CS514: Intermediate Course in Computer Systems

Lecture 11: Oct. 10, 2003

Tracking Group Membership

We've seen . . .

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- The concept of logical time
- How it can be used to build ordering into group communications systems
  - FIFO, Causal, Total (Agreed)
- Different forms of message reliability
  - Best effort, reliable, safe
- All in the context of a "static" group of processes

Today we'll see …

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- How to provide the processes in a process group with the group membership
  - As processes join and leave the group, and fail
- Using some of the tools we've already learned

Recall Virtual Synchrony: A series of "views"

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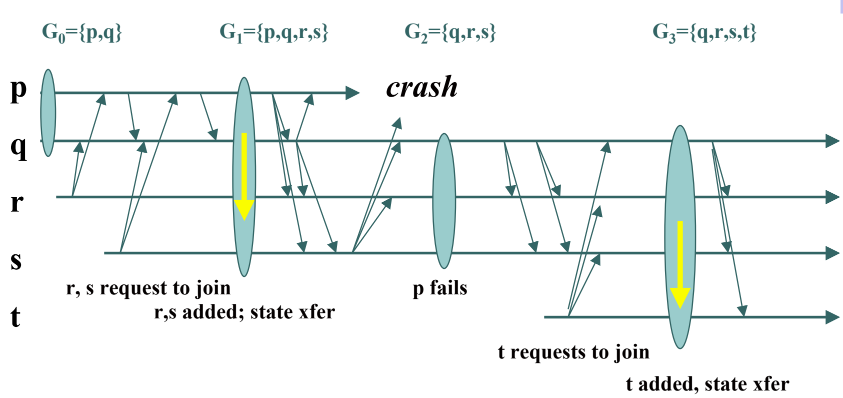

Properties of views

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- To be useful, a series of views requires certain properties:
  - Call V the old view, and V’ the subsequent new vies
- At least one process in V’ must also have been in V
  - Obviously: otherwise the system state cannot be maintained across views

Properties of views

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- The delivery semantics of messages sent but not delivered in view V must be maintained in the new view V’ for all processes both in V and V’.
  - Even when the sending process is not in V’
  - This allows the application to not worry about synchronizing system state in continuing processes
    - Only processes joining in view V’ need to be synchronized

Delivery semantics across views

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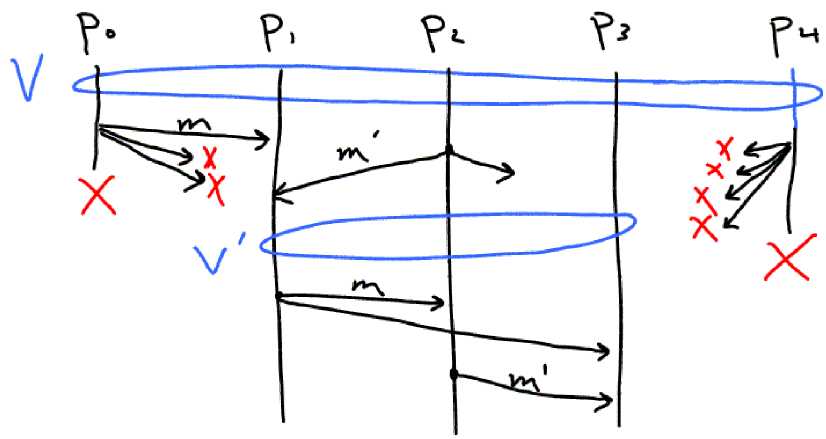

Properties of views

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- Messages sent in view V must be completed before messages are sent in V'
  - This allows correct synchronization of joining processes
  - It also allows continuing processes to synchronize process failures with system state

Message completion

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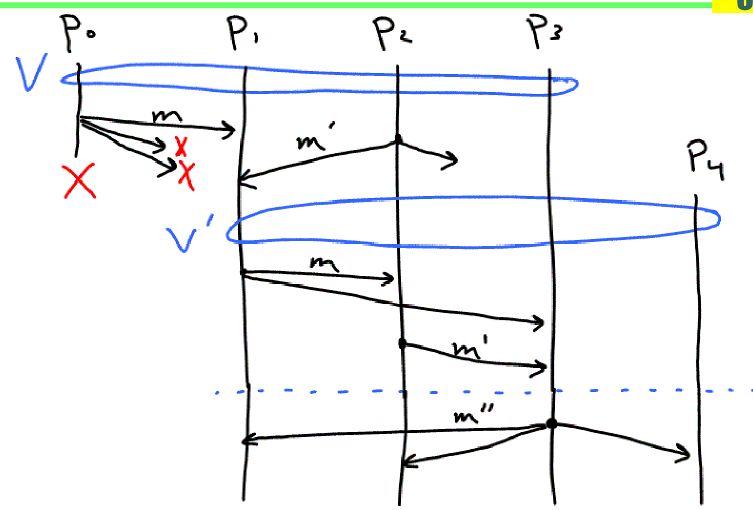

