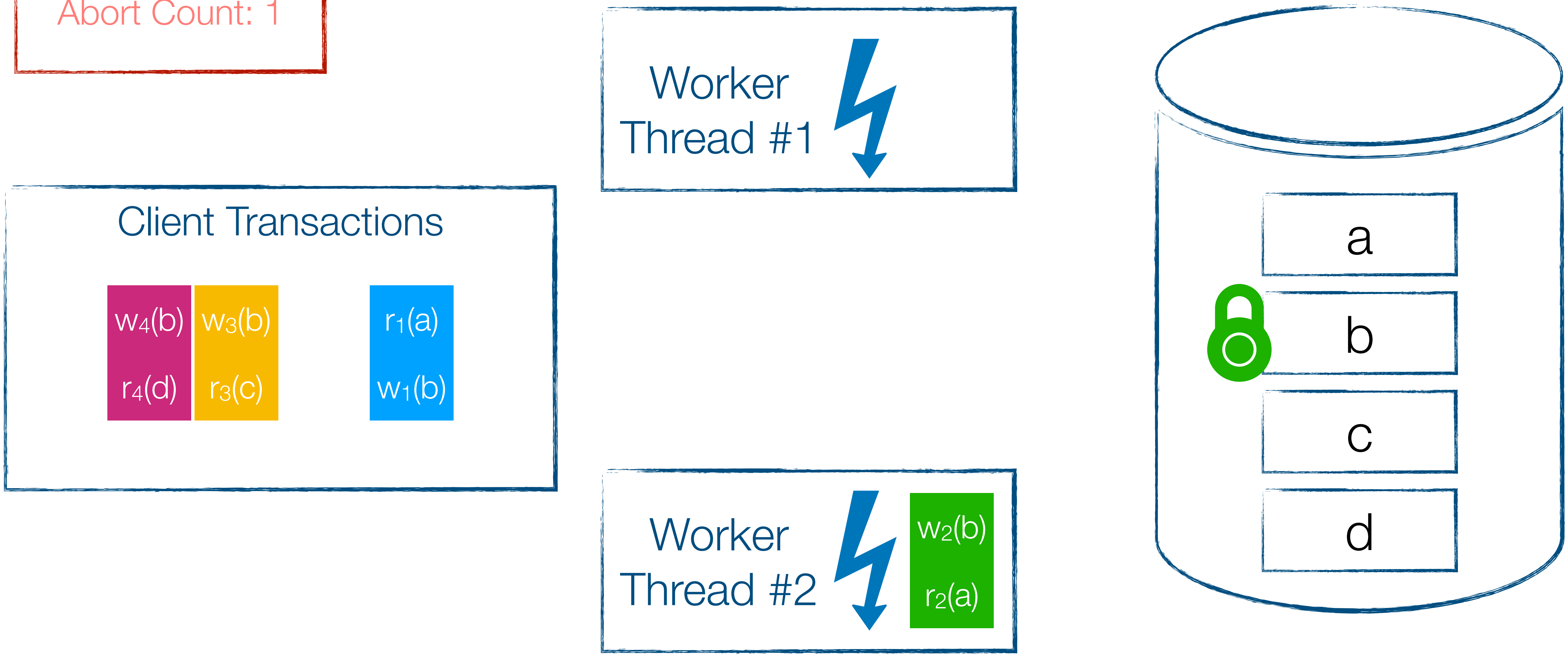
Abort Count: 0



Abort transaction (to avoid potential deadlocks)

2PL - NoWait

Abort Count: 1



Client Transactions

$w_4(b)$ $r_4(d)$

$w_3(b)$ $r_3(c)$

$r_1(a)$ $w_1(b)$

Worker Thread #1

Worker Thread #2

$w_2(b)$ $r_2(a)$

a

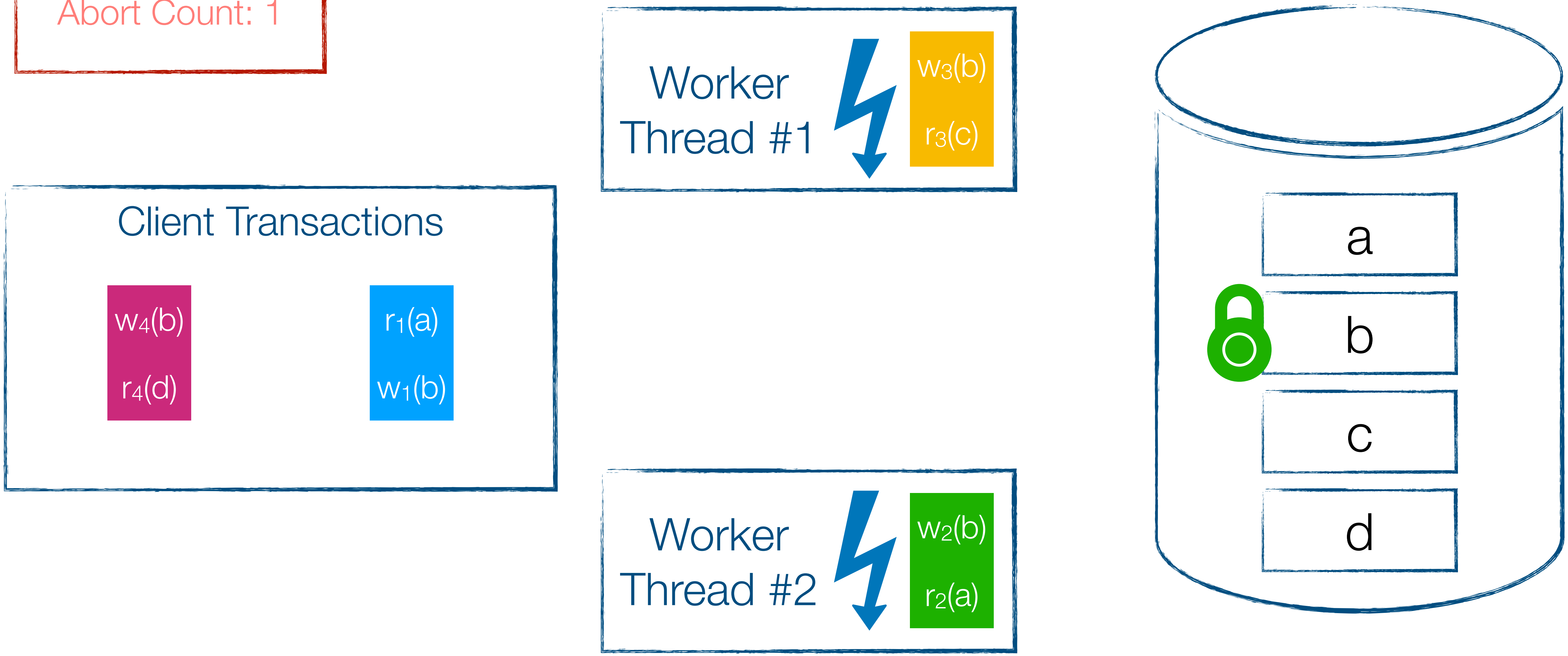
b

c

d

2PL - NoWait

Abort Count: 1



Worker Thread #1

$w_3(b)$

$r_3(c)$

Client Transactions

$w_4(b)$

$r_4(d)$

$r_1(a)$

$w_1(b)$

Worker Thread #2

$w_2(b)$

$r_2(a)$

a

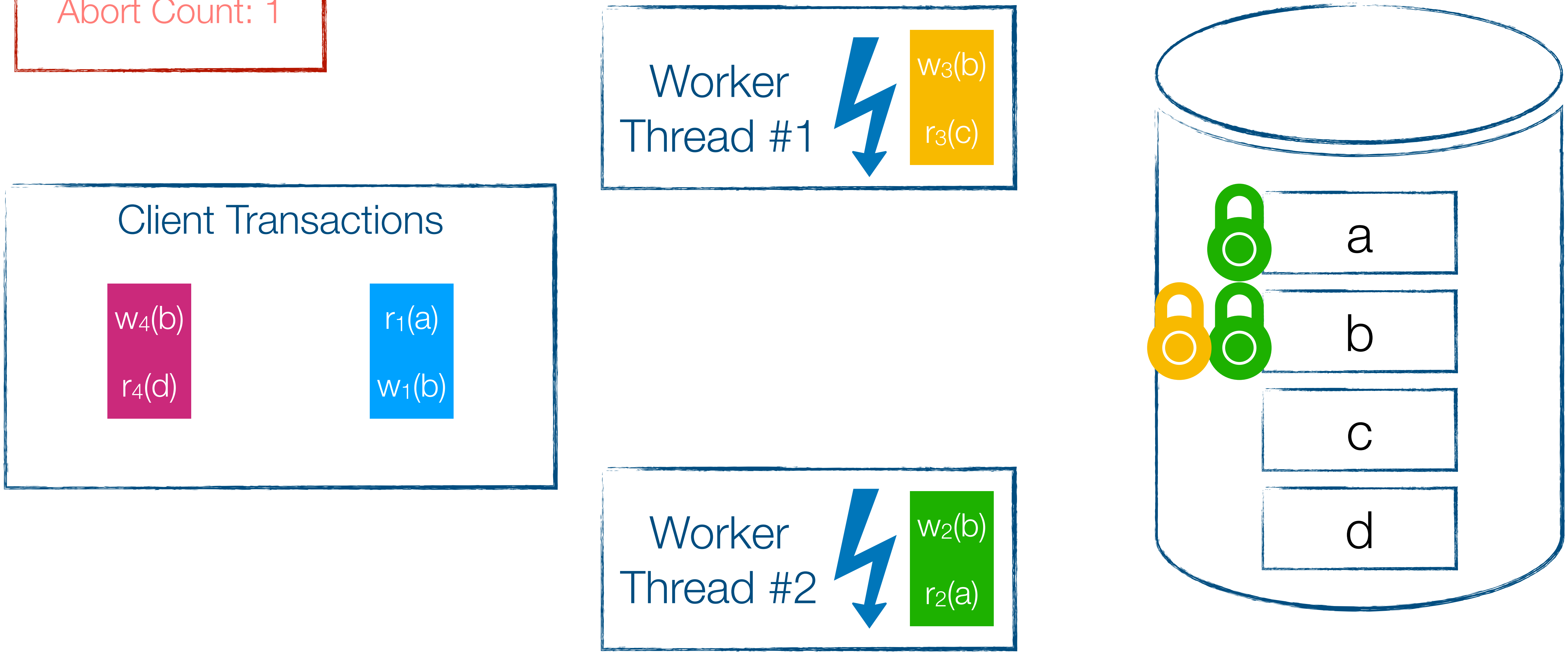
b

c

d

2PL - NoWait

Abort Count: 1



Client Transactions

$w_4(b)$
$r_4(d)$

$r_1(a)$
$w_1(b)$

Worker Thread #1

$w_3(b)$
$r_3(c)$

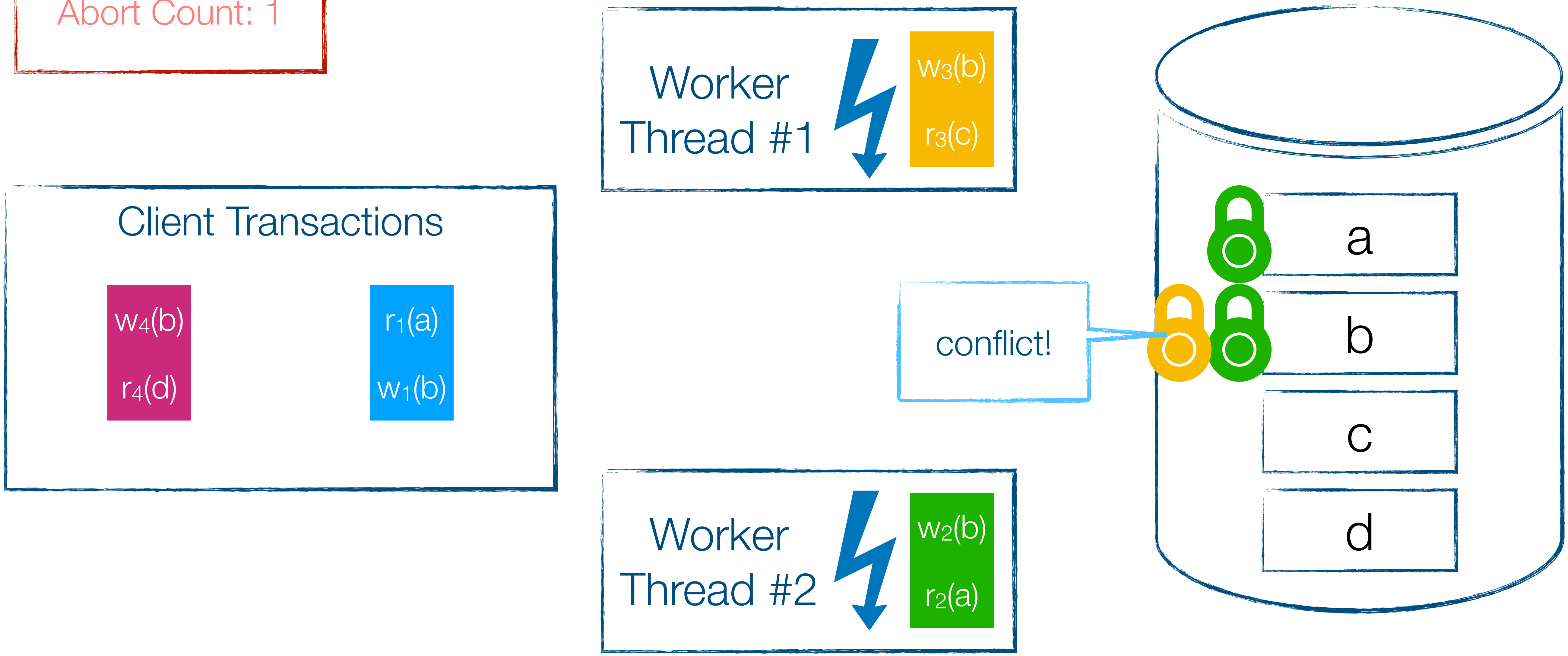
Worker Thread #2

$w_2(b)$
$r_2(a)$

a
b
c
d

2PL - NoWait

Abort Count: 1



Client Transactions

$w_4(b)$

$r_4(d)$

$r_1(a)$

$w_1(b)$

Worker Thread #1

$w_3(b)$

$r_3(c)$

Worker Thread #2

$w_2(b)$

$r_2(a)$

conflict!

a

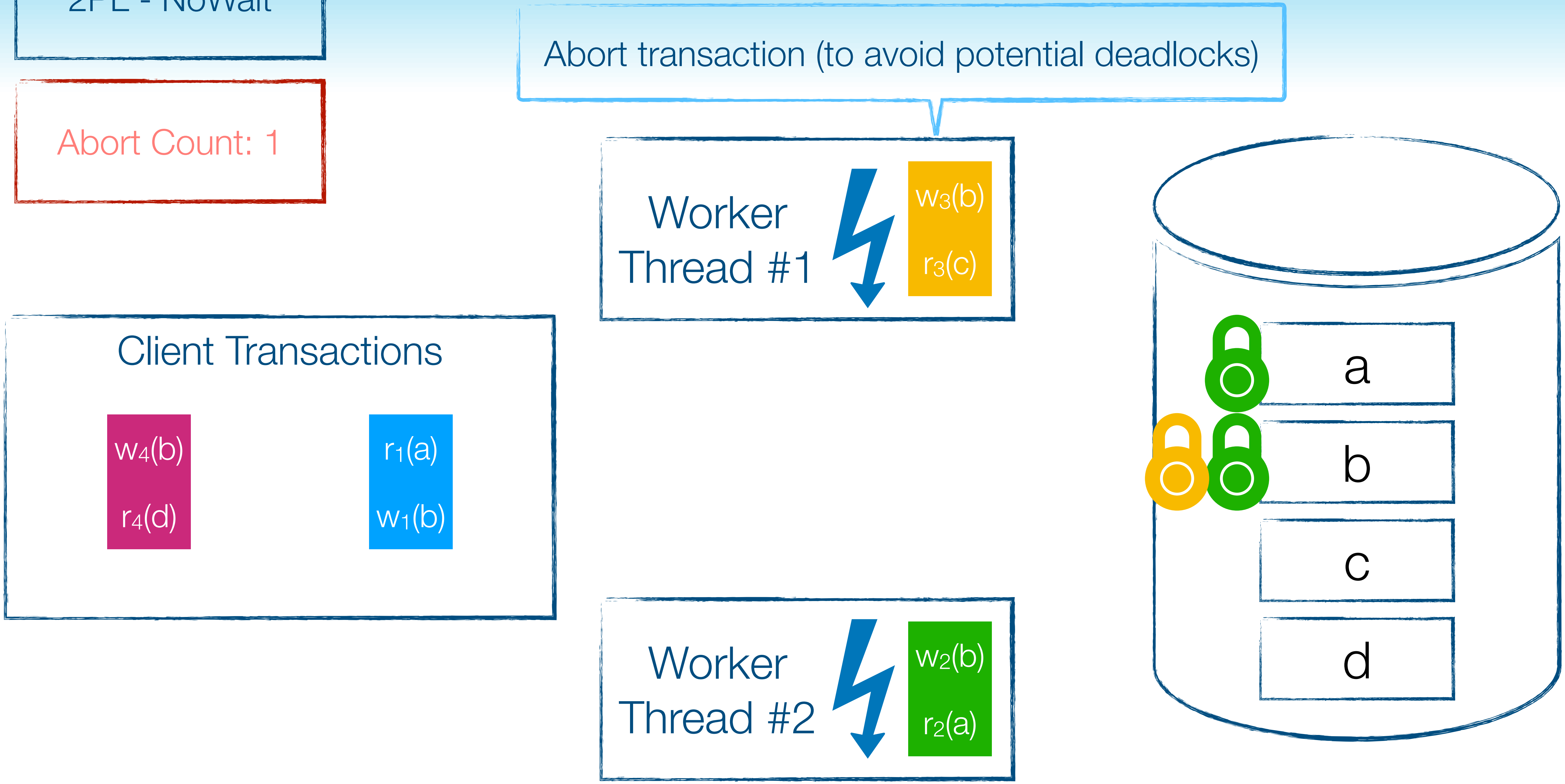
b

c

d

2PL - NoWait

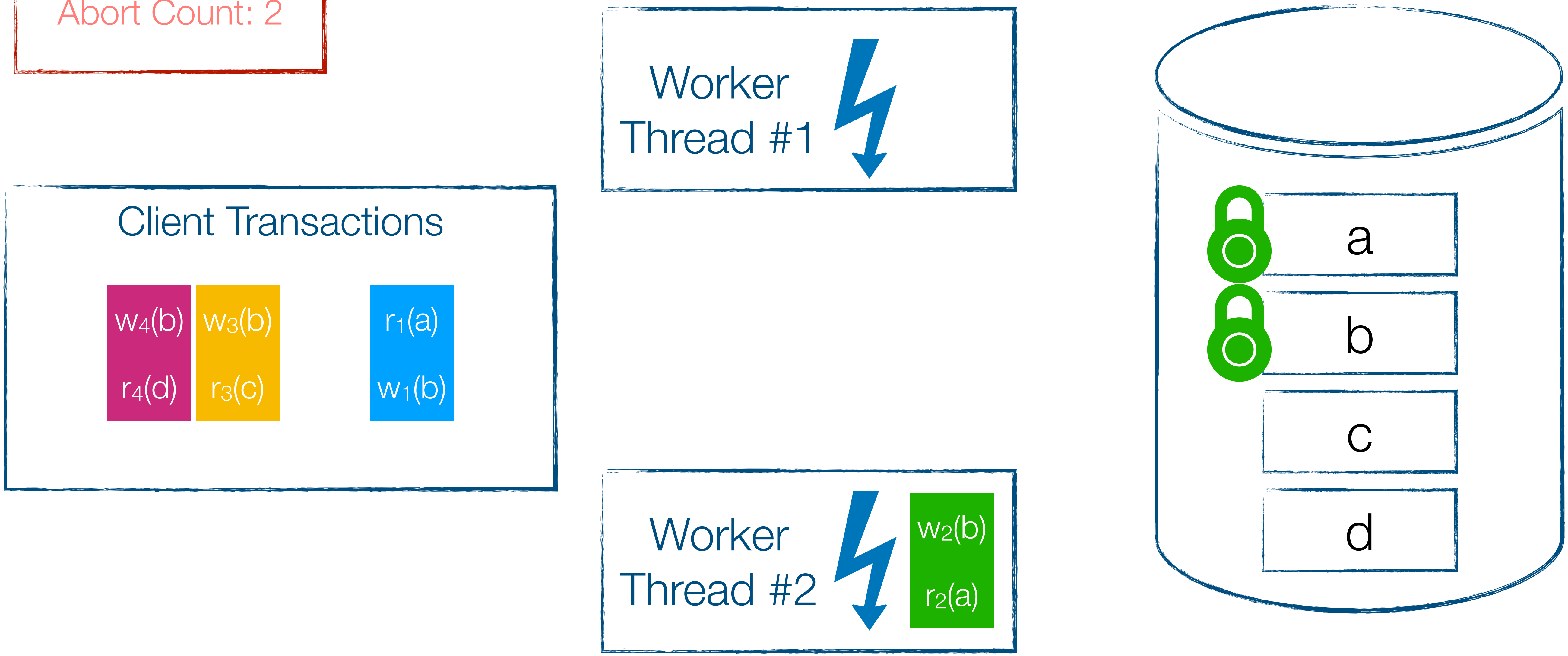
Abort Count: 1



Abort transaction (to avoid potential deadlocks)

