8 Fault Tolerant Distributed Transactions : 2PC

8.1 One Phase Commit
8.2 3PC: nonblocking
8.2 Paxos consensus
8.6 Paxos in practice

- based on Weikum / Vossen; Valduriez / Öszu; Garcia-Molina ; Reuter/ Gray

8.1 One phase commit

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Example: Calendar application

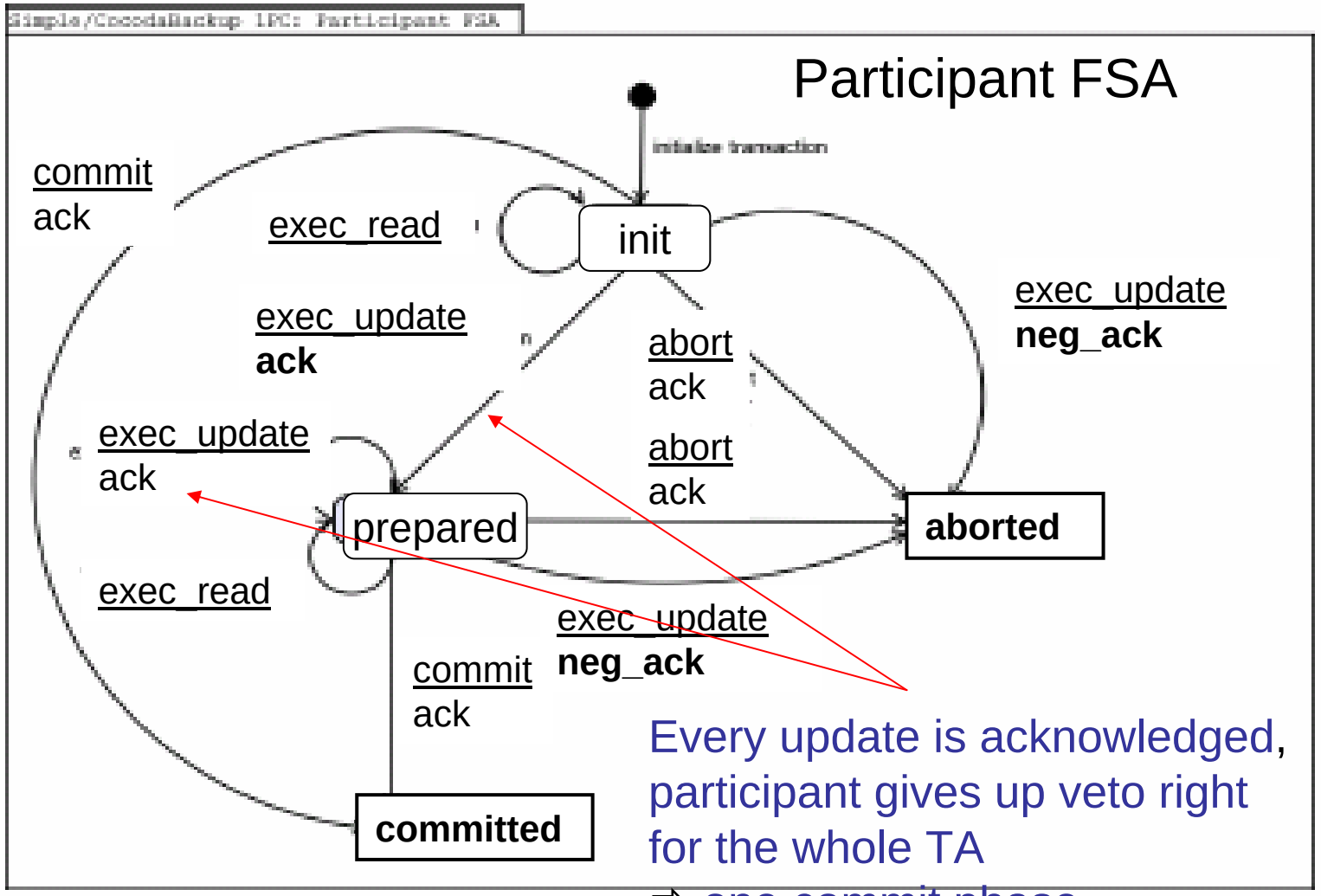
Application protocol: agreement on the date / time of some event.

e.g:

```
".. everyone happy with suggested date?
      if one participant votes no,
           coordinator makes new suggestion
      else commit  (1-phase)"
```

Agreement between nodes in processing phase, not during commit.

