CERN School of Computing

March 2019

HOW CONTAINER ORCHESTRATION CAN STRENGTHEN YOUR MICRO-SERVICES

THE APPROACH OF KUBERNETES

Riccardo Poggi

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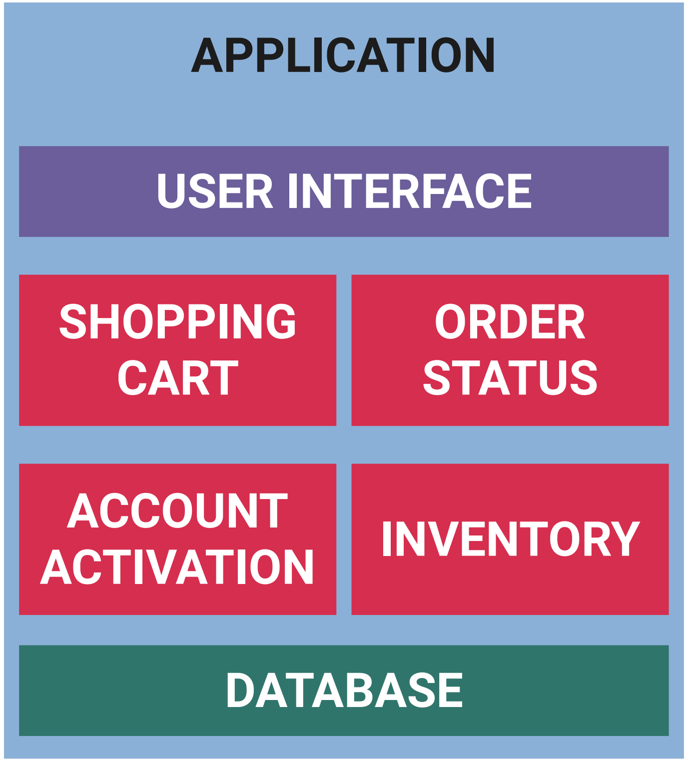
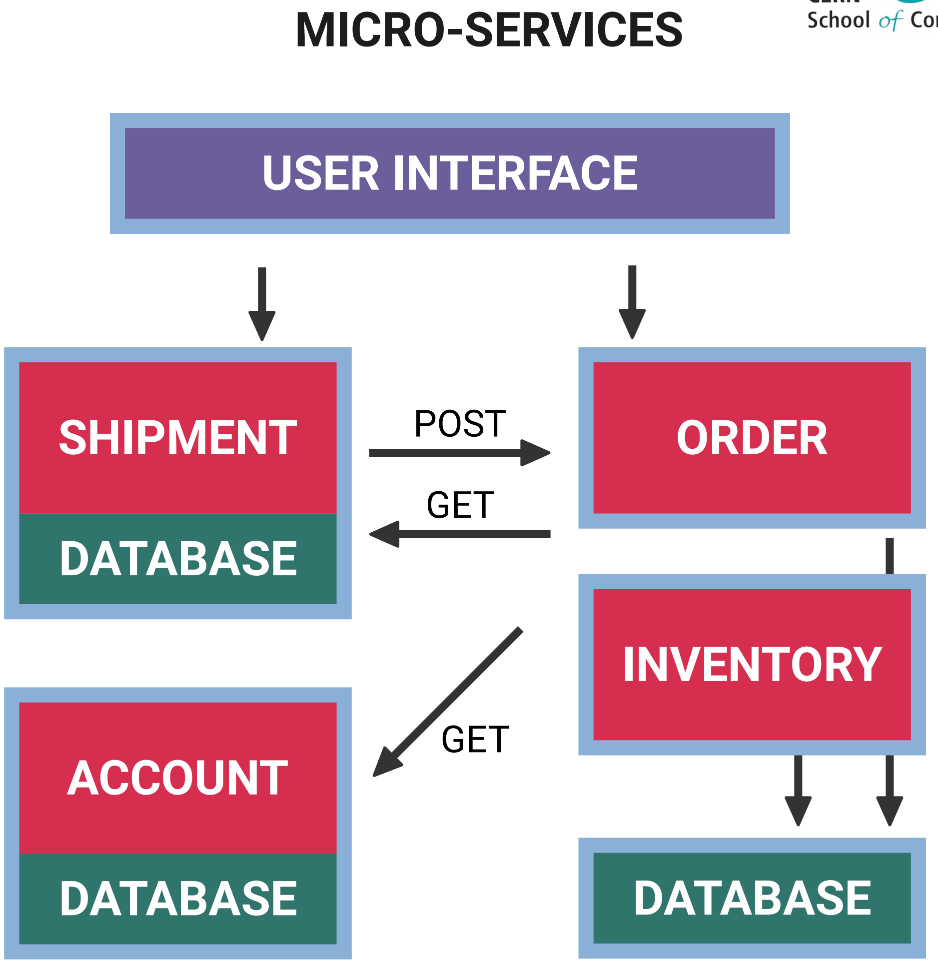
MONOLITH APPLICATION

- Key aspects
  - Single code-base
  - Single build system
  - Single executable



MICRO-SERVICES



- Key aspects
  - Loosely coupled
  - Independently deployable
  - API service communication

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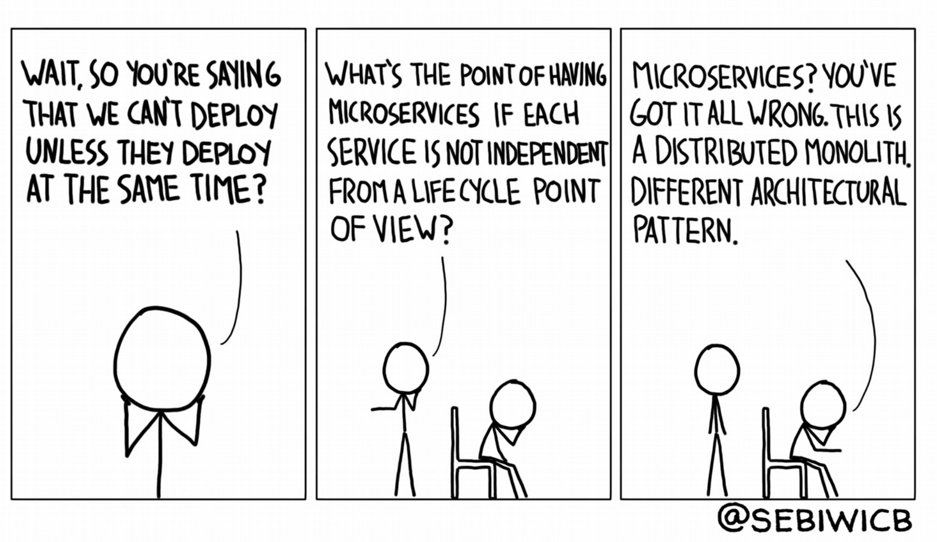

