Design Patterns for Container-Based Distributed Systems

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David Oppenheimer

Google Cloud Platform

Usenix HotCloud 2016

A Brief History

1985 - “The C++ Programming Language”

1994 - “Design Patterns: Elements of Reusable Object-Oriented Software”

1998 - J2EE

2004 - Map/Reduce

2006 - Borg

2013 - Docker

2014 - Kubernetes

Why did people develop patterns?

“Good fences do good neighbors make”

- Robert Frost

Object

Interface

Patterns provide:

A common language… improves collaboration

A common workspace… enables best-of-breed solutions

A common implementation.. because we develop libraries and frameworks

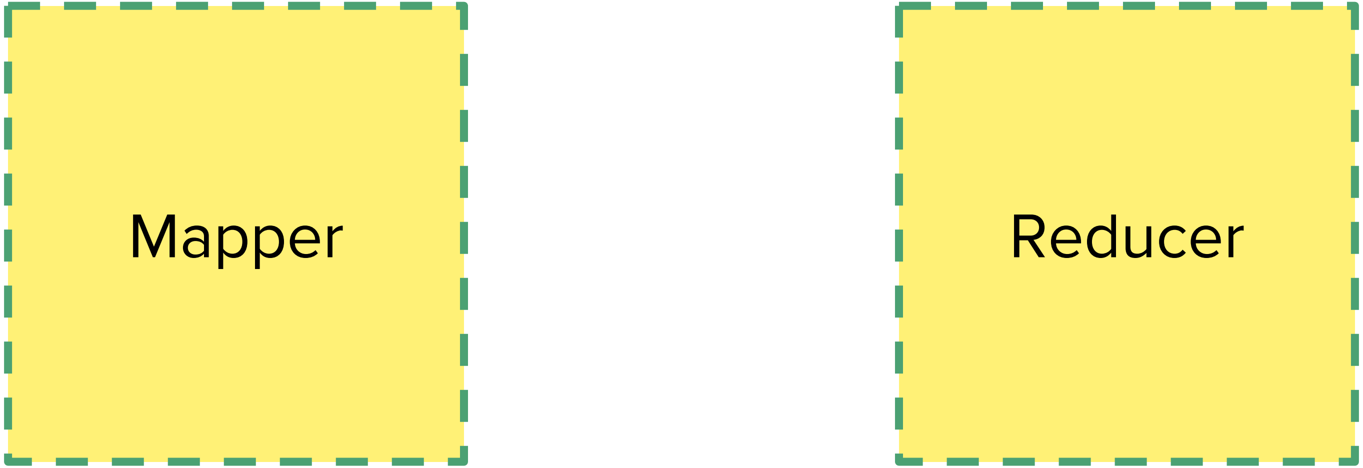
A common foundation… on which to build higher level systems

A simpler experience… makes good practices easier to adopt

A concrete example...

MapReduce: Simplified Data Processing on Large Clusters

Jeffrey Dean, Sanjay Ghemawat



Mapper

Reducer

But it’s still only one pattern, and one(ish) language

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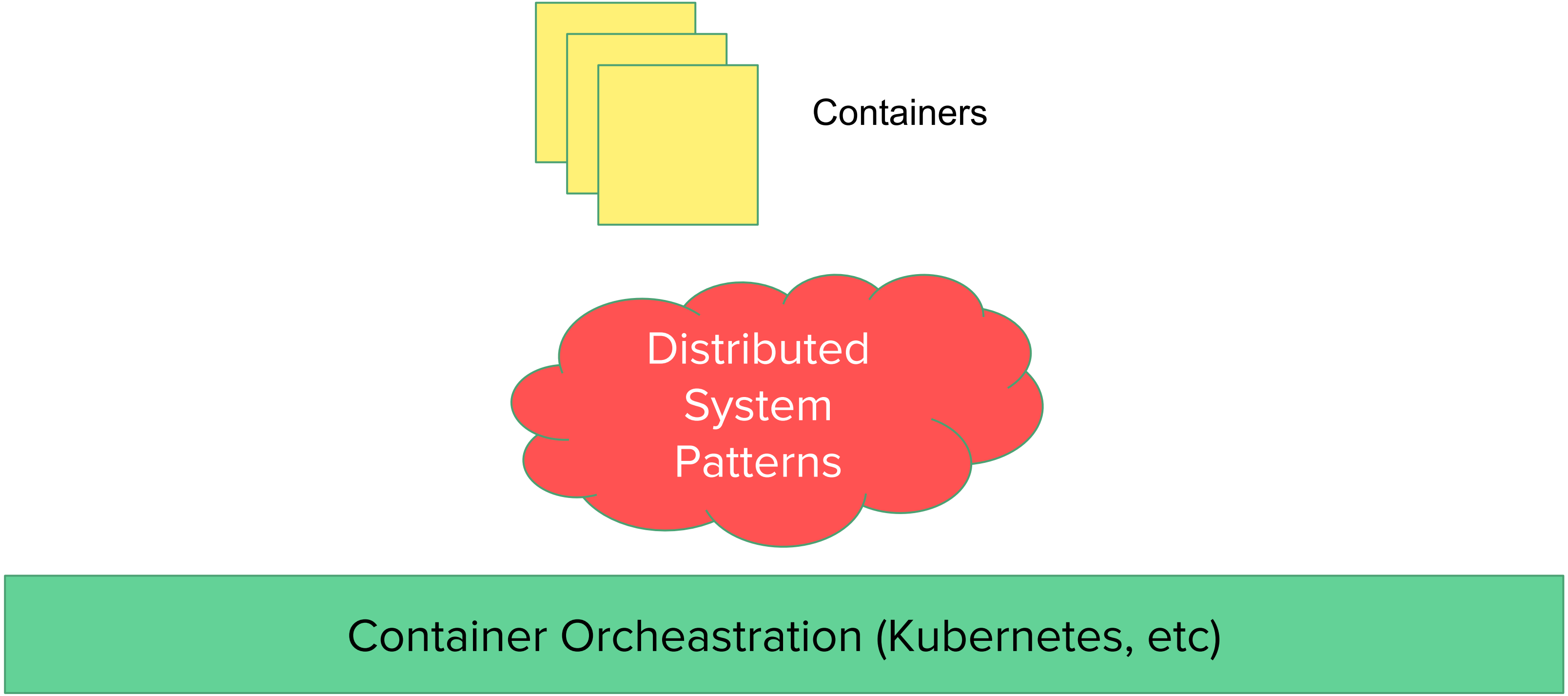

Containers
Distributed System Patterns
Container Orcheastration (Kubernetes, etc)

Container Patterns for Distributed Systems

Single-node multi-container patterns

- Sidecar
- Ambasador
- Adapter

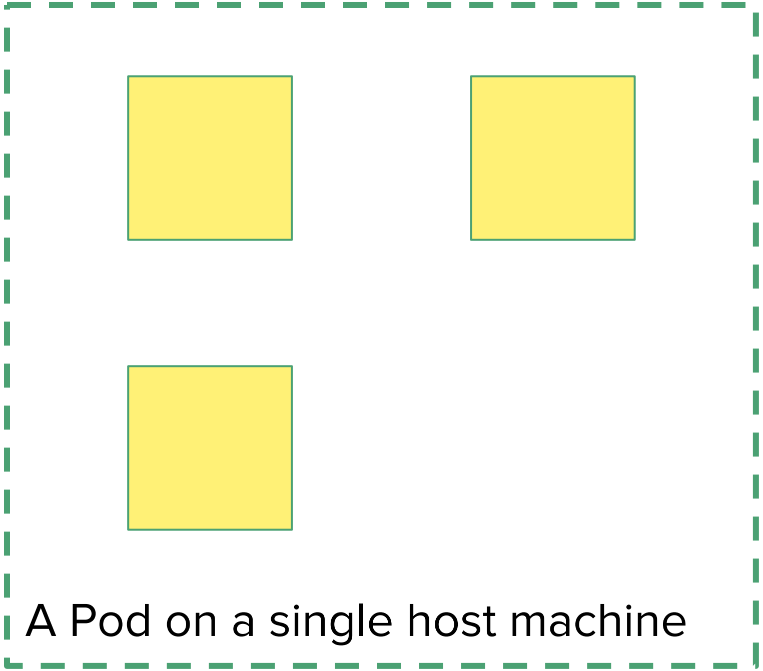
Distributed container patterns

- Leader election
- Work queue
- Scatter/gather
- ...

