Outline

- Introduction
- Background
- Distributed DBMS Architecture
- Distributed Database Design
- Distributed Query Processing
- Transaction Management
    - Commit/Termination protocols – 3PC
- Building Distributed Database Systems (RAID)
- Mobile Database Systems
- Privacy, Trust, and Authentication
- Peer to Peer Systems

Useful References

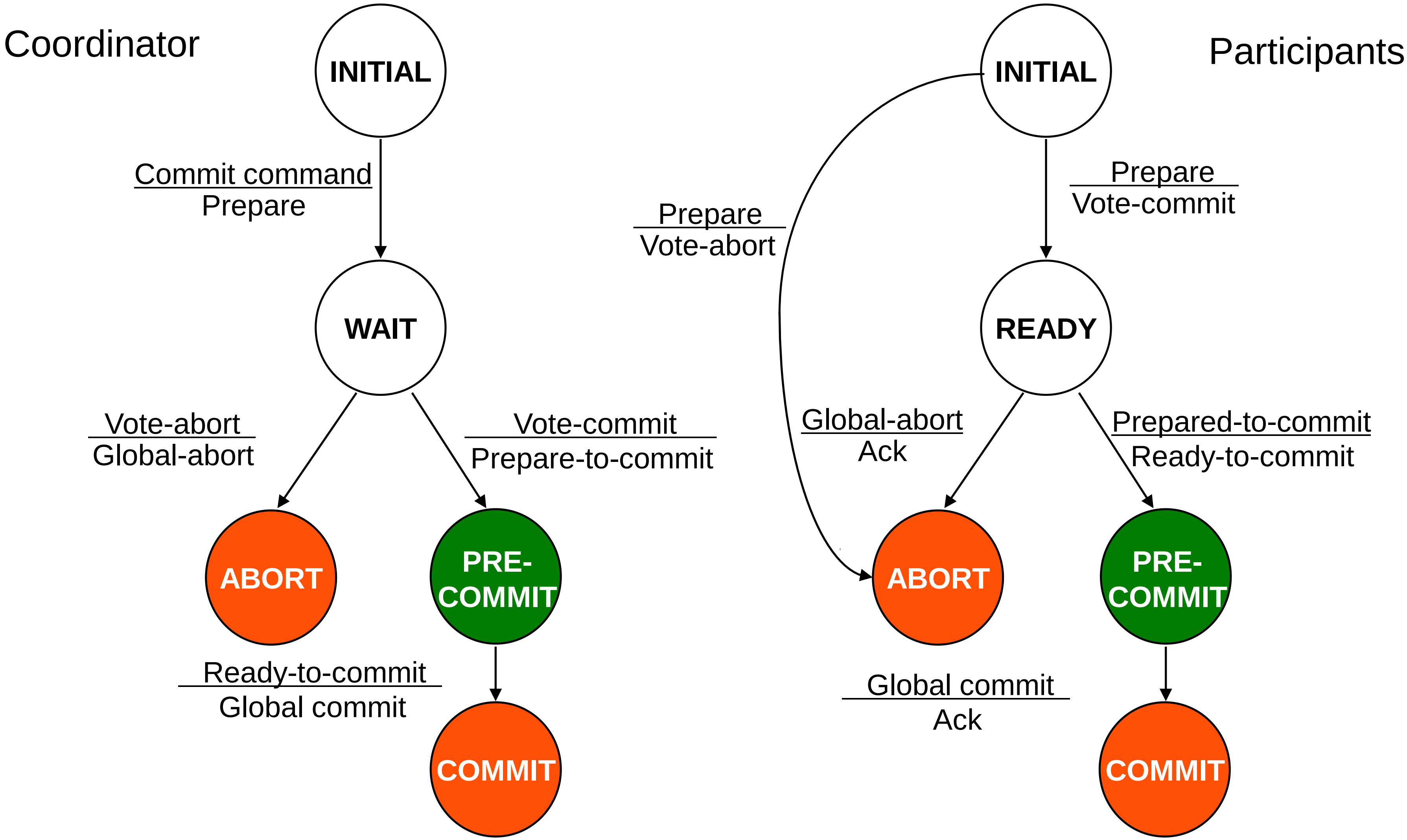
- Textbook *Principles of Distributed Database Systems*,

