Service Fabric: A Distributed Platform for Building Microservices in the Cloud

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DPRG@UIUC: http://dprg.cs.uiuc.edu
Service Fabric: aka.ms/servicefabric

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These slides were adapted for teaching purposes, the original set is available at https://shegufta.com/publications/

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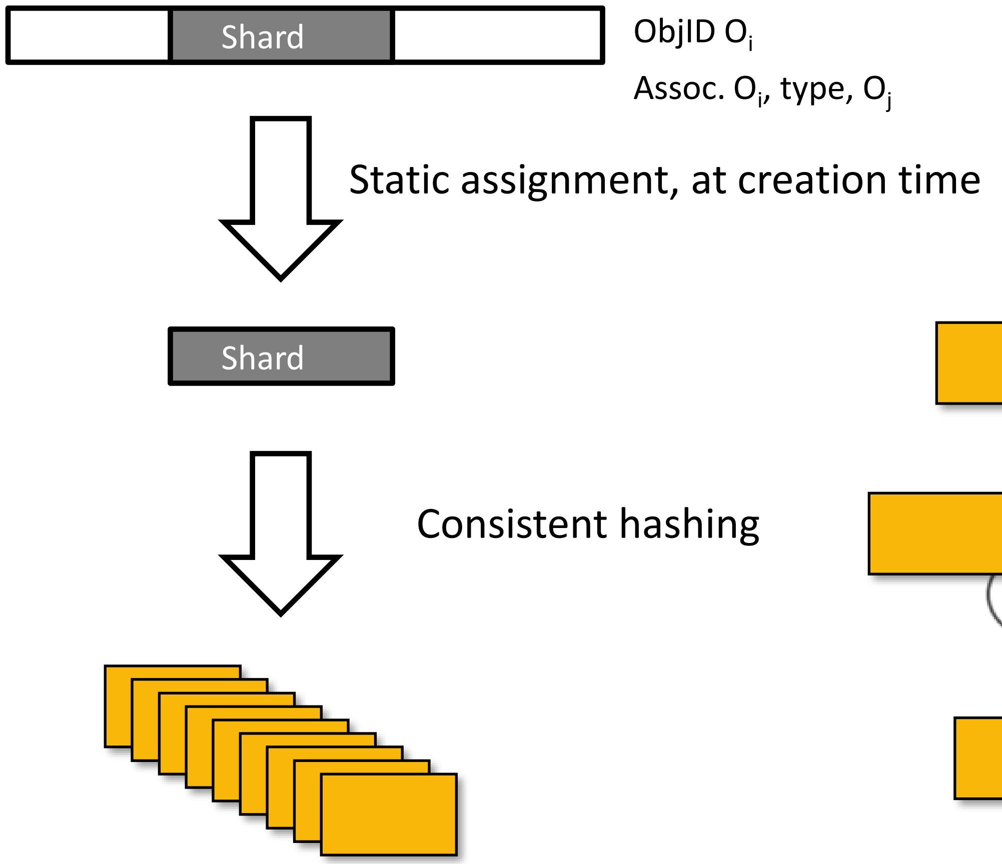
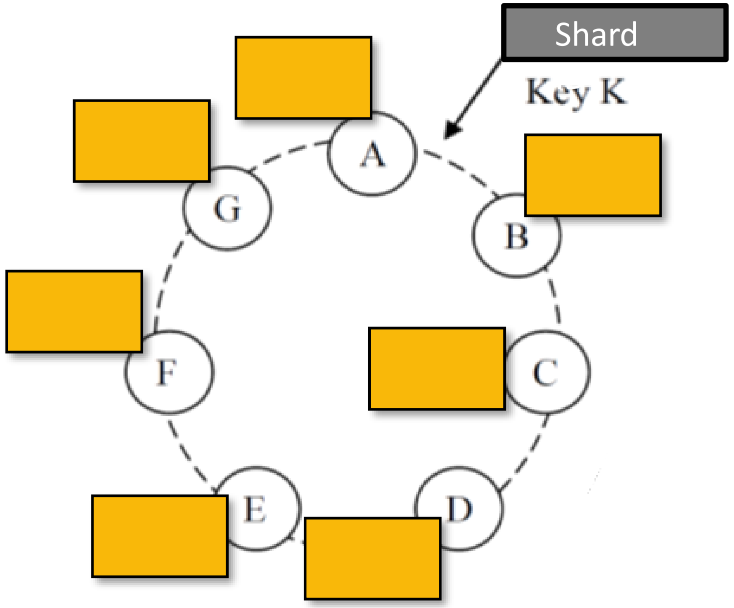
Microsoft Azure