Single-node multi-container patterns

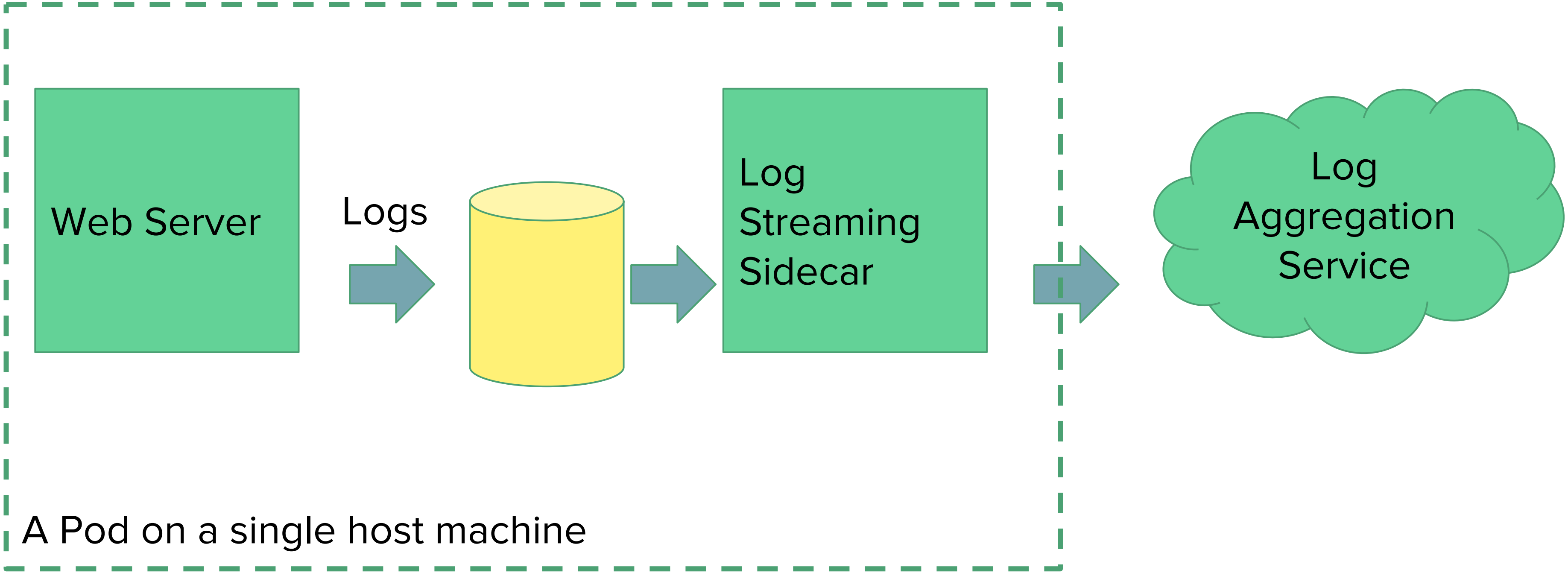
Pod

- Multiple containers
- Shared namespaces
- Shared IP address
- Atomic unit of scheduling



