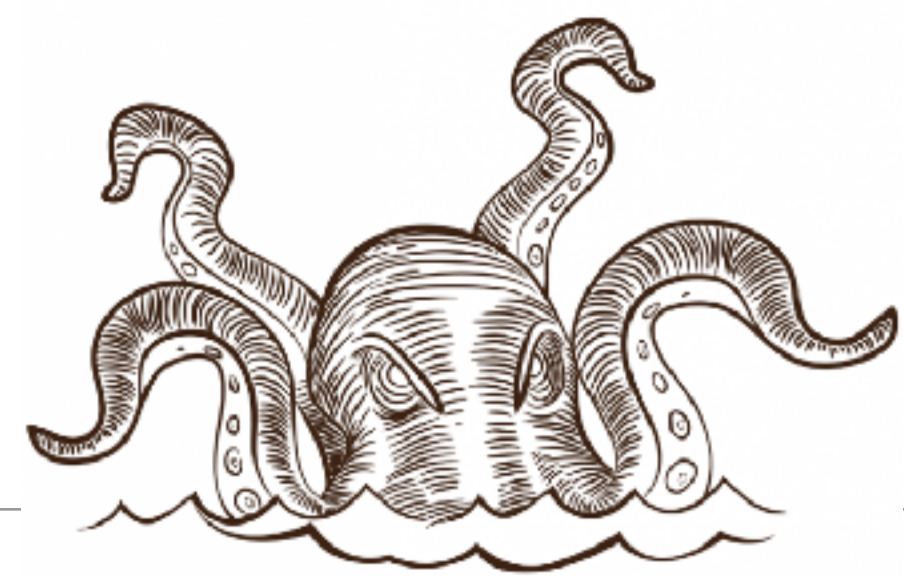
$ go get **Kraken**



A stateful approach to cluster management

08/23/2018 – LA-UR LA-UR-18-28020

Time to rethink cluster management

- Modern language and software architecture

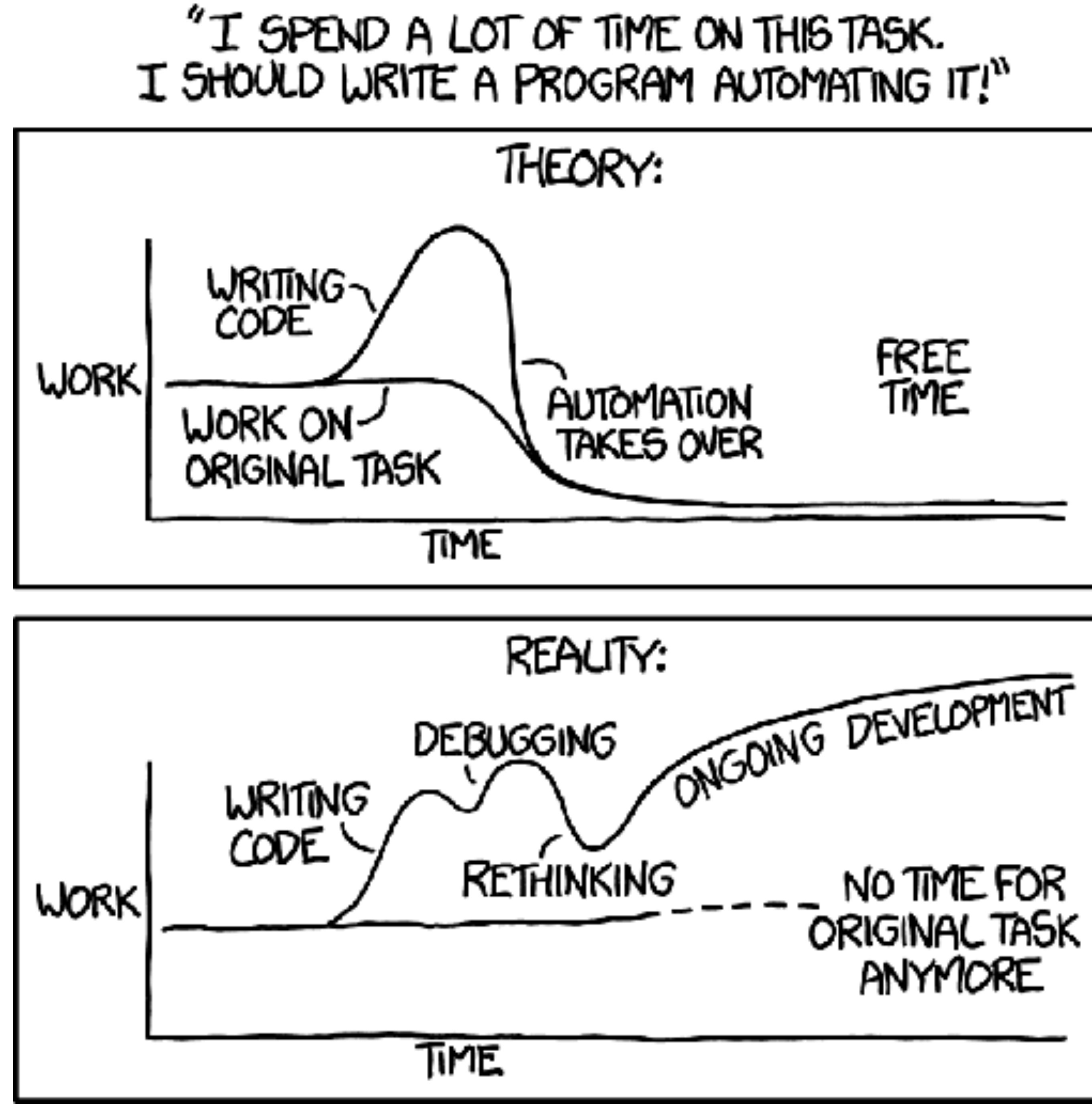
Wishlist:

- Hardware and distribution agnostic
- Complete modularity
- Microservices architecture
- Community supported project
- ***It needs to be smarter!***

What do we mean by "Smarter?"