ISIS message completion

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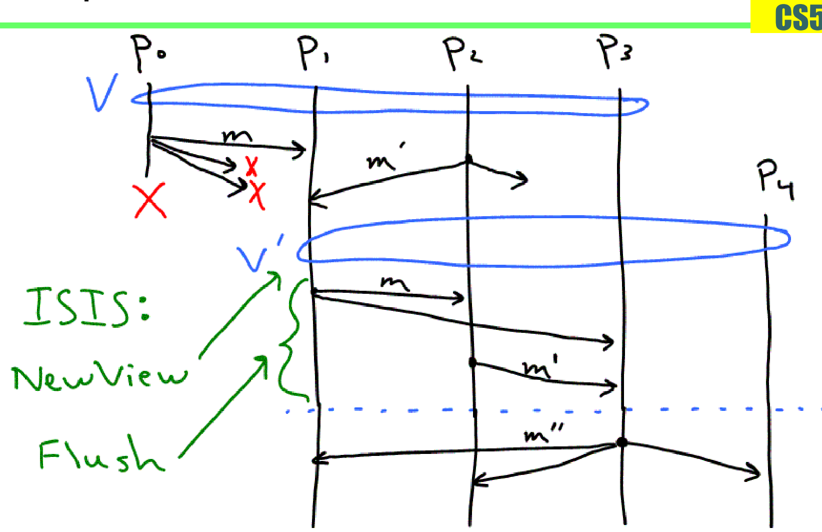

Spread message completion

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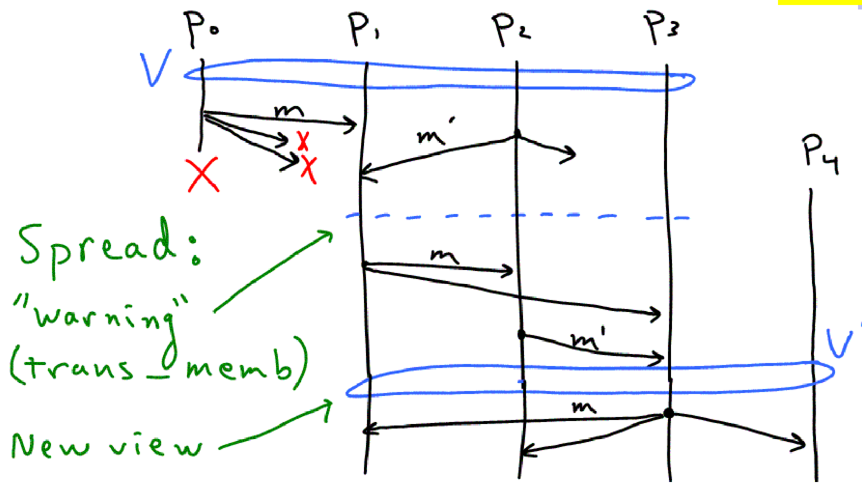

Properties of views: Two types of partitions

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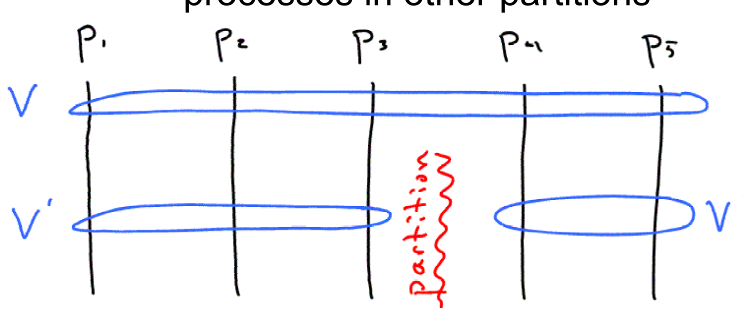
- A process group may partition
  - Processes in each partition are still alive, but cannot communicate with processes in other partitions



Properties of views: Two types of partitions

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- Primary component model: One group is considered "primary", and continues operation
  - All other groups "do nothing", and try to rejoin the primary group (possibly as new processes)
- Simultaneous components model: All groups continue operation, later groups may merge

