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

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Agenda for Today!

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- 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!

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- *"Say What???????"*

My Face when I heard of it...

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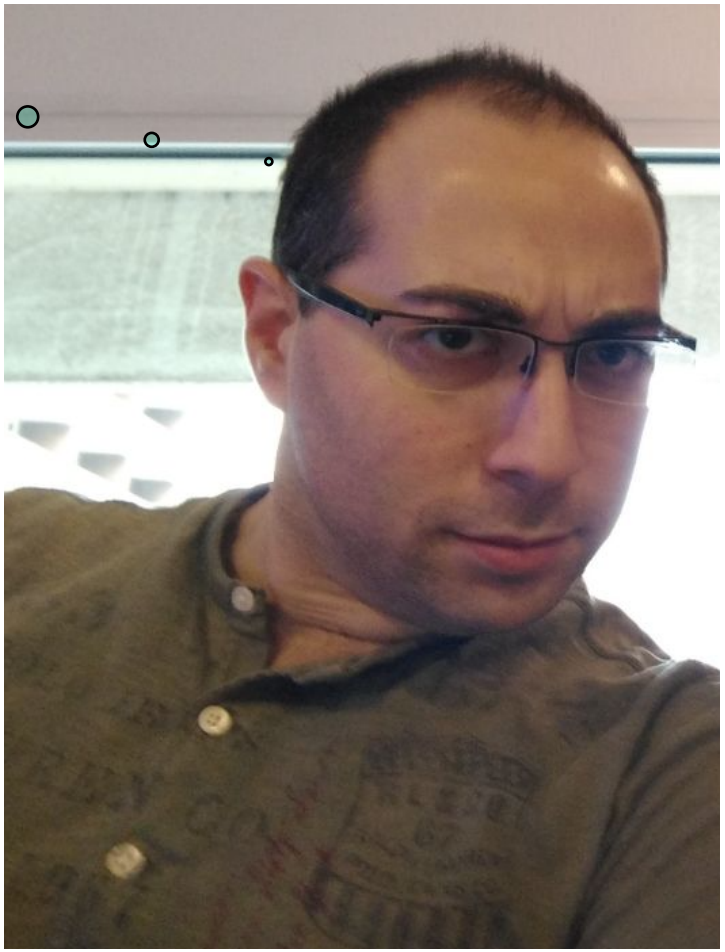
- DevOps?

"Say What???????"



But first... A bit of history!

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

It's 2013...

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- And...

It's 2013...

- And...

It's 2013…

- 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

Meanwhile in Software Engineering... Top failure causes*

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- 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

*Gartner Report 2013

Meanwhile in Software Engineering...
Top failure causes* - An Example!

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*Gartner Report 2013

Meanwhile in Software Engineering...
Top failure causes* - An Example!

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(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?