Object ID -> Shard -> Node

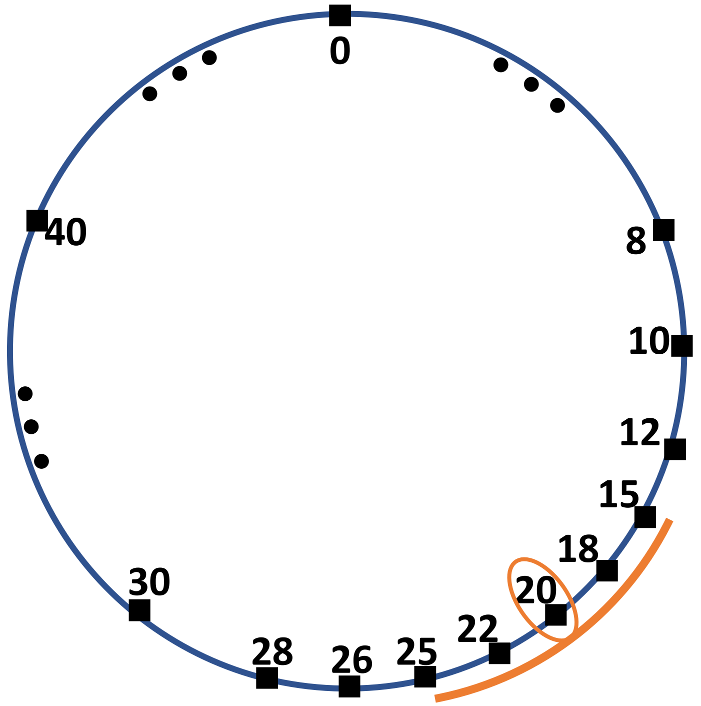




ServiceFabric (SF) Federation Subsystem

➢ **Nodes are organized in a virtual ring (SF-Ring):**
- Consists of 2^m points (e.g., m=128 bits)
- Key -> owned by the closest node
- Neighborhood set: { ‘n’ successors, ‘n’ predecessors }

➢ **Ensures:**
- Consistent Membership and Failure Detection
- Consistent Routing
- Leader Election



Routing is Bidirectional and Symmetric (SF-Routing)

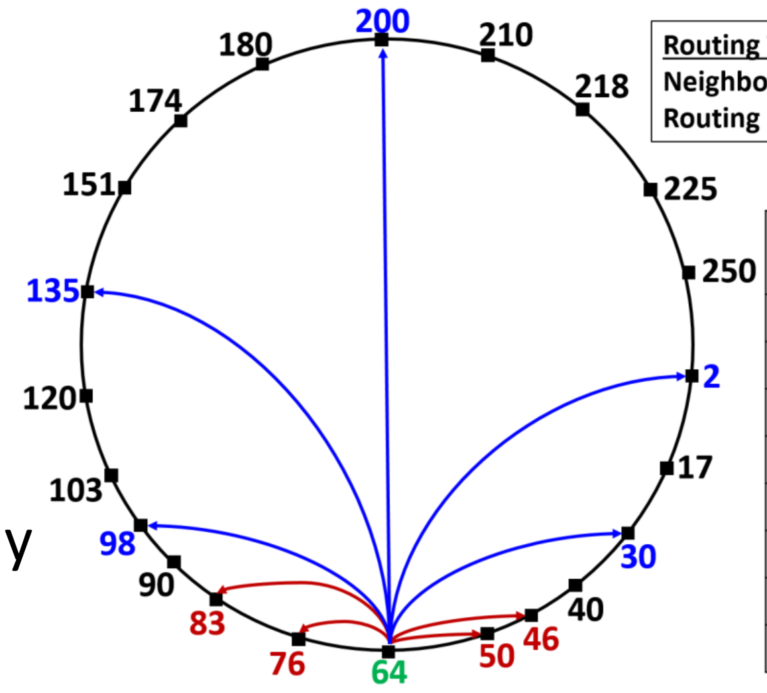
➢ i^{th} clockwise/anticlockwise routing table entry is the node whose ID is closest to the key $(n +/- 2^i) \bmod (2^m)$

➢ SF-Routing:

- Provides more routing options
- Routes message faster

➢ In latest design, SF-Routing is used for

- Discovery routing when a node starts up
- After Discovery, nodes communicate directly



Routing Table at node 64:
Neighborhood = {83,76,50,46}
Routing Partner = {200,2,30,98,135,200}

Routing Partner Calculation

Clock.	Active Node	Anti-Clock.	Active Node
$64+2^0$	64	$64-2^0$	64
$64+2^1$	64	$64-2^1$	64
$64+2^2$	64	$64-2^2$	64
$64+2^3$	76	$64-2^3$	50
$64+2^4$	83	$64-2^4$	46
$64+2^5$	98	$64-2^5$	30
$64+2^6$	135	$64-2^6$	2
$64+2^7$	200	$64-2^7$	200

Consistent Routing

- At any given time all messages sent to key ‘K’ will be received by **a unique** Node. If that node crashes, a new node will take the responsibility
  - **Leader Election:** For entire system use K=0

- Each Node owns a **routing token**:
  - A portion of the ring whose keys it is responsible for

- SF-Ring ensures following consistency properties:
  - **Always Safe:** there is **no overlap** among tokens owned by nodes
  - **Eventually Live:** Eventually every token range will be claimed by a node

- Efficiently Handle: Node Join, Leave and Fail

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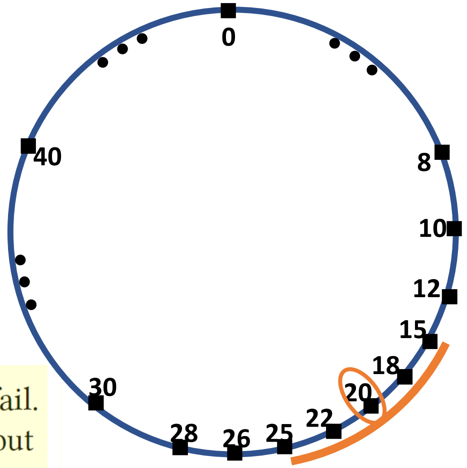
Consistent Membership and Failure Detection



