# Introduction to Database Systems CSE 444

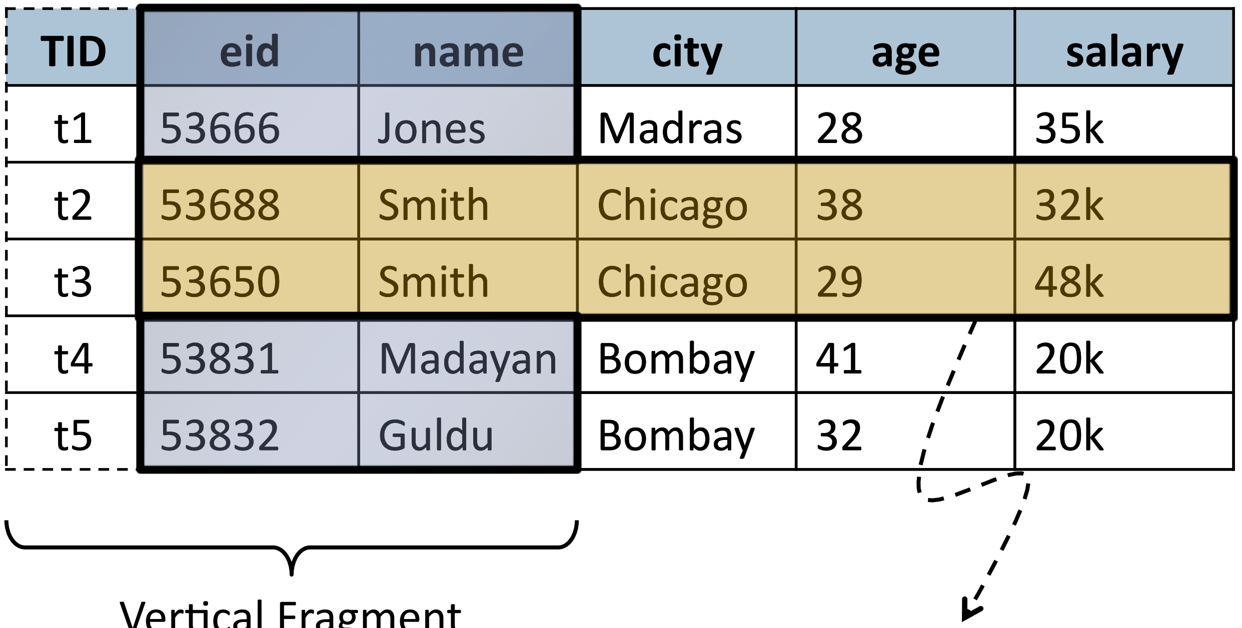
Lecture 26: Distributed Transactions

# Announcements

- Wrap-up lecture on Friday
  - Short review + example problems on the board
- Project 4 due this Friday
  - Don’t forget to terminate your jobs!!!
- Course evaluations at the end of this lecture
- Today: Distributed transactions
  - Because you loved transactions so much the first time