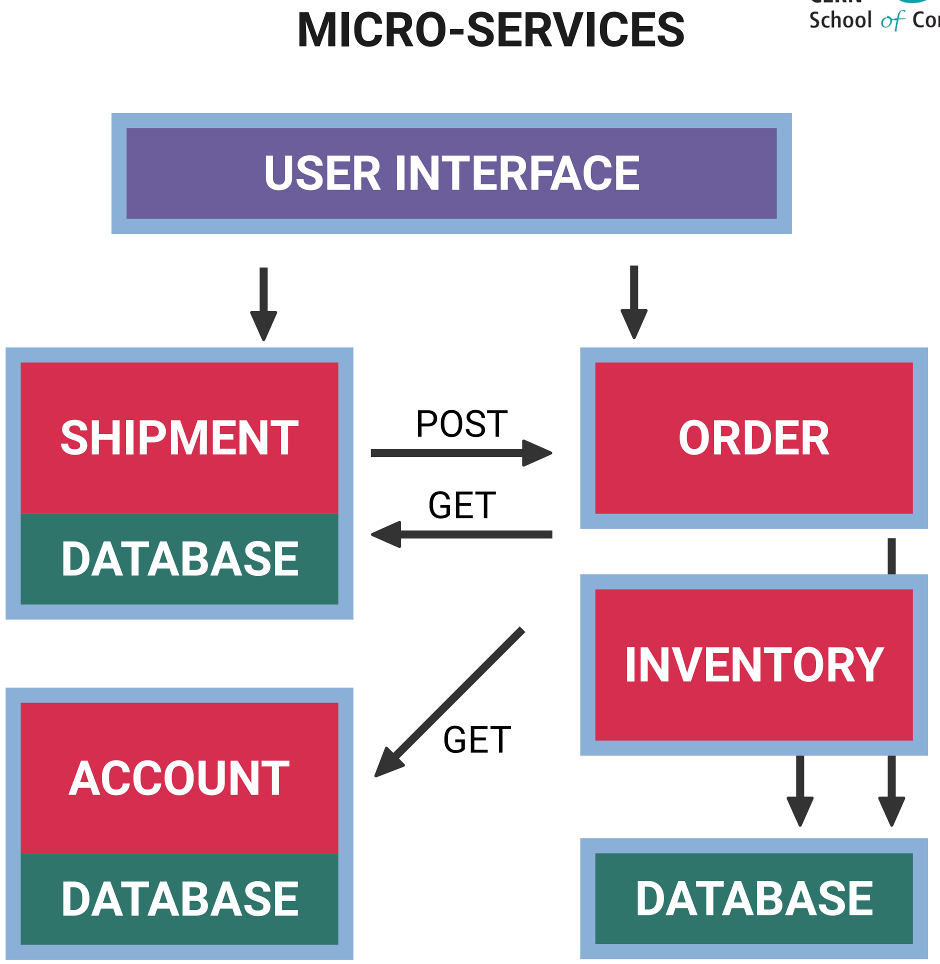

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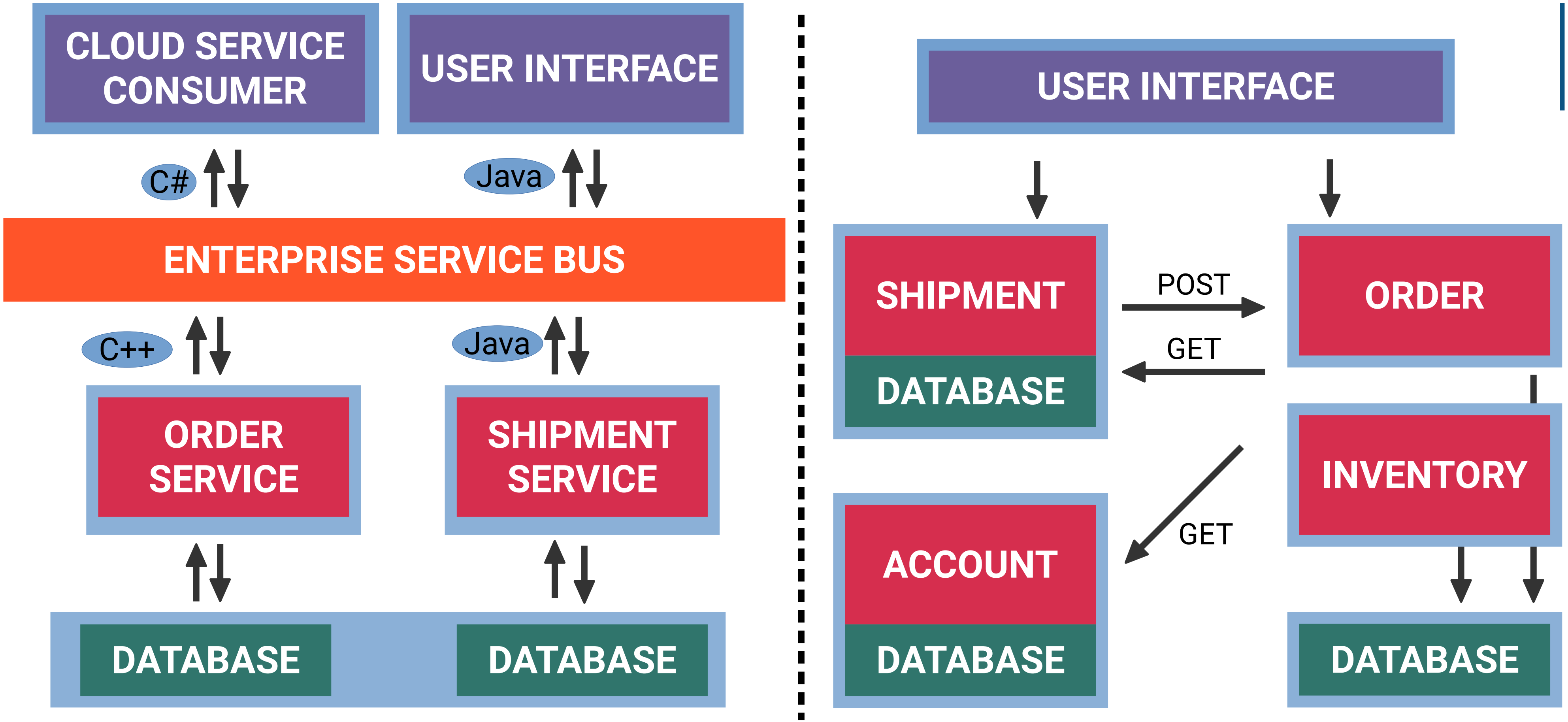
FROM SOA TO MICRO-SERVICES



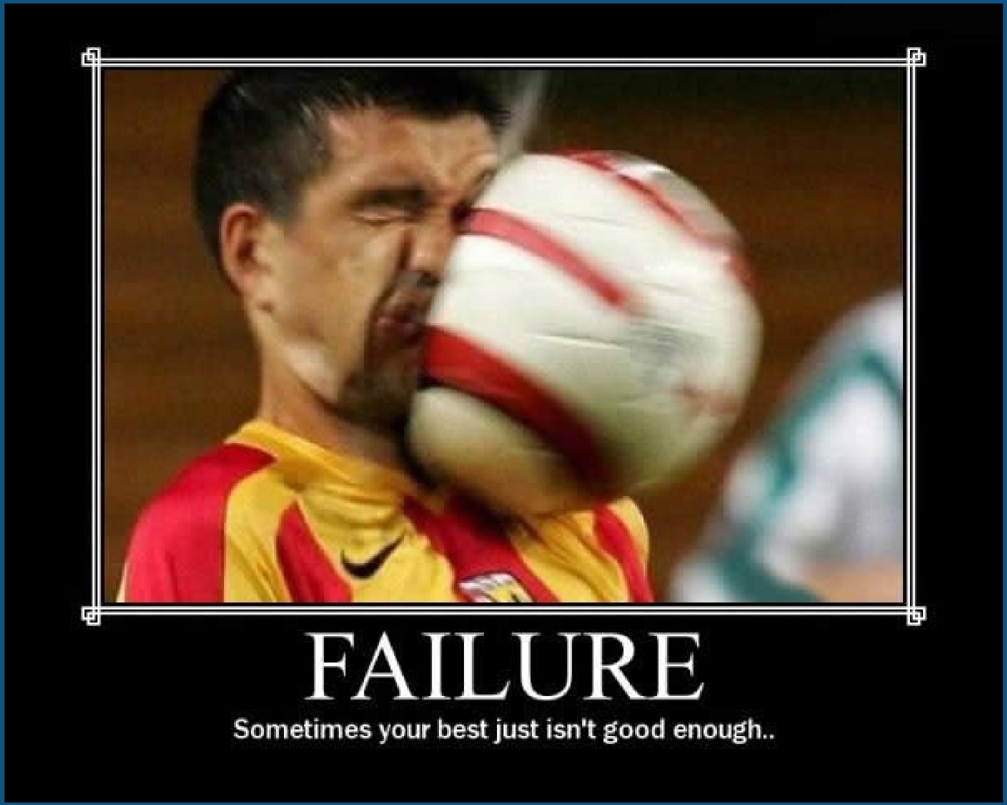
MICRO-SERVICES ARCHITECTURE

- BENEFITS
  - Highly scalable
  - Resilient
  - Easy to deploy
  - Accessible
  - More open

- CHALLENGES
  - Building
  - Testing
  - Deployment
  - Logging
  - Monitoring
  - Connectivity

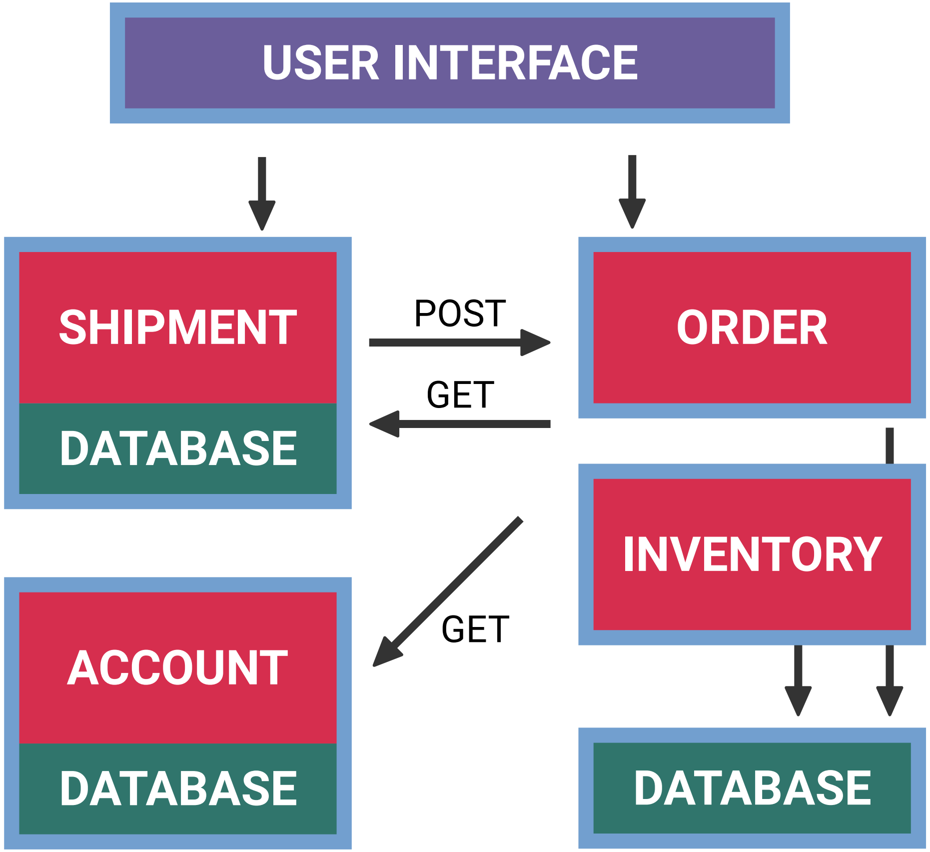
UNEXPECTED FAILURE

> "Dealing with unexpected failures is one of the hardest problems to solve
>
> especially in a distributed system"



FAULT-TOLERANCE

- Fault-tolerance
  - System able to continue proper operation in the event of failure of one or more of its components
- Resilience
- Graceful degradation
  - The ability of maintaining functionality when portions of a system break down



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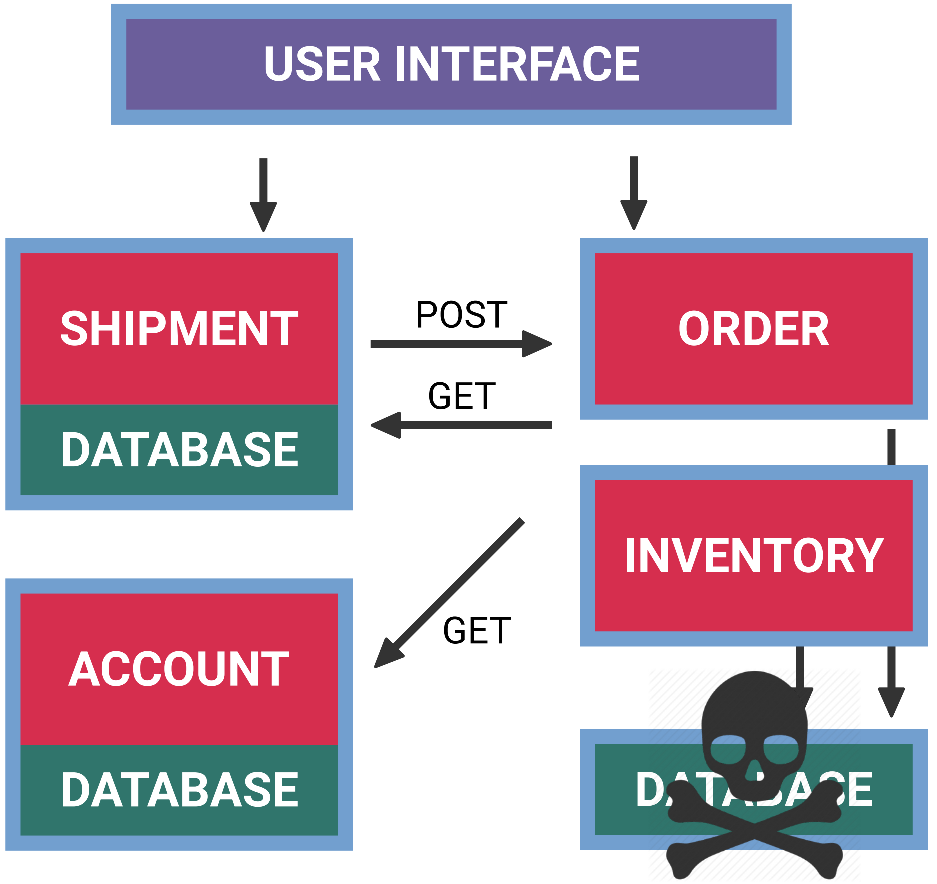
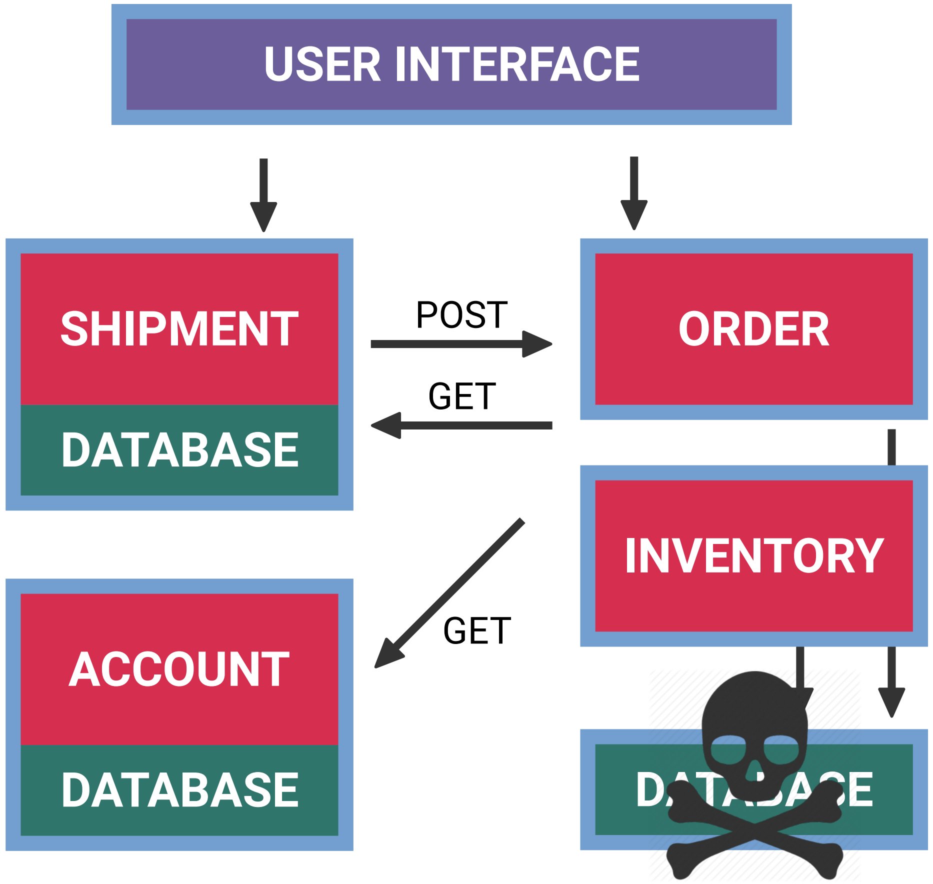