2PL - NoWait

Abort Count: 2



Client Transactions

$w_4(b)$ $w_3(b)$ $r_1(a)$

$r_4(d)$ $r_3(c)$ $w_1(b)$

Worker Thread #1

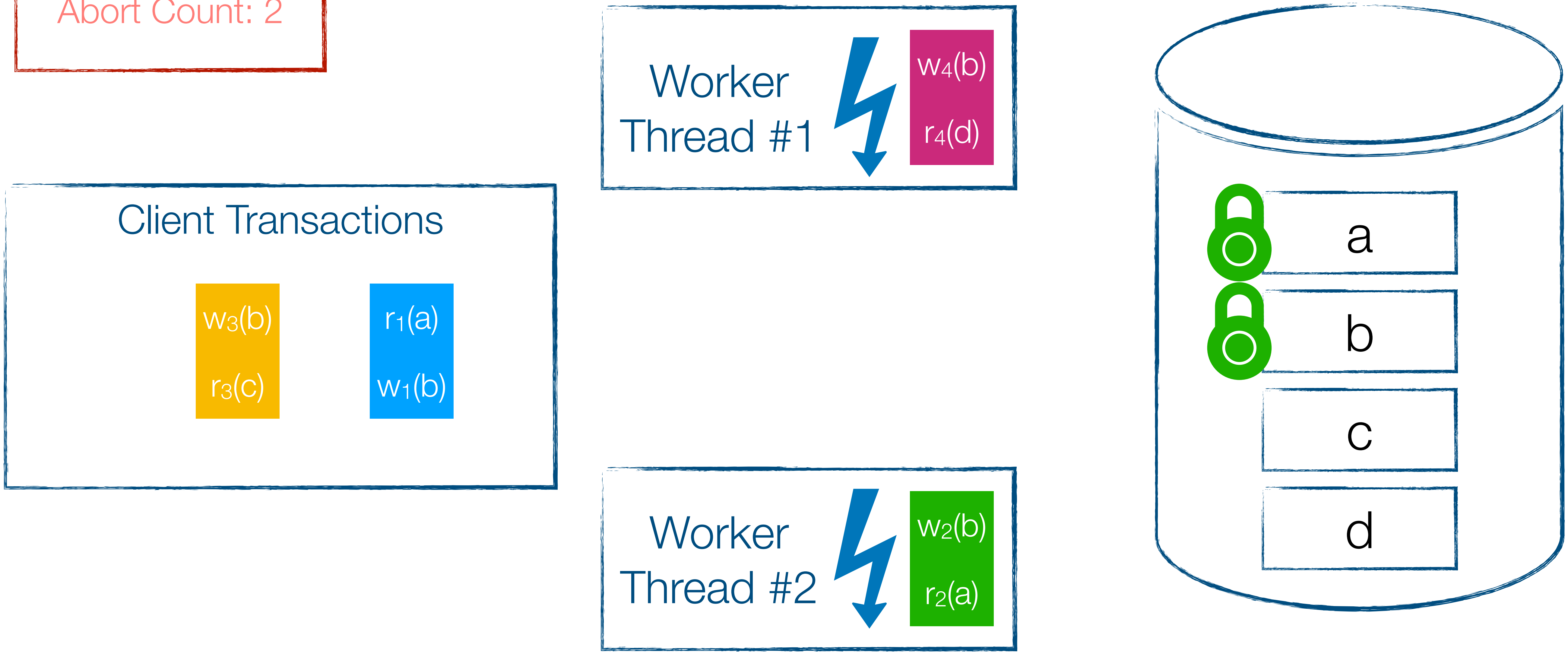
Worker Thread #2

$w_2(b)$

$r_2(a)$

2PL - NoWait

Abort Count: 2



Worker Thread #1

$w_4(b)$

$r_4(d)$

Client Transactions

$w_3(b)$

$r_3(c)$

$r_1(a)$

$w_1(b)$

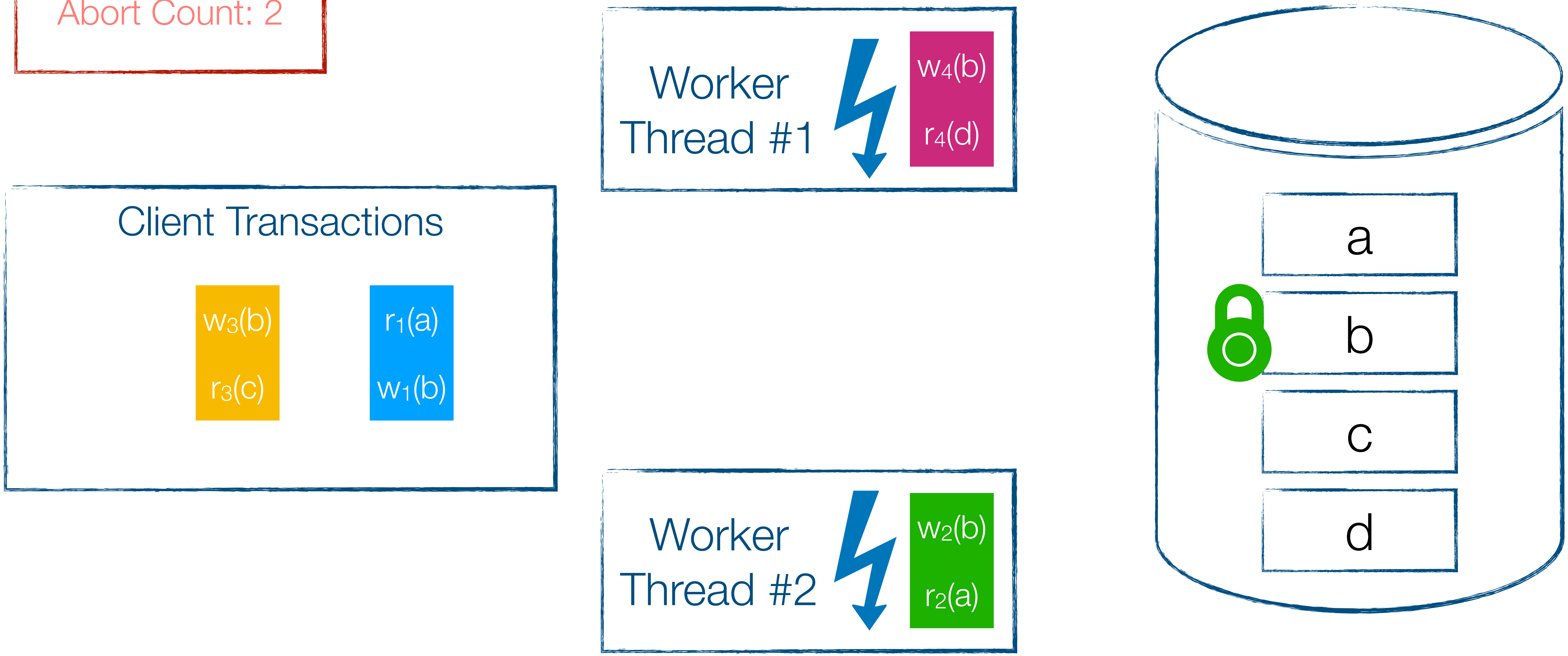
Worker Thread #2

$w_2(b)$

$r_2(a)$

2PL - NoWait

Abort Count: 2



Client Transactions

$w_3(b)$

$r_3(c)$

$r_1(a)$

$w_1(b)$

Worker Thread #1

$w_4(b)$

$r_4(d)$

Worker Thread #2

$w_2(b)$

$r_2(a)$

a

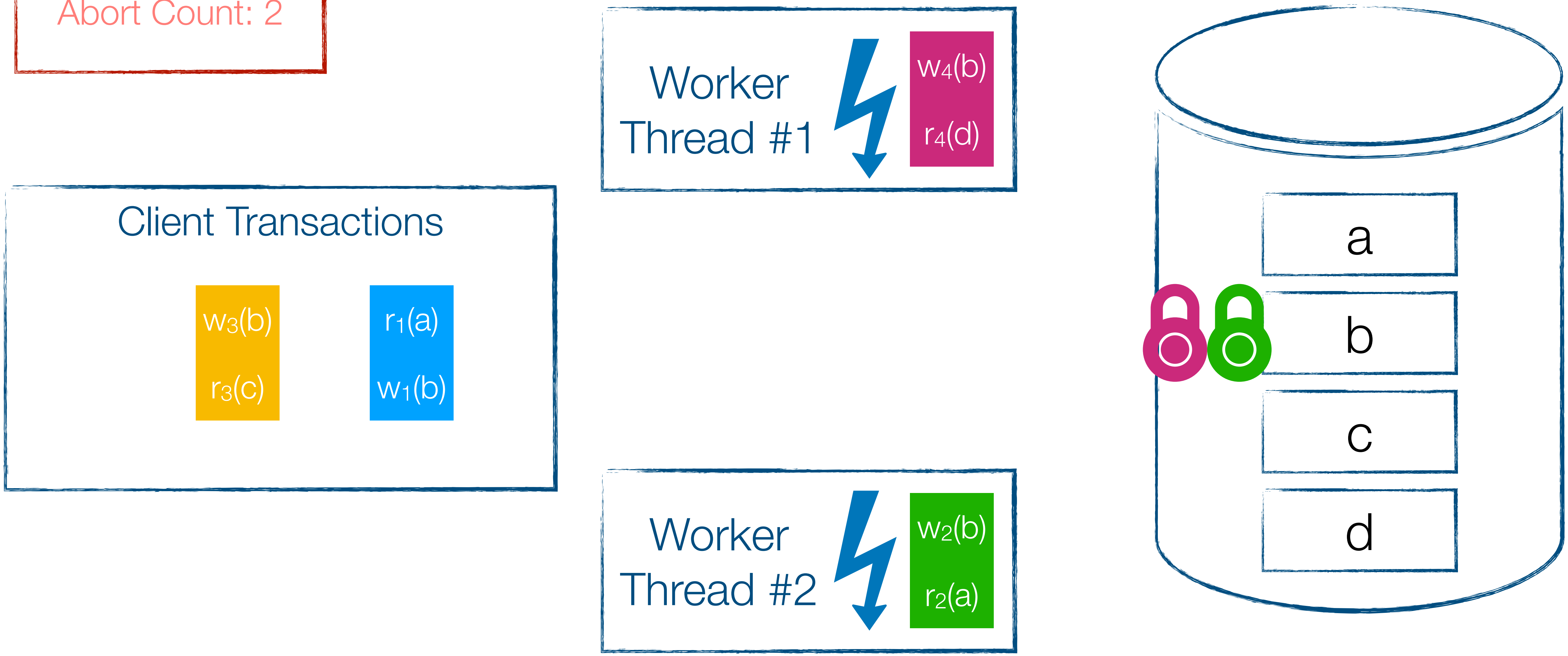
b

c

d

2PL - NoWait

Abort Count: 2



Worker Thread #1

$w_4(b)$

$r_4(d)$

Client Transactions

$w_3(b)$

$r_3(c)$

$r_1(a)$

$w_1(b)$

Worker Thread #2

$w_2(b)$

$r_2(a)$

a

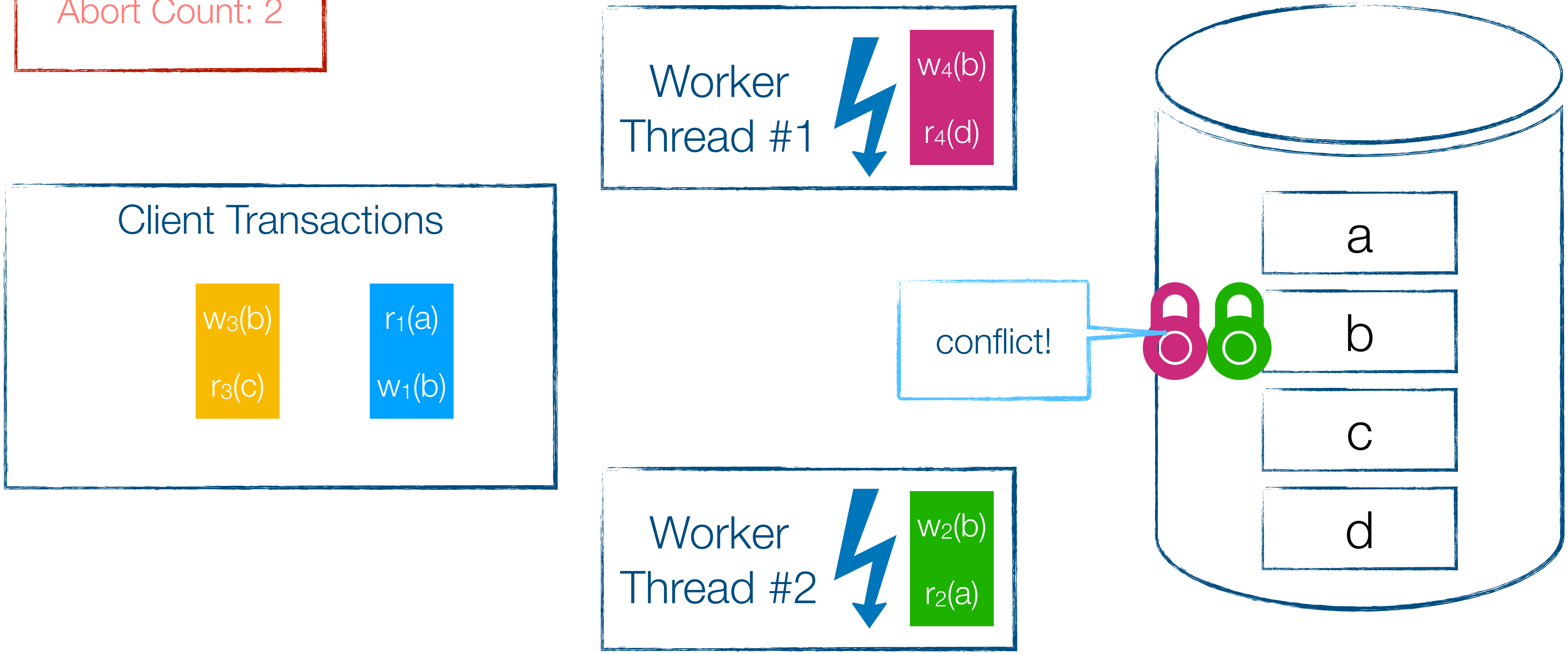
b

c

d

2PL - NoWait

Abort Count: 2



Worker Thread #1

$w_4(b)$

$r_4(d)$

Client Transactions

$w_3(b)$

$r_3(c)$

$r_1(a)$

$w_1(b)$

conflict!

Worker Thread #2

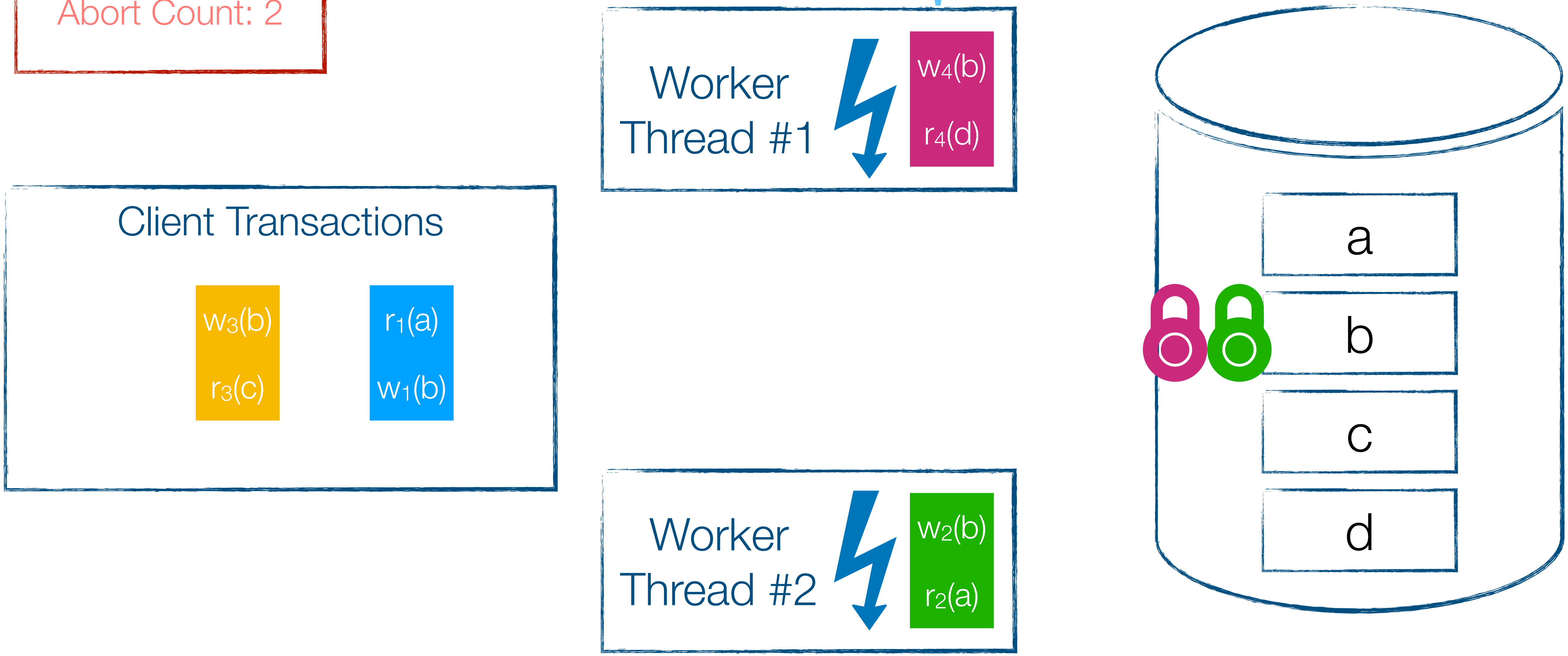
$w_2(b)$

$r_2(a)$

2PL - NoWait

Abort Count: 2

Abort transaction (to avoid potential deadlocks)



Worker Thread #1

$w_4(b)$

$r_4(d)$

Client Transactions

$w_3(b)$

$r_3(c)$

$r_1(a)$

$w_1(b)$

Worker Thread #2

$w_2(b)$

$r_2(a)$

a

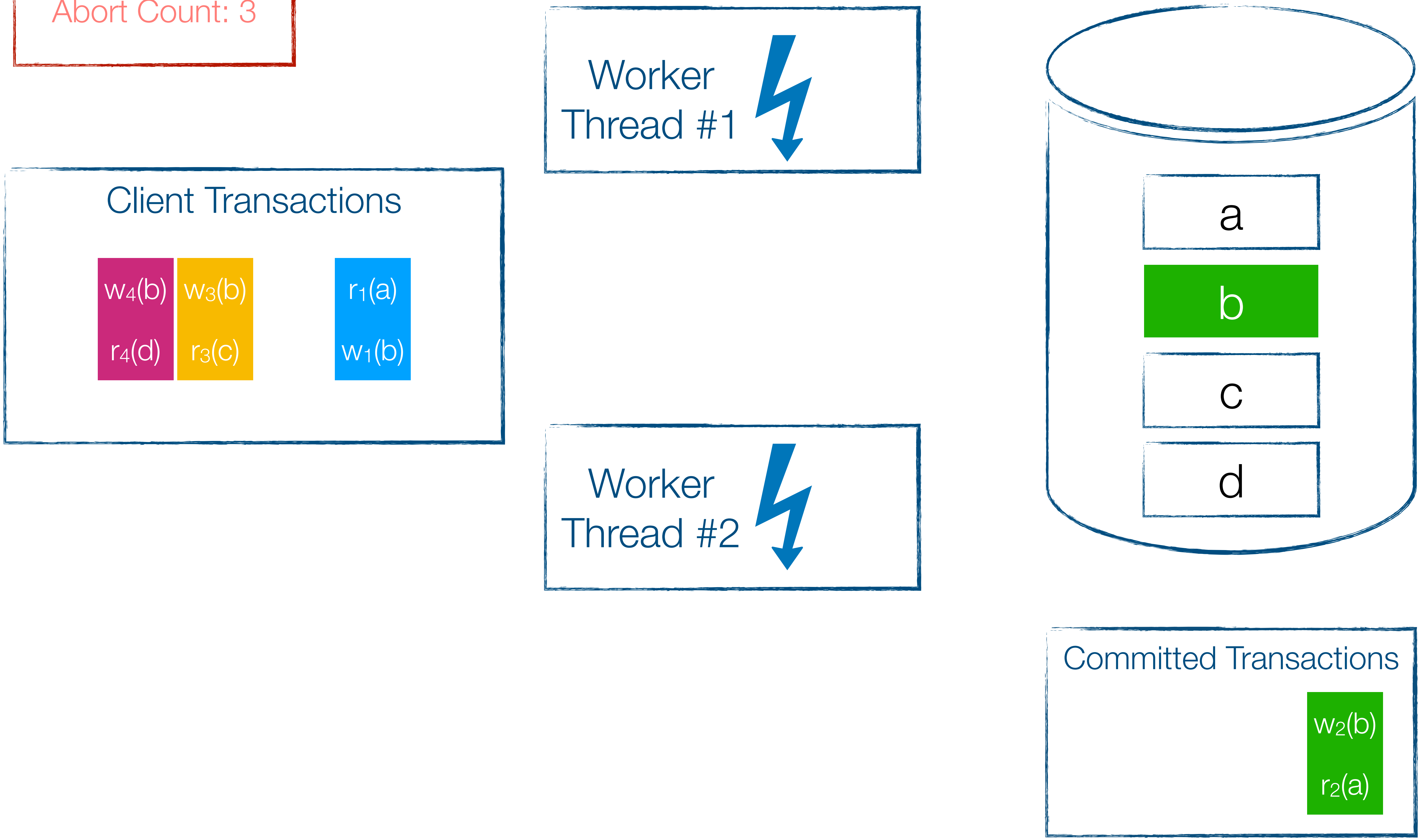
b

c

d

2PL - NoWait

Abort Count: 3



Client Transactions

$w_4(b)$ $w_3(b)$ $r_1(a)$

$r_4(d)$ $r_3(c)$ $w_1(b)$

Worker Thread #1

Worker Thread #2

a

b

c

d

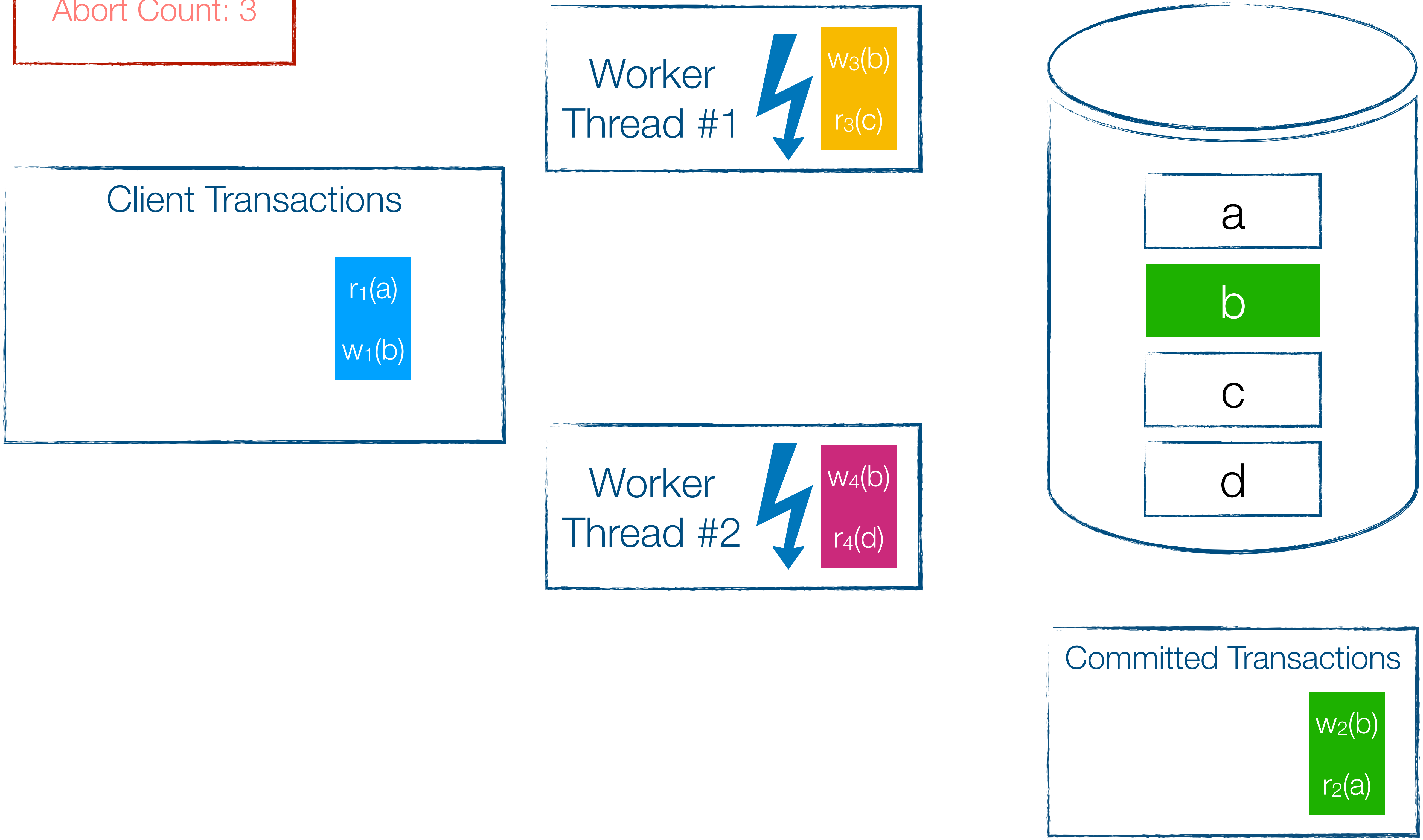
Committed Transactions

$w_2(b)$

$r_2(a)$

2PL - NoWait

Abort Count: 3



Worker Thread #1

$w_3(b)$

$r_3(c)$

Client Transactions

$r_1(a)$

$w_1(b)$

Worker Thread #2

$w_4(b)$

$r_4(d)$

a

b

c

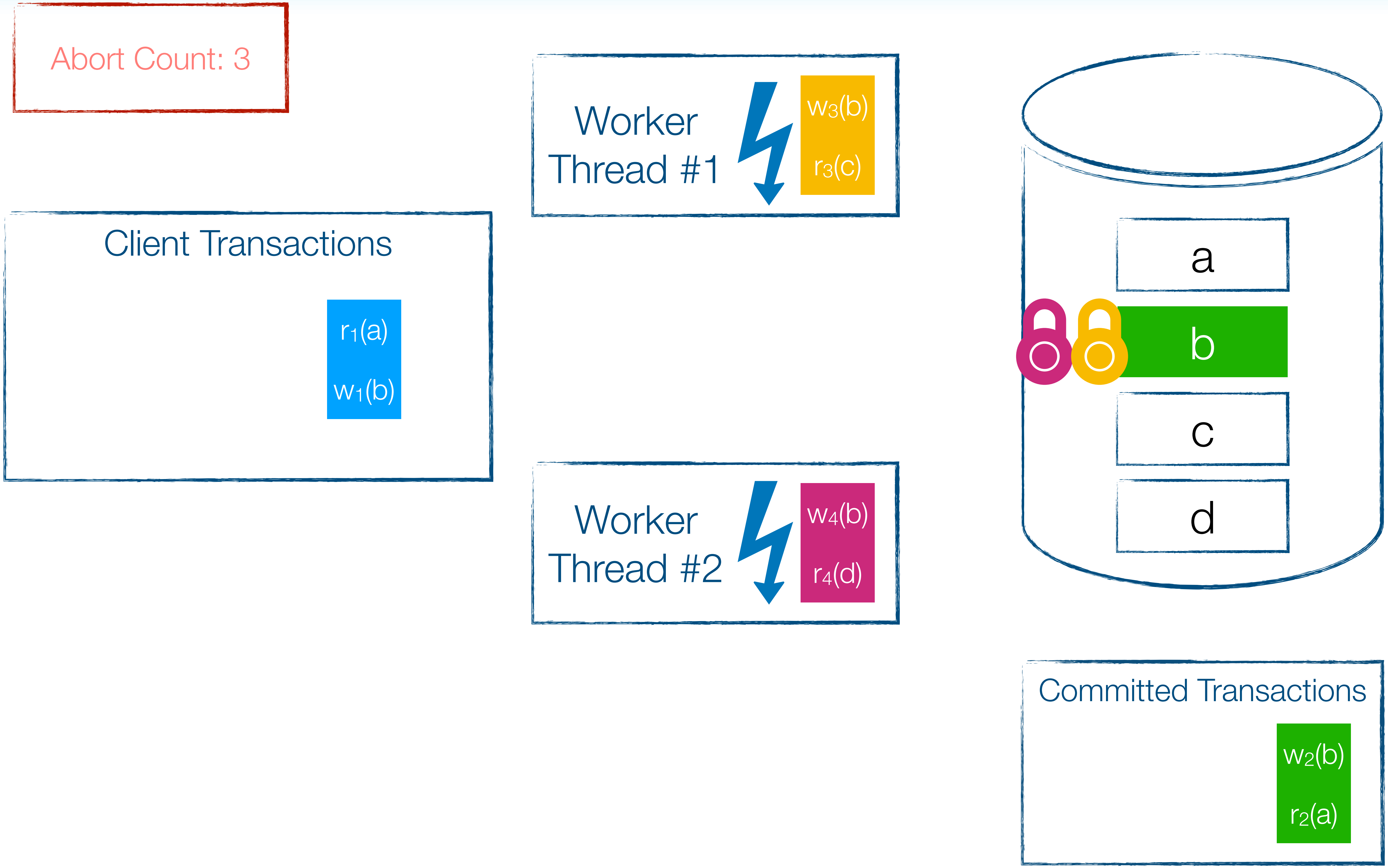
d

Committed Transactions

$w_2(b)$

$r_2(a)$

2PL - NoWait



Abort Count: 3

Client Transactions

$r_1(a)$

$w_1(b)$

Worker Thread #1

$w_3(b)$

$r_3(c)$

Worker Thread #2

$w_4(b)$

$r_4(d)$

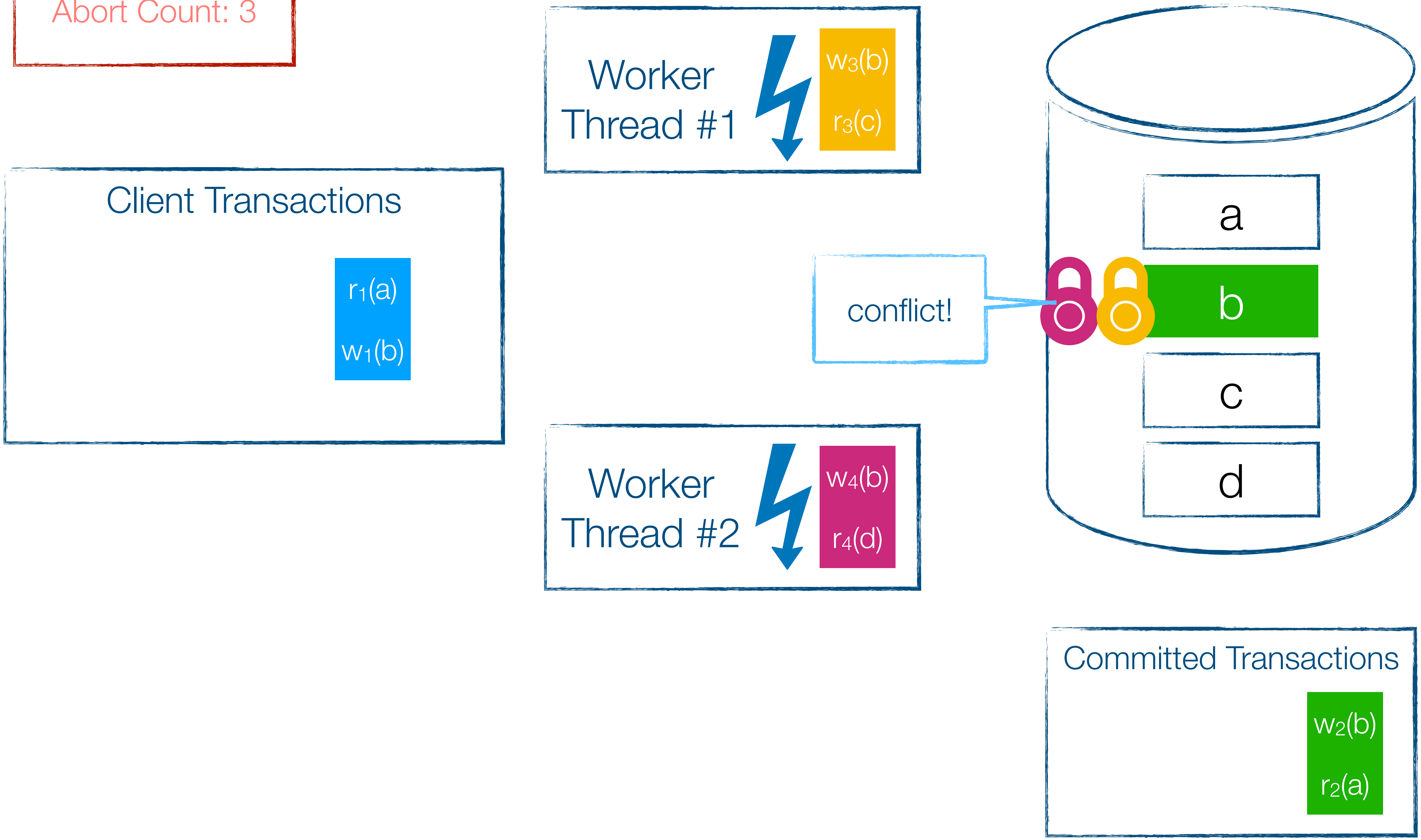
Committed Transactions

$w_2(b)$

$r_2(a)$

2PL - NoWait

Abort Count: 3



Worker Thread #1

$w_3(b)$

$r_3(c)$

Client Transactions

$r_1(a)$

$w_1(b)$

conflict!

a

b

c

d

Worker Thread #2

$w_4(b)$

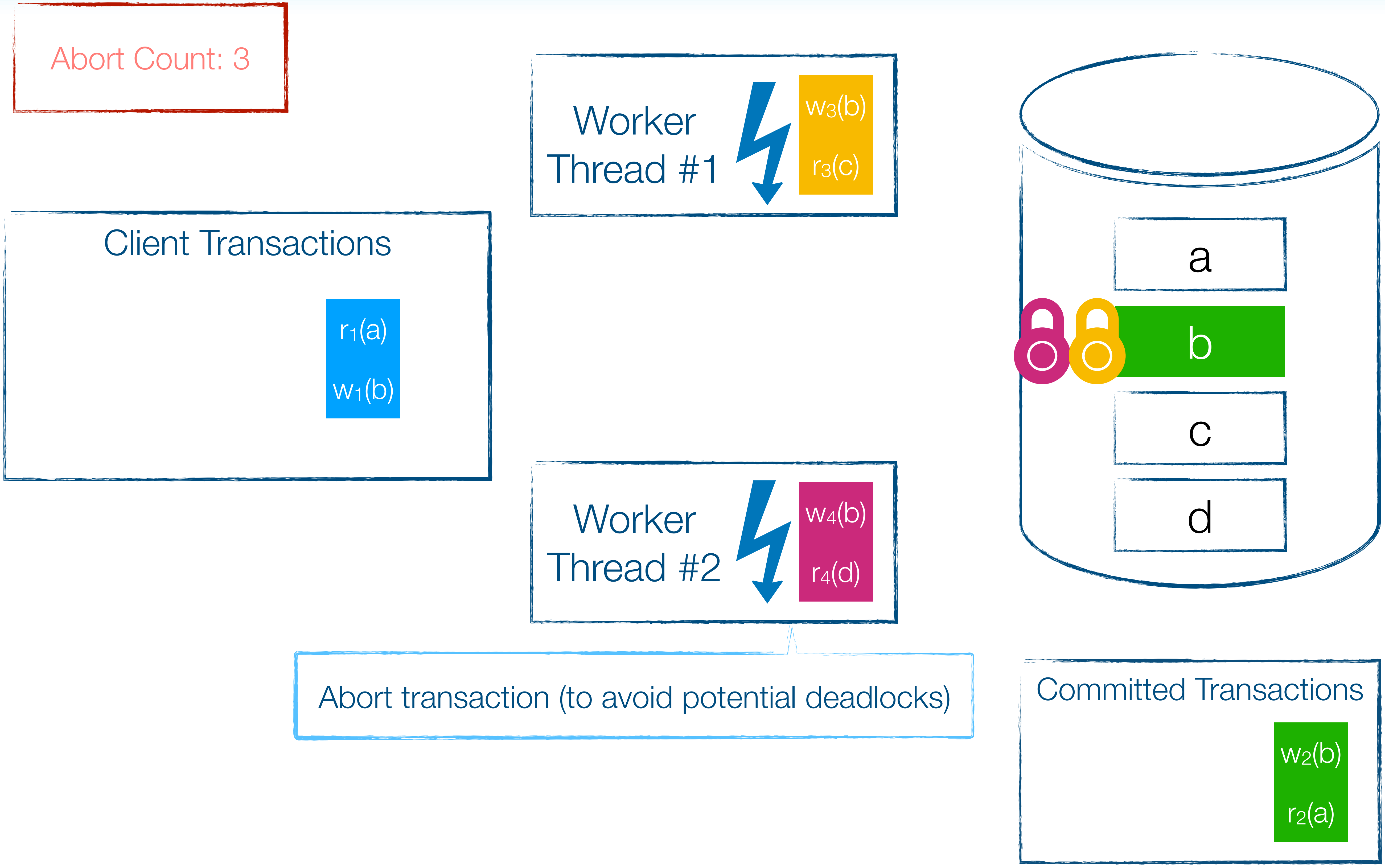
$r_4(d)$

Committed Transactions

$w_2(b)$

$r_2(a)$

2PL - NoWait



Abort Count: 3

Client Transactions

$r_1(a)$

$w_1(b)$

Worker Thread #1

$w_3(b)$

$r_3(c)$

Worker Thread #2

$w_4(b)$

$r_4(d)$

Abort transaction (to avoid potential deadlocks)

