

Software Maintenance in the Serverless Era: DevOps, Infrastructure Code, and More

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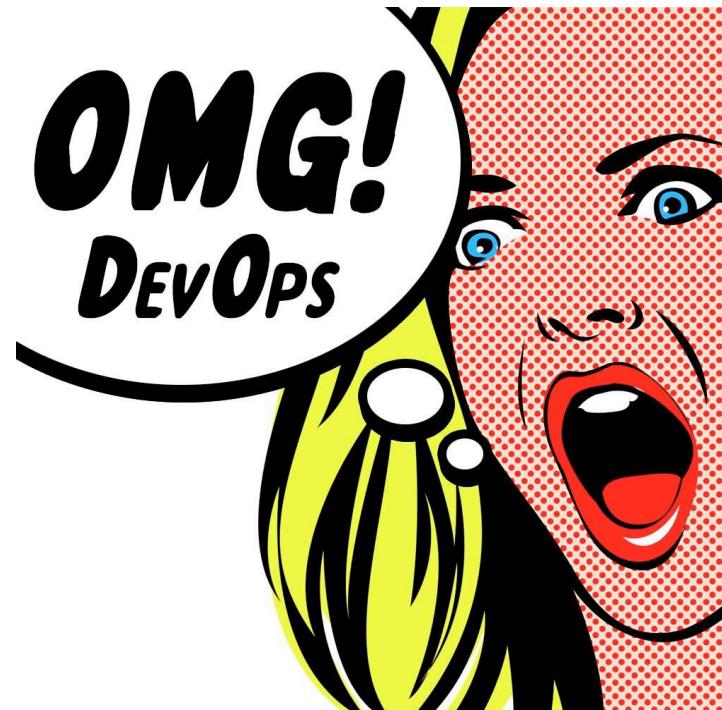
Agenda for Today!

- Some context...
 - DevOps Explained
 - DevOps Tactics in Action: Maintaining Infrastructure-as-Code & TOSCA
 - DevOps Tactics in Action: Maintaining Microservices & Serverless
 - Conclusions & Take-home messages
-

Hot Topic for Today!

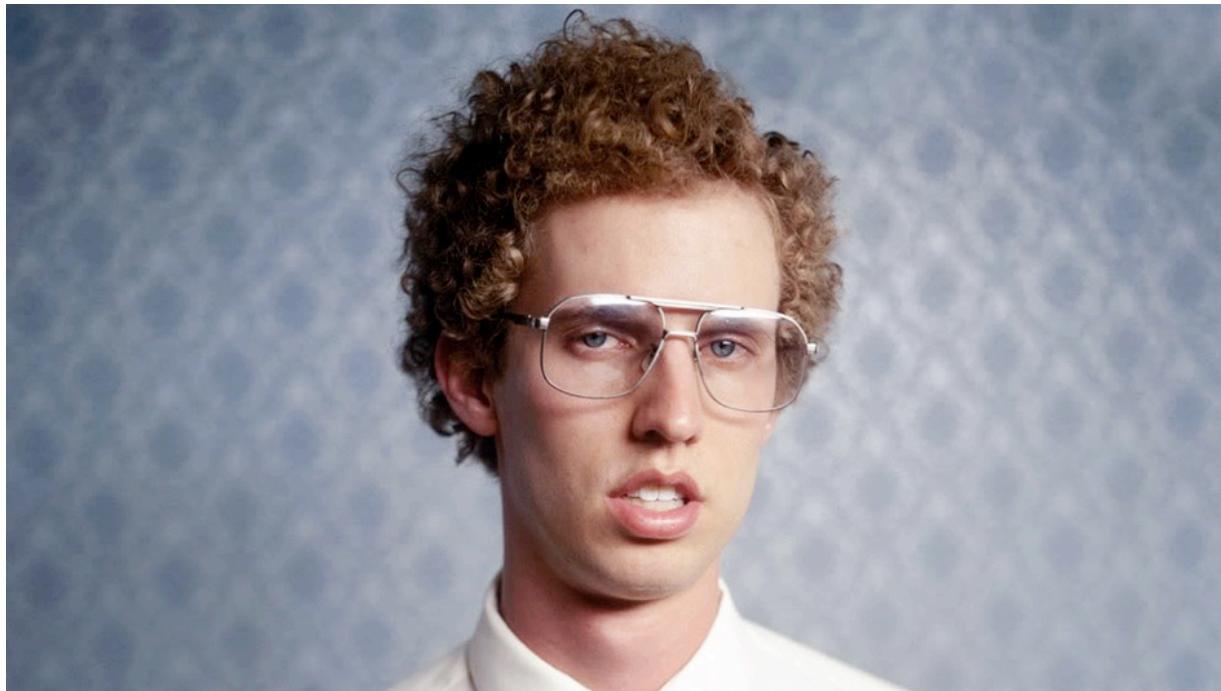
“DevOps is a set of practices intended to reduce the time between committing a change to a system and the change being placed into normal production, while ensuring high quality.”

L. Bass et Al. [11]



Hot Topic for Today!

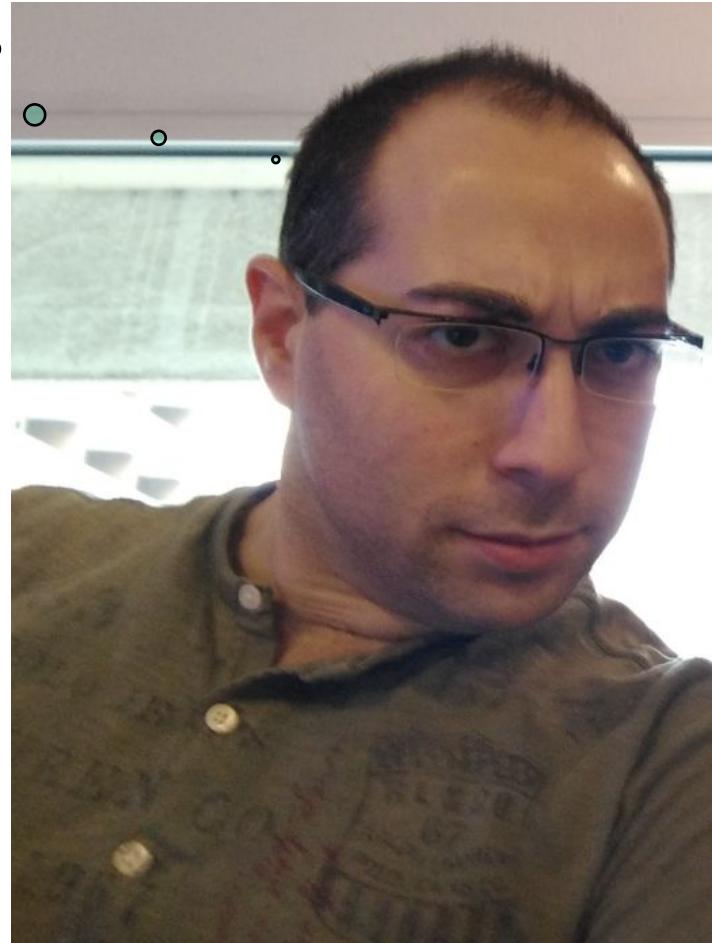
- ▶ “Say What??????”



My Face when I heard of it...

- DevOps?

▶ “Say What??????”



But first... A bit of history!

- Let's take a step back to where it all began...



It's 2013...

- And...
-

It's 2013...

- And...



- And... EU election 2014: Italy's Renzi triumphs as comic Grillo loses ground

New PM scores sweeping victory in election, leaving former comic Beppe Grillo's anti-establishment 5-Star Movement and Silvio Berlusconi's Forza Italia trailing



Top failure causes*

- Unrealistic deadlines, e.g., imposed by someone external to the technical staff
- Requirements & people change (too) often
- Effort and resources have been estimated in an overly optimistic way,
- Risks have not been taken into account from the start of the project.
 - Risks can be technical or human difficulties
 - Communication problems among staff members
 - Difficulty by the management to recognize recurrent delays and take immediate action
 - Subversive stakeholders

- Unrealistic deadlines, e.g., imposed by someone external to the technical staff
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Meanwhile in Software Engineering... Top failure causes* - An Example!

(UNFORESEEN) OVERHEAD COST: 174,000,000 \$ (give or take)*

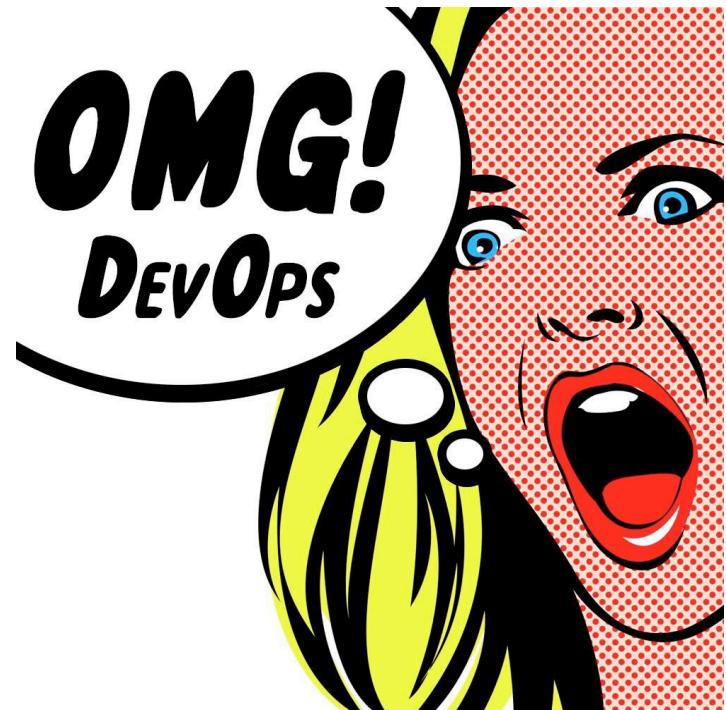


*<http://www.cio.com/article/2380827/developer/6-software-development-lessons-from-healthcare-gov-s-failed-launch.html>

How is DevOps a response?

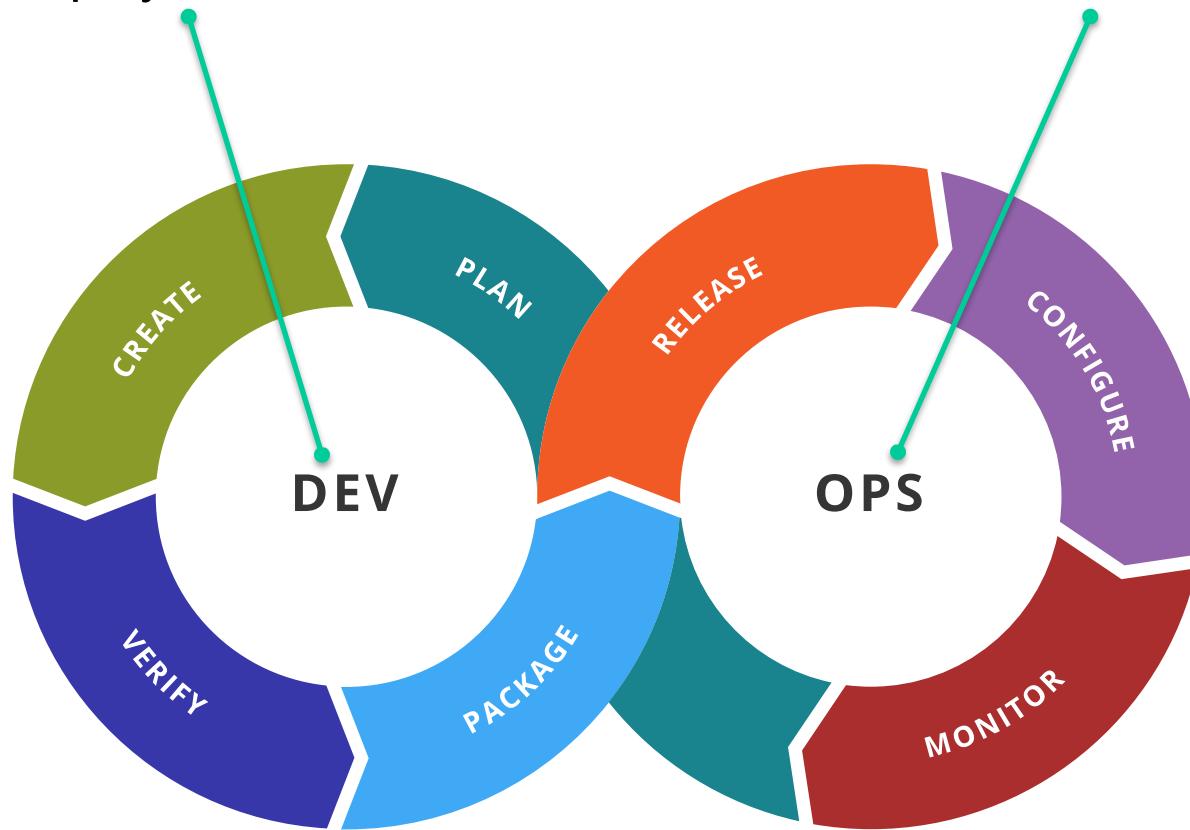
“DevOps is a set of practices intended to reduce the time between committing a change to a system and the change being placed into normal production, while ensuring high quality.”

L. Bass et Al. [11]



What is DevOps?