HIGH-AVAILABILITY

- Redundancy
  - Eliminate single points of failure
  - Failure of a component does not mean failure of the entire system
- Reliable crossover
  - Not to have crossover be a single point of failure
- Monitoring
  - Detection of failures as they occur
  - A user may never see a failure, but the maintenance activity must



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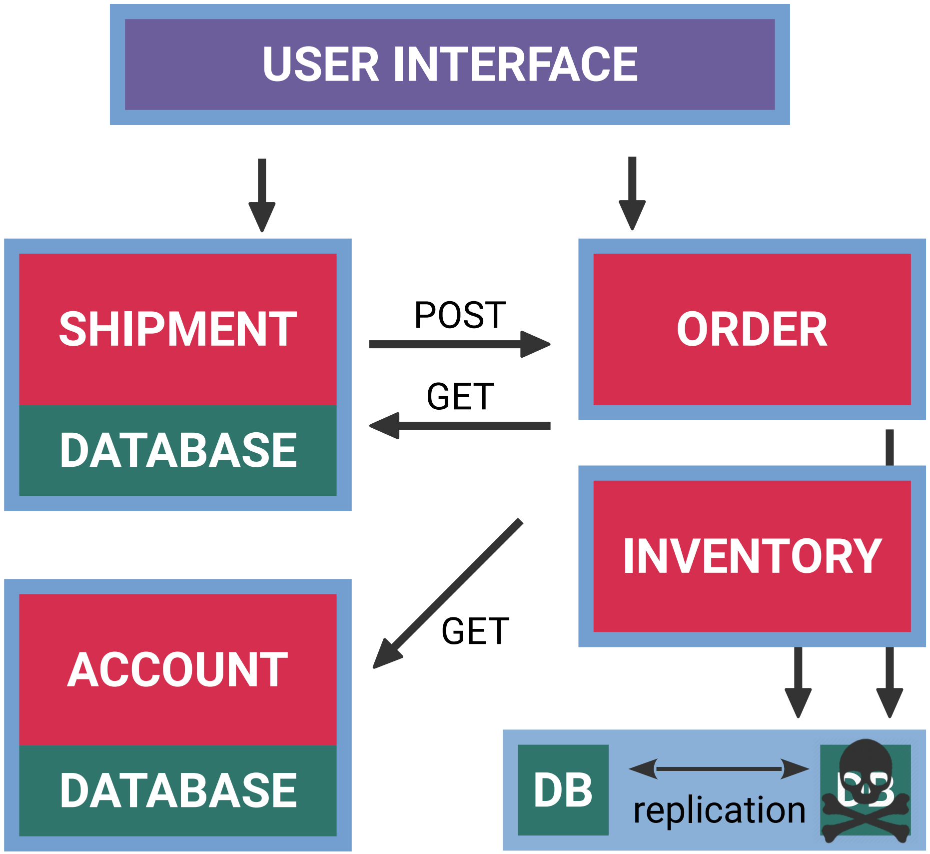


FAIL-OVER POLICY

- Fail-over policy
  - Failure as an unrecoverable critical issue
  - Implementing the behaviour a service follows in case of its own failure
- Last action before failing
  - Does the service holds important data which needs to be saved?
  - Does the service has a configuration or status which needs to be saved?
- Termination
  - “Failure” can also be externally induced
  - Graceful kill (close)

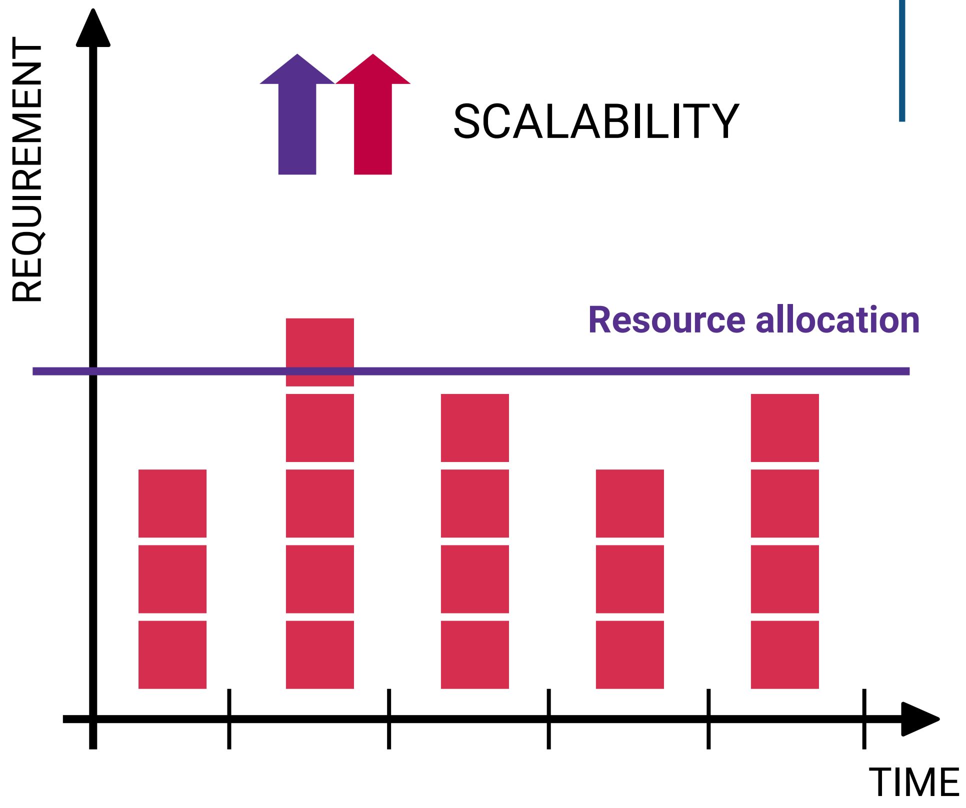
SIGKILL **SIGTERM**

```
def sigterm_handler(signal, frame):
    # save the state here or do whatever you want
    print('booyah! bye bye')
    sys.exit(0)

signal.signal(signal.SIGTERM, sigterm_handler)
```

SCALABILITY & ELASTICITY

- Requirement as a function of time
  - Resource allocation and server instantiation
- Scalability
  - Increasing the capacity
  - The available resources match the current and future usage plans
  - Scaling up: increasing the ability of an individual server
  - Scale out: adding multiple servers
- Elasticity
  - Increasing or reducing the capacity based on the load
  - The available resources match the current demands as closely as possible



