CS514: Intermediate Course in Computer Systems

Lecture 14: Oct. 15, 2003

Tracking Group Membership (part 2)

Coordinator-based membership

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- All membership events fed through the coordinator
  - Coordinator uses 2PC to insure all processes agree on membership
- If coordinator fails, oldest active process takes over coordinator role
  - Using a 3PC

So first, lets look at 2PC and 3PC

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- Lets look at 2PC and 3PC "generically"---that is, outside the context of membership protocols
  - In fact, we'll look at 2/3PC assuming a static membership
- Then we'll apply it to membership protocols per se

Fundamental idea:

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- Essentially like running a vote, where unanimity is required
  - I.e., outcome is yes if all vote yes
  - Outcome is no otherwise
- Two phases:
  - First gather votes from all *participants*
  - Then tell all participants the outcome of the vote

Human example

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- Say you want to schedule a meeting among a group of people
  - Must find a time when *all* people can attend---if any one cannot attend, must find another time

Meeting coordinator's actions:

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- First ask everyone "can you come at 2:00?"
- Wait for replies
- If anyone replies 'no', tell everybody there is no meeting
  - ***abort***
- If everyone replies 'yes', tell everybody there is a meeting
  - ***commit***

Meeting participant's actions:

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- Coordinator asks if you can attend at 2:00
- Check your calendar
  - If your answer is no, tell the coordinator and do nothing else
- If your answer is yes, "pencil in" the meeting time, and wait for confirmation
  - *Note that now you cannot commit that meeting time to anyone else!*
- If meeting confirmed, then commit the meeting time in your calendar
- If meeting canceled, then free the meeting time in your calendar

Other key concepts in 2/3PC

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- Resources may be "put on hold" until 2PC protocol completes
  - Resources are then subsequently either taken or freed
- 2PC may occur in parallel or in serial
  - Latter happens in the context of a "transaction"

Example of 2PC in a transaction

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- You want to take a trip to the world cup, but you won't go unless you get:
  - A flight, a hotel, a rental car, *and* tickets to a few matches
- You tentatively reserve each, and either:
  - Confirm them all if you get them all
  - Cancel them all if you fail to get any one

2PC picture

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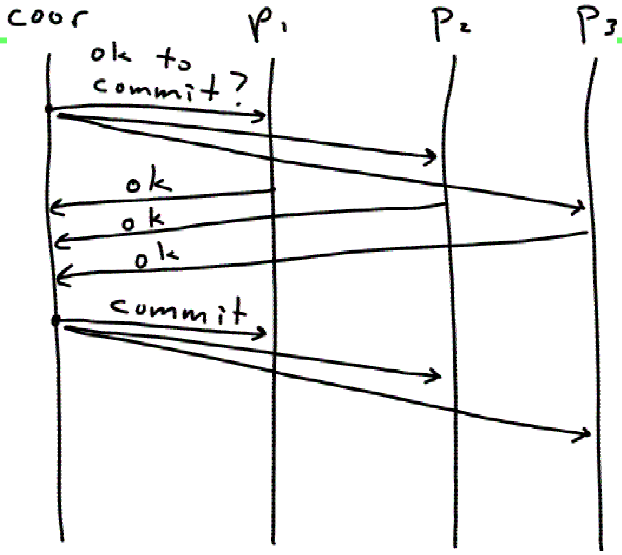

2PC picture

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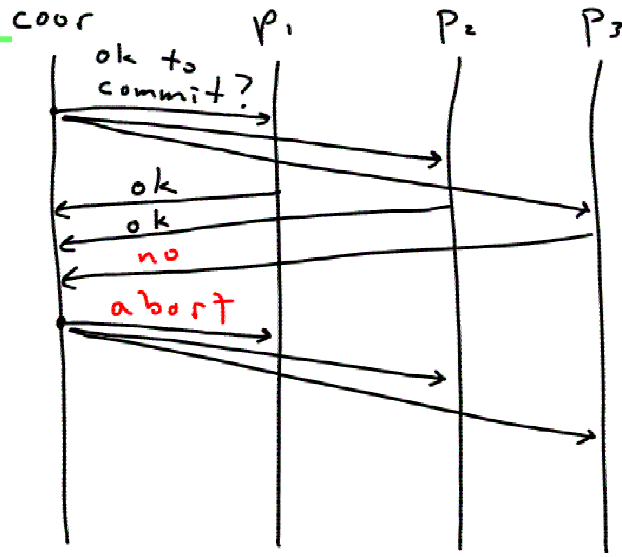