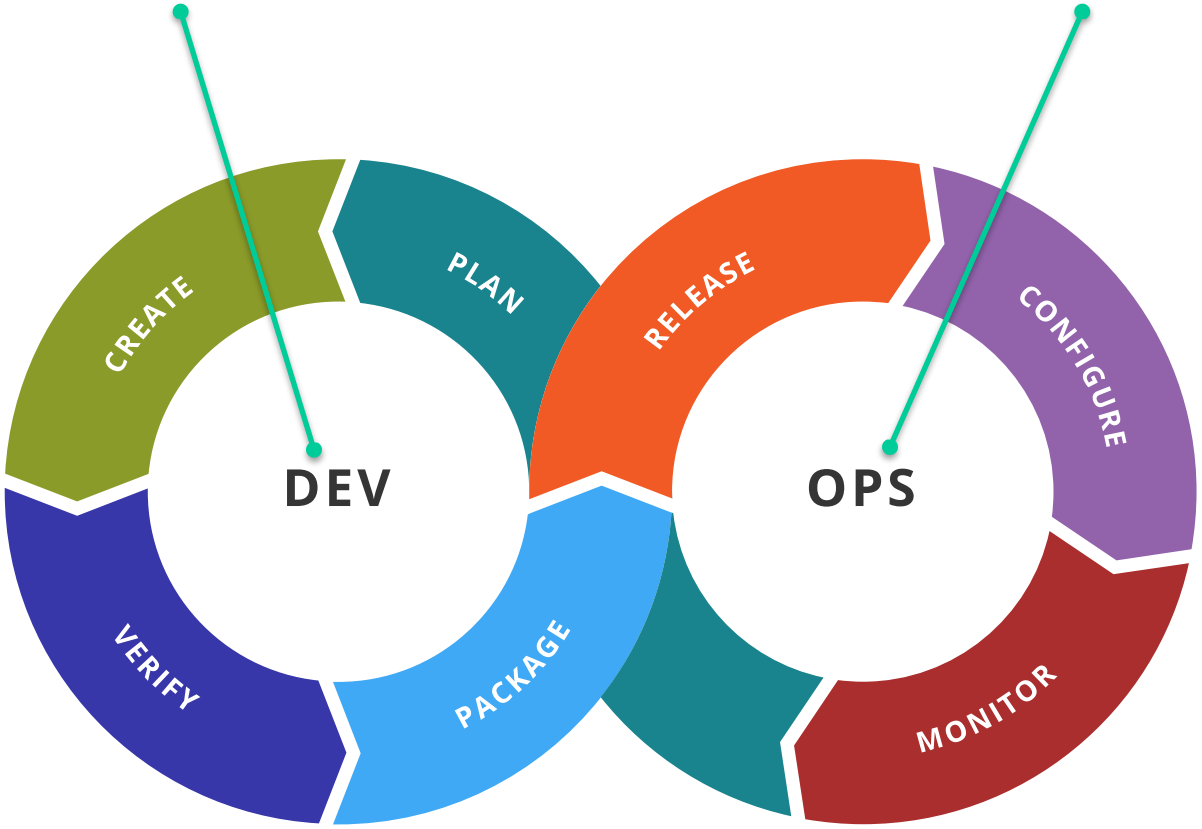
"DevOps is a set of practices intended to reduce the time between committing a change to a system and the change being placed into normal production, while ensuring high quality."

L. Bass et Al. [11]

What is DevOps?

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

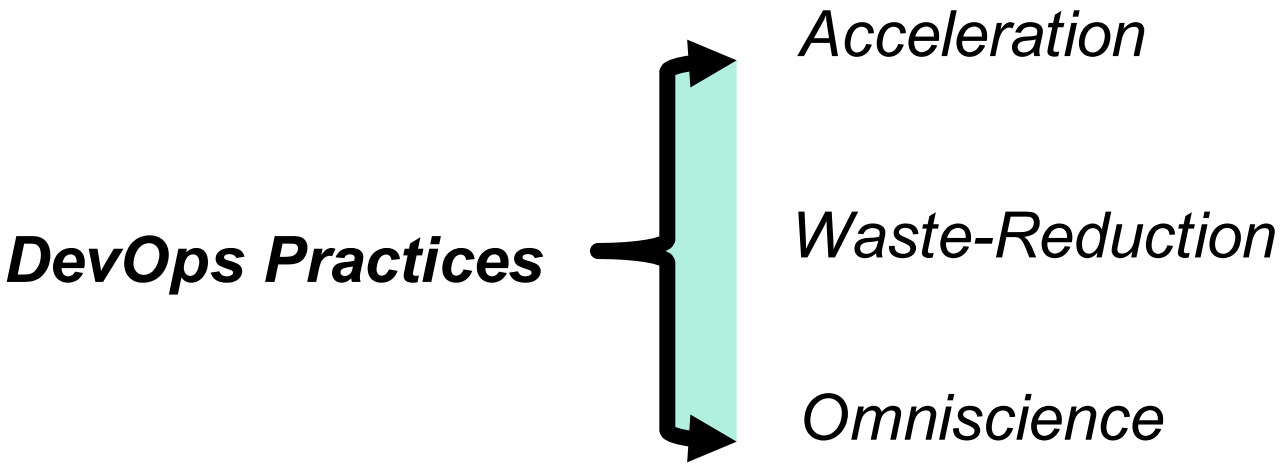
Ops Goal: "Observe the architecture runtime and provide Ops feedback to Dev…*then improve architecture continuously*"