We need our cluster manager to:

- *Boot* to a desired state
- *Maintain* that state, even in the event of soft failures
- *Manage* automated change of state, like rolling updates
- *Adjust* to changes in configuration management
- *Provide* administrative feedback on system health and state



https://xkcd.com/1319/

Ad hoc vs. Stateful Automation

Ad hoc Automation

Create scripts and hooks to handle known failure modes

- Lower initial cost of development
- No verification that failure was actually handled
- High “entropy” / difficult to maintain, or even track reliably
- Inflexible: generally designed to maintain only a single defined state

Ad hoc vs. Stateful Automation

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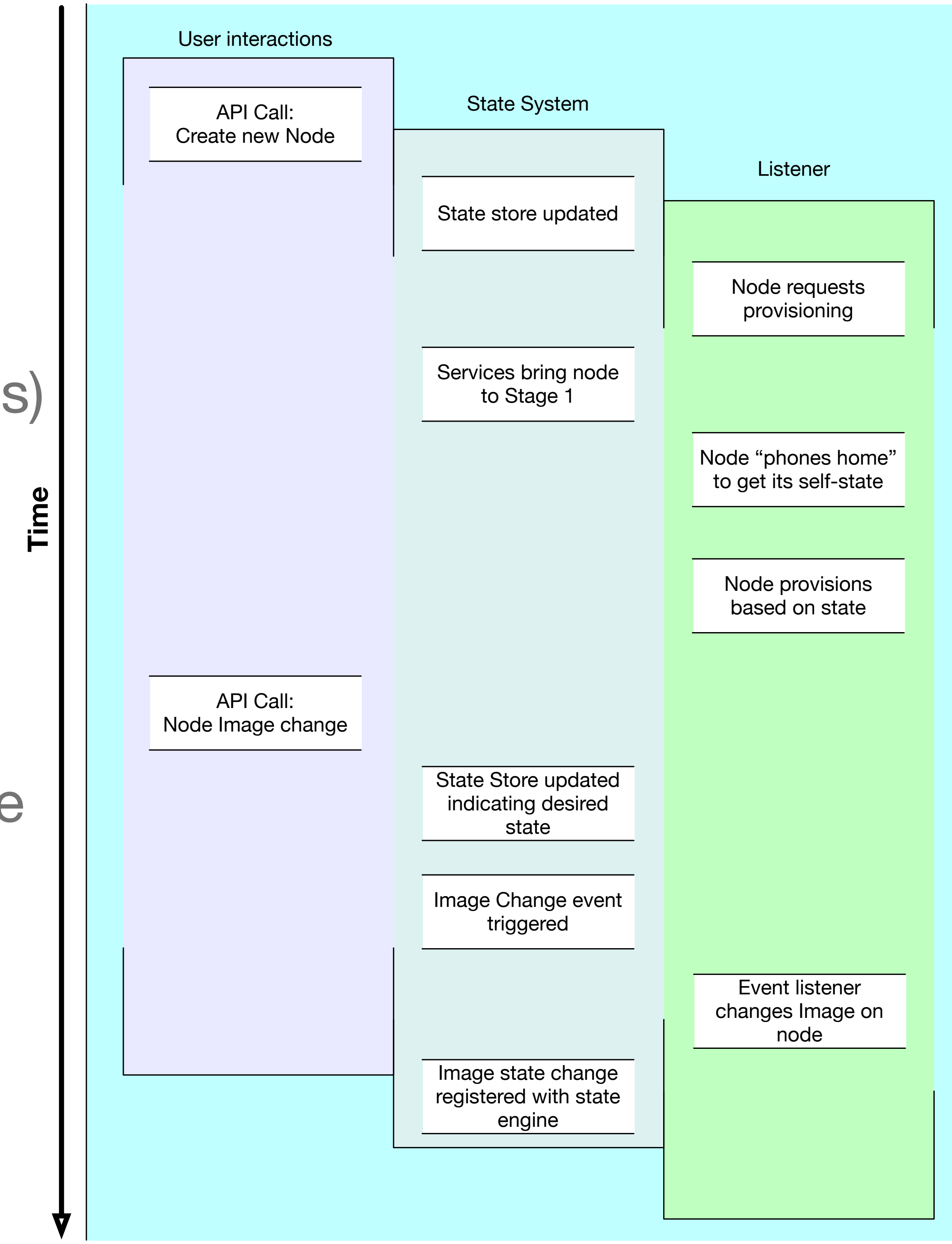
Stateful Automation

1. Keep track of desired state vs. current state
2. Know how to evolve the system from current state to desired state

- Verifies that the desired state is actually reached
- More maintainable, centralized source of automation
- Can be used to attain/maintain any state we know how to evolve to