Coordinator algorithm

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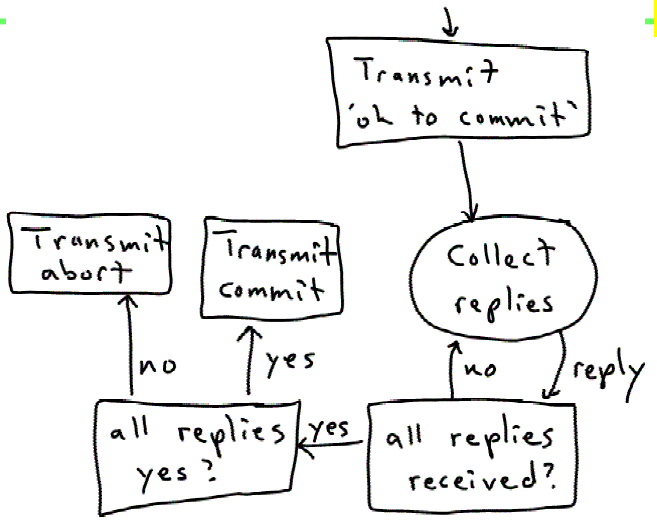

Participant algorithm

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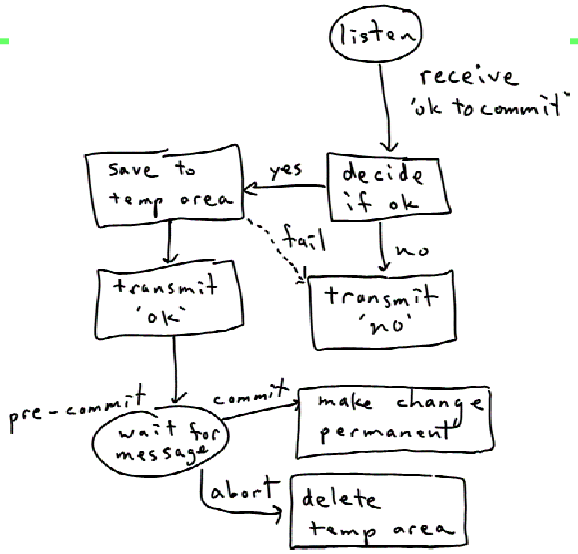

Things to consider

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- These algorithms are simple and clean, but . . .
- Don't consider various failures
  - And impact on other processes
  - Or impact on own garbage collection

Possible points of participant failure

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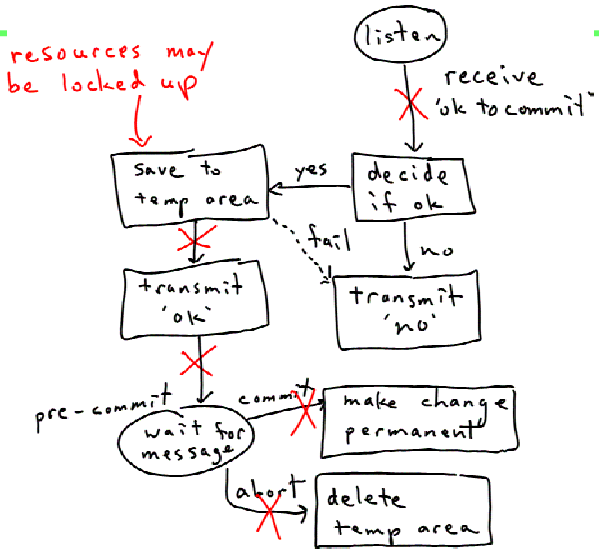