  Chapter 12.5

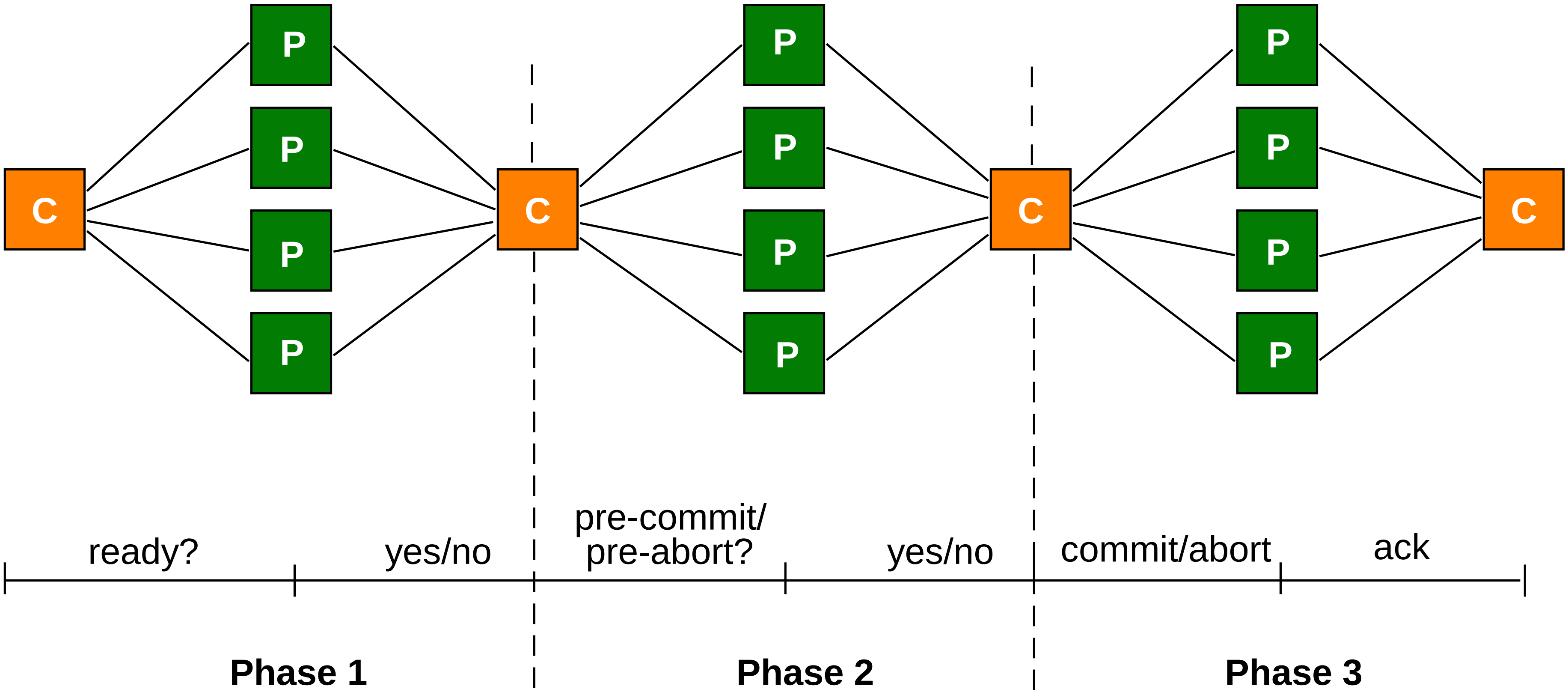
Three-Phase Commit

- 3PC is non-blocking.
- A commit protocols is non-blocking iff
  - it is synchronous within one state transition, and
  - its state transition diagram contains
    - no state which is “adjacent” to both a commit and an abort state, and
    - no non-committable state which is “adjacent” to a commit state
- Adjacent: possible to go from one stat to another with a single state transition
- Committable: all sites have voted to commit a transaction
  - e.g.: COMMIT state

State Transitions in 3PC



Communication Structure (see book)



Formalism for Commit Protocols

$$< \mathbf{Q}, \Sigma_I, \Sigma_0, \delta, V, A, C >$$

$\mathbf{Q}$:	Finite set of states
Σ_I:	Messages addressed to the site
Σ_0:	Messages sent by the site
δ:	$(\mathbf{Q}, \Sigma_I^*) \rightarrow (\mathbf{Q}, \Sigma_0^*)$
$V_i \in \mathbf{Q}$:	Initial state
$A \subset \mathbf{Q}$:	Abort states
$C \subset \mathbf{Q}$:	Commit states

Formalism for Commit Protocols

Properties:

