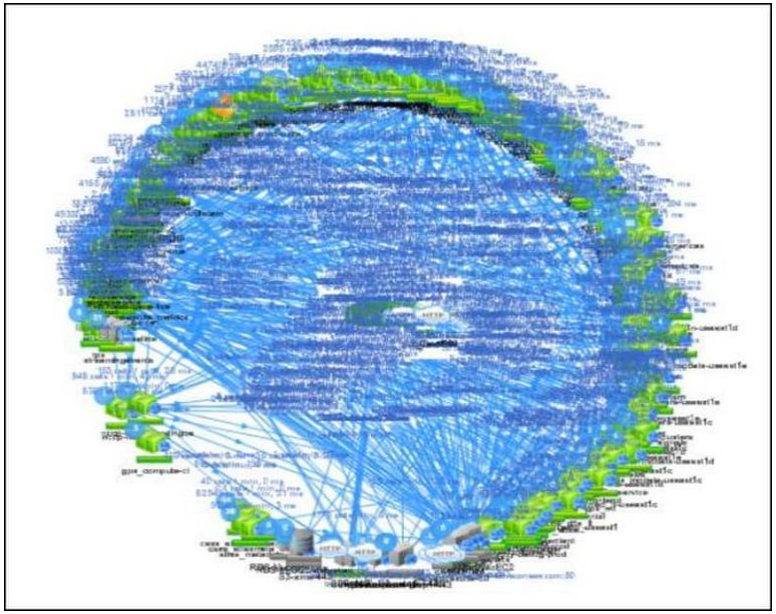
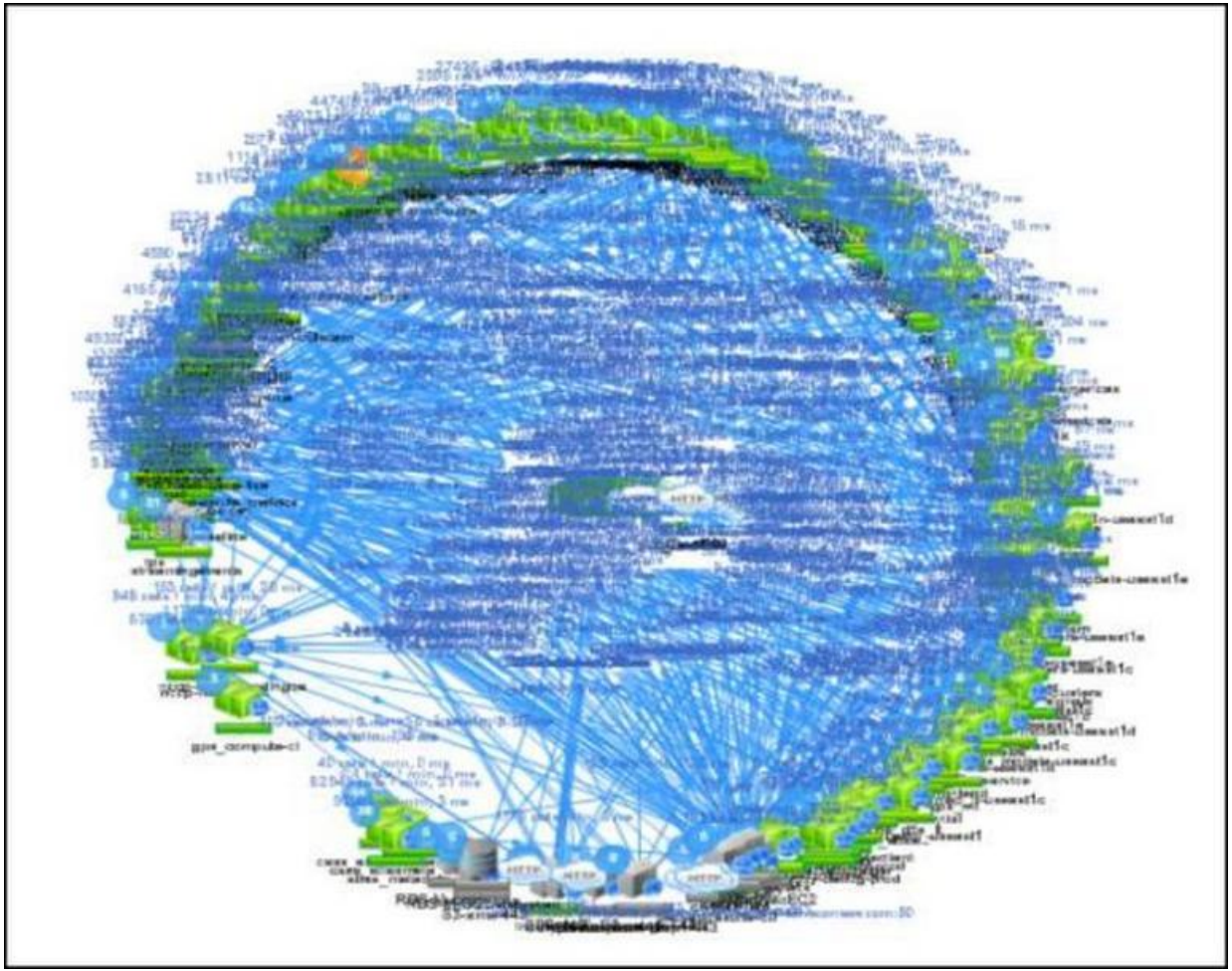
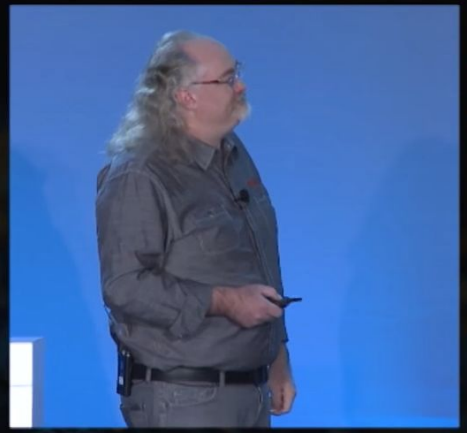
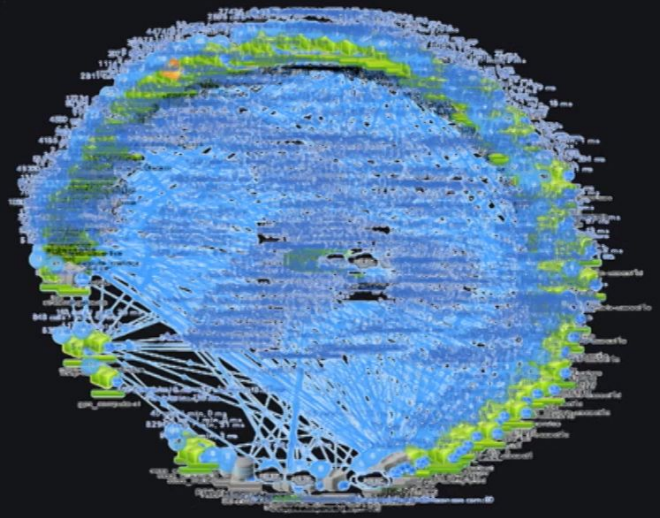
Microservices







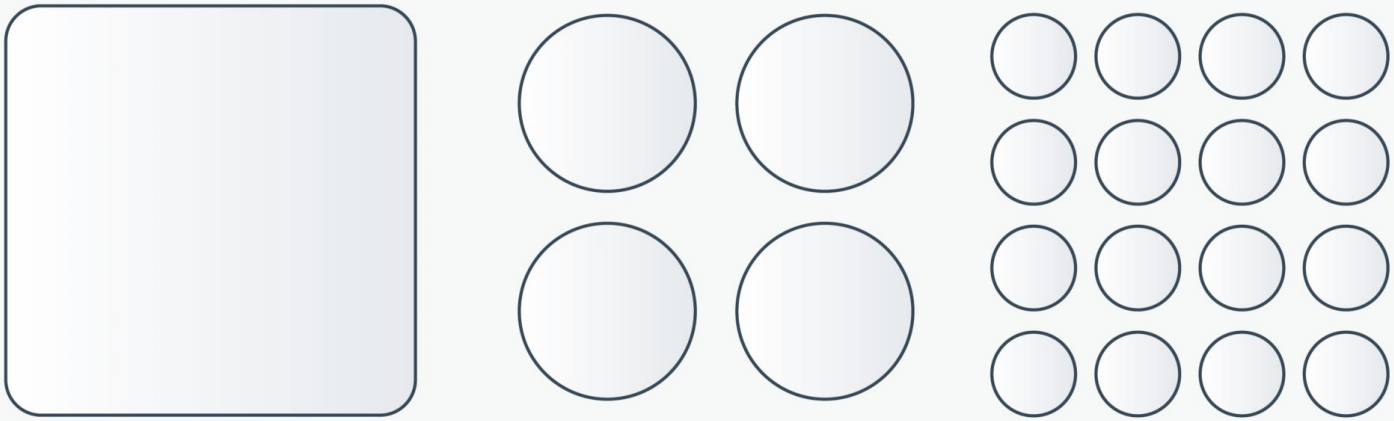
Netflix architecture



whoami

- Martin Štefanko
- Software engineer, Red Hat
- MicroProfile committer
- Microservices enthusiast
-  @xstefank

Monolithic vs. SOA vs. Microservices



Monolithic

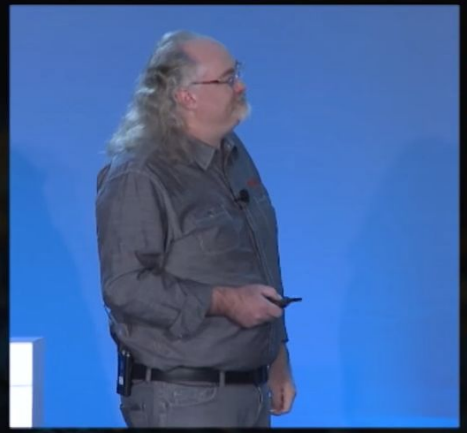
Single Unit

SOA

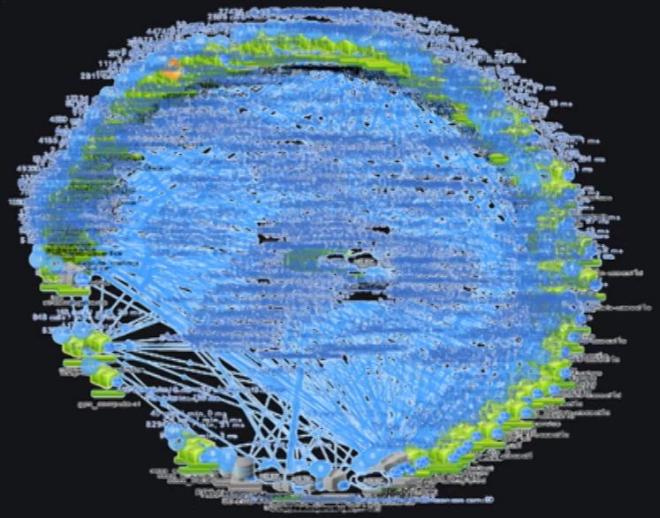
Coarse-grained

Microservices

Fine-grained



Netflix architecture



Netflix ecosystem

100s of microservices
1000s of daily production changes
10,000s of instances
100,000s of customer interactions per minute
1,000,000s of customers
1,000,000,000s of metrics
10,000,000,000 hours of streamed
10s of operations engineers

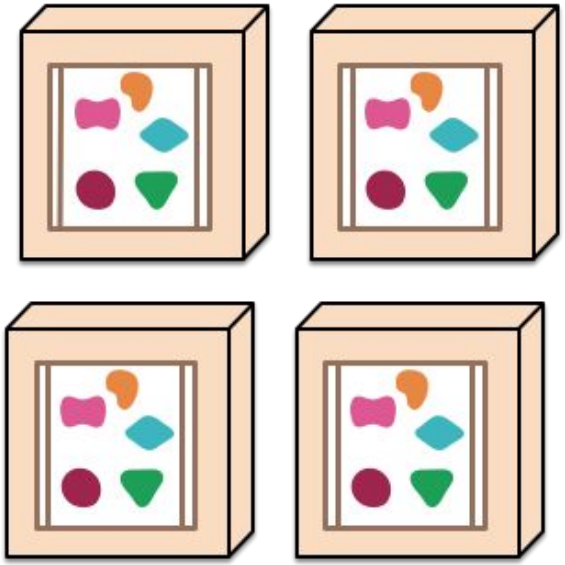
Monolith

Monolithic applications

- Common development model (past 20+ years)
- Single or small amount of deployments
- Application server
- Single process
- Components tightly coupled

A monolithic application puts all its functionality into a single process...