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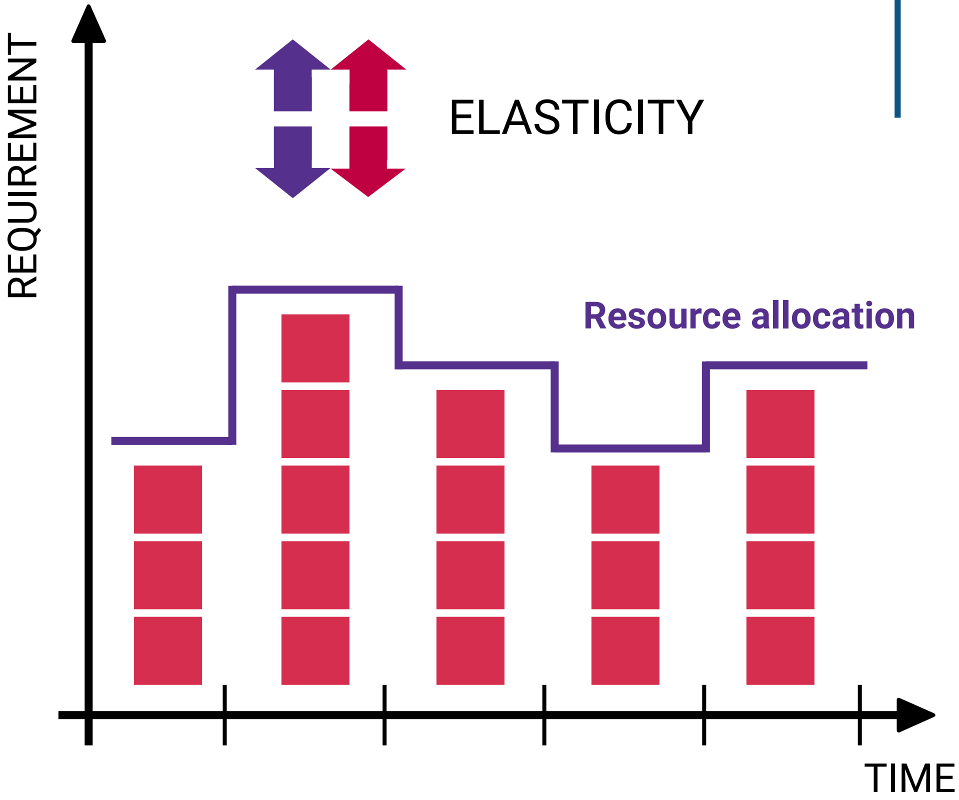
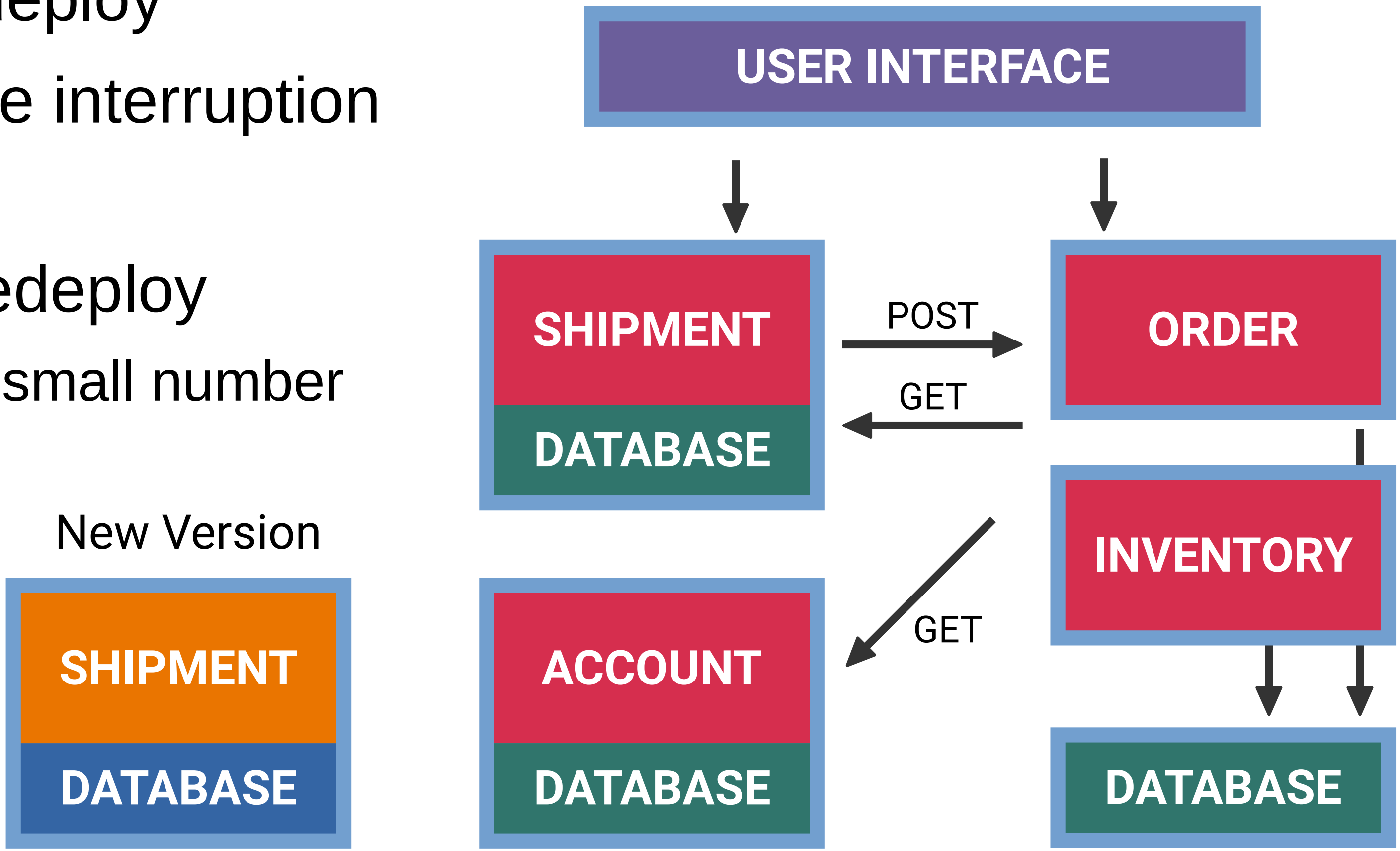


CONTINUOUS DELIVERY

- Independent deploy
- Without service interruption
  - No downtime!
- Rebuild and redeploy
  - only one or a small number of services



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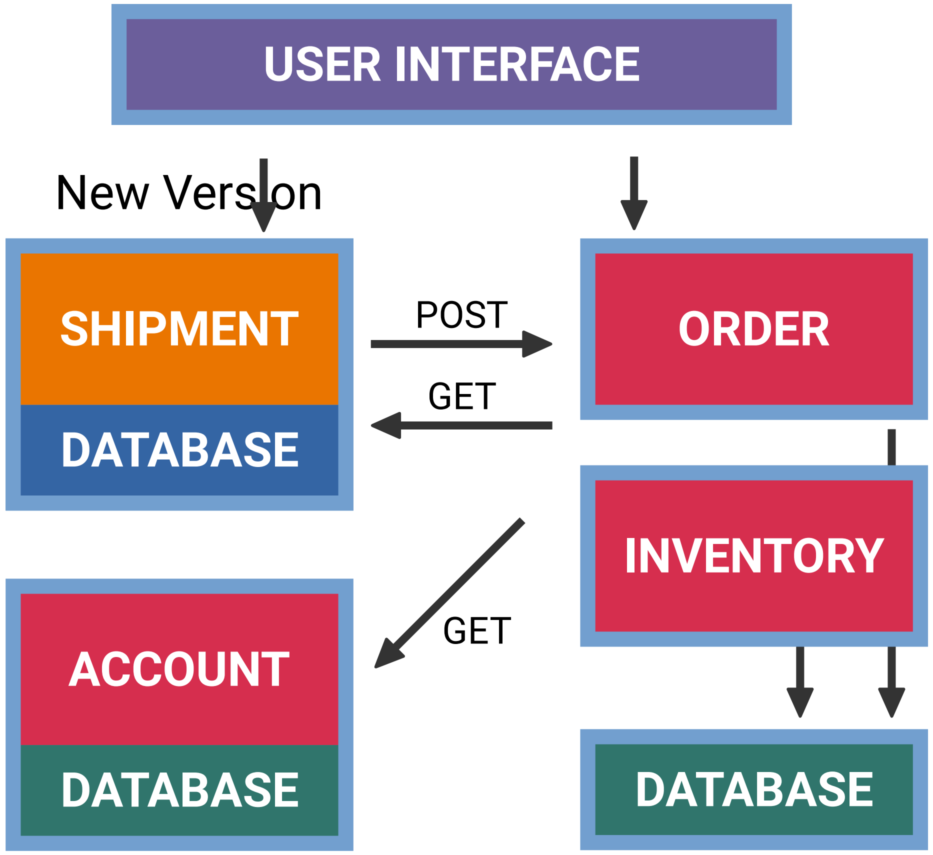
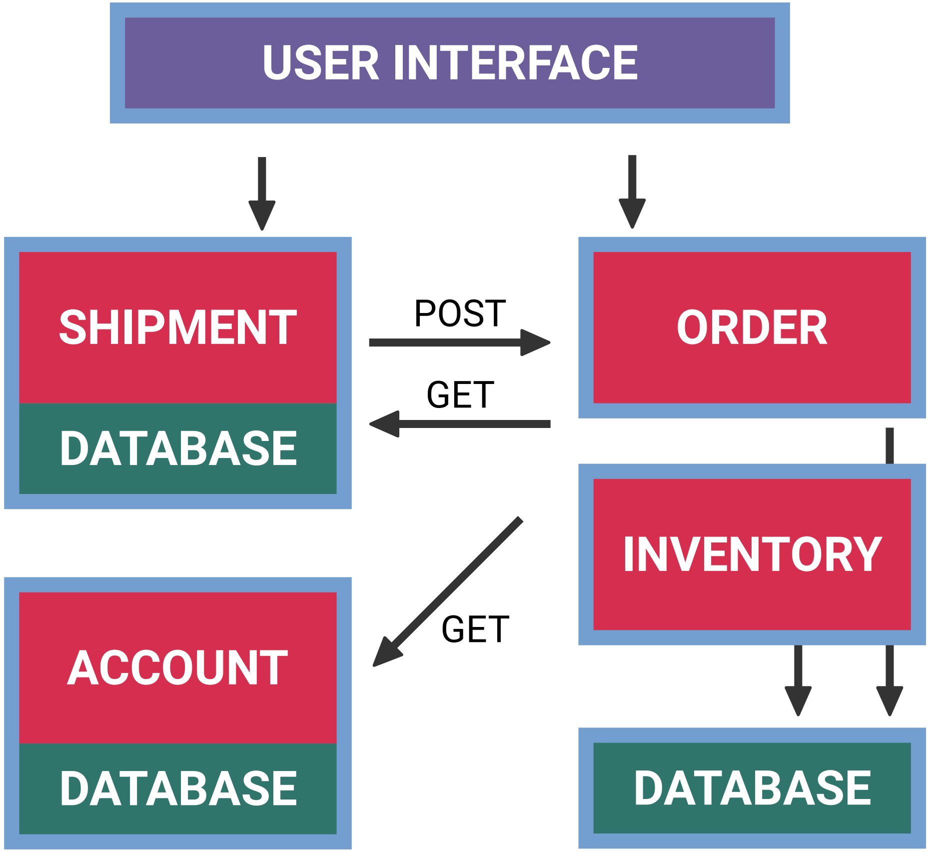


STATEFUL VS. STATELESS

- Stateful
  - Possess saved data in a database that they read from and write to directly
  - If it shares DB with other micro-services less decoupled
  - When it terminates it has to save its state (fail-over policy)
- Stateless
  - Handle request and return responses
  - All necessary information supplied on the request and can be forgot after the response
  - No permanent data
  - Nothing to save when it terminates



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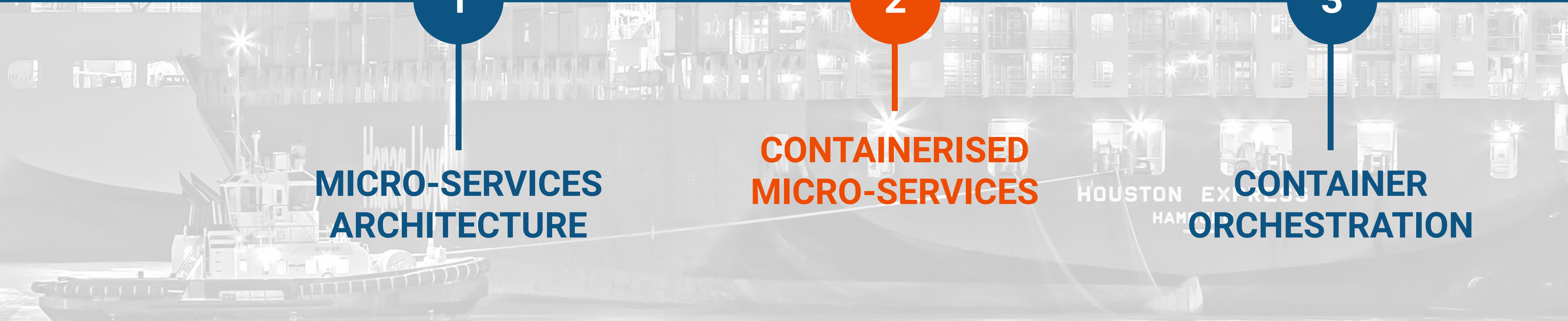