1PC: participant protocol



Characteristics of 1PC

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Blocking?

Yes! When?

Two types of blocking:

- **participant failure**
- **coordinator failure** – more serious, why?

Window of uncertainty in failure free case?

Number of messages for commit /abort?

Suppose **n participants**.

More involved task

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n participants, each having a variable x_i

clients send increments ("+j") to each of them

no individual ack of an increment operation, (but of msg received)

---- end of operation phase ------

Condition for successful operation: all increments successful (no overflow, or alike)

If not successful: participants reset x_i

Commit coordinator has to decide!

Commit phase? 1PC is not sufficient to come to a unanimous result! Why?

work phase

commit phase

8.2 Three phase commit: the basic idea

Observation:

There is no distributed commit protocol (DCP) which avoids blocking with multiple failures.*

⇒ no independent recovery of failed processes (nodes) in general

⇒ External input needed for learning the fate of the TA, i.e. commit / abort decision depends on coordinator input

Basic idea: Introduce a new state which avoids the dependency on external input

*with least one. communication failure

Last lecture: Useful Invariant

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Goal: avoid blocking!

"If a participant P is uncertain then there is no P' which got a commit decision if P, P' are alive or not" (*)

Have shown: **Invariant does not hold for 2PC**

(*) + only site failures: uncertain participants can decide to abort the TA

$\Rightarrow$ Find a protocol which satisfies (*)

Blocking

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Can blocking be avoided?

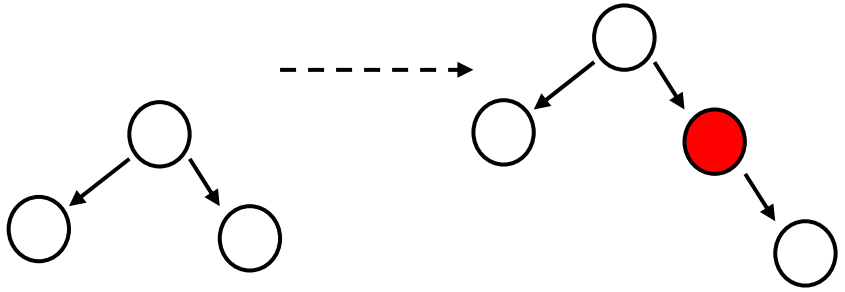
YES ...?

No "communication failure" assumption:

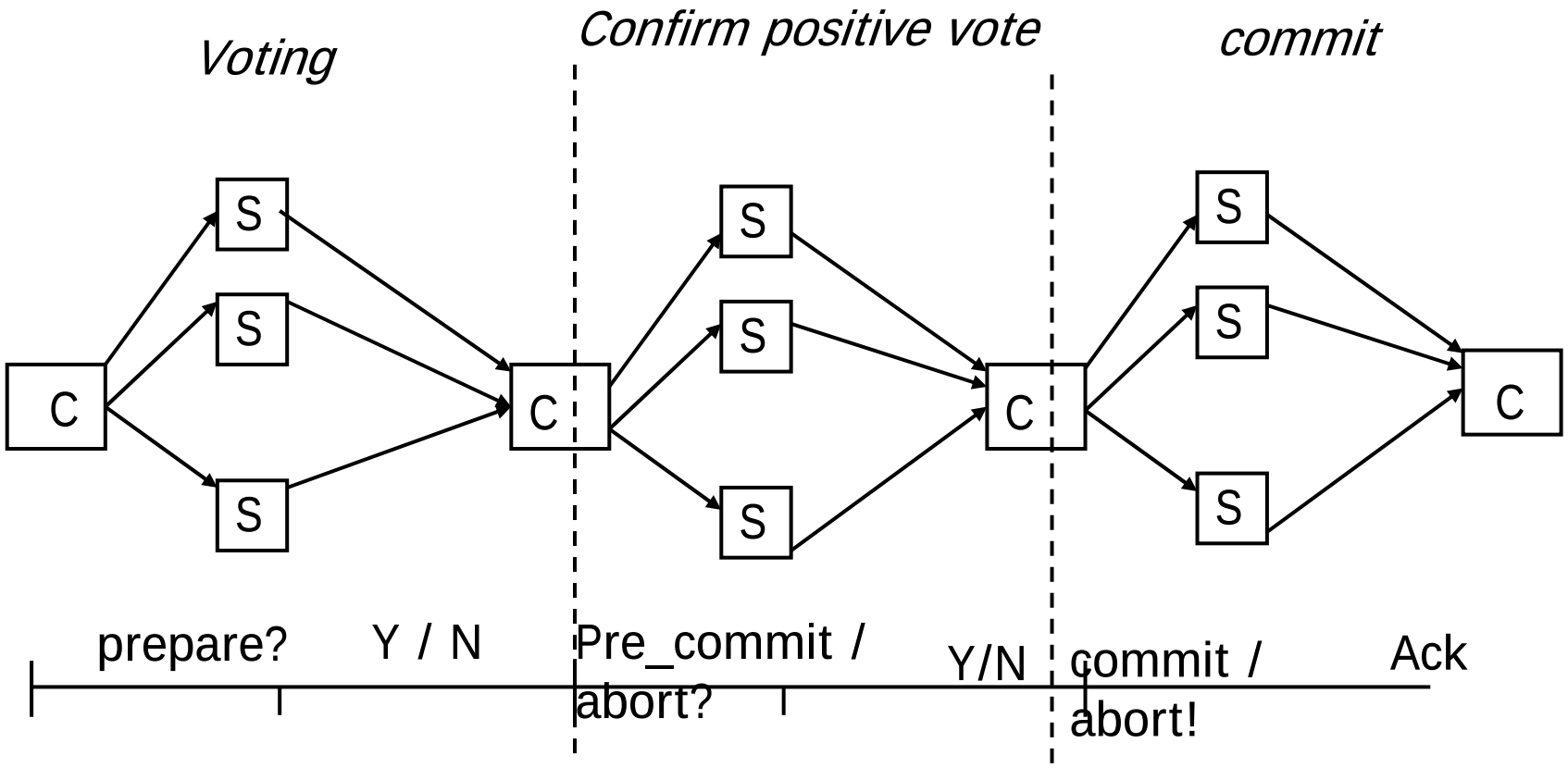
Process may fail during execution
of commit protocol, but no messages lost