... and scales by replicating the monolith on multiple servers



Monolith - advantages

- Development model == application requirements
  - Traditionally CRUD or MVC
  - Presentation - Business layer - Database
- Single or small number of archives/deployments
- Easy horizontal scaling

Monolith - problems

- Adding new functionality
- General maintenance (bug fixing, CVEs)
- Every single change means requires rebuild and redeploy of the whole application
- Replicated server instances take more resources
- Slow startup times

Monolith - problems

- Often extremely large code bases
  - Hard to understand / maintain
  - Long learning curves
  - Experts in particular system / part of the system
  - Often a commitment to a particular technology
    - Or even a specific version

Microservices

Architectural pattern

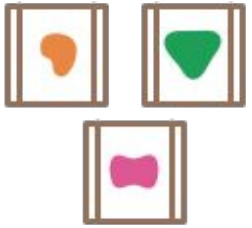
- System as a collection of small, isolated services
- Each service
  - Owns its data
  - Is independently isolated
  - Is scalable
  - Is resilient
  - Is self-maintained
- Subset/Evolution of SOA
- Intuitive approach

Architectural pattern

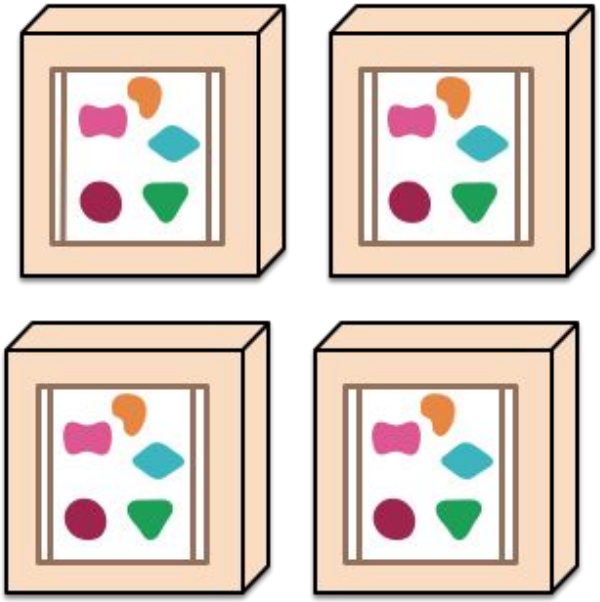
- Each service represents the separated and independent part of the system
- Interaction with other microservices is allowed only through predefined communication interfaces (API)

A monolithic application puts all its functionality into a single process...

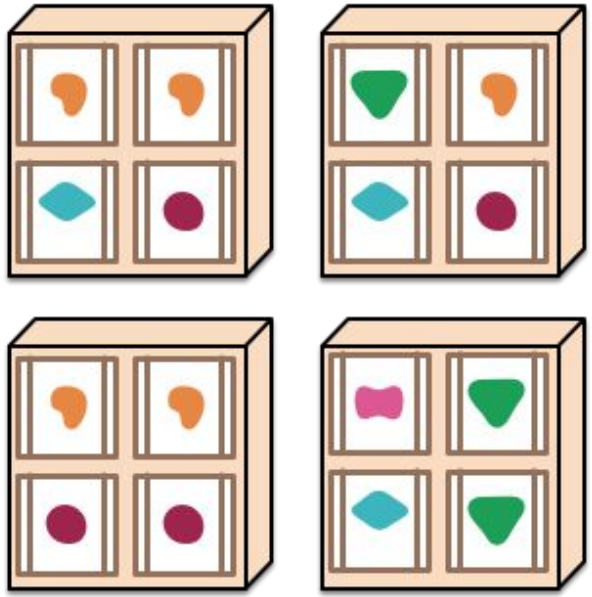
A microservices architecture puts each element of functionality into a separate service...



... and scales by replicating the monolith on multiple servers



... and scales by distributing these services across servers, replicating as needed.



Organization structure

- Teams segregation according to the architecture
- Each team is responsible for one or a small set of services
- Structured according to the business goals
  - Teams should be self-maintained
  - Devs, Testers, Front-end, ...
- One team should not have access/knowledge of different services/teams

Isolation

- Ownership of resources
- Data requests to different services prohibited only through the API
  - Control the access, computation requirements
- Service must act as an external component
- Loosely coupled services
- Virtual addresses
- Scaling, load-balancing
- Resiliency

Isolation

- Underlying technology may differ
  - Different languages
  - Different runtimes
  - Different frameworks
  - Different versions

Law of Demeter

- Microservice typically must communicate with other microservices to provide its functionality
- Principle of least knowledge
  - Each unit should have only limited knowledge about other units: only units "closely" related to the current unit
  - Each unit should only talk to its friends; don't talk to strangers

Single responsibility principle

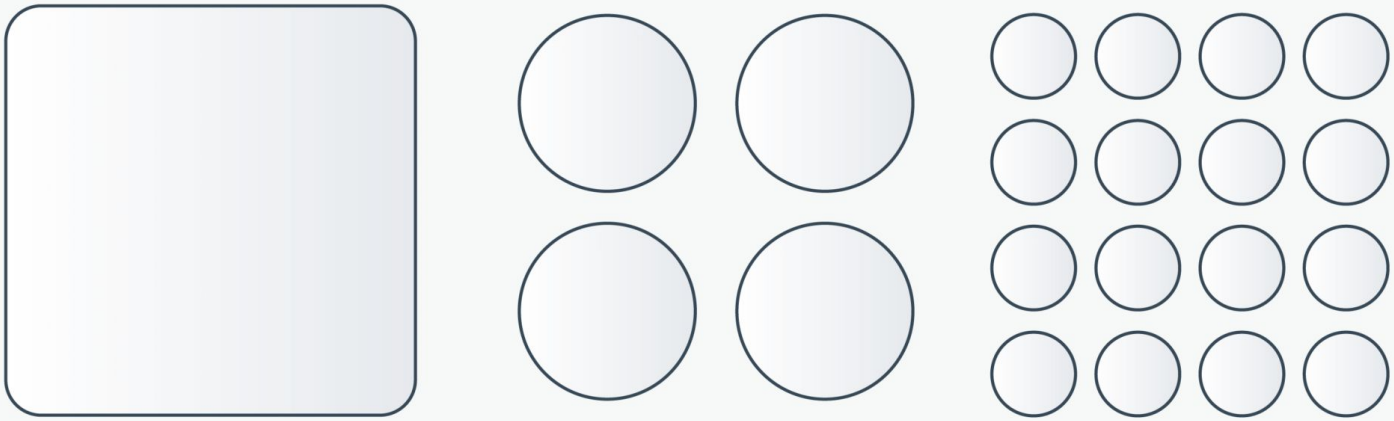
- *“micro”* doesn’t necessarily mean small
- Micro == scope of the service responsibility
- SRP - a class (microservice) should have only one reason to change
- Unix philosophy - Make each program (microservice) do one thing well

API

- Application programming interface
- Technology-agnostic
- Remote procedure calls
  - HTTP & REST
  - Apache Kafka
  - gRPC
  - AMQP, MQTT, JMS
  - ....

Microservices vs SOA

Monolithic vs. SOA vs. Microservices



Monolithic

Single Unit

SOA

Coarse-grained

Microservices

Fine-grained

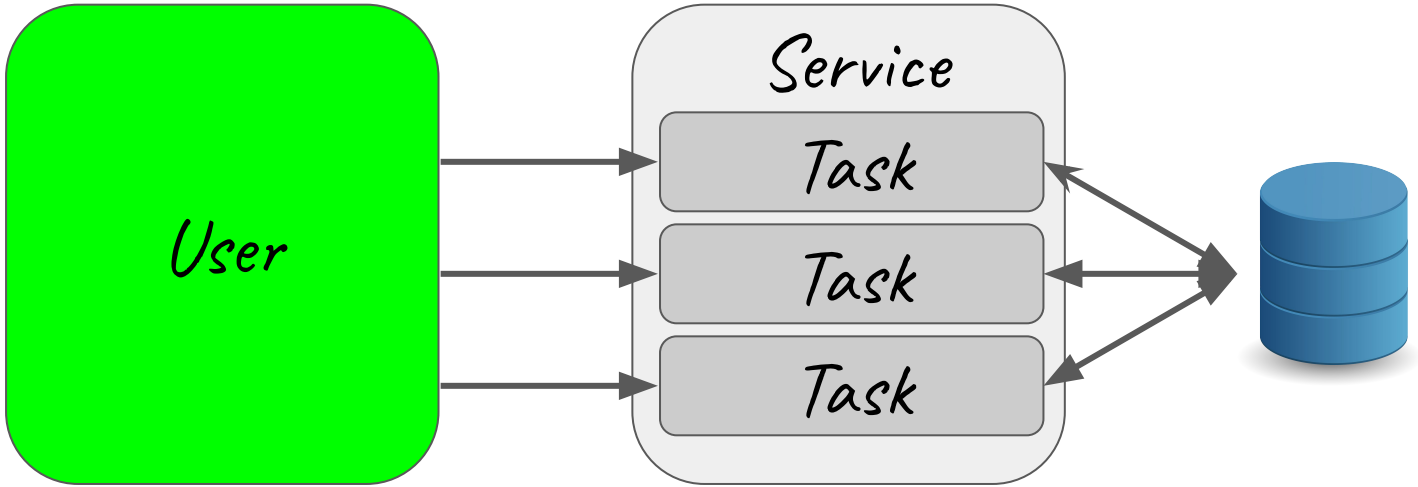
Microservices vs SOA

- Both are about services...

