# CS 194: Distributed Systems
*Distributed Commit, Recovery*

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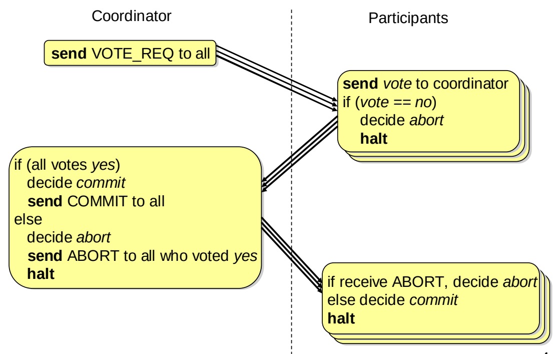
## Distributed Commit

- **Goal**: Either **all** members of a group decide to perform an operation, or **none** of them perform the operation

## Assumptions

- Failures:
  - Crash failures that can be recovered
  - Communication failures detectable by timeouts
- Notes:
  - Commit requires a set of processes to agree…
  - …similar to the Byzantine general problem…
  - … but the solution much simpler because stronger assumptions

## Two Phase Commit (2PC)



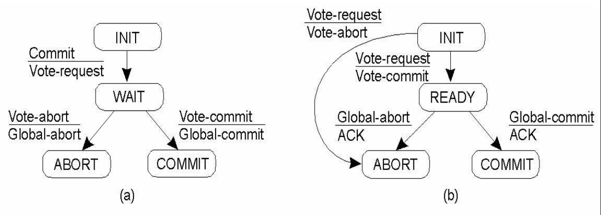
```
send VOTE_REQ to all
```

```
send vote to coordinator
if (vote == no)
    decide abort
    halt
```

```
if (all votes yes)
    decide commit
    send COMMIT to all
else
    decide abort
    send ABORT to all who voted yes
    halt
```

```
if receive ABORT, decide abort
else decide commit
halt
```

## 2PC State Machine



a) The finite state machine for the coordinator in 2PC
b) The finite state machine for a participant

## 2PC: Crash Recovery Protocol

*Stable storage* is persistent memory that supports writes that are atomic with respect to failures

Log actions:

| | |
|---|---|
| *c* sends VOTE_REQ | write `start` |
| *p* votes YES | write `yes` |
| *p* votes NO | write `abort` |
| *c* decides commit | write `commit` |
| *c* decides abort | write `abort` |
| *p* receives decision | write decision |

*commit point*

## 2PC: Crash Recovery Protocol

Upon recovery a process *r* starts reading the values logged to stable storage.

- If there is a `start` then *r* was the coordinator:
  - If there is a subsequent `abort` or `commit` then decision was made; otherwise decide *abort*.
- Otherwise, *r* was a participant:
  - If there is `abort` or `commit` then the decision was made;
  - If there is no `yes` then decide *abort*.
  - Otherwise (i.e., there is an `yes` record) run termination protocol.

... when can these records be garbage collected?

## Recovery Techniques: Checkpoints

- Goal: recover a process from error
- Backward recovery: checkpoint the state of the process periodically
  - Go to previous checkpoint, if error
  - Problem: same failure may repeat
- Forward recovery: go to a known good state if error
  - Problem: need to know in advance which error may occur

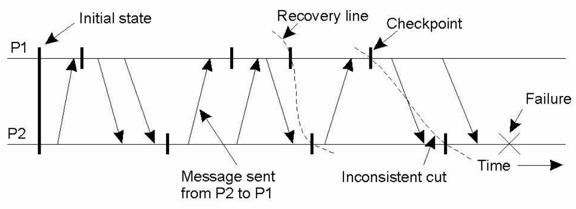
## Example: Reliable Communication

- Backward recovery: retransmit packet if lost
- Forward recovery: use erasure coding
  - Instead of sending *k* packets, send $n > k$ using erasure coding
  - As long as receiver gets at least *k* packets out of *n*, it can reconstruct the original *k* packets

## Recovery Techniques: Message Logging

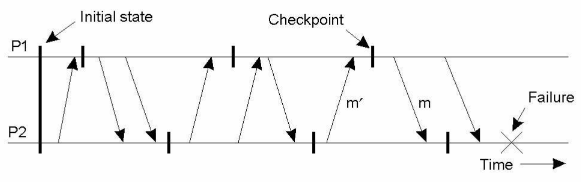
- Sender based: sender logs message before sending it out
- Receiver based: receiver logs message before delivering it
- Replay log messages between checkpoints → restore state beyond most recent checkpoint

## Distributed Checkpointing: Recovery Line



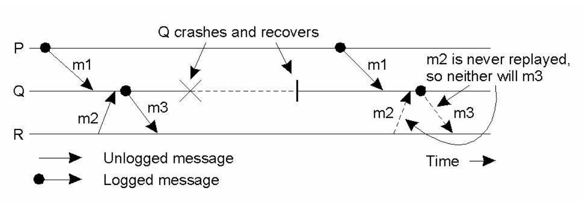
- Recovery line: most recent snapshot
  - If a process P has recorder the receipt of message m there should be a process Q that recorded sending of message m
- How do you find a recover line?

## Independent Checkpointing: The Domino Effect



- Domino effect: cascaded rollback to find a recovery line
- Solutions:
  - Coordinate checkpointing: use two-phase non-blocking protocol (see the book)
  - Logging and replaying messages

## Message Logging and Checkpointing



- Incorrect replay of messages after recovery, leading to an orphan process

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## Stable Storage

- Storage designed to survive anything except major calamities
- Use two disks to record identical information
  1) Write and verify sector on disk 1
  2) Write and verify sector on disk 2
- Recovery
  - Verify all sectors
  - If two corresponding sectors differ, copy sector from disk 1 to disk

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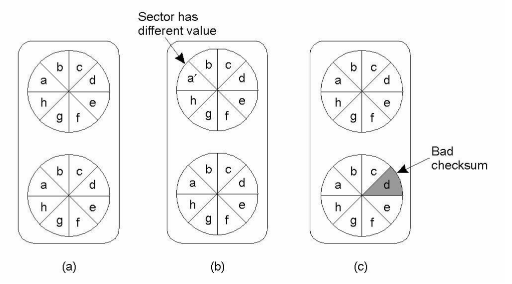
## Stable Storage Recovery



a) Stable Storage
b) Crash after drive 1 is updated
c) Bad spot

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