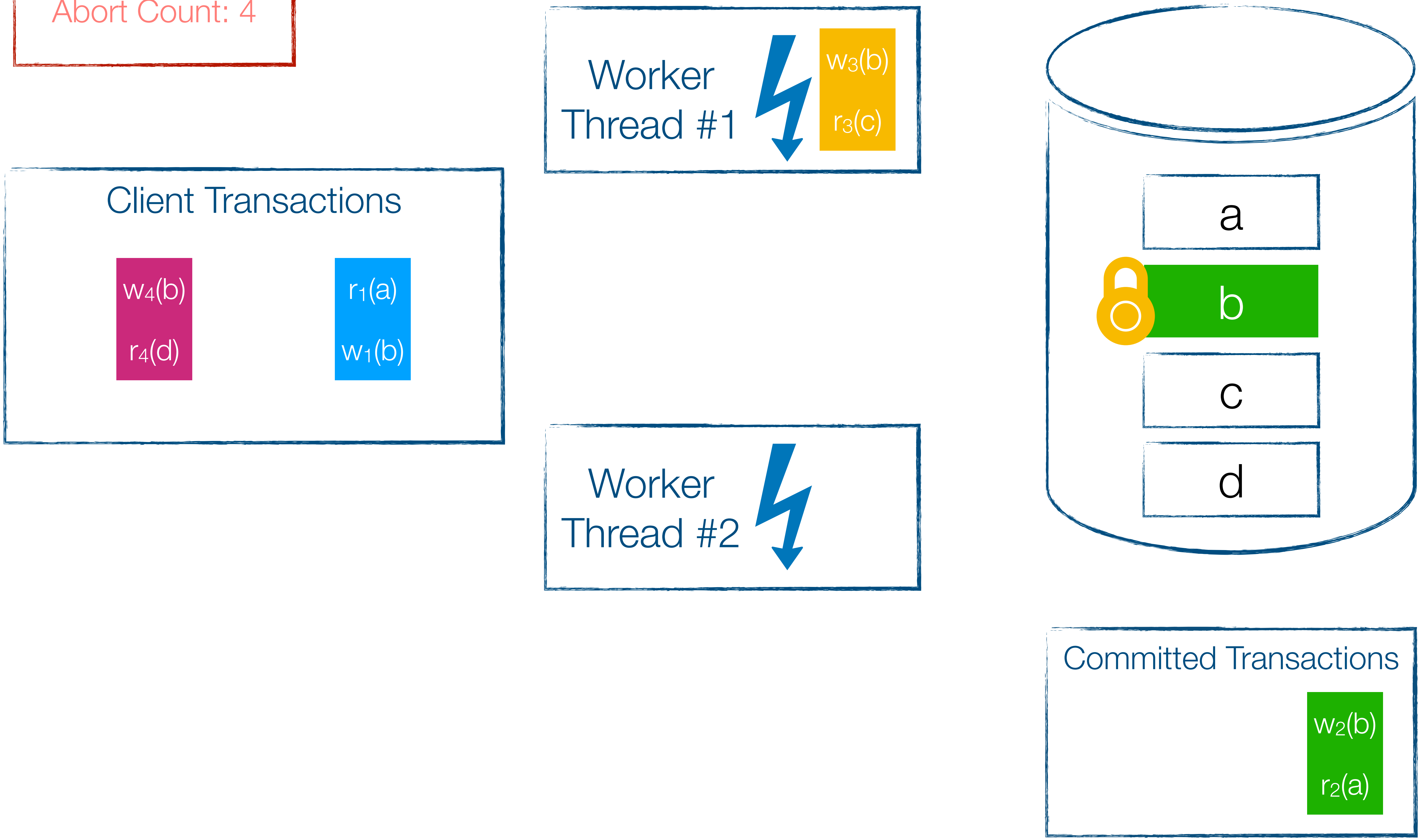
Committed Transactions

$w_2(b)$

$r_2(a)$

2PL - NoWait

Abort Count: 4



Worker Thread #1

$w_3(b)$

$r_3(c)$

Client Transactions

$w_4(b)$

$r_4(d)$

$r_1(a)$

$w_1(b)$

Worker Thread #2

a

b

c

d

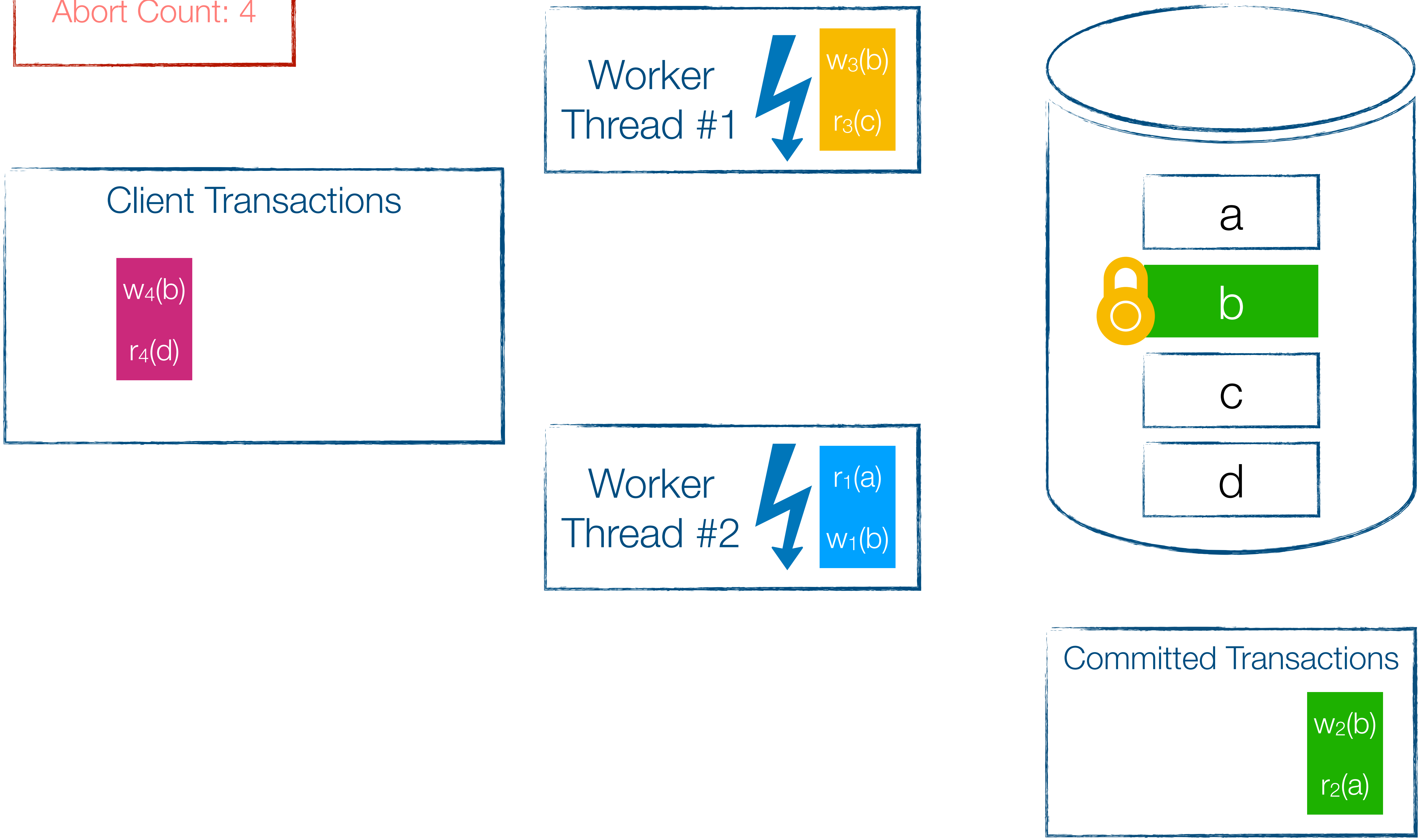
Committed Transactions

$w_2(b)$

$r_2(a)$

2PL - NoWait

Abort Count: 4



Worker Thread #1

$w_3(b)$

$r_3(c)$

Client Transactions

$w_4(b)$

$r_4(d)$

Worker Thread #2

$r_1(a)$

$w_1(b)$

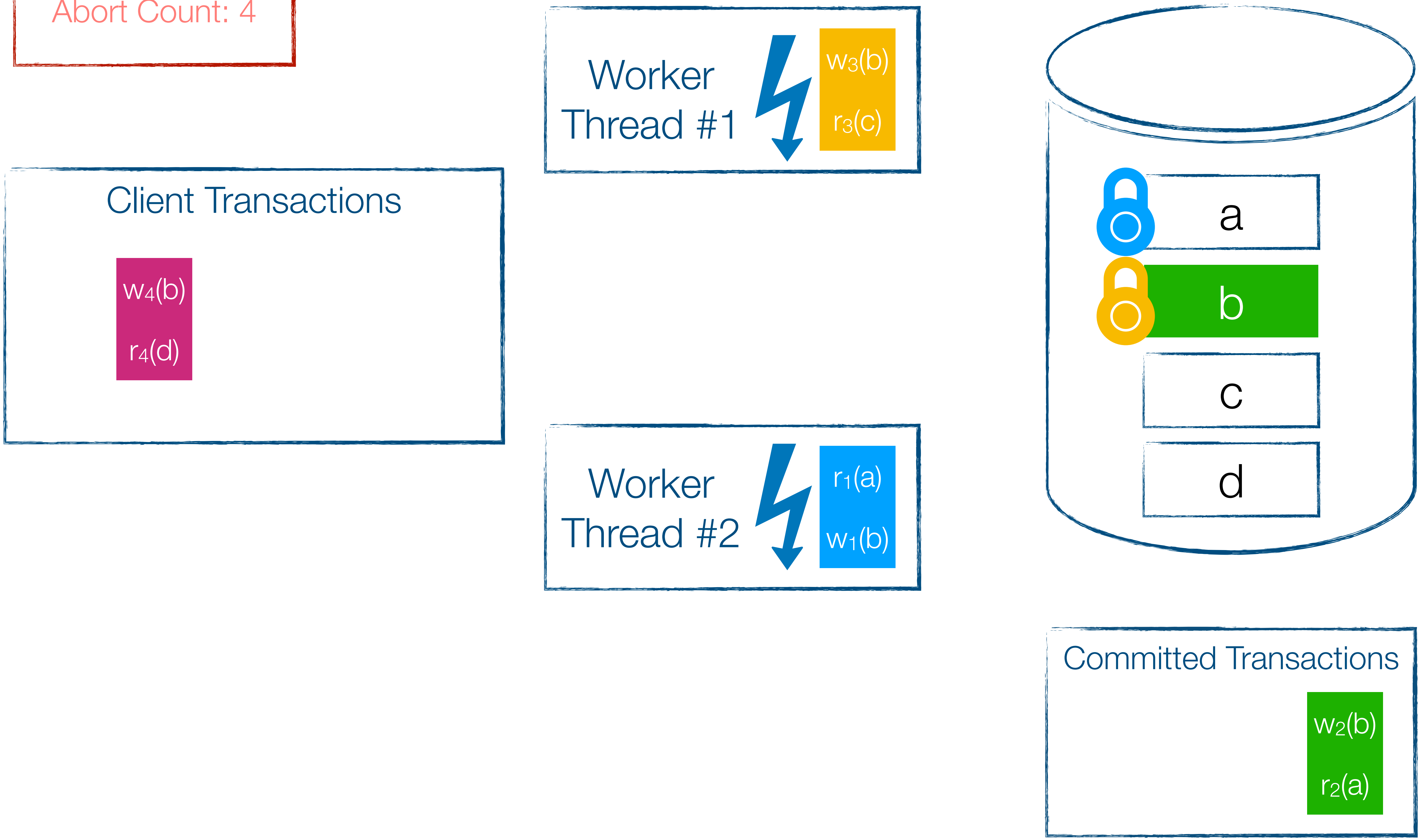
Committed Transactions

$w_2(b)$

$r_2(a)$

2PL - NoWait

Abort Count: 4



Worker Thread #1

$w_3(b)$

$r_3(c)$

Client Transactions

$w_4(b)$

$r_4(d)$

Worker Thread #2

$r_1(a)$

$w_1(b)$

a

b

c

d

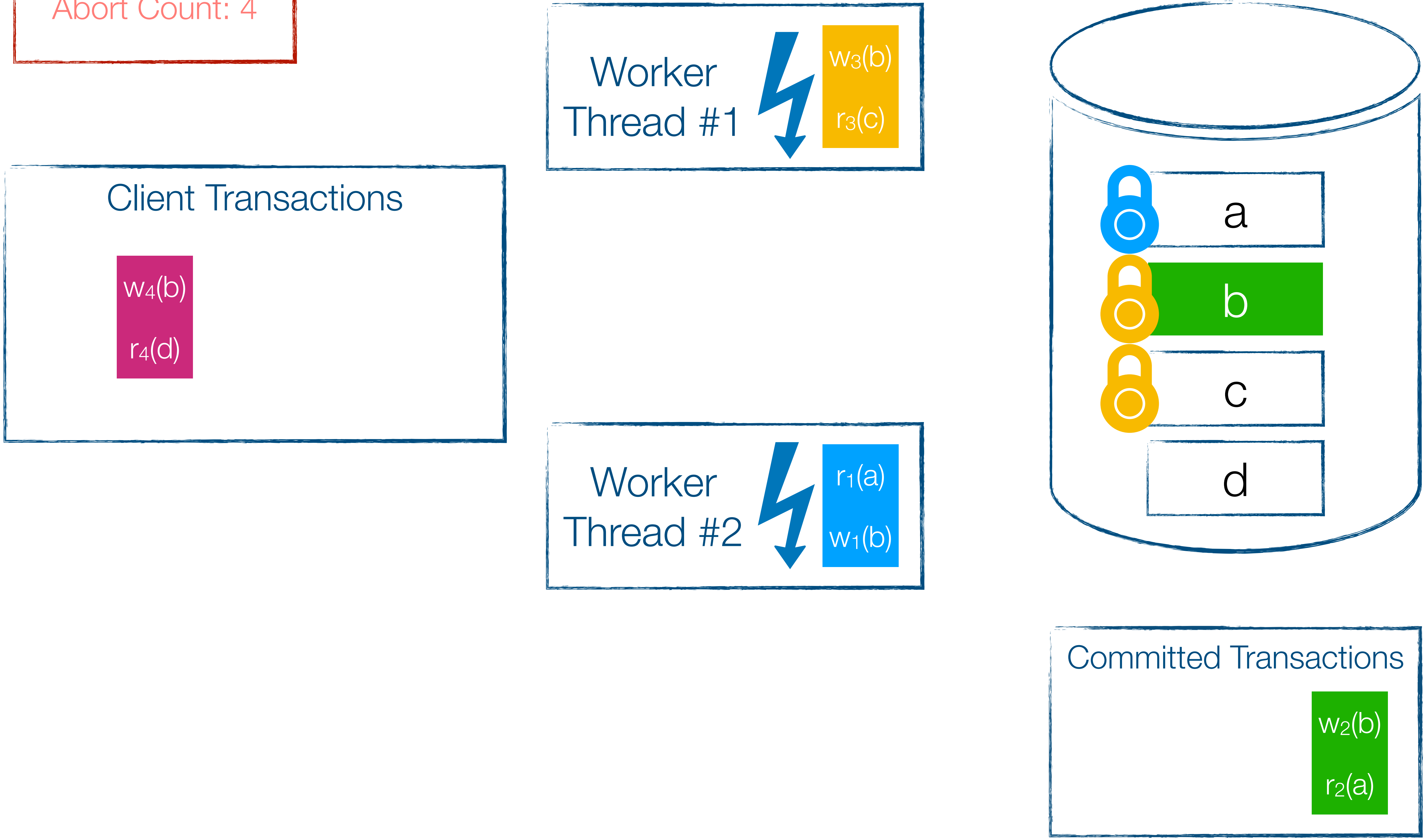
Committed Transactions

$w_2(b)$

$r_2(a)$

2PL - NoWait

Abort Count: 4



Client Transactions

$w_4(b)$

$r_4(d)$

Worker Thread #1

$w_3(b)$

$r_3(c)$

Worker Thread #2

$r_1(a)$

$w_1(b)$

Committed Transactions

$w_2(b)$

$r_2(a)$

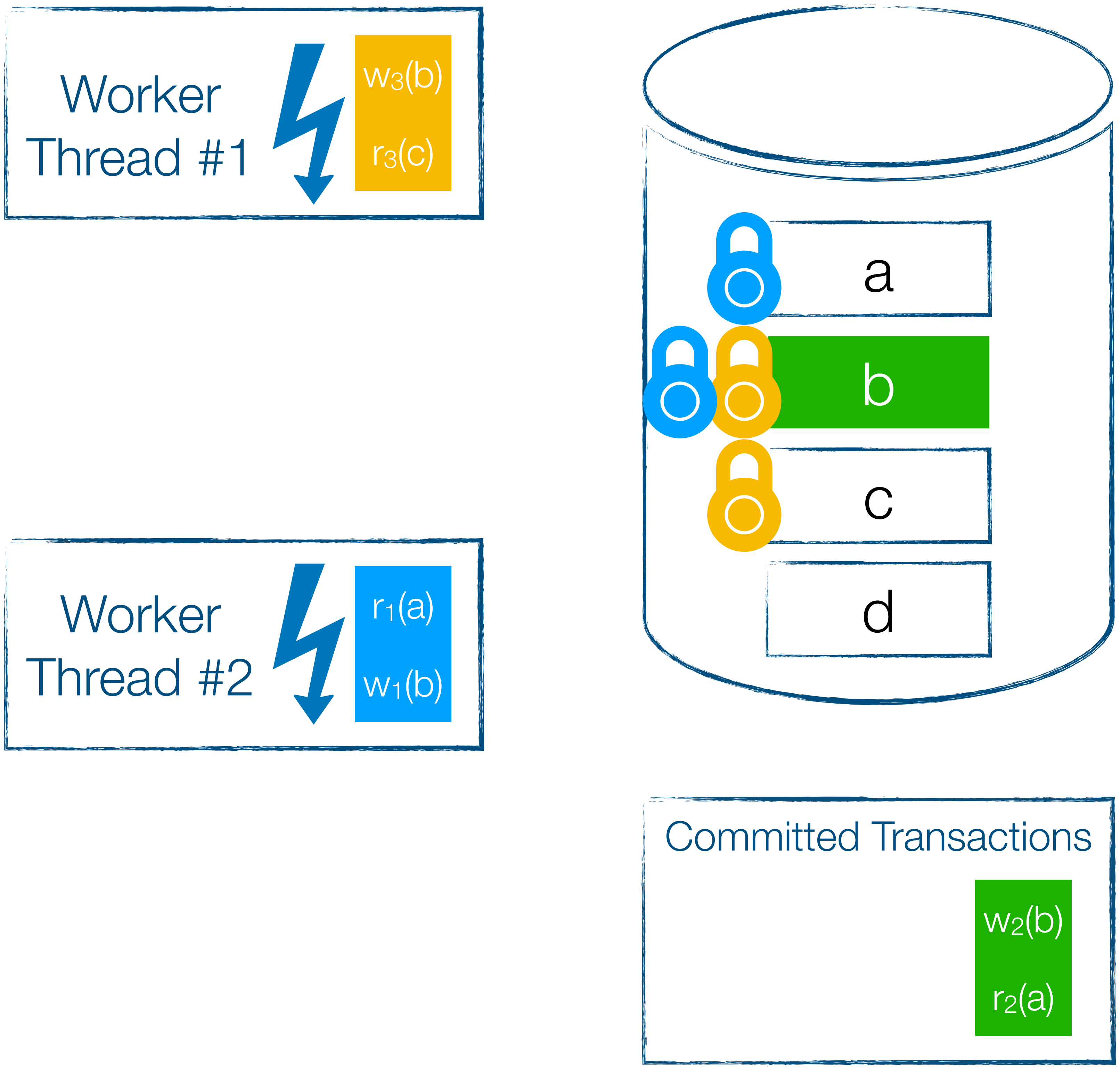
2PL - NoWait

Abort Count: 4

Client Transactions

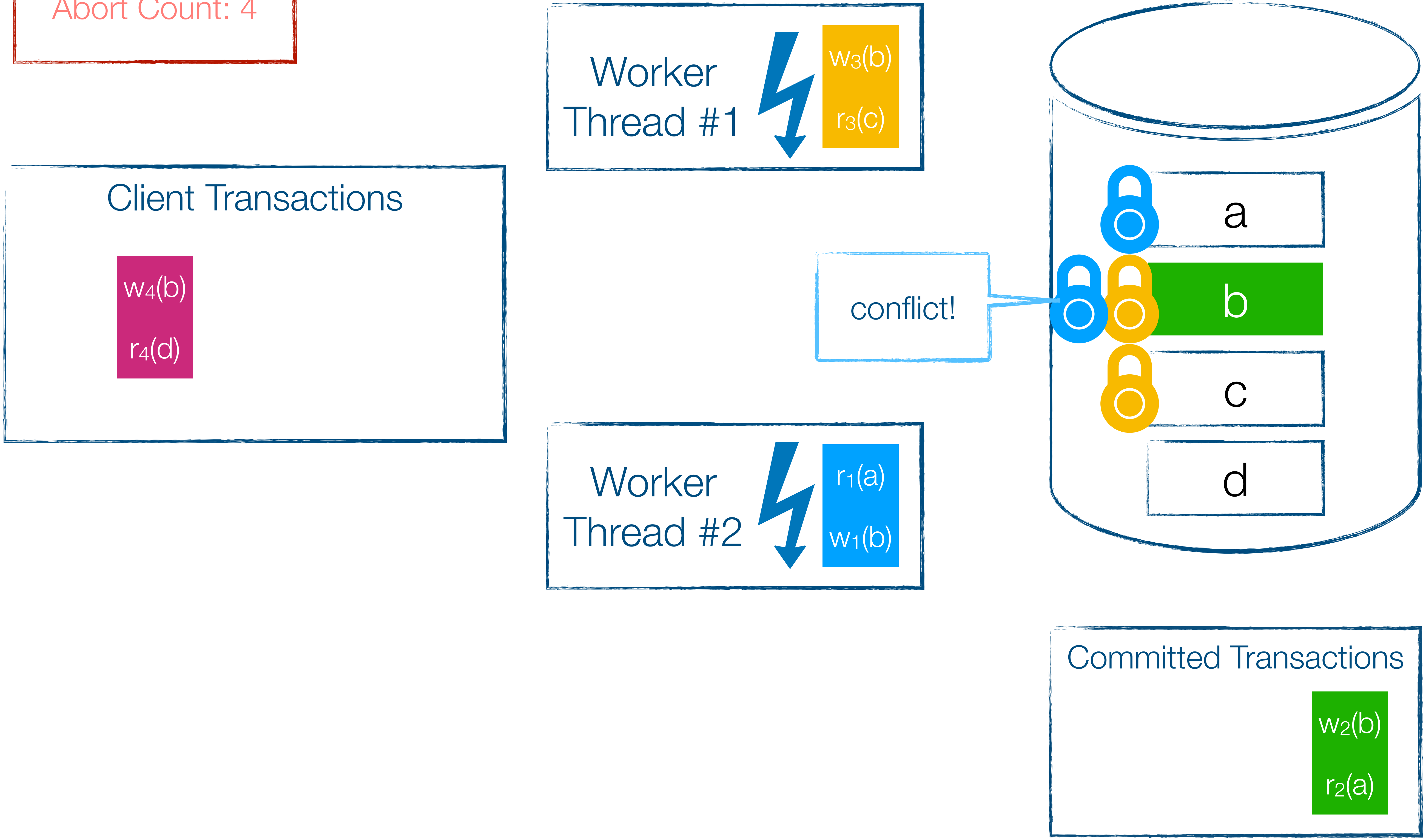
$w_4(b)$

$r_4(d)$



2PL - NoWait

Abort Count: 4



Client Transactions

$w_4(b)$

$r_4(d)$

Worker Thread #1

$w_3(b)$

$r_3(c)$

conflict!

a

b

c

d

Worker Thread #2

$r_1(a)$

$w_1(b)$

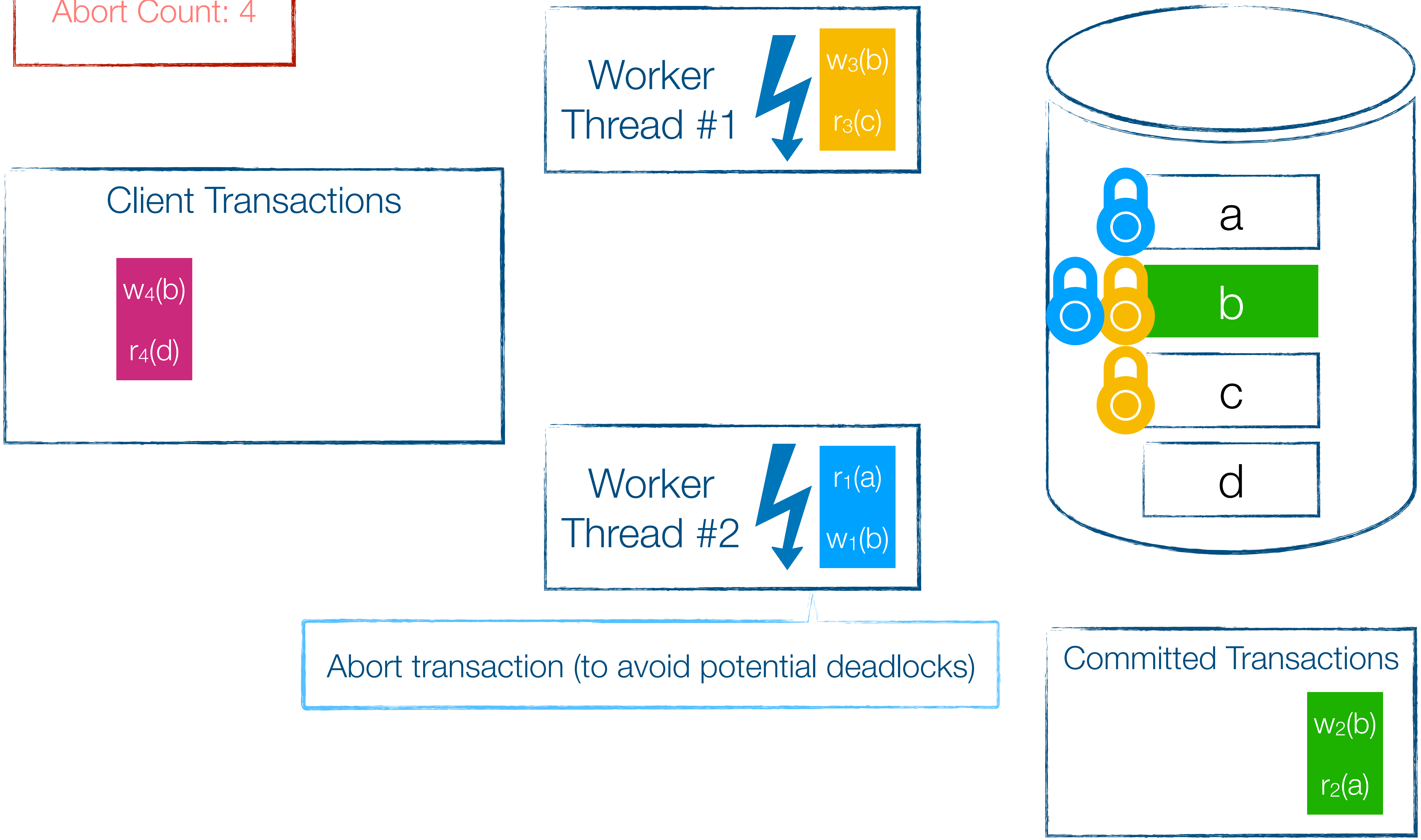
Committed Transactions

$w_2(b)$

$r_2(a)$

2PL - NoWait

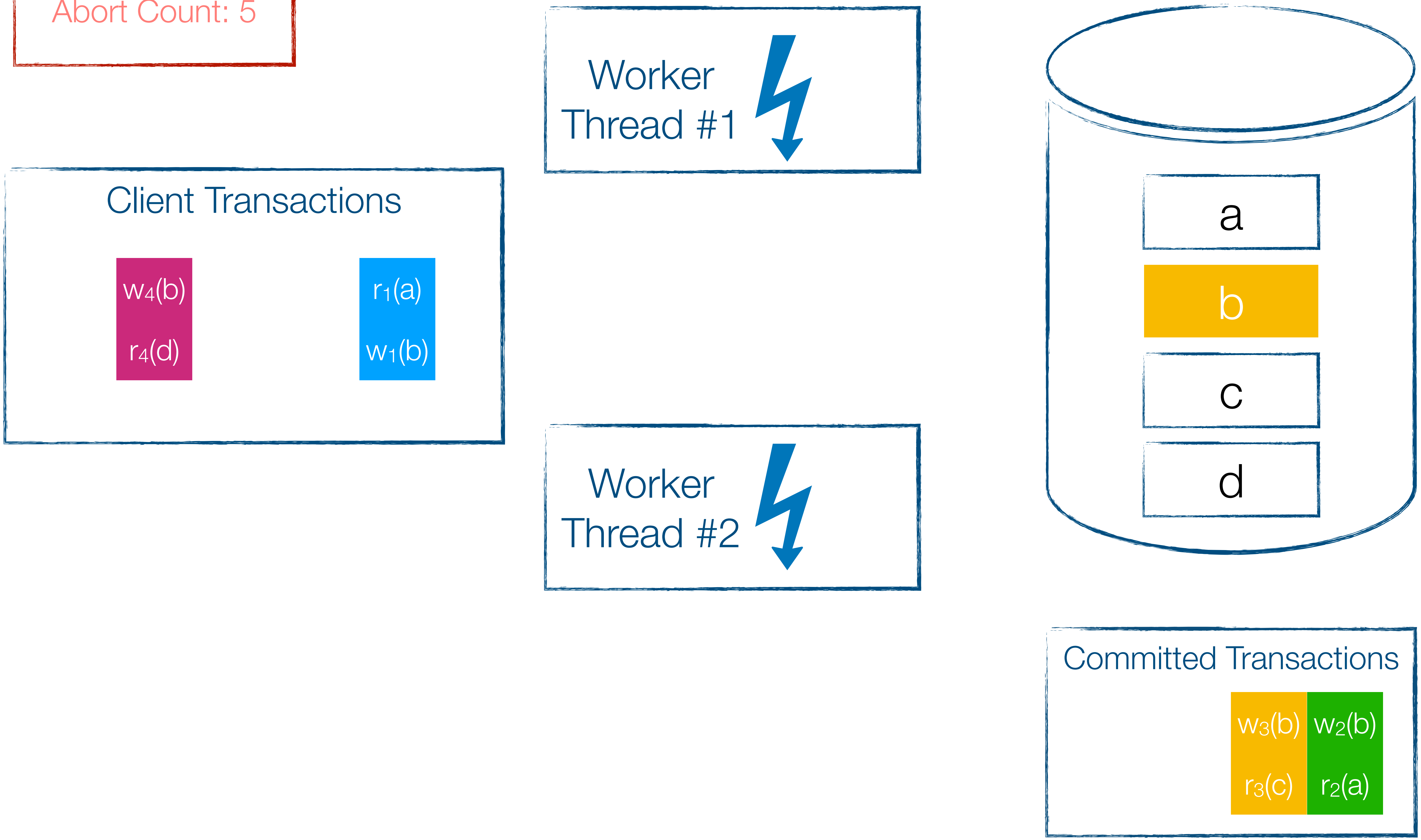
Abort Count: 4



Abort transaction (to avoid potential deadlocks)