- but the service characteristics differ

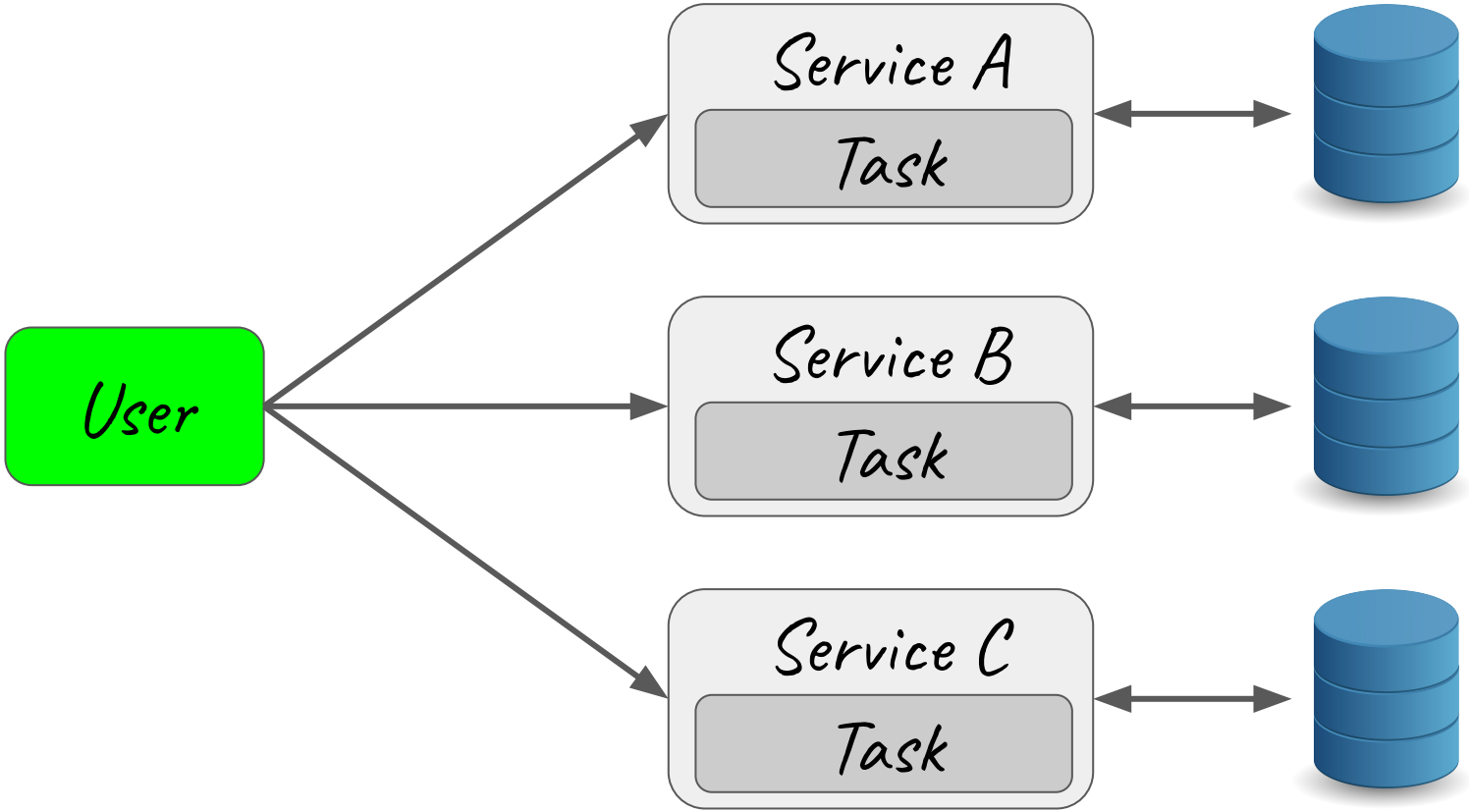
SOA

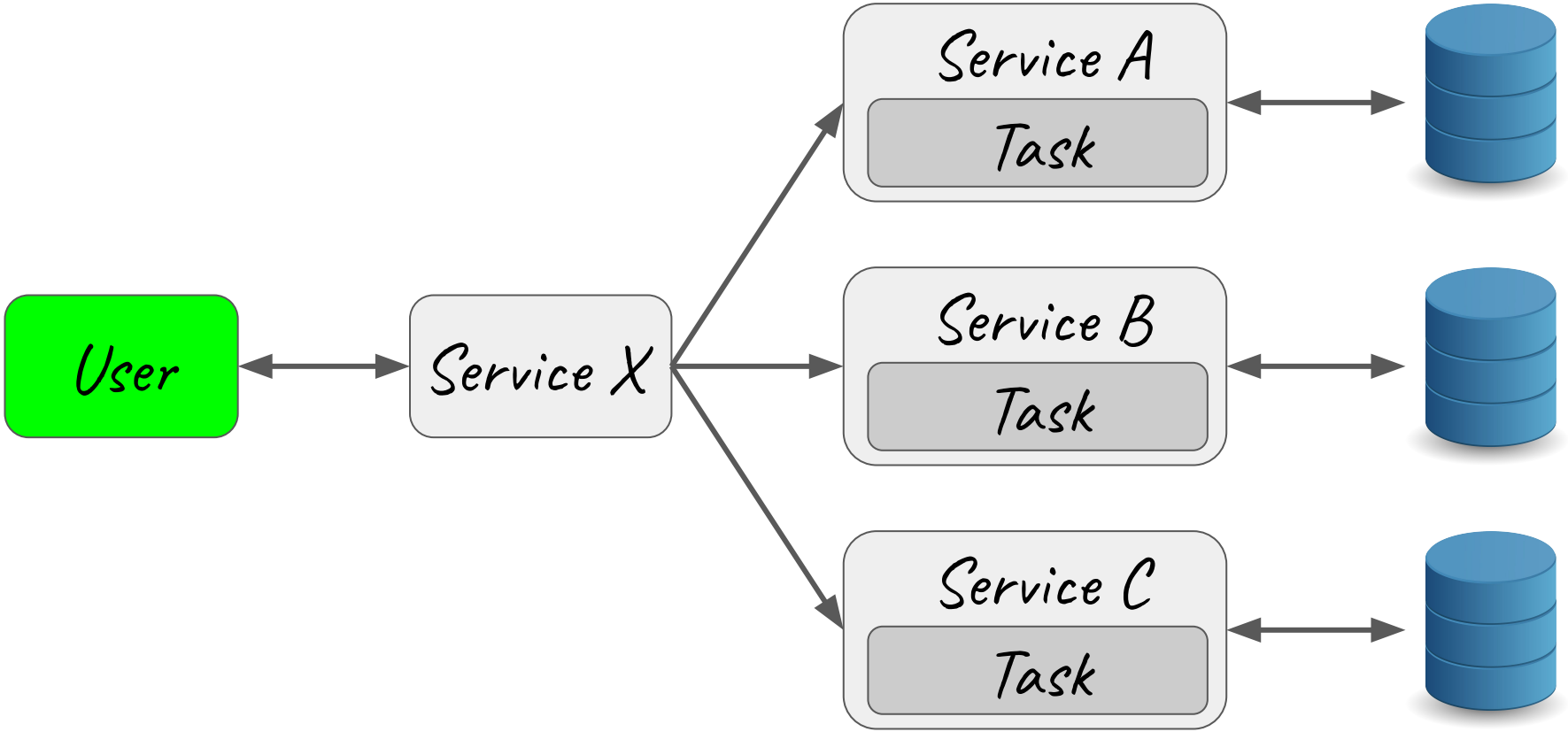
- Smaller number of services
- Each service is responsible for a particular group of functions/tasks that together provide a system functionality
- User requests are typically processed by one or a small number of services
  - User can interact with the same service in several requests/steps

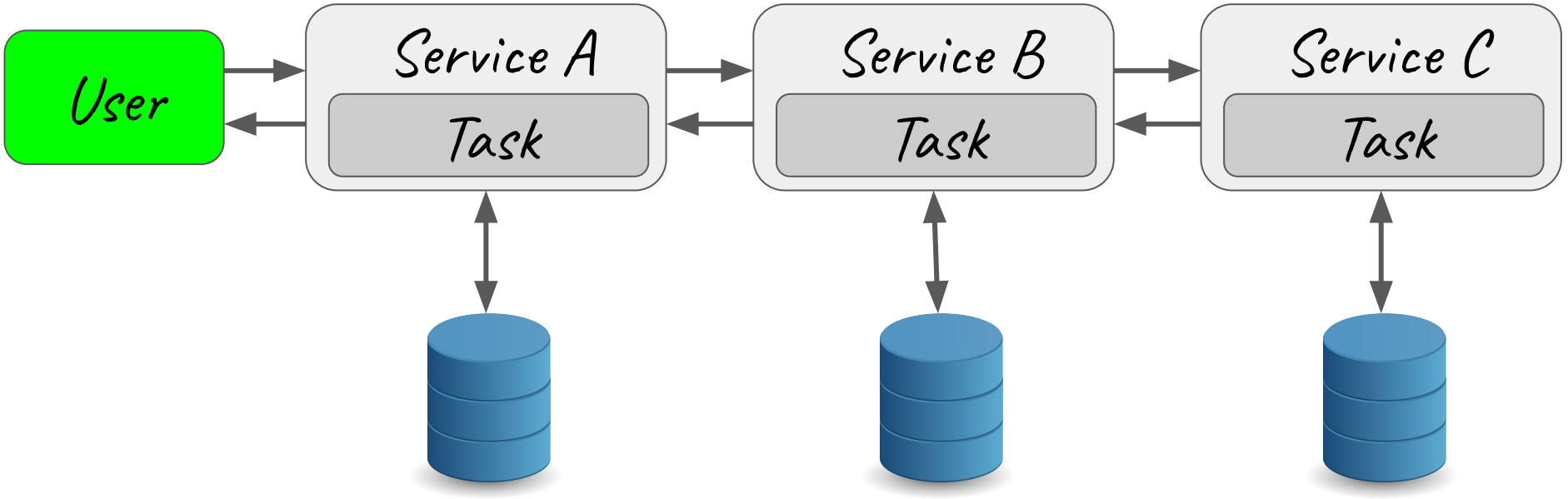

User
Service
Task
Task
Task

Microservices

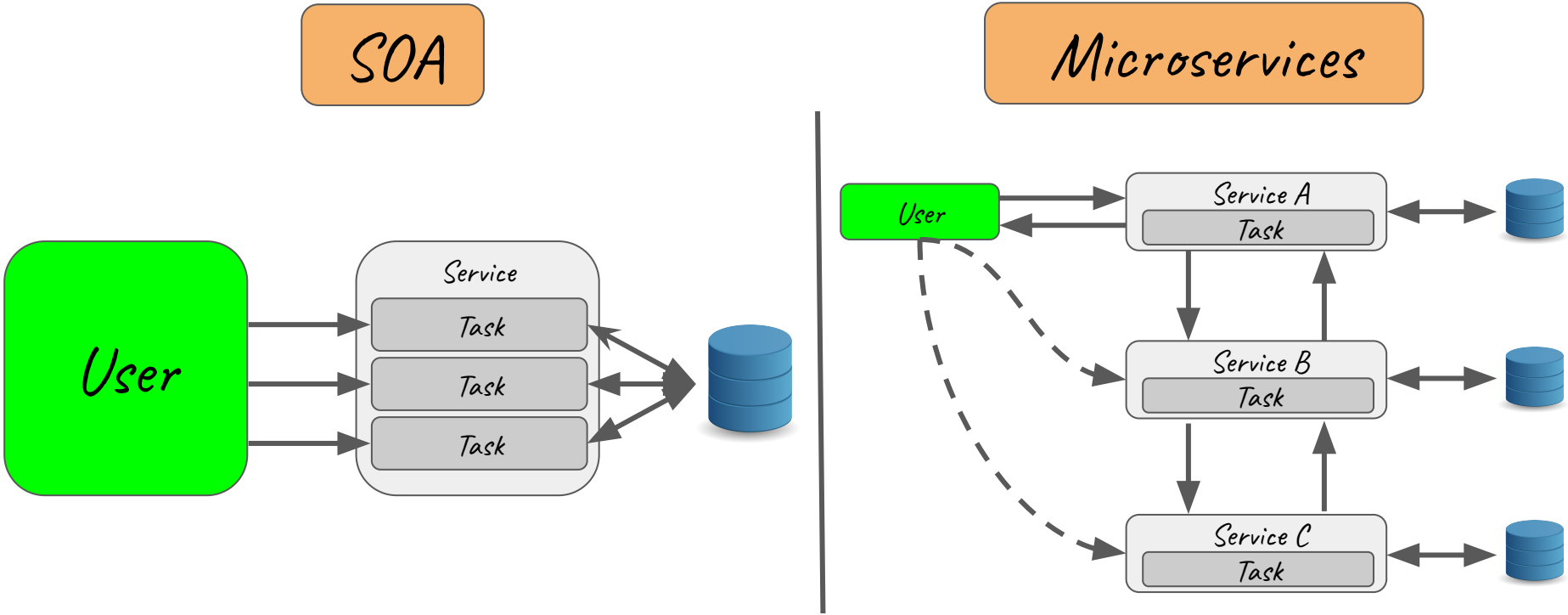
- Higher number of services
- Each service is responsible for one particular function/task
- Users typically interacts with several services (not necessarily directly)
- The system provides its functions as an collaboration/interaction between microservices