If the failure assumption (no communication failure) holds, there is a non-blocking distributed commit

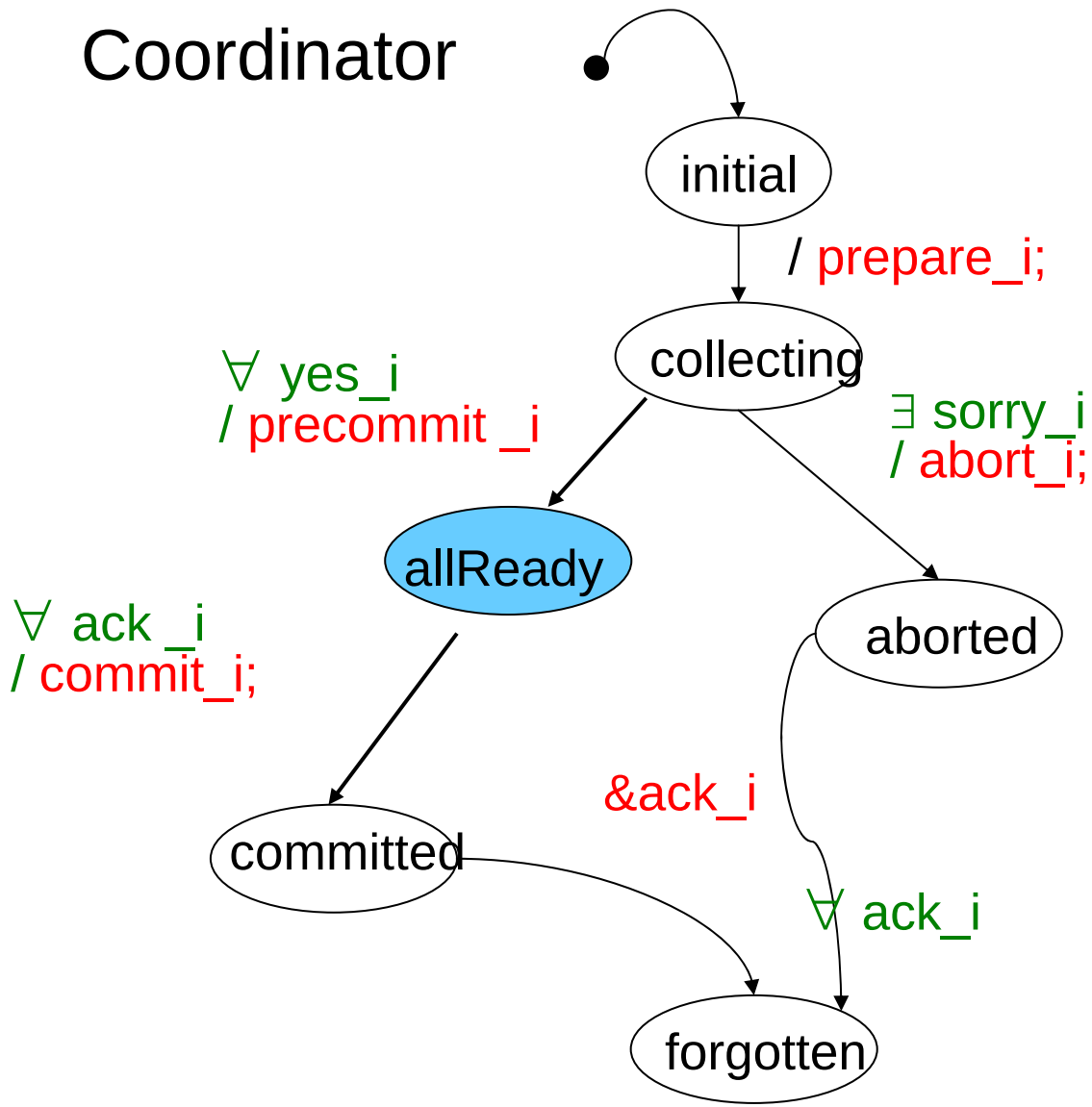
Proof idea: avoid state transitions dependent on external input