Kraken is a State Engine

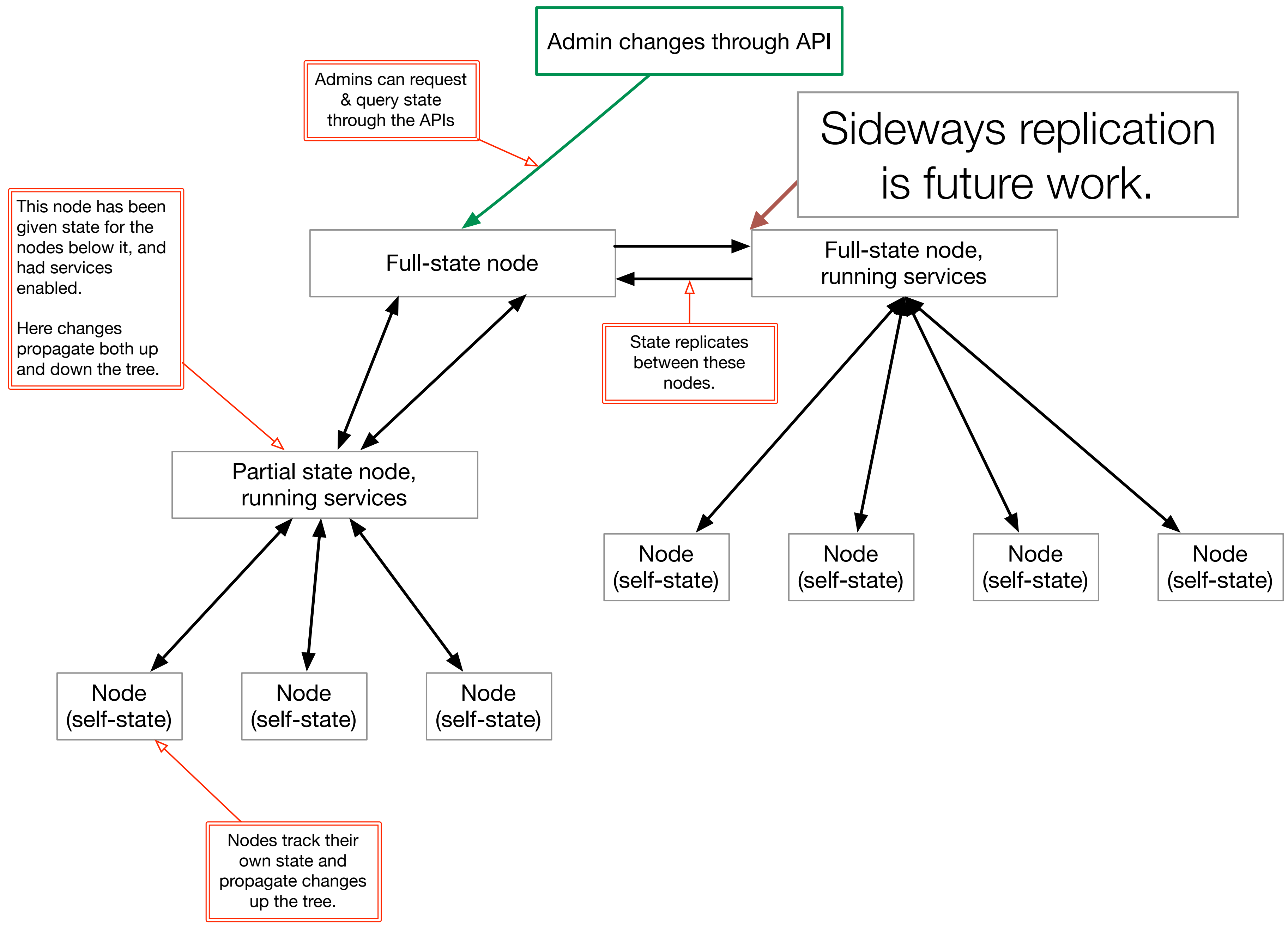
- **Kraken** is a *state engine*
    1. Tell kraken the state you want (via APIs)
    2. State changes trigger events
    3. Event listeners make things happen
- State store, event engines, services, etc. are **modules**
- The state store actively tracks the state of system components



Kraken is Distributed

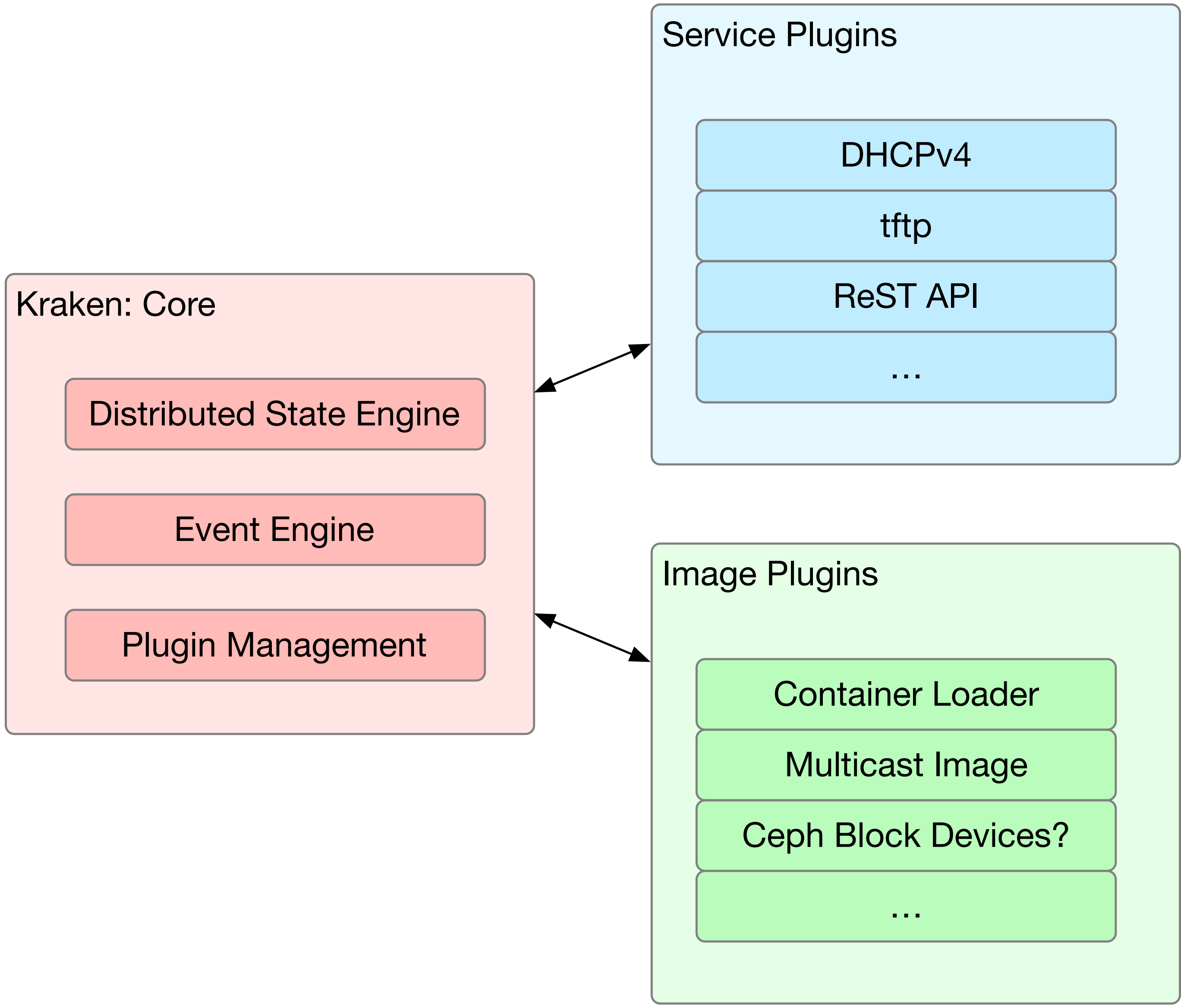
- **Kraken** is a *distributed* state engine