Sidecar

Sidecars extend and enhance



Web Server

Logs

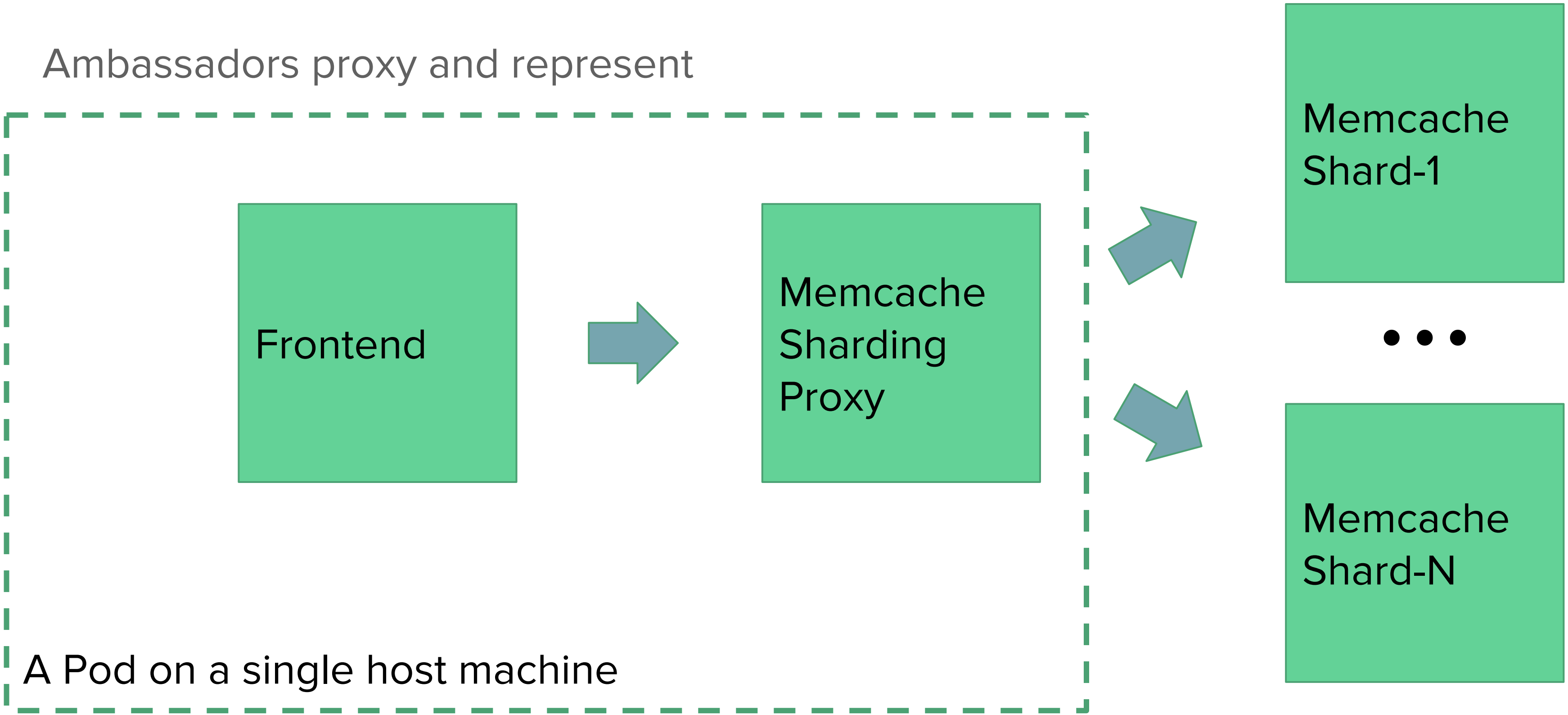
Log Streaming Sidecar

Log Aggregation Service

A Pod on a single host machine

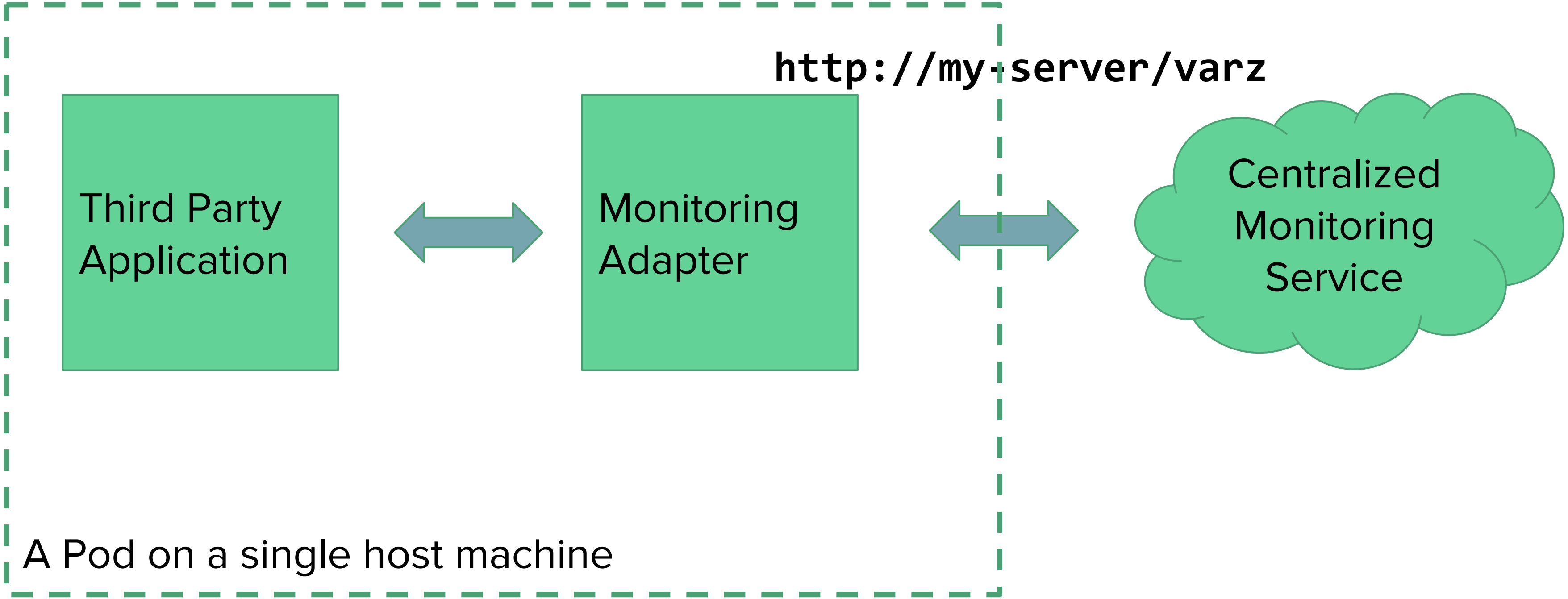
Ambassador

Ambassadors proxy and represent



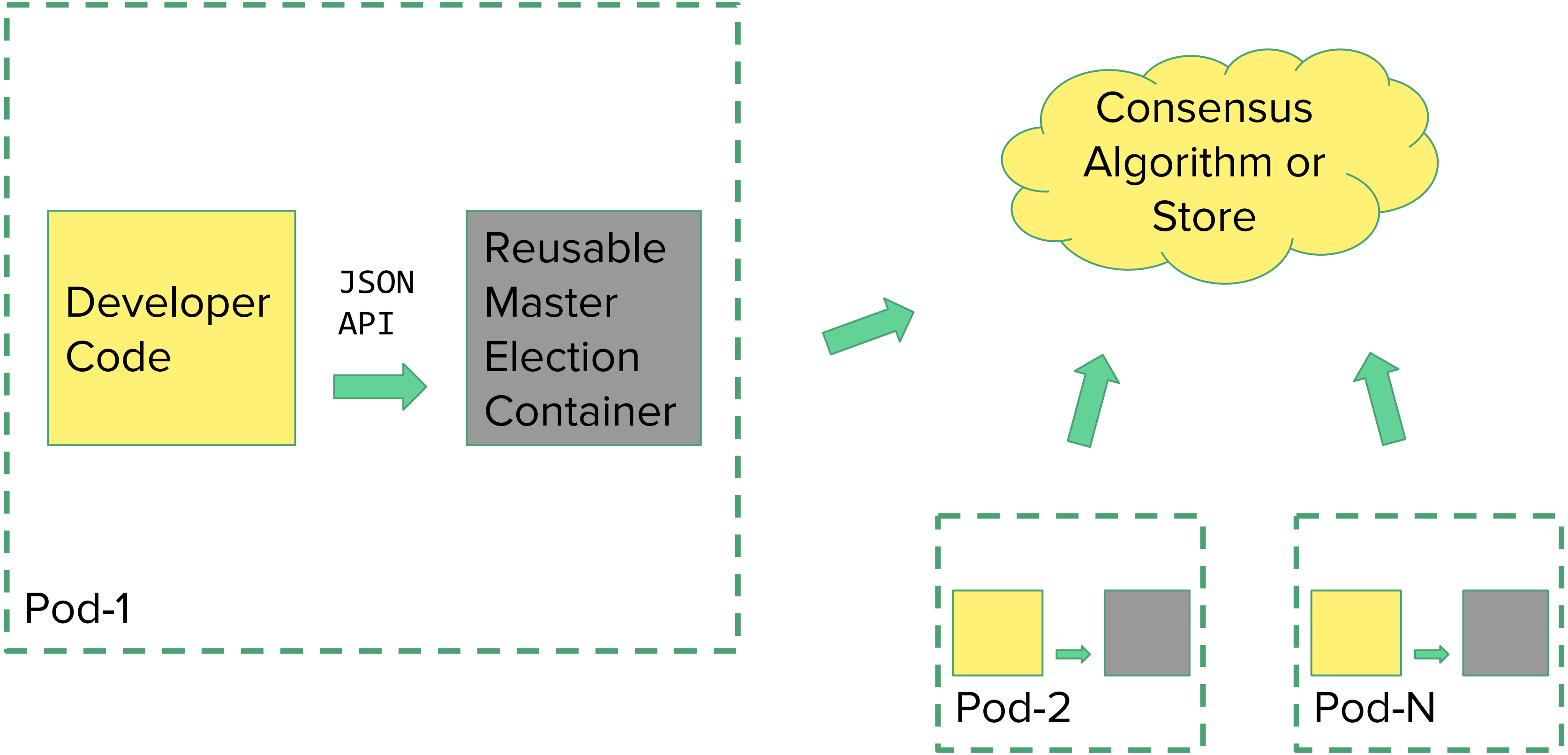
Adapters

Adapters normalize and present

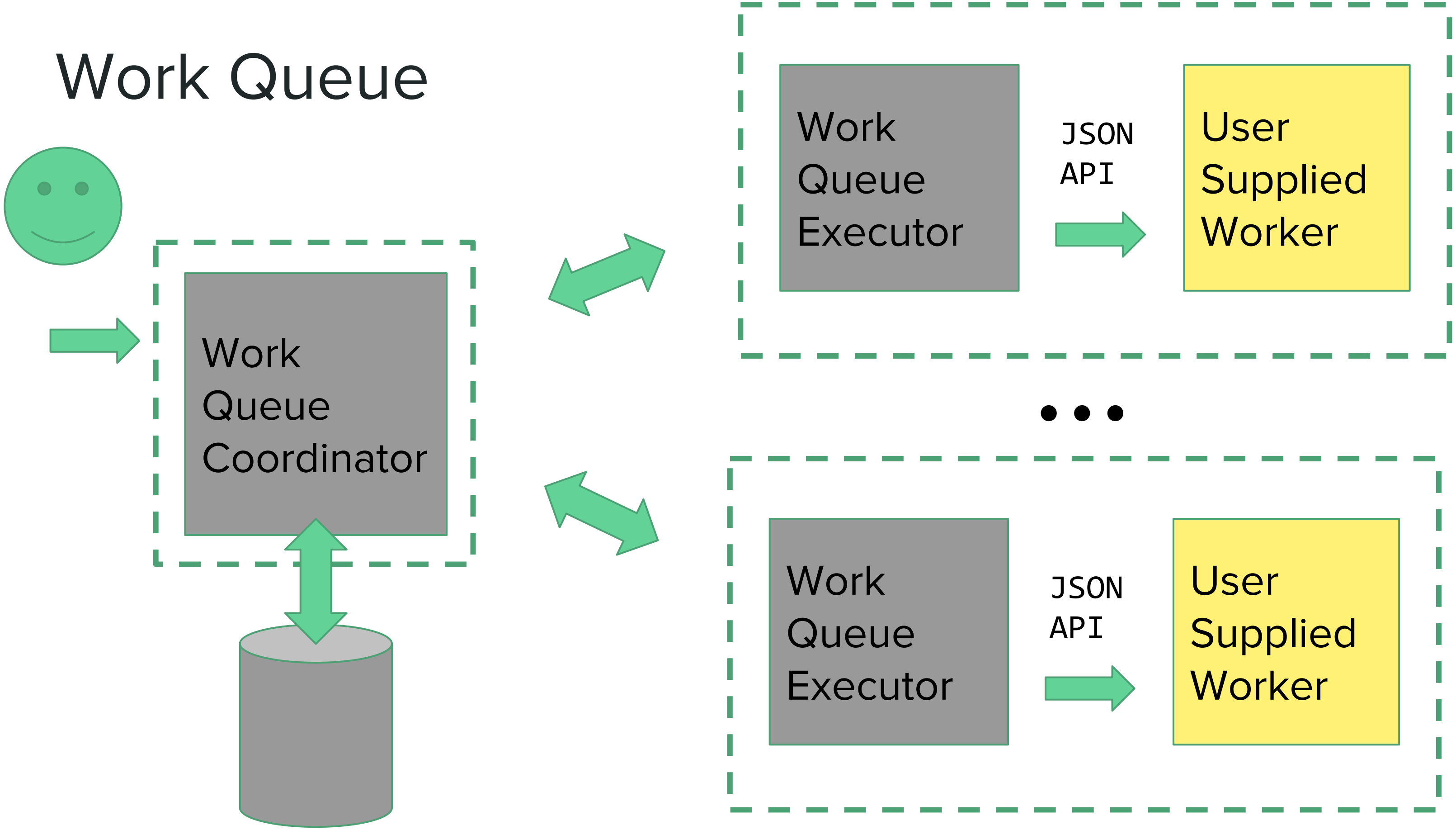