Dev Goal: “Prepare a Software Architecture designed to be immediately deployable”



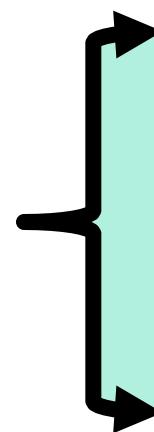
Ops Goal: “Observe the architecture runtime and provide Ops feedback to Dev...*then improve architecture continuously*”

What is DevOps?

“DevOps is a set of practices intended to reduce the time between committing a change to a system and the change being placed into normal production, while ensuring high quality.”

L. Bass et Al. [11]

DevOps Practices



Acceleration

Waste-Reduction

Omniscience

-
- **Acceleration Tactics**
 - ▶ Use Faster Organization: Merge Dev+Ops Teams...
 - ▶ Infrastructure-as-Code
 - ▶ Use Continuous Integration Tools
 - ▶ Use Continuous Deployment Tools
 - ▶ Use Continuous Testing Tools
 - ▶ ...
 - **Waste Reduction Tactics**
 - ▶ Canary Testing
 - ▶ A/B Testing
 - ▶ Reduce Documentation
 - ▶ Minimalistic Architecting → Microservices
 - ▶ ...

- **Omniscience Tactics**
 - ▶ Monitor Everything (what we call *Omniscient DevOps Analytics*)
 - ▶ Monitoring-as-a-service
 - ▶ On-The-Fly Risk Engineering
- ...

DevOps Practices: Let's throw in another one...

- **Omniscience Tactics**
 - ▶ Monitor Everything
 - ▶ Monitoring-as-a-service
 - ▶ On-The-Fly Risk Engineering
 - ▶ **Continuous Architecting**
- ...

- More granular systems continuously deployed:
 - ▶ Maintain the systems

This is a classic... accounting typically for ~70% tot. Cost for software

- More granular systems continuously deployed:
 - ▶ Maintain the systems
 - ▶ Maintain the pipelines around the systems
 - ▶ Concurrency between the above two
- Larger and more diverse organisations:
 - ▶ «Maintain» the people
 - ▶ Measure and Track the organisational structure

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- **Socio-Technical Alignment!**

DevOps Processes & Practices: Digging Further

- Continuous Architecting

Def. “architect for test, build and deploy, take quality attributes into account, take advantage of feedback from runtime” [1]

- Continuous Integration

Def. “merge all developer work-copies to a shared mainline frequently” [4]

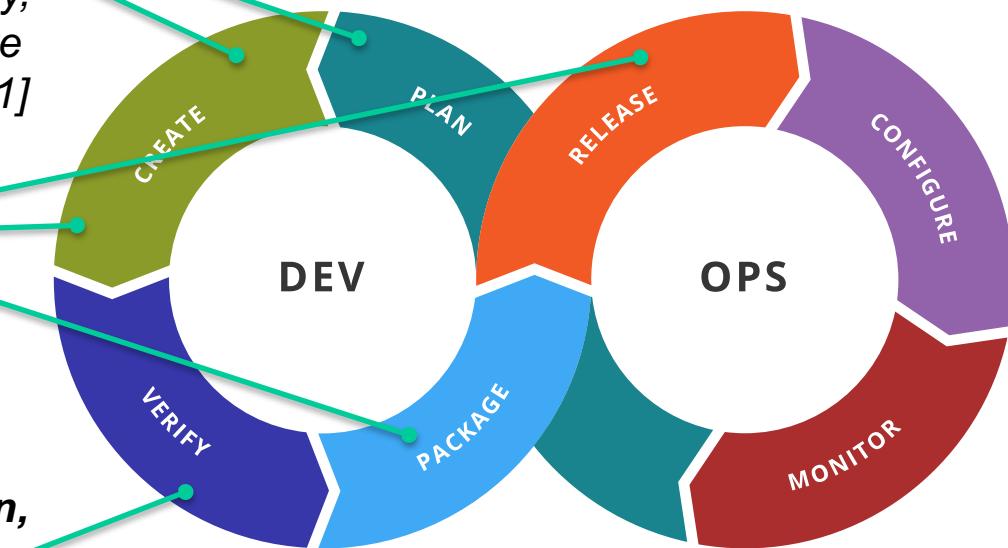
Examples. Apache Jenkins, Hudson, etc.

- Continuous Testing

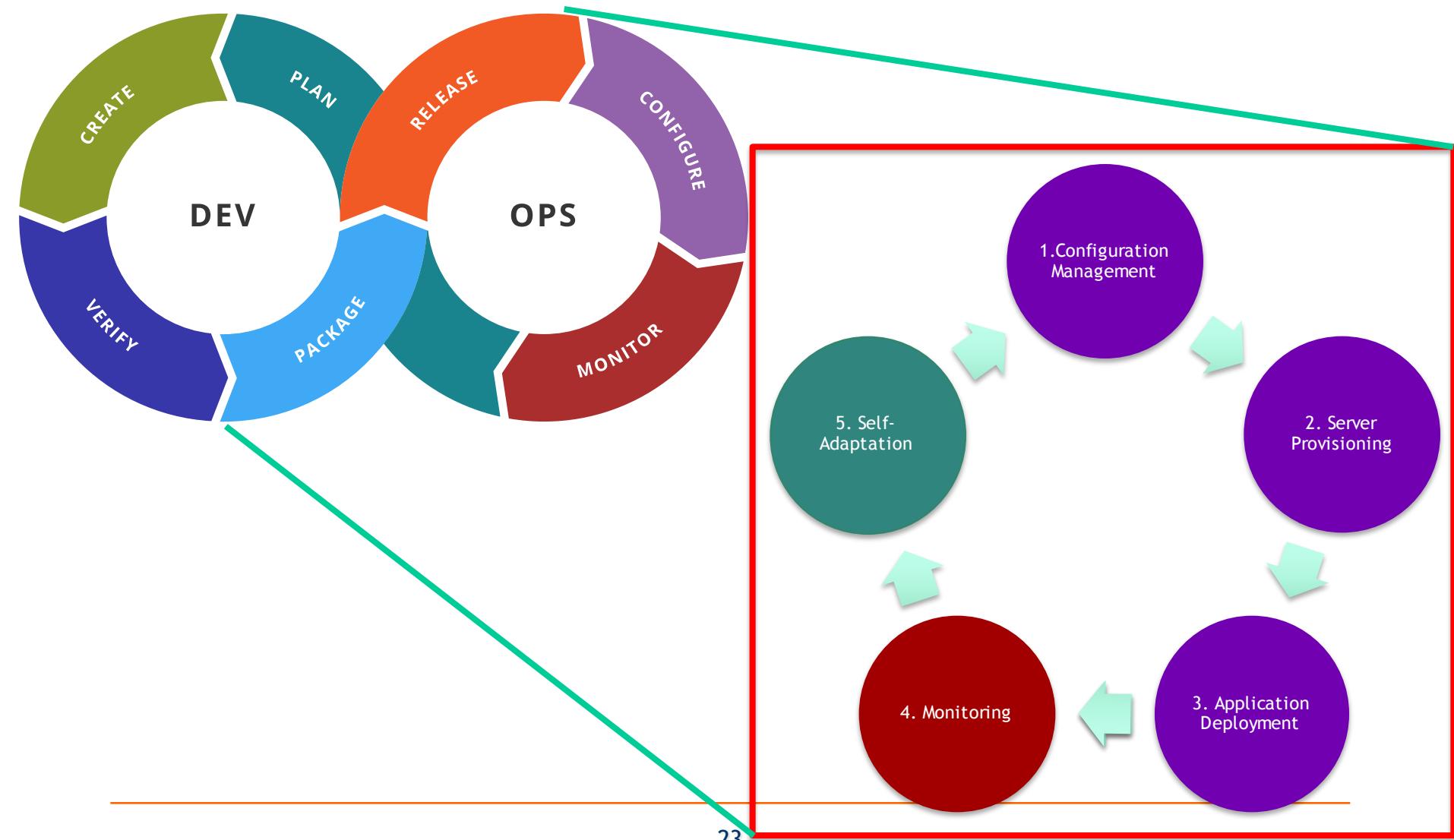
Def. “run tests as part the build pipeline so that every check-in and deployment is validated” [3]

Examples. Selenium+GitHub+LI-API, etc.

...

