Building a distributed fabric

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EMC^2

Yay! Cloud!

- Systems need to scale out to do useful things
- Self service
- Always available
- Isolate users from bare metal & OS
- Users have dedicated (& root) access to compute
- Wide area, but (generally) infrastructure has a single owner
- Commodity, off-the-shelf systems
  - Storage may not be
- Security
- Provide applications with a base layer of services
  - Iaas, PaaS, etc.
- Simple to program against

Fabric

- Distributed software infrastructure on top of Linux hosts
- Provides API & semantics to deploy & manage applications
- Applications: Object, low latency block storage, big data, user apps
- EMC's converged infrastructure
  - Storage and compute on same physical hardware
  - Dense appliance SKUs with with replaceable high capacity disks (typically 60 x 6TB per node)
  - Customer hardware: DIY
  - Disk monitoring and failure detection
  - Containerized

Building a fabric

- What services do you need to provide?
- What is your topology like?
  - Converged?
- Management layer & user applications
- What is the scale you expect to handle?
  - Build to the scale you expect
- What should the API look like?
  - Do not over-generalize APIs/models
- Fault tolerant
  - Minimum: No single point of failure
  - Better: Handle multiple failures over time.

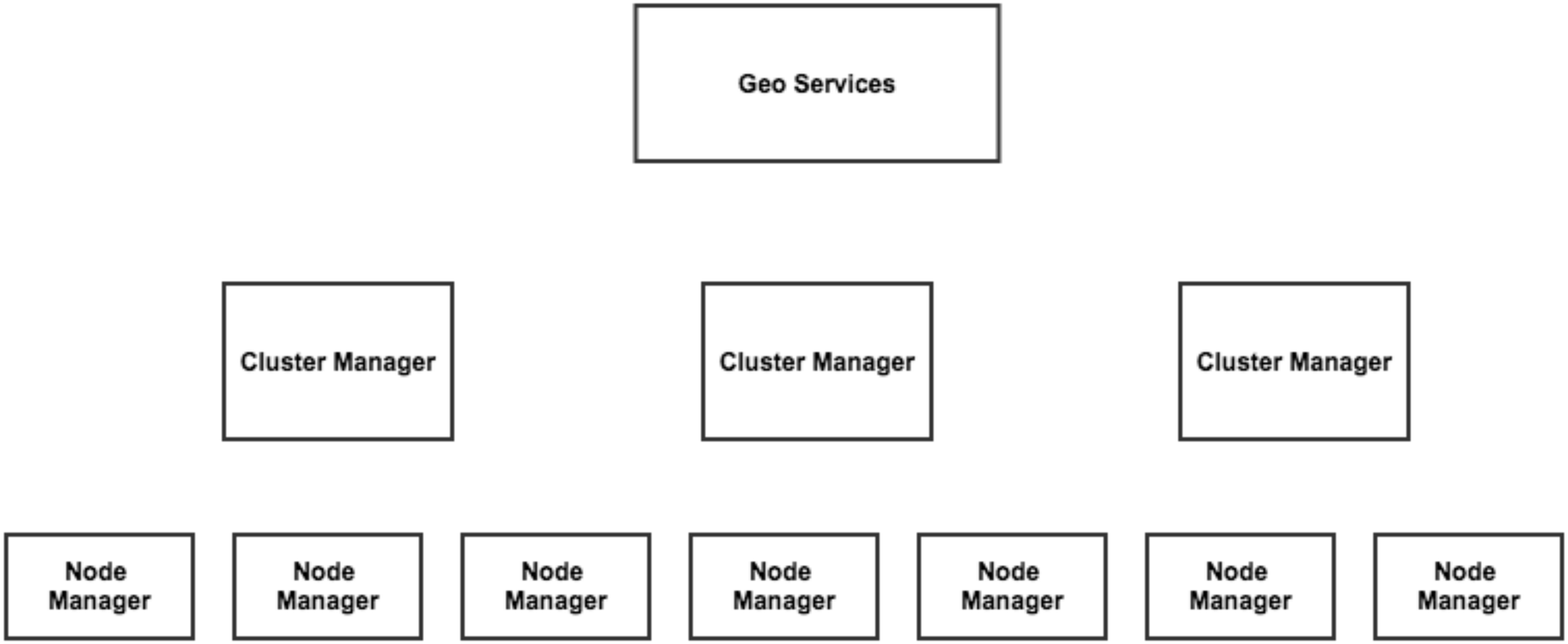
Provisioning

- API & Contract
- EC2 Model
  - VM instance with root access
  - Instance types
  - We give you the tools, you manage it
  - Not a lot of control over placement
  - Autoscaling
  - Not very performant for disk bound
    - Can pay for more CPU, IOPs, etc.