Distributed System Patterns

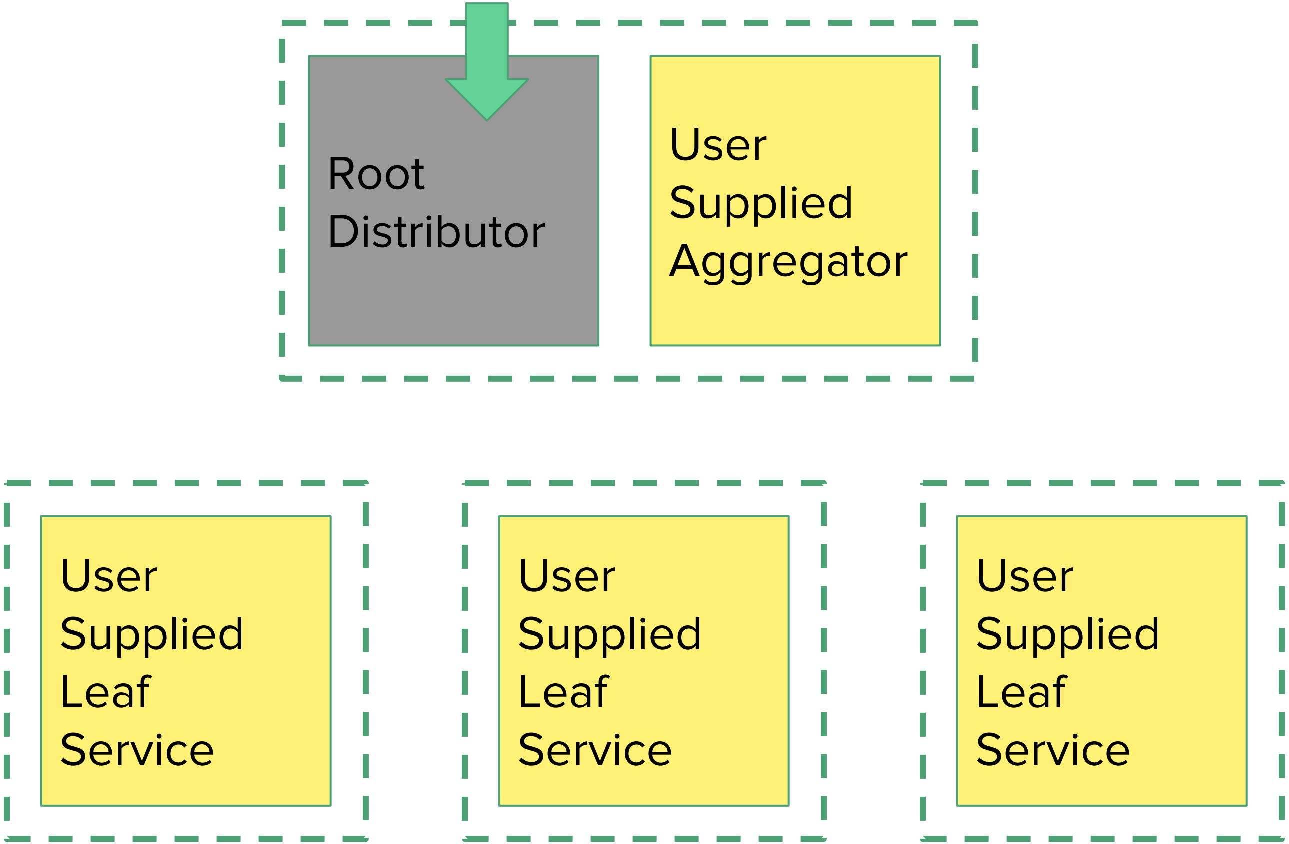
Leader Election


Developer Code
JSON API
Reusable Master Election Container
Pod-1
Consensus Algorithm or Store
Pod-2
Pod-N

Work Queue


Work Queue Coordinator
Work Queue Executor
JSON API
User Supplied Worker
Work Queue Executor
JSON API
User Supplied Worker
• • •

Scatter/Gather (aka Fan out/Fan in)