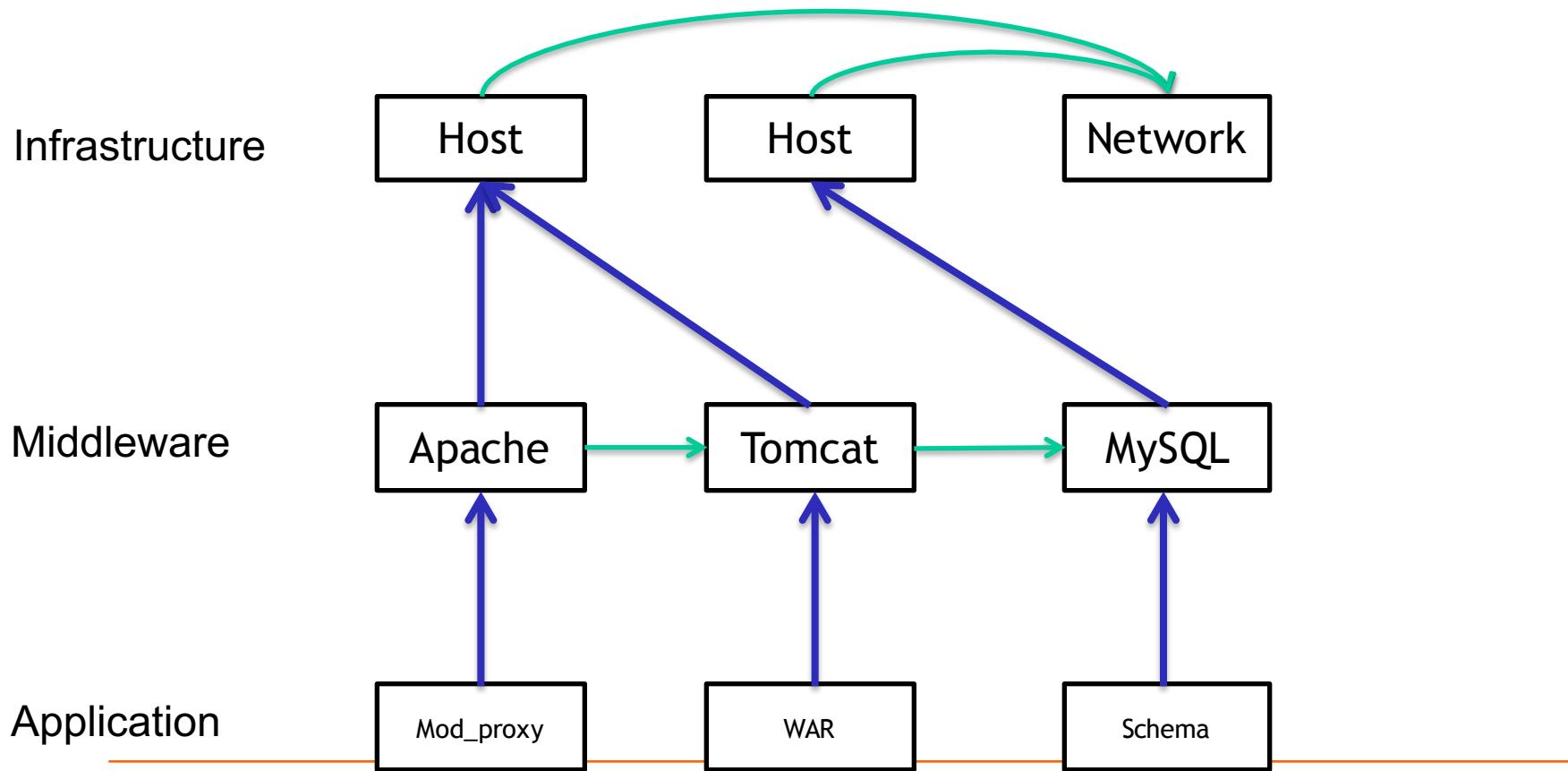


DevOps process and toolchain



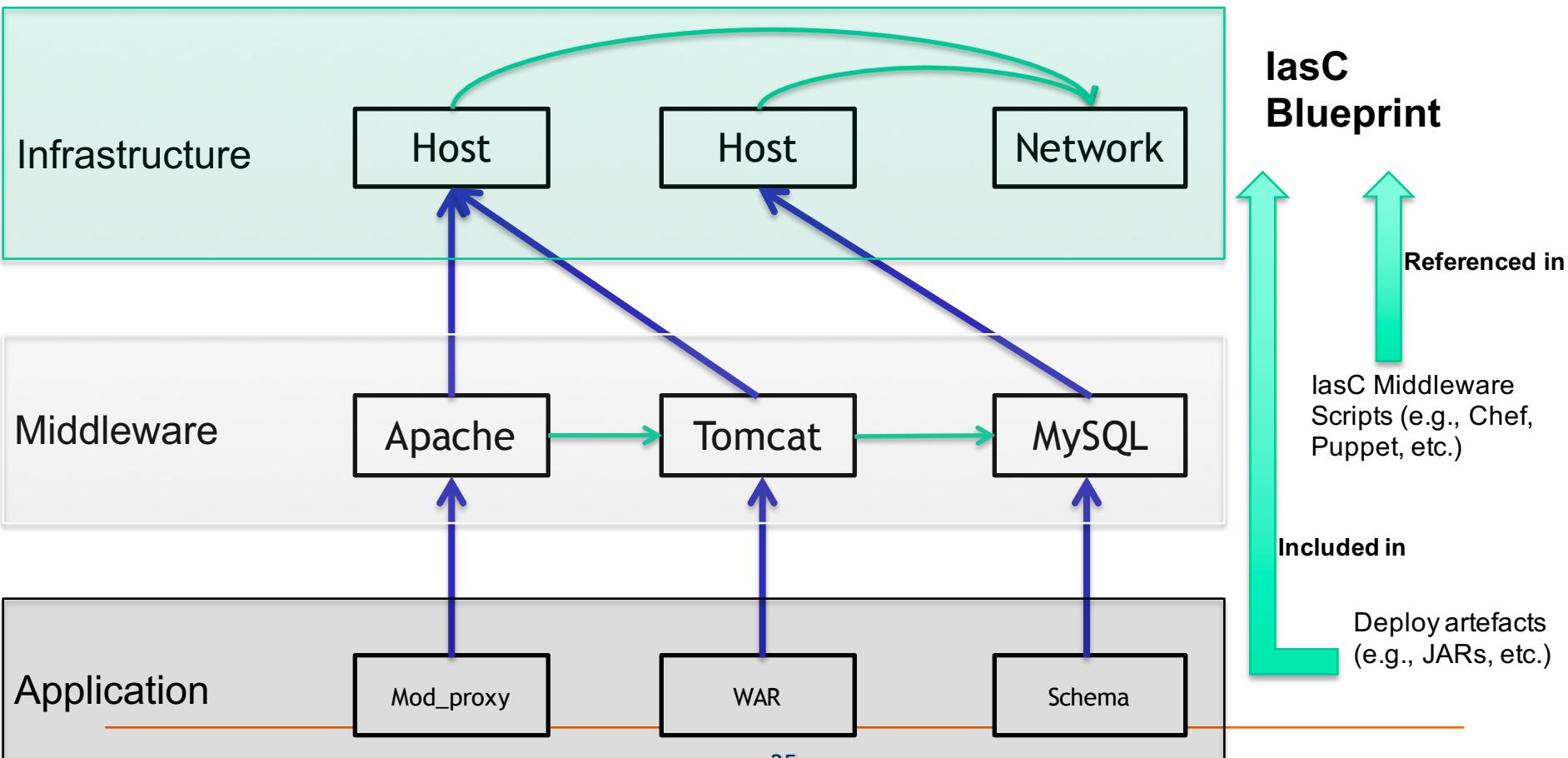
Key DevOps Tactic: Infrastructure Code

- An Application Deployment Topology, i.e., “a graph of physical artefacts that need support for several lifecycle phases (e.g., procurement, installation, configuration, deployment, undeployment, teardown, etc.)” [6]



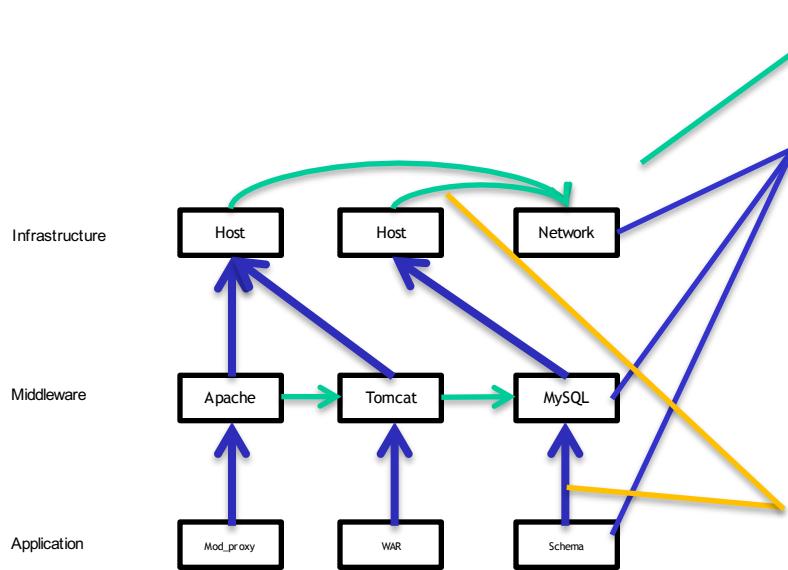
Towards standard Infrastructure Code

- **Infrastructure-as-code**, i.e., “a blueprint detailing physical artefacts, all scripts for all lifecycle phases and all artefacts needed for deployment” [6]



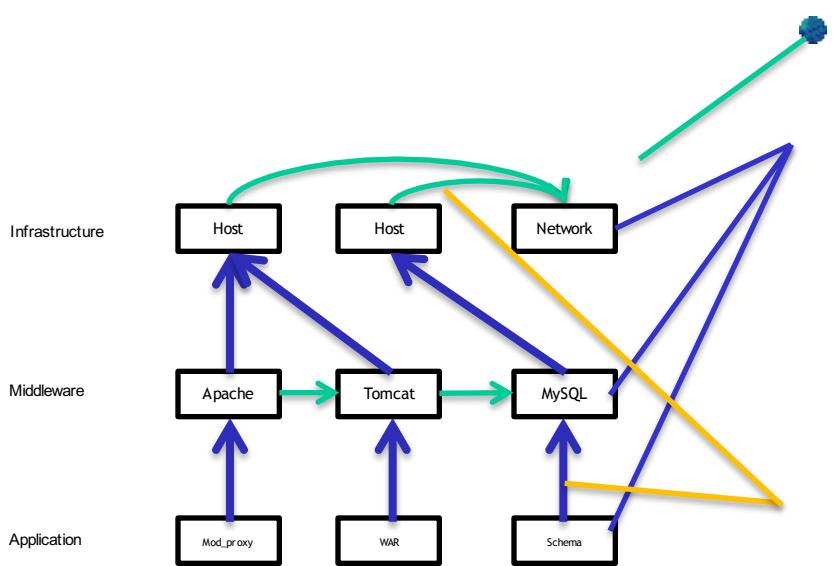
Where Does IaC fit into?

Here's What We've Seen there...



- An application topology
- 3 layers
 - ▶ Infrastructure (Cloud or DC objects)
 - ▶ Platform or Middleware (App containers)
 - ▶ Application modules, schemas and configurations
- Relationships between components:
 - ▶ What's hosted on what or installed on what
 - ▶ What's connected to what

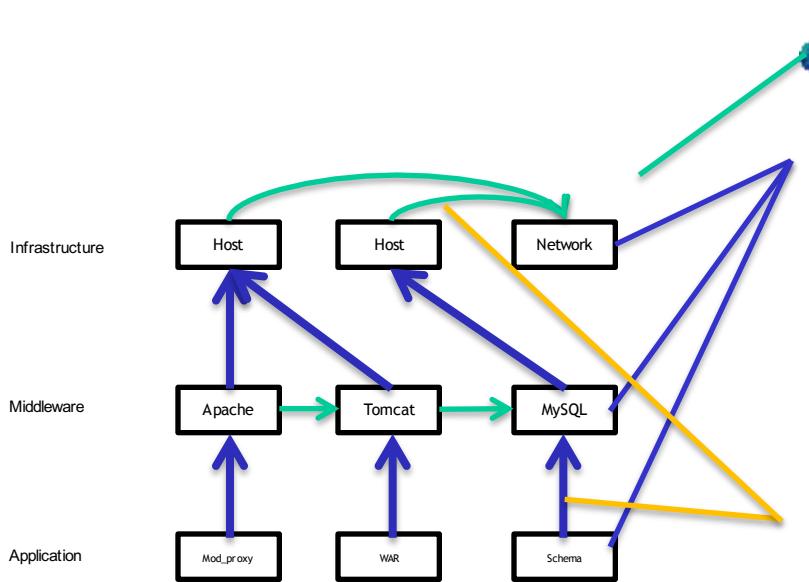
Where Does IaC fit into?



***Many* available formats (70+)*:**

- ▶ Saltstack
- ▶ Kubernetes
- ▶ CloudFormation
- ▶ Cloudify
- ▶ Ubicity
- ▶ xOpera
- ▶ HEAT
- ▶ ...

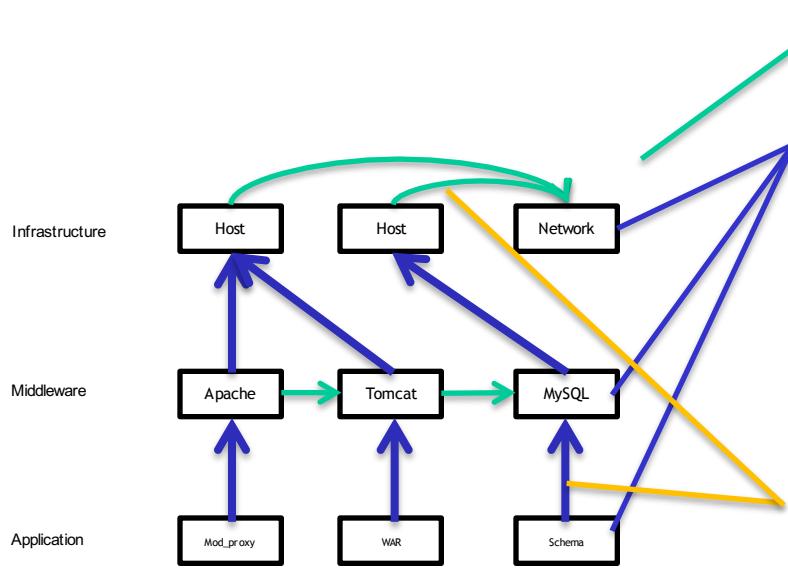
From IaC to TOSCA



TOSCA: “Topology and Orchestration Specification for Cloud Applications”

- Only ONE Standard!

From IaC to TOSCA (cont'd)

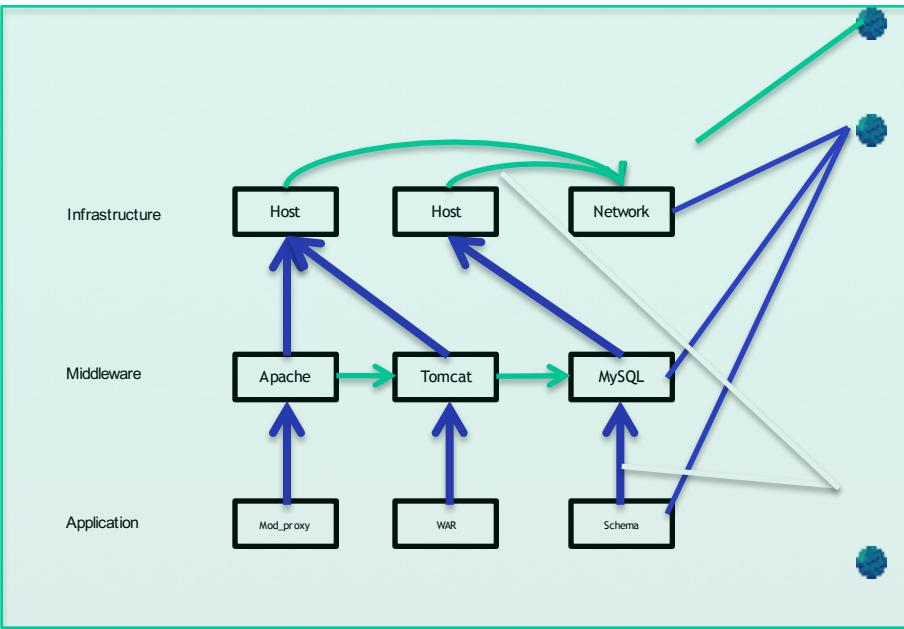


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TOSCA: “Topology and Orchestration Specification for Cloud Applications”

Where Does TOSCA fit into?

A single abstract language for IaC



TOSCA: “Topology and Orchestration Specification for Cloud Applications”

An application topology
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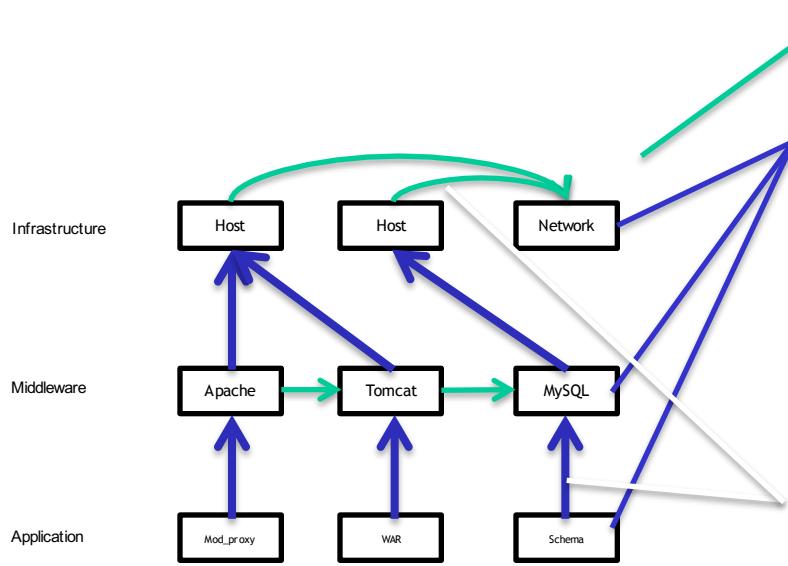
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Where Does TOSCA fit into?