Provisioning

- Managed
  - “Fabric” manages application lifecycle
- Hard vs soft constraints
  - Node/rack tagging
  - Run the object storage application on “yellow” nodes
  - Need at least xx CPU
  - SAS drives preferred
- More control over hardware
  - Applications are isolated but not necessarily adversarial
  - Direct access to disks
- Contract
  - Fabric will keep application up
  - Provide services to coordinate tasks, perform rolling upgrade, etc.

Tiered architecture



Node management

- Compute
  - Virtual Machines
  - Containers
- Storage
  - Raw disk enclosures
  - Direct attached arrays
  - Filesystems
- Networking
  - Programmable network fabric
  - VLANs
  - Iptables

Cluster management

- Nodes aggregated into “clusters”
  - Nodes may not be homogenous
- Responsible for allocation, failure detection, recovery, notification & migration
- Expansion
- Must itself be fault tolerant
  - Multiple cluster manager instances
- Credentials/certificate authority/distribution
- Application lifecycle services

Lifecycle

- Goal State: What is the “desired state” of an application?
  - e.g. versioned image, CPU, disks, ports, affinity
- Provisioning can take a long time
  - Format disks, create filesystems, open ports, create VLANs, download binaries
  - Drive towards goal state until delta is zero
- Respond to failures, requests for additional capacity (i.e. scale up/down)
- Changes performed by staging an update and then flipping a bit
  - Only the latter needs to be atomic

Geo/Wide Area

- Credential Service
- Licensing
- Federation & membership
  - Dynamic, clusters can join/leave
- Secure communication between clusters

Upgrades

- Upgrade with downtime
  - Easier and okay for management software
  - Not if the application is in the data path
- Rolling upgrades
  - Service must continue to function & accept requests
  - Run multiple versions in cluster and gradually switch over
  - Rollback
  - Versioning
- Transferring binaries or images
  - Layered filesystems: updates are diffs
  - Should not be a single point of failure

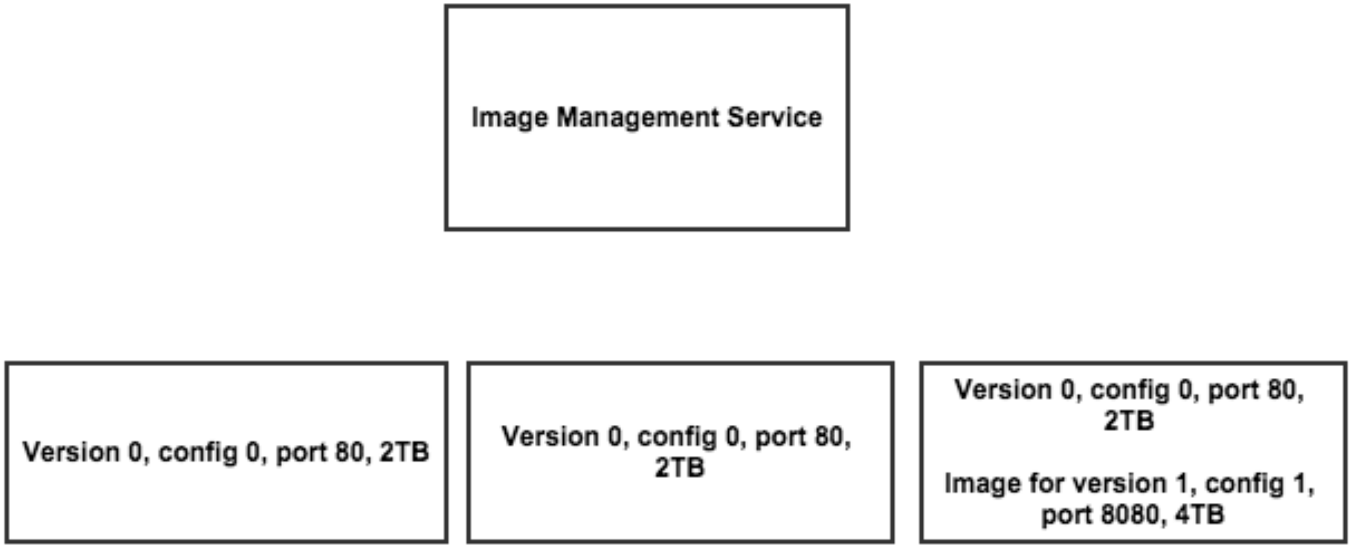
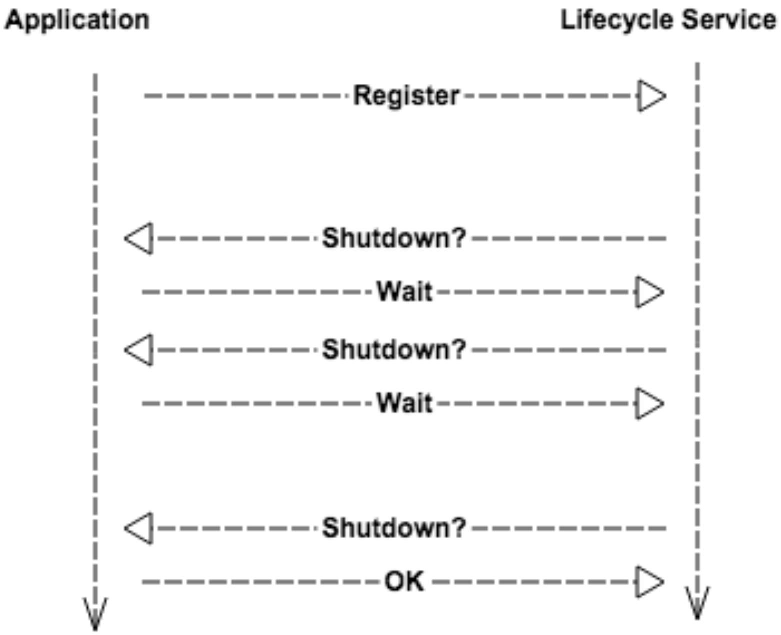