2PL - NoWait

Abort Count: 5



Client Transactions

$w_4(b)$

$r_4(d)$

$r_1(a)$

$w_1(b)$

Worker Thread #1

Worker Thread #2

a

b

c

d

Committed Transactions

$w_3(b)$

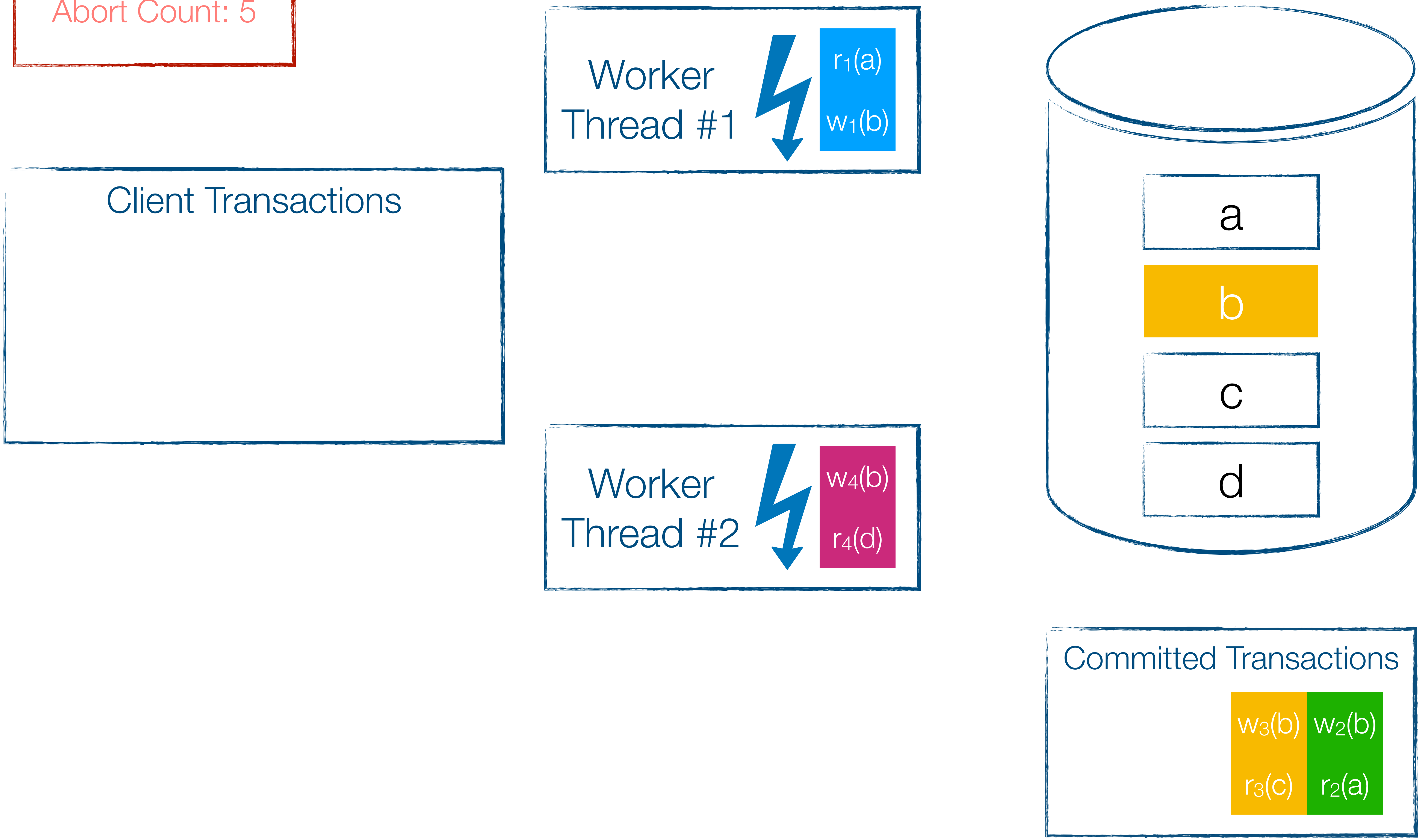
$r_3(c)$

$w_2(b)$

$r_2(a)$

2PL - NoWait

Abort Count: 5



Client Transactions

Worker Thread #1

$r_1(a)$

$w_1(b)$

Worker Thread #2

$w_4(b)$

$r_4(d)$

a

b

c

d

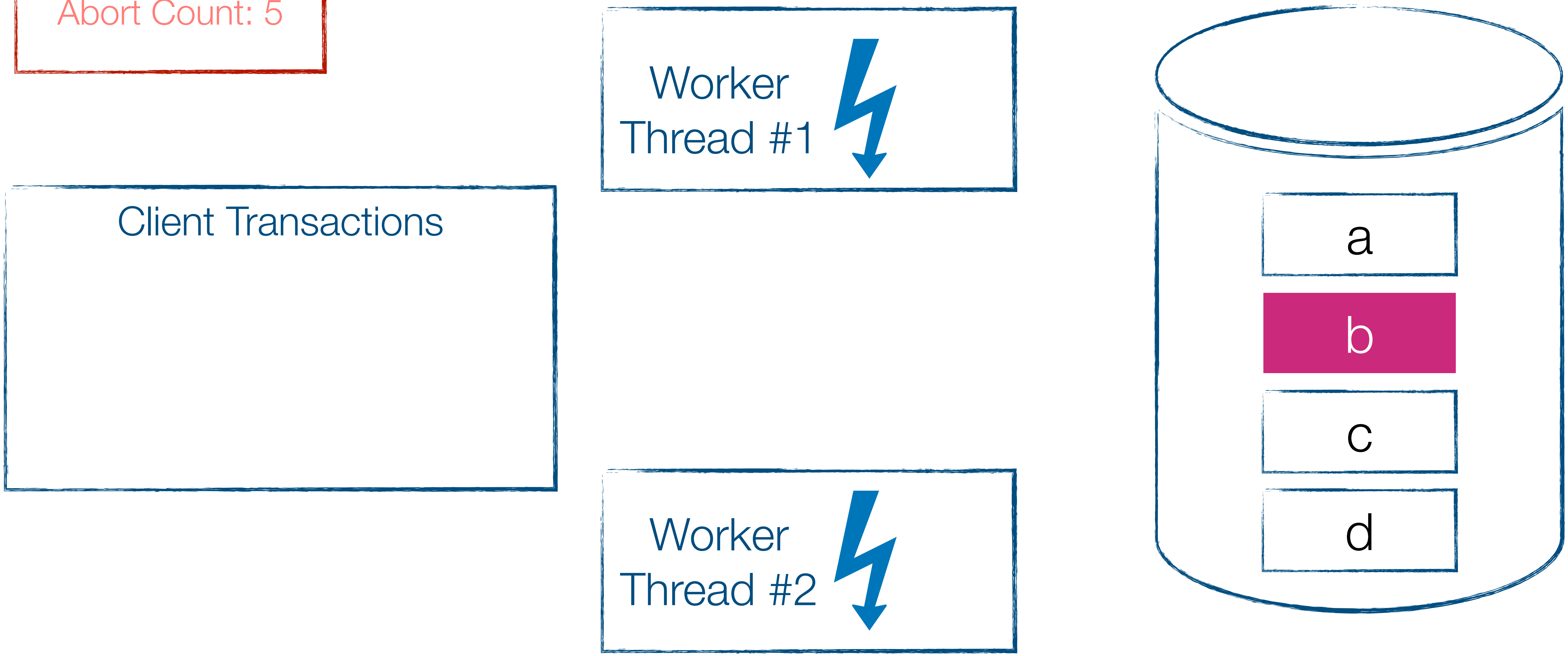
Committed Transactions

$w_3(b)$ $w_2(b)$

$r_3(c)$ $r_2(a)$

2PL - NoWait

Abort Count: 5



- Eventually transactions commit in some serial order!
- Many aborts due to high contention on record b
- Non-determinism in CC cause these aborts
- Wasted work

Committed Transactions

$w_4(b)$	$r_1(a)$	$w_3(b)$	$w_2(b)$
$r_4(d)$	$w_1(b)$	$r_3(c)$	$r_2(a)$

Key Insights

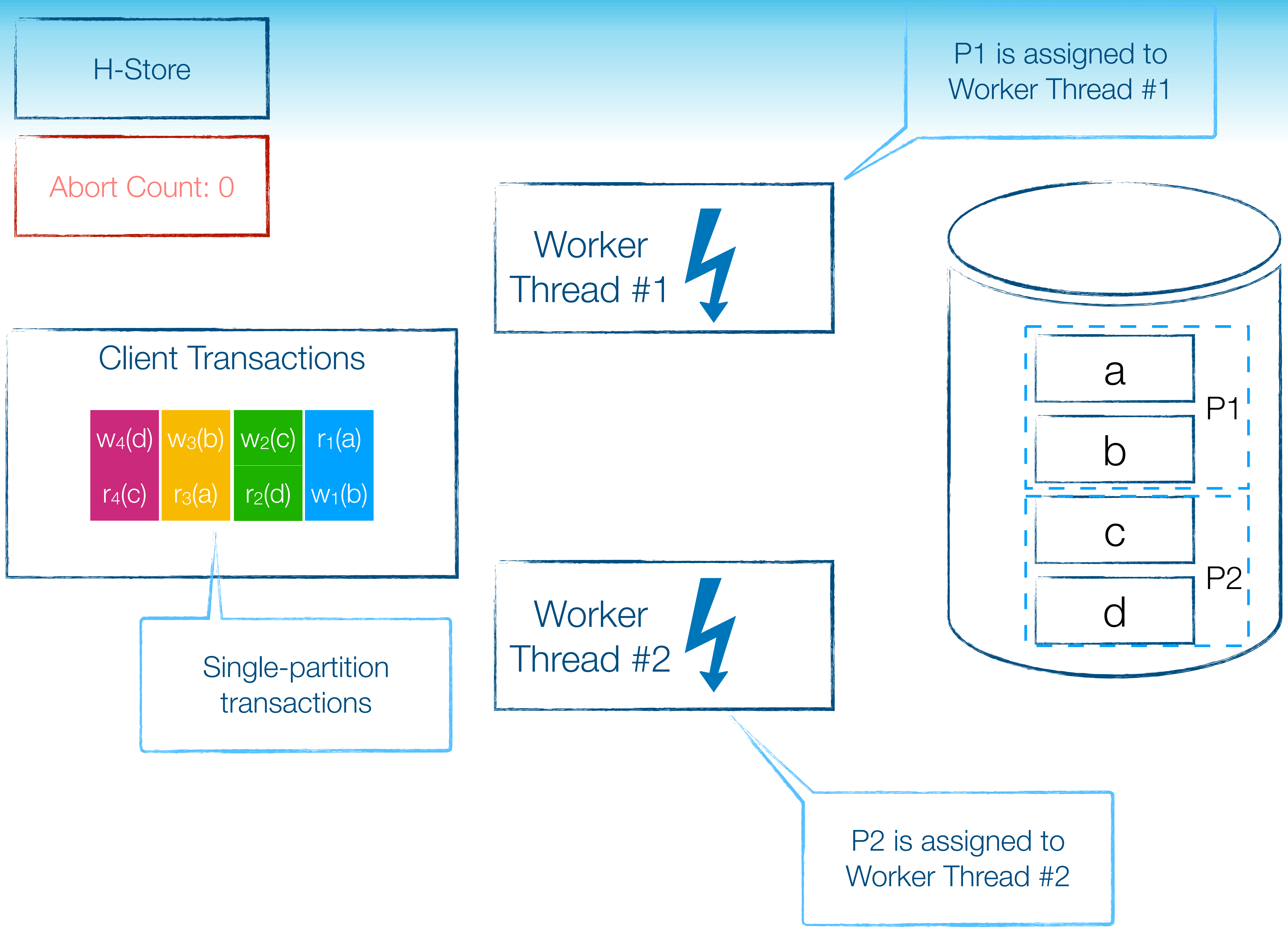
- Many aborts due to high contention
- Non-determinism in CC cause these aborts
- Can we do better?
- Is it possible to eliminate non-deterministic concurrency control from transaction execution?

Deterministic Transaction Execution

- H-Store [Kallman et al. ’08]
- Designed and optimized for horizontal scalability, multi-core hardware and in-memory databases
- Stored procedure transaction model
- Static partitioning of database
- Assigns a single core to each partition
- Execute transaction serially without concurrency control within each partition