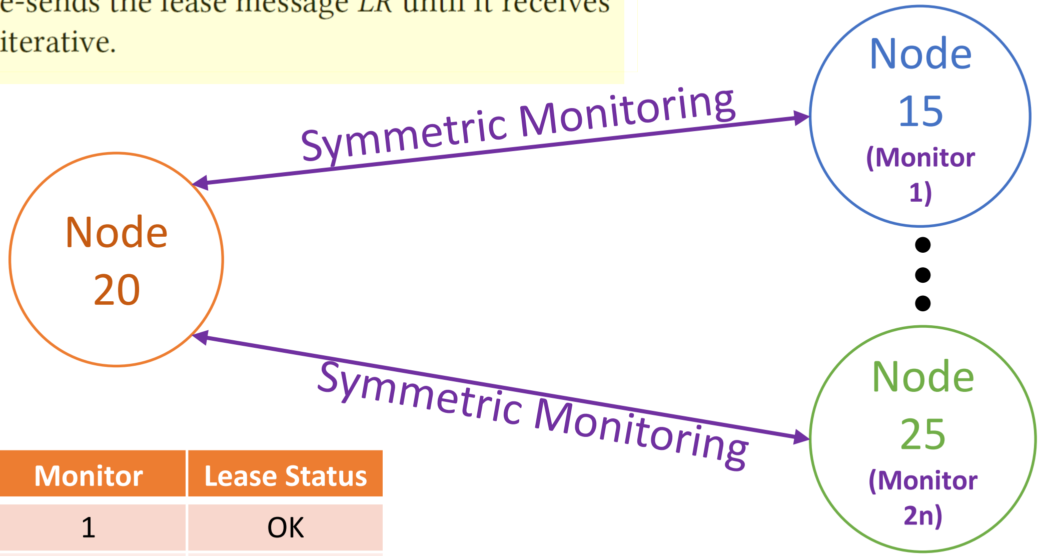
➢Design Principles:

1. Membership -> Strongly Consistent
   - For each node, all its monitors agree on its up/down status
2. Decouples Failure Detection from Failure Decision (using Arbitrator)

Lease renewal is critical, but packet drops may cause it to fail. To mitigate this, if node X does not receive LR_{ack} within a timeout (based on RTT), it re-sends the lease message LR until it receives LR_{ack}. Resends are iterative.

➢Lease Based Monitoring:

- Node A sends Lease Request to Node B
- If Node A receives ACK, lease establishes



➢Symmetric Monitoring (SM)

- Node A and Node B monitor each other

➢Node X (Decoupling **Detection**-**Decision**):

- Maintains SM with all neighbors
- If at-least one Lease fails (**Detection**)
  - ask for Arbitration (**Decision**)

Monitor	Lease Status
1	OK
…	…
2n	OK

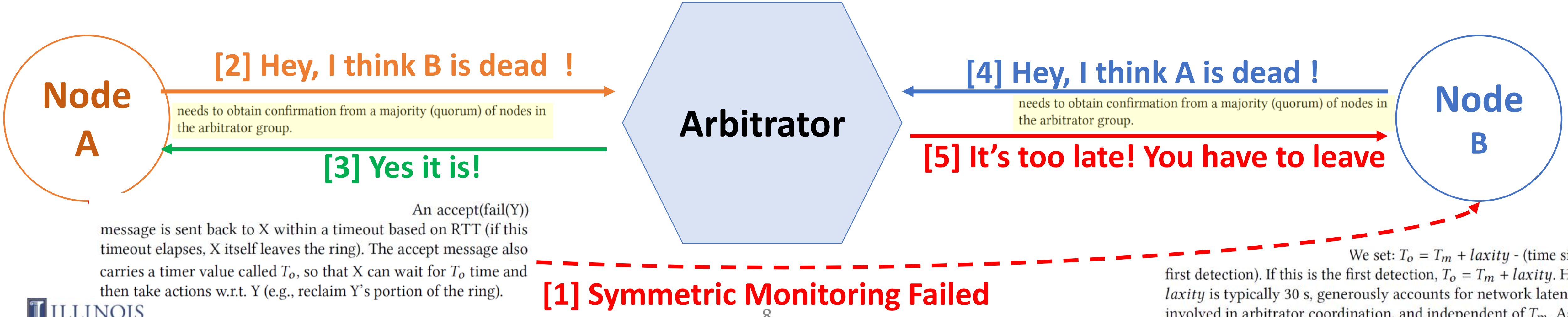
Arbitrator – Decouple Detection From Decision

Recently-failed list

<u>Arbitration Log</u>
Log 1: Time T : Node B declared dead

- Fail to renew lease (lease timeout Tm) (Detection)
  - Ask for arbitration immediately (Decision)
    - IF don't receive any reply within Tm, leave!
    - ELSE follow arbitrators decision !

In Production: Multiple Arbitrators, Quorum Based approach



An accept(fail(Y)) message is sent back to X within a timeout based on RTT (if this timeout elapses, X itself leaves the ring). The accept message also carries a timer value called T_o, so that X can wait for T_o time and then take actions w.r.t. Y (e.g., reclaim Y's portion of the ring).

We set: $T_o = T_m + laxity$ - (time since first detection). If this is the first detection, $T_o = T_m + laxity$. Here, $laxity$ is typically 30 s, generously accounts for network latencies involved in arbitrator coordination, and independent of T_m. As all timeouts are large (tens of seconds), loose time synchronization suffices.