Root Distributor

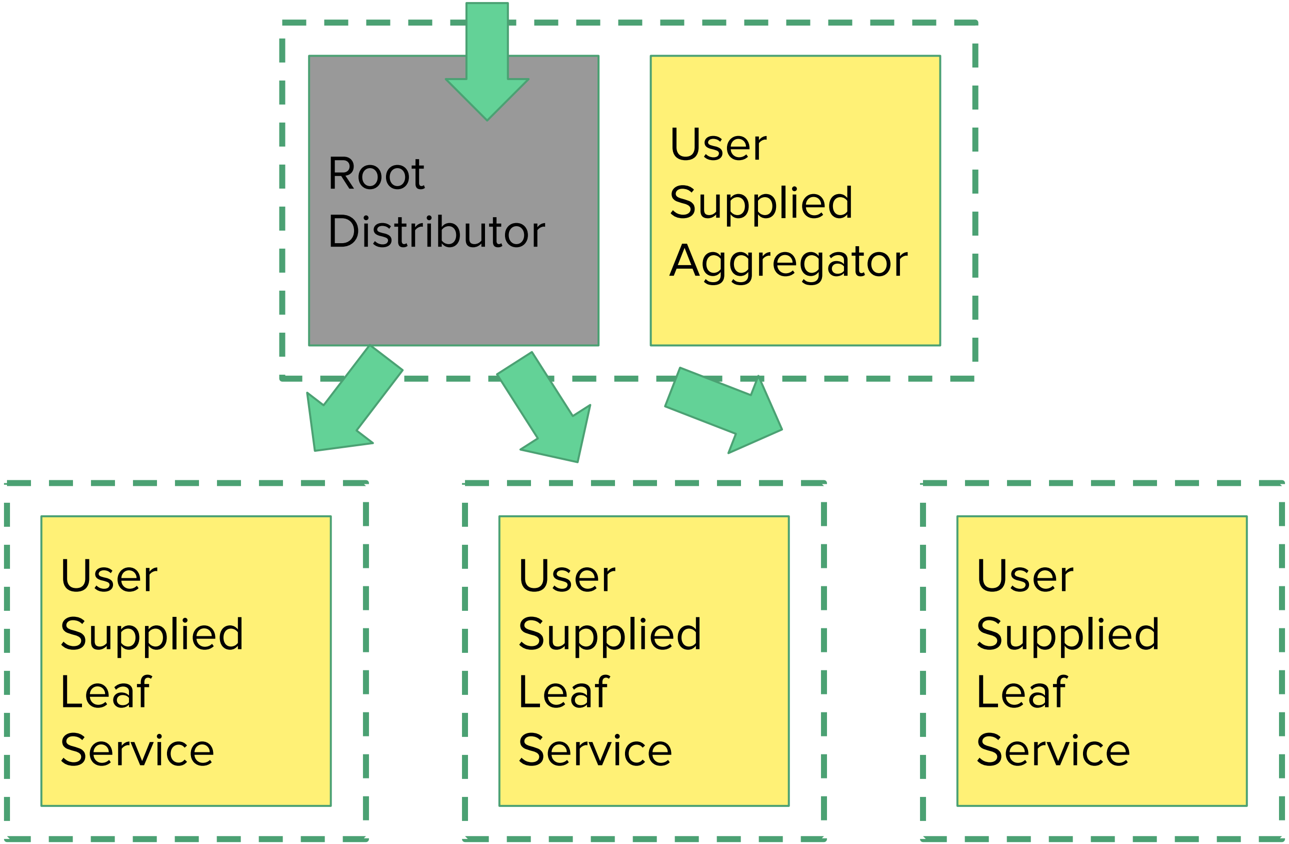
User Supplied Aggregator

User Supplied Leaf Service

User Supplied Leaf Service

User Supplied Leaf Service

Scatter/Gather (aka Fan out/Fan in)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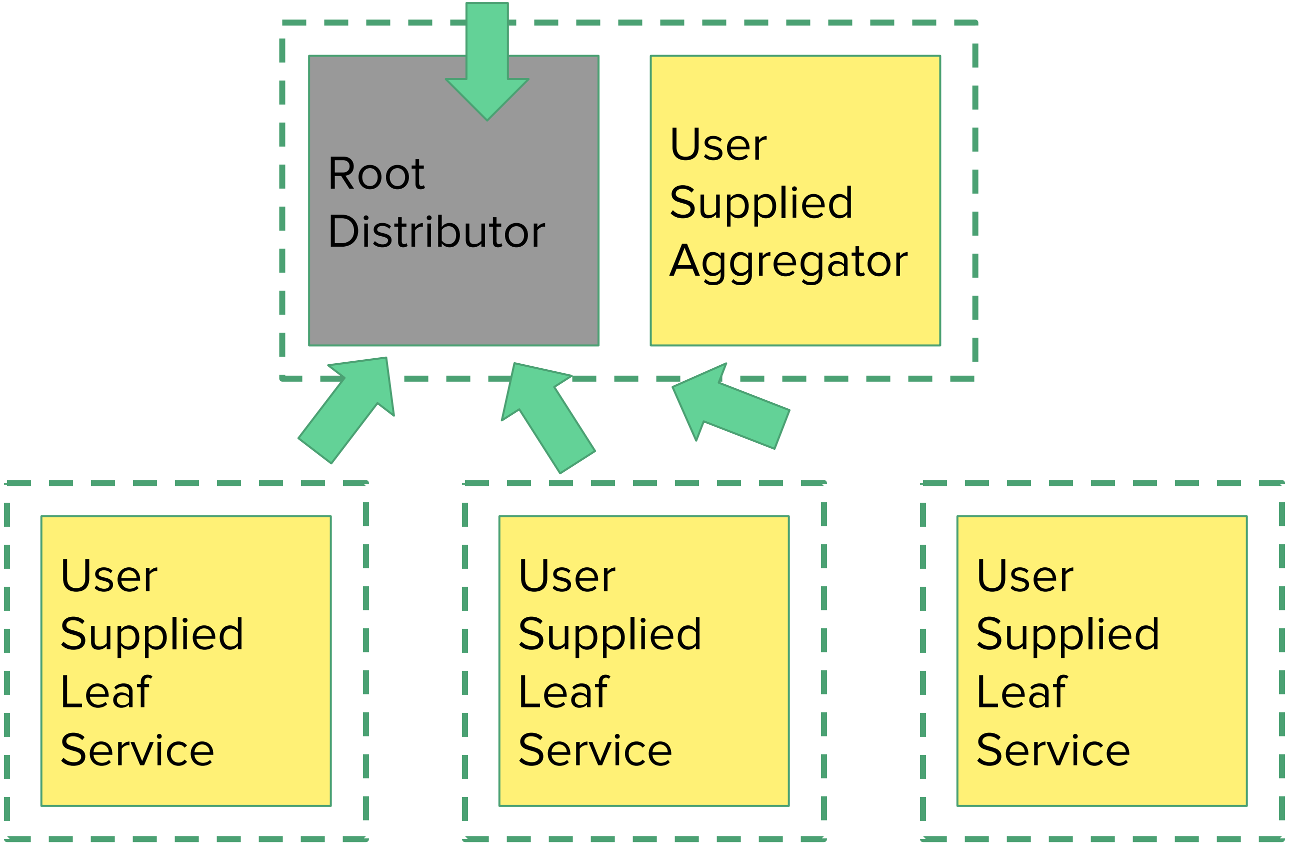