H-Store

Abort Count: 0



Client Transactions

$w_4(d)$	$w_3(b)$	$w_2(c)$	$r_1(a)$
$r_4(c)$	$r_3(a)$	$r_2(d)$	$w_1(b)$

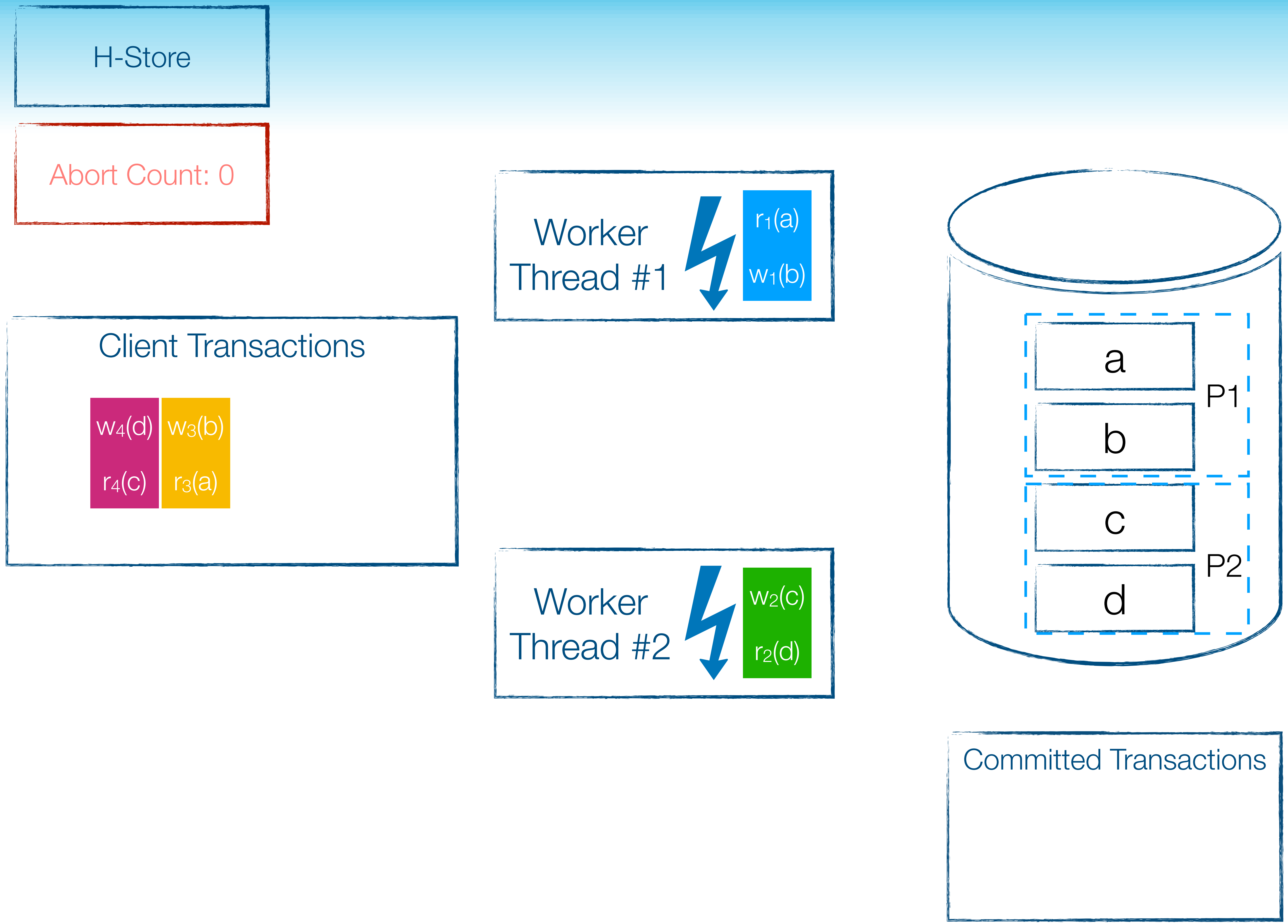
Single-partition transactions

Worker Thread #1

Worker Thread #2

P1 is assigned to Worker Thread #1

P2 is assigned to Worker Thread #2



H-Store

Abort Count: 0

Worker Thread #1

$r_1(a)$

$w_1(b)$

Client Transactions

$w_4(d)$ $w_3(b)$

$r_4(c)$ $r_3(a)$

Worker Thread #2

$w_2(c)$

$r_2(d)$

a

b

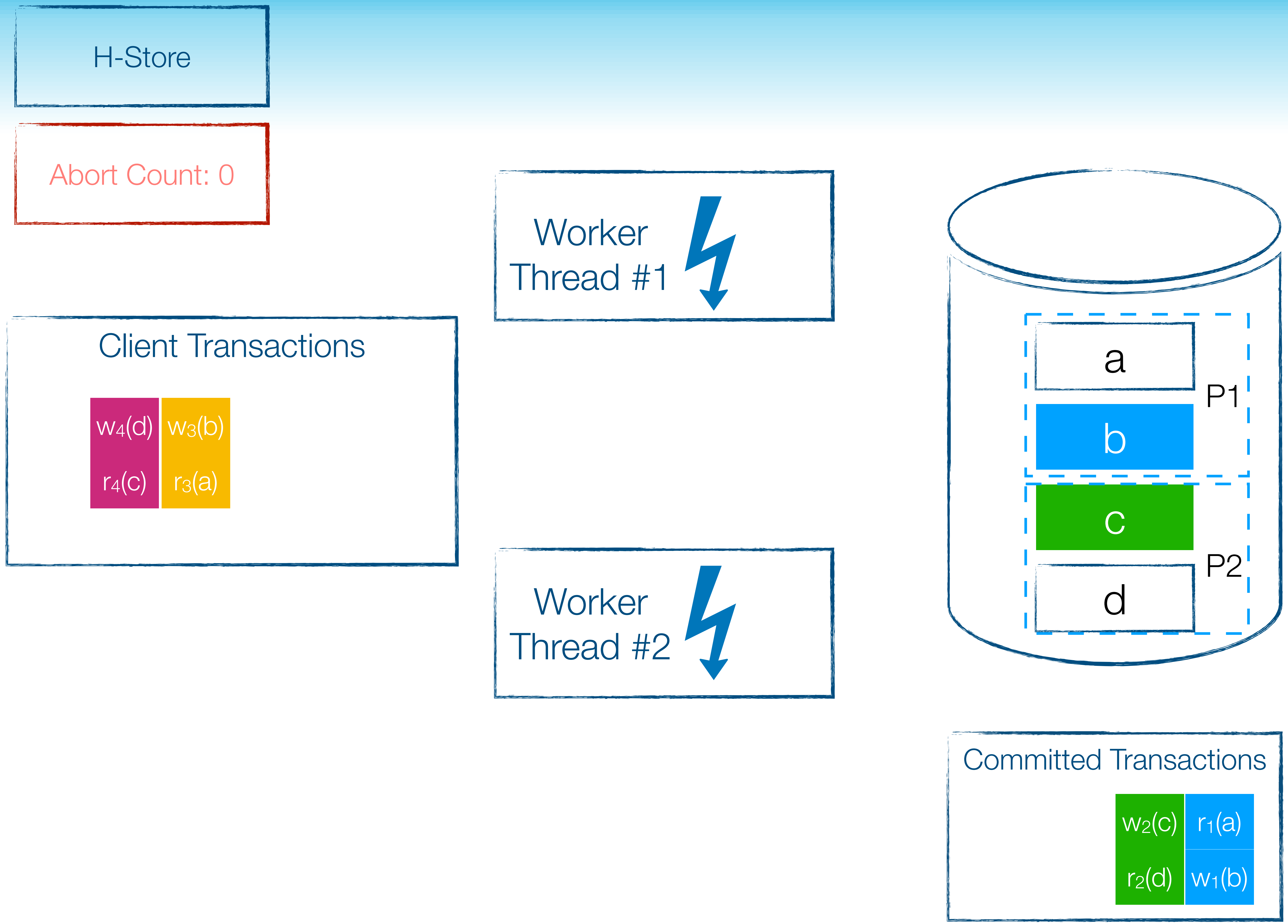
P1

c

d

P2

Committed Transactions



H-Store

Abort Count: 0

Client Transactions

$w_4(d)$ $w_3(b)$

$r_4(c)$ $r_3(a)$

Worker Thread #1

Worker Thread #2

a

b

P1

c

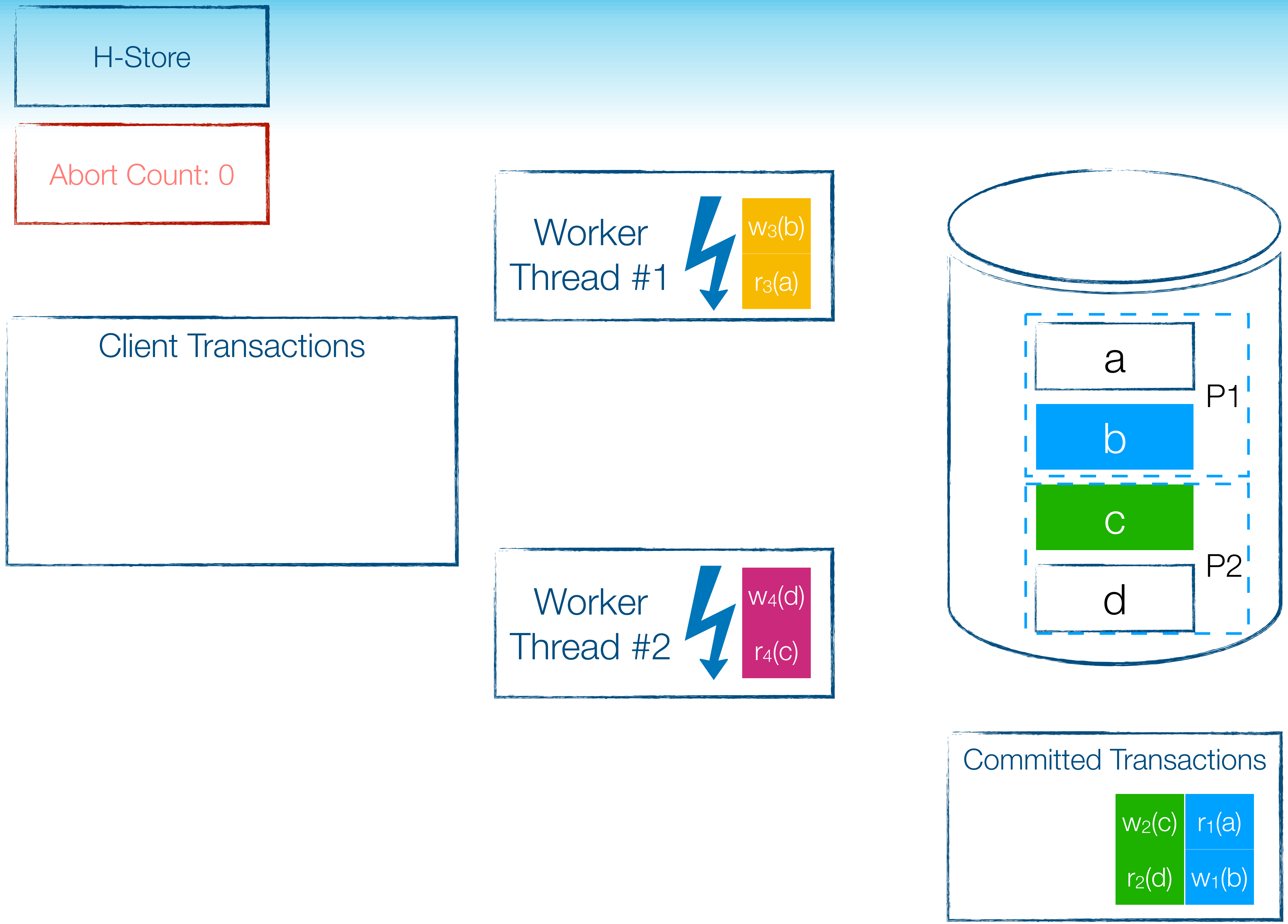
d

P2

Committed Transactions

$w_2(c)$ $r_1(a)$

$r_2(d)$ $w_1(b)$



H-Store

Abort Count: 0

Client Transactions

Worker Thread #1

$w_3(b)$

$r_3(a)$

Worker Thread #2

$w_4(d)$

$r_4(c)$

a

b

P1

c

d

P2

Committed Transactions

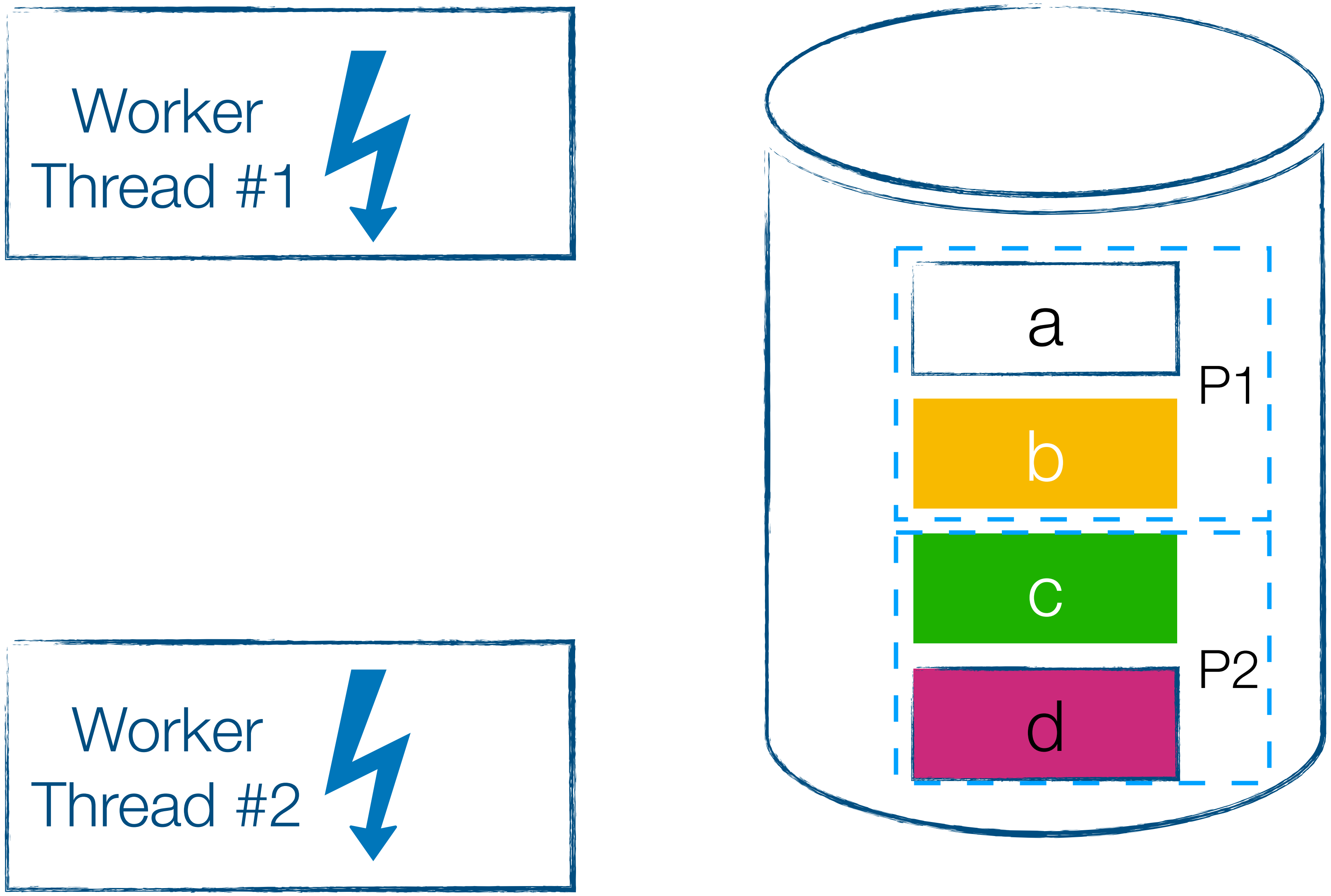
$w_2(c)$ $r_1(a)$

$r_2(d)$ $w_1(b)$

H-Store

Abort Count: 0

Client Transactions

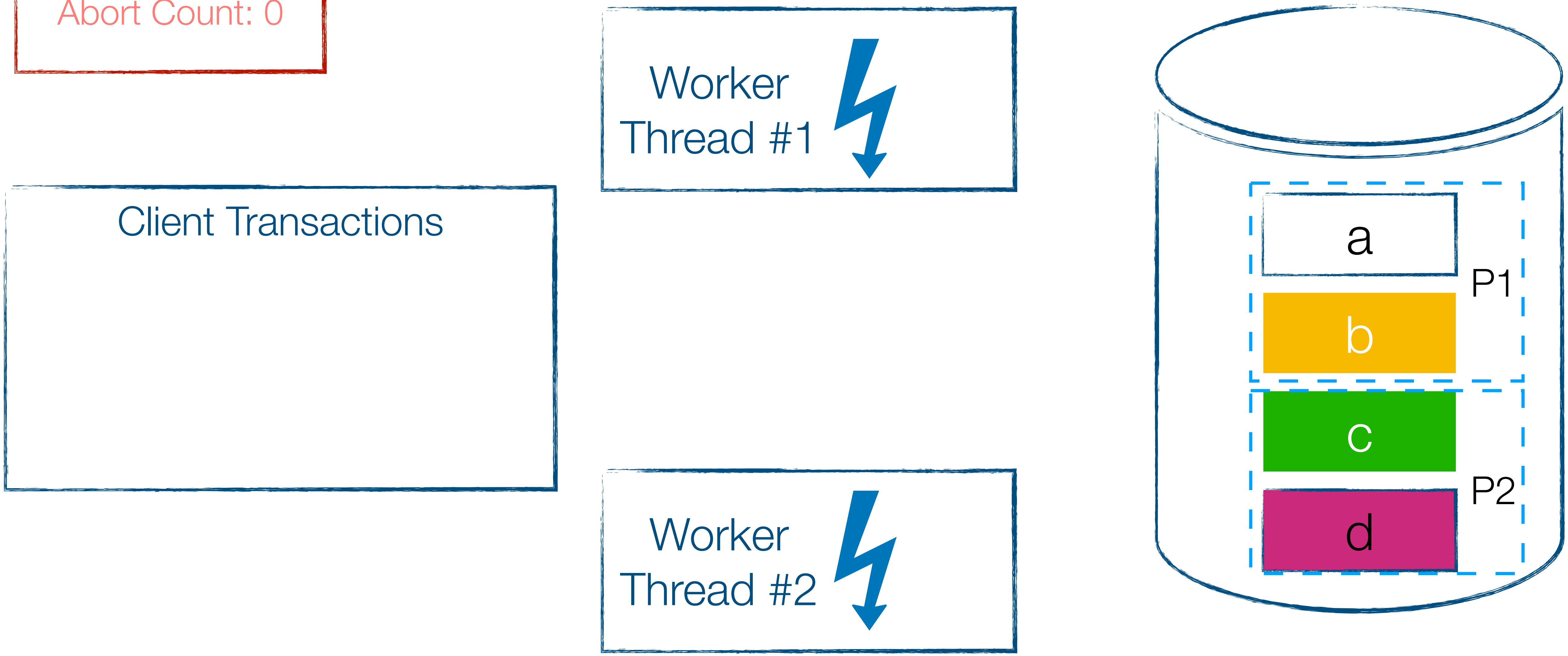


Committed Transactions

$w_4(d)$	$w_3(b)$	$w_2(c)$	$r_1(a)$
$r_4(c)$	$r_3(a)$	$r_2(d)$	$w_1(b)$

H-Store

Abort Count: 0



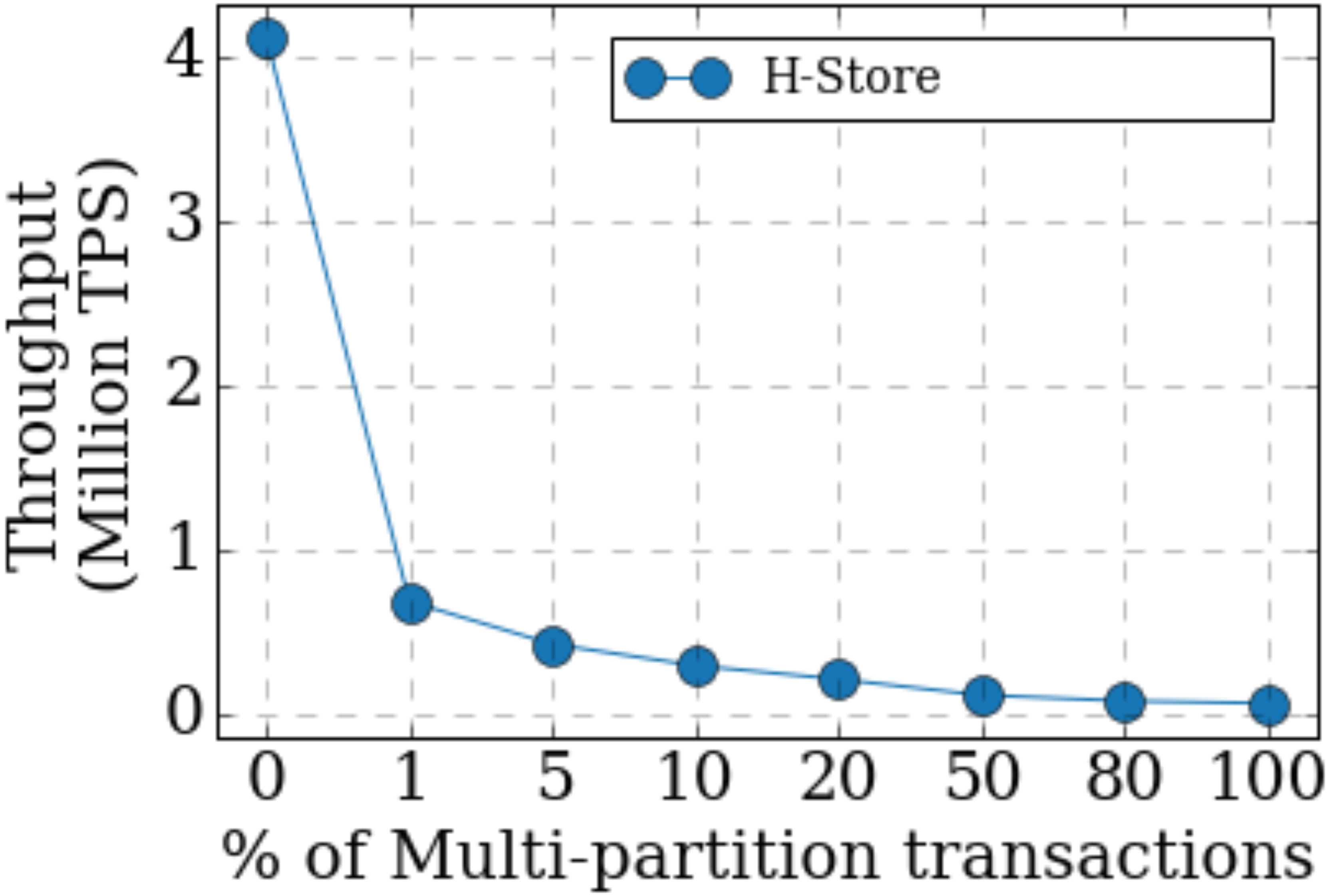
Committed Transactions

$w_4(d)$	$w_3(b)$	$w_2(c)$	$r_1(a)$
$r_4(c)$	$r_3(a)$	$r_2(d)$	$w_1(b)$

- ✓ Deterministic Execution
- ✓ No aborts because of CC
- ✓ Minimal coordination among threads

◉ Performs well only when transactions are single-partitioned

Effect of Increasing Percentage of Multi-Partition Transactions in the Workload



H-Store is sensitive to the percentage of multi-partition transactions in the workload

Can We Do Better?

Our motivations are

- Efficiently exploits multi-core and large main-memory systems
- Provide serializable multi-statement transactions for key-value stores
- Scales well under high-contention workloads

Desired Properties

- Concurrent execution over shared data
- Not limited to partitionable workloads
- Without any concurrency controls

Is it possible to have concurrent execution over shared data without having any concurrency controls?

Introducing: QueCC

Queue-Oriented, Control-Free, Concurrency Architecture

A two parallel & independent phases of priority-driven planning & execution

Phase 1: Deterministic priority-based planning of transaction operations in parallel

- ➡ *Plans take the form of **Prioritized Execution Queues***
- ➡ Execution Queues inherits predetermined priority of its planner
- ➡ Results in a deterministic plan of execution

Phase 2: Priority driven execution of plans in parallel

- ➡ Satisfies the ***Execution Priority Invariance***

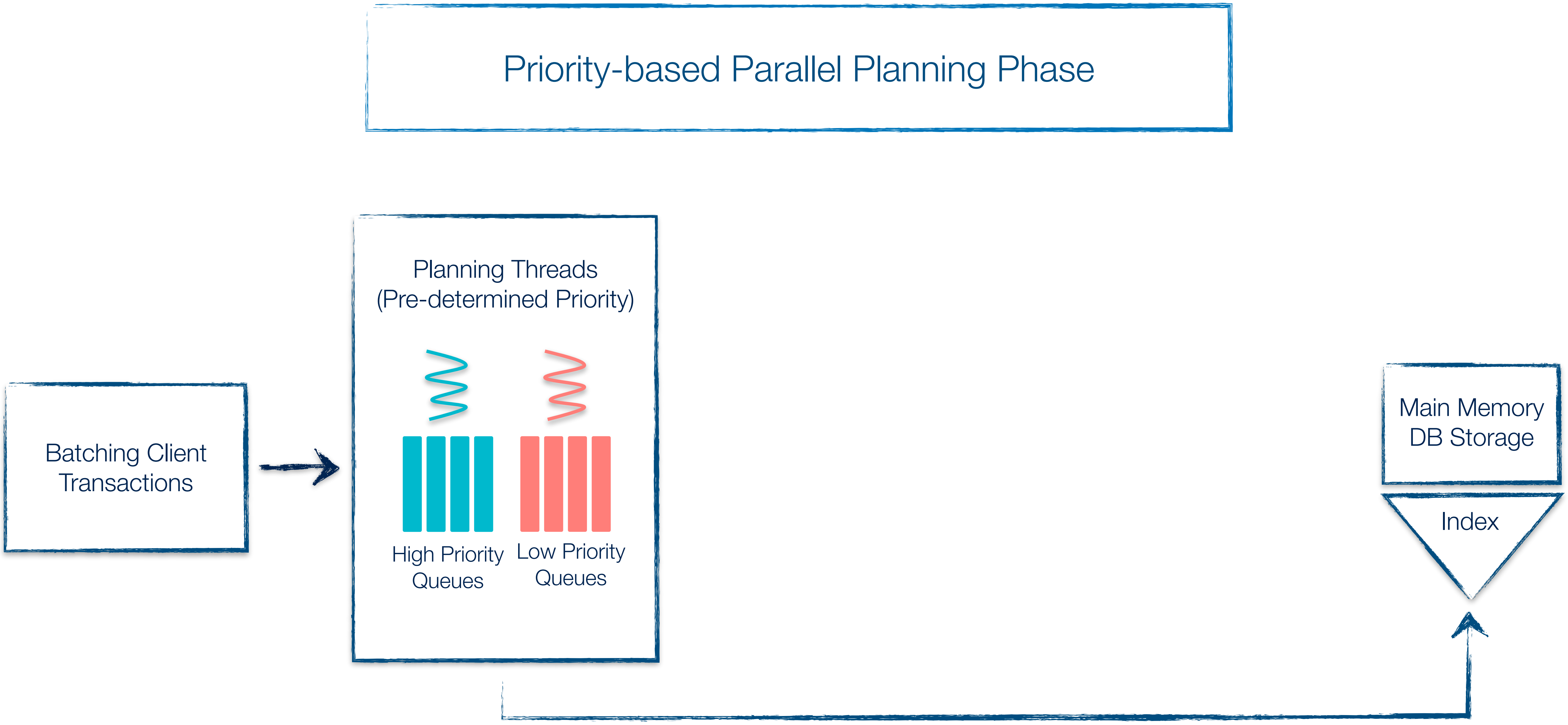
"For each record (or a queue), operations that belong to higher priority queues (created by a higher priority planner) must always be executed before executing any lower priority operations."

QueCC Architecture

Priority-based Parallel Planning Phase

Batching Client Transactions

QueCC Architecture



Priority-based Parallel Planning Phase

Batching Client Transactions

Planning Threads (Pre-determined Priority)

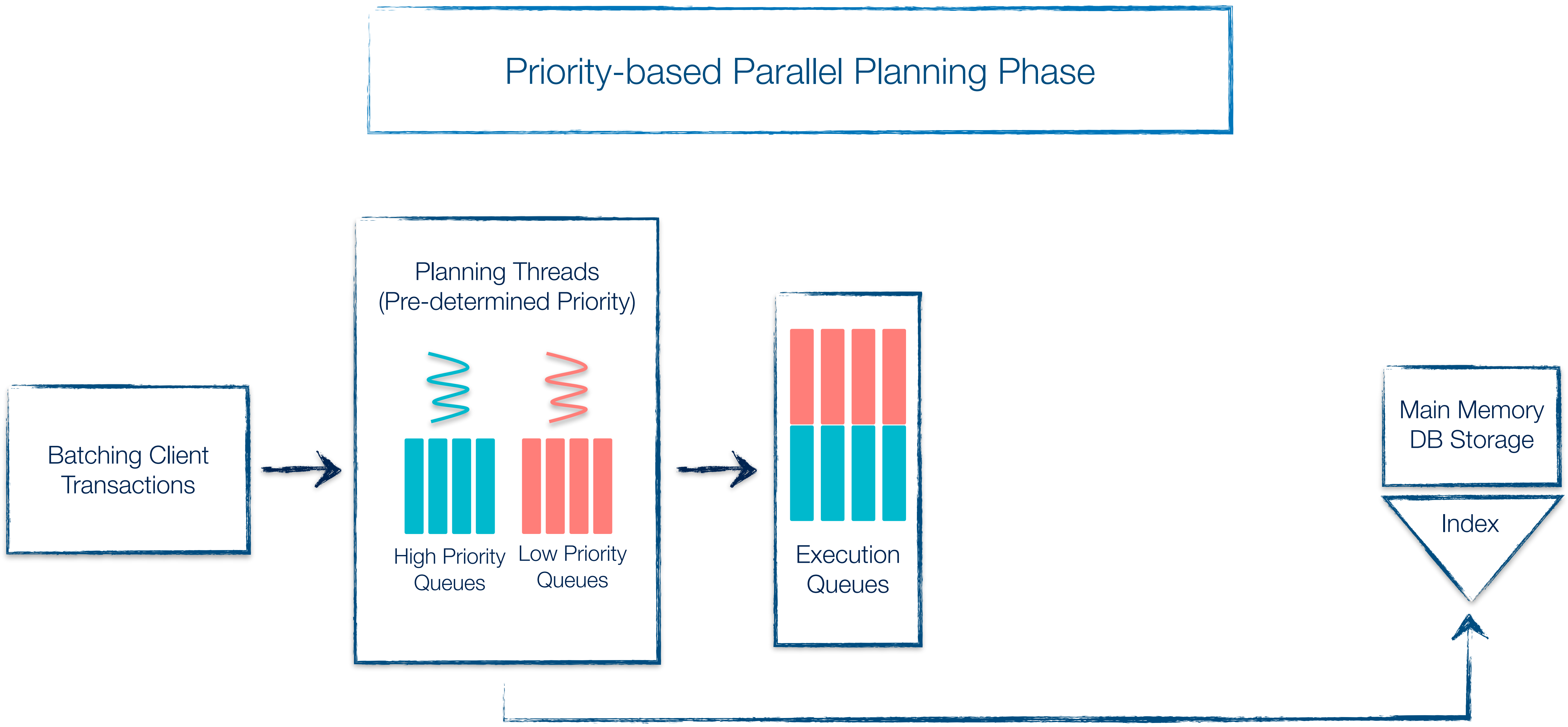
High Priority Queues

Low Priority Queues

Main Memory DB Storage

Index

QueCC Architecture



Priority-based Parallel Planning Phase

Batching Client Transactions

Planning Threads (Pre-determined Priority)

High Priority Queues

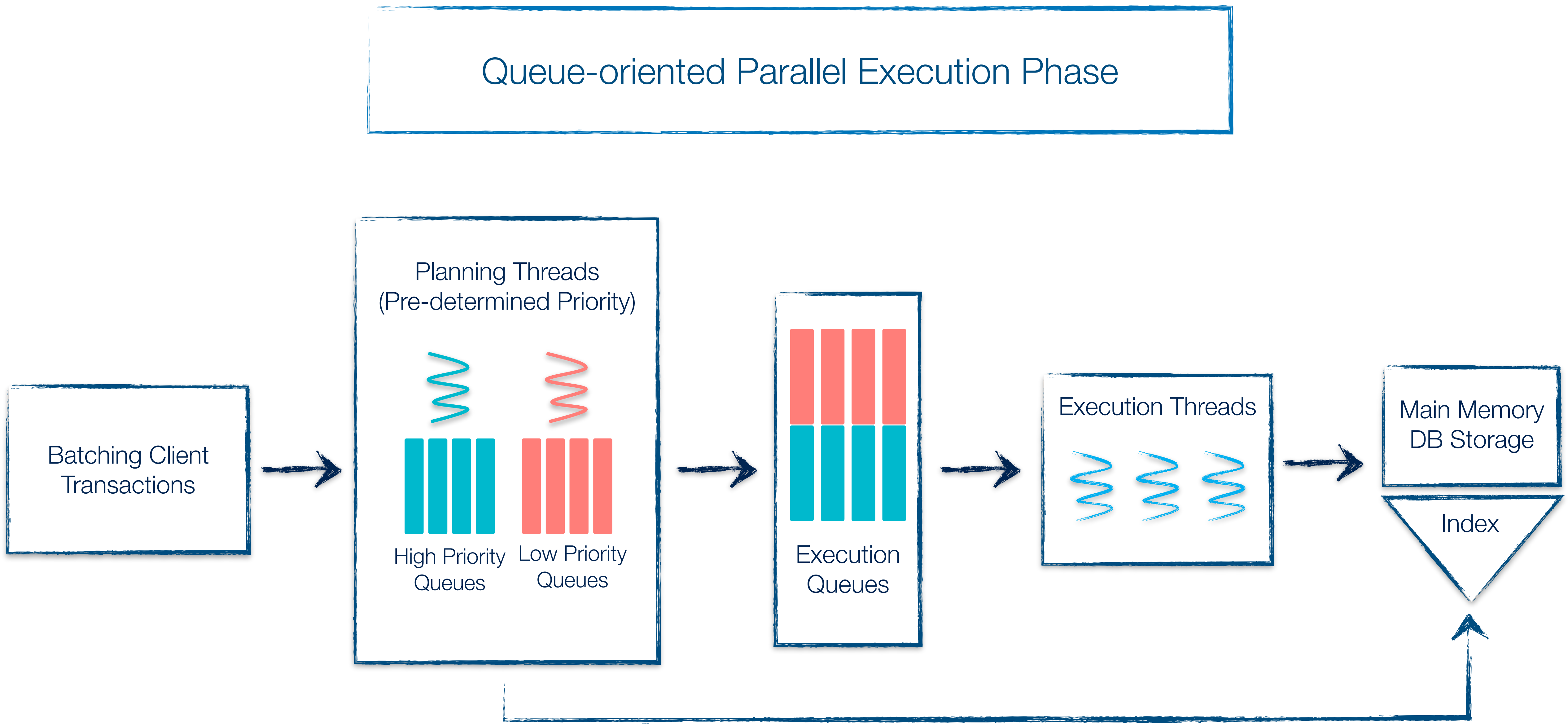
Low Priority Queues

Execution Queues

Main Memory DB Storage

Index

QueCC Architecture



Queue-oriented Parallel Execution Phase

Batching Client Transactions

Planning Threads (Pre-determined Priority)