Image Management Service
Version 0, config 0, port 80, 2TB
Version 0, config 0, port 80, 2TB
Version 0, config 0, port 80, 2TB
Image for version 1, config 1, port 8080, 4TB

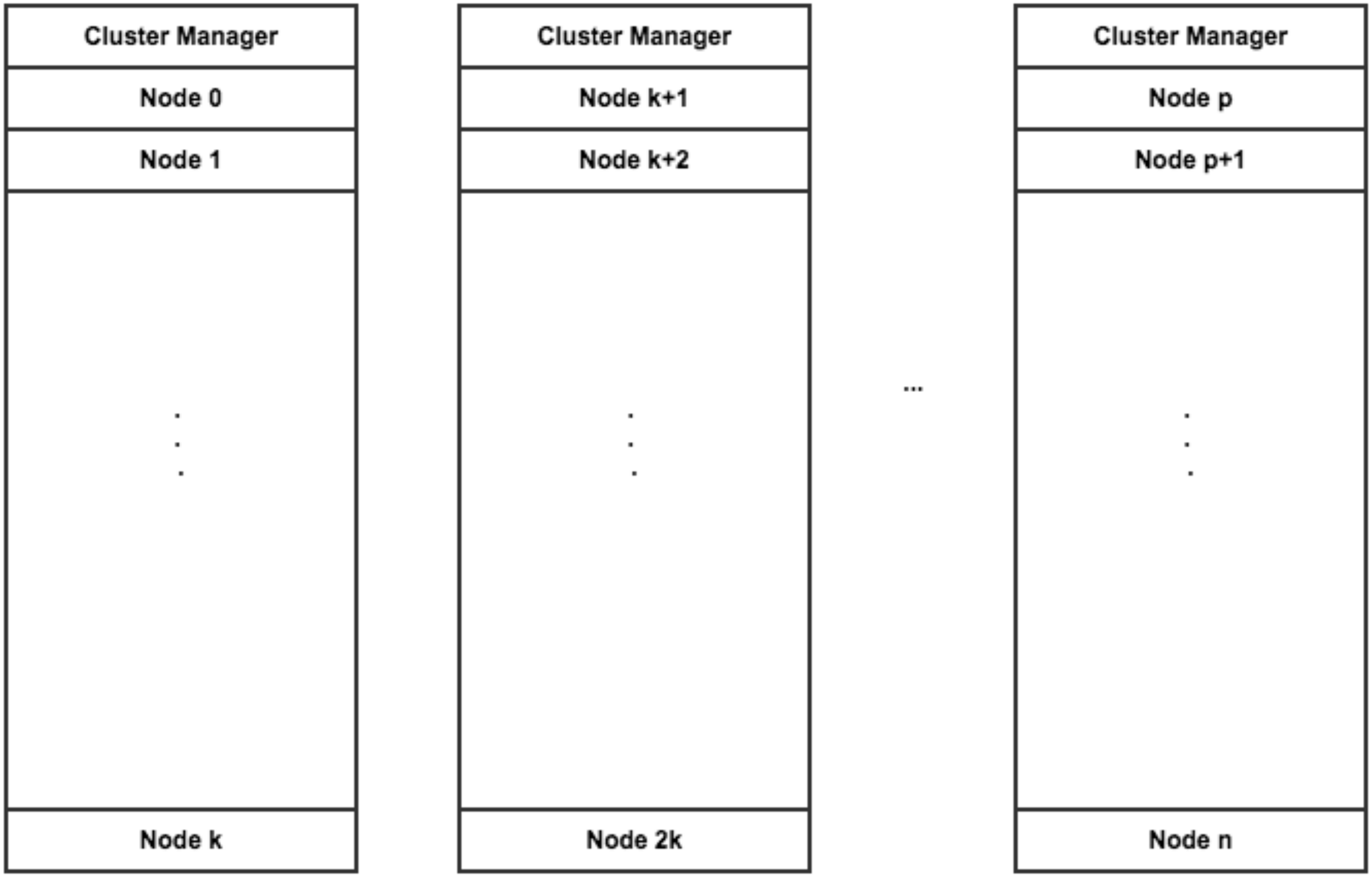

Application
Lifecycle Service
Register
Shutdown?
Wait
Shutdown?
Wait
Shutdown?
OK

Polling vs events

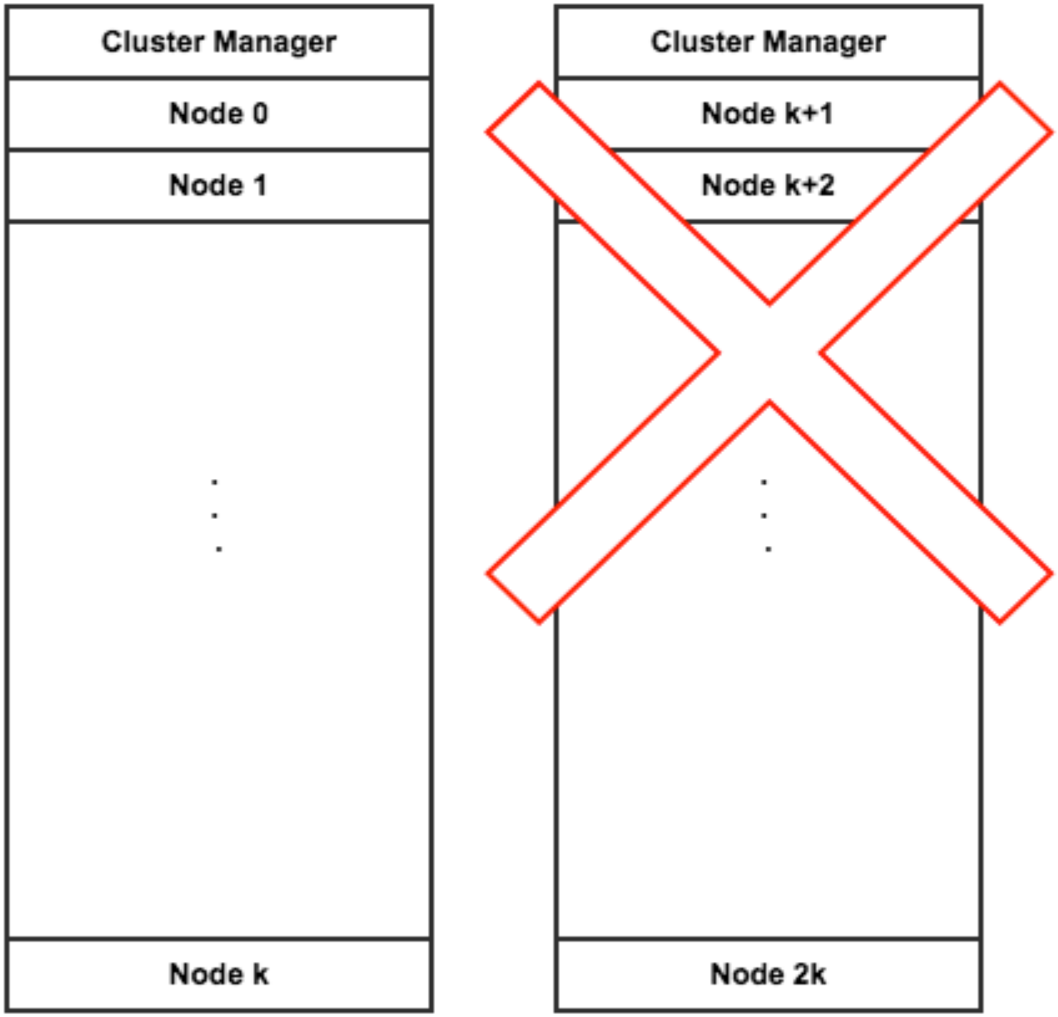
- Polling
  - Periodically ask for state information
- On timeout, take some action
  - Declare component as “unhealthy”
  - Initiate failover
- Events: push out state changes in “real time”
  - More responsive, don’t need to wait for next poll period
- In practice, need a combination
  - Events may be lost
- “Eventing” can be made reliable
  - Seq numbers, persistence, compact encoding, etc.
  - Accessible over REST (give me events starting at seq # X)