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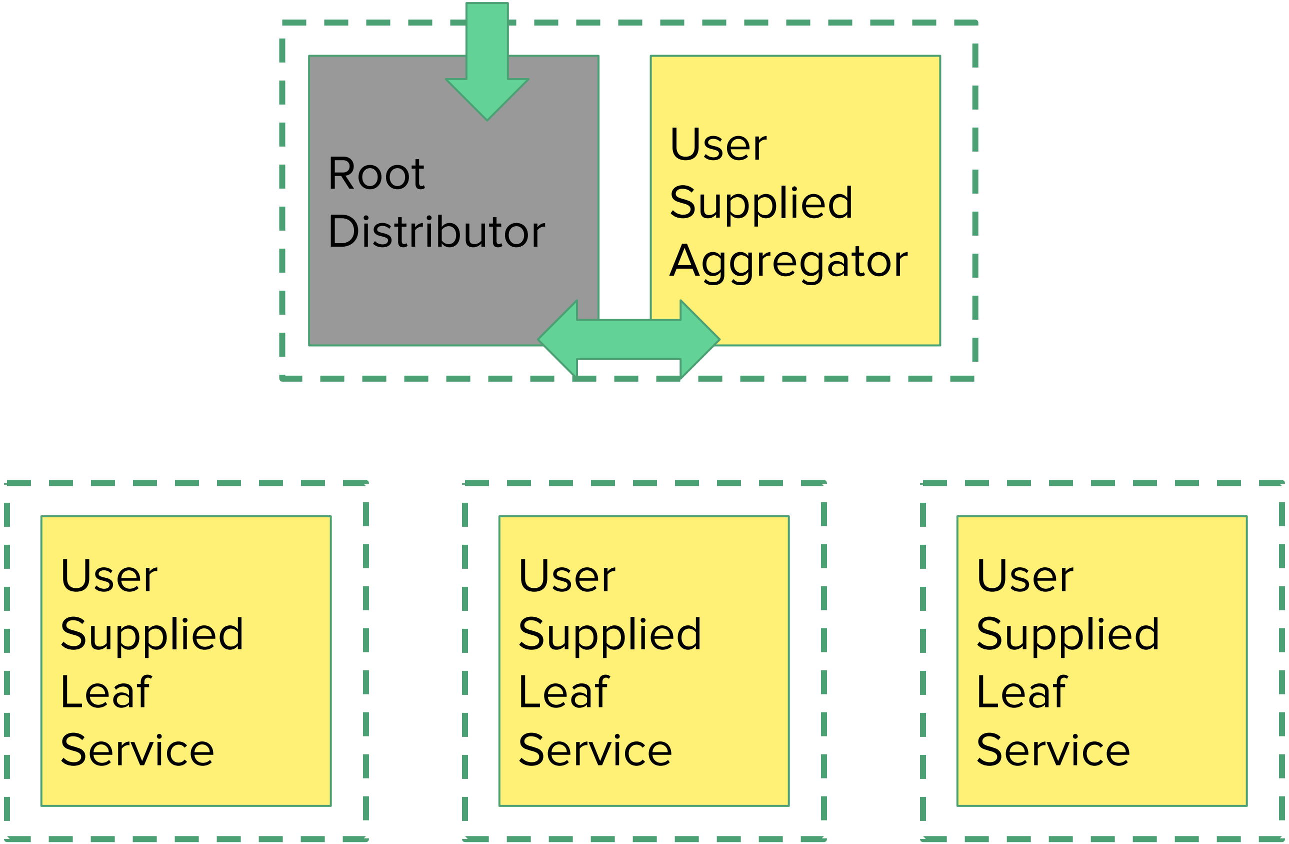
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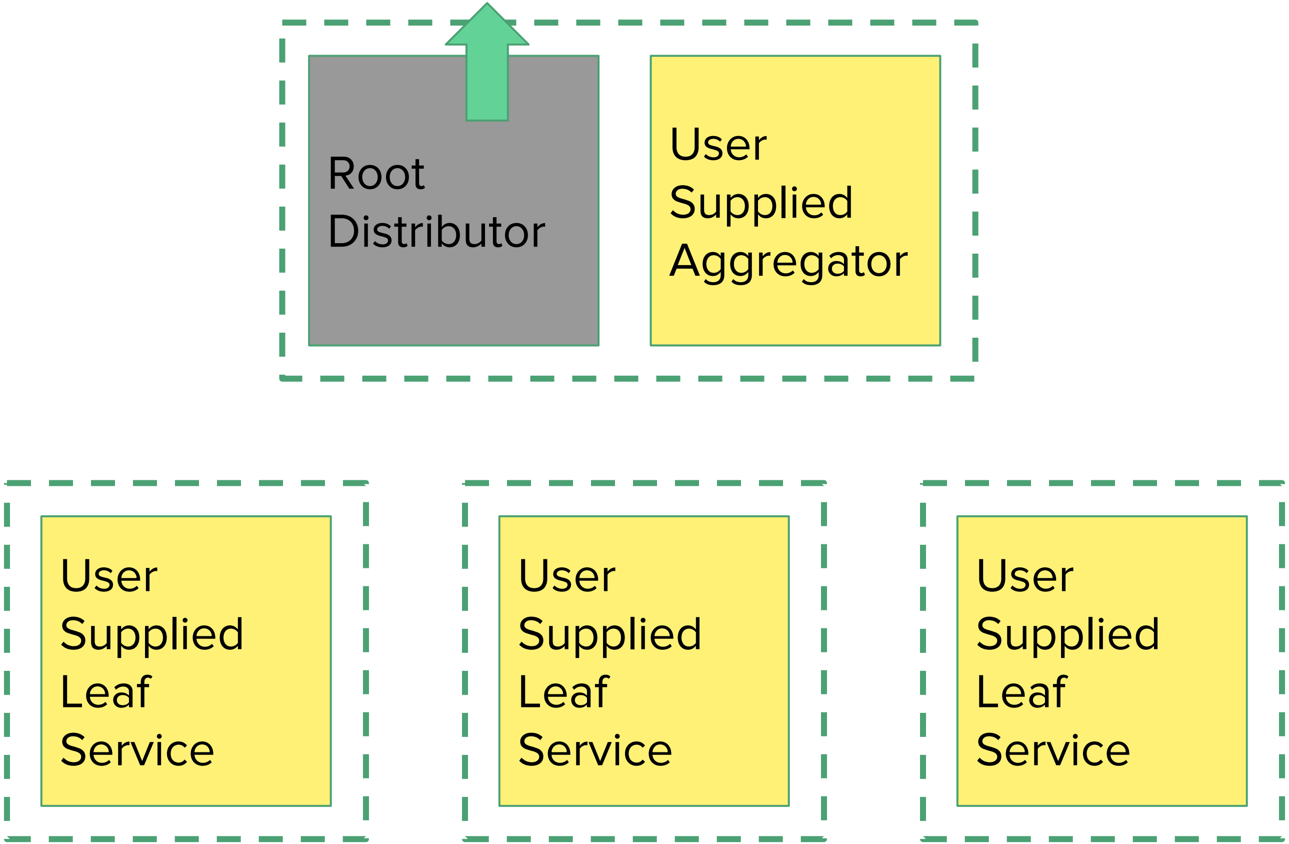