Logs allow recovery after failure

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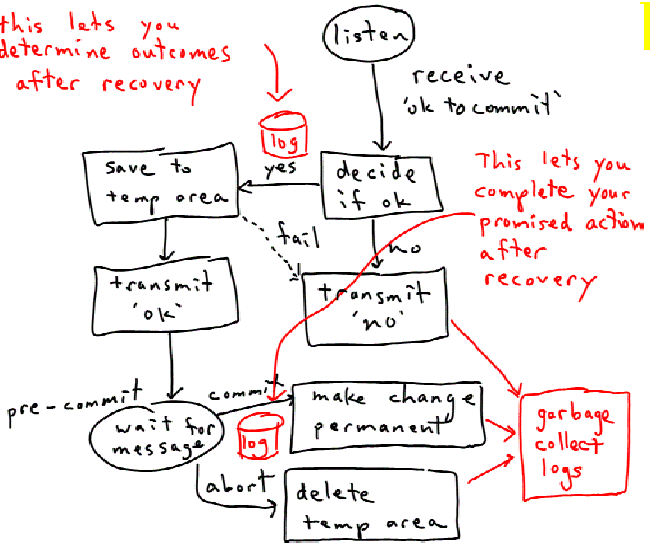

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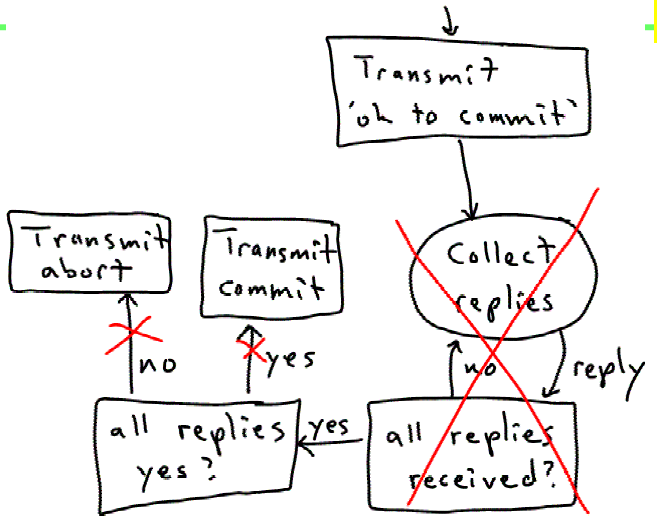

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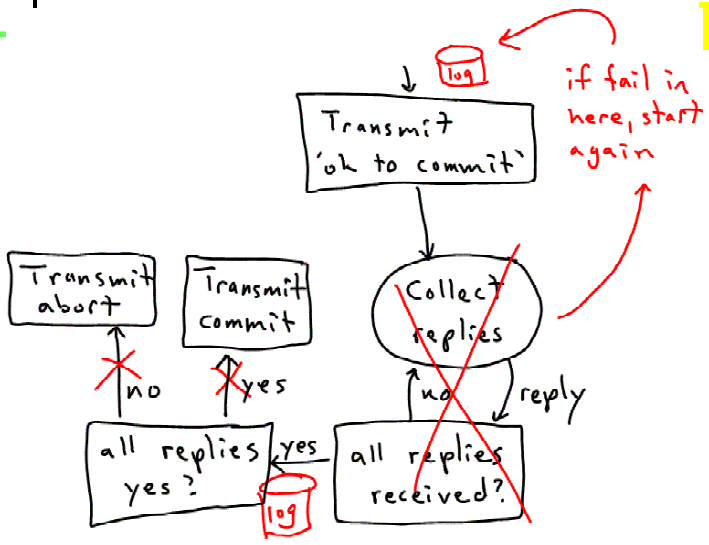