1. State can propagate up/down a tree of nodes.
2. *(Future)* State can replicate sideways.
3. Every node tracks at least its own state and propagates changes up.
4. Any node can be given a portion of state, including the “running this service” state, temporarily or permanently providing services to all or a portion of nodes.



Kraken is Modular

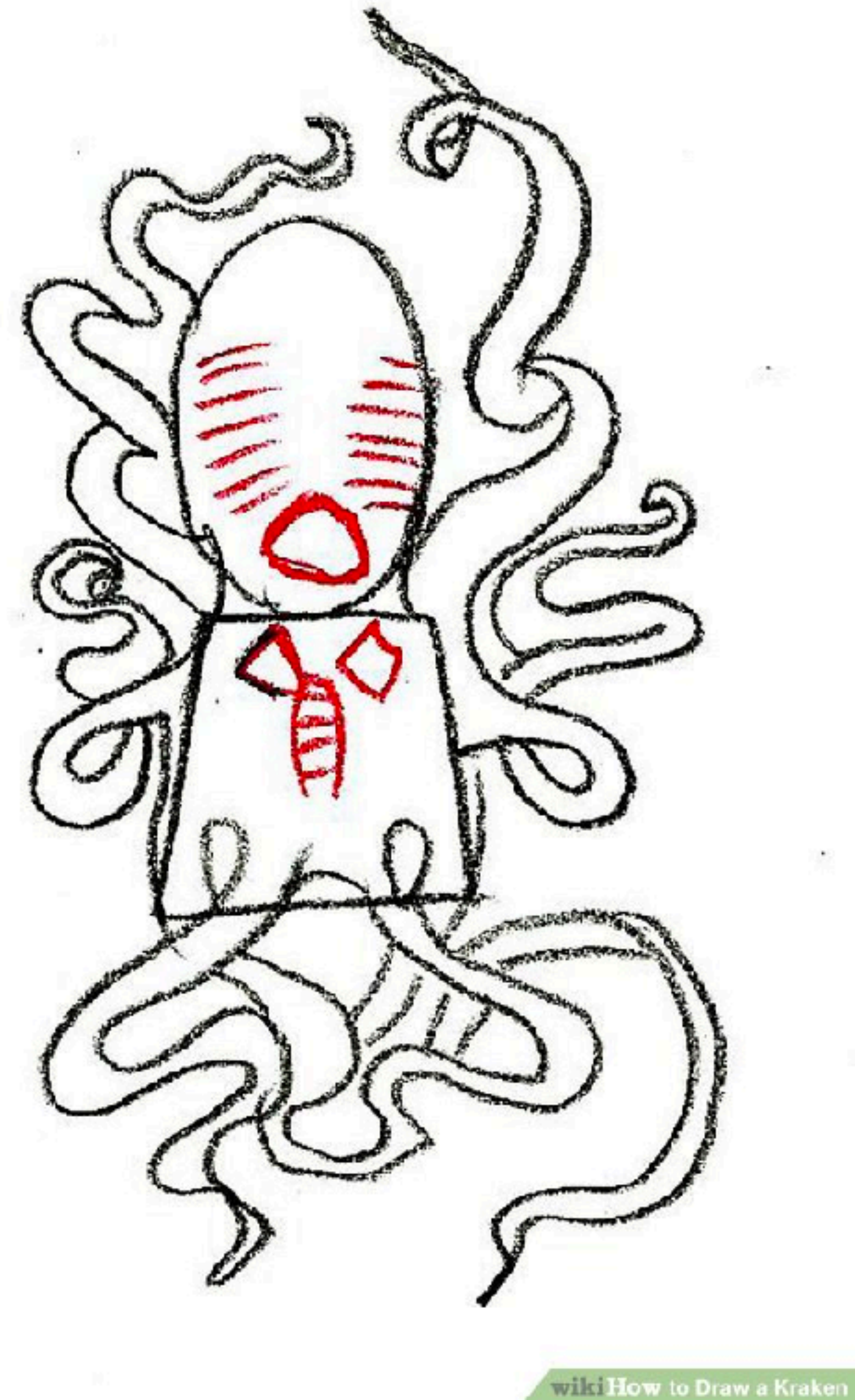
- The Core of Kraken:
  - Distributed State Engine (and query language)
  - Event Engine/State Evolution
  - Plugin Management
- Services are modules, and are controlled through State
- Image distribution and loading is modular
- Different classes of modules can be added as needed (Scheduler integration, BMC interfaces, etc.)
- Modules can be Go interfaces, or outside processes communicating via RPC or ReST API



State of the Kraken

- Basic set of functional microservices
- Can boot multiple architectures
- Uses layered container images in reference implementation
  - …but much still to be done.
- Code just released on GitHub:

  http://github.com/hpc/kraken



We need smarter cluster management for the future of HPC

References

[1] E.A. Brewer. Towards robust distributed systems (abstract). In *Proceedings of the 19th Annual ACM Symposium on Principles of Distributed Computing*, July 2000.