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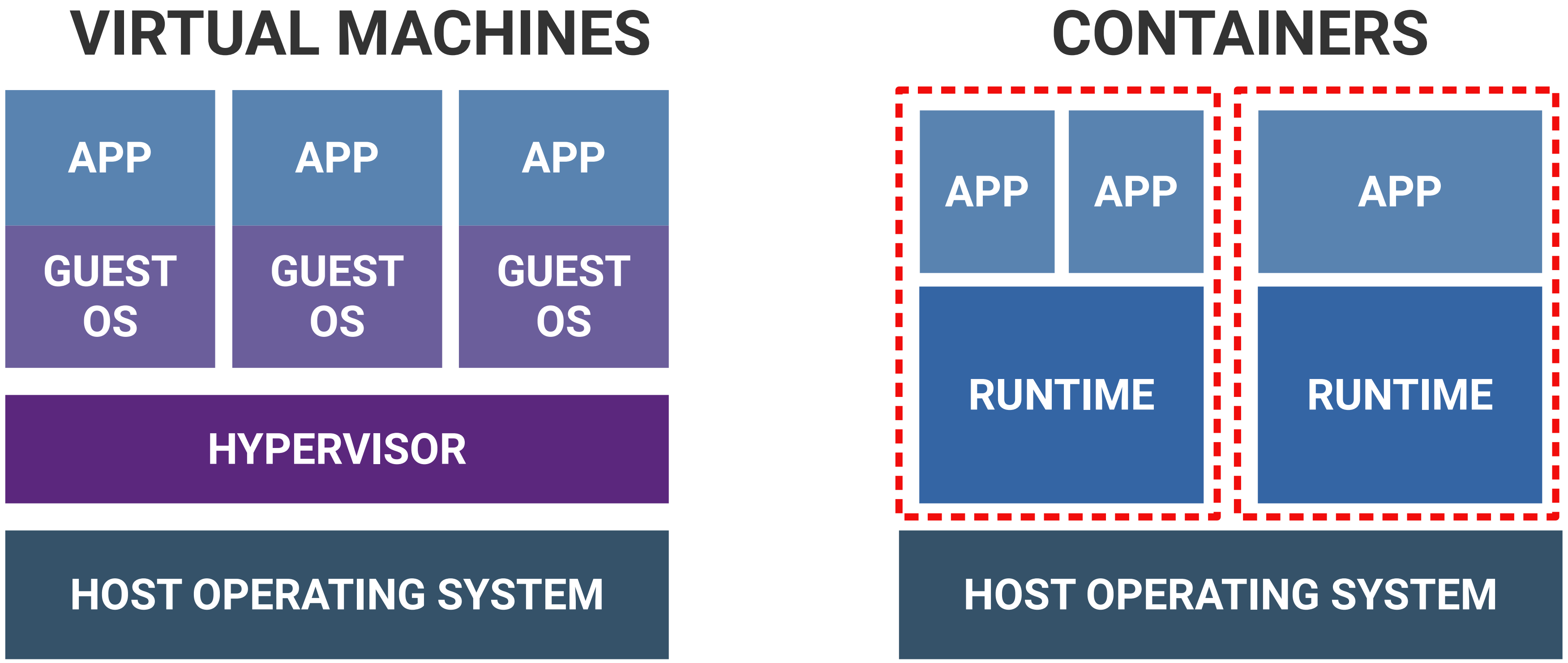


VMs have their own OS kernel, while containers share it with the host OS

CGROUPS & NAMESPACES

CGROUP

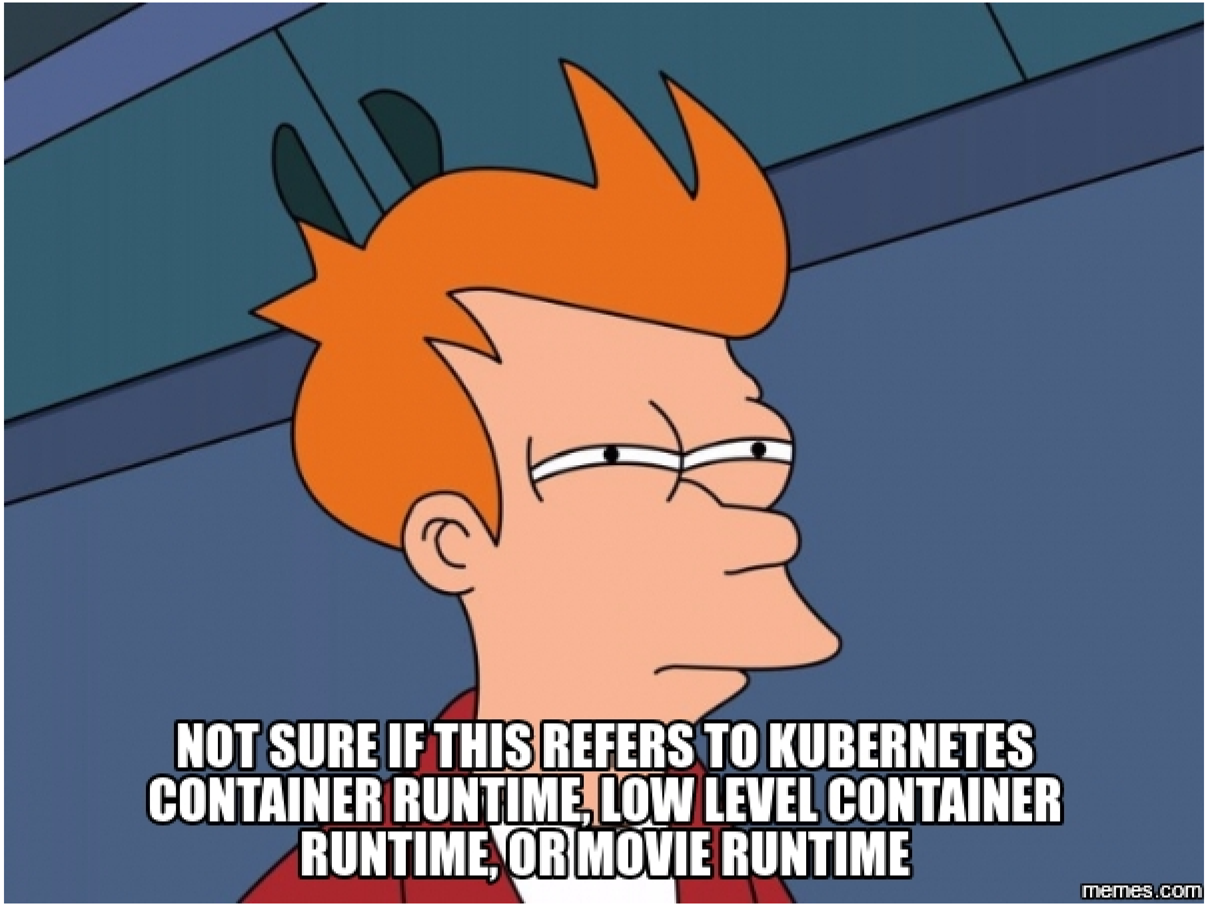
Cpu, memory, I/O, ...

NAMESPACES

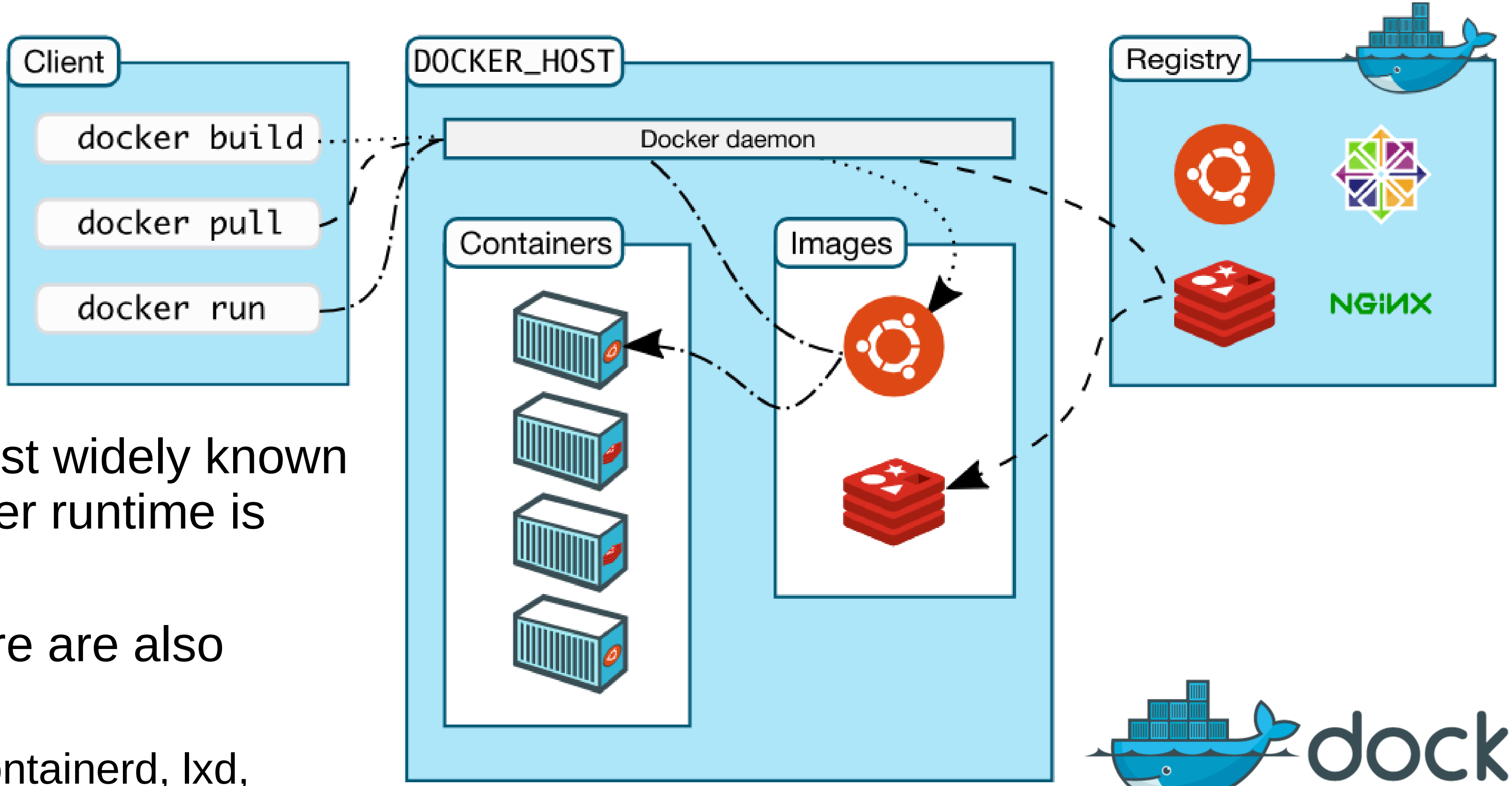
Cgroup, IPC, network, mount, PID, User, ...