Non-blocking commit, three phases

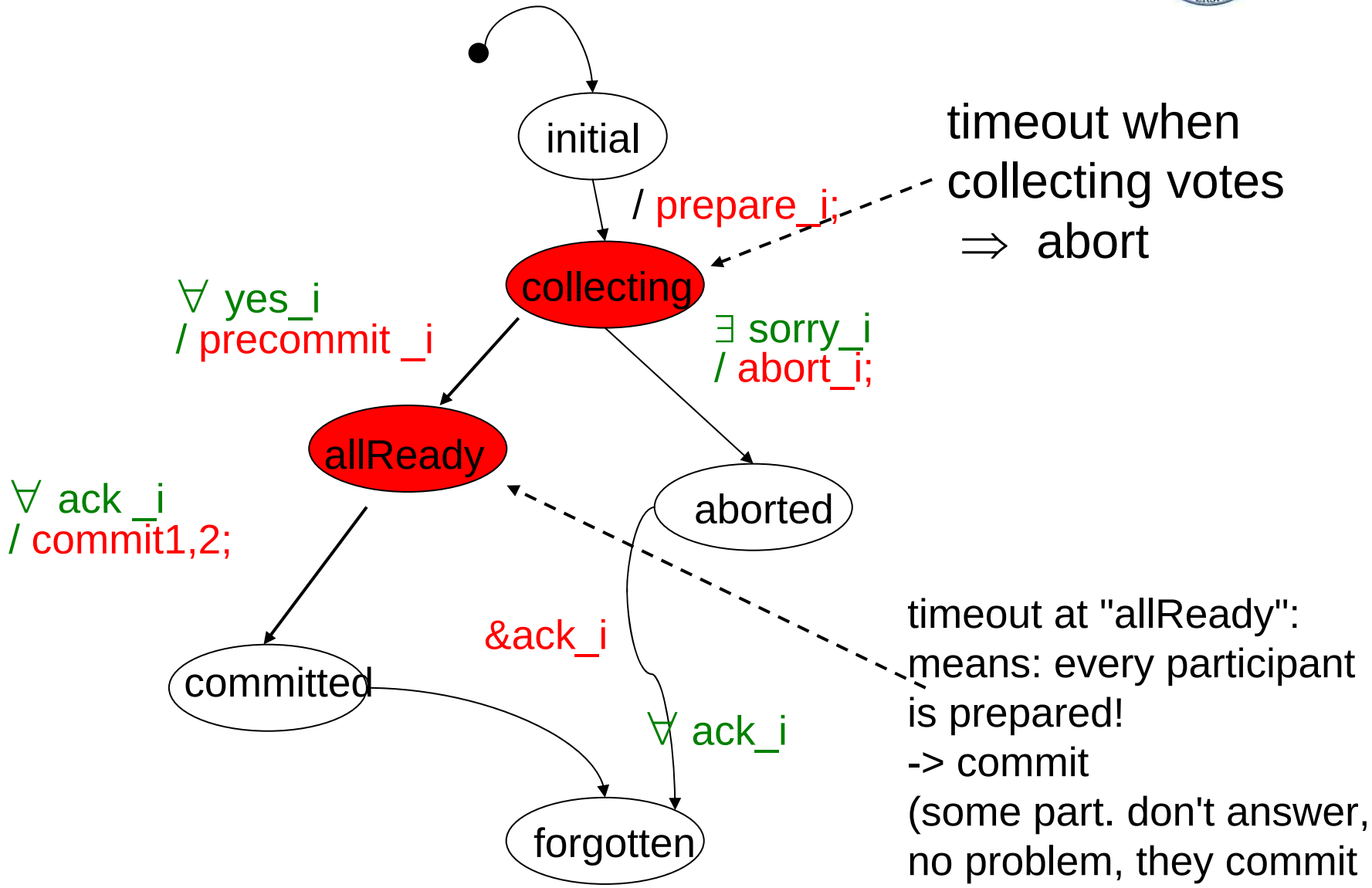


3 PC - coordinator



At "allReady":
every participant is prepared!
-> TA can commit

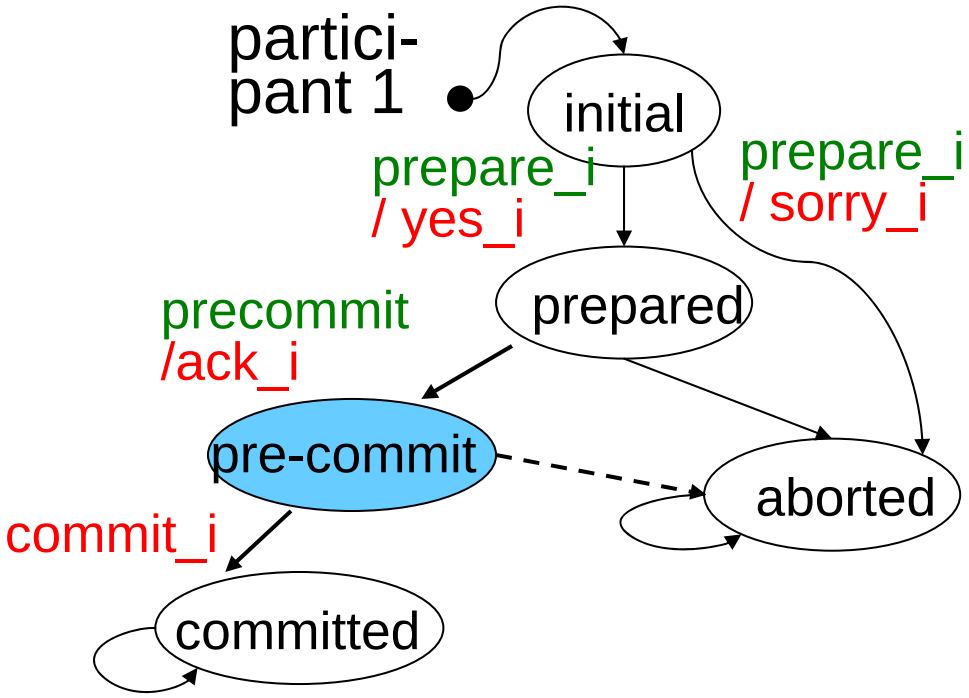
Coordinator termination



timeout when collecting votes
⇒ abort

timeout at "allReady": means: every participant is prepared!
-> commit
(some part. don't answer, no problem, they commit later)

3PC - participant

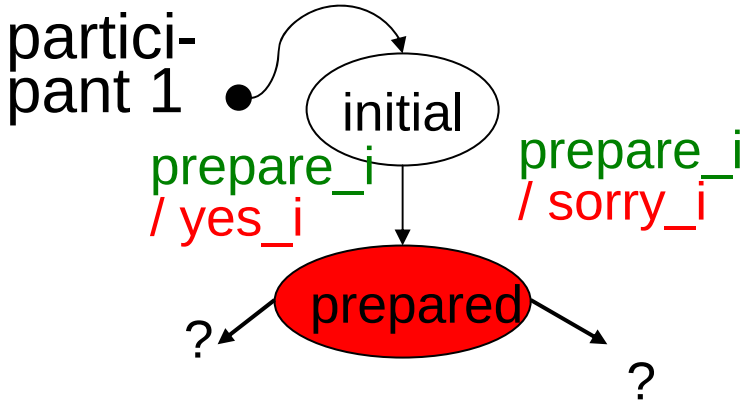


Why no blocking?