Failures & redundancy

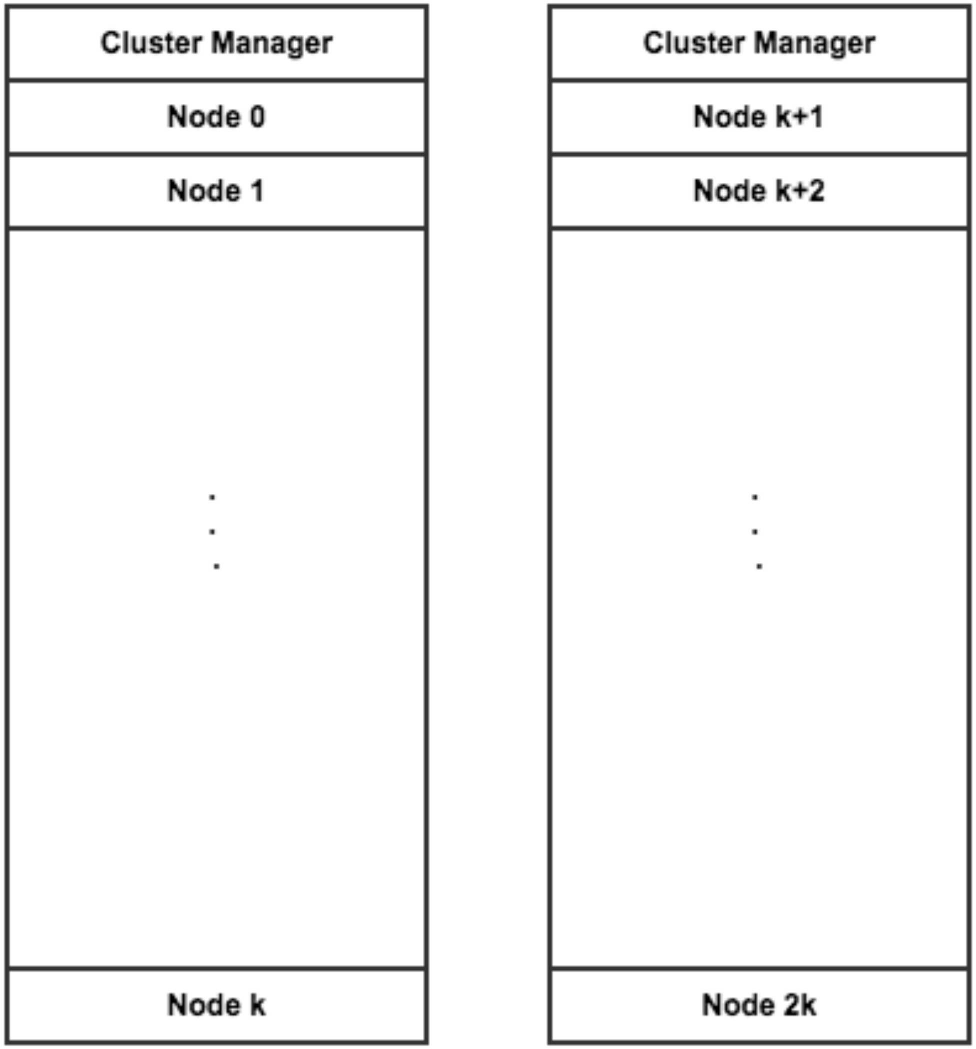
- Fault domains
  - Set of components that share a single point of failure
  - Physical and software
- Distribute components based on fault domains
  - Fault isolation: If a failure occurs, system is still available
  - Performance
- System should return to “non degraded” state