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: Let's take a look

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- **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
  - …

DevOps Practices: Let's take a look

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- **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**
- …

Maintenance Challenges

- More granular systems continuously deployed:
  - Maintain the systems

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

Maintenance Challenges

- 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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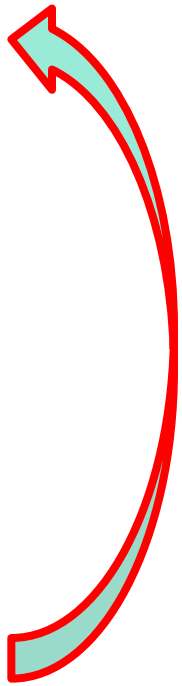


- **Socio-Technical Alignment!**

DevOps Processes & Practices: Digging Further

- Continuous Architecting

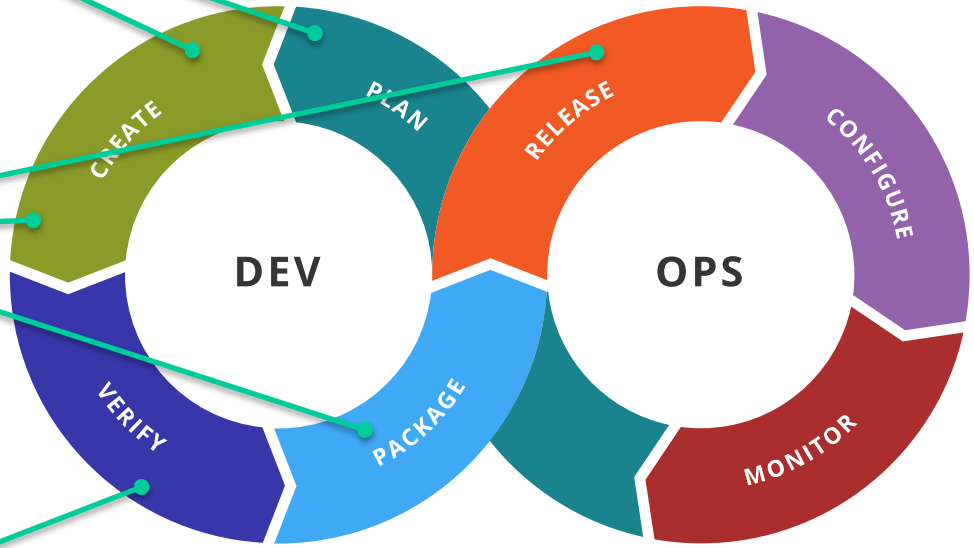
Def. *"architect for test, build and deploy, take quality attributes into account, take advantage of feedback from runtime" [1]*

- Continuous Integration

Def. *"merge* all developer work-copies to a shared mainline frequently*" [4]*
***Examples. Apache Jenkins**, **Hudson,** etc.*