# Partitioned data

Employee

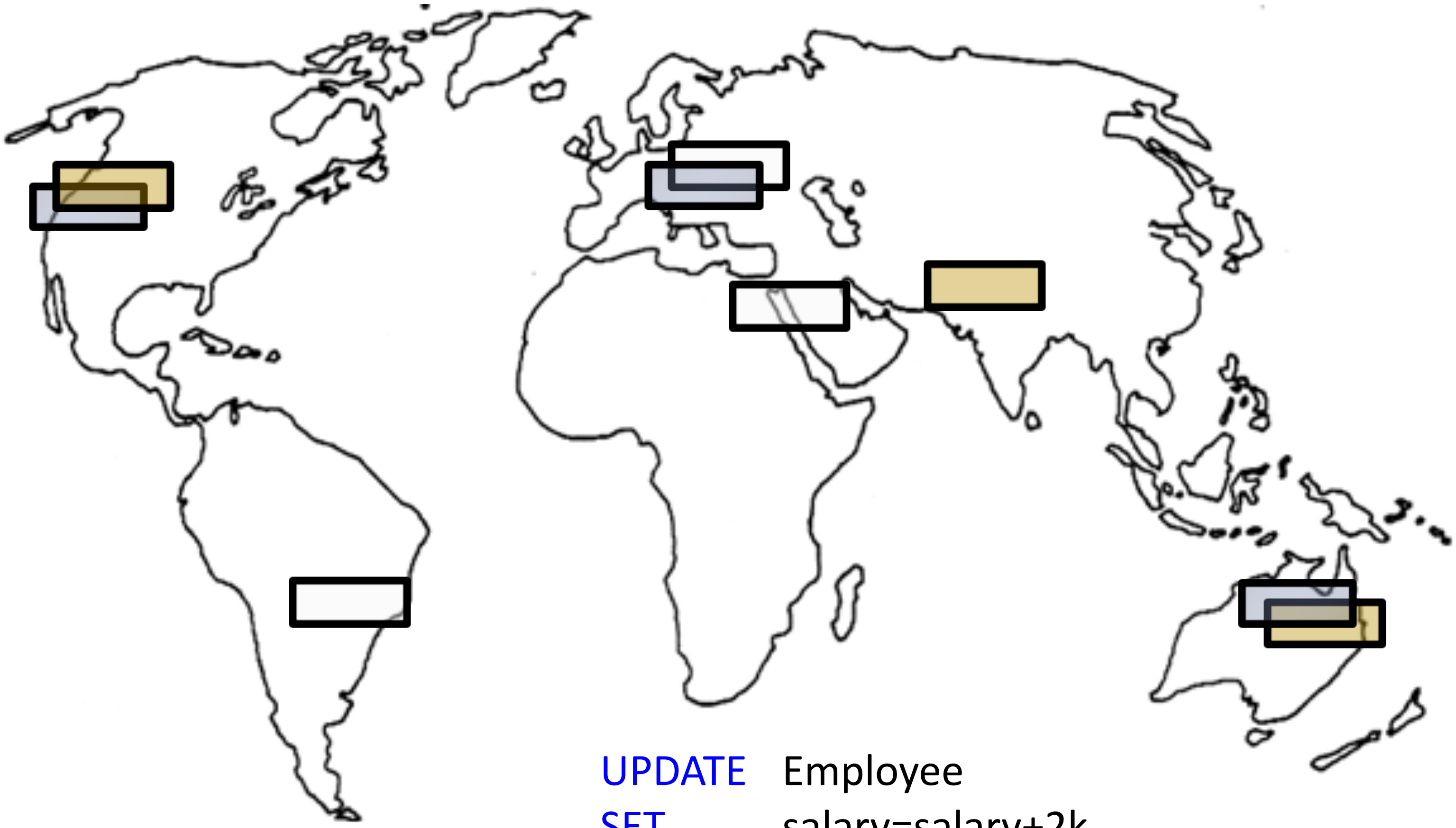


| TID | eid | name | city | age | salary |
|---|---|---|---|---|---|
| t1 | 53666 | Jones | Madras | 28 | 35k |
| t2 | 53688 | Smith | Chicago | 38 | 32k |
| t3 | 53650 | Smith | Chicago | 29 | 48k |
| t4 | 53831 | Madayan | Bombay | 41 | 20k |
| t5 | 53832 | Guldu | Bombay | 32 | 20k |

Vertical Fragment

Horizontal Fragment

# Distributed Data



```
UPDATE   Employee
SET      salary=salary+2k
WHERE    age>30
```

# Distributed Catalog

- How do we identify a relation?
  - Naming issues:
    - *local name + birth site =* ***global relation name***
    - *+replica_id =* ***global replica name***

- Centralized catalog
  - Vulnerable to single-site failure
  - Compromizes site autonomy

- R* approach:
  - Local catalog describing all local relations
  - Birth site also keeps track of replicas and fragments
    - Could be cached at other sites

# Remember Transactions?

- ACID

- Distributed Concurrency Control
  - How can locks for objects be managed?
  - How can deadlocks be detected?