Service A
Task
Service B
Task
Service C
Task
User

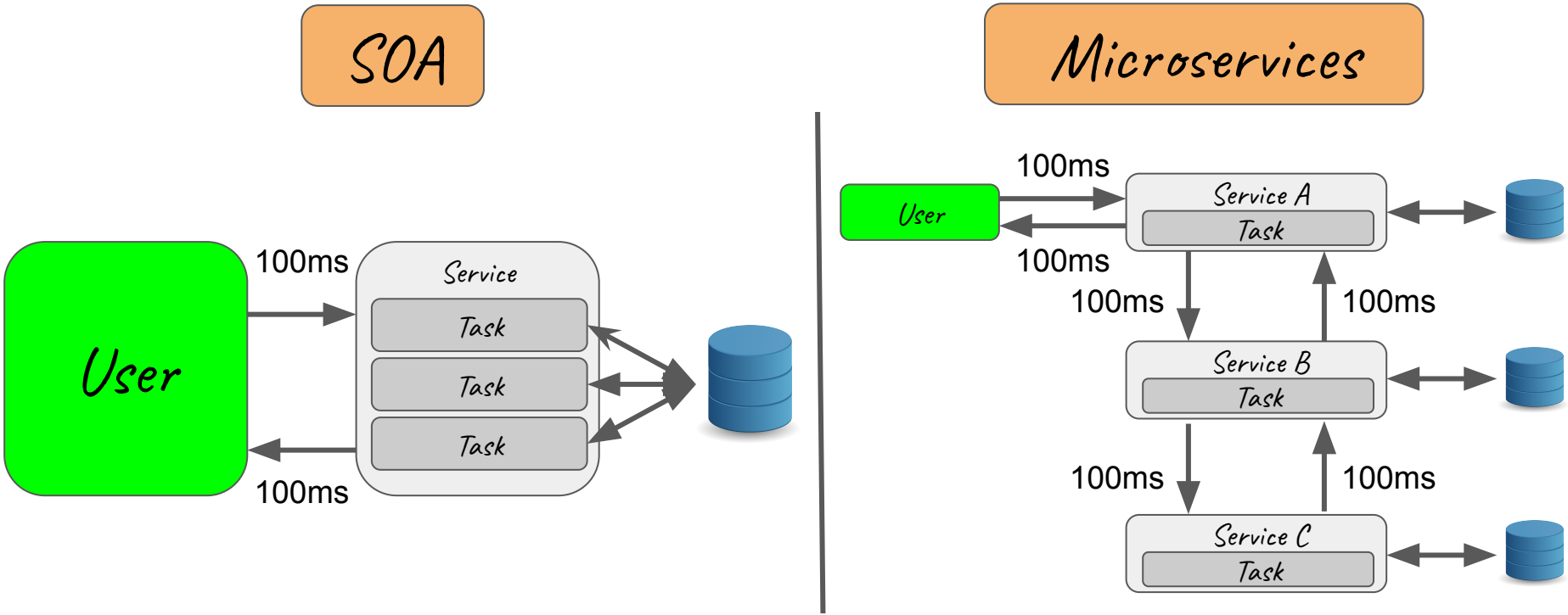

User
Service X
Service A
Task
Service B
Task
Service C
Task


User
Service A
Task
Service B
Task
Service C
Task

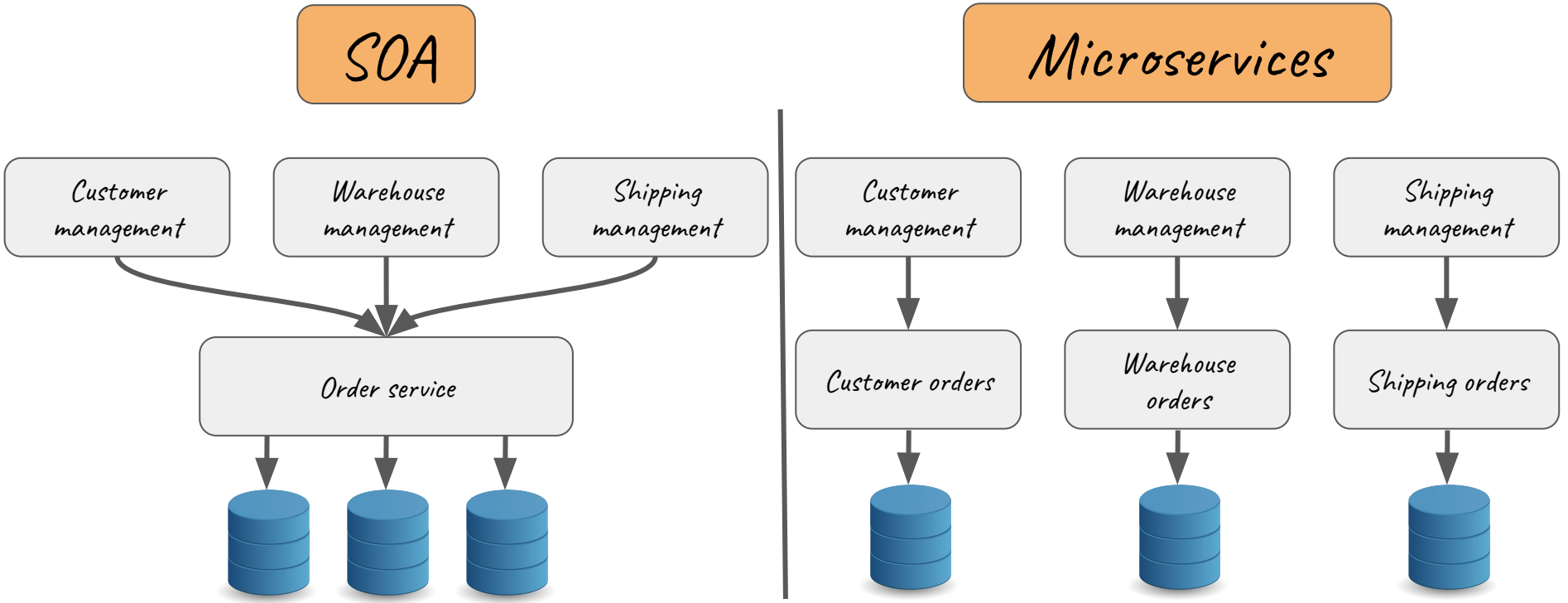
Service organization



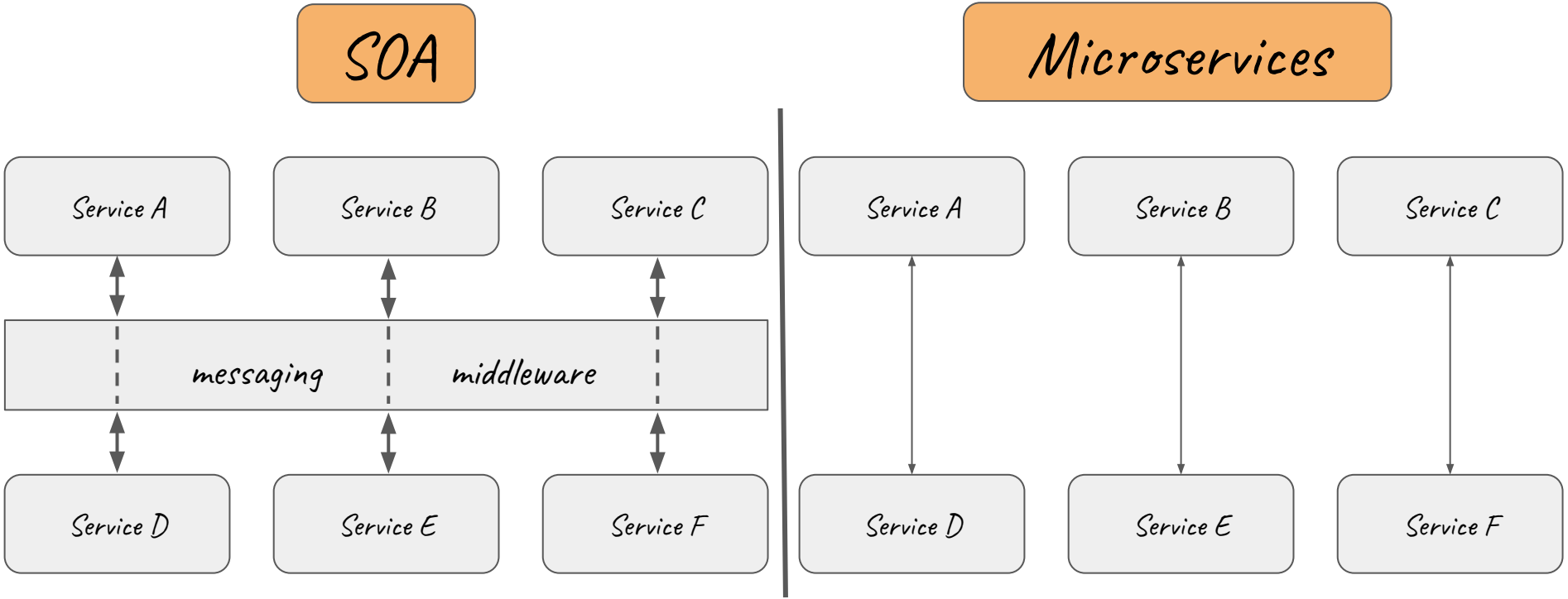
Task granularity



Component sharing



Message exchange



SOA

- Share **as much as possible**
- Importance on the **business functionality reuse**
- Common **governance** and **standards**

Microservices

- Share **as little as possible**
- Importance on **bounded contexts**
- Focus on **people, collaboration, freedom of options**

SOA

- **Enterprise service bus** (ESB)
- **Standardized messaging** protocols
- **Multi-threaded**

Microservices

- **Direct communication** (service mesh)
- **Lightweight protocols** (HTTP/REST, Kafka)
- **Single-threaded** (event loop)

SOA

- Maximize **service reusability**
- **Traditional technologies** (Relation DBs)

Microservices

- Focus on **service decoupling**
- **Modern technologies**, faster adoption (NoSQL)

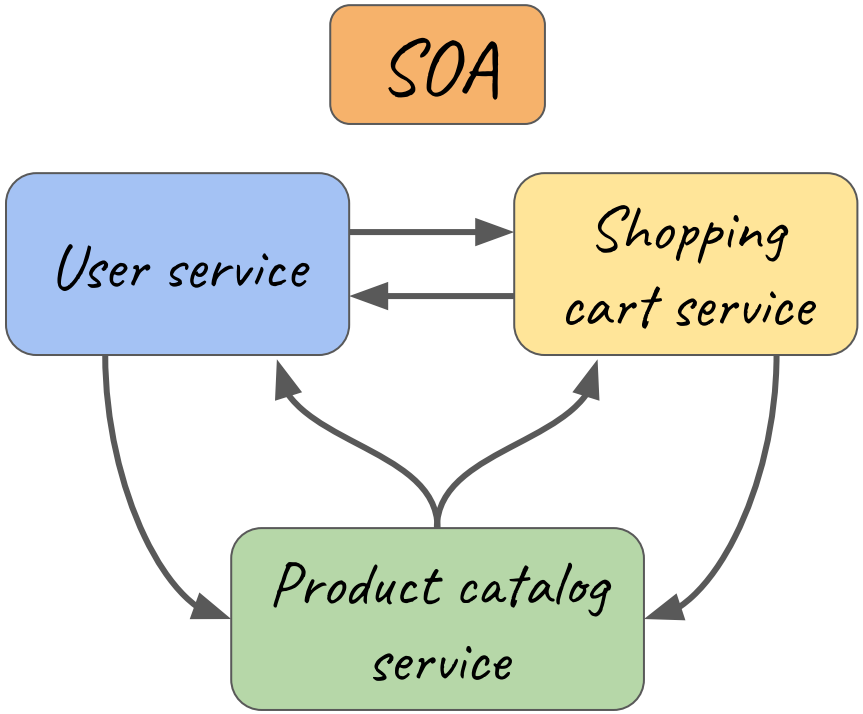
SOA

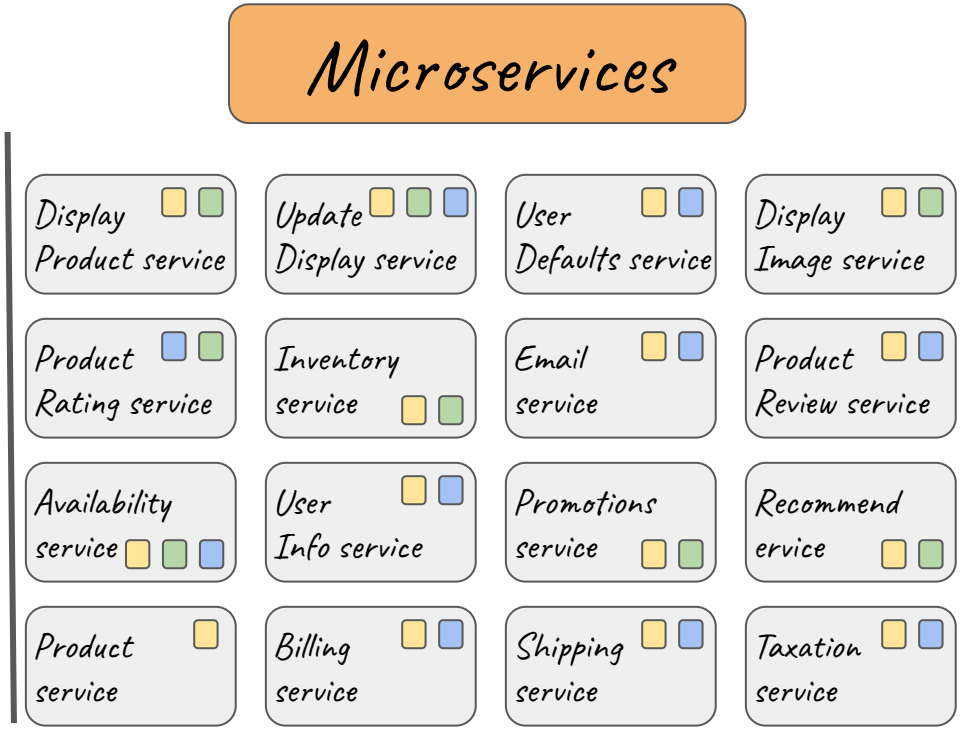
- Any change still resembles problems similar to monoliths
- Traditional development models

Microservices

- Any change is only local to a particular service (or add a new service)
- Strong focus on **DevOps** and **CI/CD**

Example


SOA
User service
Shopping cart service
Product catalog service


Microservices
Display Product service
Update Display service
User Defaults service
Display Image service
Product Rating service
Inventory service
Email service
Product Review service
Availability service
User Info service
Promotions service
Recommend ervice
Product service
Billing service
Shipping service
Taxation service

Principles of microservices

Principles of microservices

- Perspective of business use cases and the solution architecture
- Based on the work of Sam Newman
  - S. Newman,Building Microservices, 1st ed. O'Reilly Media, Inc.,2015
  - S. Newman, "Principles of Microservices," 2016. [Online]. Available: http://samnewman.io/talks/principles-of-microservices/

1. Modeled around the business concepts

- Microservices and teams that are maintaining them should correspond to the same business domain
- Microservices are more stable
- Requirements don’t change frequently
- Developers are focused on the particular system segment

2. Adapting a culture of automation

- With the increasing number of services, their maintenance , administration, and deployment can become unmanageable
- Automation of the is essential
  - Service testing
  - CI/CD
  - Deployment strategy

3. Hiding the internal implementation details

- To keep the option of independent development
- Related to bounded-contexts defined by DDD
  - The context is separated by an explicit interface represented as an API
  - This allows teams to specify which utilities of the service can be shared and which must be hidden
  - Every request must be processed throught this interfac

4. Decentralizating all things

- Self-sustaining development == services are maintained autonomously
- Decision making delegated to the team maintaining the microservice
- Relevant business logic should be kept in the service and the communication should be as simple as possible

Conway’s law

> Any organization that designs a system (defined broadly) will produce a design whose structure is a copy of the organization’s communication structure.

5. Independent deployments

- Most important principle
- A microservice deployment shouldn’t influence the lifespan of any other service
- Various techniques
  - Consumer-driven contracts
  - Test suites for individual parts of the domain
  - CI
  - B/G testing, canary deployments, mirroring

6. Customer first

- Service calls must be as simple as possible for customers
- API documentation (Swagger, OpenAPI)
- Service discovery
- Transparency of the call propagation

7. Failure isolation

- Fault tolerance to other services failures
- No single point of failure
- Network failures
- Various techniques
  - Fallbacks
  - Retries
  - Timeouts
  - Circuit breakers
  - Bulkheads

8. High observability

- Monitoring
  - Individual services
  - System monitoring
- Tracing
  - Synthetic transactions
  - Correlation IDs
- Logging
  - Aggregated logs

Technologies

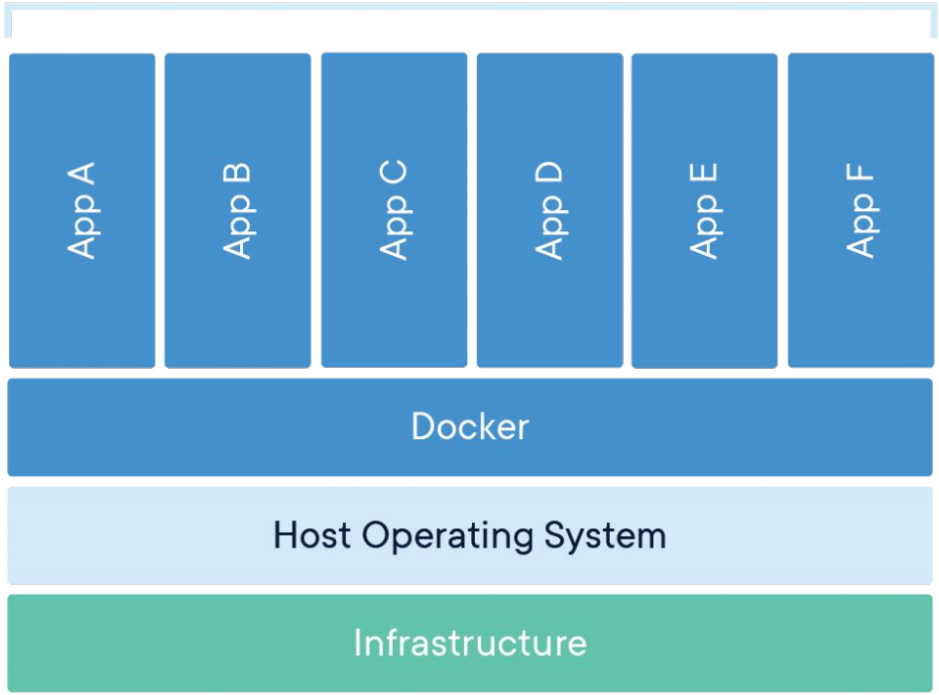
Docker (containers)