[2] D. Terry. Replicated Data Consistency Explained Through Baseball. *MSR Technical Report, 2011.*

[3] CouchDB documentation. http://guide.couchdb.org/draft/consistency.html#figure/4

[4] W. Vogels. Eventual Consistent. *Communications of the ACM*,Vol. 52, No. 1., 2009.

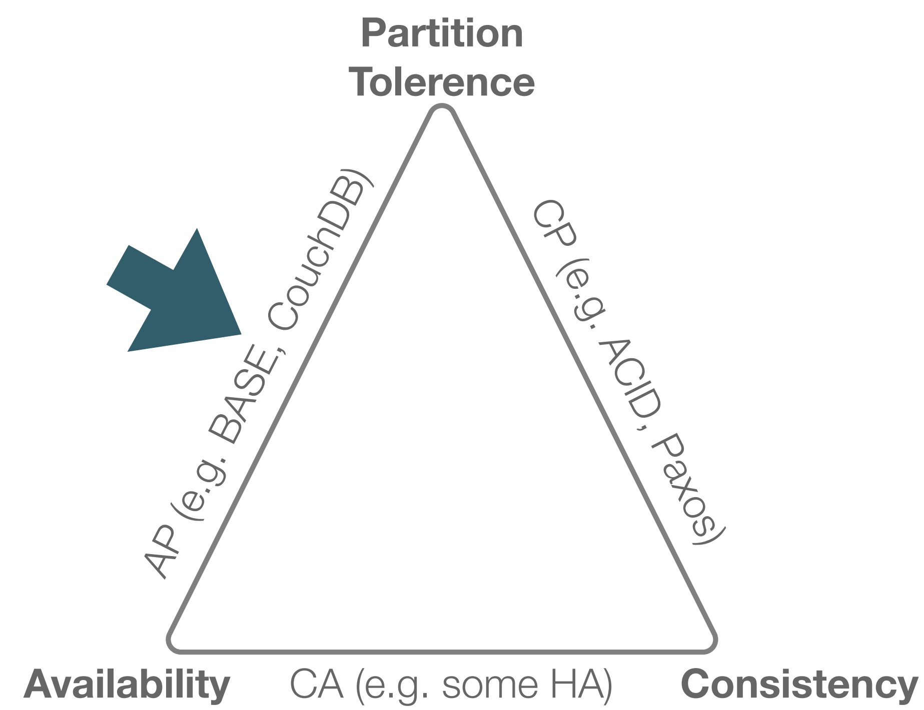
[5] D. Arnold, B. Miller. Scalable Failure Recovery for High-performance Data Aggregation. In IEEE Symposium on Parallel & Distributed Processing (IPDPS), May 2010.

Auxiliary slides

Consistency & Availability of state

- It’s more important that we keep nodes running
- It’s less important if nodes occasionally do something wrong
    - As long as it fixes itself
    - And doesn’t interrupt jobs
- We should be consistent when we can, but available always
- We need to scale HUGE
    - Paxos, Raft, 2-phase commit… are out.
    - Look to Azure, AWS, etc… who all use *Eventual Consistency* for this kind of service.

CAP Theorem



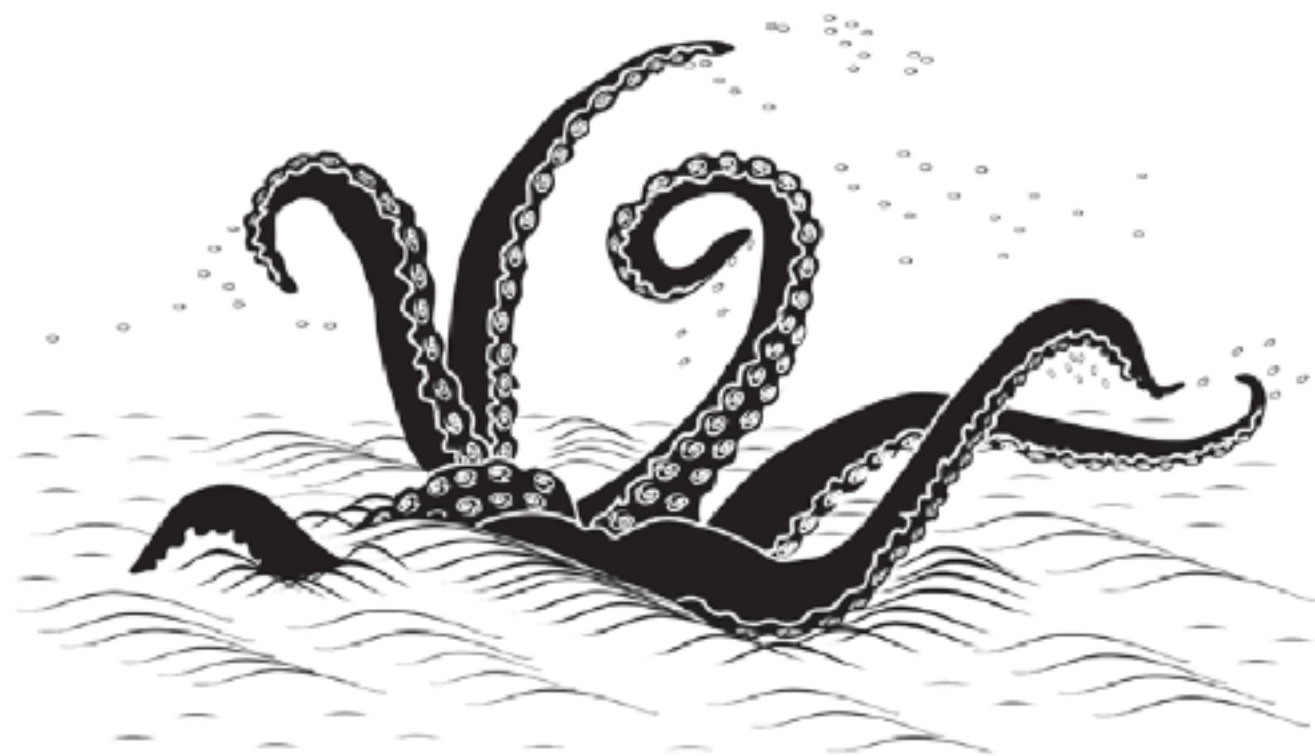
Guarantee	Consistency	Performance	Availability
Strong Consistency	excellent	poor	poor
Eventual Consistency	poor	excellent	excellent
Consistent Prefix	okay	good	excellent
Bounded Staleness	good	okay	poor
Monotonic Reads	okay	good	good
Read My Writes	okay	okay	okay