A single abstract language for IaC

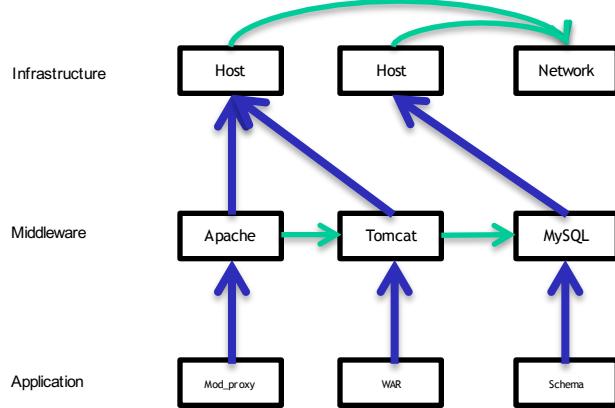


- An application topology
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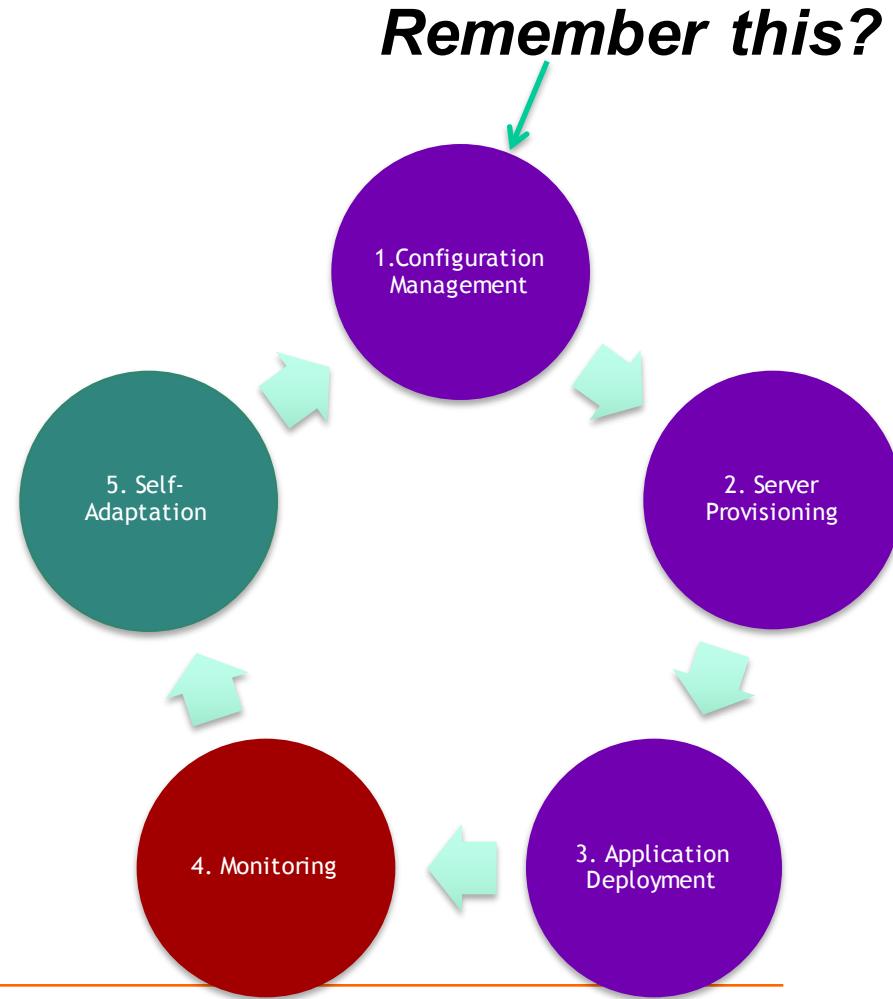
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A single abstract language for IaC

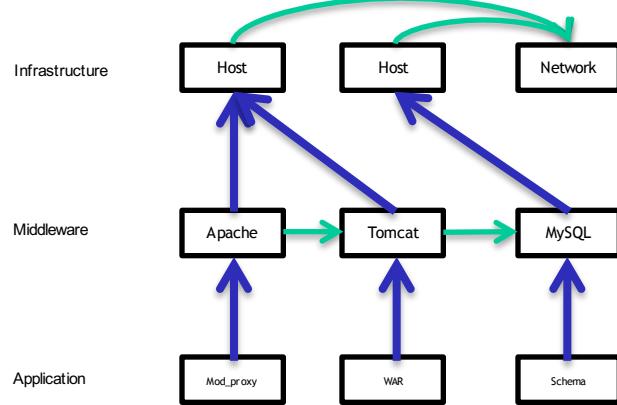


**TOSCA: “Topology and
Orchestration Specification
for Cloud Applications”**

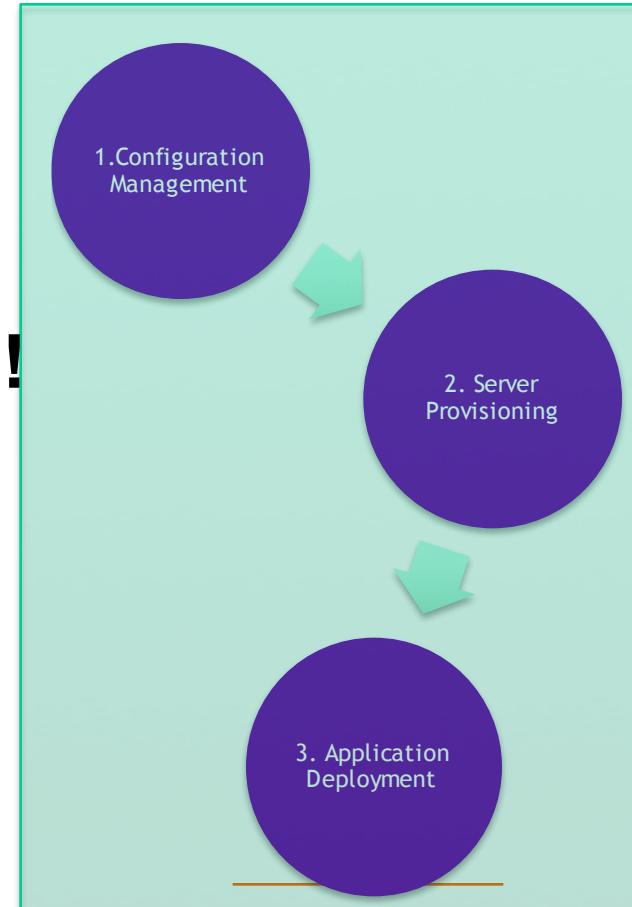


Where Does IaC and TOSCA fit into?

A single abstract language for IaC



Orchestration!



**TOSCA: “Topology and
Orchestration Specification
for Cloud Applications”**

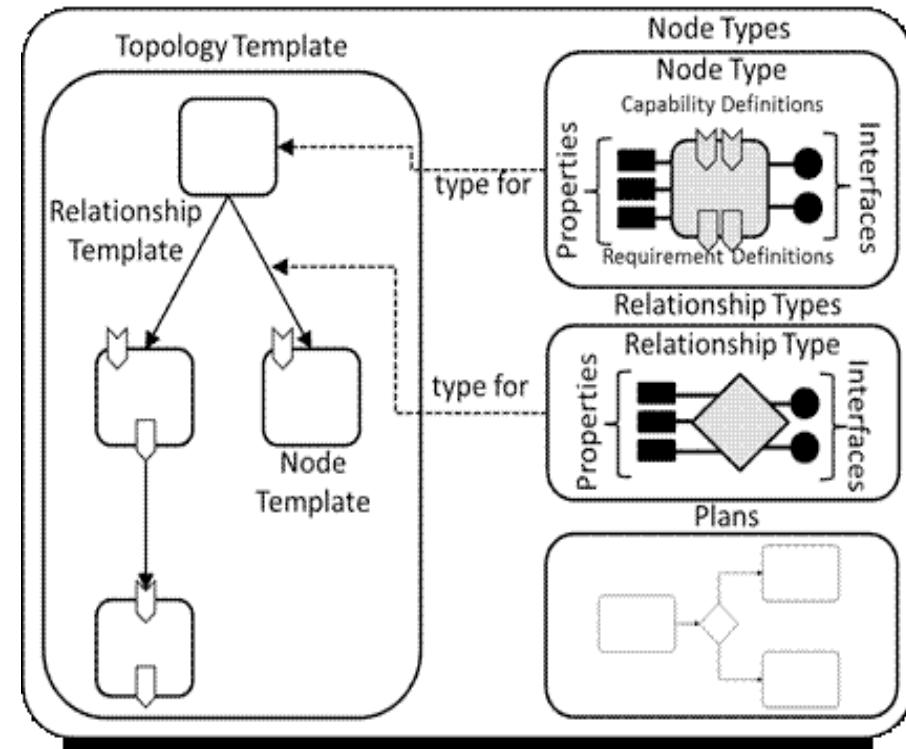
Bored yet?

- 10 min
Break?



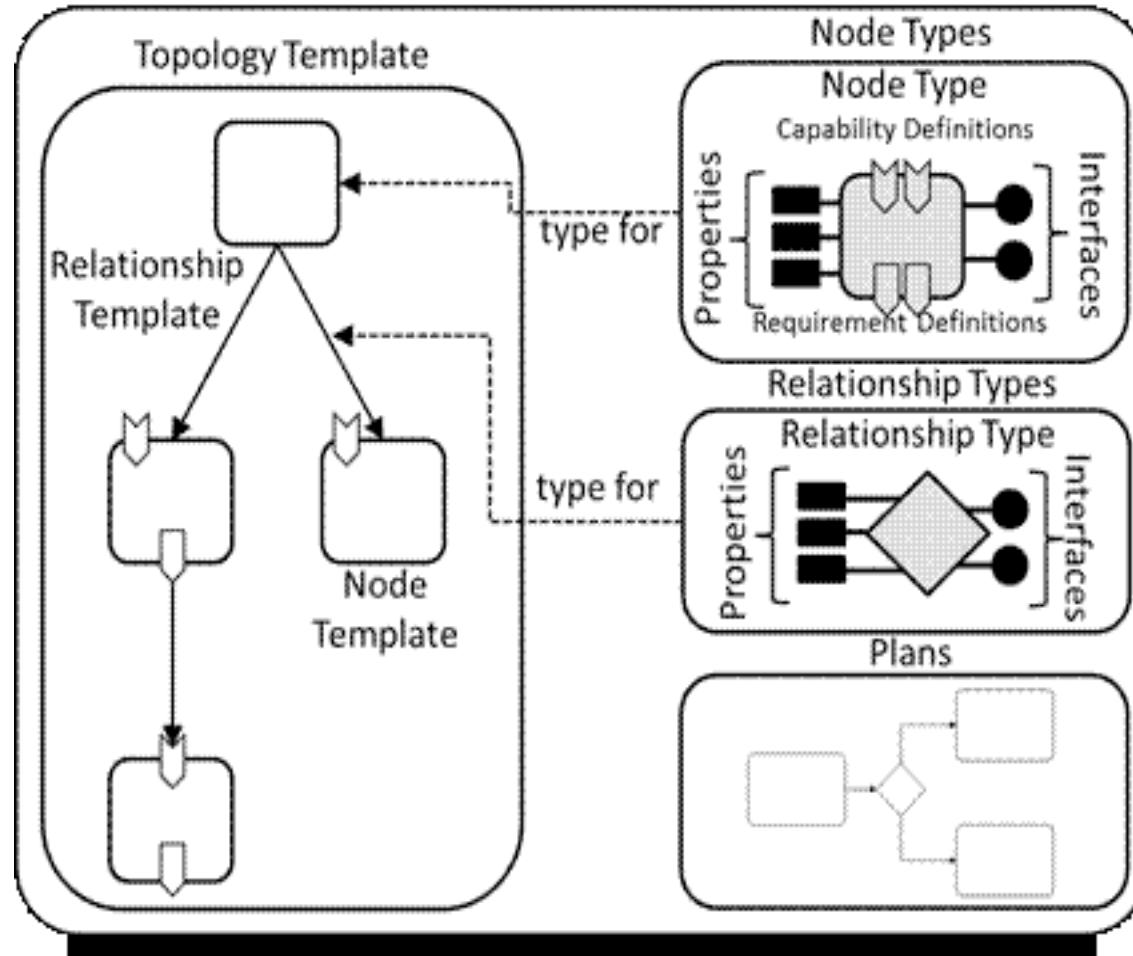
**Coming up next... TOSCA,
IaC Explained!**

What's in a TOSCA Topology?