Primary component model

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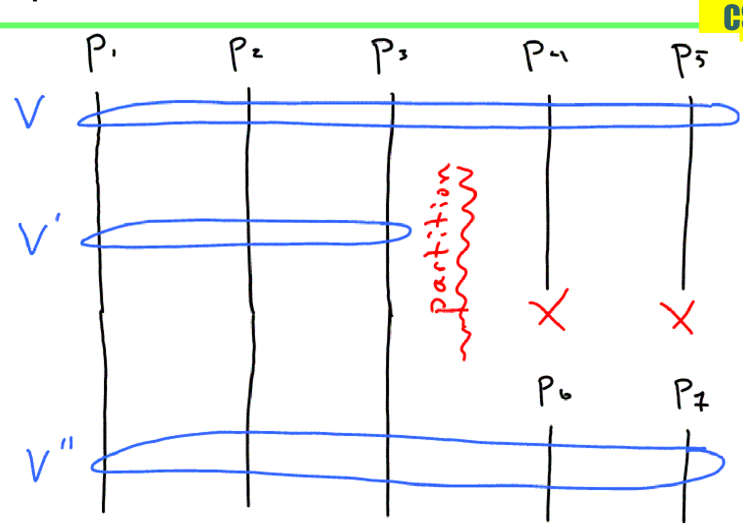

Simultaneous components model

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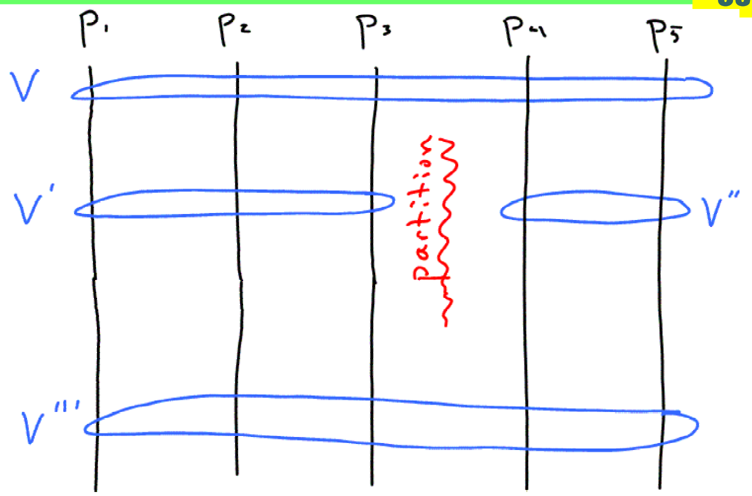

Primary component model

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- In the case of ISIS, the primary component is the one with a majority of processes from the previous view
  - Note that no group may have a majority!
  - In this case, the system is essentially restarted
- Typically a "partition" occurs when a single computer loses its network interface
- In LAN environment, it is not hard to prevent "non-trivial" (single node) partitions

Simultaneous component model

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- In many (most?) high availability environments, simultaneous components doesn't make sense
  - Two partitioned groups cannot think they are controlling the same air space!
- Merging system state is hard
  - May have consistency issues!

Word of caution: some things are impossible!

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- In general, group communications systems cannot tolerate all possible failures
  - Either theoretically or in practice
    - Non-majority partitions
    - Byzantine failures
    - Some "unfortunately timed" failures
- But in practice we can come close (and still get decent performance)

One-tier or two-tier group membership service

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- One-tier: all processes in group participate in membership protocol
- Two-tier: a small group of processes offer a "group membership service"
  - Multiple "client" process groups subscribe to the service
  - The group member service keeps track of client group membership
  - The group member service also keeps track of its own membership

Two-tier group membership service

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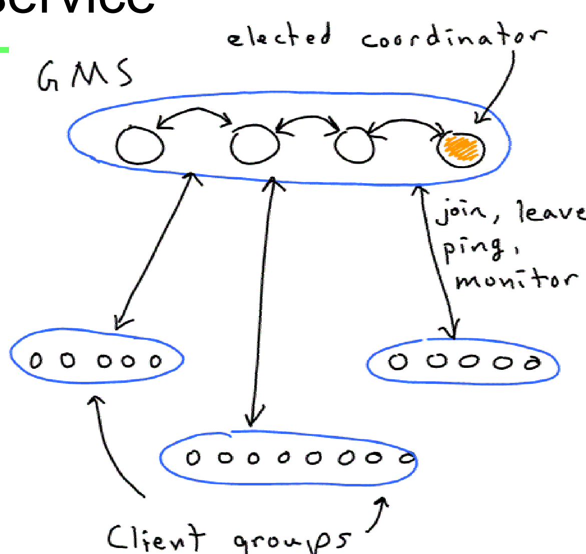

Why two tiers?