Table 2. Consistency, Performance, and Availability Trade-offs

[1] E.A. Brewer. Towards robust distributed systems (abstract). In *Proceedings of the 19th Annual ACM Symposium on Principles of Distributed Computing*, July 2000.
[2] D. Terry. Replicated Data Consistency Explained Through Baseball. *MSR Tech*

We need *two* kinds of state

1. "Configuration state"
   - What we want the system to look like
   - Is specified by the administrators (or configuration management)
2. "Discoverable state"
   - What the system actually looks like
   - State is automatically discovered on the node(s)



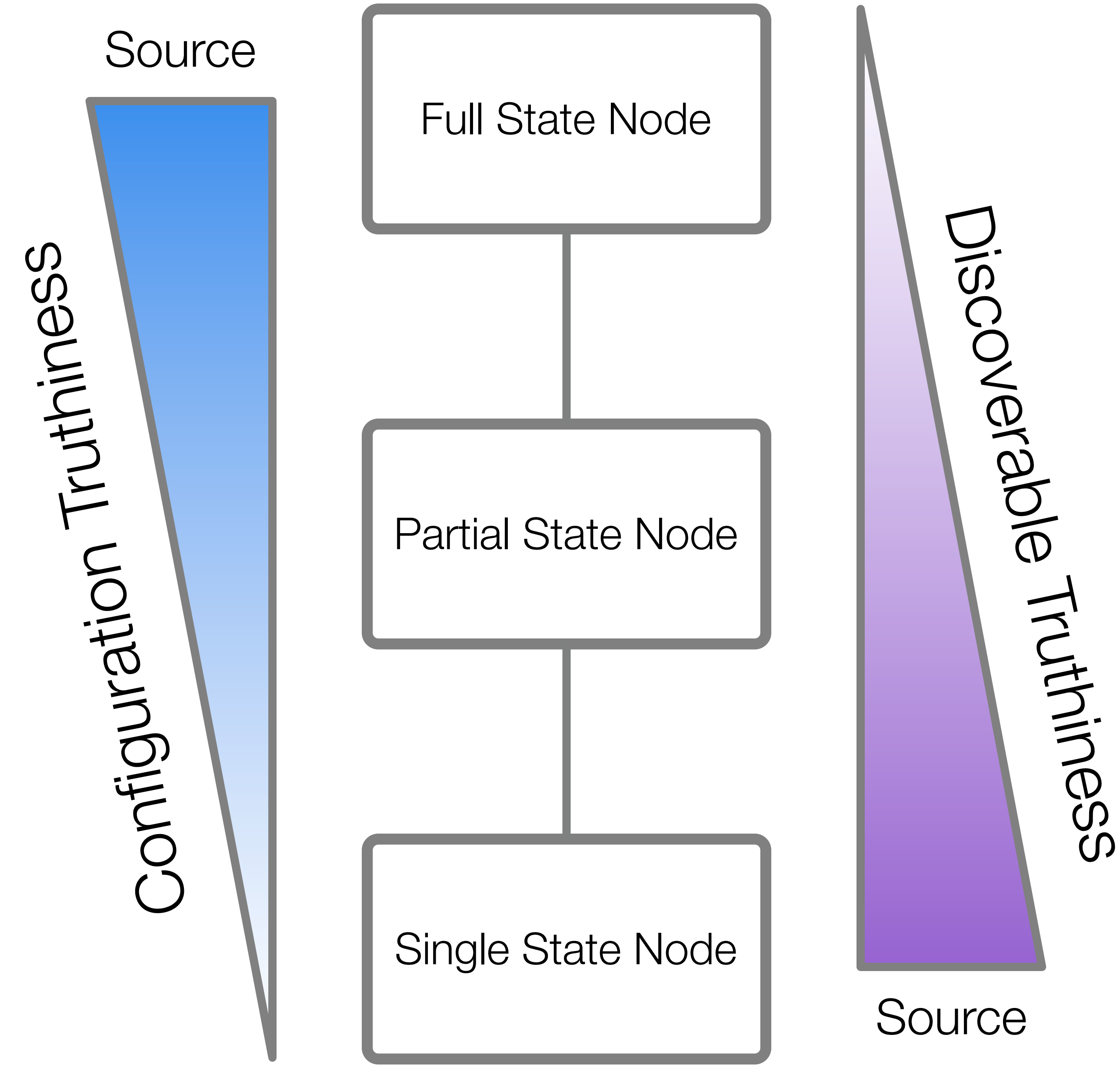
Birth of the Kraken

Four rules of Kraken state

1. There will always be a well-defined *source of truth*
2. We will *never guarantee synchronicity* of state
3. State can be wrong as long as it *eventually* converges
4. State will be *small*

Rule 1: Source of Truth

1. The source of truth for *Configuration* state is the *Full State Node* (FSN)
    - Configuration state is set through the FSN
    - In event of failure, the nearest available node to the FSN is trusted
2. The source of truth for *Discoverable* state is the *Single State Node* (SSN)
    - SSN has modules to read actual state, e.g. hardware health
    - If the SSN is not initialized, or declared dead, the parent is trusted