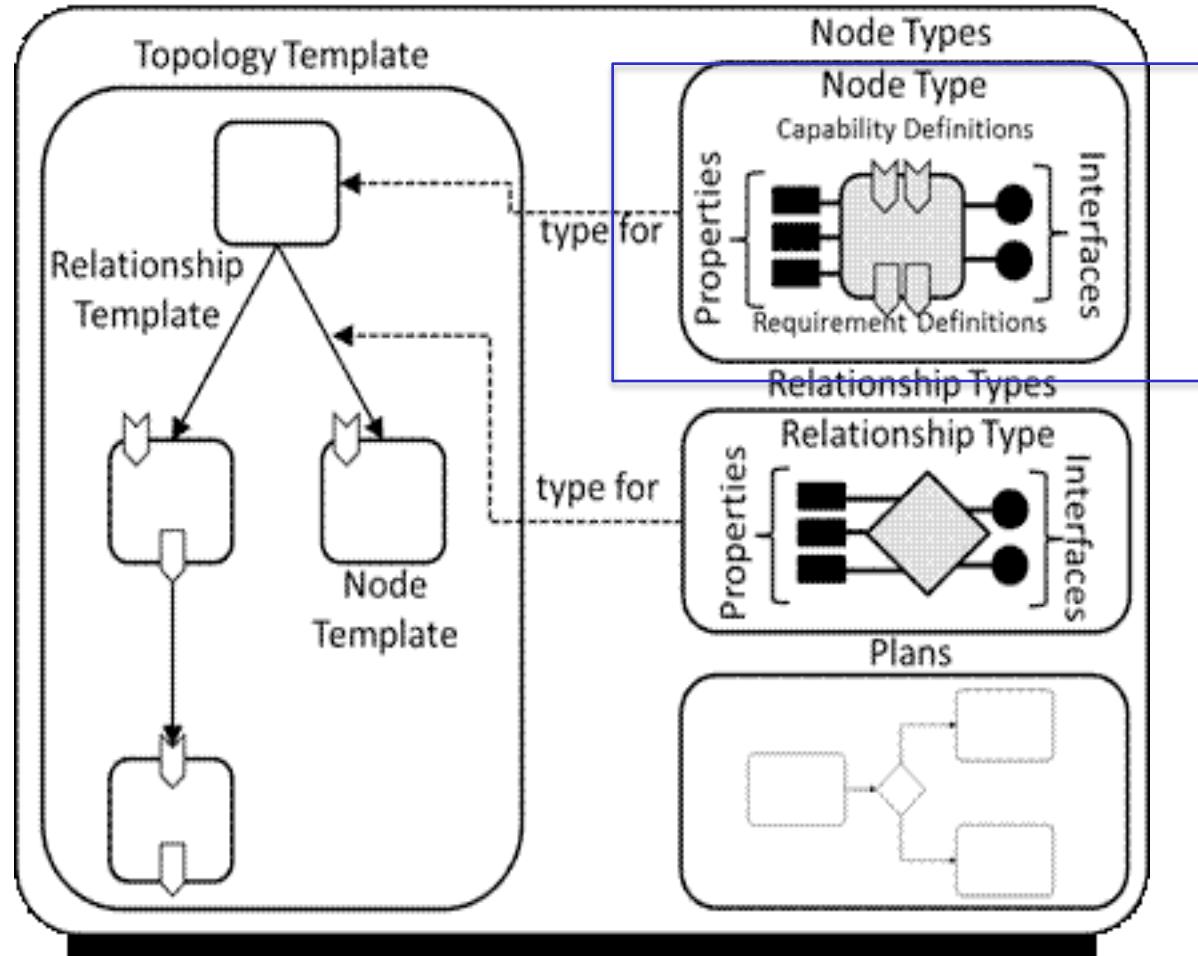


- component in the topology are called **Nodes**
- Each Node has a **Type** (e.g. Host, BD, Web server).
 - ▶ The Type is abstract and hence portable
 - ▶ The Type defines **Properties** and **Interfaces**
- An **Interface** is a set of hooks (named **Operations**)
- Nodes are connected to one another using **Relationships**

TOSCA Service Template [7]



TOSCA Service Template



Node Type

- Describes a Cloud or Software type (e.g. Server or Apache)
- Maps the type to the actual impl. of the lifecycle interface

```
tosca.interfaces.node.Lifecycle:  
  create:  
    description: Basic lifecycle create operation.  
  configure:  
    description: Basic lifecycle configure operation.  
  start:  
    description: Basic lifecycle start operation.  
  stop:  
    description: Basic lifecycle stop operation.  
  delete:  
    description: Basic lifecycle delete operation.
```

Node Type (cont.)

- Defines properties as YAML maps
- Might define capabilities (What it can provide to other nodes)

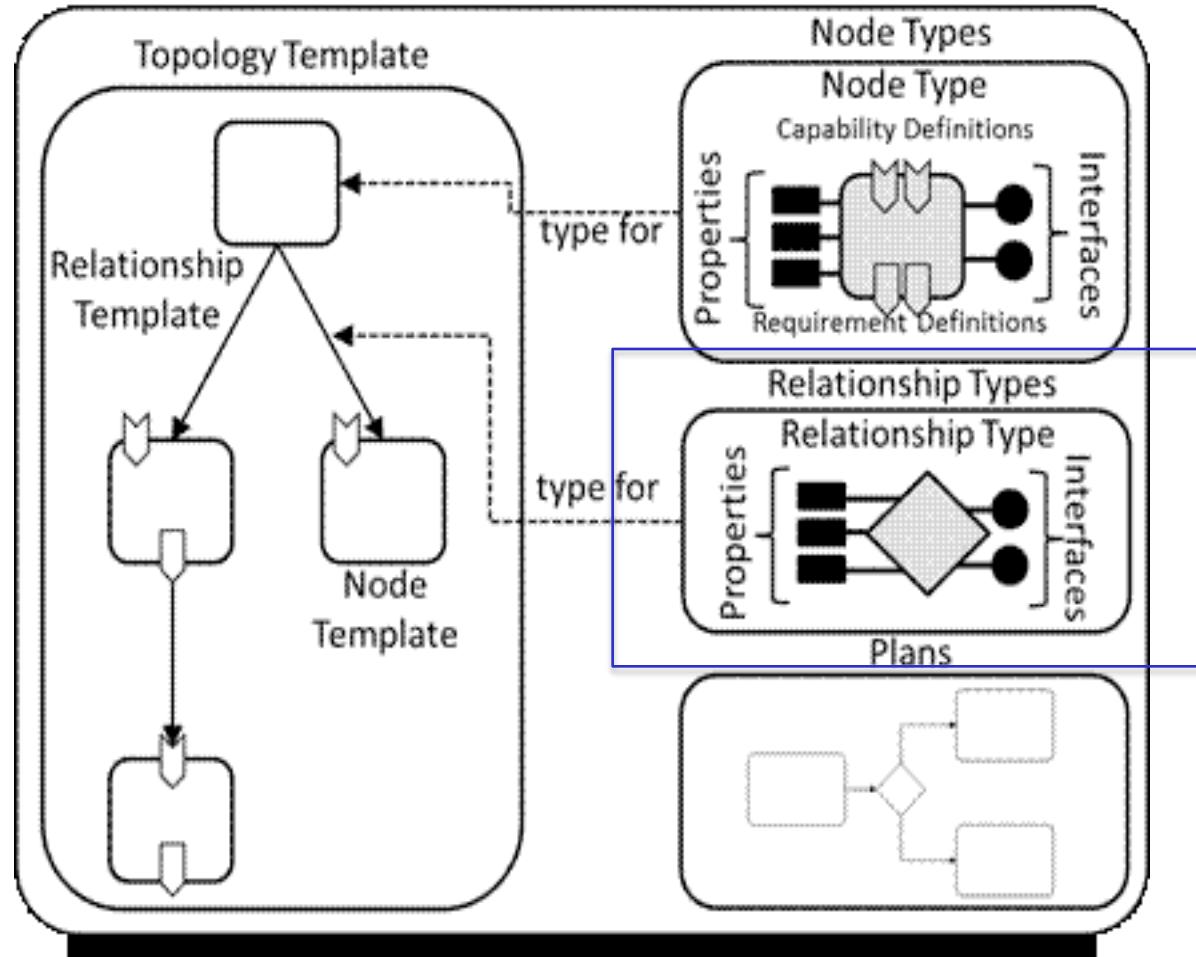
```
tosca.nodes.DBMS
  derived_from: tosca.nodes.SoftwareComponent
  properties:
    dbms_root_password:
      type: string
      description: the root password for the DBMS service
    dbms_port:
      type: integer
      description: the port the DBMS service will listen to for data and requests
  capabilities:
    host:
      type: Container
      containee_types: [ tosca.nodes.Database ]
```

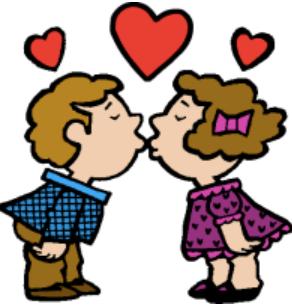
Node Type (cont.)

- Might define requirements (what it needs from other nodes)

```
tosca.nodes.Database:  
  derived_from: tosca.nodes.Root  
  properties:  
    db_user:  
      type: string  
      description: user account name for DB administration  
    db_password:  
      type: string  
      description: the password for the DB user account  
    db_port:  
      type: integer  
      description: the port the underlying database service will listen to data  
    db_name:  
      type: string  
      description: the logical name of the database  
  requirements:  
    - host: tosca.nodes.DBMS  
  capabilities:  
    - database_endpoint: tosca.capabilities.DatabaseEndpoint
```

TOSCA Service Template





Relationship Type

- Requirements and Capabilities are an implicit way to describe relationships
 - Usually you need the explicit way
 - ▶ You need hooks to configure the source or target node or both
 - So relationships have types and interfaces as well
-

- The basic relationship types are:
 - ▶ **dependsOn** - abstract type and its sub types:
 - ▶ **hostedOn** - a node is contained within another
 - ▶ **connectsTo** - a node has a connection configured to another
- The basic interface is `configure`
 - ▶ `preconfigure_source`, `preconfigure_target`
 - ▶ `postconfigure_source`, `postconfigure_target`
 - ▶ `add_target`, `remove_target`

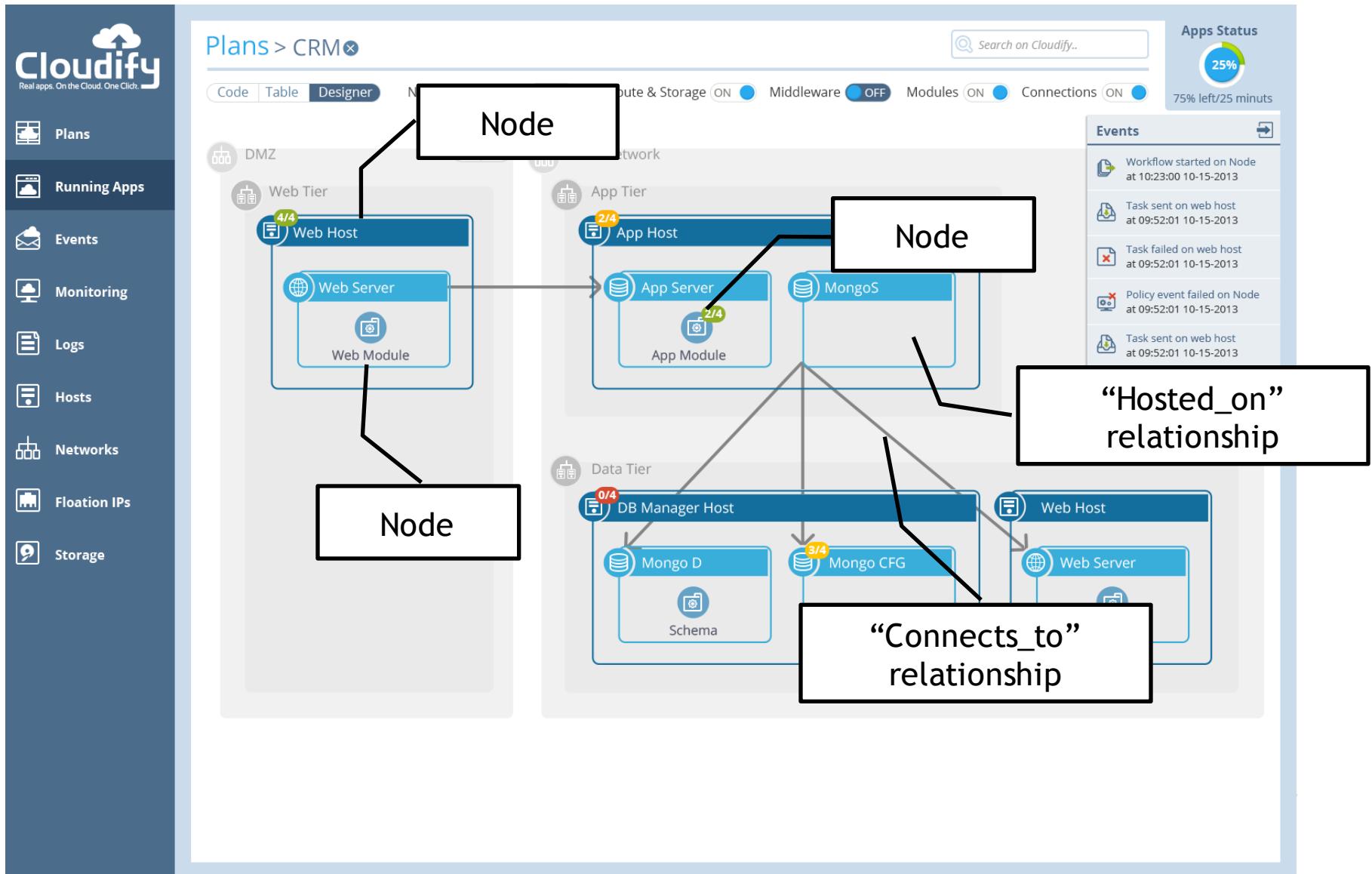
-
- An instance of a type (like Object to Class)
 - Has specific properties
 - Has artifacts:
 - ▶ What to install
 - ▶ How to install (mapped to interface hooks)
 - Has requirements and capabilities (or relationships)

Node Template (Examples)

```
node_templates:  
    wordpress:  
        type: tosca.nodes.WebApplication.WordPress  
        properties:  
            # omitted here for sake of brevity  
        requirements:  
            - host: apache  
            - database: wordpress_db  
        interfaces:  
            tosca.interfaces.relationships.Configure:  
                pre_configure_source: scripts/wp_db_configure.sh
```

```
node_templates:  
    wordpress:  
        type: tosca.nodes.WebApplication.WordPress  
        properties:  
            # omitted here for sake of brevity  
        requirements:  
            - host: apache  
            - database: wordpress_db  
                relationship_type: my.types.WordpressDbConnection
```

Translated to TOSCA



- Imperative flow algorithm
 - Using a workflow engine
 - Timing the invocation of operations on different node
 - Examples? Any BPMN specification!
 - *But... Considered out of scope for the standard (but currently debated, two factions formed in the TOSCA TC)*
-

- Brings monitoring to the orchestration as input
 - Ongoing evaluation of Rules
 - Enforce SLA, Health, and anything else
 - Can invoke more processes
 - **Standard Structure:** <Event><Condition><Action>
 - **Standard Types:**
 - ▶ Access-Control;
 - ▶ Placement;
 - ▶ QoS (Quality) or (Continuity) CoS;
 - **Example?**
-

TOSCA Policy Example

Event Type

```
<event_type_name>:  
  derived_from: <parent_event_type>  
  version: <version_number>  
  description: <policy_description>
```

Event
name of a normative TOSCA Event Type

Condition
described as a constraint of an attribute of the node (or capability) identified by the filter.