- **Container** - a standardized unit of software
- Packages code and its dependencies, runtime, system tools, system libraries, settings
- Users build **Docker images** - lightweight, standalone, executable package of software
- Images can be run anywhere where Docker is installed
- **Docker hub** (hub.docker.com)

Docker containers

- Container is runtime representation of the image
- Containers run on Docker Engine
- It doesn’t matter on which platform (Linux, Mac, Windows) you run
- Containers isolate software from its environment
- Uniform behavior everywhere

Containerized Applications



Docker Engine

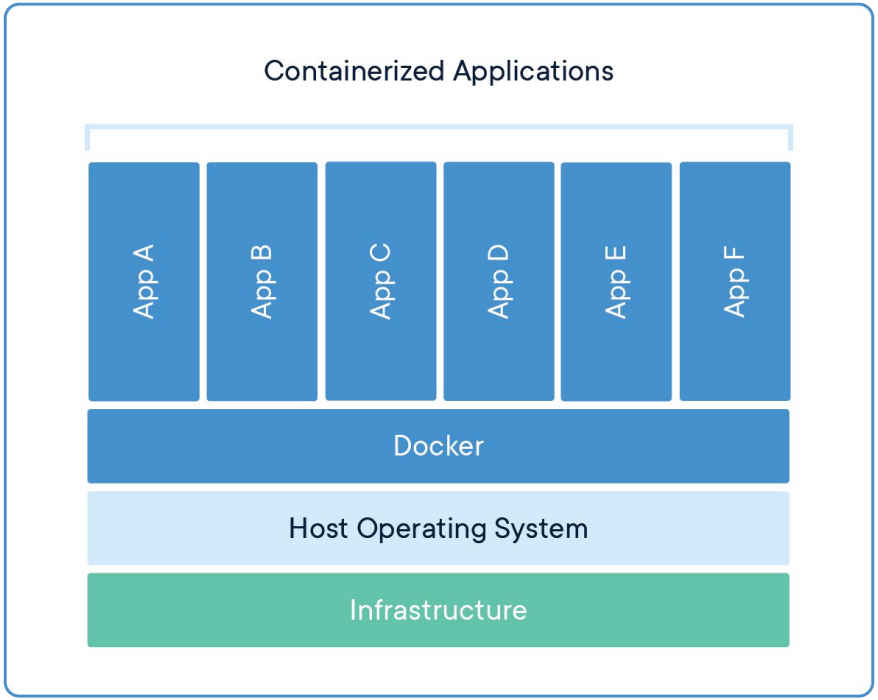
- **Standard** - Docker created the industry standard for containers, so they could be portable anywhere

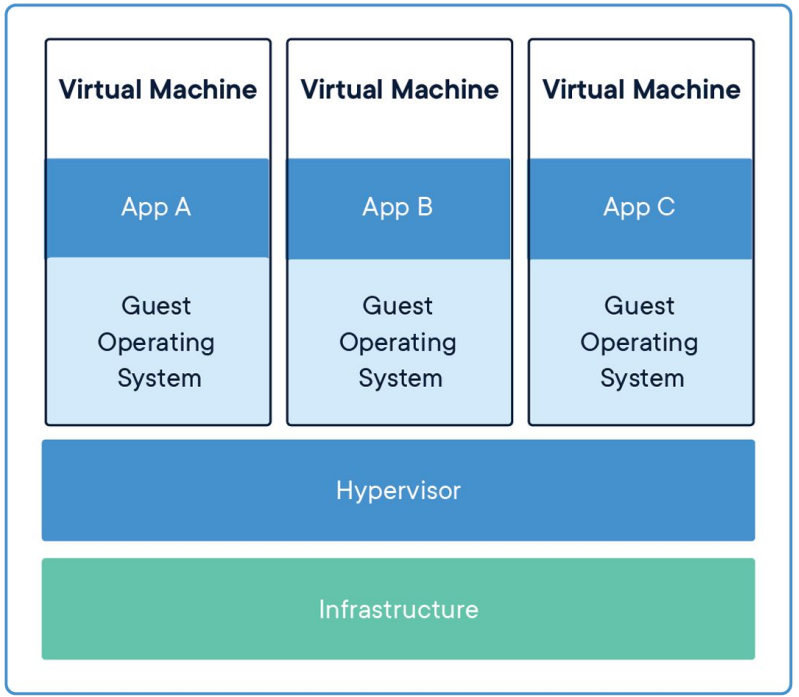
- **Lightweight** - Containers share the machine's OS system kernel and therefore do not require an OS per application

- **Secure**: Applications are safer in containers and Docker provides the strongest default isolation capabilities in the industry

Containers vs Virtual Machines

Containers and virtual machines have similar resource isolation and allocation benefits, but function differently because **containers virtualize the operating system instead of hardware**. Containers are more portable and efficient.


Containerized Applications
App A
App B
App C
App D
App E
App F
Docker
Host Operating System
Infrastructure


Virtual Machine
Virtual Machine
Virtual Machine
App A
App B
App C
Guest Operating System
Guest Operating System
Guest Operating System
Hypervisor
Infrastructure

Docker - standardization

- Docker launched in 2013 - revolution in application development
- In June 2015, Docker donated the container image specification and runtime code now known as runc, to the **Open Container Initiative (OCI)**
- Other alternatives - Podman, Buildah

Dockerfile

```
FROM registry.access.redhat.com/ubi8/ubi-minimal
WORKDIR /work/
COPY target/*-runner /work/application
RUN chmod 775 /work
EXPOSE 8080
CMD ["./application", "-Dquarkus.http.host=0.0.0.0"]
```

```
$ docker help

Usage:  docker COMMAND

Management Commands:
  container   Manage containers
  image       Manage images

Commands:
  attach      Attach to a running container
  build       Build an image from a Dockerfile
  create      Create a new container
  pull        Pull an image or a repository from a registry
  push        Push an image or a repository to a registry
  run         Run a command in a new container
```

Kubernetes

- Container orchestration
- an open-source system for automating deployment, scaling, and management of containerized applications
- Groups containers to logical units
- Easy administration
- De facto standard for cloud deployments

kubernetes

Search

Overview

Cluster

- Cluster Roles
- Namespaces
- Nodes
- Persistent Volumes
- Storage Classes

Namespace

All namespaces

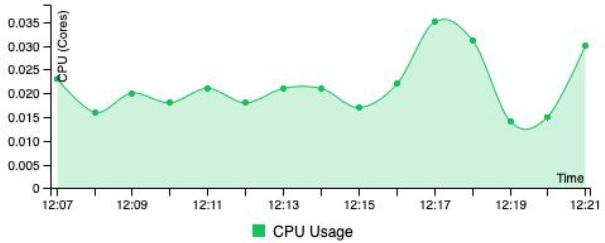
Overview

Workloads

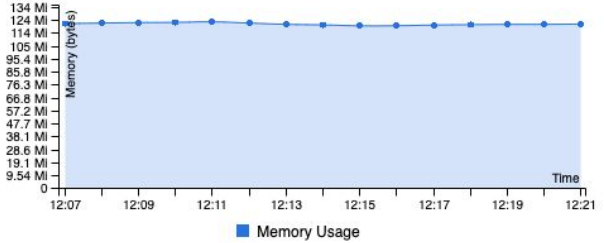
- Cron Jobs
- Daemon Sets
- Deployments
- Jobs
- Pods
- Replica Sets
- Replication Controllers
- Stateful Sets

Workloads

CPU Usage



Memory Usage



Workload Status

Kubernetes objects

- **Pod** - basic executions unit
  - Process running in the cluster
  - One or multiple containers
  - Replaceable unit, can be restarted anytime (health checks)
- **Service** - exposure of application (pods) as a network service
  - Abstraction of the access to pods

Kubernetes objects

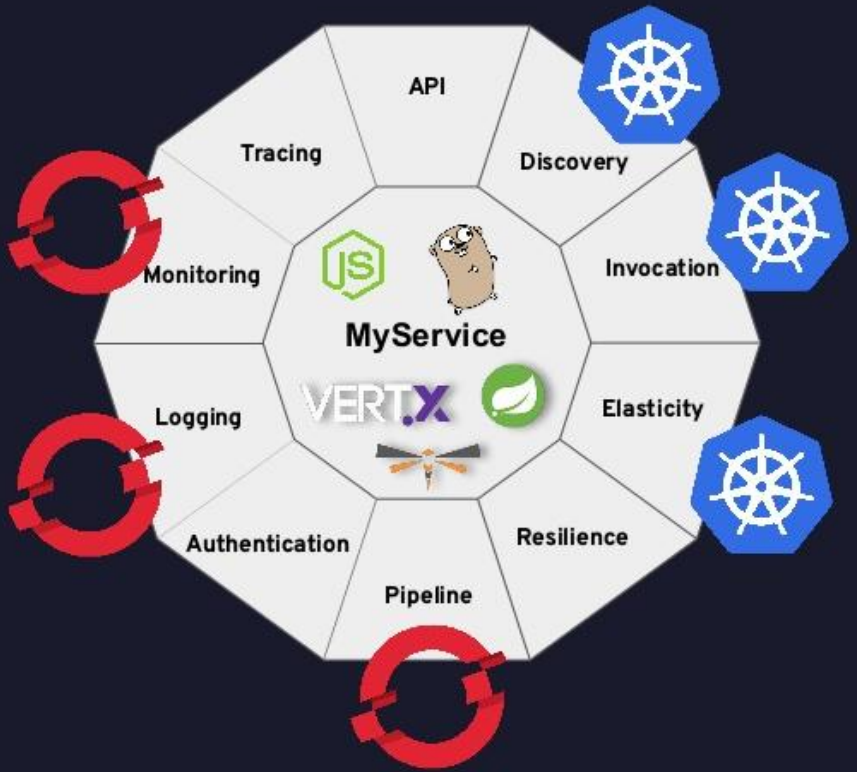
- **Volume** - storage shared between containers in the pod
- **Deployment** - declarative updates for pods
  - User describes the desired state
  - Deployment controller (dc) changes the actual state to the desired state at controlled rate
  - New state of the pods, rollbacks, scaling,...

```
$ kubectl help

Basic Commands (Beginner):
  create         Create a resource from a file or from stdin.
  expose         Take a replication controller, service, deployment or pod and expose it as a new

Kubernetes Service
  run            Run a particular image on the cluster
  set            Set specific features on objects

Deploy Commands:
  rollout        Manage the rollout of a resource
  scale          Set a new size for a Deployment, ReplicaSet, Replication Controller, or Job
  autoscale      Auto-scale a Deployment, ReplicaSet, or ReplicationController
```

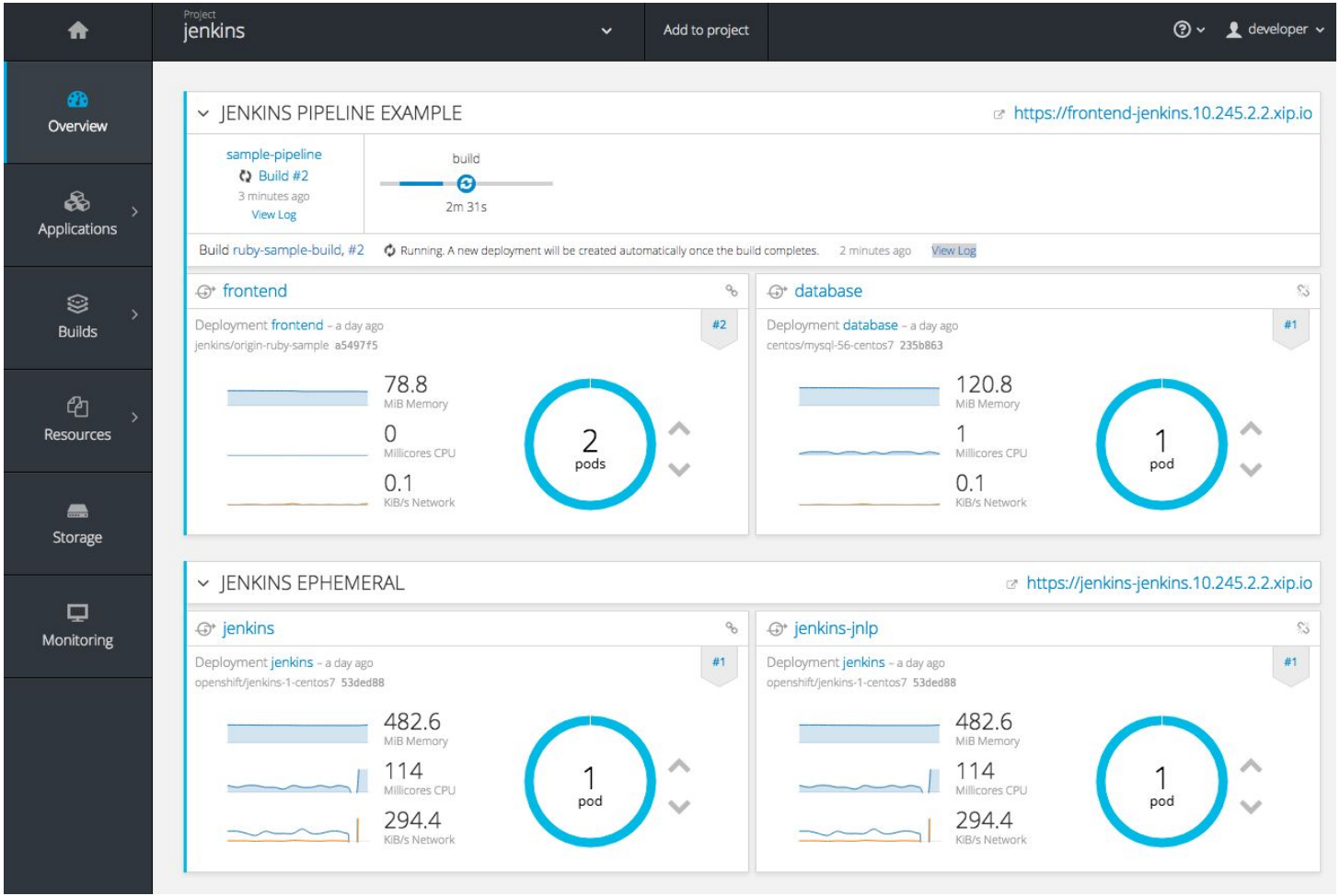
OpenShift

- Fork of Kubernetes developed and maintained at Red Hat
- Commercial product with support
- Automated installation, upgrades, and lifecycle management throughout the container stack