Rule 2: Asynchronous

- We never guarantee that either configuration or discoverable state is the same throughout the tree
- There is no equivalent to a “barrier” or “sync” operation
- Any microservice that requires such an operation must provide its own mechanism for sync
- This *greatly* improves scalability
- Example: multicast image deployment would need to have its own mechanism to say all nodes are ready to receive

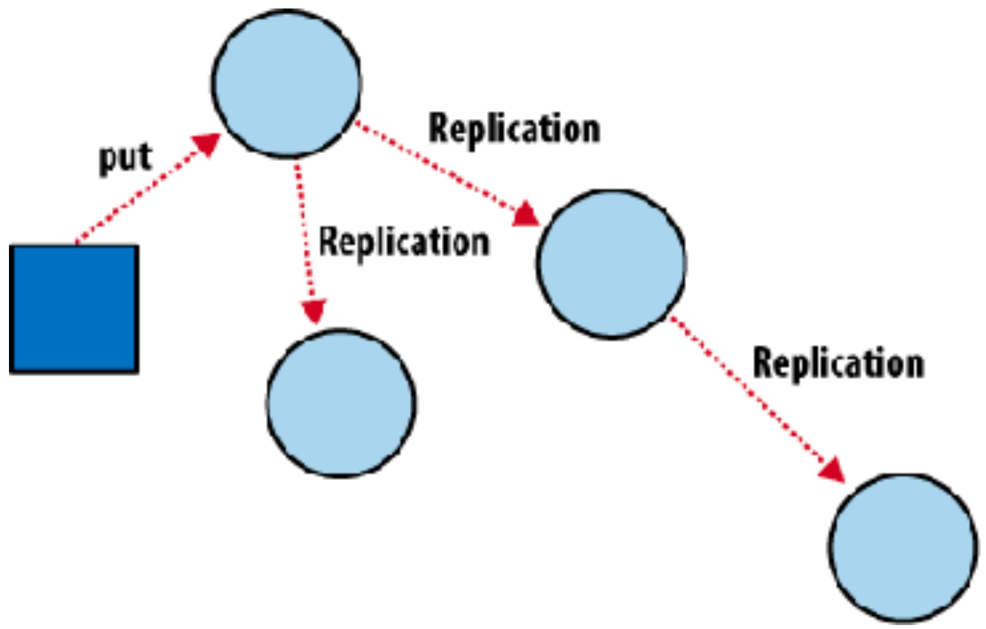
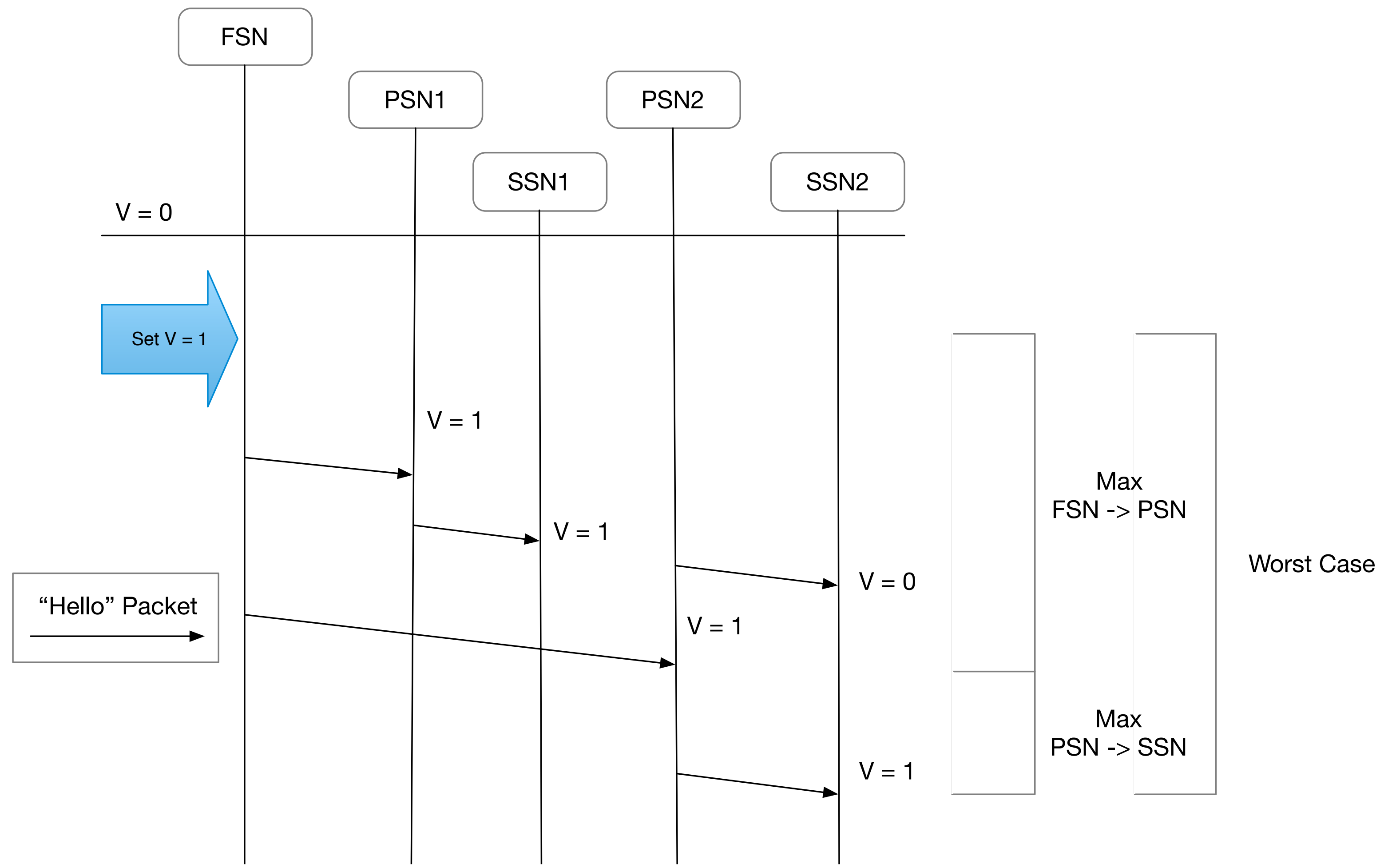


Figure [1]: Incremental replication between CouchDB nodes.