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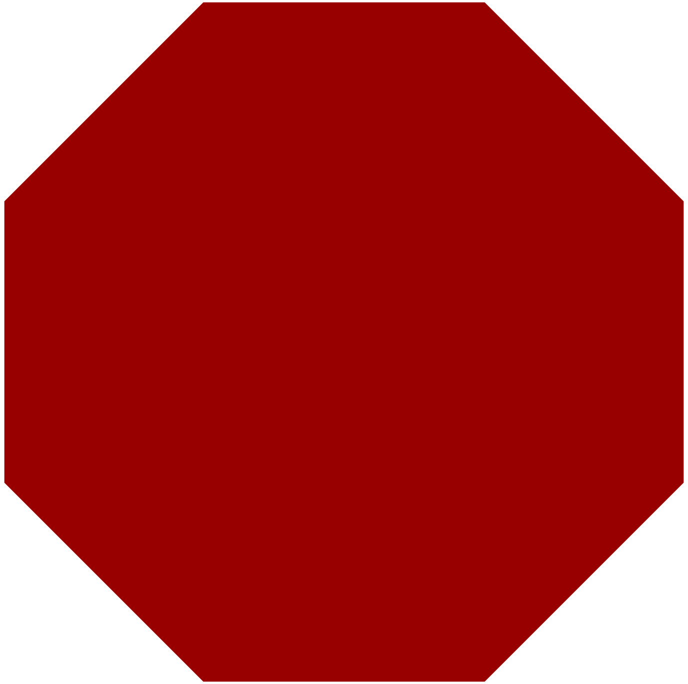
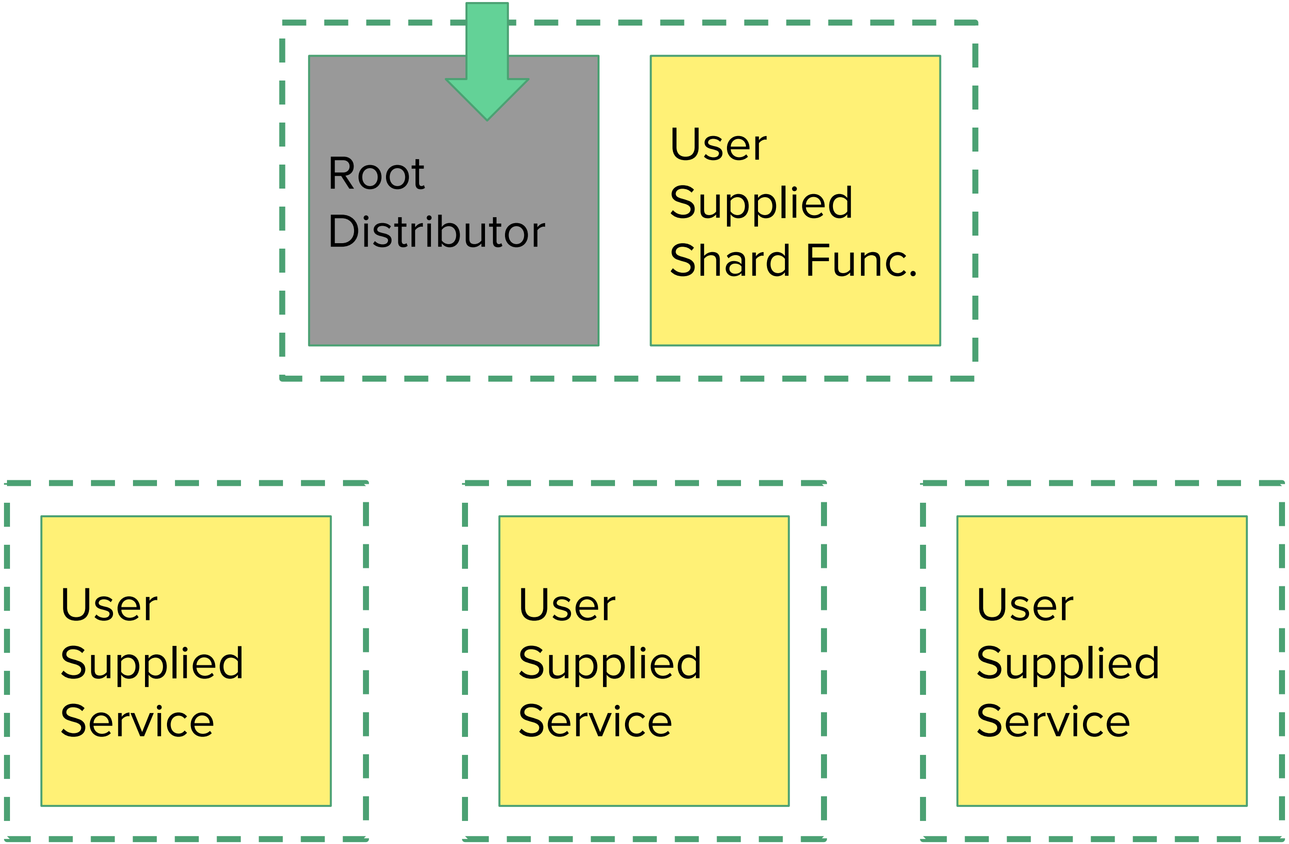
Thanks!



Sharded Service



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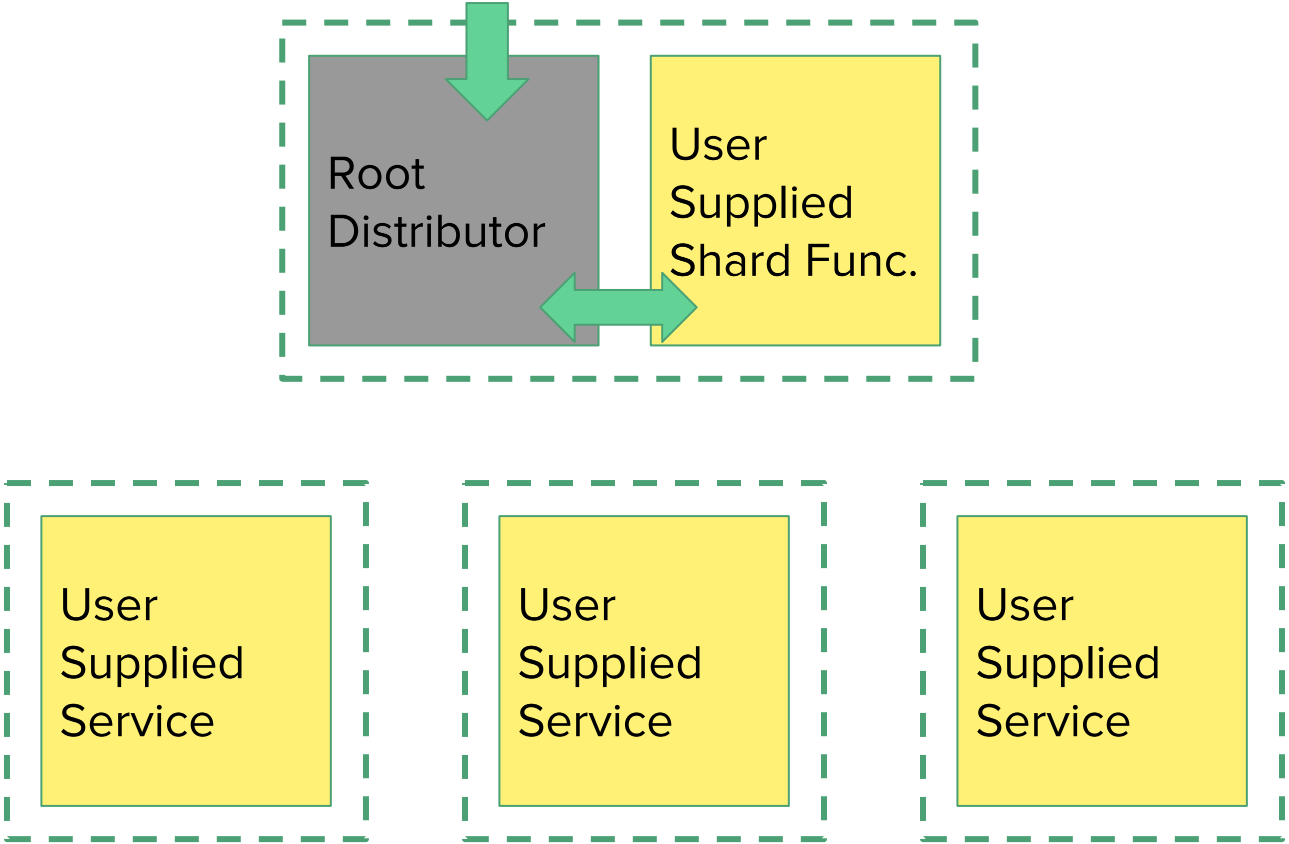