Cluster Manager
Node 0
Node 1
Node k
Cluster Manager
Node k+1
Node k+2
Node 2k
...
Cluster Manager
Node p
Node p+1
Node n

Fault domain



Handling faults



Cluster Manager

Node 0

Node 1

.
.
.

Node k

Cluster Manager

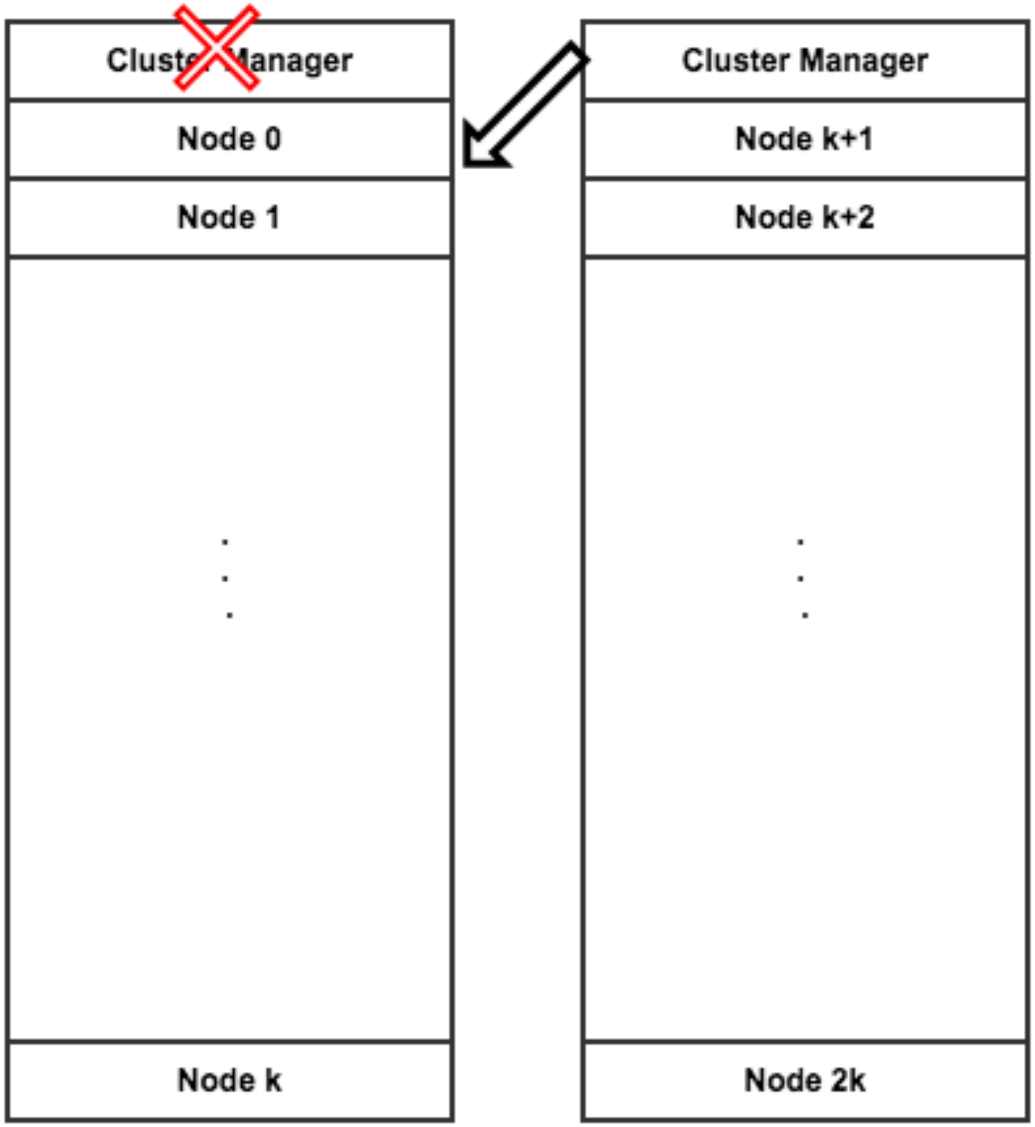
Node k+1

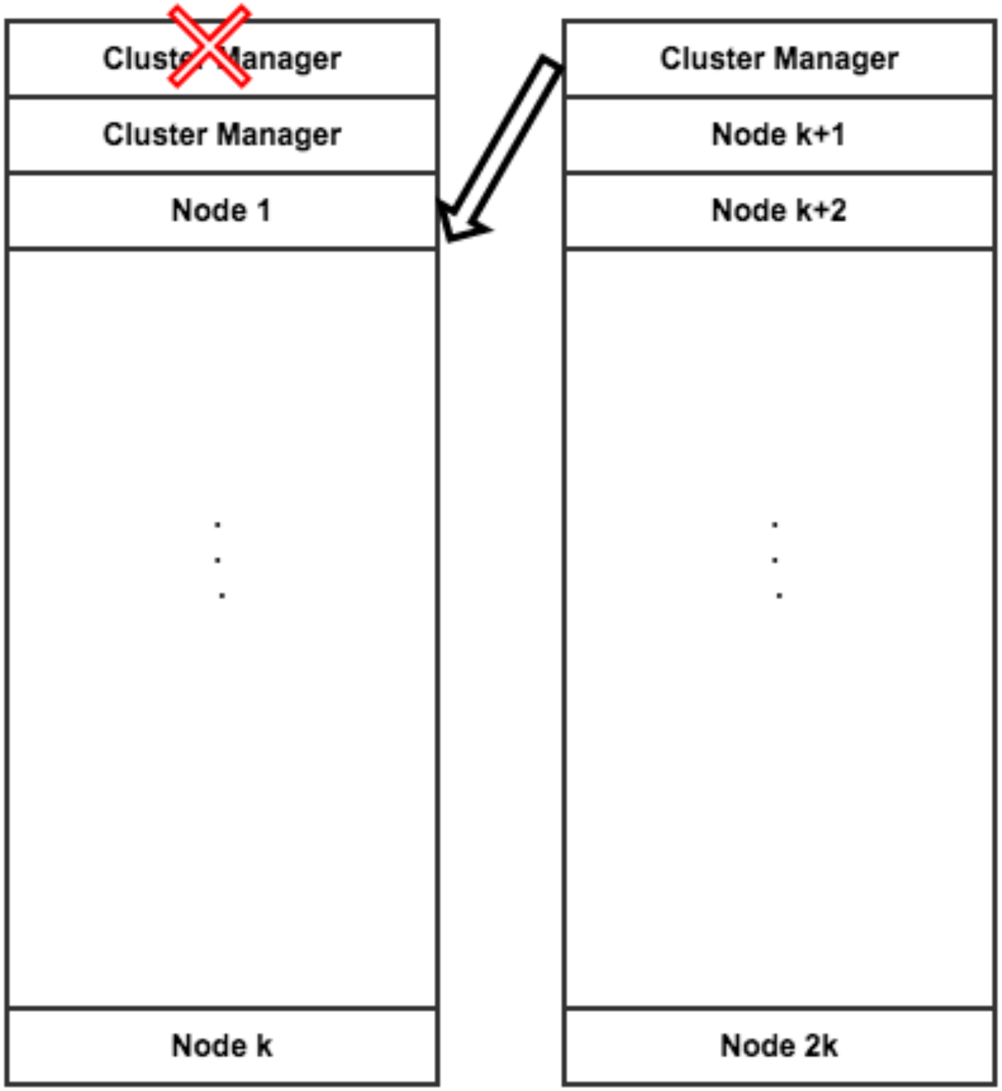
Node k+2

.
.
.