But require acks from participants to garbage collect

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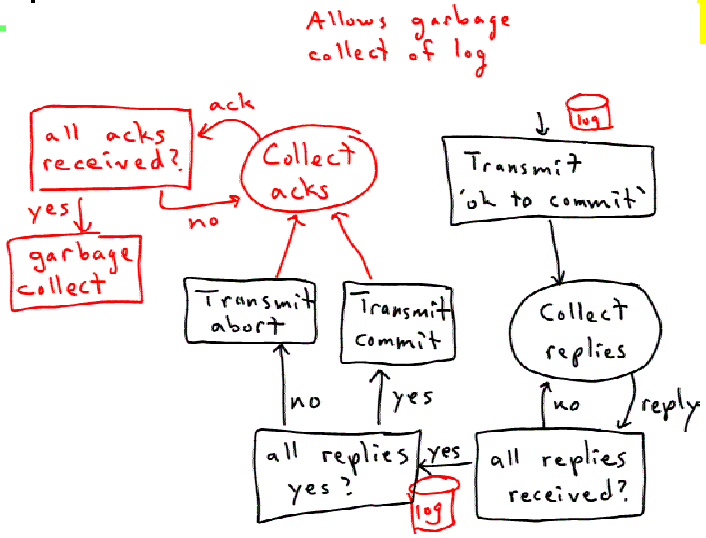

And duplicate message detection in participants

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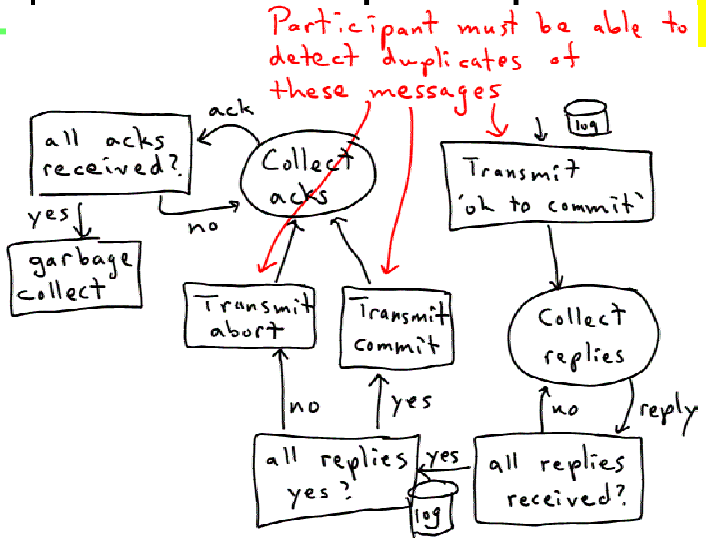

This naïve approach leads to lockup

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- If coordinator crashes, participants cannot release locked up resources
- We would at least like to be able to terminate a given 2PC protocol without the coordinator
  - Even if we don't have the ability to elect a new coordinator
- *Can a participant finish the coordinator role?*
  - Only if it knows the 2PC result (abort or commit)

Participant completion of 2PC

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- Participants that know outcome must wait until it is sure all other participants know outcome
- Participants in pre-commit can detect coordinator failure and finish the 2PC protocol

Participant completion of 2PC

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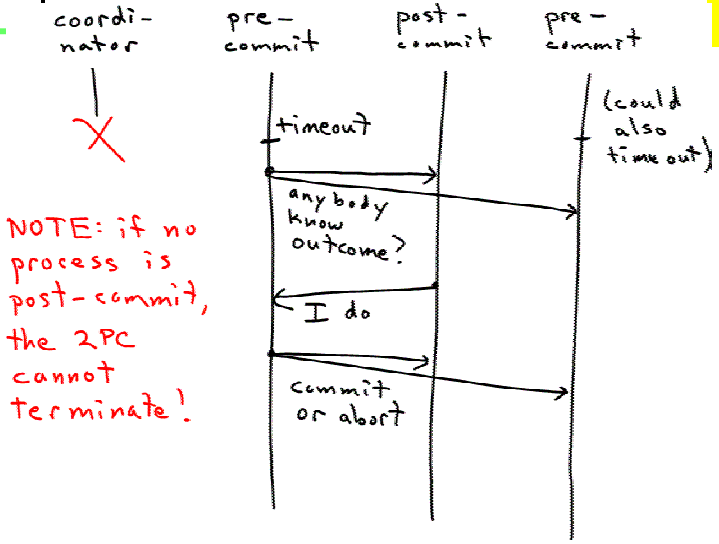