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- Group membership protocol doesn't scale well
  - $O(N^2)$
  - Two- or even Three-phase commit
- Some groups may be large
- Some processes may be in multiple groups
- Therefore better to have one small dedicated group membership service

Two-tier GMS details

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- GMS processes well-known (clients are configured with list)
- Clients contact any alive GMS process and join, maintain keep-alive
  - If client detects GMS process is dead, it attaches to another
  - If GMS process detects client is dead, it removes the client from the group list
- GMS processes maintain group lists, report changes to clients

Recall *sequencer* and *token* approaches to ordering

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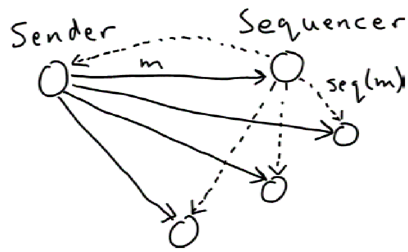
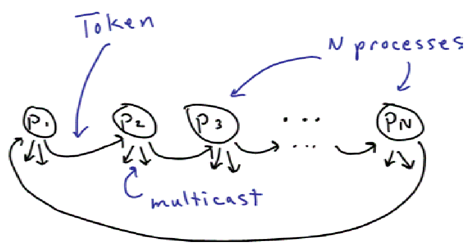


Sequencer-based Ordering

Token-based Ordering



Analogous approaches to membership views

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- Organizer-based membership
  - ISIS, Ensemble
- Token-based membership
  - Totem, Transis
- We'll look at Totem and ISIS

Token-based membership

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- Based on a single message: JOIN
- Used by newly joining process
- Also used by a process that detects a failure in another process
  - For instance, the process expecting to get the token next
- JOIN message contains:
  - List of *included* processes (those in the new view)
  - List of *excluded* processes (those not in the new view)

Basic algorithm

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- Every process periodically broadcasts JOIN until it hears identical JOINs from all other included processes

Token membership: process crashed

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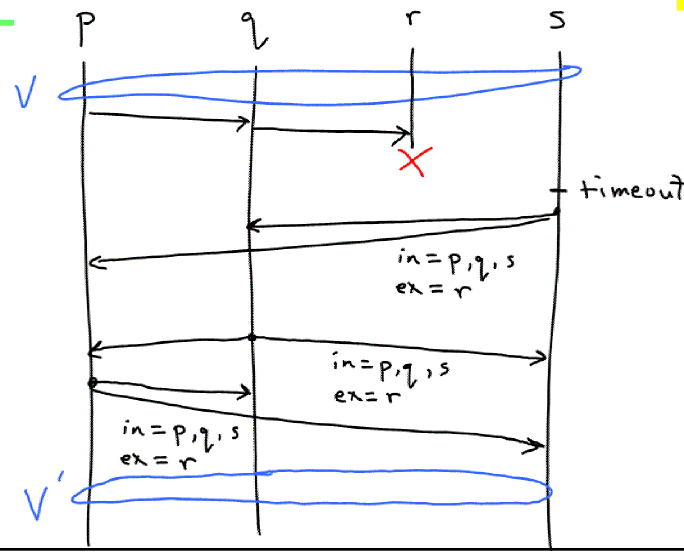

Token membership: process didn't crash

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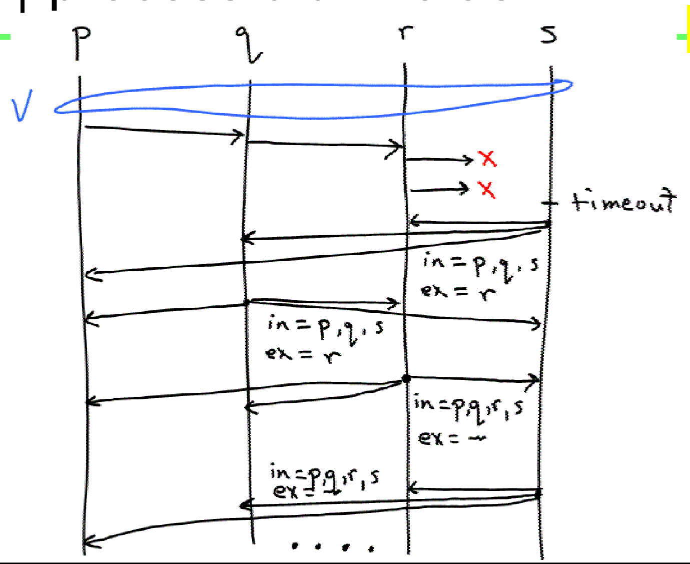