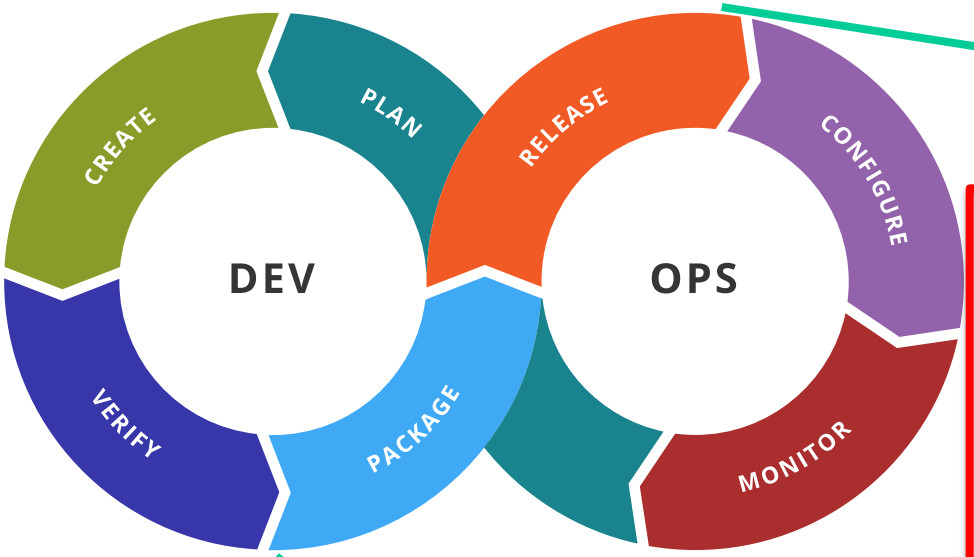
- Continuous Testing

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

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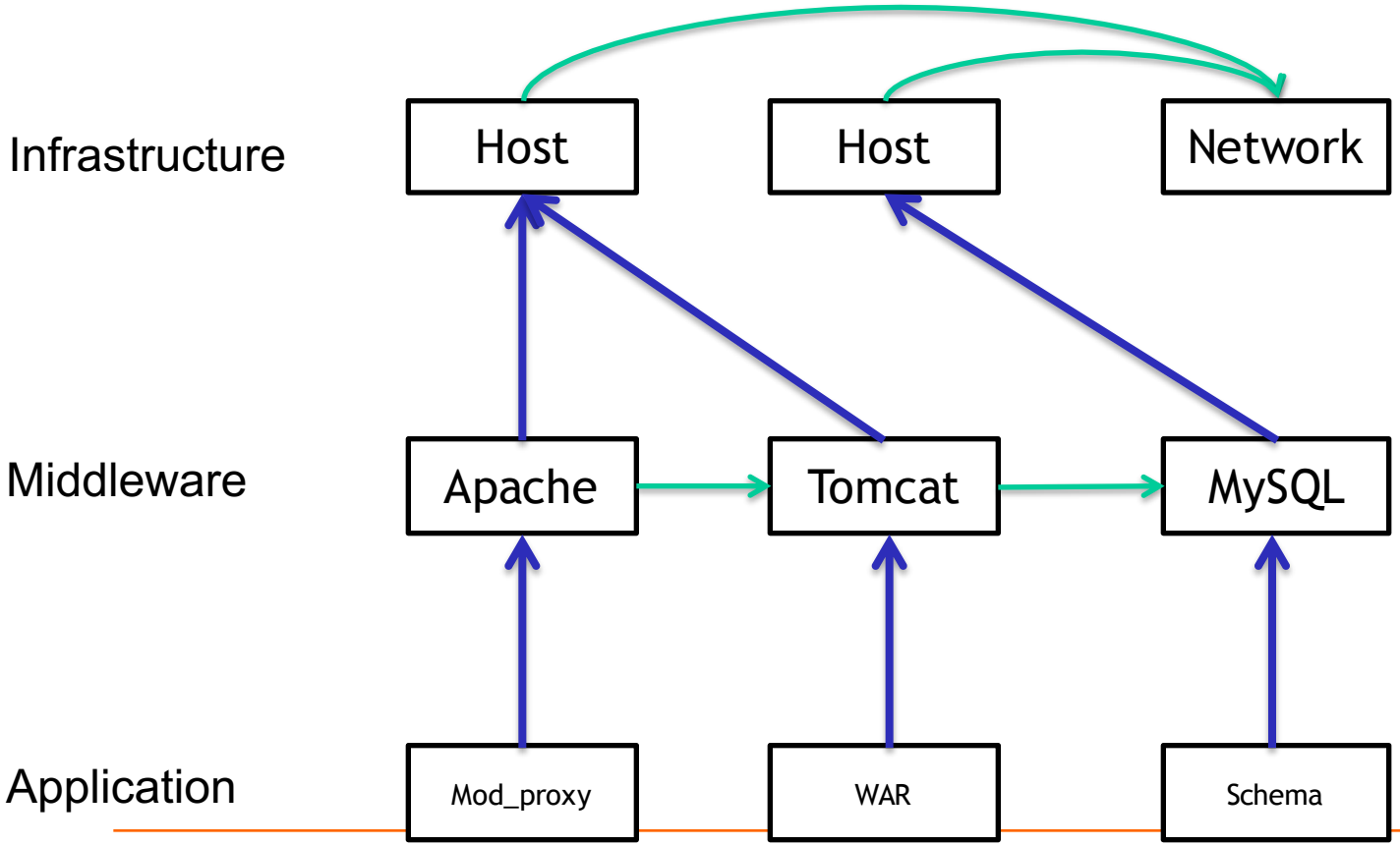
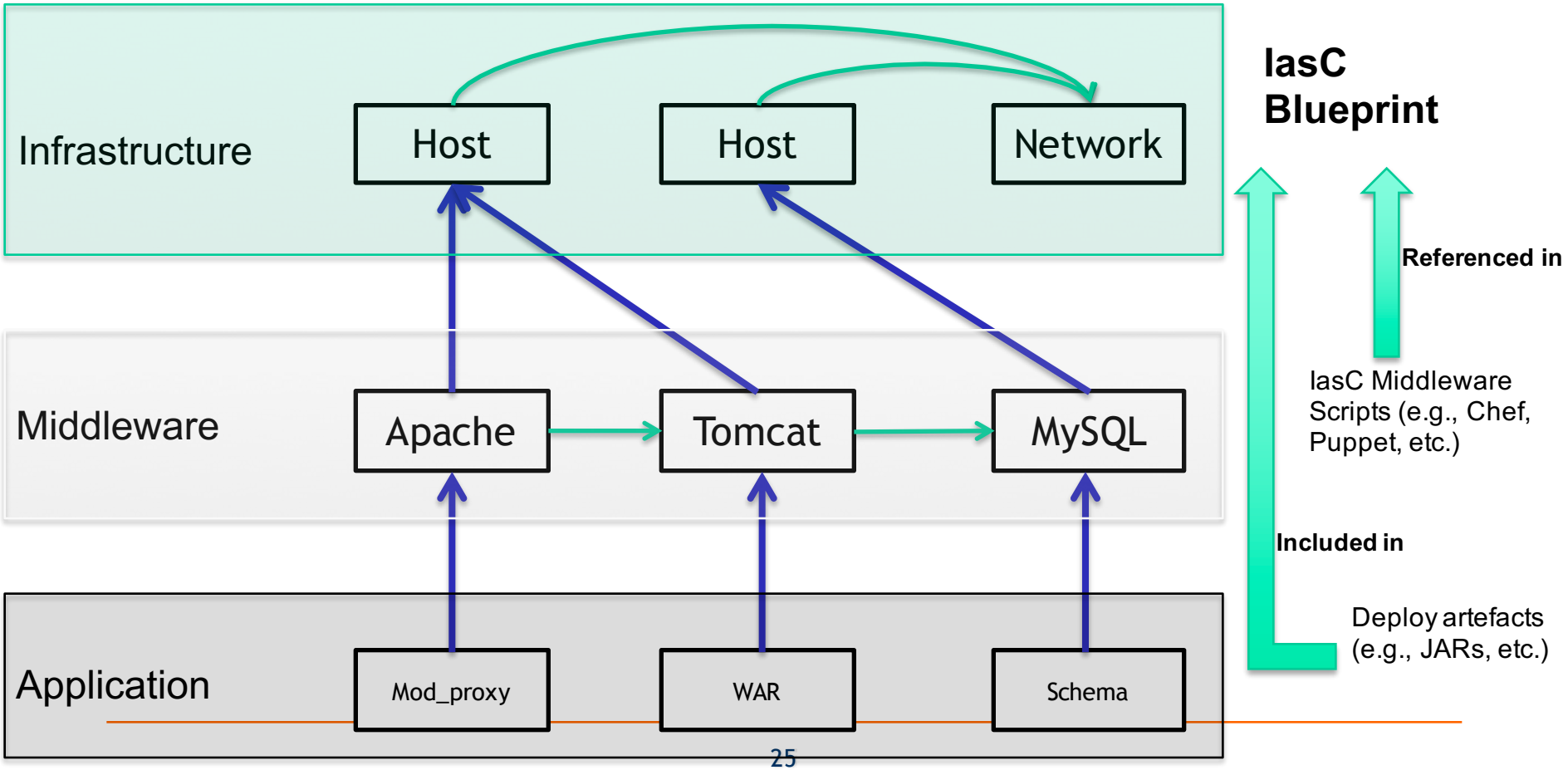
➔ **An Application Deployment Topology**, i.e., "a graph of physical artefacts that need support for several lifecycle phases (e.g., procurement, installation, configuration, deployment, undeployment, teardown, etc.)" [6]