Post-commit participant has to delay garbage collect

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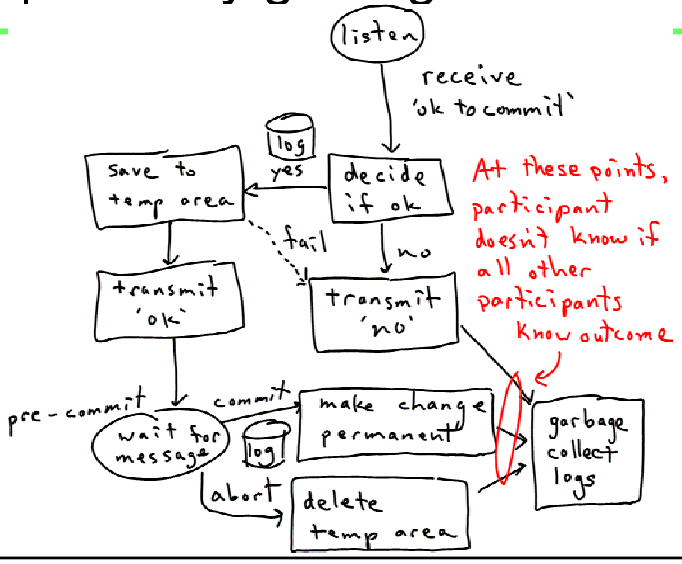

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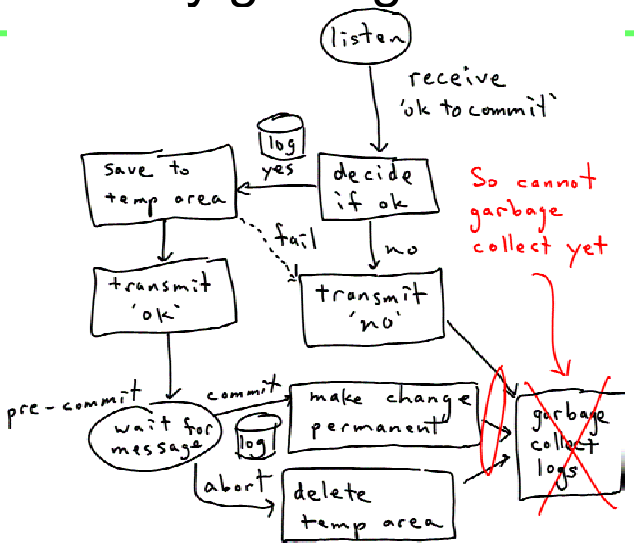

Final 2PC participant algorithm!

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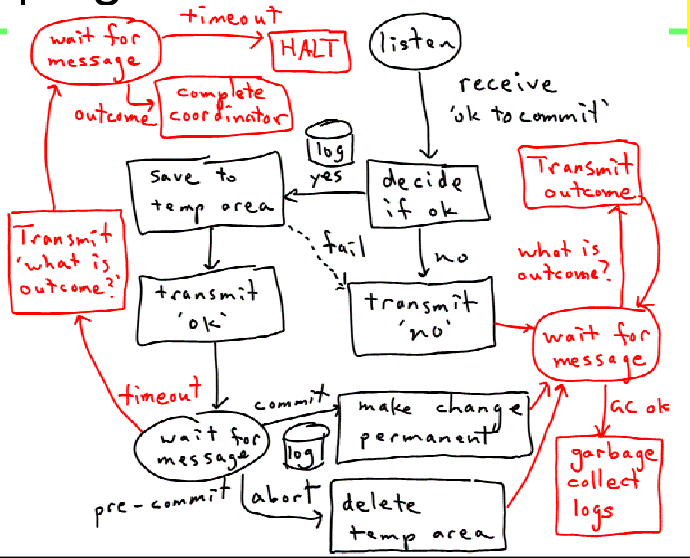