High Priority Queues

Low Priority Queues

Execution Queues

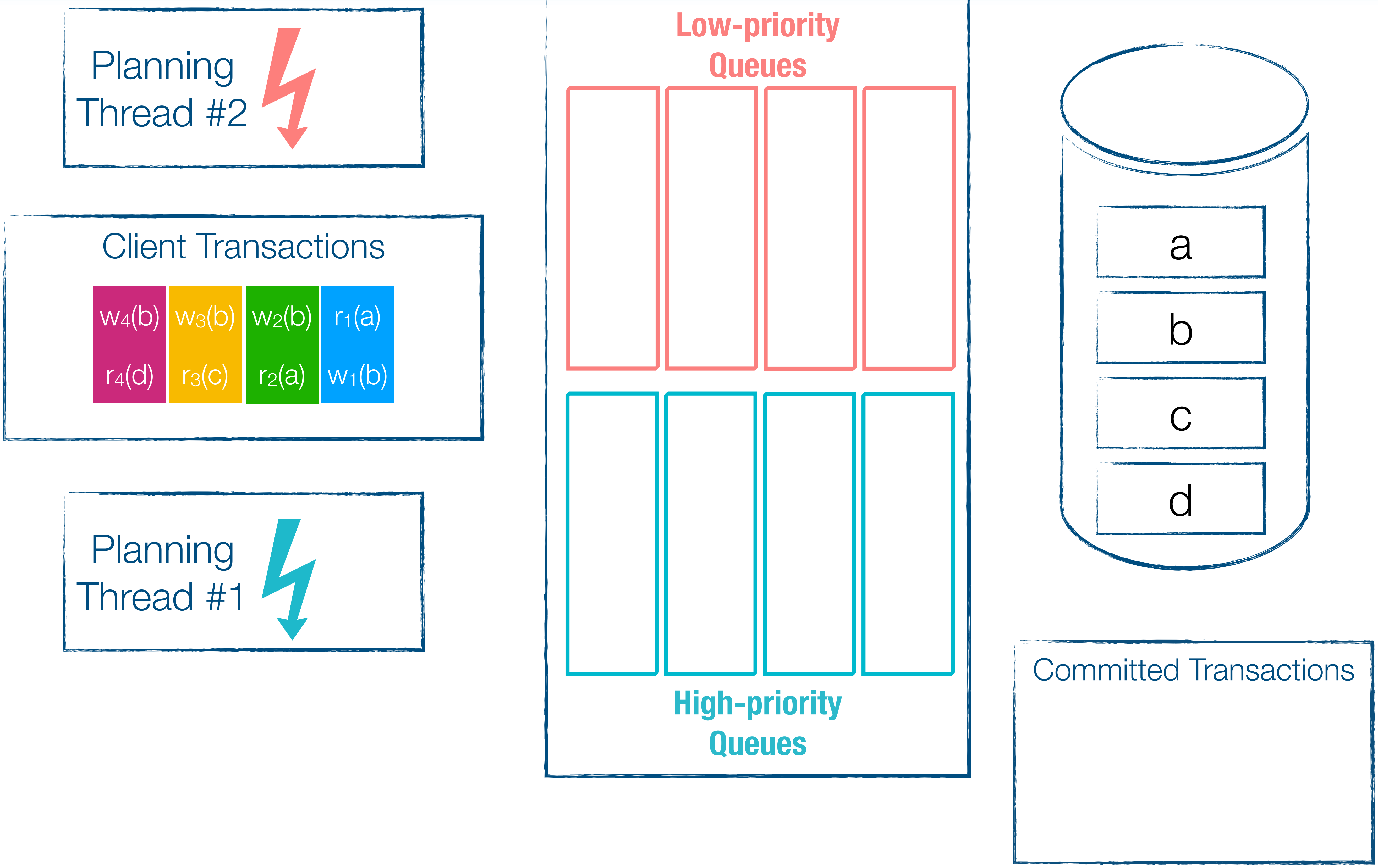
Execution Threads

Main Memory DB Storage

Index

QueCC

Abort Count: 0



Planning Thread #2

Client Transactions

$w_4(b)$	$w_3(b)$	$w_2(b)$	$r_1(a)$
$r_4(d)$	$r_3(c)$	$r_2(a)$	$w_1(b)$

Planning Thread #1

Priority Groups

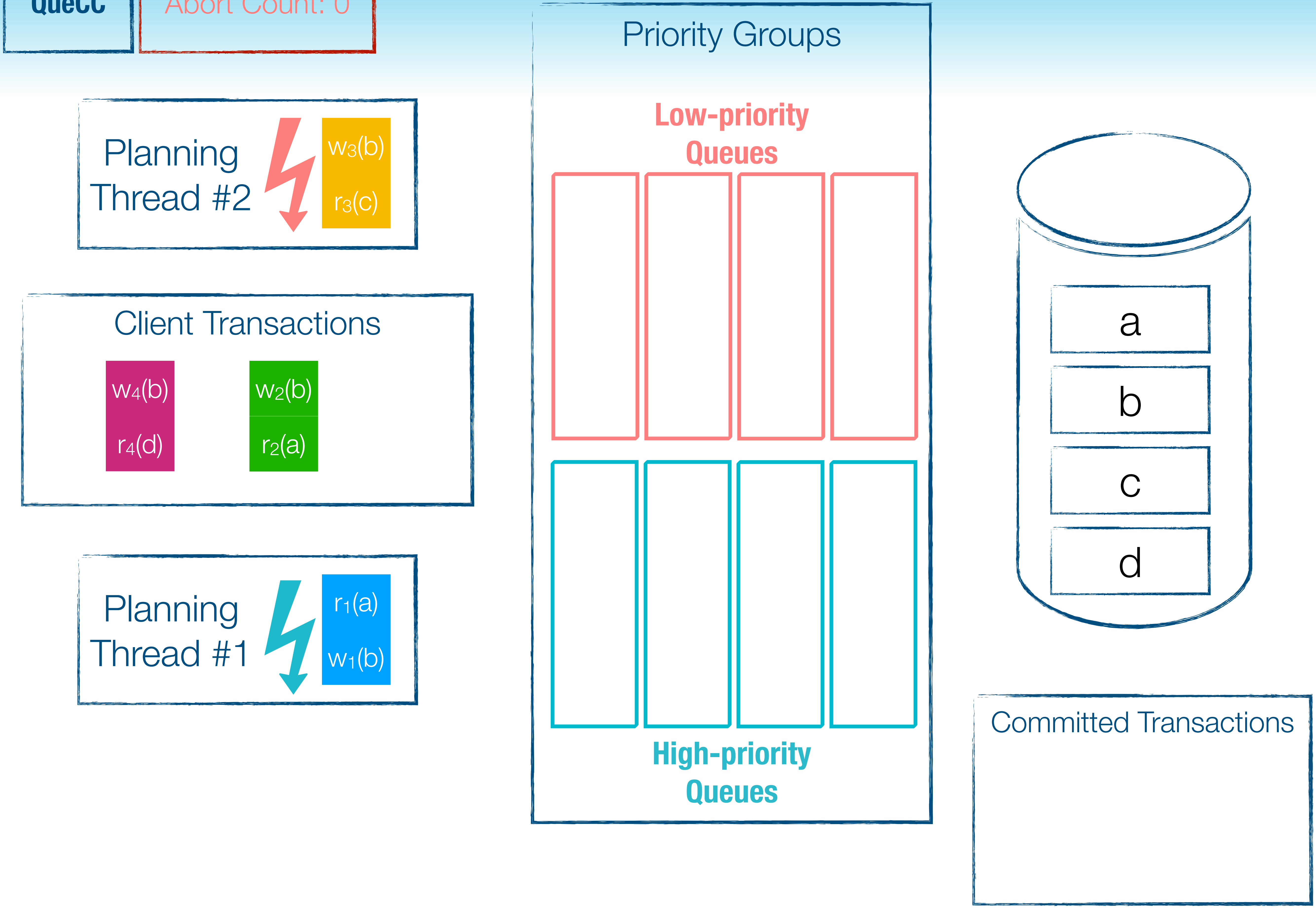
Low-priority Queues

High-priority Queues

Committed Transactions

QueCC

Abort Count: 0



Planning Thread #2

$w_3(b)$ $r_3(c)$

Client Transactions

$w_4(b)$ $r_4(d)$

$w_2(b)$ $r_2(a)$

Planning Thread #1

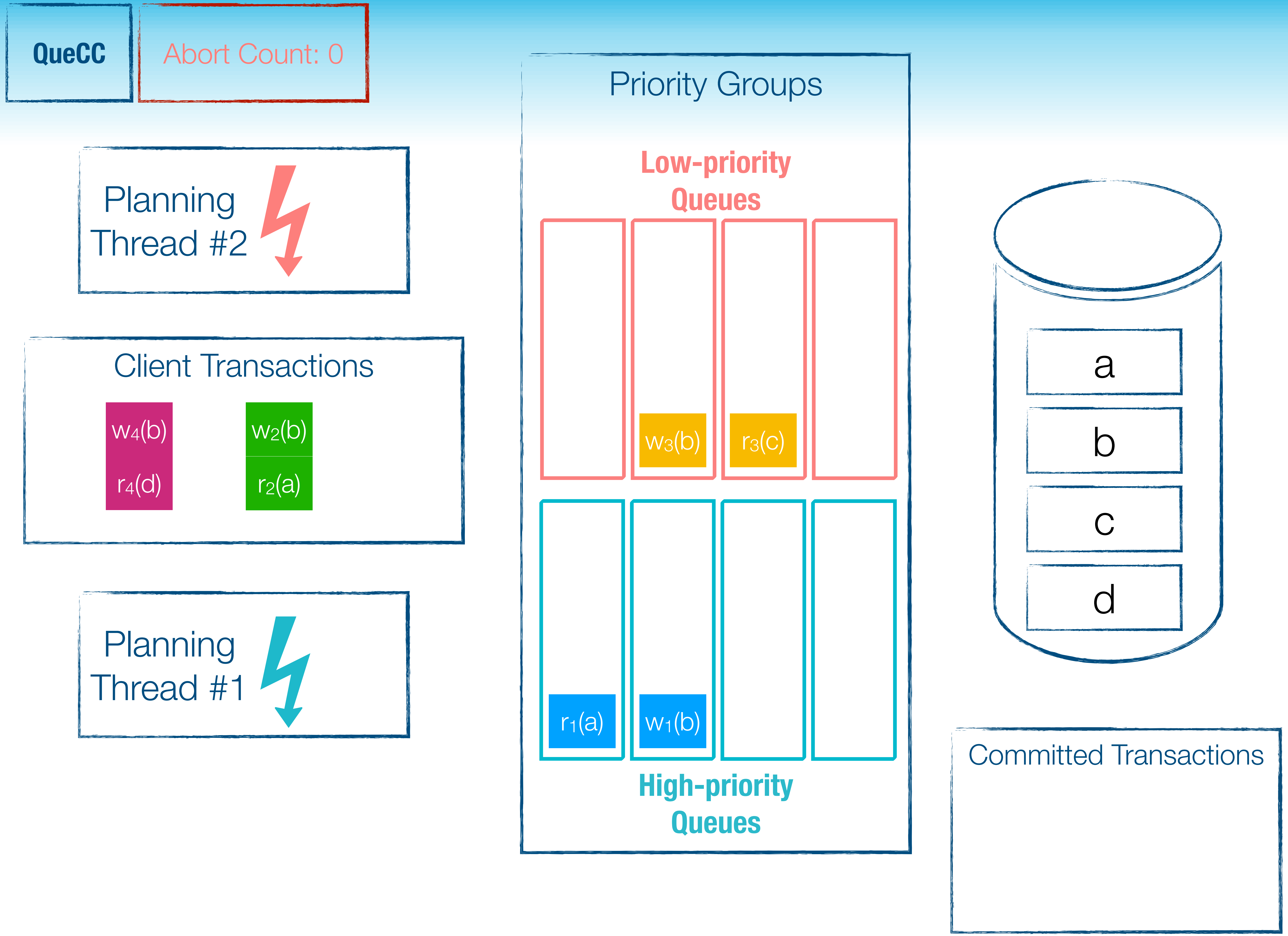
$r_1(a)$ $w_1(b)$

Priority Groups

Low-priority Queues

High-priority Queues

Committed Transactions



QueCC

Abort Count: 0

Planning Thread #2

Client Transactions

$w_4(b)$ $r_4(d)$

$w_2(b)$ $r_2(a)$

Planning Thread #1

Priority Groups

Low-priority Queues

$w_3(b)$ $r_3(c)$

$r_1(a)$ $w_1(b)$

High-priority Queues

a

b

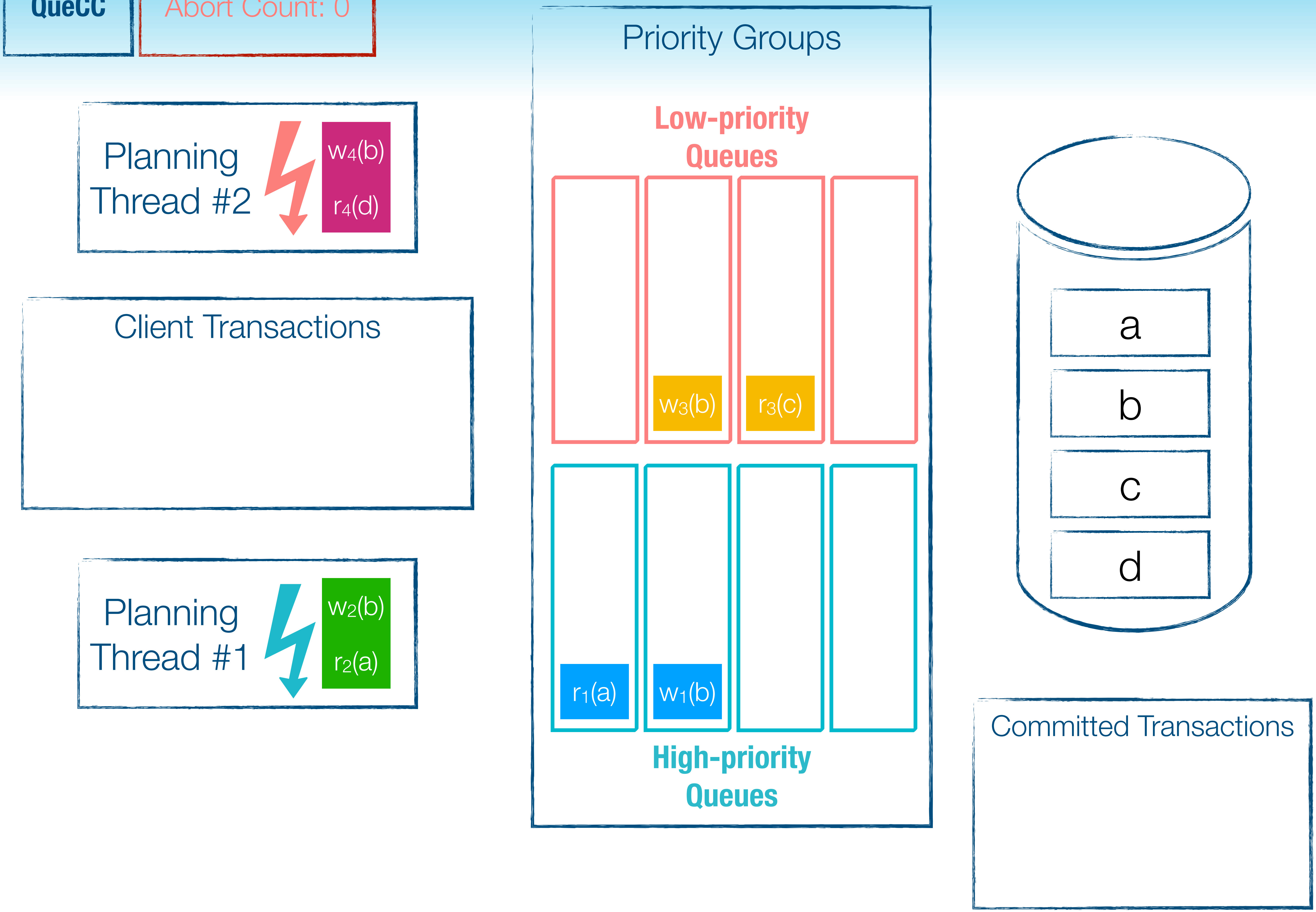
c

d

Committed Transactions

QueCC

Abort Count: 0



Priority Groups

Planning Thread #2

$w_4(b)$

$r_4(d)$

Client Transactions

Planning Thread #1

$w_2(b)$

$r_2(a)$

Low-priority Queues

$w_3(b)$

$r_3(c)$

$r_1(a)$

$w_1(b)$

High-priority Queues

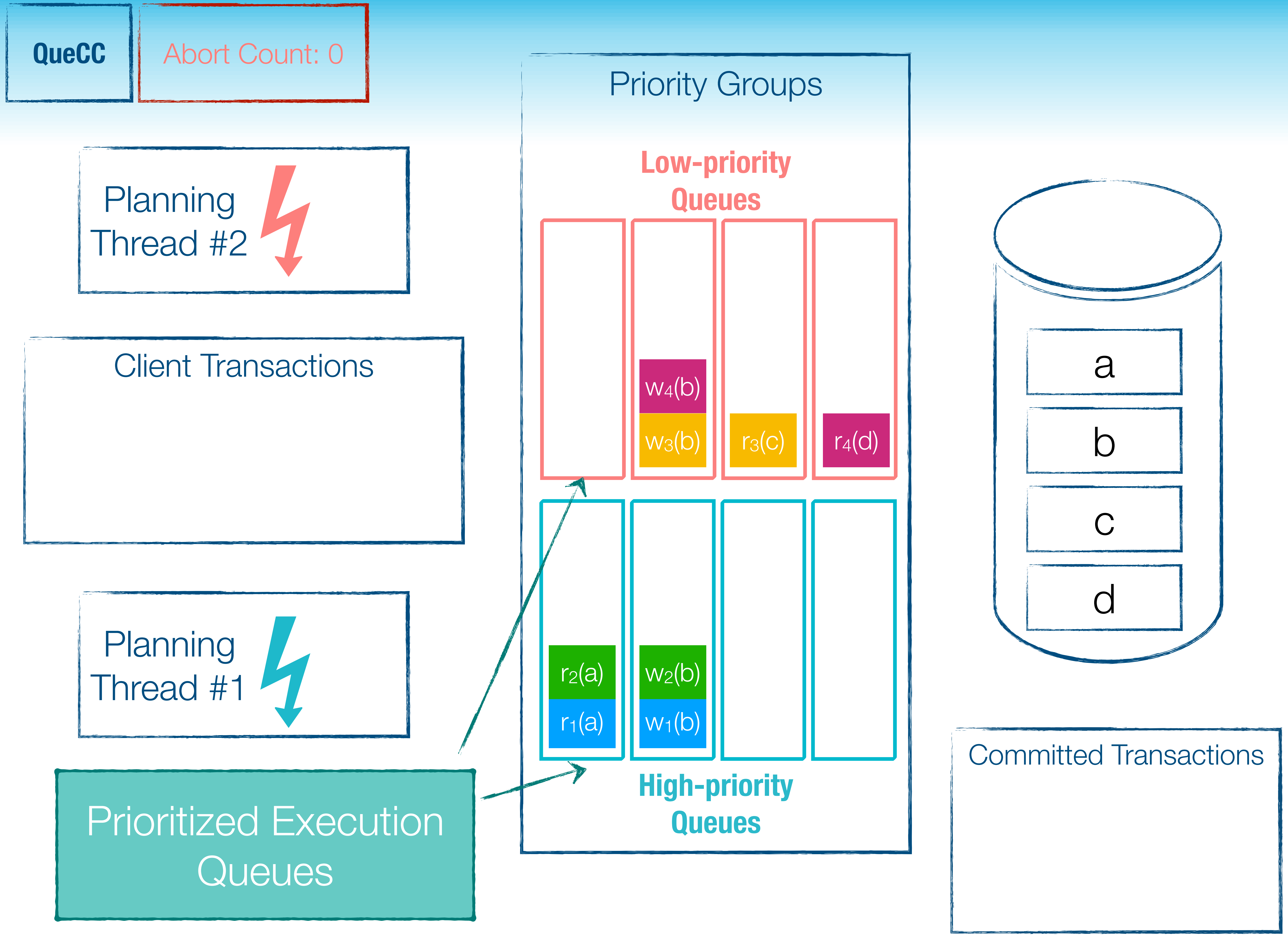
a

b

c

d

Committed Transactions



QueCC

Abort Count: 0

Planning Thread #2

Client Transactions

Planning Thread #1

Prioritized Execution Queues

Priority Groups

Low-priority Queues

$w_4(b)$

$w_3(b)$

$r_3(c)$

$r_4(d)$

$r_2(a)$

$r_1(a)$

$w_2(b)$

$w_1(b)$

High-priority Queues

a

b

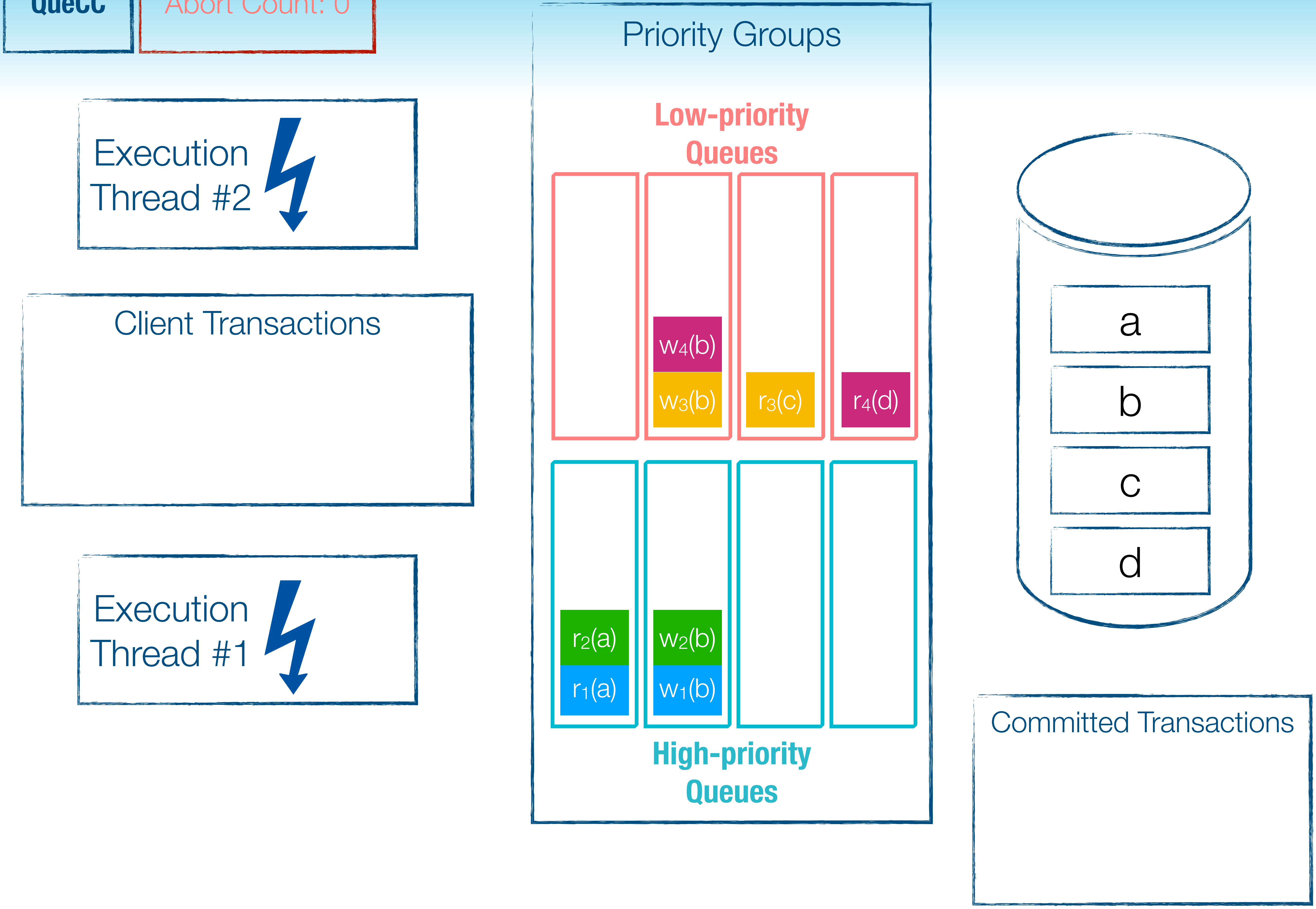
c

d

Committed Transactions

QueCC

Abort Count: 0



Priority Groups

Low-priority Queues

High-priority Queues

Execution Thread #2

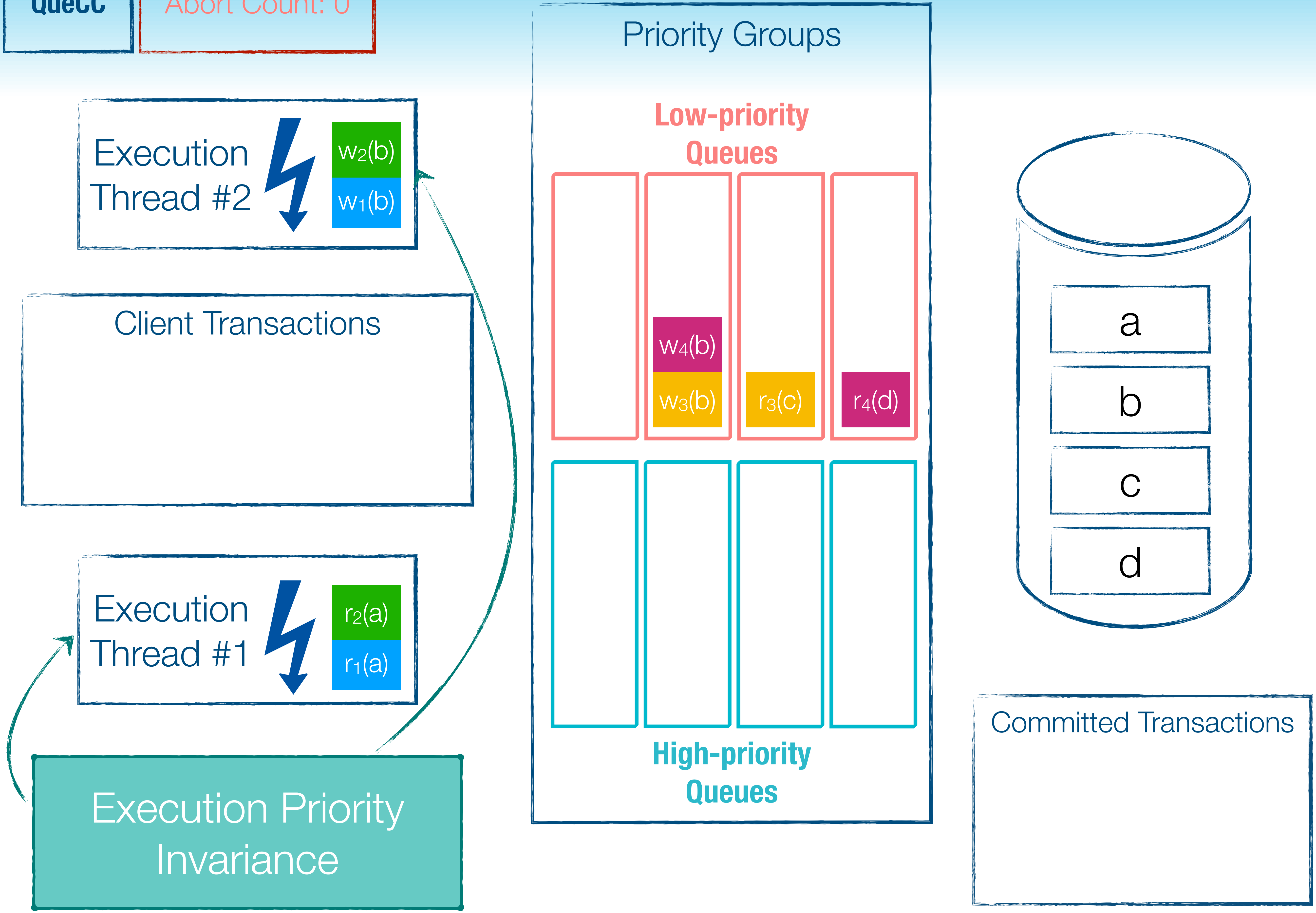
Client Transactions

Execution Thread #1

Committed Transactions

QueCC

Abort Count: 0



Priority Groups

Low-priority Queues

$w_4(b)$

$w_3(b)$

$r_3(c)$

$r_4(d)$

High-priority Queues

Execution Thread #2

$w_2(b)$

$w_1(b)$

Client Transactions

Execution Thread #1

$r_2(a)$

$r_1(a)$

Execution Priority Invariance

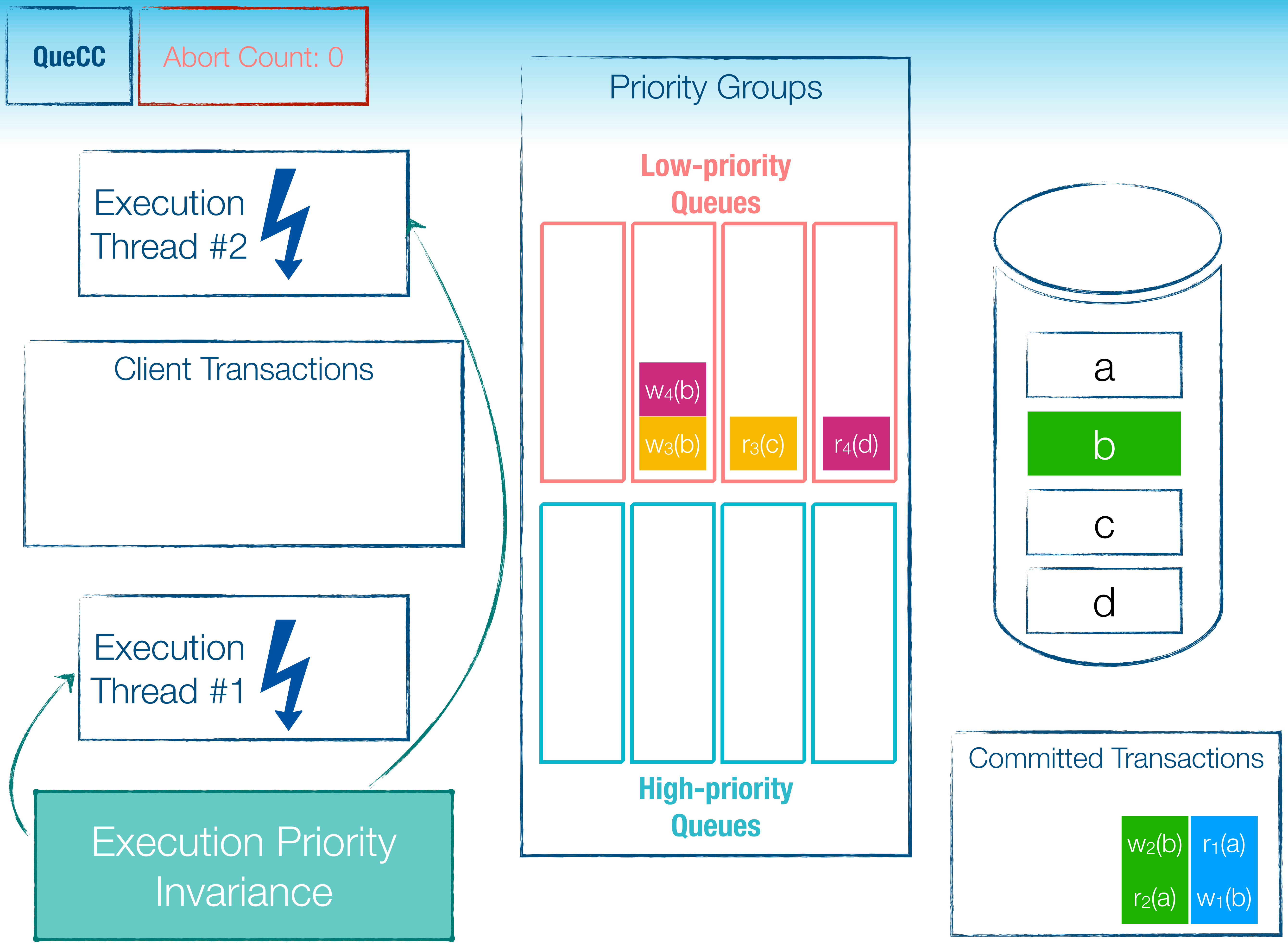
a

b

c

d

Committed Transactions



QueCC

Abort Count: 0

Execution Thread #2

Client Transactions

Execution Thread #1

Execution Priority Invariance

Priority Groups

Low-priority Queues

$w_4(b)$

$w_3(b)$

$r_3(c)$

$r_4(d)$

High-priority Queues

a

b

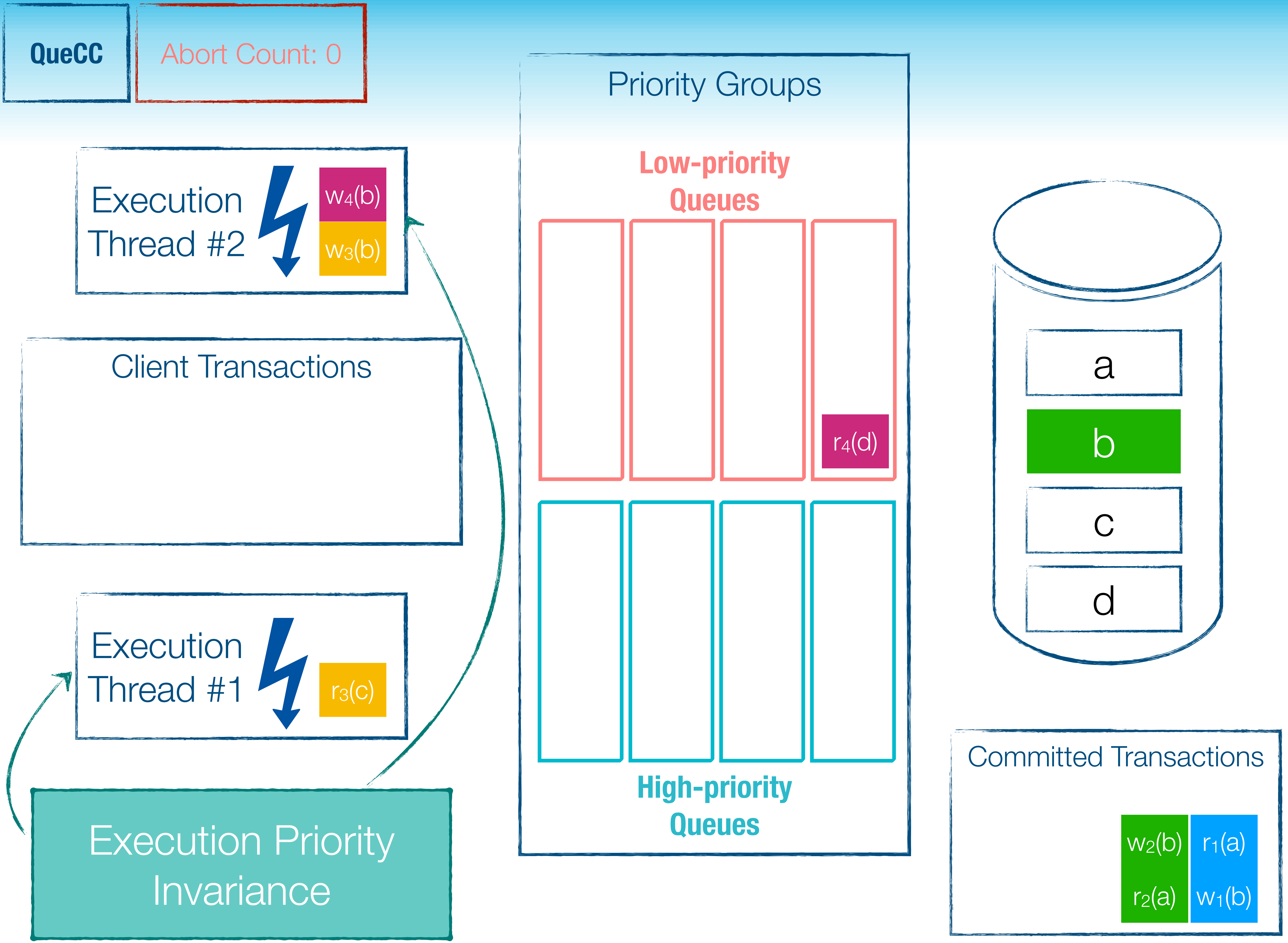
c

d

Committed Transactions

$w_2(b)$ $r_1(a)$

$r_2(a)$ $w_1(b)$



QueCC

Abort Count: 0

Execution Thread #2

$w_4(b)$

$w_3(b)$

Client Transactions

Execution Thread #1

$r_3(c)$

Execution Priority Invariance

Priority Groups