CONTAINER RUNTIME

- Container Runtime
  - In a OCI/CNI compatible version is a daemon process
  - Creates and executes a container
- To fully create a container:
  1. Creates the rootfs filesystem.
  2. Creates the container
     - Set process namespaces and cgroups
  3. Connects the container to a network
  4. Starts the user process



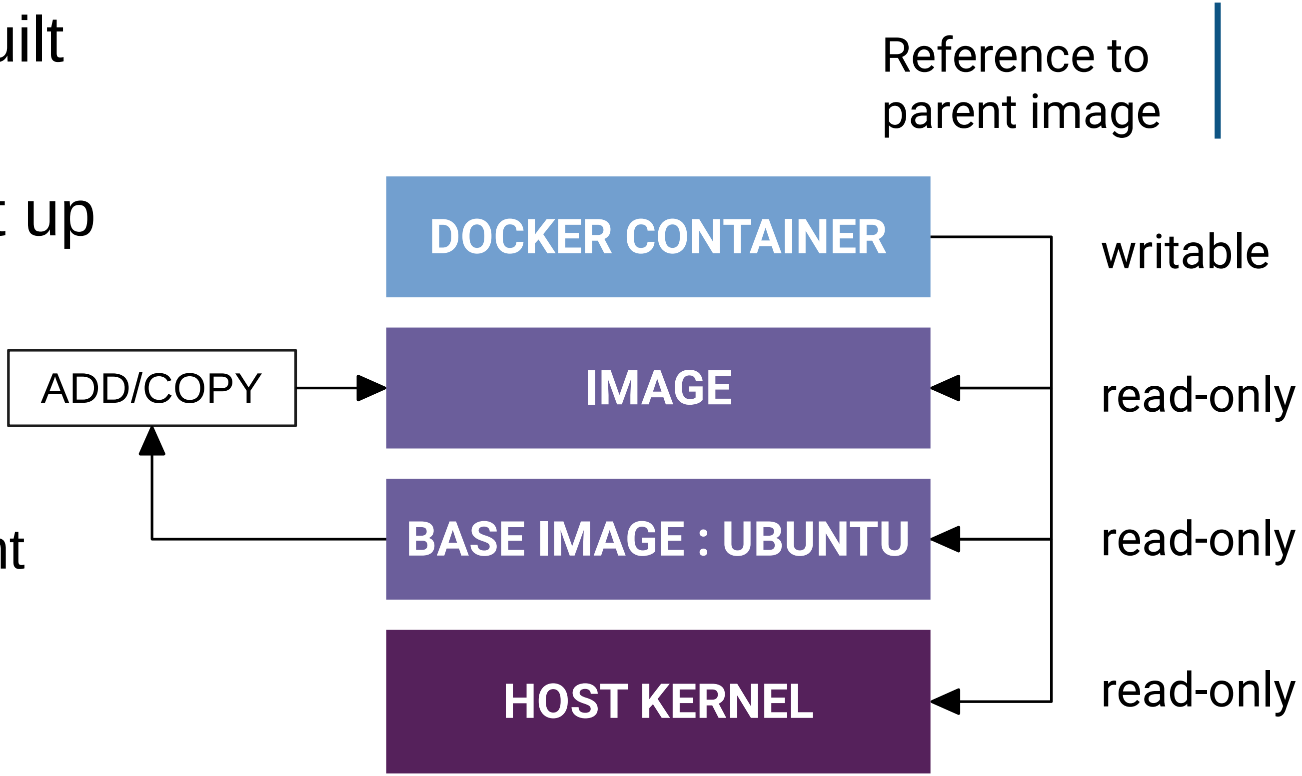
ENTERS DOCKER



- The most widely known container runtime is Docker
- But there are also others
  - rkt, containerd, lxd, singularity, etc..

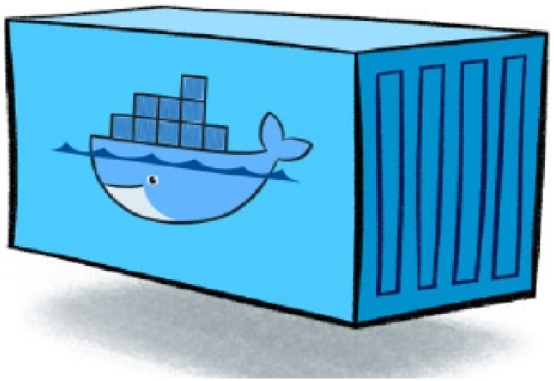
DOCKER IMAGE

- Docker images are built from a base image
- Base images are built up using instructions
  - Run a command
  - Add a file or directory
  - Create an environment variable
  - What process to run when launching a container from this image

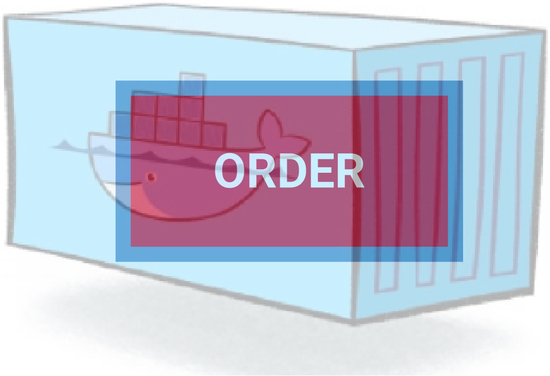


DOCKERFILE

```
# Dockerfile
FROM ubuntu:latest

RUN apt-get update
RUN apt-get install -y python python-pip
RUN pip install Flask

COPY . /app

CMD python /app/order_service.py
```

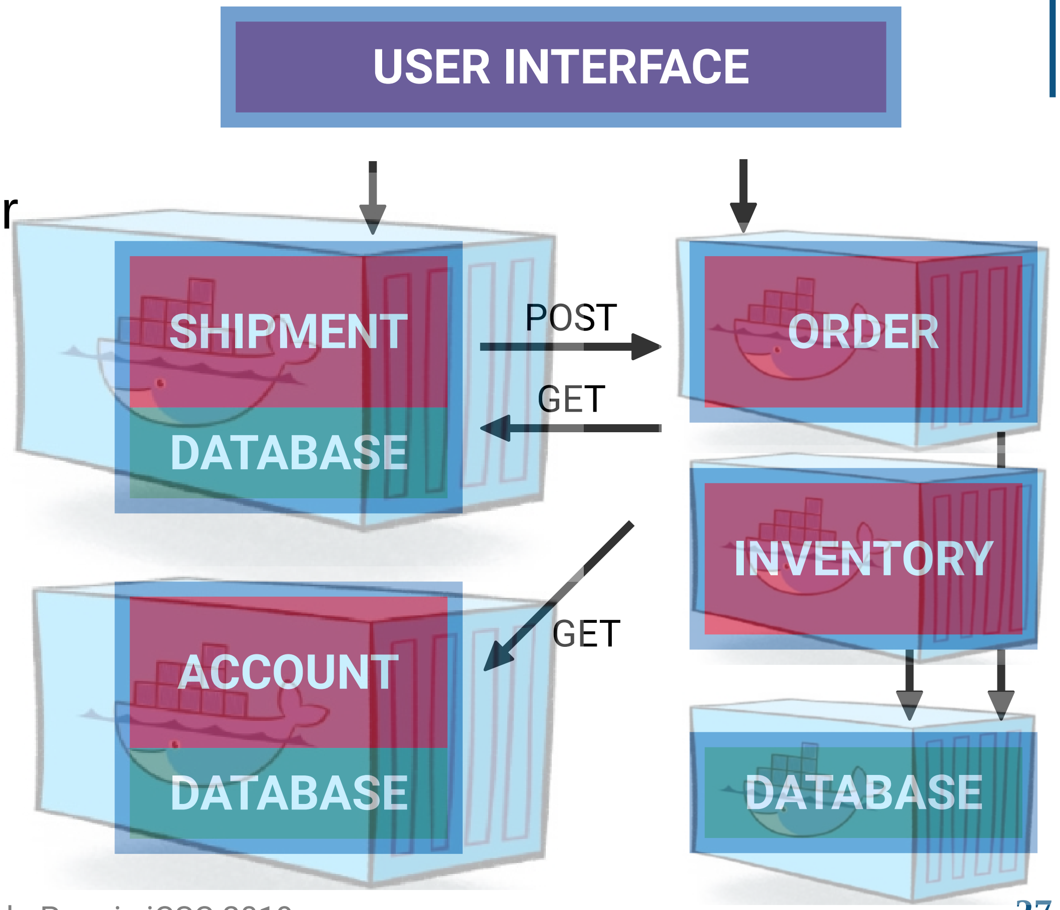


```
$ docker build -t my-image .
$ docker run my-image
```



CONTAINERISED MICRO-SERVICES

- Apply containers to micro-services architecture
  - One-to-one map for single independent services container
  - Decoupling inside/outside container
- Questions still to be solved
  - Tightly coupled processes inside one container?
  - Everything running on one single node
  - Redundancy and scalability



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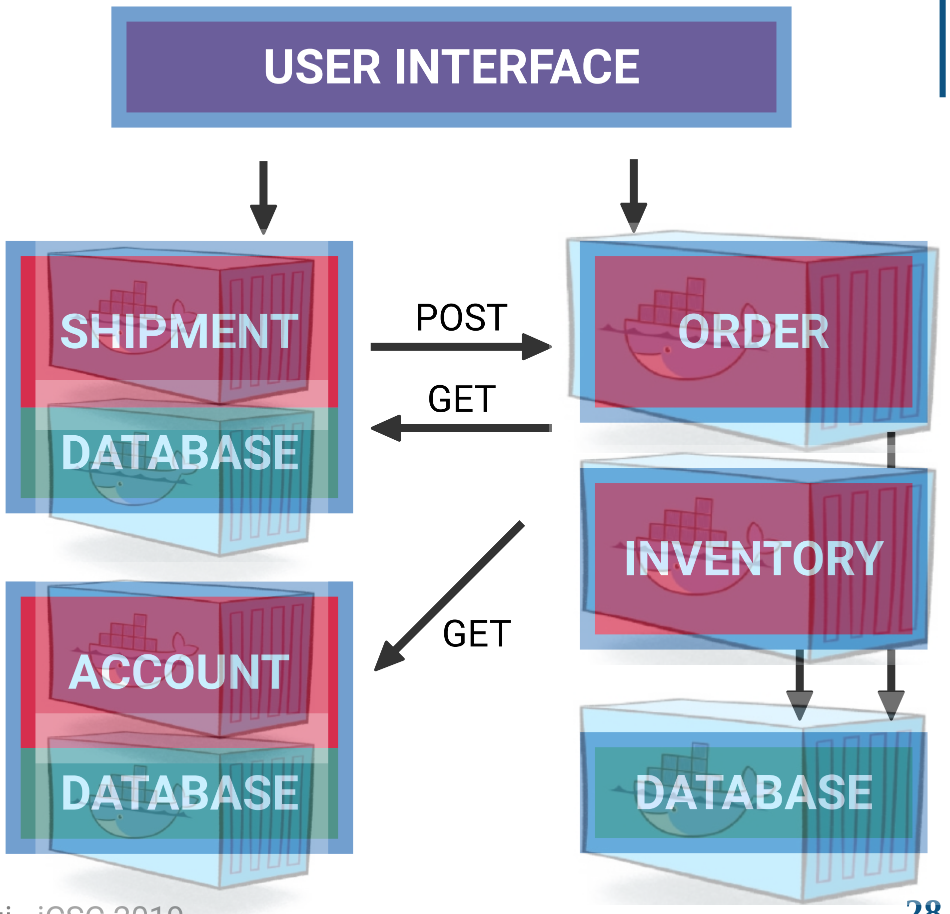