(compare with original naïve algorithm…)

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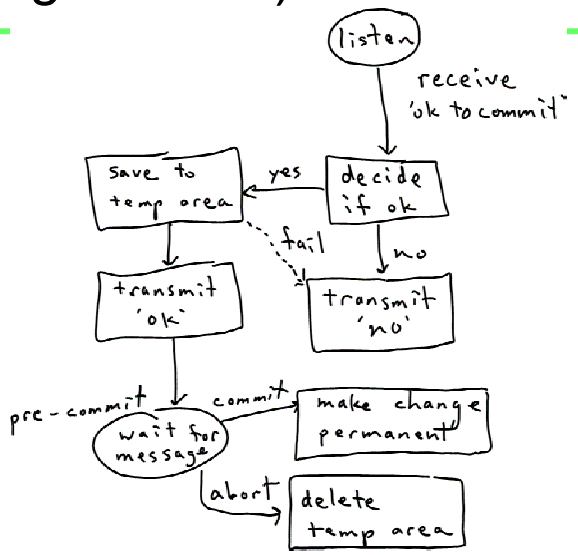

Final 2PC coordinator algorithm!

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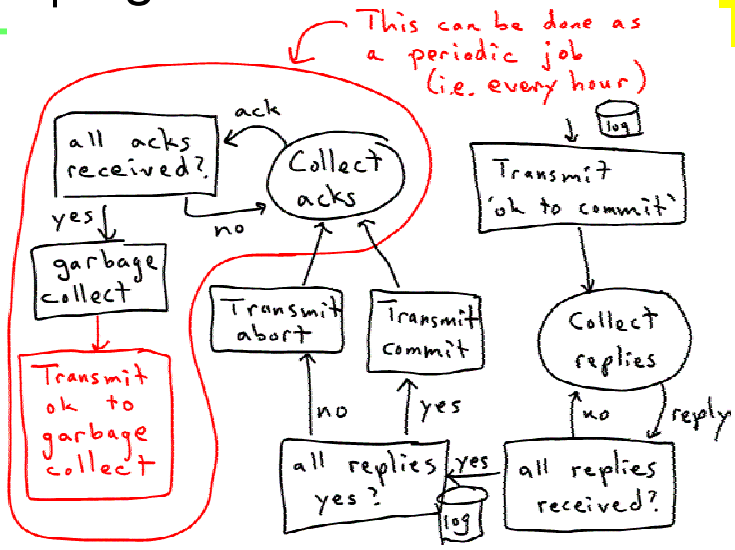

(again, compare with original naïve algorithm…)

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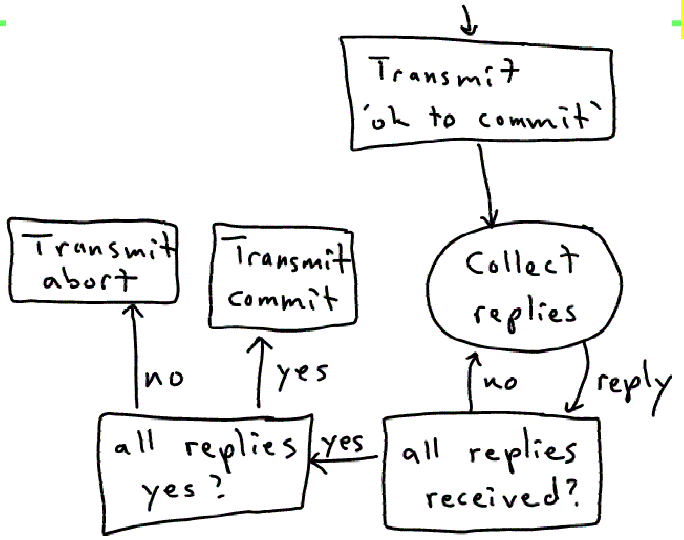