[3] CouchDB documentation. http://guide.couchdb.org/draft/consistency.htr

Rule 3: Eventual consistency

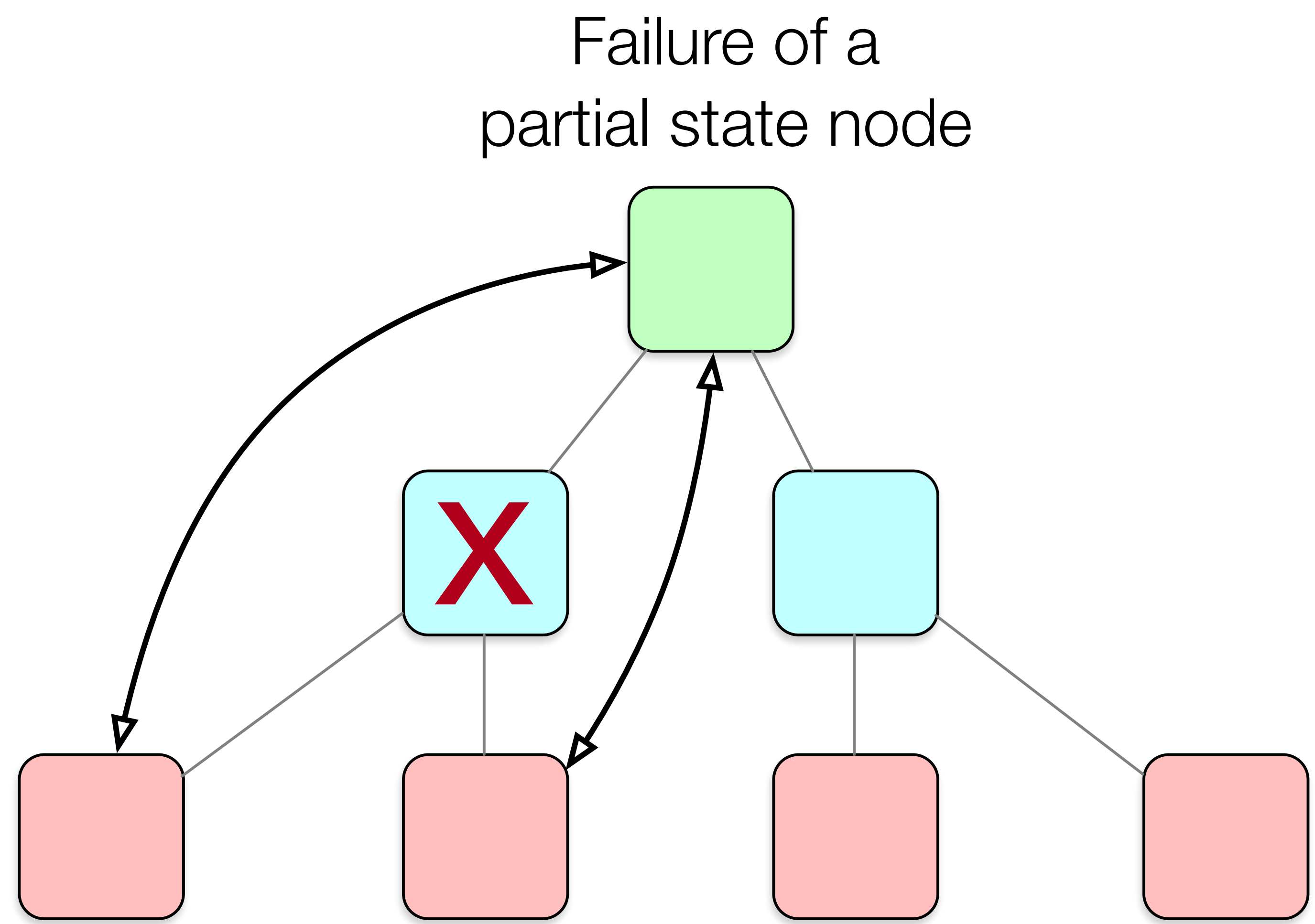
- Different parts of the tree may be out of sync at any given time, but…
  - ➡ In absence of changes, *sync will converge*
    - ➡ And the max time to converge is well-defined
- Hence, we may make mistakes
  - ➡ But we will correct them "quickly"



[4] W. Vogels. Eventual Consistent. *Communications of the ACM*,Vol. 52, No. 1., 200
[2] D. Terry. Replicated Data Consistency Explained Through Baseball. *MSR Technica*

Rule 4: State is small

- State synchronization is accomplished with 1-way "hello" messages containing the state of a node
- State needs to be contained with a single network packet (ideally single node)
- We should build trees to load balance microservices, not the state engine itself
- This allows recovery from partial state node failure to simply skip to the parent



[5] D. Arnold, B. Miller. Scalable Failure Recovery for High-performance Data Aggregation. In IEEE Symposium on Parallel & Distributed Processing (IPDPS), May 2010.

Kraken: Why?

- Current open provisioning systems are old, poorly maintained and too restrictive
- Need a flexible platform that can easily test new techniques
- Need a cluster manager that is designed to scale to meet demands of NextGen supercomputers
- Needs to be written in a modern language with modern design patterns
- Needs to support diverse hardware and architectures