Low-priority Queues

$r_4(d)$

High-priority Queues

a

b

c

d

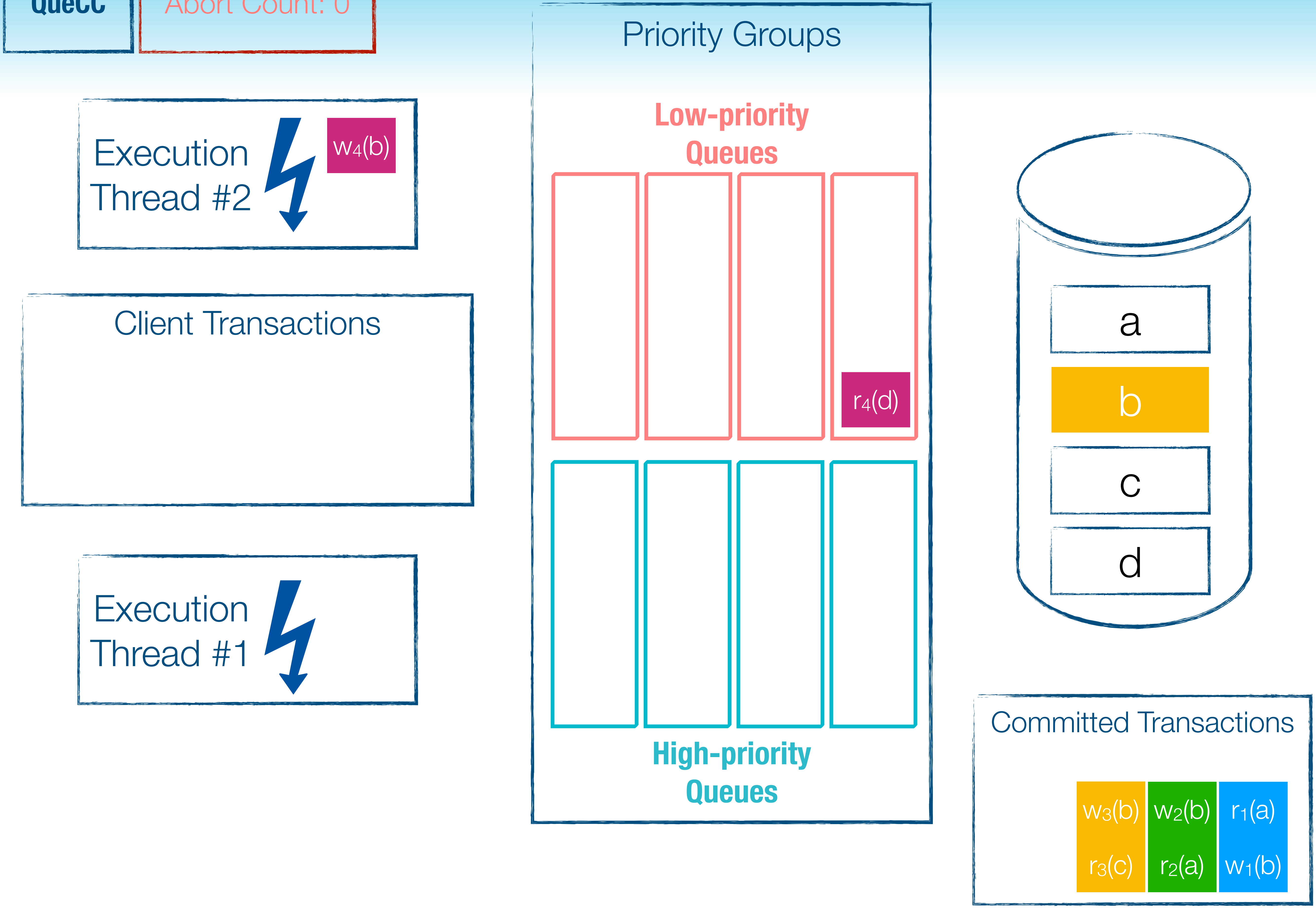
Committed Transactions

$w_2(b)$ $r_1(a)$

$r_2(a)$ $w_1(b)$

QueCC

Abort Count: 0



Execution Thread #2

$w_4(b)$

Client Transactions

Execution Thread #1

Priority Groups

Low-priority Queues

$r_4(d)$

High-priority Queues

a

b

c

d

Committed Transactions

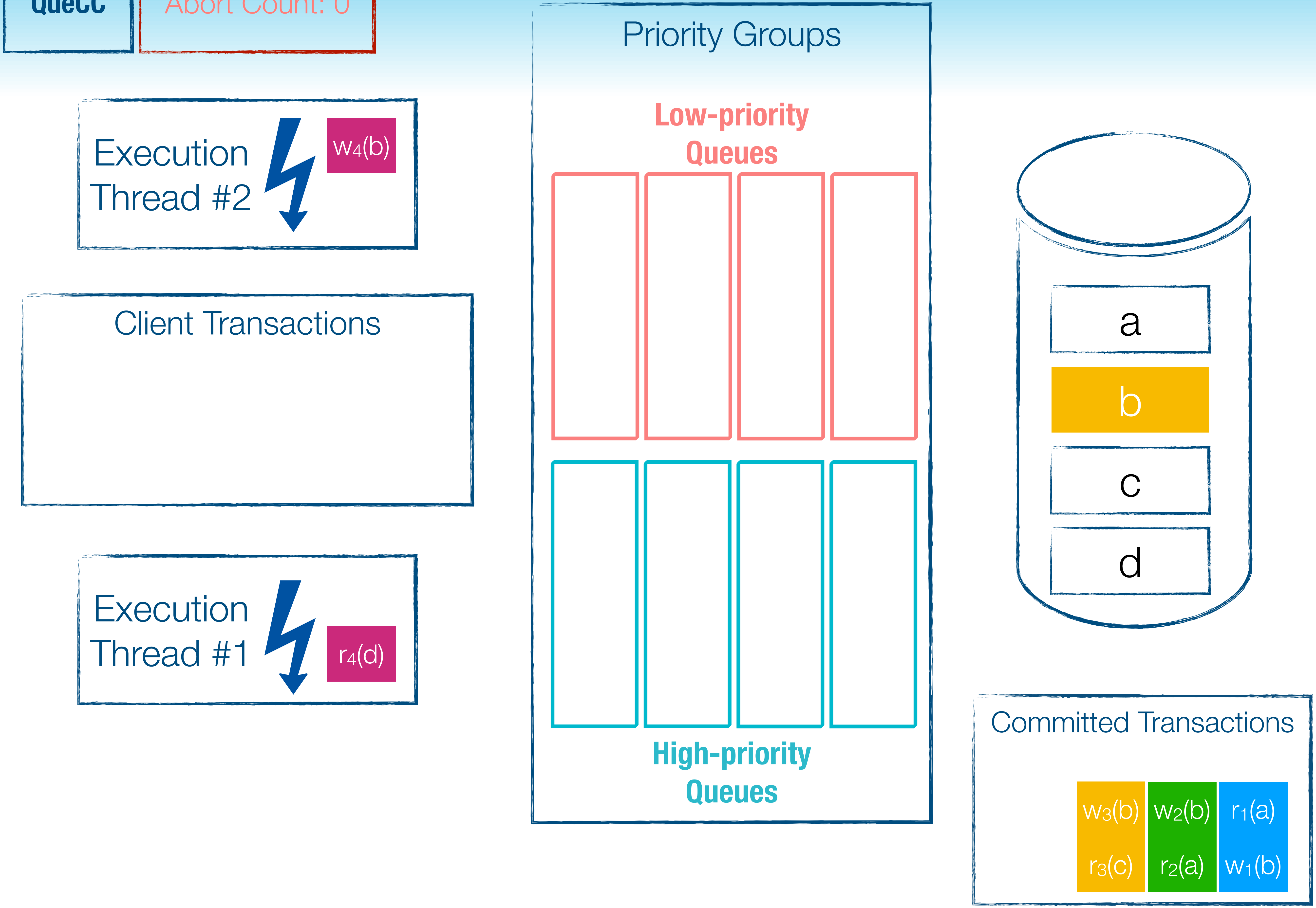
$w_3(b)$ $r_3(c)$

$w_2(b)$ $r_2(a)$

$r_1(a)$ $w_1(b)$

QueCC

Abort Count: 0



Execution Thread #2

$w_4(b)$

Client Transactions

Execution Thread #1

$r_4(d)$

Priority Groups

Low-priority Queues

High-priority Queues

a

b

c

d

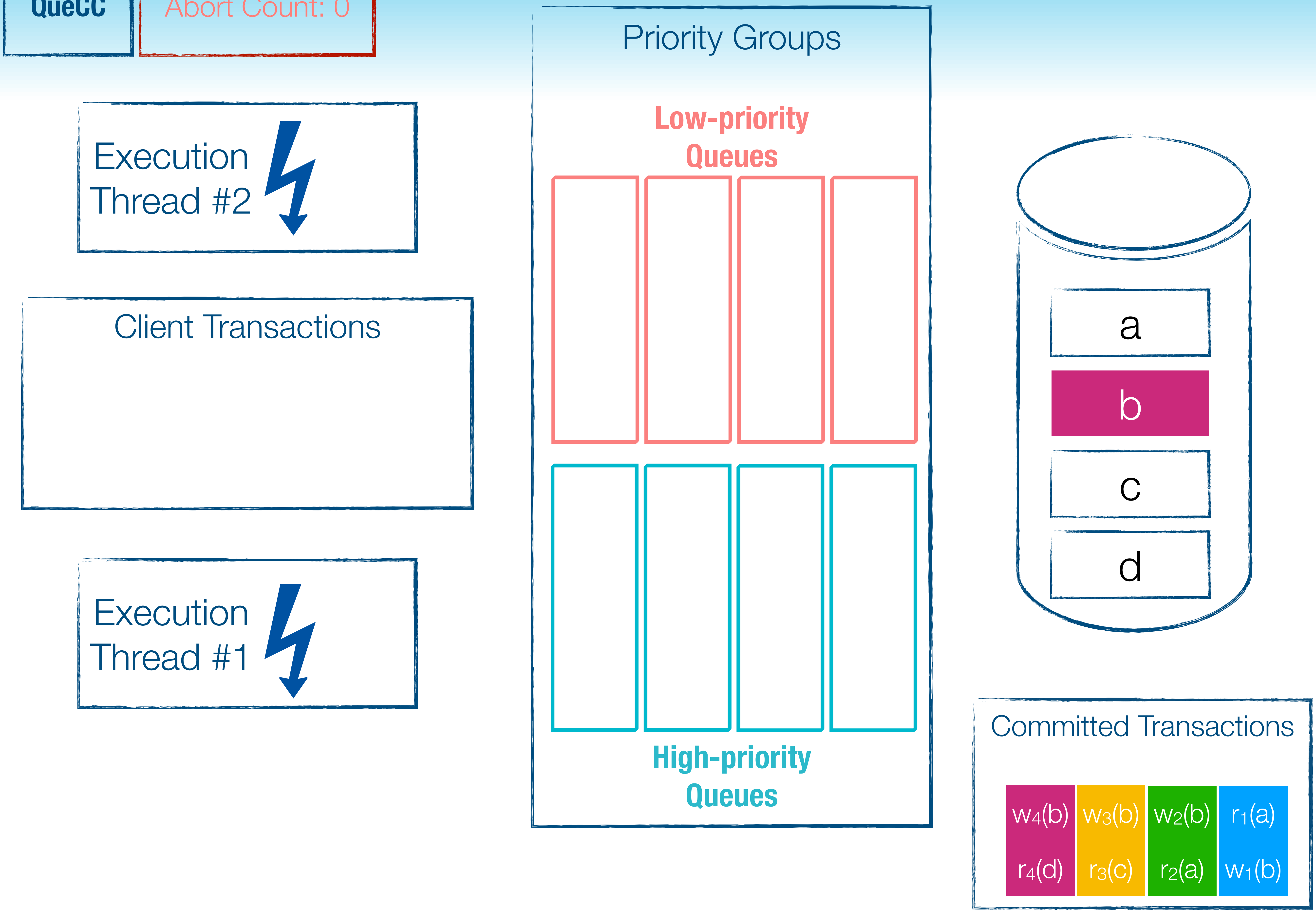
Committed Transactions

$w_3(b)$ $w_2(b)$ $r_1(a)$

$r_3(c)$ $r_2(a)$ $w_1(b)$

QueCC

Abort Count: 0



Execution Thread #2

Client Transactions

Execution Thread #1

Priority Groups

Low-priority Queues

High-priority Queues

a

b

c

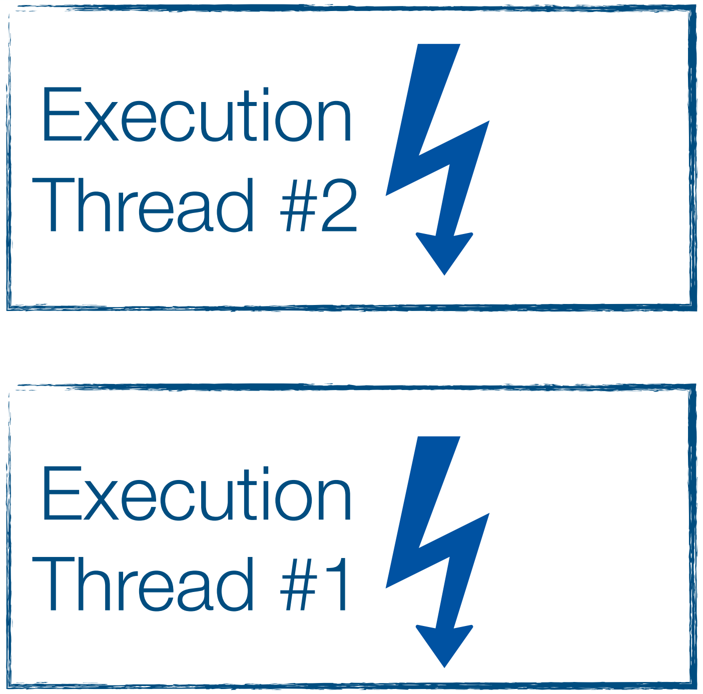
d

Committed Transactions

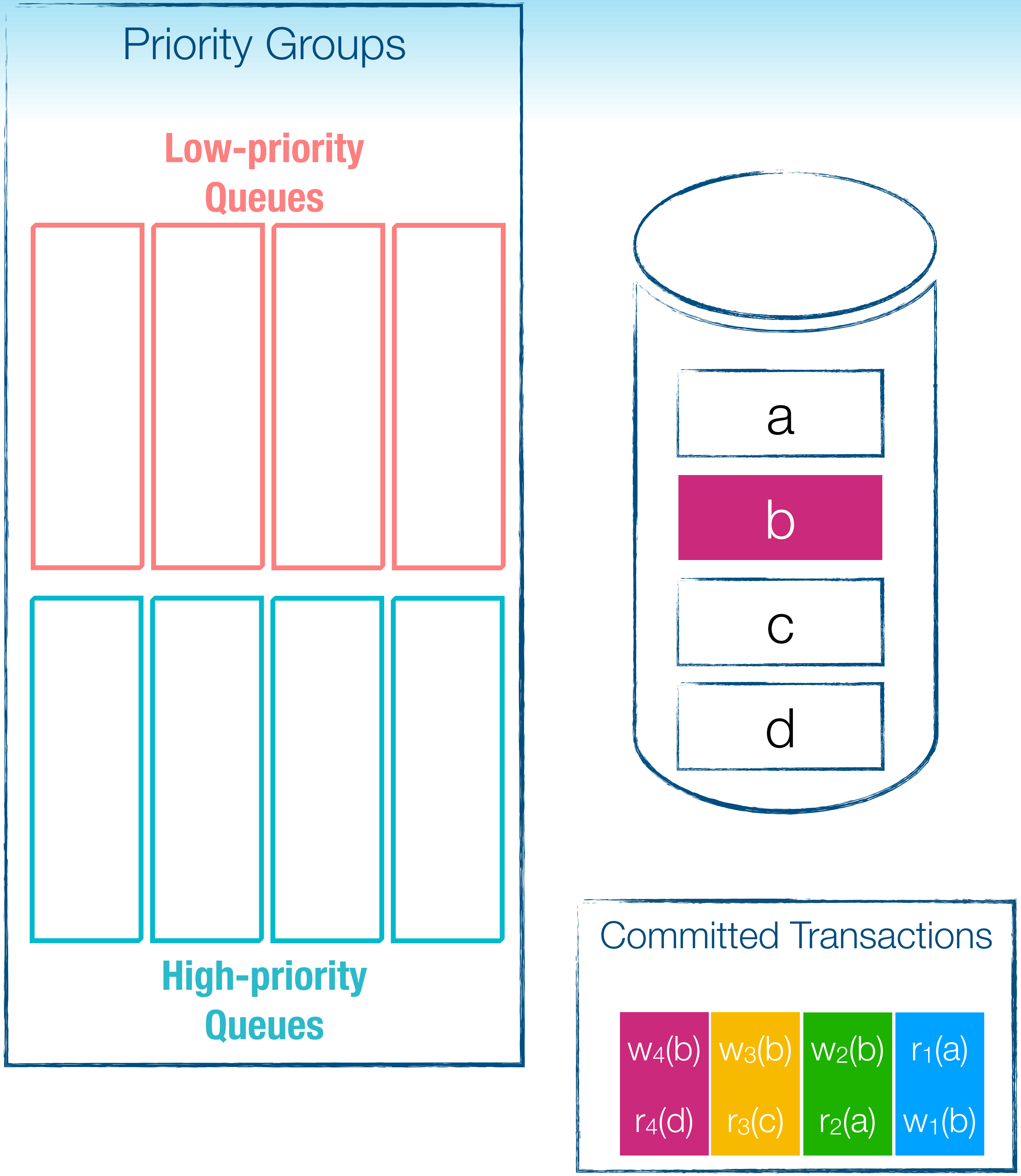
$w_4(b)$	$w_3(b)$	$w_2(b)$	$r_1(a)$
$r_4(d)$	$r_3(c)$	$r_2(a)$	$w_1(b)$

QueCC

Abort Count: 0



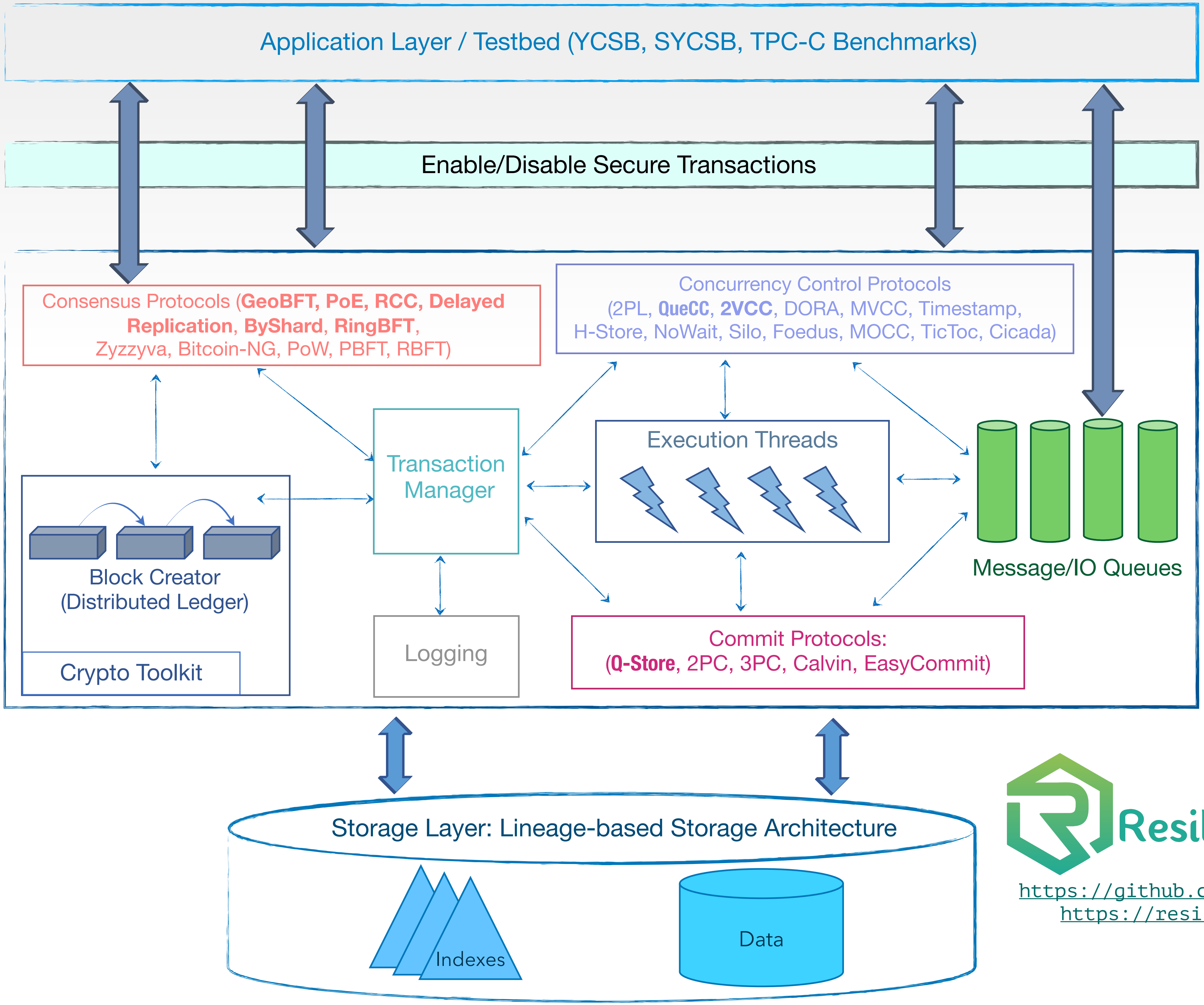
- ✓ Deterministic Execution
- ✓ No aborts because of CC
- ✓ Minimal coordination among threads
- ✓ Not sensitive to multi-partition transactions
- ✓ Exploits Intra-transaction parallelism



Committed Transactions

$w_4(b)$	$w_3(b)$	$w_2(b)$	$r_1(a)$
$r_4(d)$	$r_3(c)$	$r_2(a)$	$w_1(b)$

ResilientDB Blockchain Fabric



Application Layer / Testbed (YCSB, SYCSB, TPC-C Benchmarks)

Enable/Disable Secure Transactions

Consensus Protocols (**GeoBFT, PoE, RCC, Delayed Replication**, **ByShard**, **RingBFT**, Zyzzyva, Bitcoin-NG, PoW, PBFT, RBFT)

Concurrency Control Protocols (2PL, **QueCC**, **2VCC**, DORA, MVCC, Timestamp, H-Store, NoWait, Silo, Foedus, MOCC, TicToc, Cicada)

Block Creator (Distributed Ledger)

Crypto Toolkit

Transaction Manager

Execution Threads

Message/IO Queues

Logging

Commit Protocols: (**Q-Store**, 2PC, 3PC, Calvin, EasyCommit)

Storage Layer: Lineage-based Storage Architecture

Indexes

Data

ResilientDB

https://github.com/resilientdb/
https://resilientdb.com/

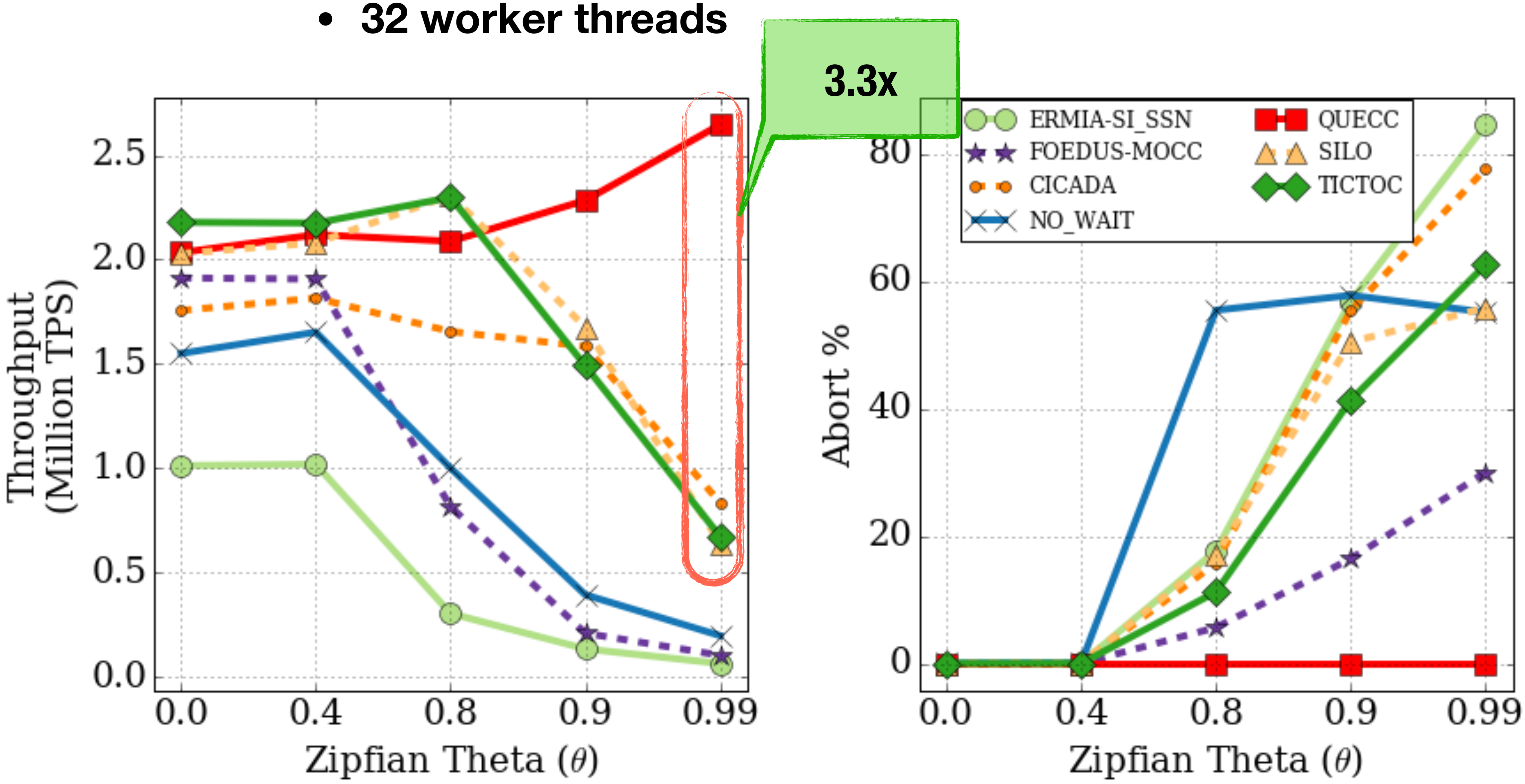
Fault-tolerant Distributed Transactions on Blockchain., S. Gupta, J. Hellings, M. Sadoghi

Evaluation Environment

Hardware	Microsoft Azure instance with 32 core CPU: Intel Xeon E5-2698B v3 *32KB L1 data an instruction caches* *256KB L2 cache* *40MB L3 cache* RAM: 448GB
Workload	YCSB: 1 table,10 operations, 50% RMW, Zipfian distribution TPCC: 9 tables, Payment and NewOrder, 1 Warehouse
Software	Operating System: Ubuntu LTS 16.04.3 Compiler: GCC with –O3 compiler optimizations