Action
Describes either:
a)a well-known strategy
b)an implementation artifact (e.g., scripts, service) to invoke
with optional property definitions as inputs (to either choice)

Policy Definition

```
<policy_name>:  
  type: <policy_type_name>  
  description: <policy_description>  
  properties: <property_definitions>  
  # allowed targets for policy association  
  targets: [ <list_of_valid_target_templates> ]  *  
  triggers:  
    <trigger_symbolic_name_1>:  
      event: <event_type_name>  
      # TODO: Allow a TOSCA node filter here  
      # required node (resource) to monitor  
      target_filter:  
        node: <node_template_name> <node_type>  
        # Used to reference another node related to  
        # the node above via a relationship  
        requirement: <requirement_name>  
        # optional capability within node to monitor  
        capability: <capability_name>  
        # required clause that compares an attribute  
        # with the identified node or capability  
        # for some condition  
        condition: <constraint_clause>  
      action:  
        # a) Define new TOSCA normative strategies  
        # per-policy type and use here OR  
        # b) allow domain-specific names  
        <operation_name>: # (no lifecycle)  
          # TBD: Do we care about validation of types?  
          # If so, we should use a TOSCA Lifecycle type  
        description: <optional_description>  
        inputs: <list of property_assignments>  
        implementation: <script> | <service_name>  
    <trigger_symbolic_name_2>:  
    ...  
    <trigger_symbolic_name_n>:
```

TOSCA Policy Example – Entities that compose Policy

(Event, Condition, Action) model

Event Type

```
<event_type_name>:  
  derived_from: <parent_event_type>  
  version: <version_number>  
  description: <policy_description>
```

Event
name of a normative
TOSCA Event Type

Condition
described as a
constraint of an
attribute of the
node (or capability)
identified by the
filter.

Action
Describes either:
a)a well-known
strategy
b)an implementation
artifact (e.g.,
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invoke

*with optional property
definitions as inputs
(to either choice)*

```
<policy_name>:  
  type: <policy_type_name>  
  description: <policy_description>  
  properties: <property_definitions>  
  # allowed targets for policy association  
  targets: [ <list_of_valid_target_templates> ] *  
  triggers:  
    <trigger_symbolic_name_1>:  
      event: <event_type_name>  
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          # If so, we should use a TOSCA Lifecycle type  
          description: <optional_description>  
          inputs: <list of property_assignments>  
          implementation: <script> | <service_name>  
    <trigger_symbolic_name_2>:  
    ...  
    <trigger_symbolic_name_n>:
```

Example Senlin “scaling_out_policy_ceilometer.yaml”

using the Kubernetes “redis” example

TOSCA Policy

Symbolic name for the trigger (could be used to reference an externalized version; however, this would violate a Policy’s integrity as a “Security document”)

Describe NODE to attach an alarm | alert | event to

i.e., Using the “node”, “req”, “cap” and “condition” keys would be expressed as a descriptive “filter”

List optional input parms. here

```
my_scaling_policy:  
  type: tosca.policies.scaling  
  properties: # normative TOSCA properties for scaling  
    min_instances: 1  
    max_instances: 10  
    default_instances: 3  
    increment: 1  
  # target the policy at the “Pod”  
  targets: [redis-master-pod]  
  triggers:  
    resize_compute: # symbolic name  
      event: tosca.events.resource.utilization  
    target_filter:  
      node: master-container  
      requirement: host  
      capability: Container  
      condition: utilization greater_than 80%  
    action:  
      # map to SENLIN::ACTION::RESIZE  
      scaleup: # logical operation name  
        inputs: # optional inputs parameters  
          number: 1  
        strategy: BEST_EFFORT  
        Implementation: <script> | <service_name>
```

Target is a Kubernetes Pod of the tosca.groups.placement type

TOSCA normative event type (name) that would map to domain-specific names (e.g., OpenStack Ceilometer)

Find the attribute via the topology:
a) Navigate to node (directly or via the requirement name) and optionally the Capability name
b) The condition to map & register with the target monitoring service (e.g., Ceilometer)

TODO:
Need a % data type for TOSCA

Note: we combined the Senlin “Action” of SENLIN::ACTION::RESIZE with the strategy: BEST_EFFORT to have one name

*more info online

Putting it All Together

```
tosca_definitions_version: tosca_simple_yaml_1_0_0

description: >
    This TOSCA simple profile deploys nodejs, mongodb, elasticsearch, logstash and
    kibana each on a separate server
    with monitoring enabled for nodejs server where a sample nodejs application is
    running. The syslog and collectd are
    installed on a nodejs server.

imports:
- tosca_base_type_definition.yaml
- paypalpizzastore_nodejs_app.yaml
- elasticsearch.yaml
- logstash.yaml
- kibana.yaml
- collectd.yaml
- rsyslog.yaml

dsl_definitions:
host_capabilities: &host_capabilities
    # container properties (flavor)
    disk_size: 10 GB
    num_cpus: { get_input: my_cpus }
    mem_size: 4096 MB
os_capabilities: &os_capabilities
    architecture: x86_64
    type: Linux
    distribution: Ubuntu
    version: 14.04

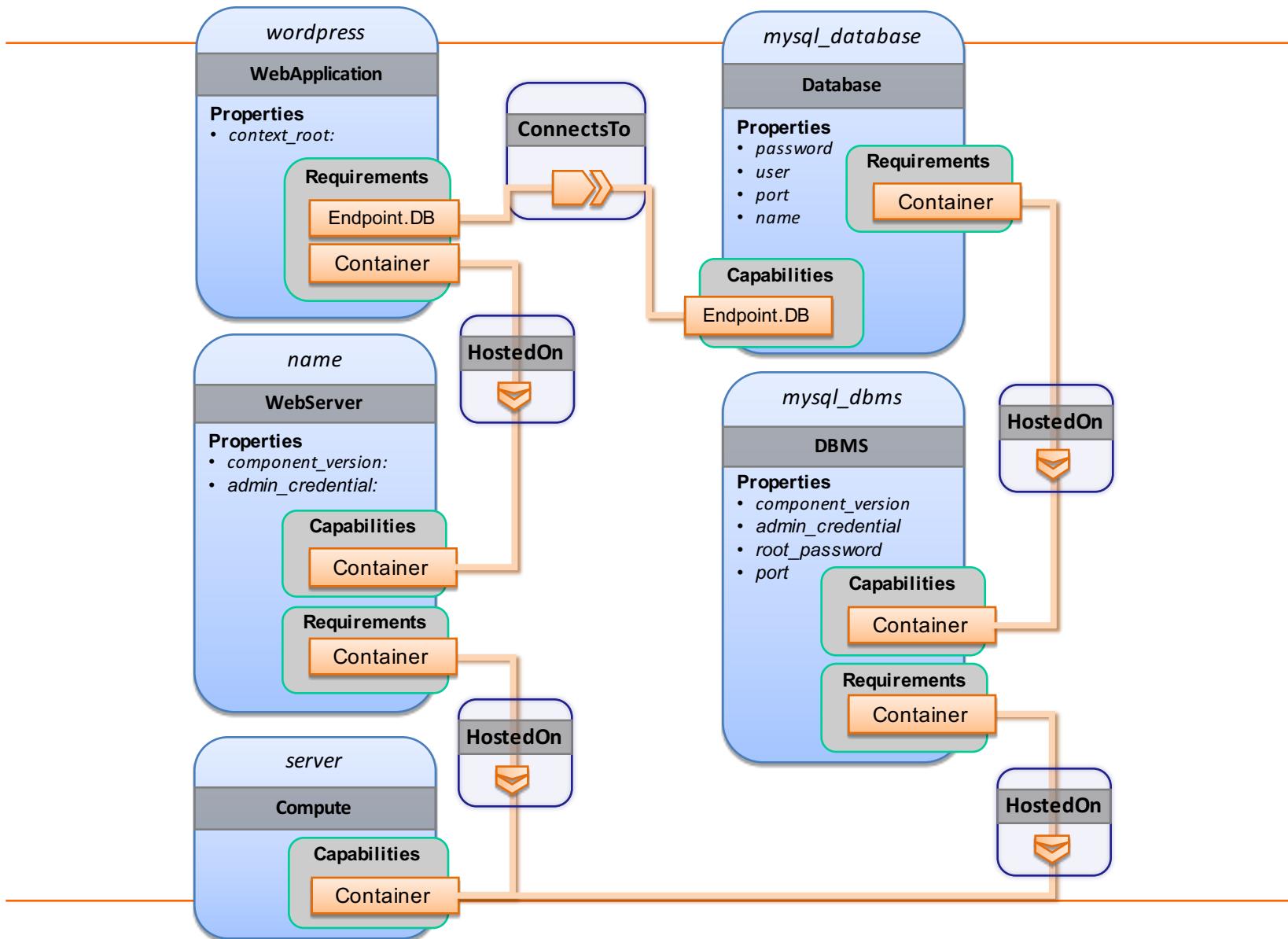
topology_template:
inputs:
my_cpus:
    type: integer
    description: Number of CPUs for the server.
constraints:
- valid_values: [ 1, 2, 4, 8]
...
```

• TOSCA Template contains:

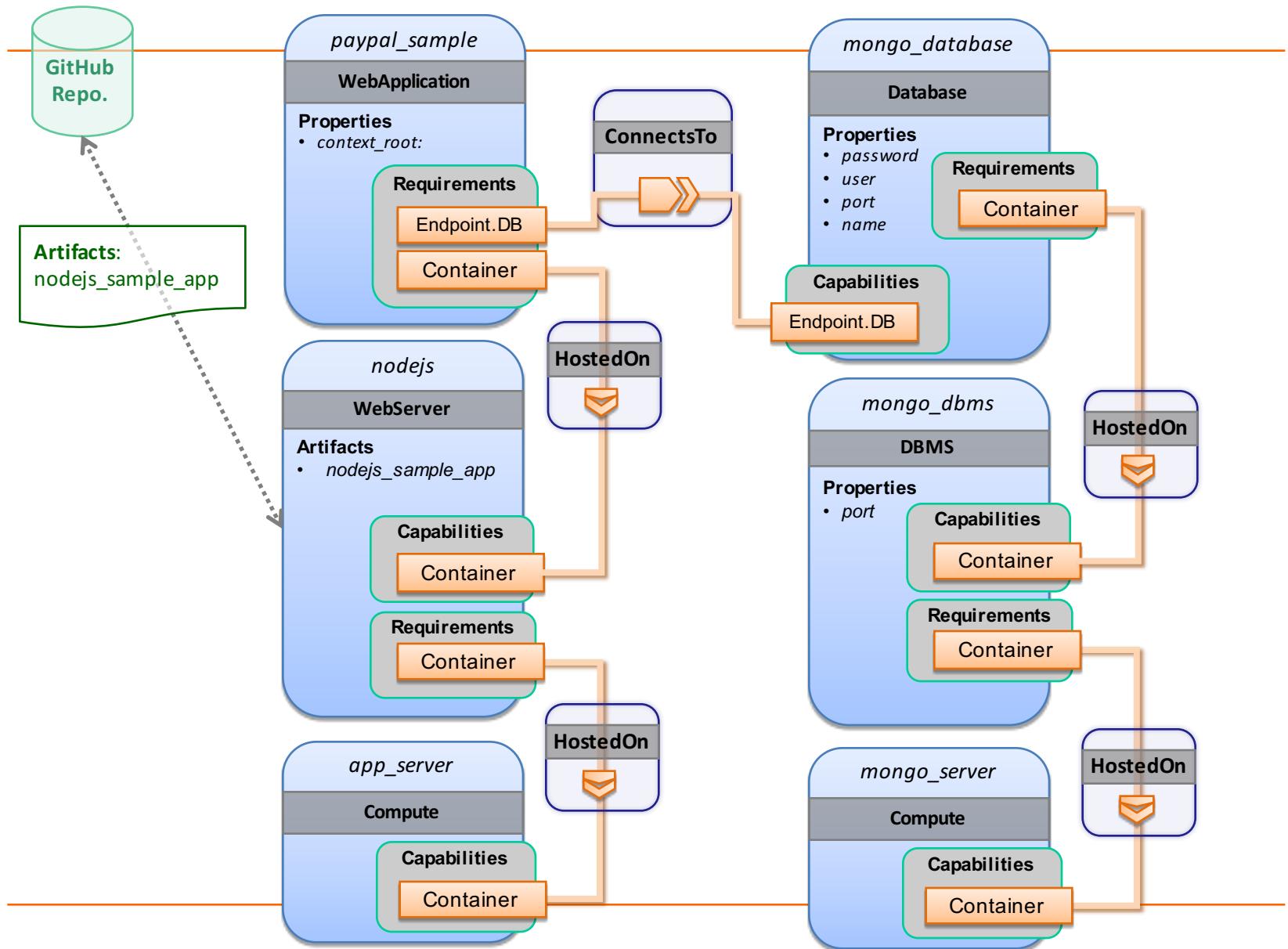
- ▶ Application Topology
 - Nodes
 - Interfaces
 - Properties
 - Artifacts (Plugins in Cloudify)
 - Relationships
 - Interfaces
- ▶ Workflows
- ▶ Policies