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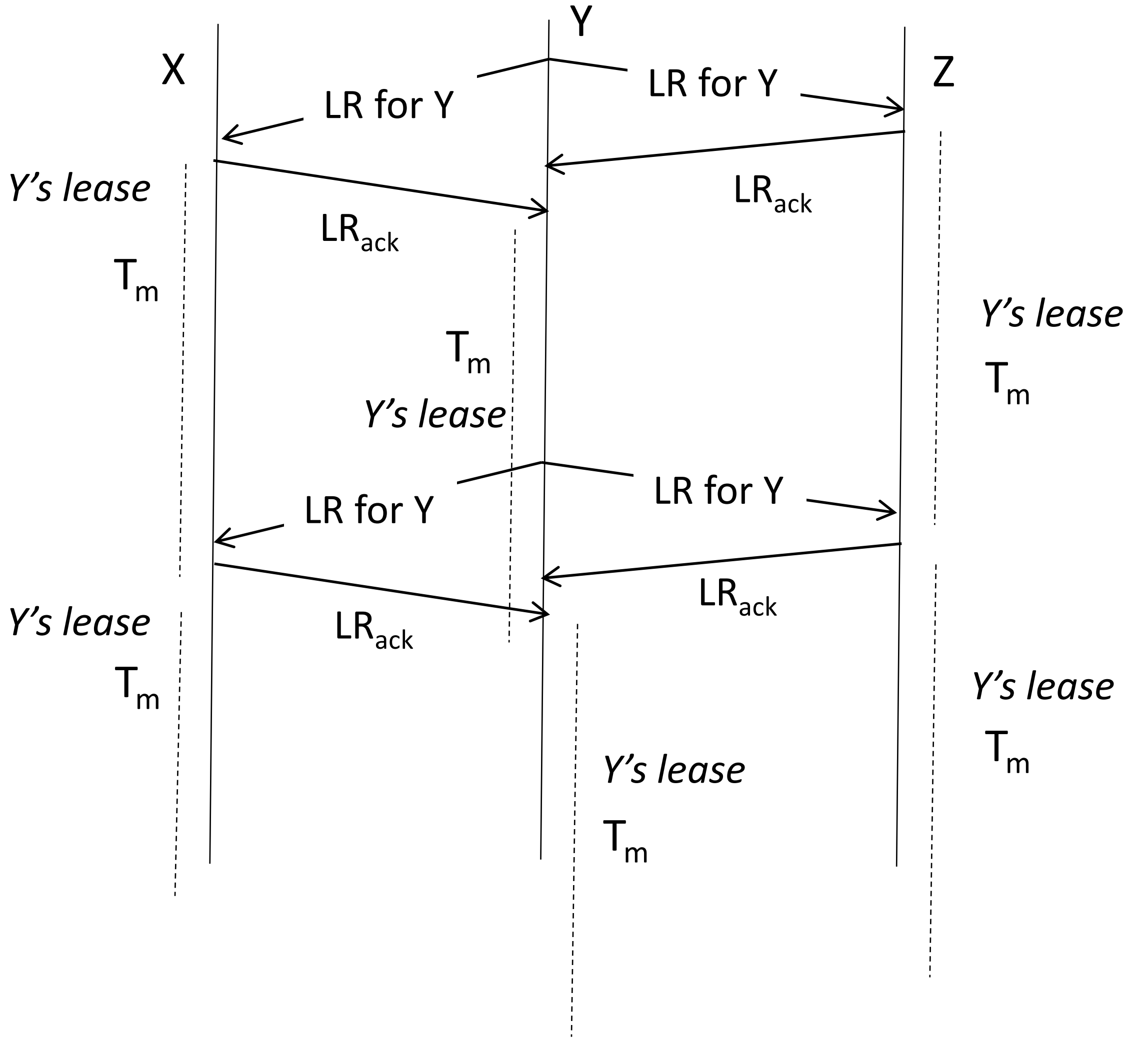
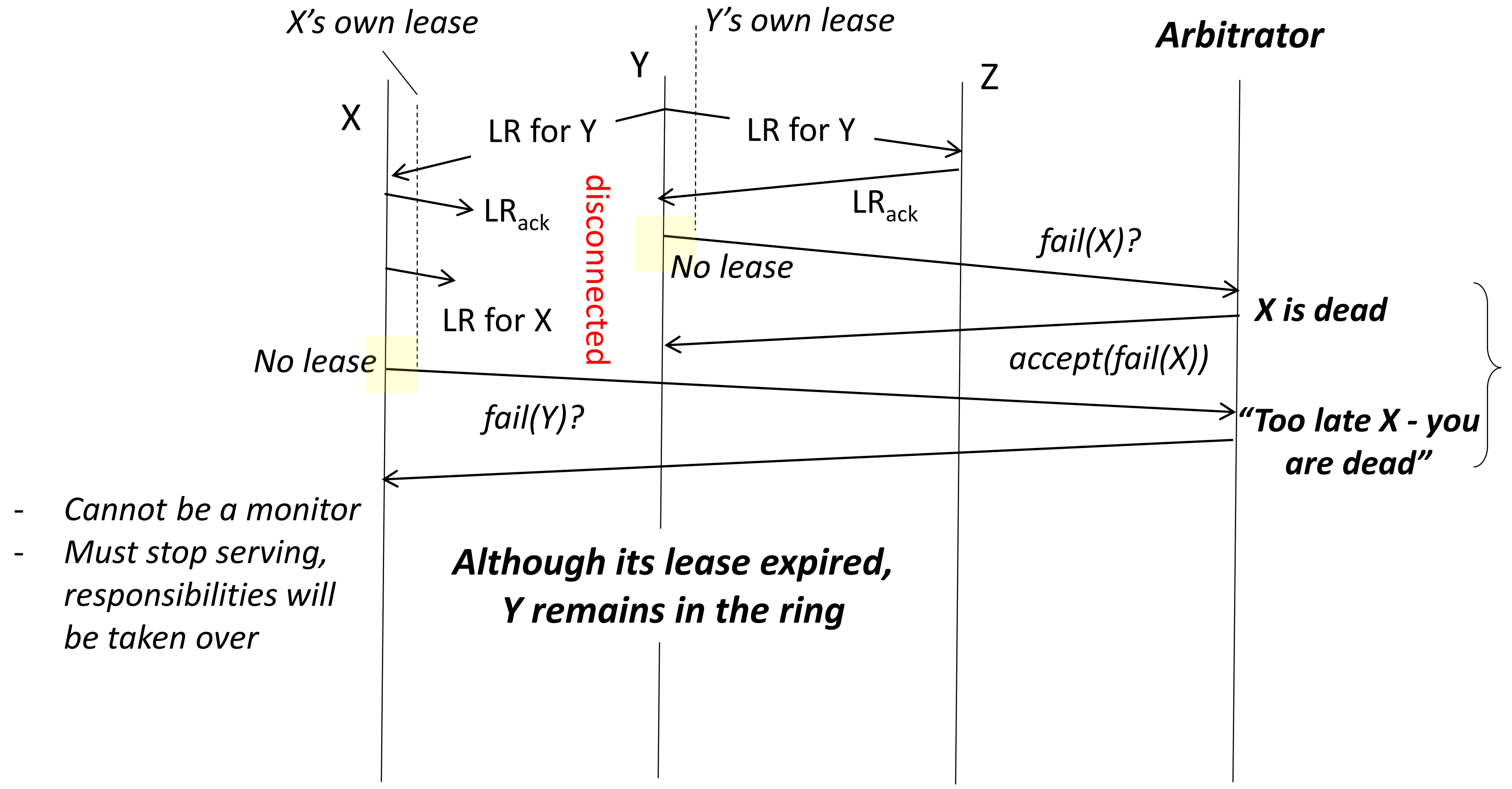