- Distributed Recovery
  - Atomicity and Durability need to be enforced across sites

- In a distributed setting, a Xact spawns subtransactions

# Distributed Lock management

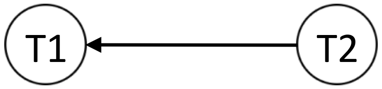
- Centralized
  - one site deals with lock and unlock requests

- Primary Copy
  - One copy of an object is designated as primary, and requests are handled at that site

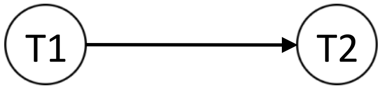
- Fully Distributed
  - Manage requests locally

# Deadlock detection

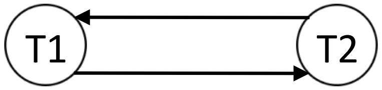
- Local and global waits-for graphs



At site A



At site B



Global waits-for graph

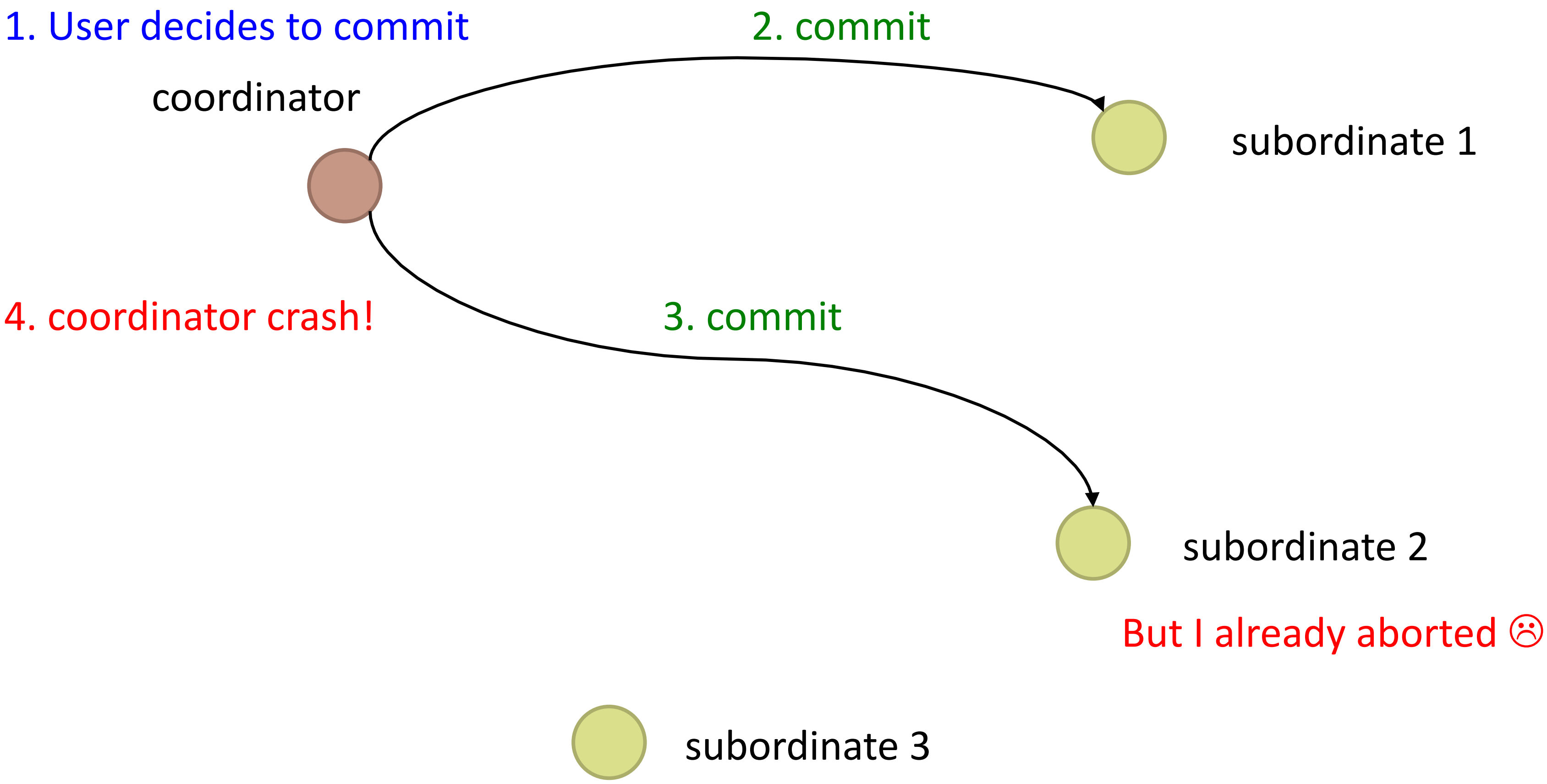
- 3 algorithms:
  1. Construct global waits-for graph periodically at a centralized site
  2. Construct waits-for graphs hierarchically
  3. Abort long waiting transactions

- Phantom Deadlocks!