Microservices'ilities + OpenShift



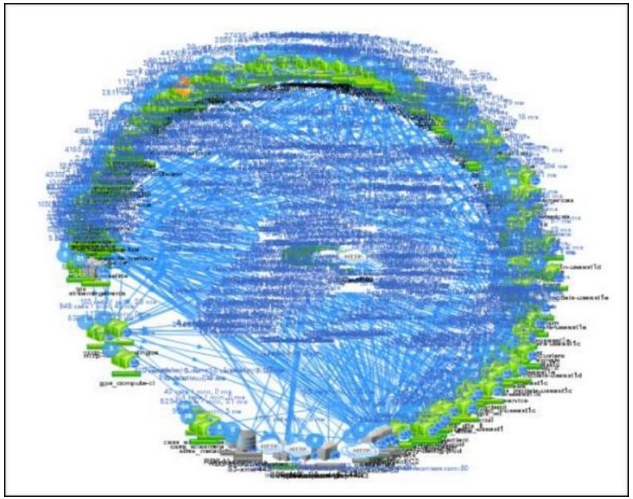
RED HAT DEVELOPERS

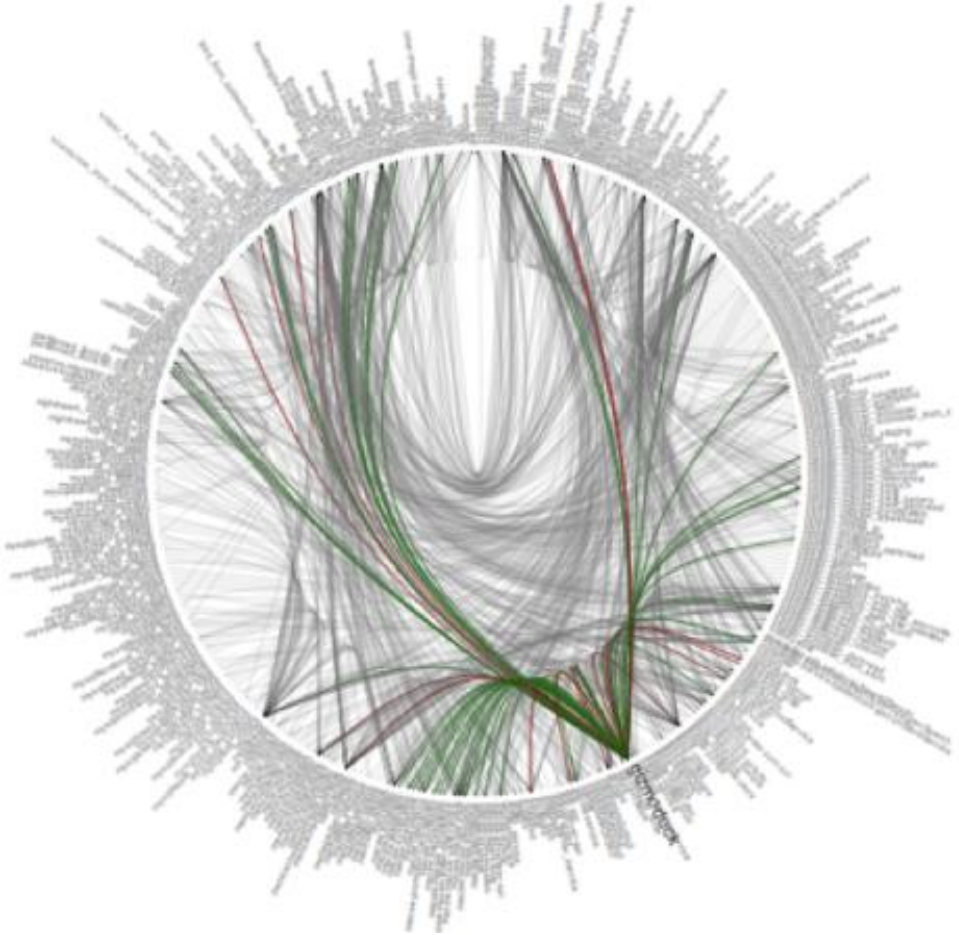

Project
jenkins
Add to project
developer
Overview
Applications
Builds
Resources
Storage
Monitoring
JENKINS PIPELINE EXAMPLE
https://frontend-jenkins.10.245.2.2.xip.io
sample-pipeline
Build #2
3 minutes ago
View Log
build
2m 31s
Build ruby-sample-build, #2
Running. A new deployment will be created automatically once the build completes.
2 minutes ago
View Log
frontend
Deployment frontend – a day ago
jenkins/origin-ruby-sample a5497f5
#2
78.8
MiB Memory
0
Millicores CPU
0.1
KiB/s Network
2
pods
database
Deployment database – a day ago
centos/mysql-56-centos7 235b863
#1
120.8
MiB Memory
1
Millicores CPU
0.1
KiB/s Network
1
pod
JENKINS EPHEMERAL
https://jenkins-jenkins.10.245.2.2.xip.io
jenkins
Deployment jenkins – a day ago
openshift/jenkins-1-centos7 53ded88
#1
482.6
MiB Memory
114
Millicores CPU
294.4
KiB/s Network
1
pod
jenkins-jnlp
Deployment jenkins – a day ago
openshift/jenkins-1-centos7 53ded88
#1
482.6
MiB Memory
114
Millicores CPU
294.4
KiB/s Network
1
pod

```
$ oc help

Basic Commands:
  types           An introduction to concepts and types
  new-project     Request a new project
  new-app         Create a new application
  status          Show an overview of the current project
  project         Switch to another project
  projects        Display existing projects
  explain         Documentation of resources
  cluster         Start and stop OpenShift cluster

Build and Deploy Commands:
  new-build       Create a new build configuration
  start-build     Start a new build

Troubleshooting and Debugging Commands:
  logs            Print the logs for a resource
```

Istio - service mesh

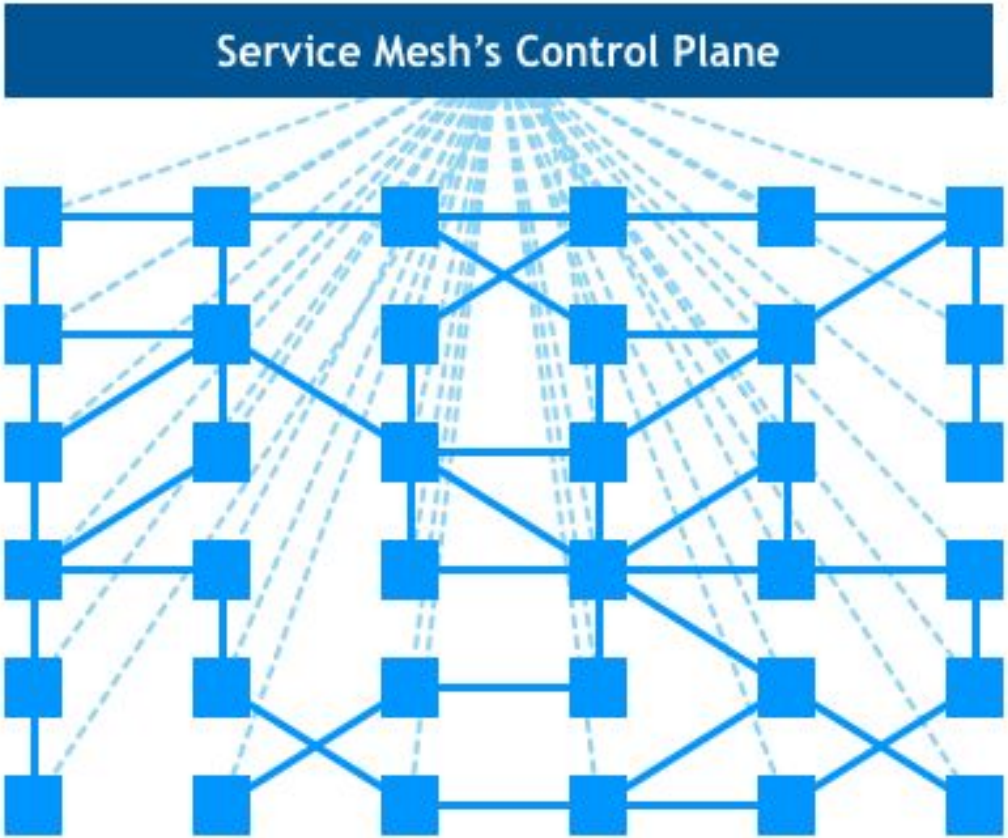
- **Service mesh** - the network of microservices that make up the application and the interactions between them





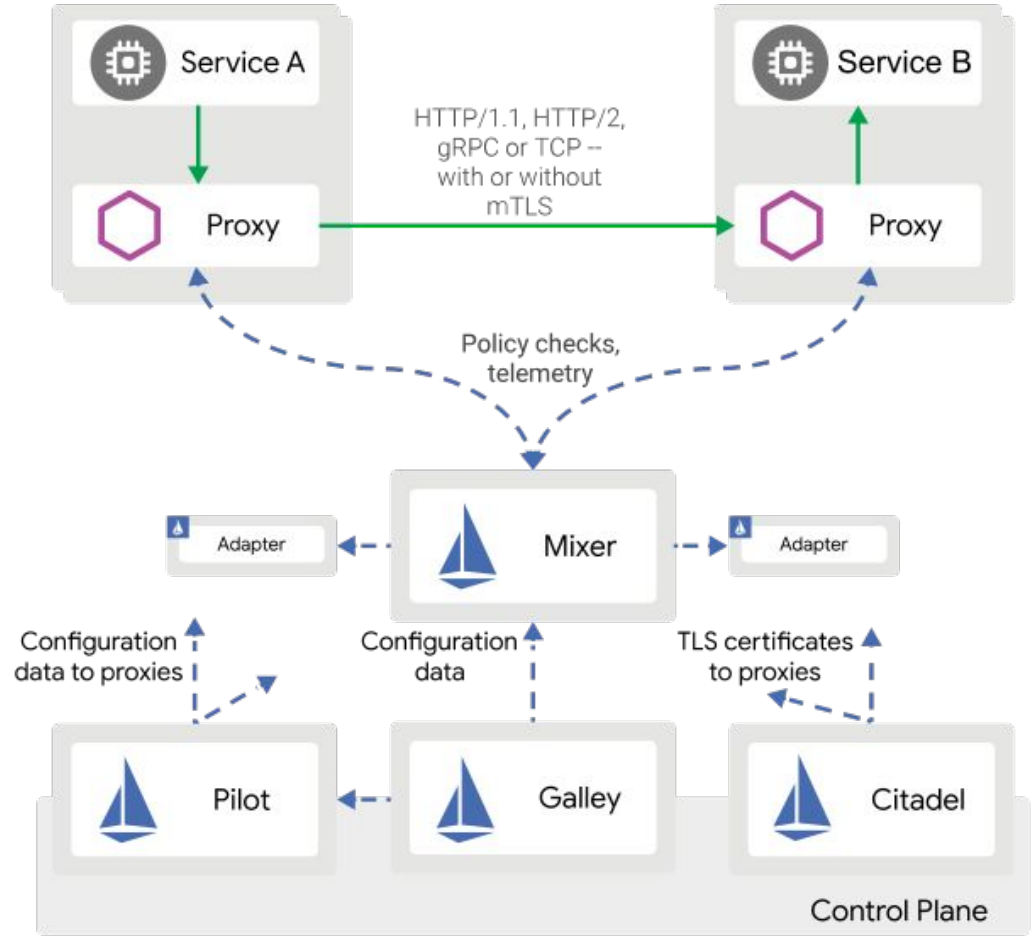
Istio - service mesh

- As a service mesh grows in **size and complexity**, it can become **harder to understand and manage**
- requirements include **discovery**, **load balancing**, **failure recovery, metrics, and monitoring**
- operational requirements, like **A/B testing, canary rollouts, rate limiting, access control, and end-to-end authentication**