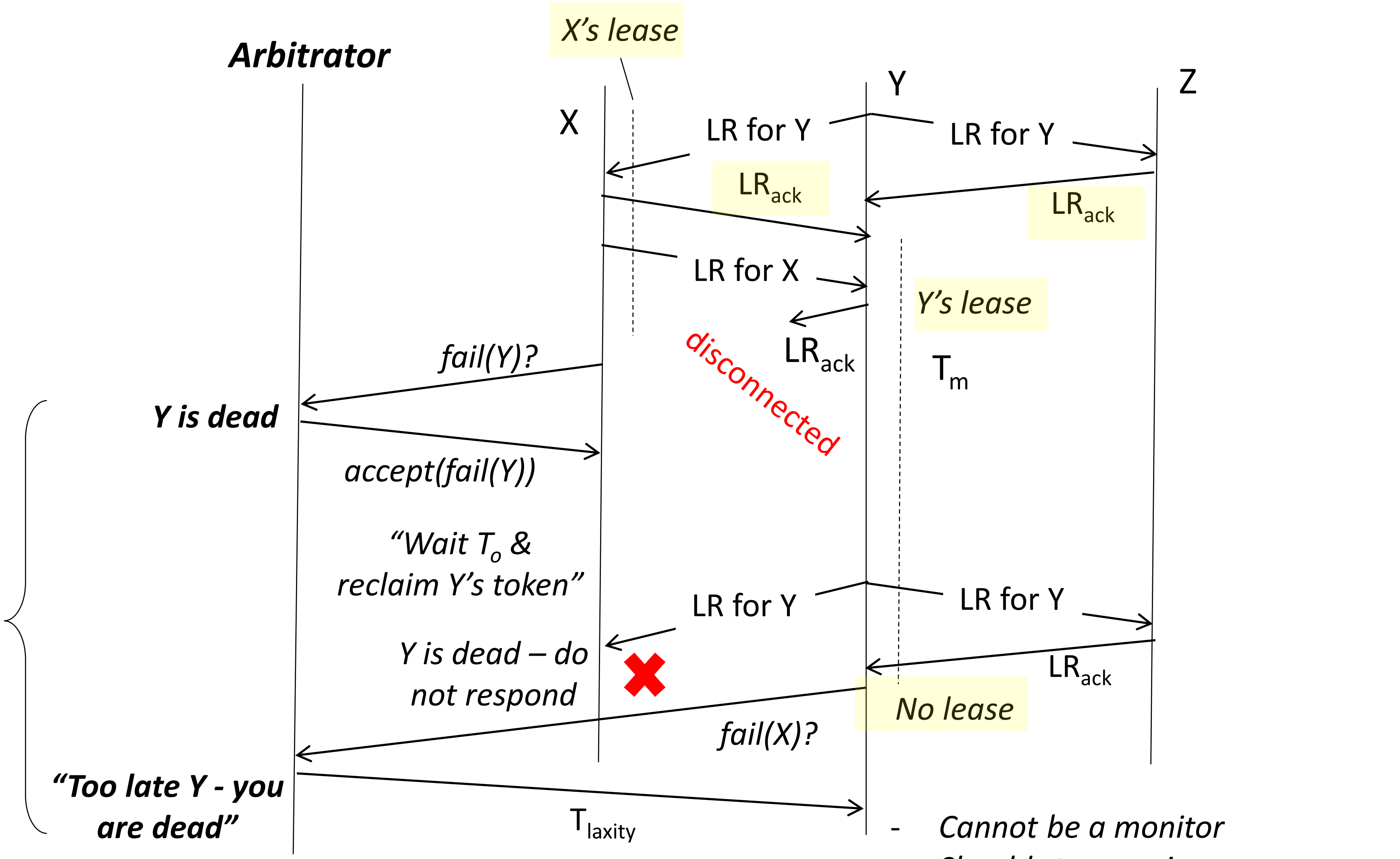
Each node Y and its monitors (X, Z) maintain Y's lease