# Distributed Recovery

- Either all subtransactions must commit or none of them
- Regular logging + commit protocol
- The transaction manager at the originating site is the coordinator
- The transaction managers at the subtransactions' sites are the subordinates

# 2 Phase Commit: Motivation



1. User decides to commit

2. commit

coordinator

subordinate 1

4. coordinator crash!

3. commit

subordinate 2

But I already aborted ☹

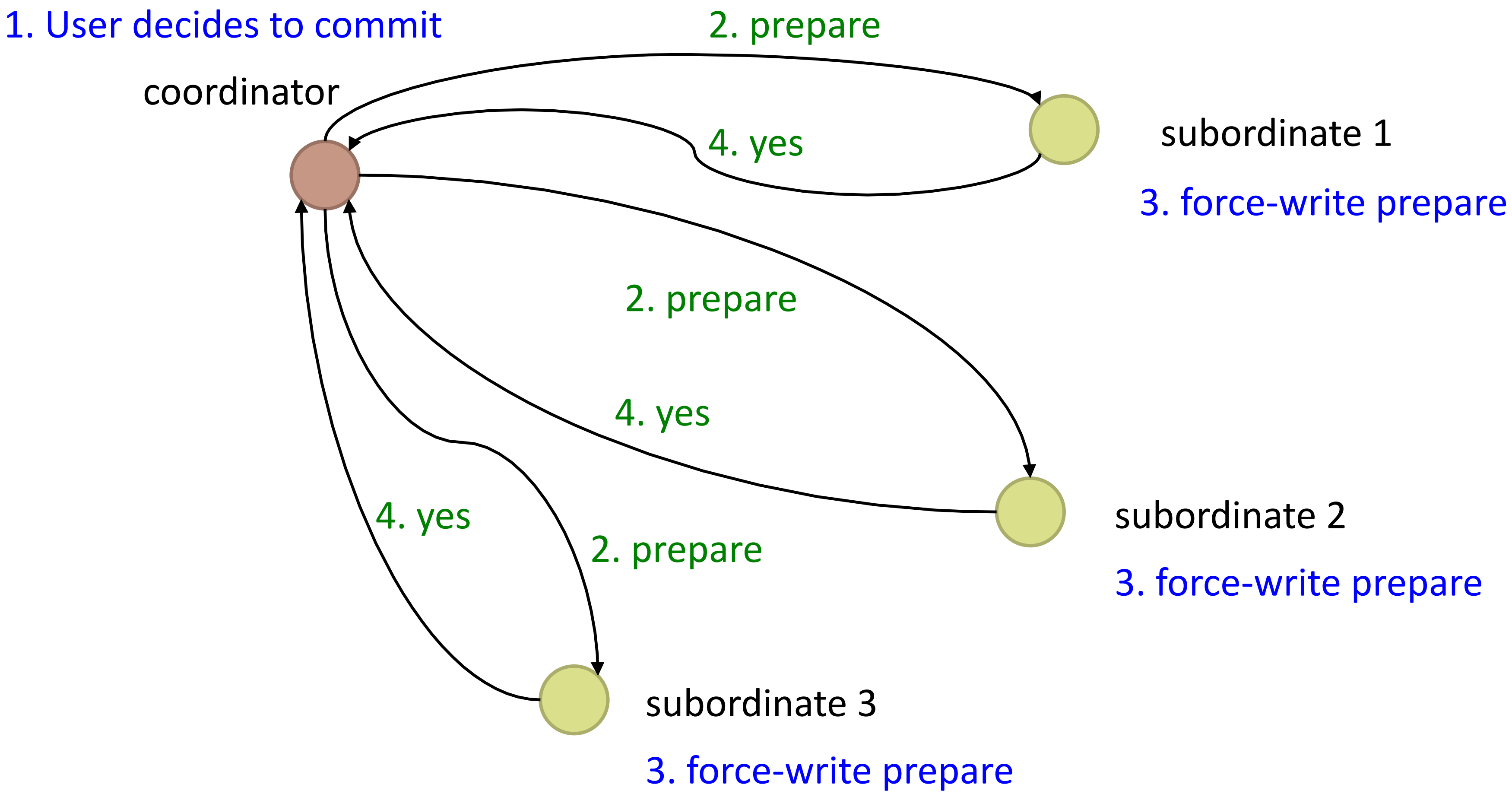
subordinate 3

# 2 Phase Commit

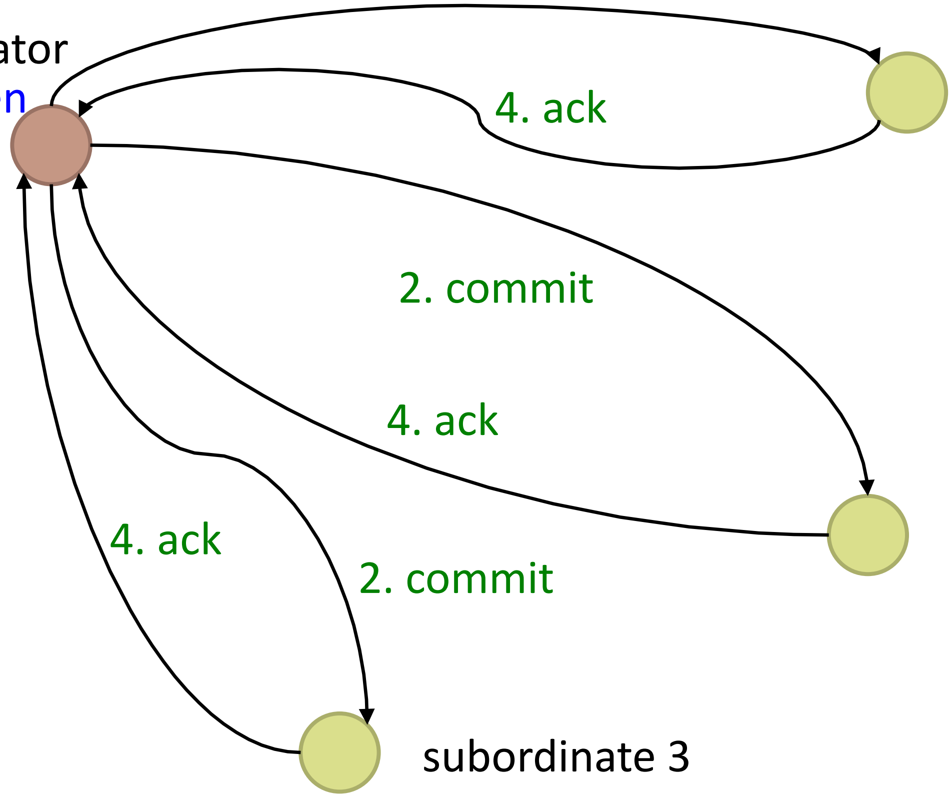
- Use 2 phases: a voting phase and a termination phase

- Principle:
  - When a process makes a decision, it votes yes/no or commit/abort
  - A subordinate acknowledges messages (acks)
  - Force-write log record before sending
  - Log records include Xact and coordinator ids
  - Coordinator logs ids of subordinates