Effect of Varying Contention

- **5 write and 5 read operation per transaction**
- **32 worker threads**



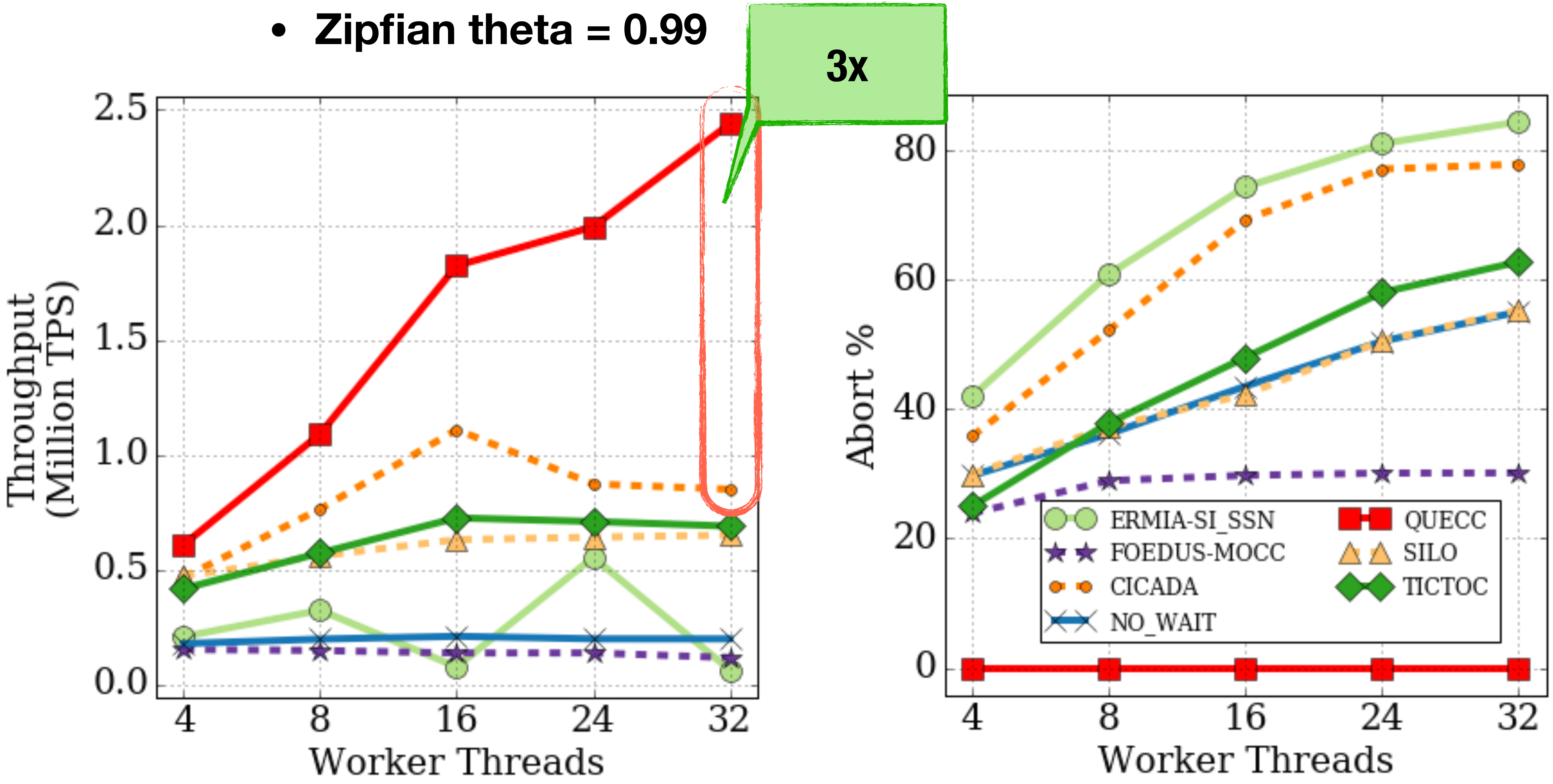
3.3x

Workload contention resiliency

Cache locality under high-contention

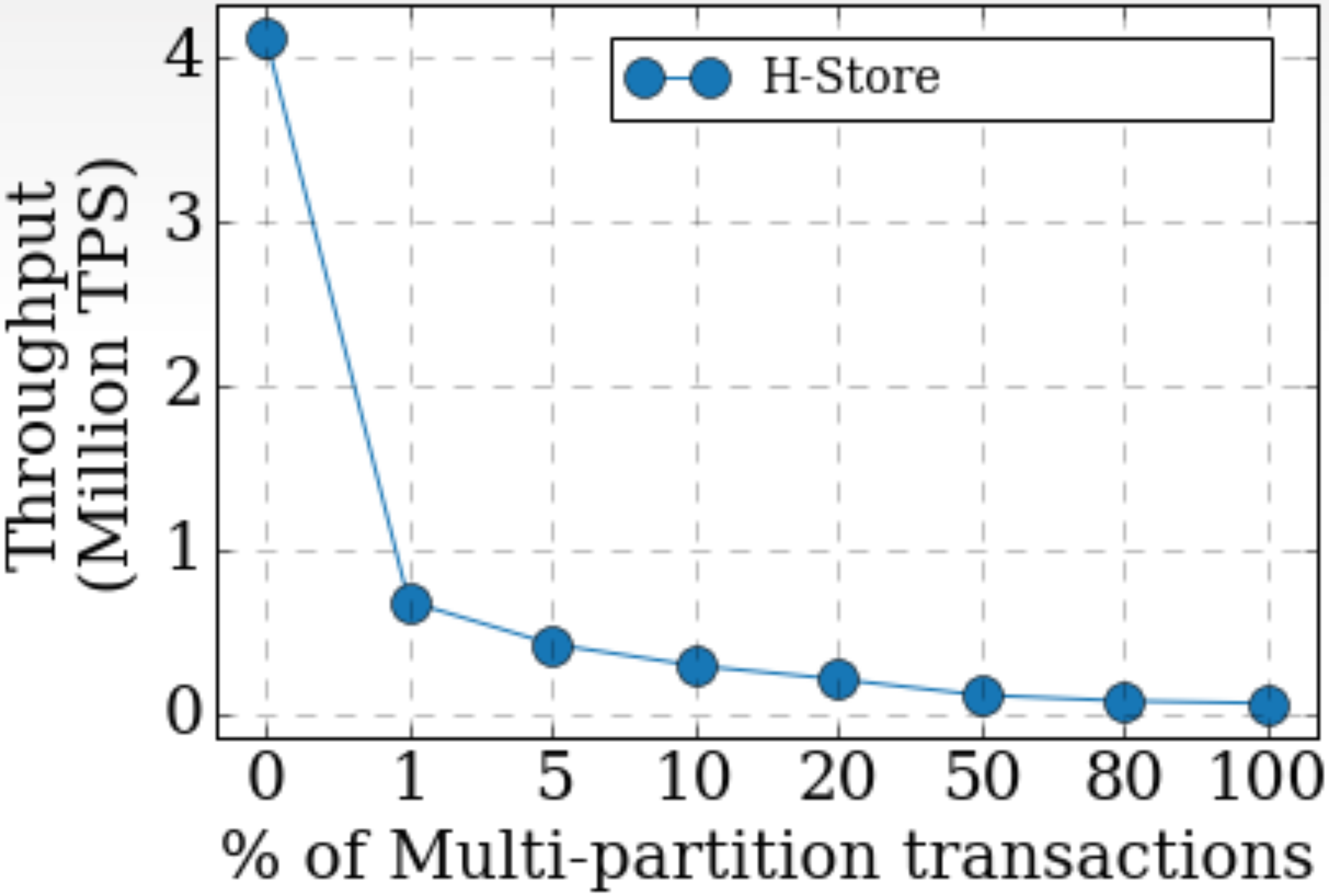
Effect of Varying Worker Threads

- **5 write and 5 read operation per transaction**
- **Zipfian theta = 0.99**

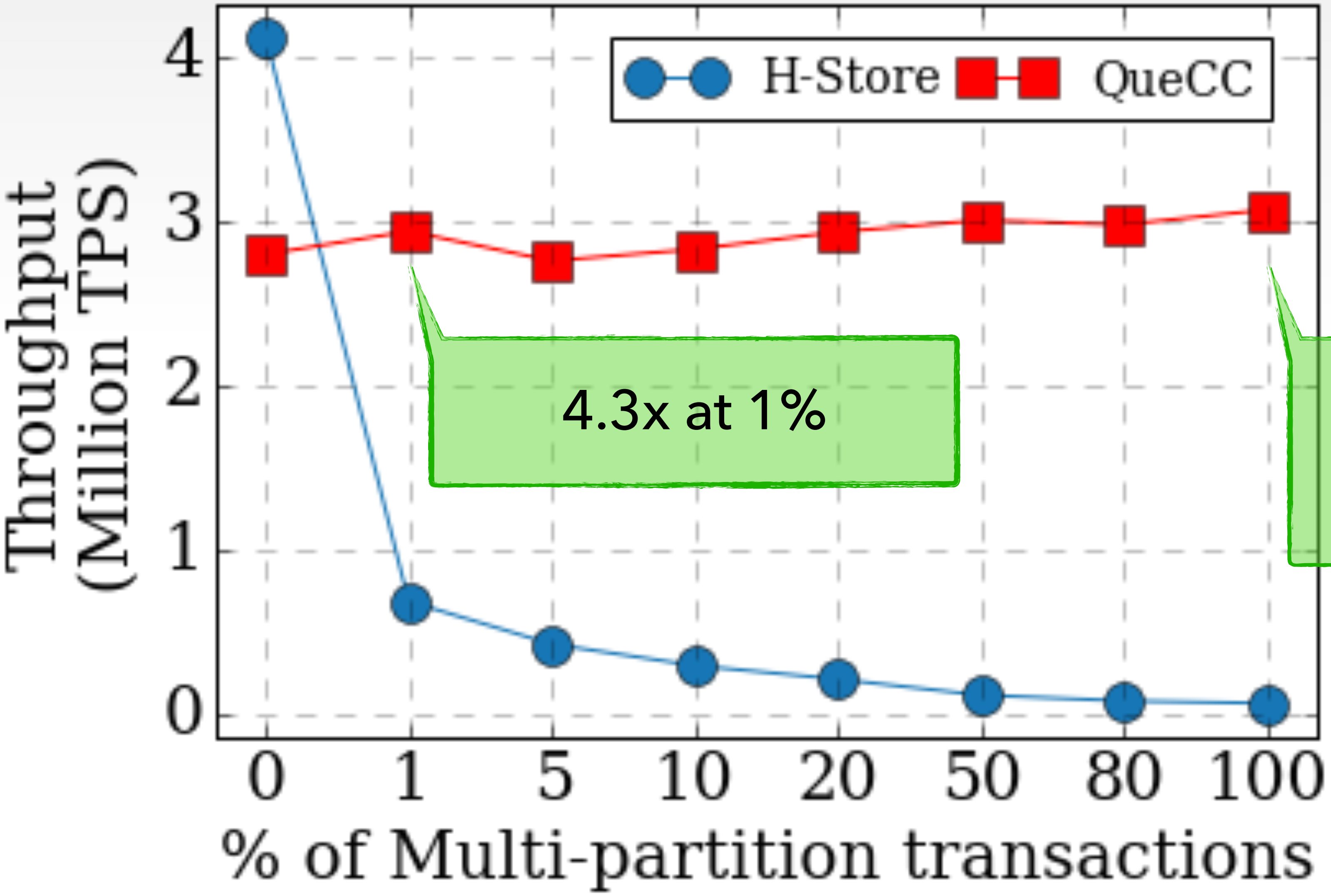


Avoiding thread coordination & eliminating all execution-induced aborts

Effect of Increasing Percentage of Multi-Partition Transactions in the Workload



Effect of Increasing Percentage of Multi-Partition Transactions in the Workload



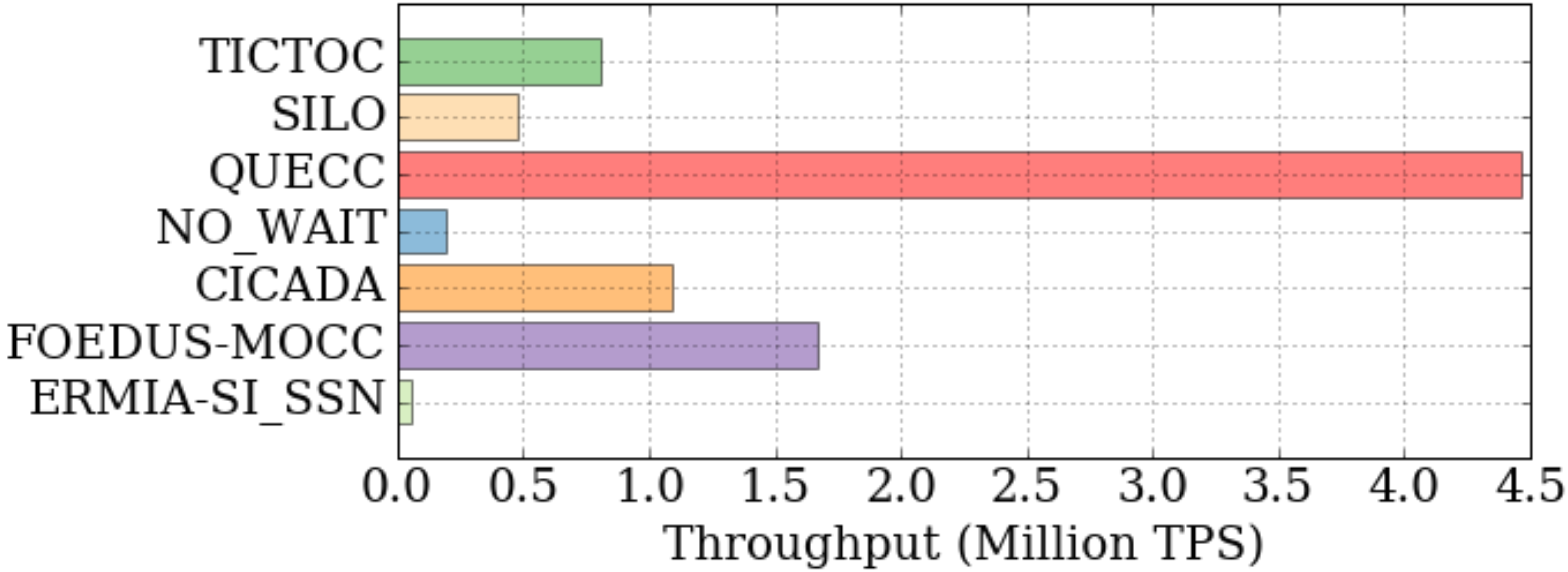
4.3x at 1%

Two orders of Magnitude

QueCC is not sensitive to multi-partitioning

TPC-C Results

1 Warehouse (highly contended workload)
50% Payment + 50% NewOrder transaction mix



QueCC can achieve up to 3x better performance on high-contention TPC-C workloads

QueCC Conclusions

✓ Efficient, parallel and deterministic in-memory transaction processing

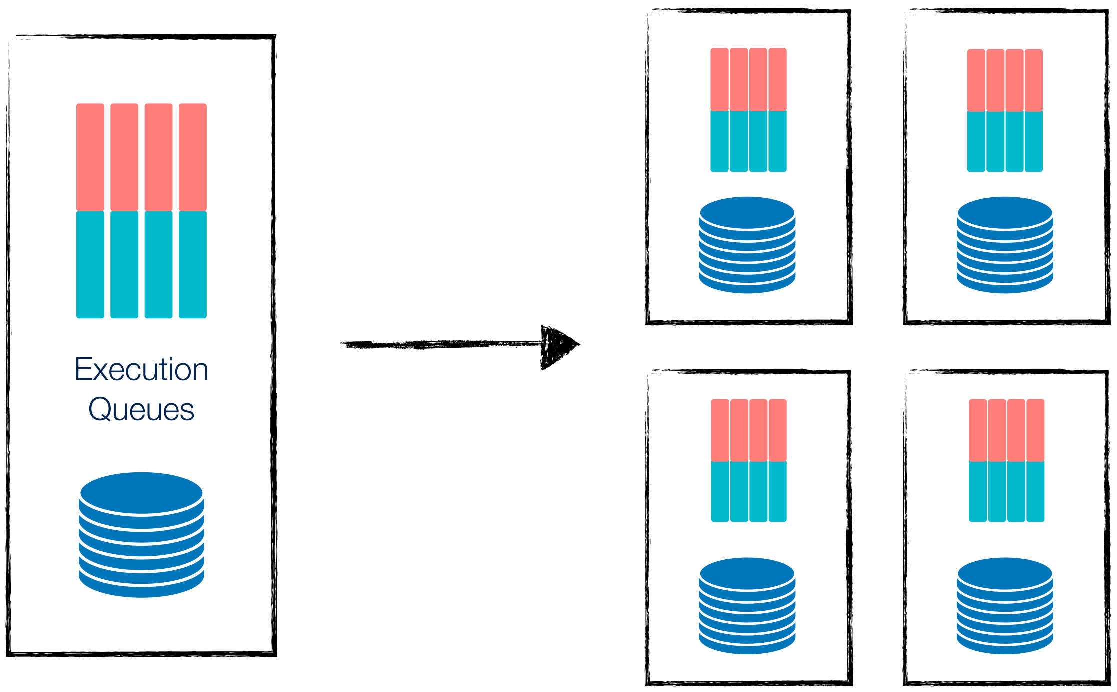
✓ Eliminates almost all aborts by resolving transaction conflicts *a priori*

✓ Works extremely well under high-contention workloads

What’s Next: Q-Store

QueCC

Q-Store



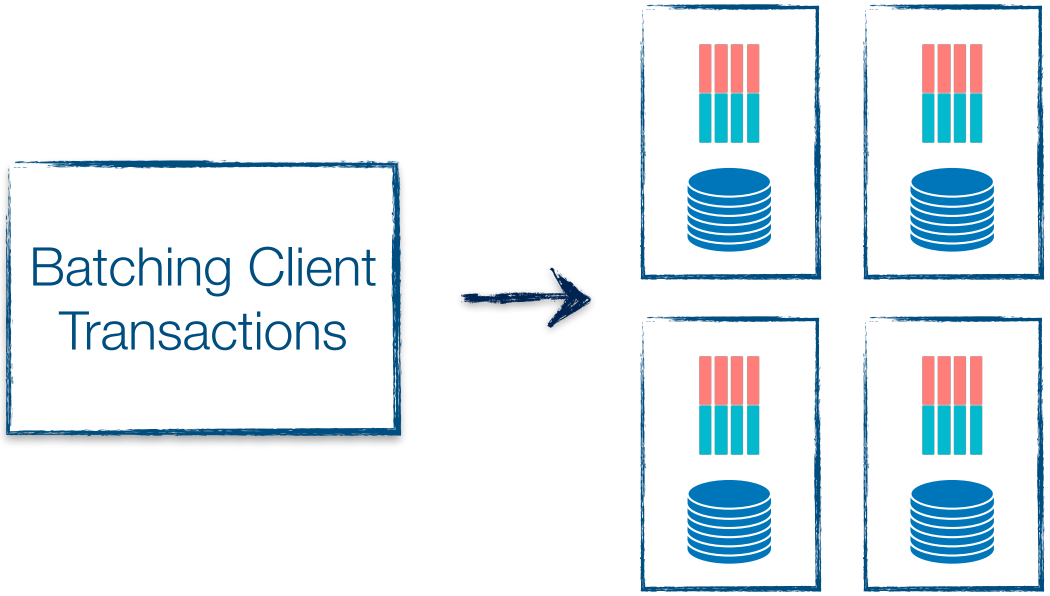
Execution Queues

Multi-core
Single-node

Partitioned
on Distributed
Cluster

Q-Store: Distributed, Multi-partition Transactions via Queue-oriented Execution and Communication., T. Qadah, S. Gupta, M. Sadoghi, EDBT 2020

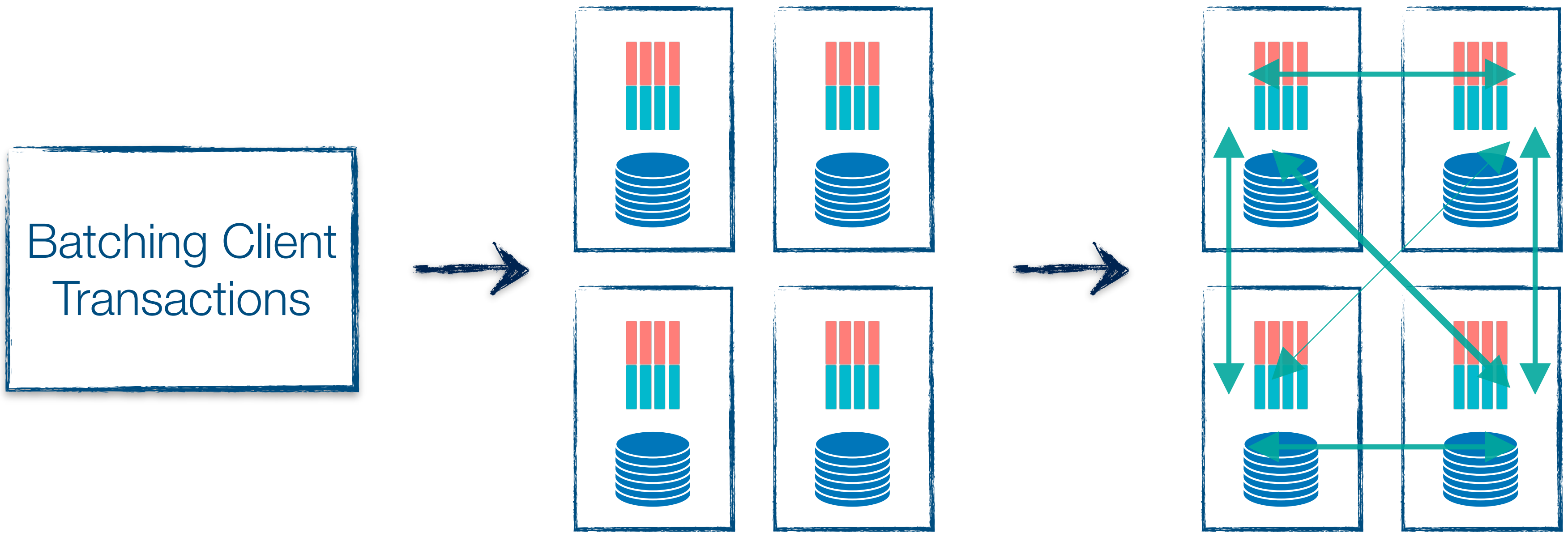
What’s Next: Q-Store



Plan Local and Remote Execution Queues

Q-Store: Distributed, Multi-partition Transactions via Queue-oriented Execution and Communication., T. Qadah, S. Gupta, M. Sadoghi, EDBT 2020

What’s Next: Q-Store



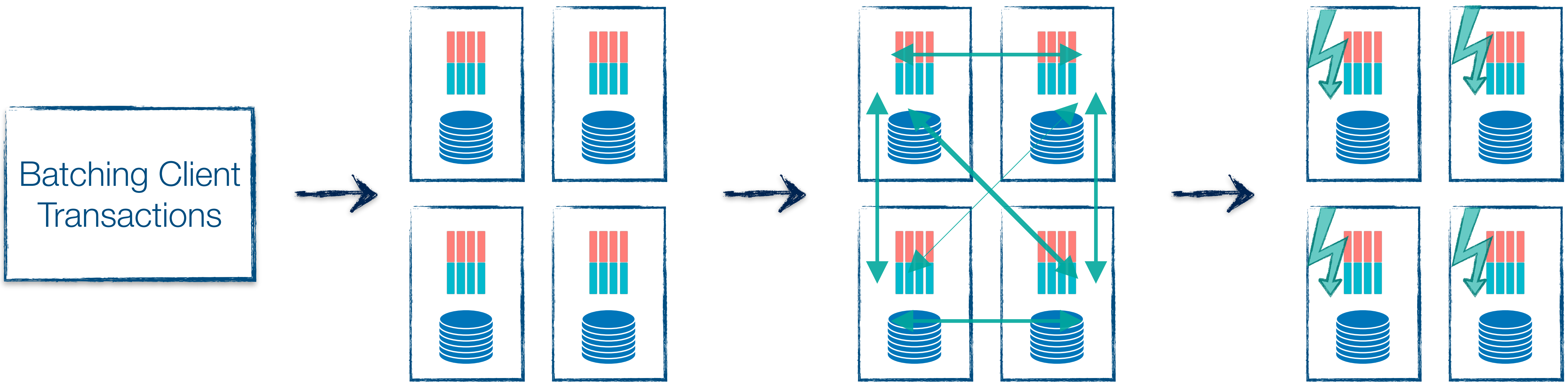
Batching Client Transactions

Plan Local and Remote Execution Queues

Deliver Remote Execution Queues

Q-Store: Distributed, Multi-partition Transactions via Queue-oriented Execution and Communication., T. Qadah, S. Gupta, M. Sadoghi, EDBT 2020

What’s Next: Q-Store



Batching Client Transactions

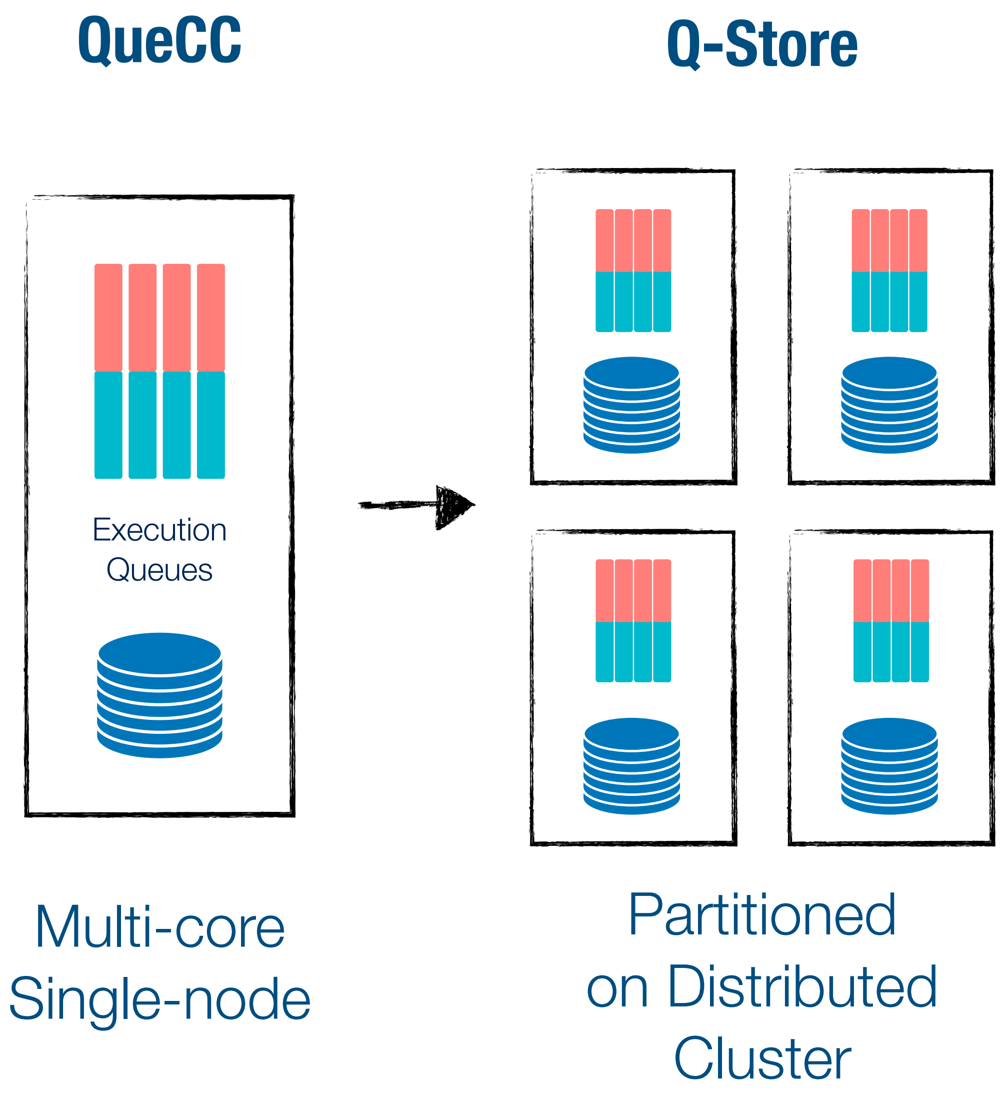
Plan Local and Remote Execution Queues

Deliver Remote Execution Queues

Execute Queues

Q-Store: Distributed, Multi-partition Transactions via Queue-oriented Execution and Communication., T. Qadah, S. Gupta, M. Sadoghi, EDBT 2020

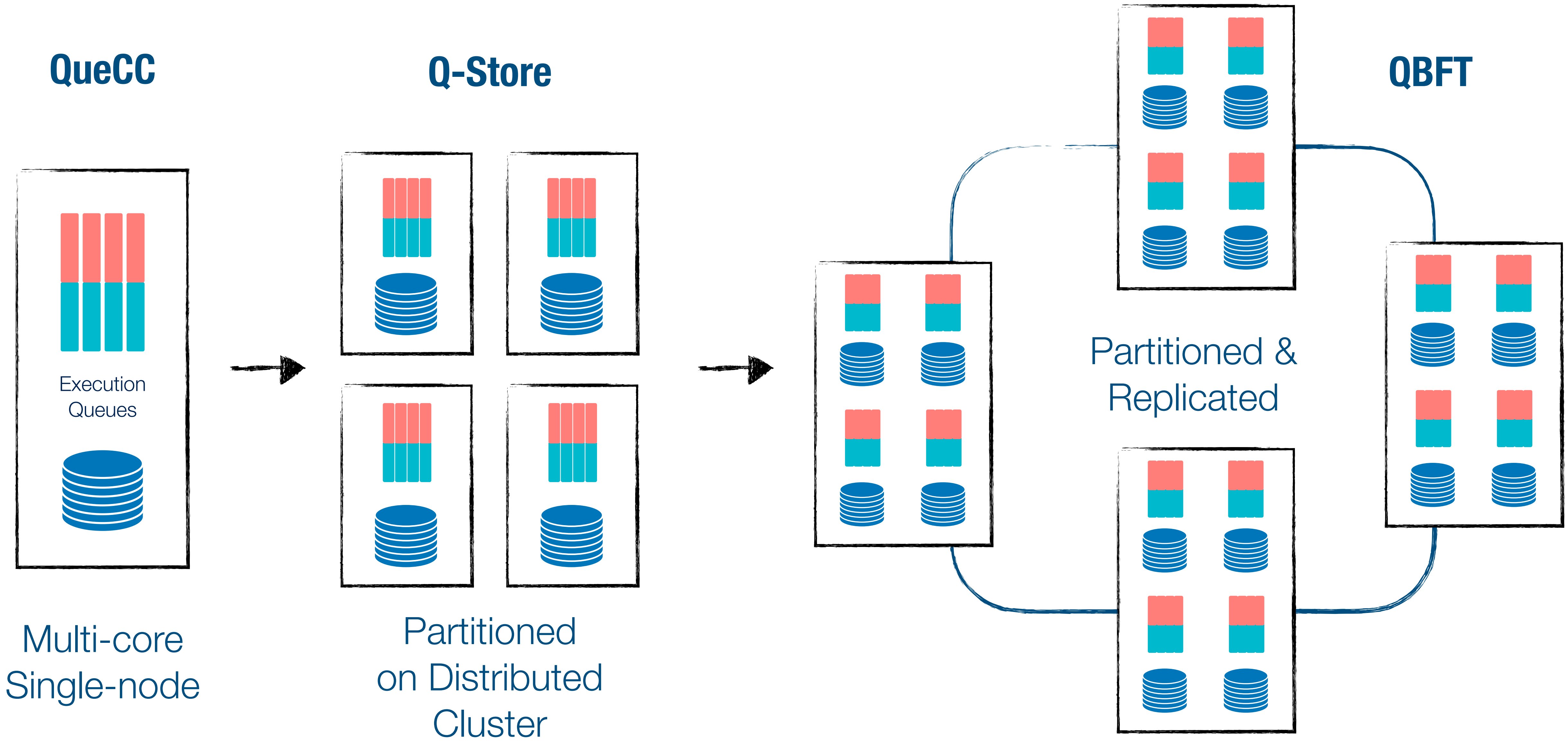
What’s Next: Q-Store



- ✓ Parallel and distributed
- ✓ Queue-oriented execution and communication
- ✓ Minimal coordination among nodes and threads

Q-Store: Distributed, Multi-partition Transactions via Queue-oriented Execution and Communication., T. Qadah, S. Gupta, M. Sadoghi, EDBT 2020

What's Next: QBFT



QueCC

Execution Queues

Multi-core Single-node

Q-Store

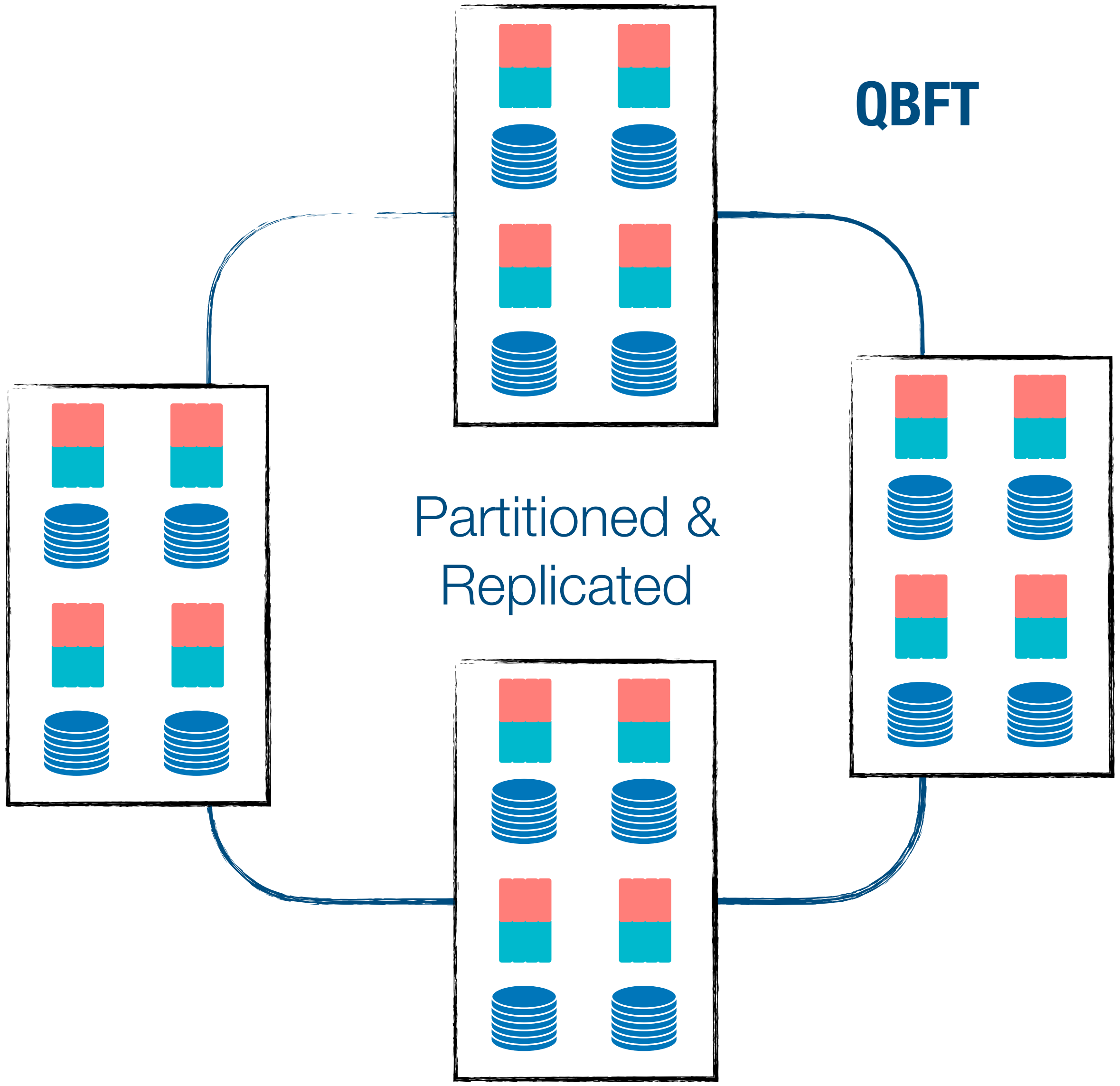
Partitioned on Distributed Cluster

QBFT

Partitioned & Replicated

What’s Next: QBFT

- ✓ Queue-oriented Byzantine Fault-Tolerance
- ✓ Resilient planning followed by resilient execution


QBFT
Partitioned &
Replicated