X and Y's LR's are almost simultaneous and both fail: <u>only one of them is kicked out</u>, <u>situation is resolved fast</u>



Y's lease is renewed, then Y suffers temporary disconnection: Y can be kicked out, may only find out in (up to) T_m time



- Cannot be a monitor
- Should stop serving, responsibilities will be taken over

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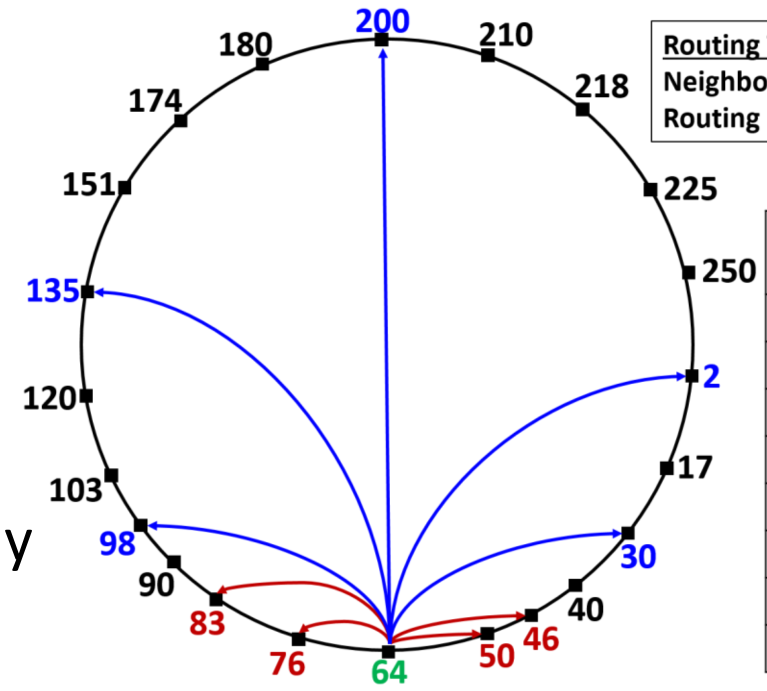

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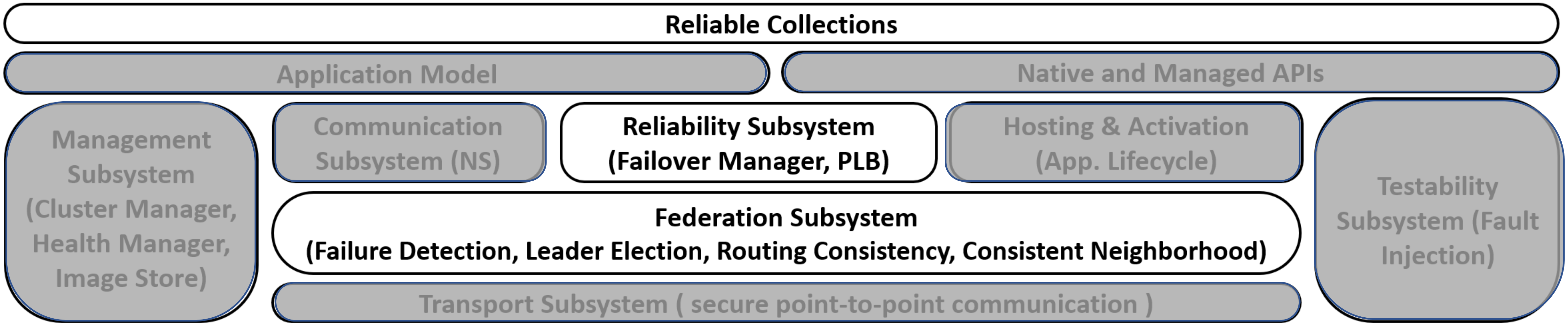
Service Fabric and Its Goals