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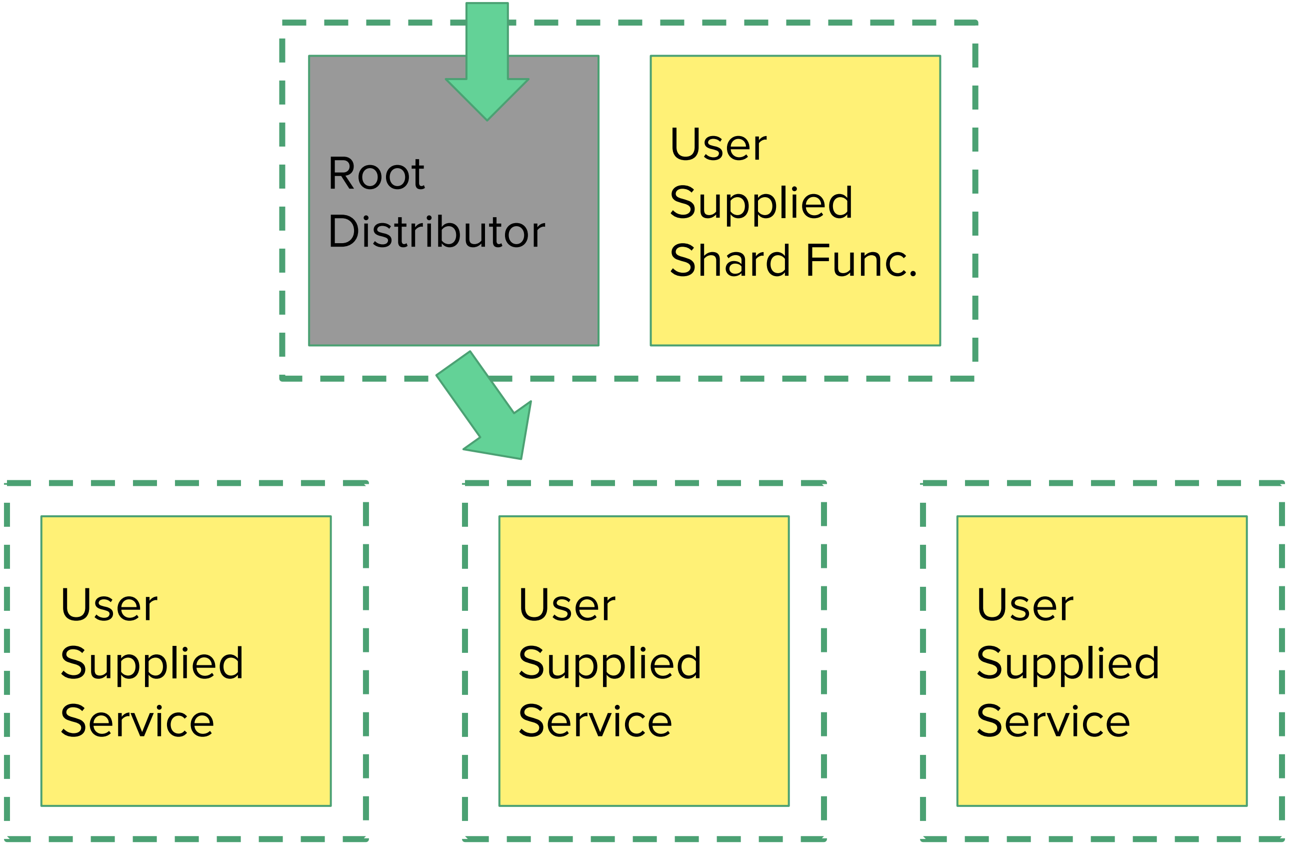
User Supplied Shard Func.

User Supplied Service

User Supplied Service

User Supplied Service

Sharded Service



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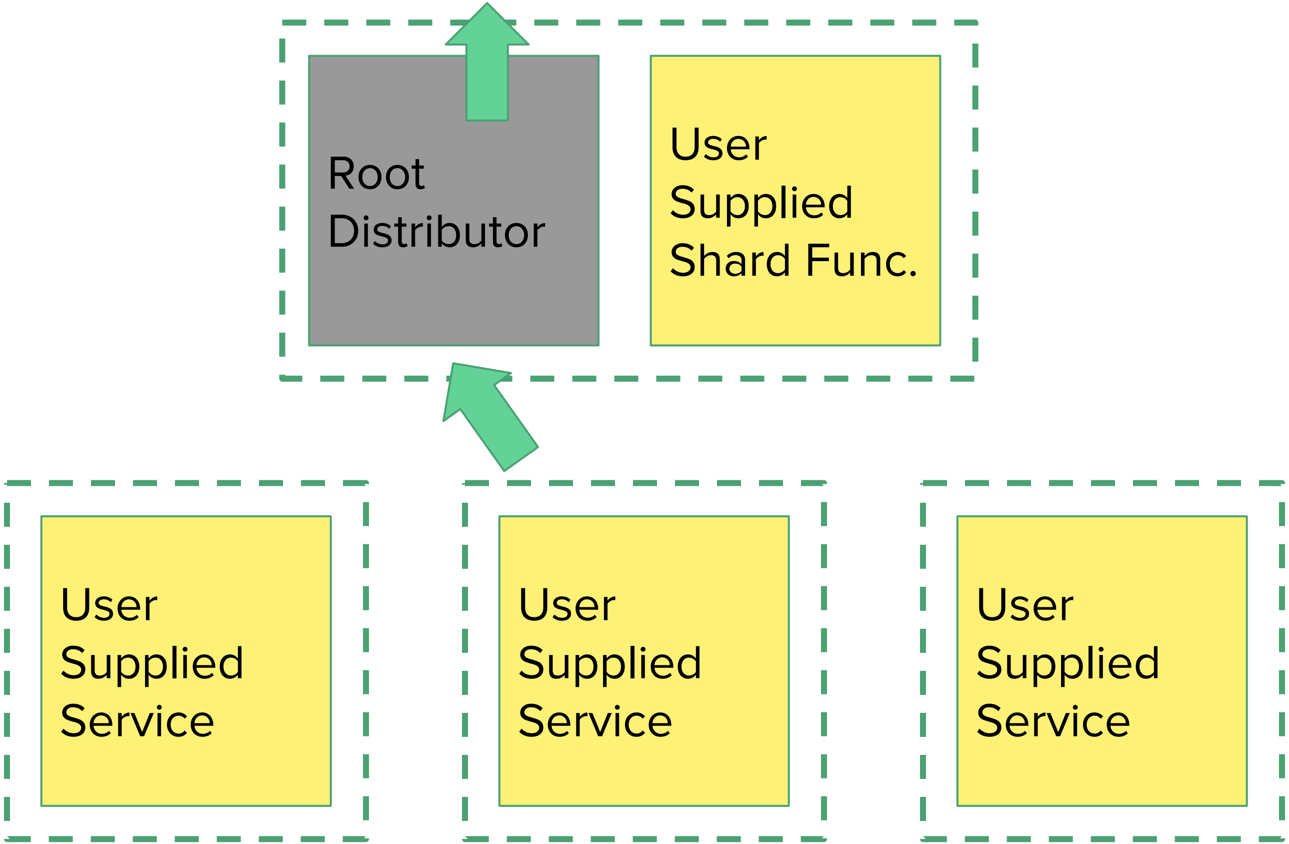

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