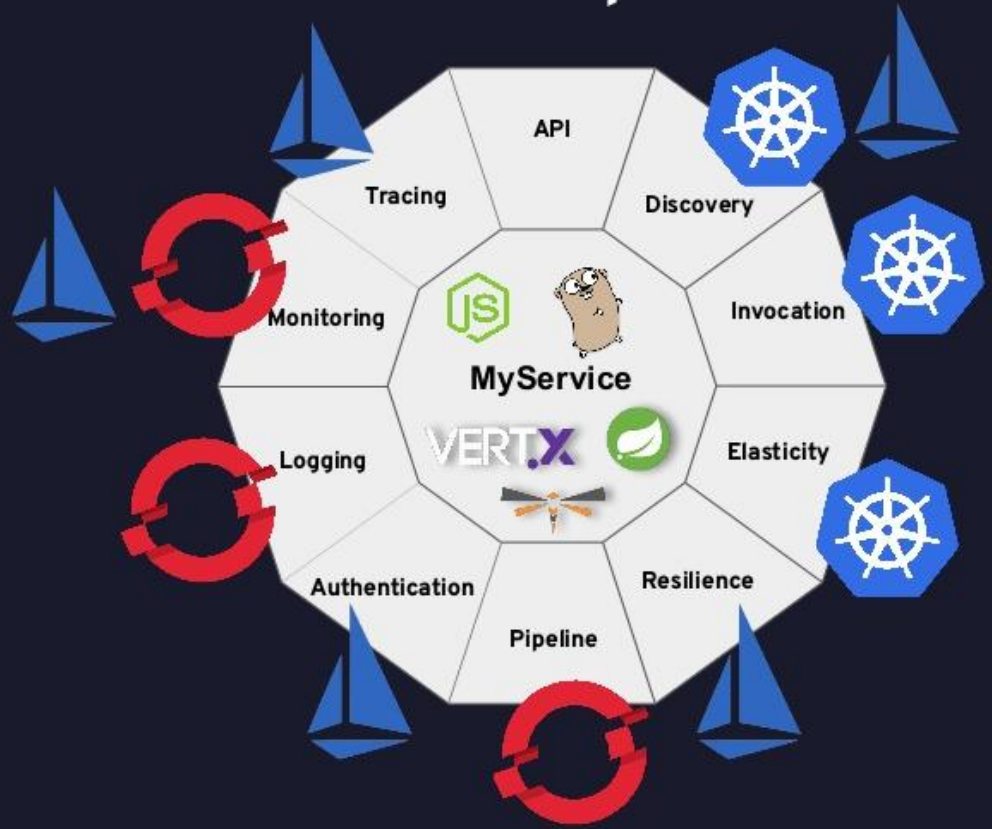

Service Mesh's Control Plane

Istio - Envoy

- Sidecar container
- Deployed in the same pod as the application container
- All network traffic goes through the Envoy proxy


Service A
Service B
HTTP/1.1, HTTP/2,
gRPC or TCP --
with or without
mTLS
Proxy
Proxy
Policy checks,
telemetry
Adapter
Mixer
Adapter
Configuration
data to proxies
Configuration
data
TLS certificates
to proxies
Pilot
Galley
Citadel
Control Plane

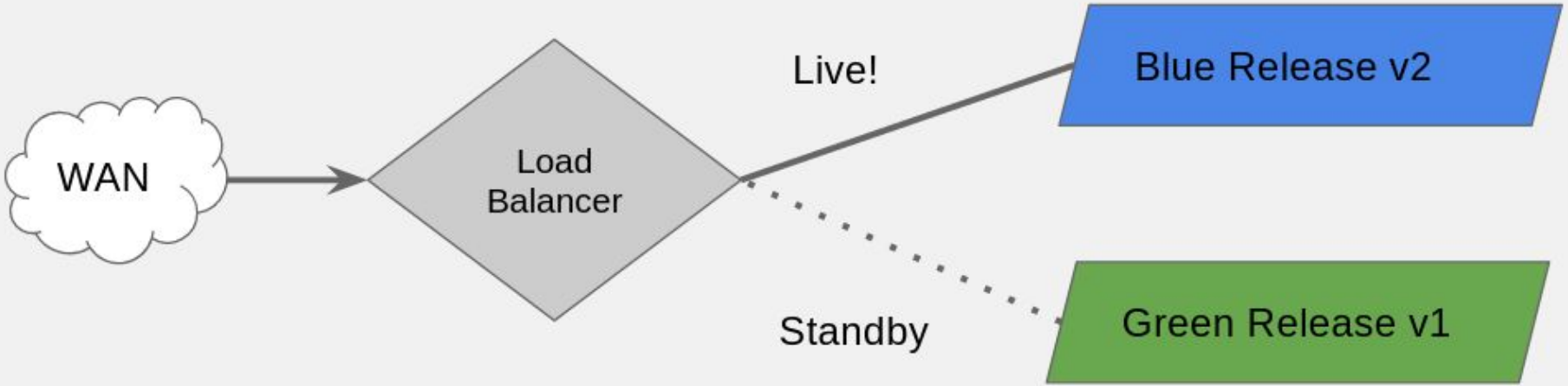
Microservices'ilities + OpenShift + Istio

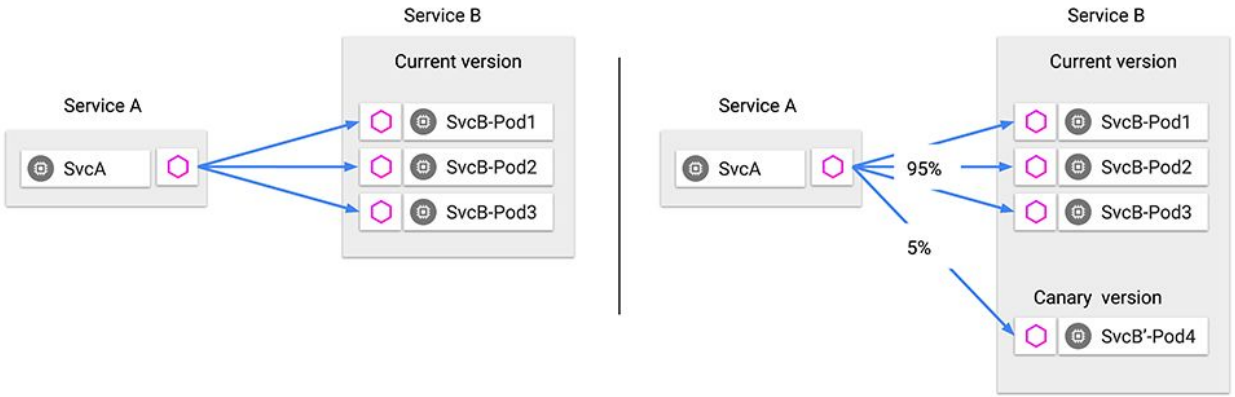


RED HAT DEVELOPERS

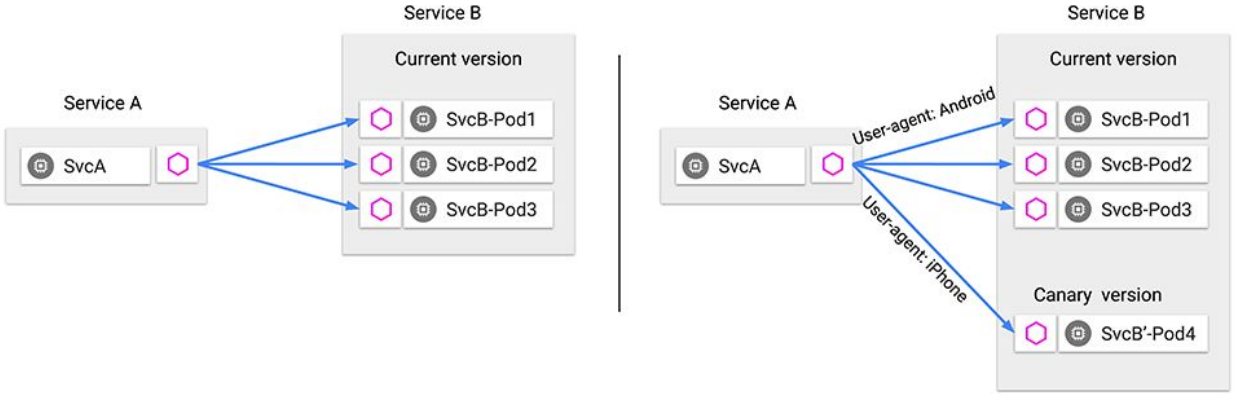
Blue / Green Deployment

Keep a hot standby ready in case a new release is flawed.

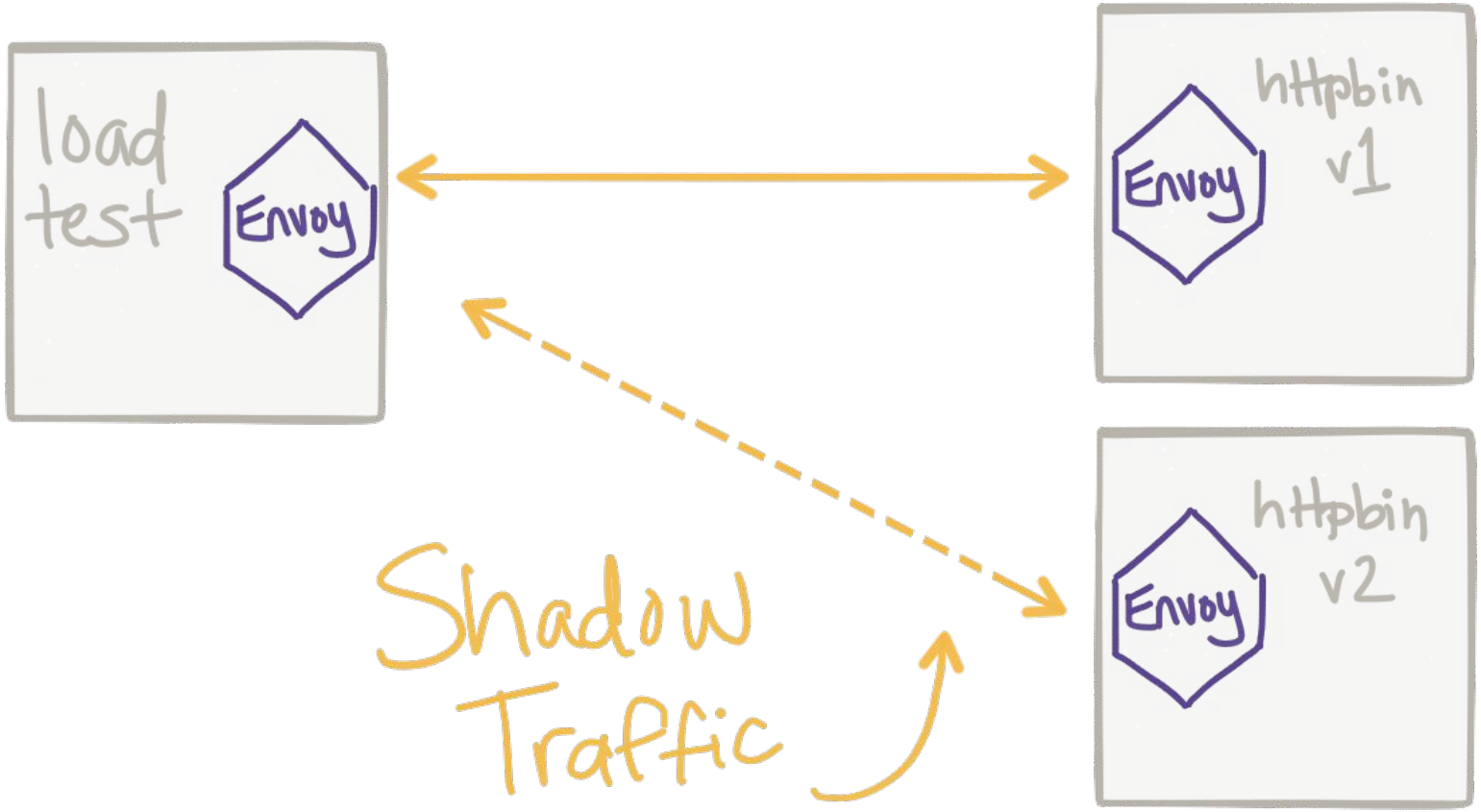




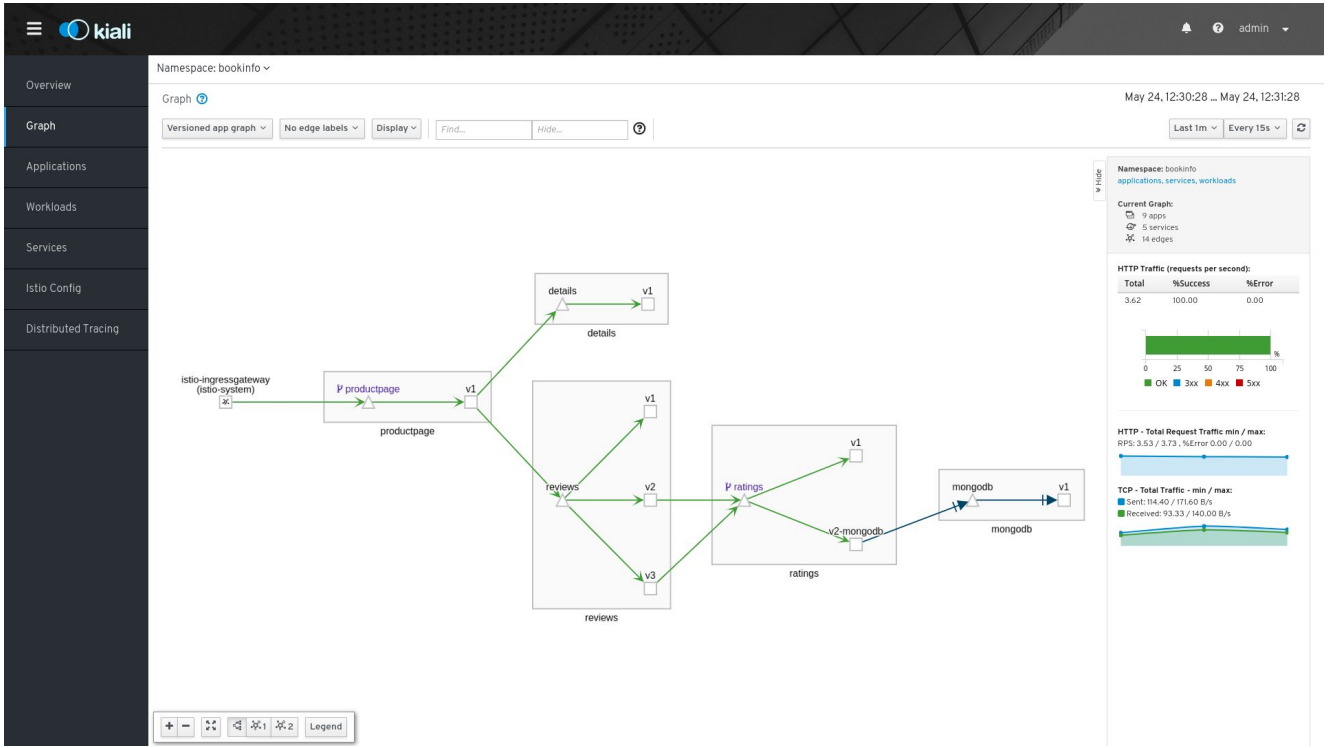
Traffic splitting decoupled from infrastructure scaling - proportion of traffic routed to a version is independent of number of instances supporting the version