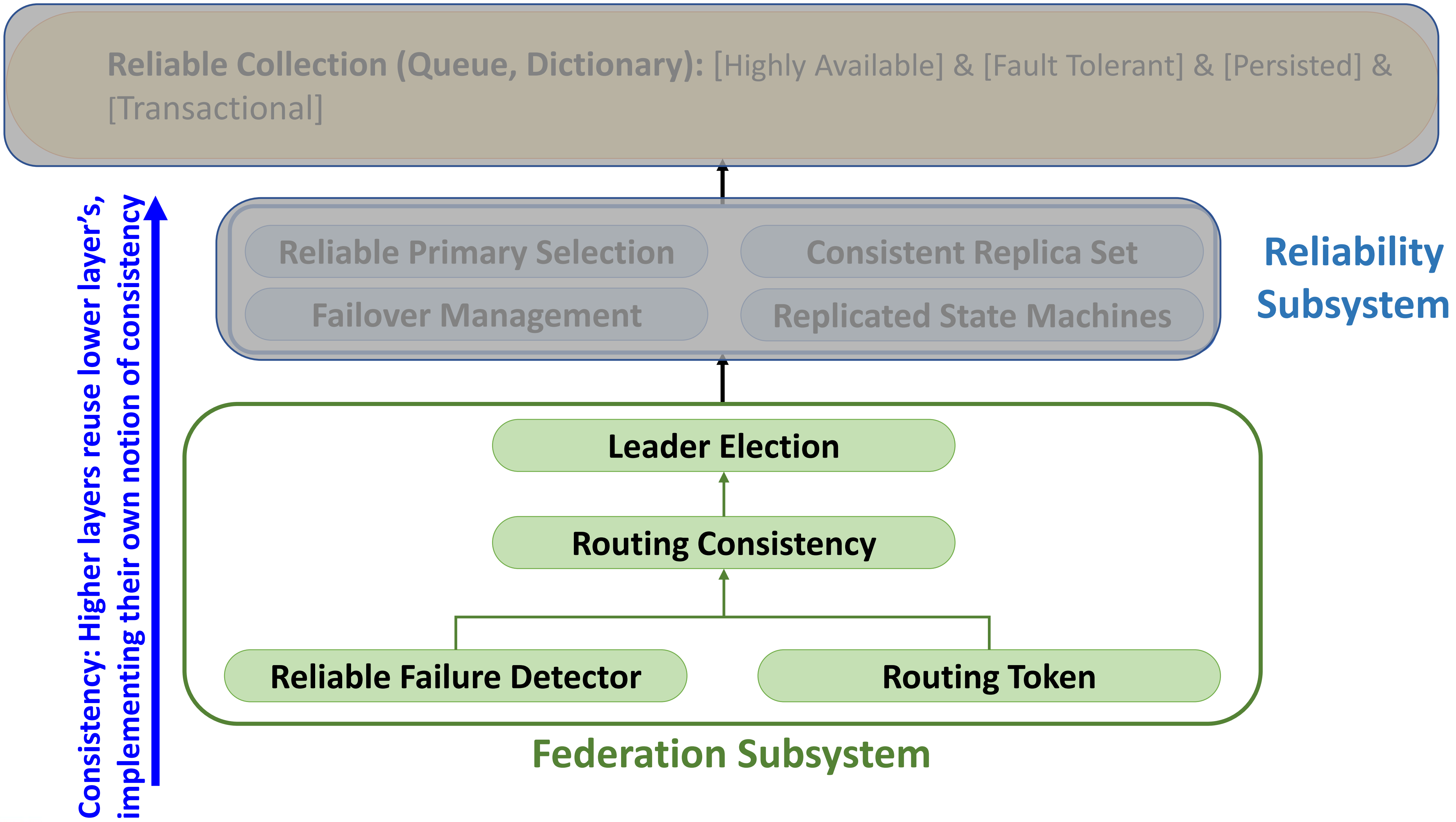
- **Support for Strong Consistency:**
  - Ground Up
  - Higher layer focuses on “their” relevant notion of consistency (ACID at Reliable Collections)

- **Fault Tolerance**

- **Support for Stateful Microservices:**
  - Microservices can have their **own state**