# 2 Phase Commit: Phase 1



# 2 Phase Commit: Phase 2



1. Force-write commit

coordinator

5. Write end then forget Xact

2. commit

4. ack

subordinate 1

3. force-write commit

5. Commit Xact and forget it

2. commit

4. ack

subordinate 2

3. force-write commit

5. Commit Xact and forget it

4. ack

2. commit

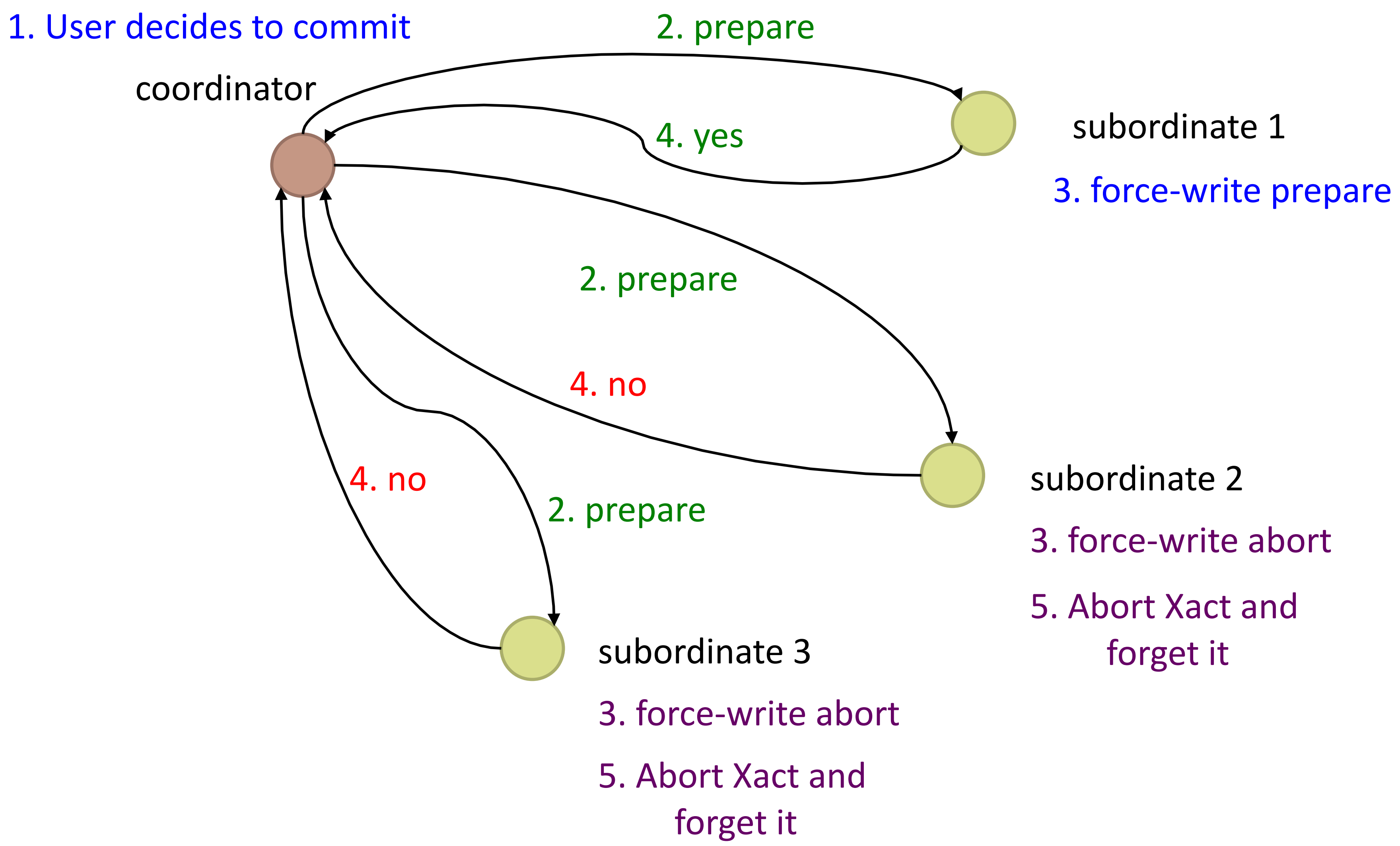
subordinate 3

3. force-write commit

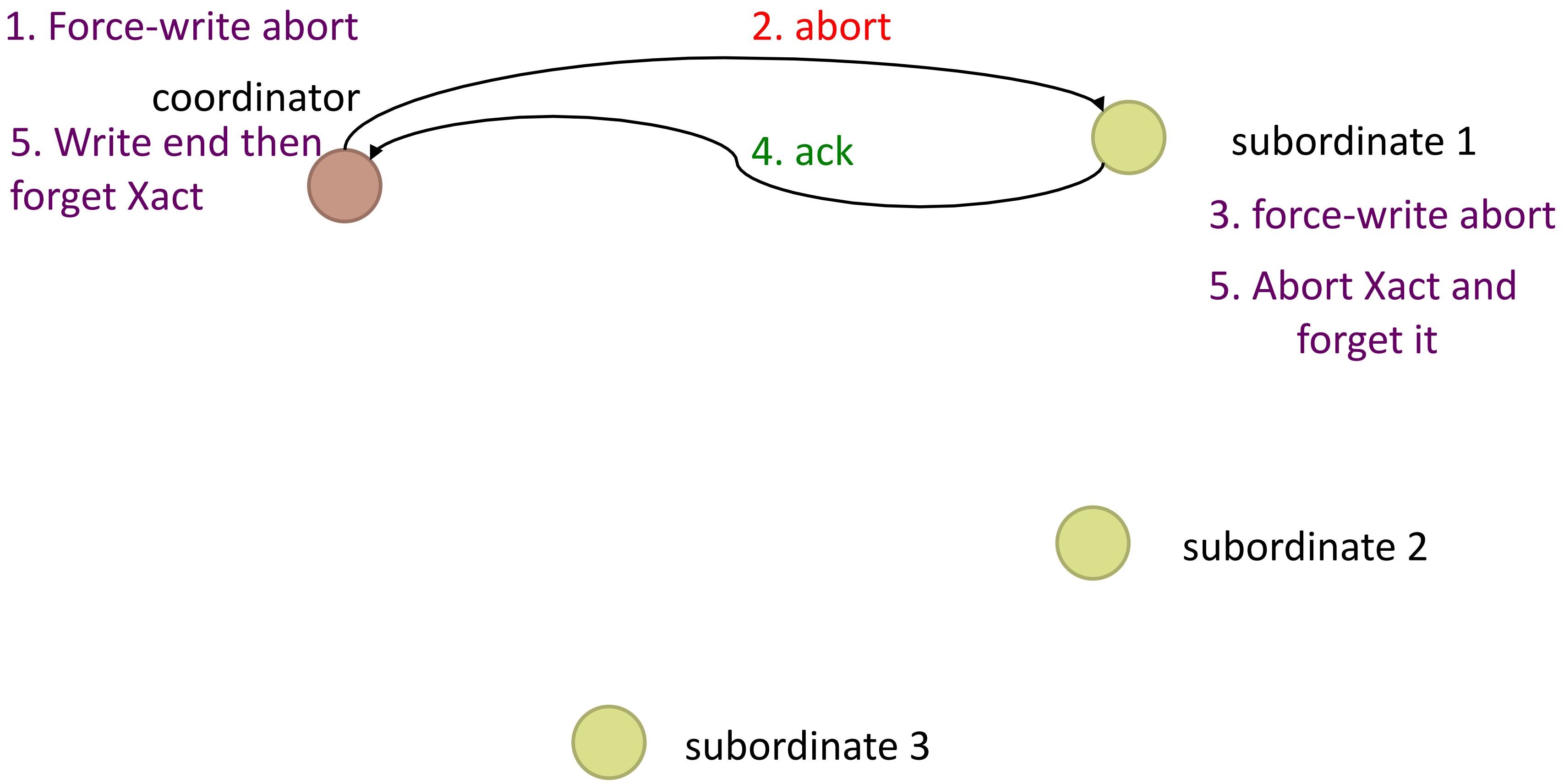
5. Commit Xact and forget it

Xact is now committed

# 2 Phase Commit: Phase 1 with abort



# 2 Phase Commit: Phase 2



1. Force-write abort

2. abort

coordinator

5. Write end then forget Xact

4. ack

subordinate 1

3. force-write abort

5. Abort Xact and forget it

subordinate 2

subordinate 3

# Restart after failure

- How do we know if we are coordinator or subordinate, and what do we do?

- We see a commit or abort record
  - We are coordinator: send to subordinates until we get an ack

- We see a prepare record
  - We are subordinate: contact coordinator to determine status

- We see no prepare, commit or abort
  - We can unilaterally abort

Any issues?

# Refinement: 2PC with presumed abort

- Observations:
  - Coordinator waits for acks to ‘forget’ Xact
  - no information = abort
  - A reader does not care for commit/abort outcome
- Refinements:
  - If abort is decided, remove Xact from Xact table immediately
  - If I get an abort msg, no need to ack
  - The abort log record of the coordinator does not need the subordinate list
  - Abort records don’t need to be force-written
  - A reader Xact votes reader instead of yes/no
  - Coordinator does not need to communicate further with readers
  - If all are readers, no need for the 2nd phase