Token membership: new process joins during algorithm

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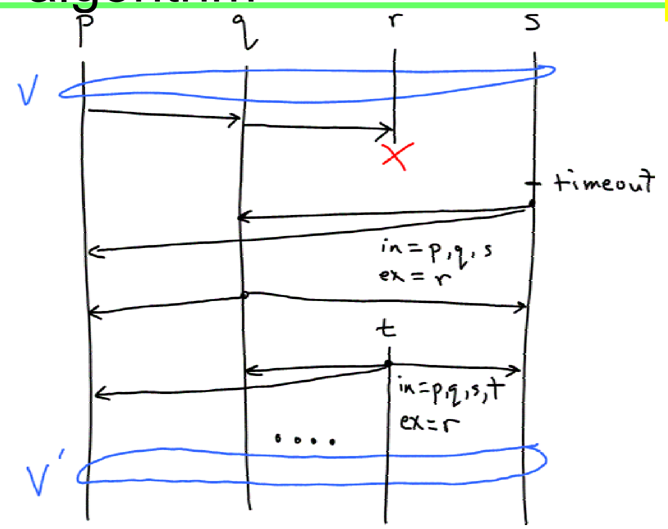

Token membership state transition diagram

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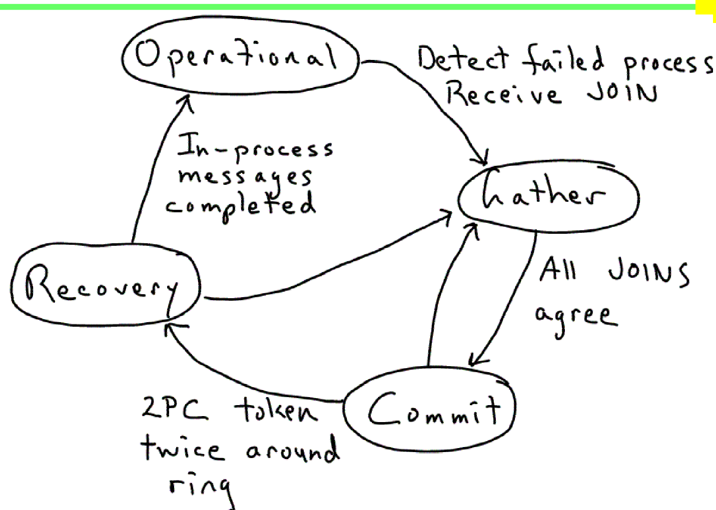

Token membership states

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- *Operational*—normal message delivery (stable ring)
- *Gather*—JOIN messages
- *Commit*—Uses token to verify agreement on membership
  - Required because JOIN messages may be received out of order
  - Token initiated by lowest-ID process
  - Token travels around ring twice—like two-phase commit (2PC)

Token membership states

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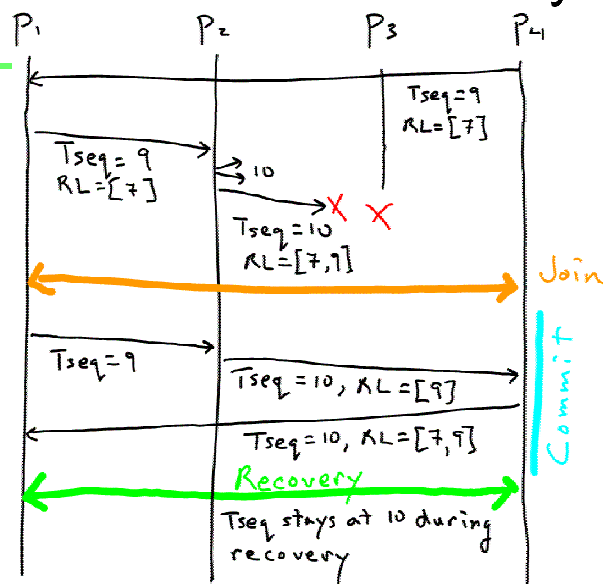
- *Recovery*—Before recovering messages, must recover token sequence number, retransmit list, and ARU
  - Token was lost in previous “ring” (view), so token contents also lost
  - This probably done during commit
  - Recovery finished when retransmit list is empty, and ARU = token sequence number
  - Token itself indicates final transition to *Operational* state

Commit and Recovery



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- Next lecture we'll look at Coordinator-based membership

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