1. $A \cap C = \phi$
2. $V_i \notin A$ and $V_i \notin C$

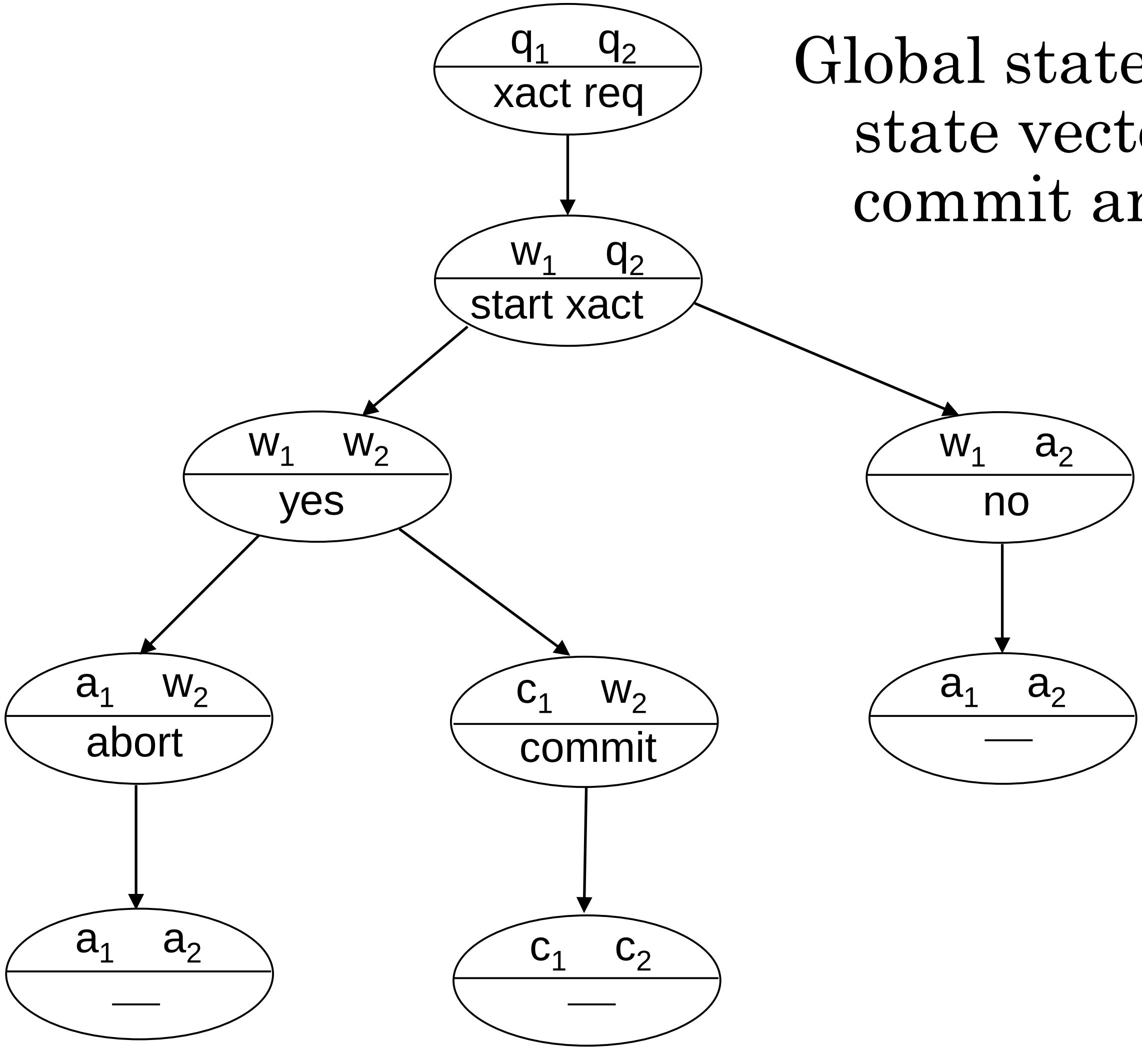
Protocols are non-deterministic:

- Sites make local decisions.
- Messages can arrive in any order.

Global State Definition

- Global state vector containing the states of the local protocols.
- Outstanding messages in the network
- A global state transition occurs whenever a local state transition occurs at a participating site.
- Exactly one global transition occurs for each local transition.

Global Sate Graph



Global state is inconsistent if its state vector contains both a commit and abort state.

Two states are potentially concurrent if there exists a reachable global state that contains both local states.

Concurrency set of s is set of all local states that are potentially concurrent with it. C(s)

$$C(w_1) = \{q_2, a_2, w_2\}$$

The sender set for s,

$$S(s) = \{t / t \text{ sends message } m \ \& \ m \in M\}$$

where M be the set of messages that are received by s.

t is a local state.

States of Various States in the Commit Protocol

- Global state inconsistent if it contains both
  - local commit state
  - local abort state
- Final state if
  - All local states are final
- Terminal state if:
  - there exists an immediately reachable successor state
  - $\Rightarrow$ deadlock
- Committable state (local) if:
  - all sites have voted yes on committing the transaction
- Otherwise, non-committable

An Example when Only a Single Site Remains Operational

- This site can safely abort the transaction if and only if the concurrency set for its local state does not contain a commit state
- This site can safely commit only if
  - Its local state must be "committable"
  - And the concurrency set for its state must not contain an abort state.
- A blocking situation arises when
  - The concurrency set for the local state contains both a commit and an abort state
  - Or the site is in a "noncommittable" state and the concurrency set for that state contains a commit state
    - The site can not commit because it can not infer that all sites have voted yes on committing
    - It can not abort because another site may have committed the transaction before crashing.
- There observations imply the simple but power result in the next slide

Fundamental Non-blocking Theorem

- **Definition**: protocol is synchronous within one state transition if one site never leads another site by more than one state transition.
- **Theorem** Fundamental non-blocking: A protocol is non-blocking iff
  - There exists no local state s

    C(s) = A (abort) and C (commit)
  - And there exists no non-committable state s

    C(s) = C (commit)
- **Lemma**: A protocol that is synchronous within one state transition is non-blocking iff:
  - No local state is adjacent to both a commit & an abort state
  - No non-committable state is adjacent to a commit state

Three-Phase Commit Protocol