- Participant waits at 'prepared' or 'pre-commit'

Termination for prepared participants

Participants



Timeout in "prepared":
Find a new coordinator
and terminate according
to state of other participants

NewCoord:
"abort" ⇨ Action "abort"

NewCoord:
"prepared" ⇨other participants
in "prep"| "abort"|"
Action: abort

NewCoord:
"pre-c" ⇨other participants in
"prep"|"pre-c"| "commit"
Action: "commit"
idempotent? ⇒ continue
3PC-coordinator protocol

Timeout in "pre-commit": in an analogue manner

Net Partitioning

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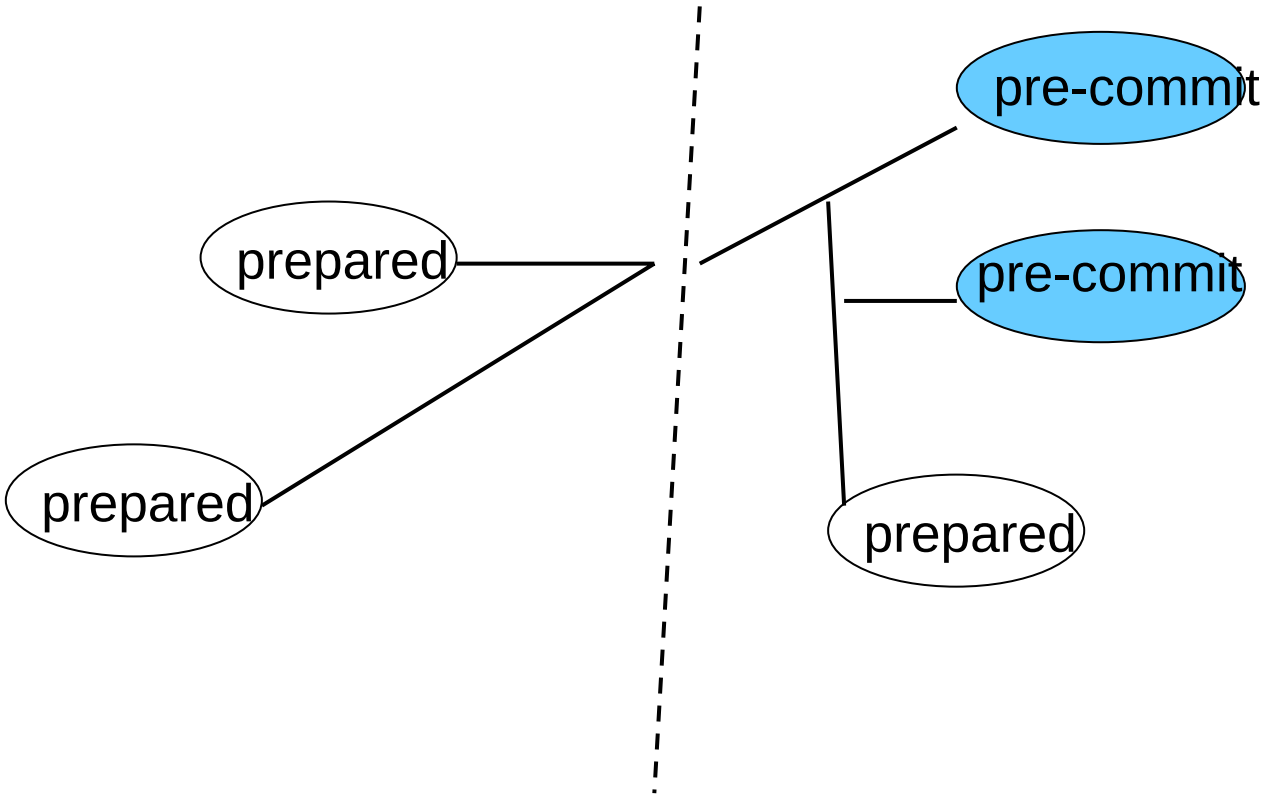
Why does protocol not work in partitioned net?



Decides: abort

Decides: commit

How important is 3PC?

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Three phase commit challenging….

… but not really important in practice – up to now (?)

Message overhead

("Make typical case fast", is failure typical?)

Practice today:

- make 2 PC fast,
- reduce blocking probability
- blocking seems to be important (see Oracle's commit point), but no serious analysis

All kinds of variants

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e.g

Early Commit:

- Send commit with last operation
- leads to unblocking, but uncertainty
- compensation if final decision is abort

"Early Prepare"

- Send prepare with last operation
- may lead to longer blocking phase
- what else? (-> Übungen)