-
- WordPress+MySQL
 - NodeJS App+MongoDB

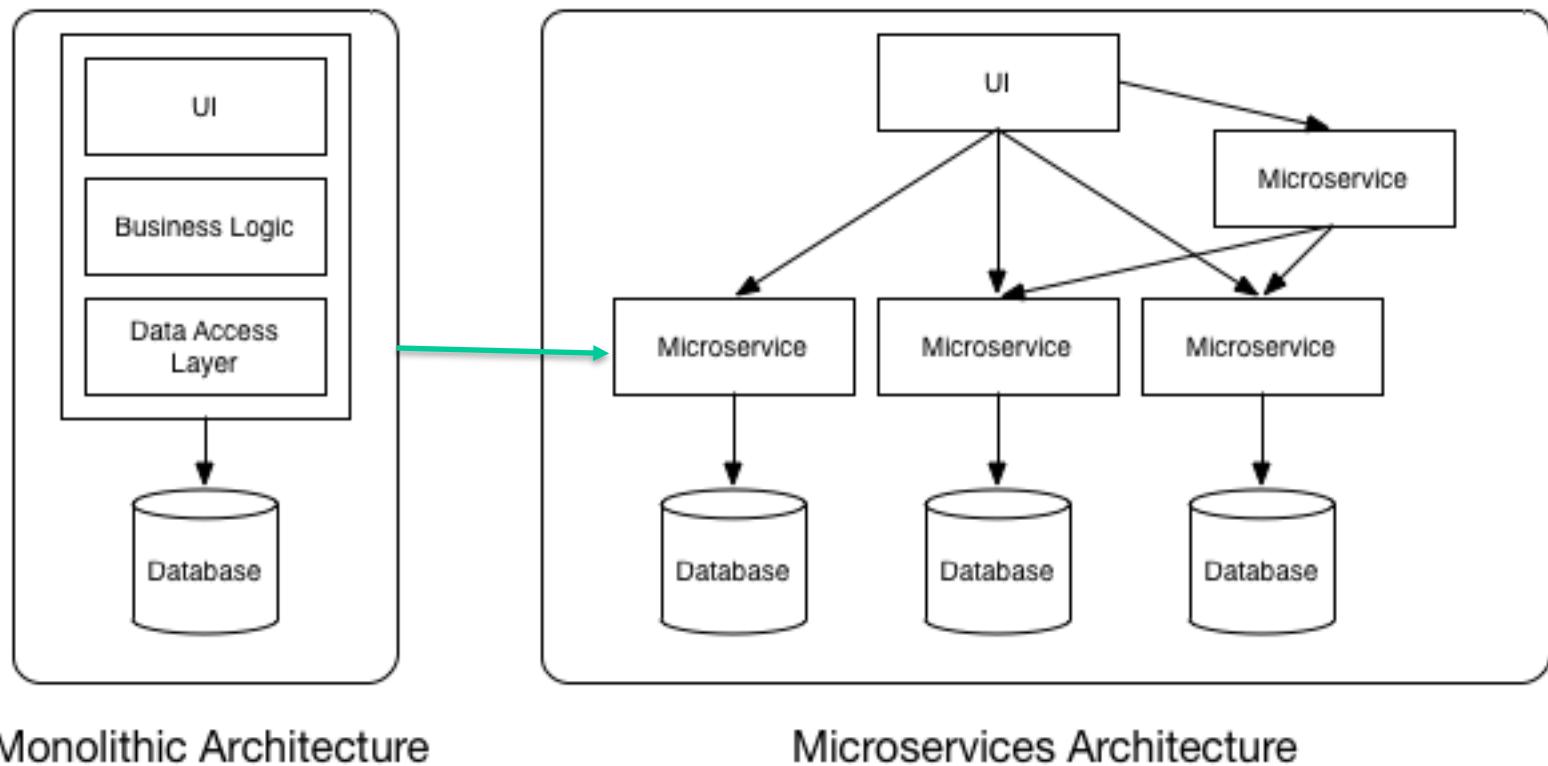
WebServer-DBMS-1: WordPress - MySQL



WebServer-DBMS-3: Nodejs - MongoDB



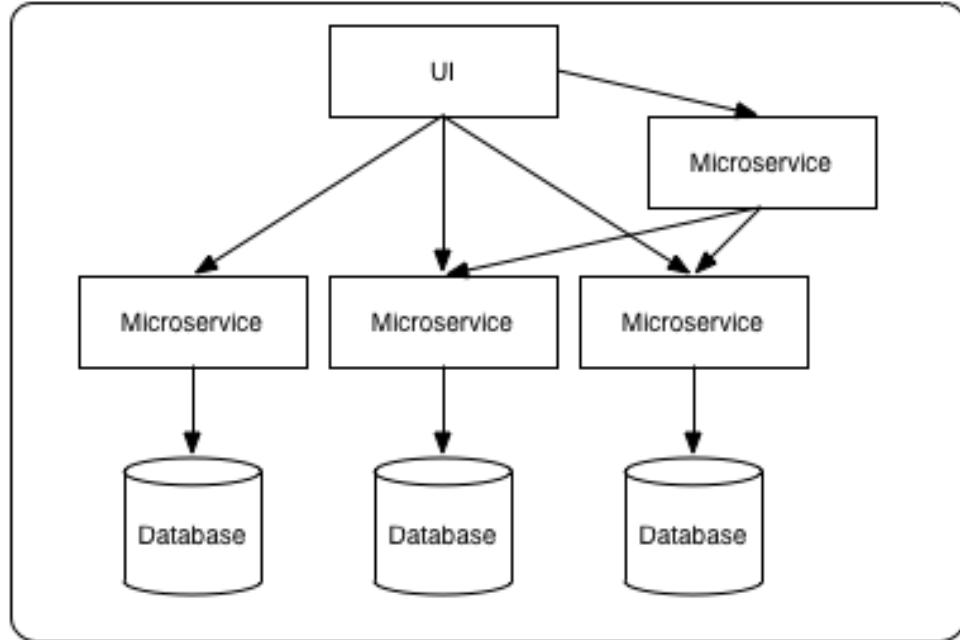
IaC in action: Continuous Architecting & Microservices



Microservices

Architecture Principles:

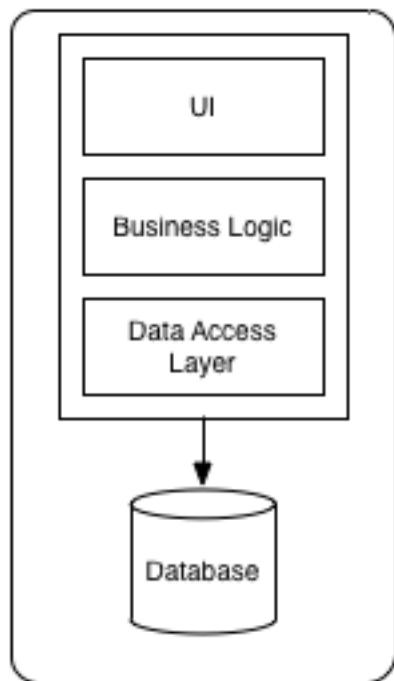
- Statelessness
- Available in multiple copies
- No data sharing among peers
- Each microservice its own DB
- Data-Intensive Message Brokering
 - Message queues



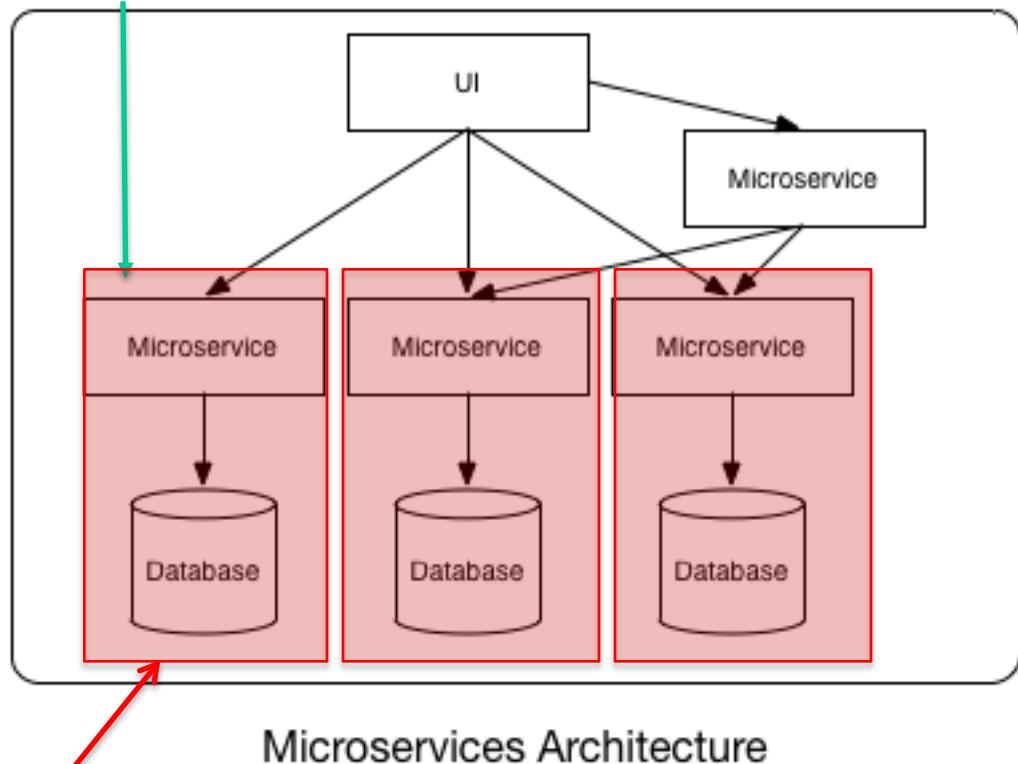
Microservices Architecture

Why Micro-?

Stateless
Available in multiple
No data sharing among microservices
Each microservice uses a specific database



Monolithic Architecture



Microservices Architecture

Container!