Node 2k

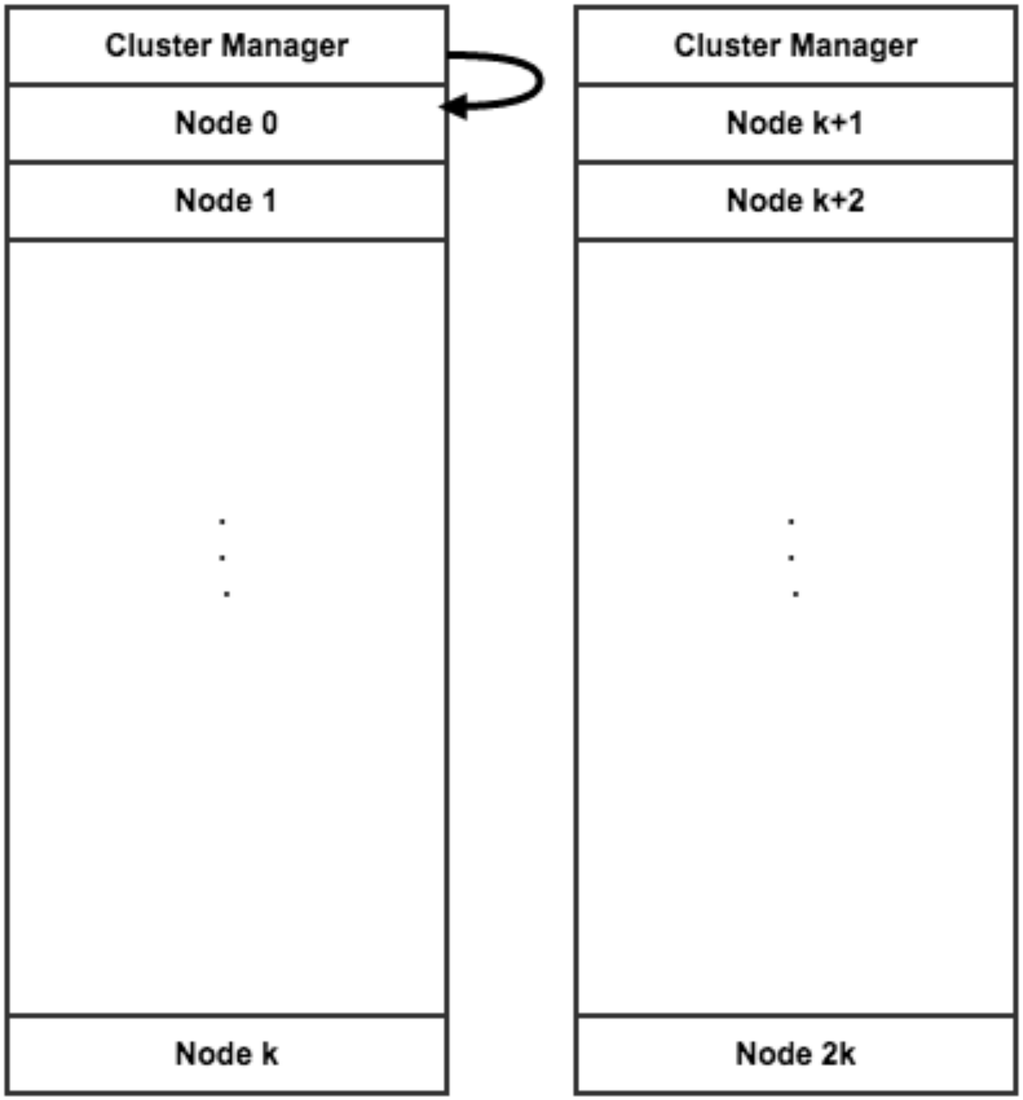
Handling faults





Cluster Manager is an Application!

Handling faults



Operator friendliness

- Provide guidelines for infrastructure
  - e.g. sane naming for nodes/racks, redundant switches, etc.
- Notifications: Send events out
- Have a consistent command line experience
- Be able to take over node/cluster & enter maintenance mode
- Configuration management
  - Ability to dynamically update node or cluster-wide defaults from a single terminal
  - Accessible over web services
  - If possible, standardize, but not always possible
    - e.g. OS commands might be different
- Your system will break
  - Yay, but you designed a good upgrade experience!

Software design principles

- Immutability
  - Do not pass around entities with “nullable” fields
- Get your primitives right
  - Threading, profiling, logging, etc.
- Know where your state is
  - State changes should be explicit
  - Avoid side effects
  - Should be able to reason about state changes
- Snapshots, events & replay
- Abstraction
  - Pluggable: can run on laptop or a dense cluster
- Don’t assume you will get notified
  - Component software defects can cause a cascade
  - Push events along with polling
- Audit logs
  - Required for sanity & compliance