Content-based traffic steering - The content of a request can be used to determine the destination of a request

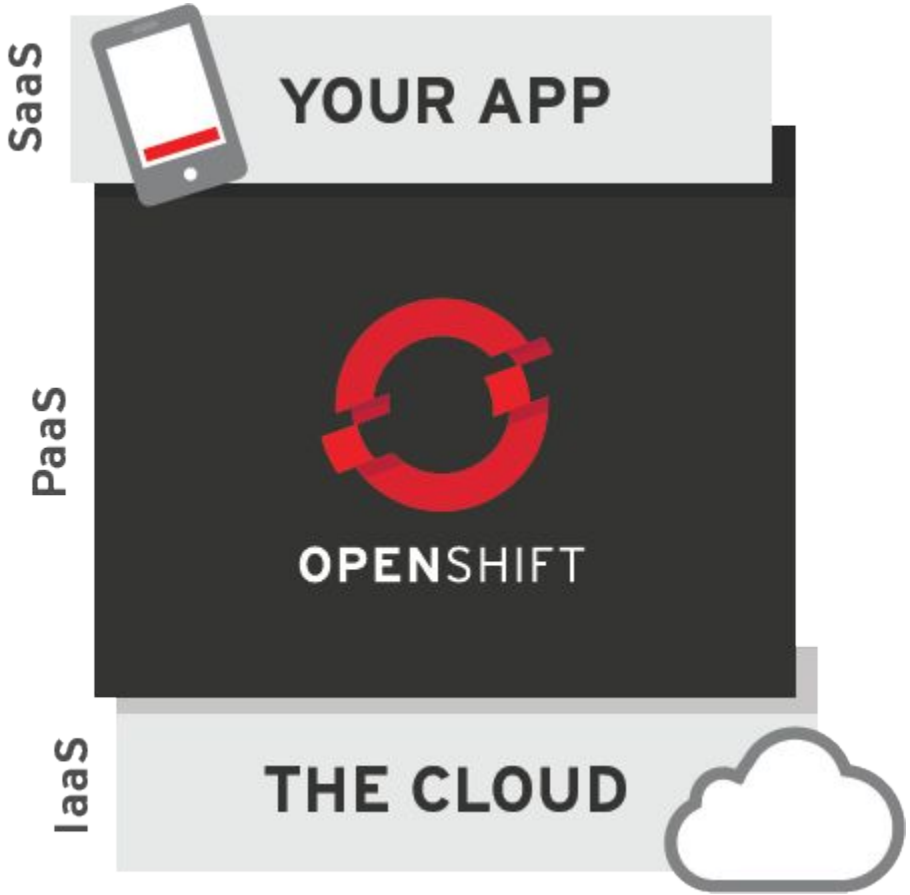

load test
Envoy
Envoy
httpbin v1
Envoy
httpbin v2
Shadow Traffic

Kiali – service mesh observability



Cloud computing

- IaaS - Infrastructure as a service
  - VMs, servers, storage, network
- PaaS - Platform as a service
  - Execution runtime, database, application server managed Kubernetes, Openshift
- SaaS - Software as a Service
  - Provided applications, CRM, Email, communication


SaaS
YOUR APP
PaaS
OPENSHIFT
IaaS
THE CLOUD

Cloud-native applications

- Basically microservices
- Designed for cloud deployments
- High requirements on
  - **Low memory utilization**
  - **Low processing requirements**
  - **Fast start-ups**
  - Automation of the app lifecycle
  - CI/CD pipelines

12-factor applications

1. **Codebase** - One codebase tracked in revision control, many deploys
2. **Dependencies** - Explicitly declare and isolate dependencies
3. **Config** - Store config in the environment
4. **Backing services** - Treat backing services as attached resources
5. **Build, release, run** - Strictly separate build and run stages

12-factor applications

6. **Processes** - Execute the app as one or more stateles processes
7. **Port binding** - Export services via port binding
8. **Concurrency** - Scale out via the process model
9. **Disposability** - Maximize robustness with fast startup and graceful shutdown
10. **Dev/prod parity** - Keep development, staging, and production as similar as possible

12-factor applications

11. **Logs** - Treat logs as event streams
12. **Admin processes** - Run admin/management tasks as one-off processes

Relational DBs

Distributed tracing

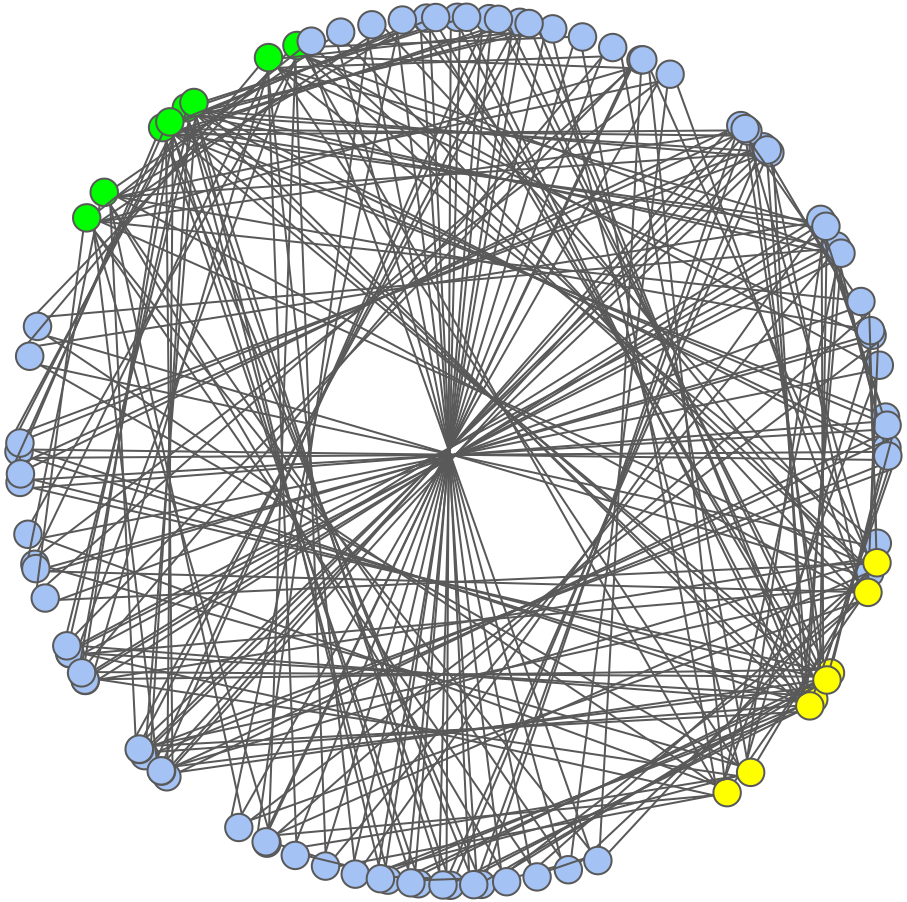
Fault tolerance

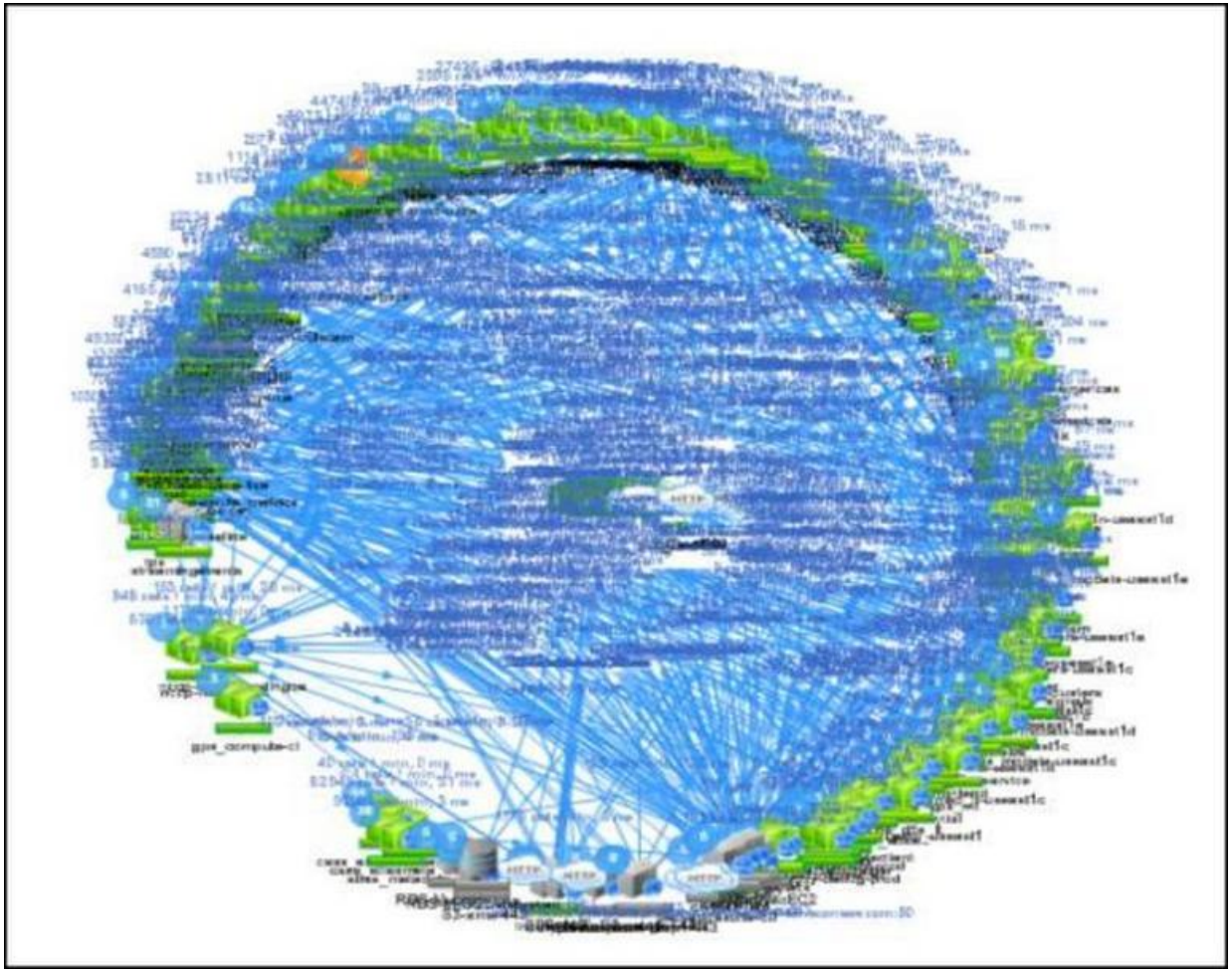
NoSQL DBs

Security

Metrics / monitoring

Demo





Thank you

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- mstefank@redhat.com

Resources

- https://www.zdnet.com/article/to-be-a-microservice-how-smaller-parts-of-bigger-applications-could-remake-it/ originally by Bruce Wong
- https://medium.com/refraction-tech-everything/how-netflix-works-the-hugely-simplified-complex-stuff-that-happens-every-time-you-hit-play-3a40c9be254b
- https://dzone.com/articles/microservices-vs-soa-whats-the-difference
- https://martinfowler.com/articles/microservices.html
- https://www.docker.com/resources/what-container
- https://github.com/kubernetes/kubernetes/blob/master/logo/logo.svg
- https://docs.aws.amazon.com/eks/latest/userguide/dashboard-tutorial.html
- https://www.slideshare.net/asotobu/service-mesh-patterns
- https://access.redhat.com/documentation/en-us/openshift_container_platform/3.3/html/release_notes/release-notes-ocp-3-3-release-notes
- https://thenewstack.io/history-service-mesh/
- https://philcalcado.com/2017/08/03/pattern_service_mesh.html
- https://istio.io/docs/concepts/what-is-istio/
- http://dougbtv.com/nfvpe/2017/06/05/istio-deploy/
- https://blog.aquasec.com/istio-service-mesh-traffic-control
- https://blog.christianposta.com/microservices/traffic-shadowing-with-istio-reduce-the-risk-of-code-release/
- https://github.com/kiali/kiali
- https://blog.openshift.com/what-is-platform-as-a-service-paas/
- https://serverless.zone/abstracting-the-back-end-with-faas-e5e80e837362
- https://softwareengineeringdaily.com/2016/09/08/relational-databases-with-craig-kerstiens/
- https://www.getfilecloud.com/blog/2014/08/leading-nosql-databases-to-consider/
- https://www.jaegertracing.io/
- https://blog.twitter.com/engineering/en_us/a/2012/distributed-systems-tracing-with-zipkin.html
- https://www.trzcacak.rs/imgm/iTJioJh_prometheus-logo-logo-prometheus/
- https://en.wikipedia.org/wiki/File:Grafana_logo.png
- https://design.jboss.org/keycloak/index.htm
- https://github.com/Netflix/Hystrix