Service Fabric Major Subsystems

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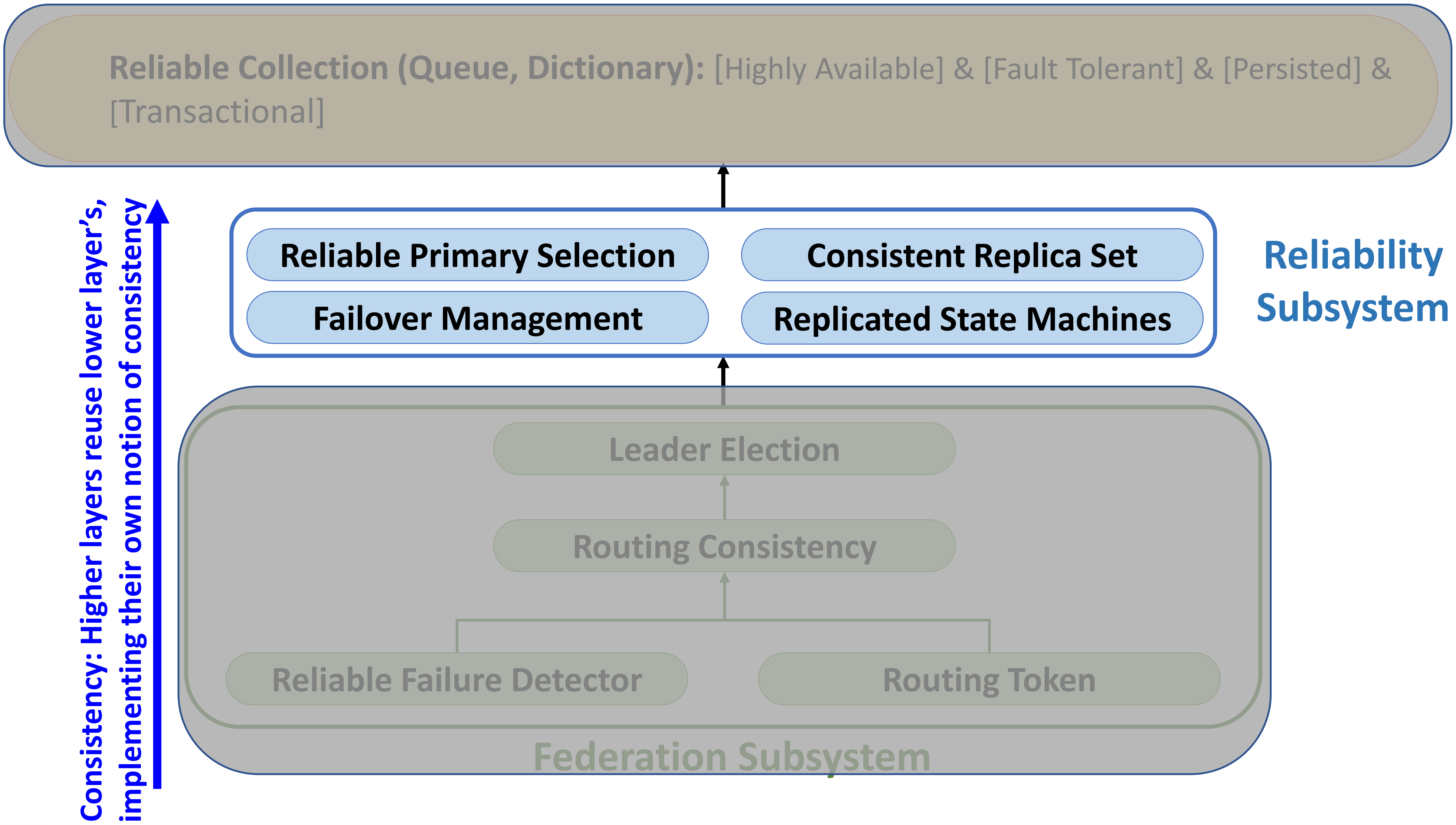
Consistent Replica Set
Failover Management
Replicated State Machines
Reliability Subsystem
Consistency: Higher layers reuse lower layer's, implementing their own notion of consistency
Leader Election
Routing Consistency
Reliable Failure Detector
Routing Token
Federation Subsystem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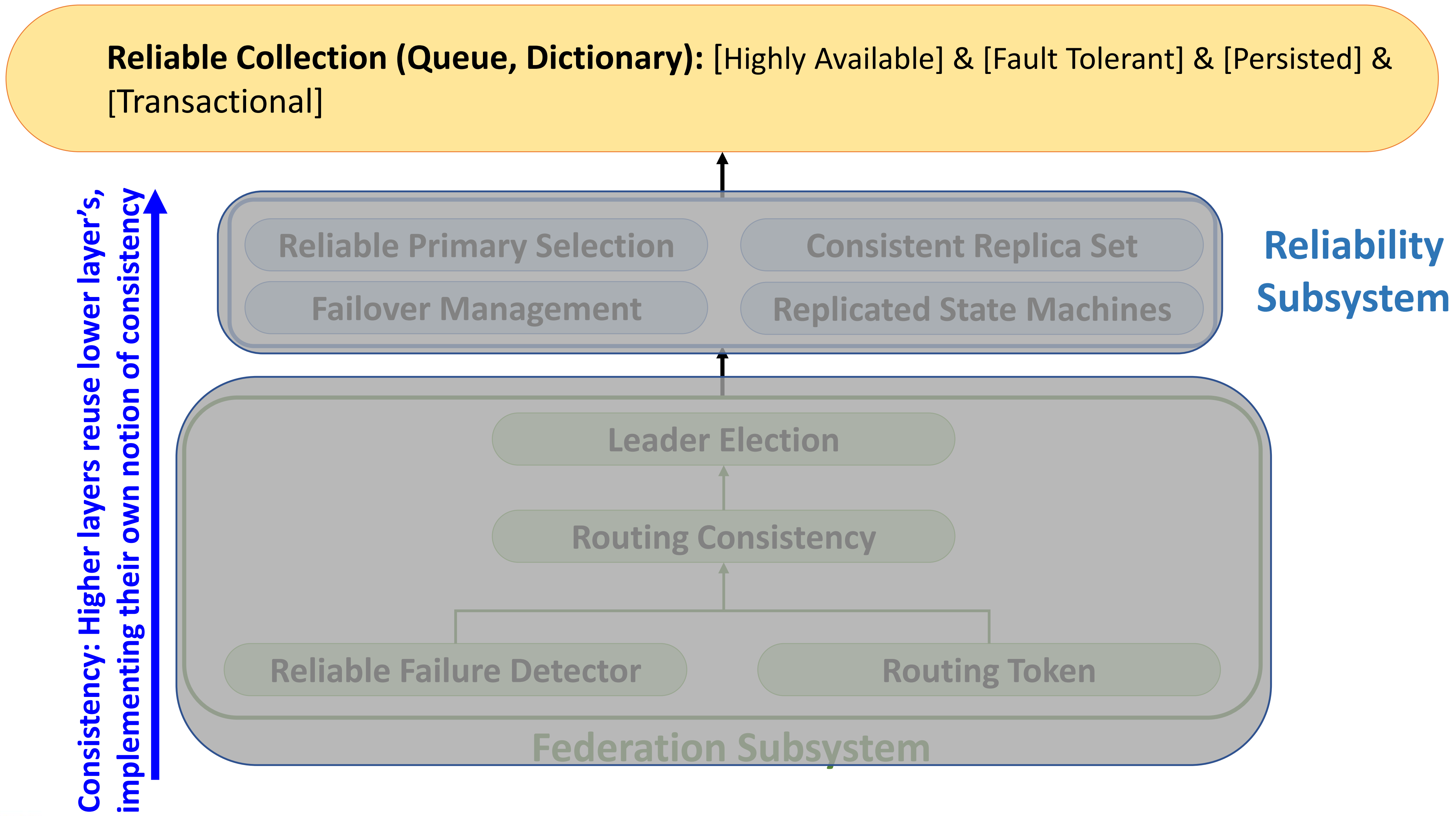
Reliability Subsystem

- **Provides:**
  - Replication
  - High Availability
  - Load Balancing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Reliable Collection (Queue, Dictionary)

- **Reliable Collections:**
  - Fault Tolerant
  - Highly Available
  - Persisted, Replicated
  - Transactional

- **Leverages lower layer guarantees** (Failure Detection, Leader election, load balance etc.)

- **Used in Stateful Microservices**

Evaluation – SF Arbitrator vs. Fully Distributed Scheme

SF arbitrator approach

If a node fails to maintain lease, it will gracefully leave the system
It is the fully distributed way of maintaining strong consistency

Total neighbors