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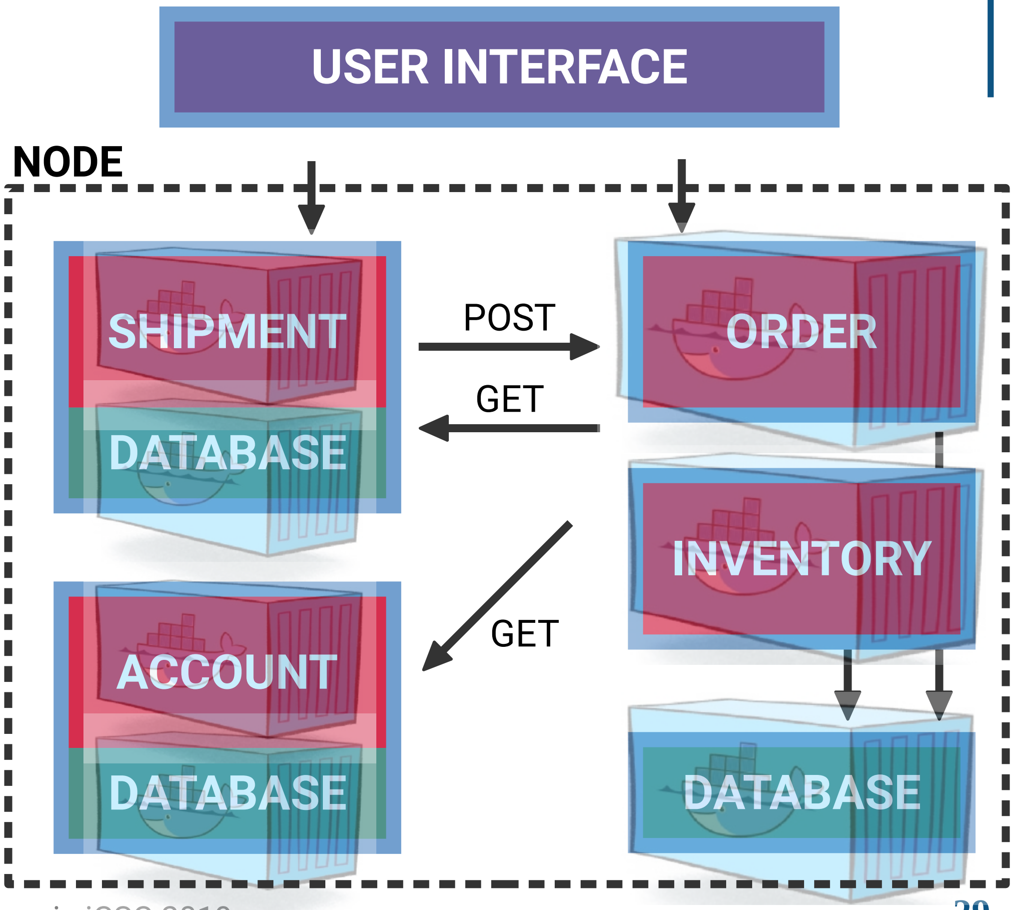

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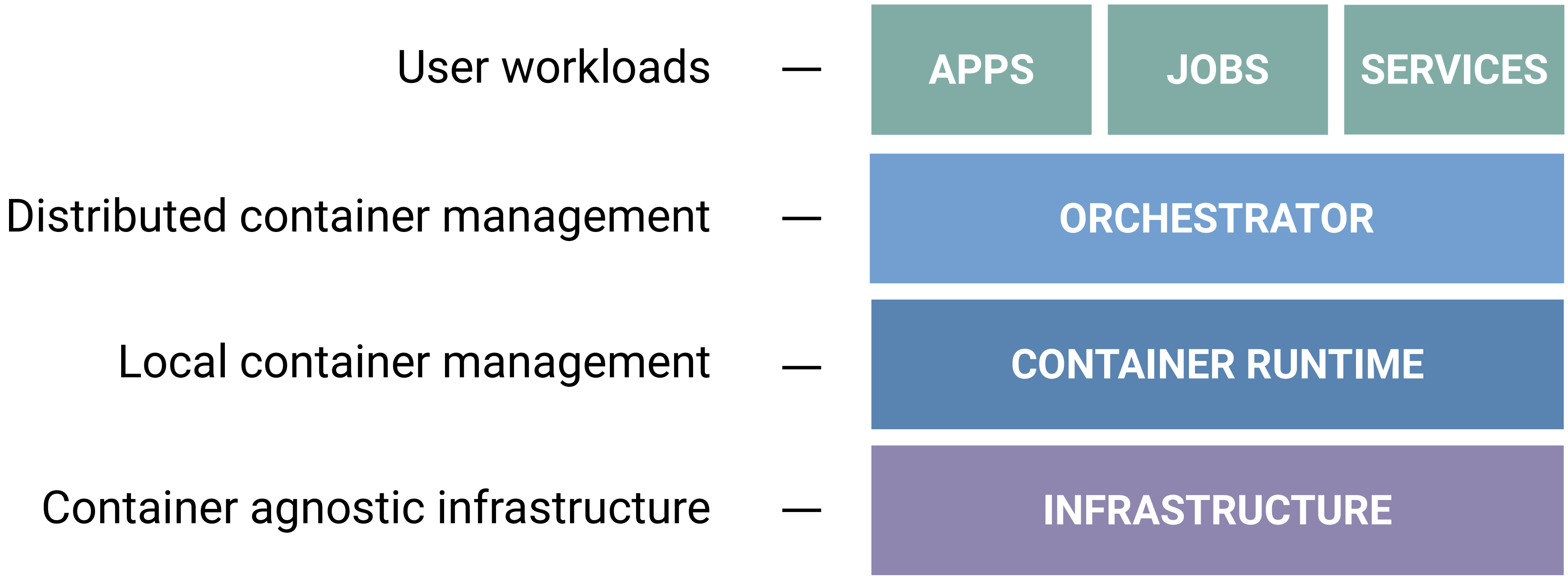
ORCHESTRATION

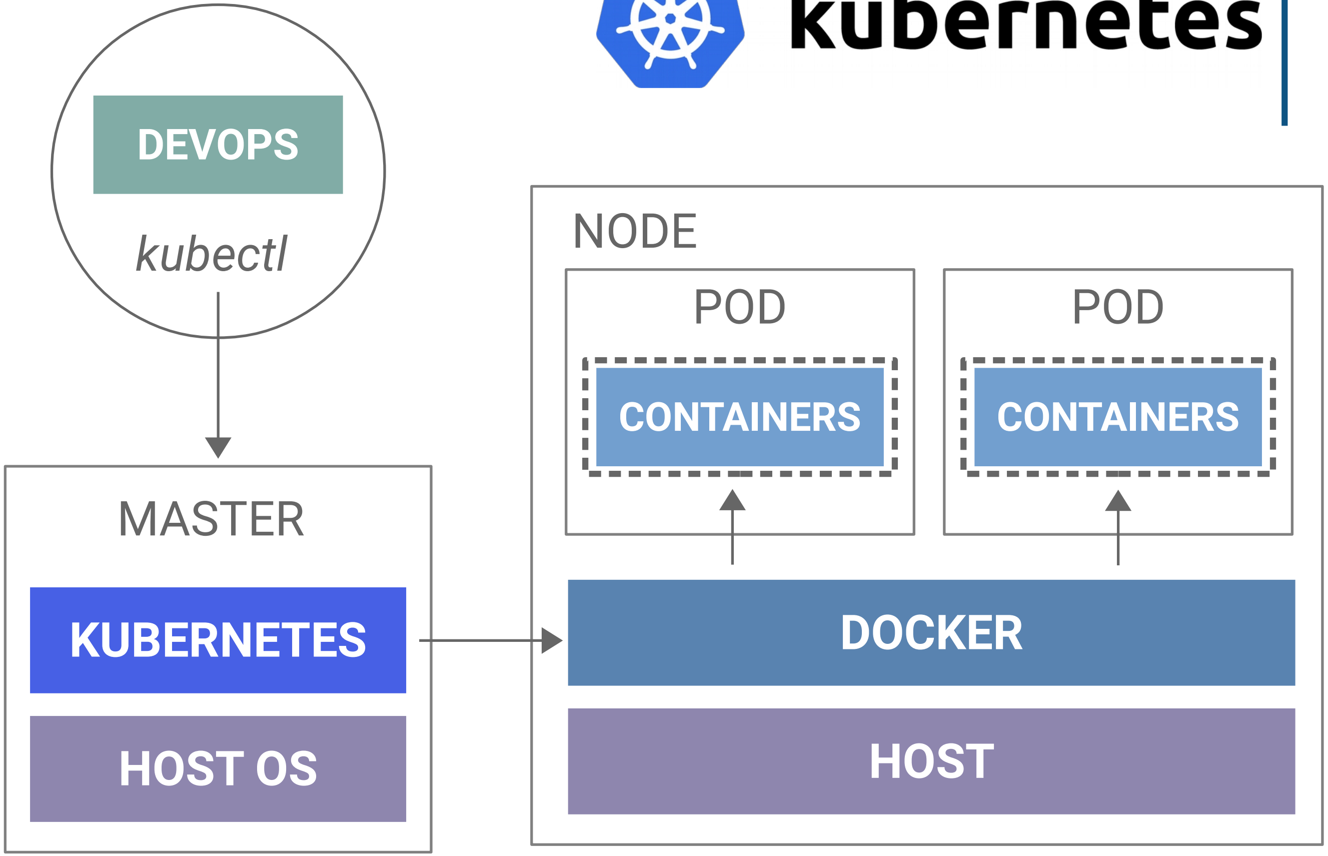
- Orchestration
  - Automated arrangement
  - Coordination
  - Management
- Useful tool for
  - Service Discovery
  - Load Balancing
  - Health checks
  - Auto-scaling
  - Zero-downtime deploys
  - (And much more...)