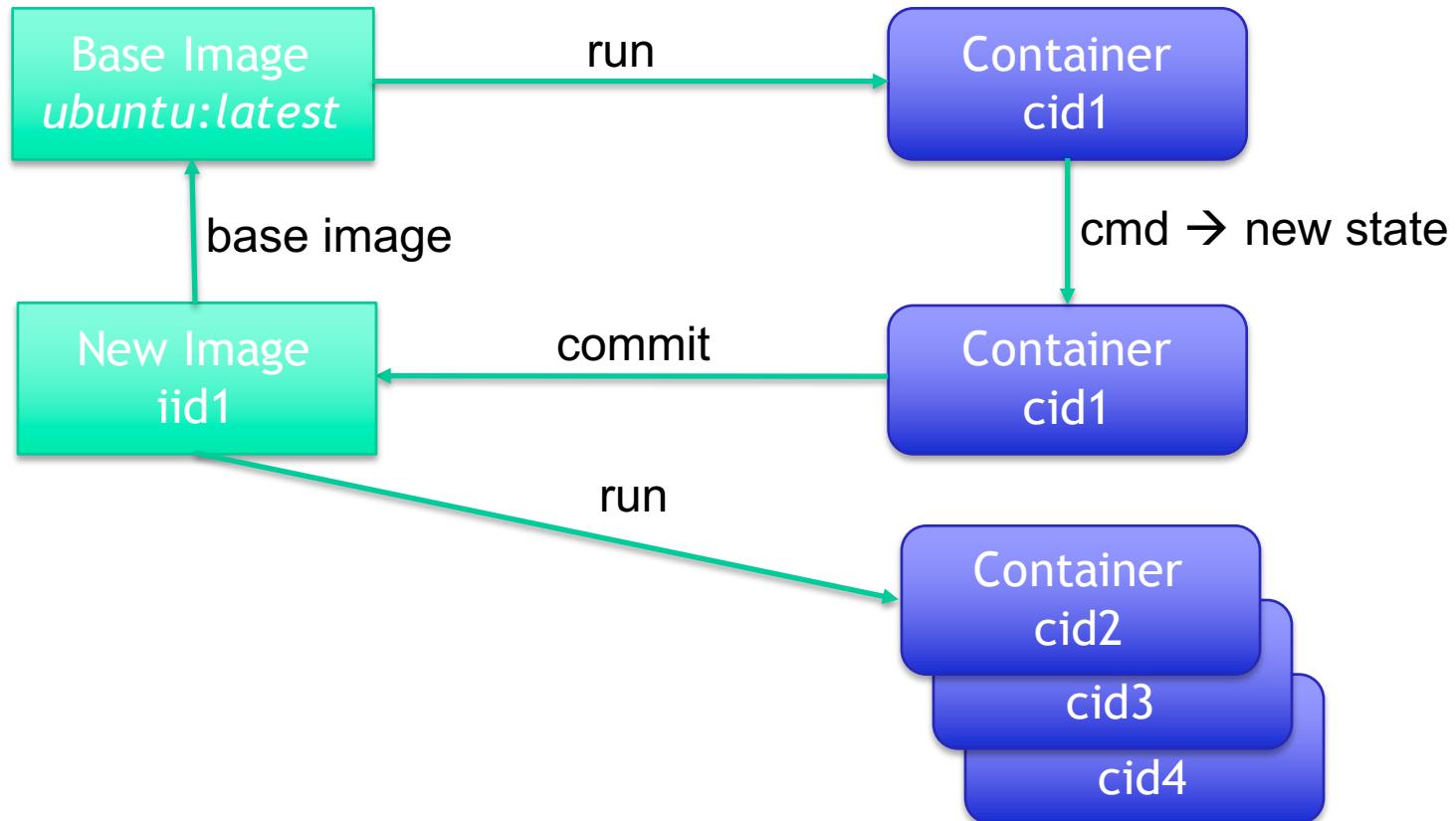
-
- Maintain IaC
 - Maintain containerization tech
 - Maintain infrastructure back-end (if owned) or go serverless!

-
- Terms & Definitions
 - Examples & Use-cases

- Persisted snapshot that can be run
 - ▶ *images*: List all local images
 - ▶ *run*: Create a container from an image and execute a command in it
 - ▶ *tag*: Tag an image
 - ▶ *pull*: Download image from repository
 - ▶ *rmi*: Delete a local image
 - This will also remove intermediate images if no longer used

- Runnable instance of an image
 - ▶ *ps*: List all running containers
 - ▶ *ps -a*: List all containers (incl. stopped)
 - ▶ *top*: Display processes of a container
 - ▶ *start*: Start a stopped container
 - ▶ *stop*: Stop a running container
 - ▶ *pause*: Pause all processes within a container
 - ▶ *rm*: Delete a container
 - ▶ *commit*: Create an image from a container

Image vs. Container JADS

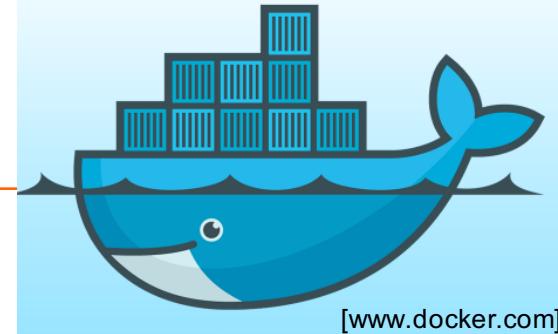


Example: Docker

Docker is an open-source project that automates the deployment of applications inside software containers, by providing an additional layer of abstraction and automation of operating system-level virtualization on Linux.

[Source: en.wikipedia.org]

Docker: Name



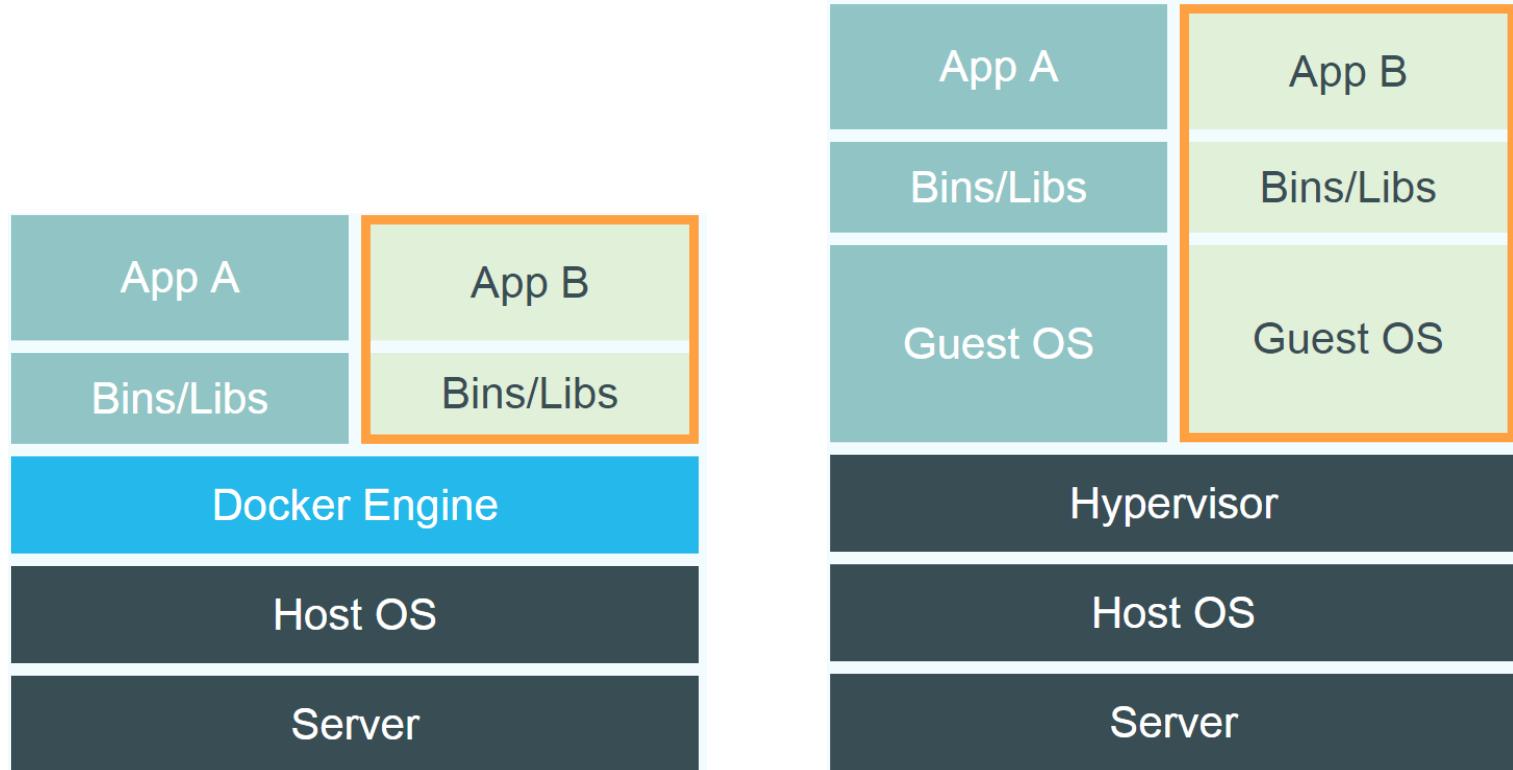
[www.docker.com]

docker [naut.]: der Dockarbeiter, der Hafenarbeiter

Source: leo.org

- Provide a uniformed wrapper around a software package: «*Build, Ship and Run Any App, Anywhere*» [www.docker.com]
 - ▶ Similar to shipping containers: The container is always the same, regardless of the contents and thus fits on all trucks, cranes, ships, ...

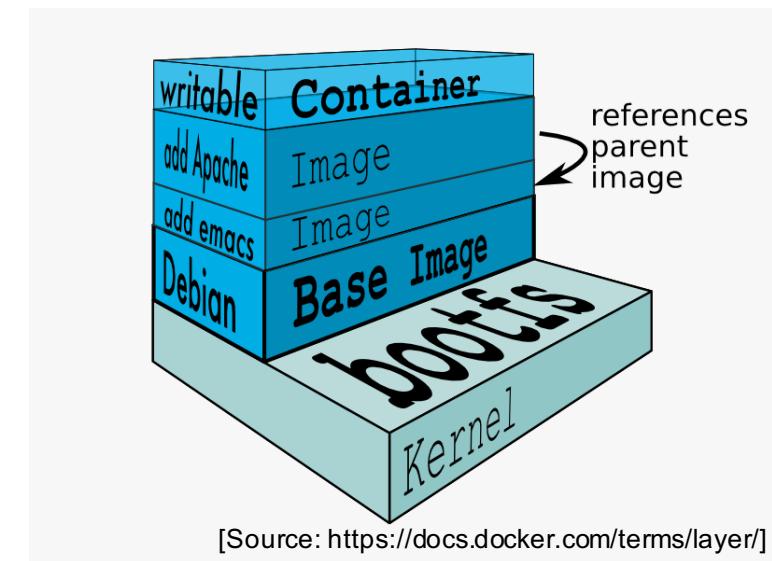
Docker vs. Virtual Machines



Source: <https://www.docker.com/whatisdocker/>

Docker Technology

- libvirt: Platform Virtualization
- LXC (LinuX Containers): Multiple isolated Linux systems (containers) on a single host
- Layered File System



Run Platforms

- Various Linux distributions (Ubuntu, Fedora, RHEL, Centos, openSUSE, ...)
- Cloud (Amazon EC2, Google Compute Engine, Rackspace)
- 2014-10: Microsoft announces plans to integrate Docker with next release of Windows Server

Simple Command - Ad-Hoc Container

- docker run ubuntu echo Hello World
 - ▶ docker images [-a]
 - ▶ docker ps -a

Container → Dockerfile JADS

- Create images automatically using a build script: «Dockerfile»
- Can be versioned in a version control system like Git or SVN, along with all dependencies
- Docker Hub can automatically build images based on dockerfiles on Github

Dockerfile Example JADS

- Dockerfile:

- ▶ FROM ubuntu
ENV DOCK_MESSAGE Hello My World
ADD dir /files
CMD ["bash", "someScript"]

- docker build [DockerFileDir]
- docker inspect [imageId]

Docker Hub

- Public repository of Docker images
 - ▶ <https://hub.docker.com/>
 - ▶ docker search [term]
- Automated: Has been automatically built from Dockerfile
 - ▶ Source for build is available on GitHub

Docker Use-Cases

- Development Environment
- Environments for Integration Tests
- Quick evaluation of software
- Microservices
- Multi-Tenancy
- Unified execution environment
(dev → test → prod (local, VM,
cloud, ...))

Docker Use-Cases

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Containers vs. Serverless JADS

Hold on... what is
serverless?

- And why the H*** do I need it?

- You take a *microservice* and reduce it to a single *function!*
- **Design Principles**
 - ▶ **Compute Atomicity:** raw compute-power on demand;
 - ▶ **Circa-Zero provisioning:** design for computations, forget about servers;
 - ▶ **Trigger-based, event-driven design:** you configure events, (e.g., API requests, uploads) that trigger your serverless function to execute;

- DevOps is a set of tactics that accelerate lead-time;
- We saw two tactics more in depth but there are plenty more and they all cause trouble!
 - ▶ Infrastructure code to automate entire delivery pipelines → *maintenance nightmare!*
 - ▶ Microservices & containers + serverless granularize the architecture → *maintenance nightmare!*
- Research and Practice around DevOps are converging;

Example Senlin “scaling_out_policy_ceilometer.yaml”

using the Kubernetes “redis” example

TOSCA Policy

Symbolic name for the trigger (could be used to reference an externalized version; however, this would violate a Policy’s integrity as a “Security document”)

Describe NODE to attach an alarm | alert | event to

i.e., Using the “node”, “req”, “cap” and “condition” keys would be expressed as a descriptive “filter”

List optional input parms. here

```
my_scaling_policy:  
  type: tosca.policies.scaling  
  properties: # normative TOSCA properties for scaling  
    min_instances: 1  
    max_instances: 10  
    default_instances: 3  
    increment: 1  
  # target the policy at the “Pod”  
  targets: [redis-master-pod]  
  triggers:  
    resize_compute: # symbolic name  
      event: tosca.events.resource.utilization  
    target_filter:  
      node: master-container  
      requirement: host  
      capability: Container  
      condition: utilization greater_than 80%  
    action:  
      # map to SENLIN::ACTION::RESIZE  
      scaleup: # logical operation name  
        inputs: # optional inputs parameters  
          number: 1  
        strategy: BEST_EFFORT  
        Implementation: <script> | <service_name>
```

Target is a Kubernetes Pod of the tosca.groups.placement type

TOSCA normative event type (name) that would map to domain-specific names (e.g., OpenStack Ceilometer)

Find the attribute via the topology:
a) Navigate to node (directly or via the requirement name) and optionally the Capability name
b) The condition to map & register with the target monitoring service (e.g., Ceilometer)

TODO:
Need a % data type for TOSCA

Note: we combined the Senlin “Action” of SENLIN::ACTION::RESIZE with the strategy: BEST_EFFORT to have one name

*more info online

That's all folks!

Any Questions?



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