Coordinator algorithm optimization

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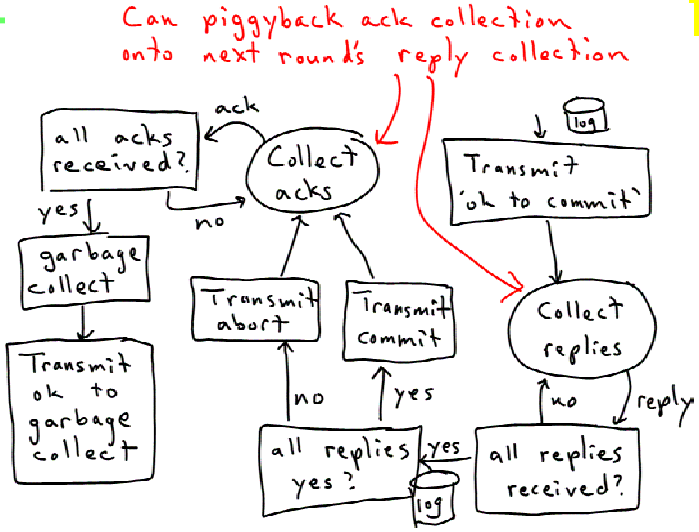

Coordinator algorithm optimization

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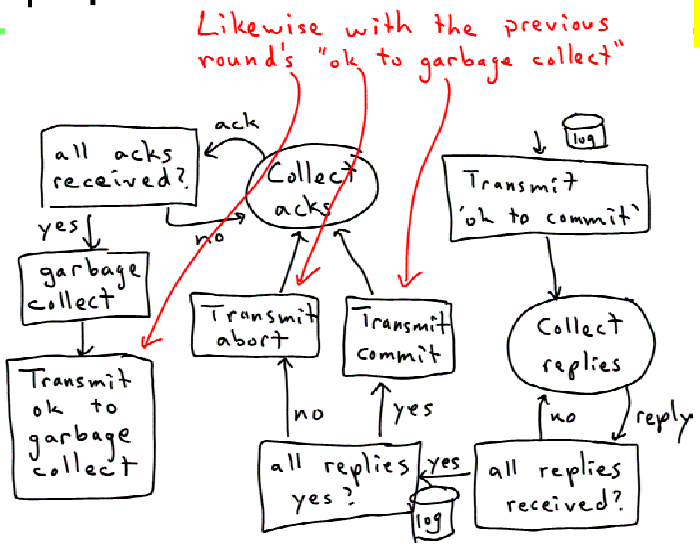

3PC can prevent the coordinator failure lockup

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- We won't cover it in class
  - (or on the final exam)
- You can read about it in Ken's book if you are curious
- It is a nice result, but too expensive to do in practice

Coordinator-based membership protocol

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- Coordinator manages the whole process
- Any process can detect failure of another process
  - Report it to the coordinator
  - There is constant keep-alive activity
- Any new process can send a join request to the coordinator
- Thus, at some point in time, coordinator has a join and leave list, and starts a new view

New view, no coordinator failure

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- Basically a 2PC
- In first phase, coordinator announces the join and leave lists, collects acks
  - At this point, existing processes “shun” leaving processes
  - This helps insure that they kill themselves in a fail-stop way (if not already dead)
  - The coordinator must receive acks from a majority of processes
- In the second phase, the coordinator commits the changes

New view, with coordinator failure

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- If the coordinator is detected as failed, the next oldest process assumes the coordinator role
- The new coordinator announces itself, starts collecting acks
  - At this point, the old coordinator is shunned, and will kill itself if alive
- When it has a majority of acks, the new coordinator will start the 2PC of the previous slide

Majority of processes fail

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- To avoid simultaneous partitioned segments operating independently, if a majority of processes fail, a new view cannot be established
  - Alarms go off, and the system must be restarted, essentially by hand