PLATFORM OVERVIEW



KUBERNETES

- **Master**
  - The machine that controls Kubernetes nodes
- **Node**
  - The machines that perform the requested and assigned tasks
- **Pod**
  - A group of one or more containers deployed to a single node
- **kubectl**
  - Command line configuration tool for Kubernetes



POD

- A Pod is the basic building block of Kubernetes
  - The smallest and simplest unit
- “one-container-per-Pod”
  - Most common Kubernetes use case
  - Pod as a wrapper around a single container
- Encapsulate multiple co-located containers
  - Tightly coupled
  - Need to share resources

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: demo
spec:
  containers:
  - image: ubuntu:18-demo
    name: ubuntu
```

```
$ kubectl create -f pod.yaml
pod demo created
$ kubectl get pod demo
NAME     READY    STATUS     RESTARTS    AGE
demo     1/1      Running    0           1m
$ kubectl delete pod demo
pod demo deleted
```

REPLICASET

- Kubernetes Controller
  - Changes the system to move it from the current to the desired state
- ReplicaSet
  - Ensures that a specified number of pod replicas are running at any given time

```
$ kubectl create -f replicaset.yaml
replicaset "demo" created
$ kubectl get replicaset demo
NAME      DESIRED   CURRENT   AGE
demo      2         2         40s
$ kubectl scale --replicas=4 replicaset/demo
replicaset "demo" scaled
$ kubectl delete replicaset demo
replicaset "demo" deleted
```

```yaml
apiVersion: apps/v1
kind: ReplicaSet
metadata:
  name: demo
spec:
  replicas: 4
  selector:
    matchLabels:
      # this replicaset will apply to every template
      app: demo

  # pod template spec
  template:
    metadata:
      labels:
        app: demo
    spec:
      containers:
      - name: ubuntu
        image: ubuntu:18-demo
```

DEPLOYMENT

- Deployment controller
  - Declarative update for Pods and ReplicaSet
- Rollout
  - Ensure max unavailable/surge
  - e.g. at least 75% are up (25% max unavailable)
- Roll back

```
$ kubectl create -f deployment.yaml
deployment "demo" created
$ kubectl get deployment demo
NAME     DESIRED   CURRENT   UP-TO-DATE   AVAILABLE   AGE
demo     2         2         2            2           40s
$ # alternatives: 'kubectl edit' or 'kubectl apply -f'
$ kubectl patch deployment -p {"spec": [...] "value": "v2"}
"demo" patched
$ kubectl rollout undo deployment/demo
$ kubectl delete deployment demo
deployment "demo" deleted
```

```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: demo
spec:
  replicas: 4
  selector:
    matchLabels:
      app: demo
  template:
    metadata:
      labels:
        app: demo
    spec:
      containers:
      - image: ubuntu:18-demo
        name: ubuntu
        env:
        - name: VERSION
          value: "v1"
```

SERVICE

- Service
  - Abstraction to functionally group Pods
  - e.g. Front-end Pods, back-end Pods
- Consistent front for a set of Pods to offer a given service
- Possible to scale up and down Pods

```yaml
apiVersion: v1
kind: Service
metadata:
  name: demo
spec:
  ports:
  - port: 80
    targetPort: 8080
  selector:
    run: demo
```

```
$ kubectl create -f deployment.yaml
$ kubectl create -f service.yaml
service "demo" created
$ kubectl get service demo
NAME     CLUSTER-IP       EXTERNAL-IP    PORT(S)    AGE
demo     10.254.132.169   <none>         80/TCP     30s
$ kubectl scale deployment/demo --replicas=4
$ kubectl delete svc demo
$ kubectl delete deployment demo
```

ORCHESTRATED MICRO-SERVICES

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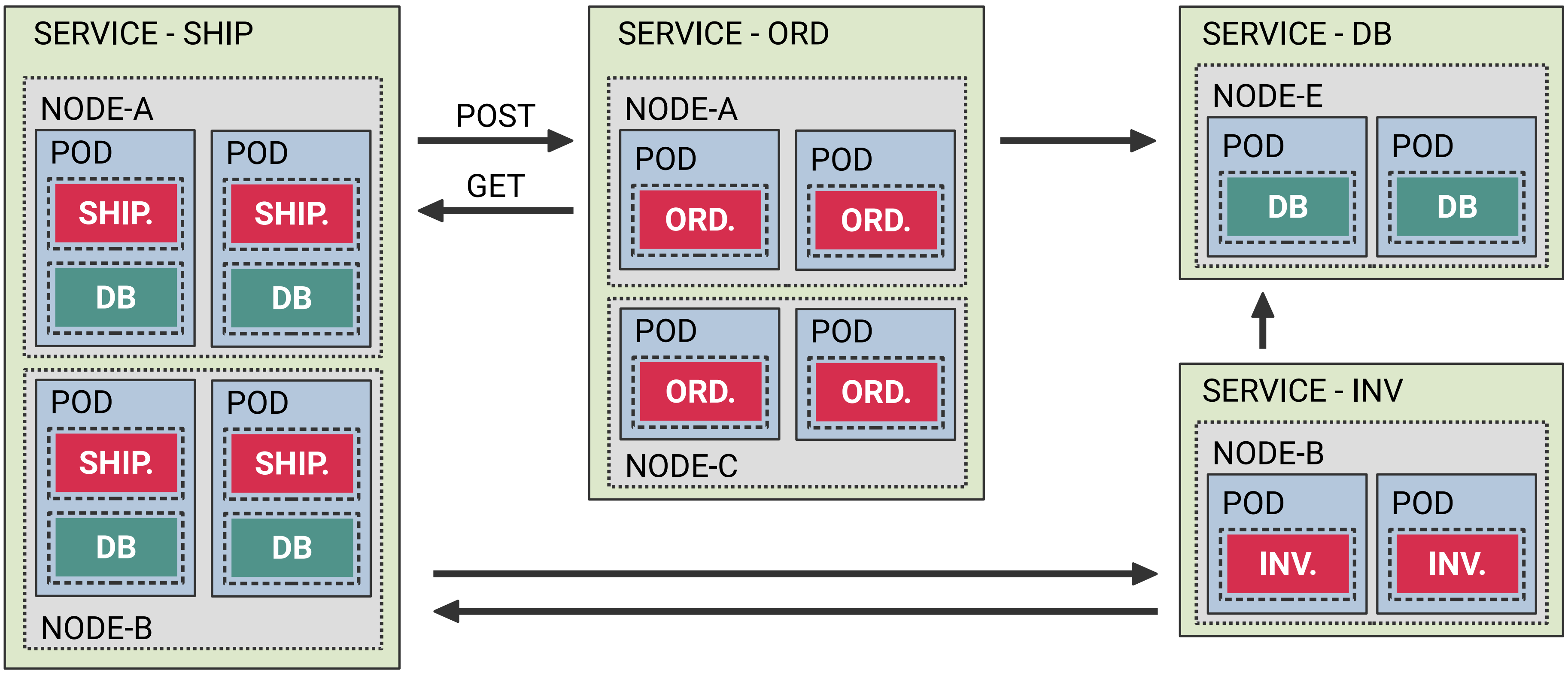

SUMMARY OF OUR JOURNEY

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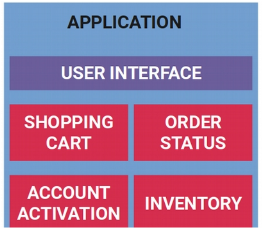

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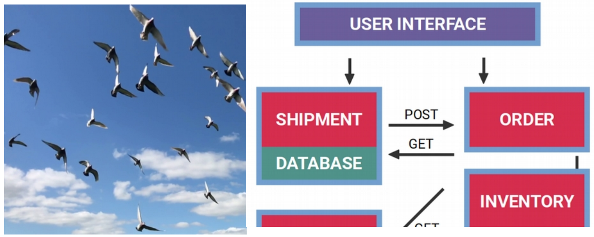

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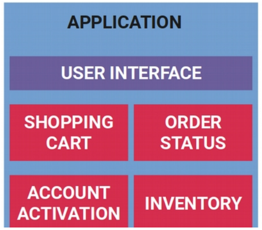

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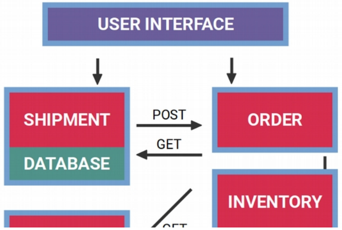
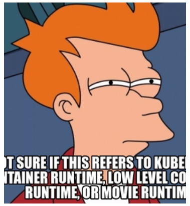
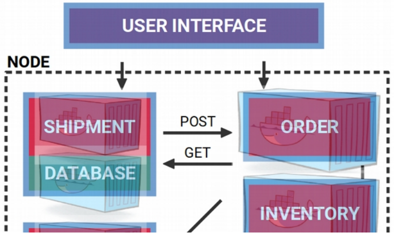


CONTAINER





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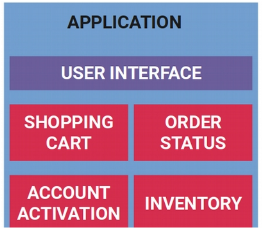

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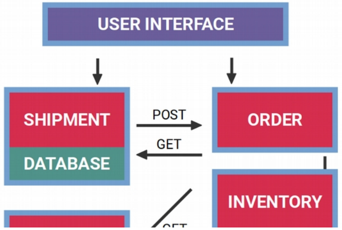

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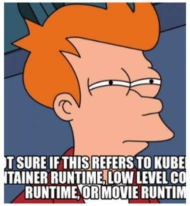
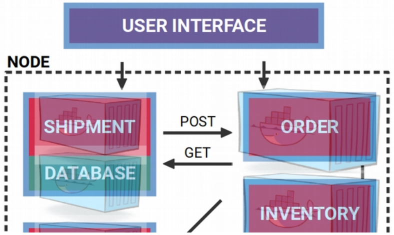
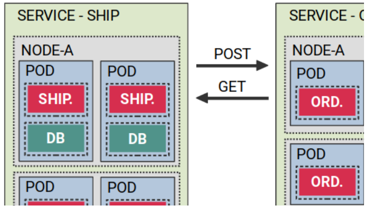




ORCHESTRATION



THE END

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Exercise session

Today @16:00

513-1-024 (CERN)

Wednesday, 6 March 2019

15:30	Coffee
16:00	How container orchestration can strengthen your micro-services: the approach of Kubernetes (exercise 1)
17:00	How container orchestration can strengthen your micro-services: the approach of Kubernetes (exercise 2)

Thank You!

ACKNOWLEDGEMENTS

Many thanks to all those who helped shaping this lecture and exercises!

- iCSC Mentors:
  - Sebastian Lopienski
  - Enric Tejedor Saavedra
- CERN IT Support
  - Ricardo Brito Da Rocha
- Beta tester:
  - Luca Gardi
  - Marco Valente