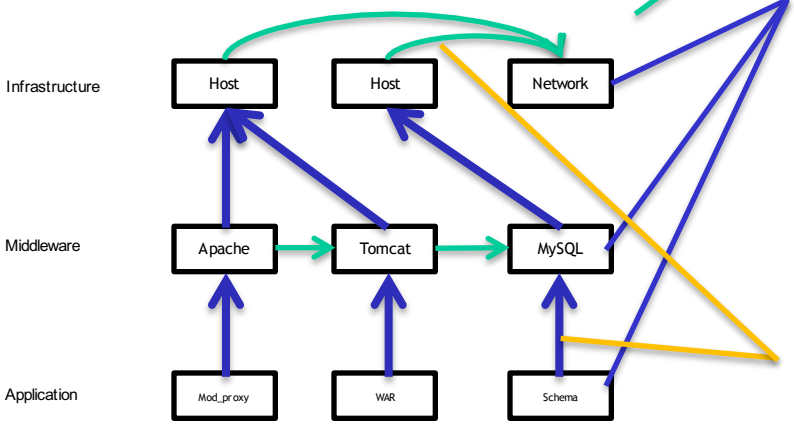
Towards standard Infrastructure Code

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



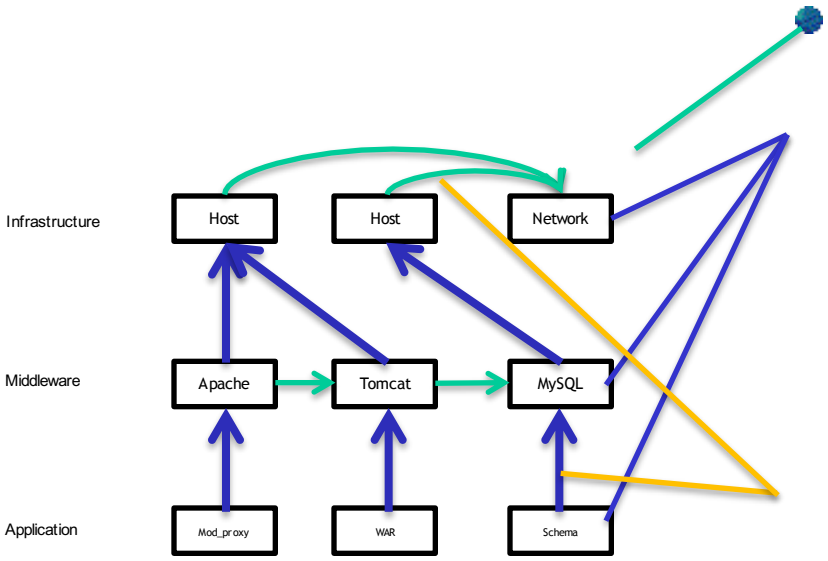
Where Does IaC fit into?

Here's What We've Seen there…



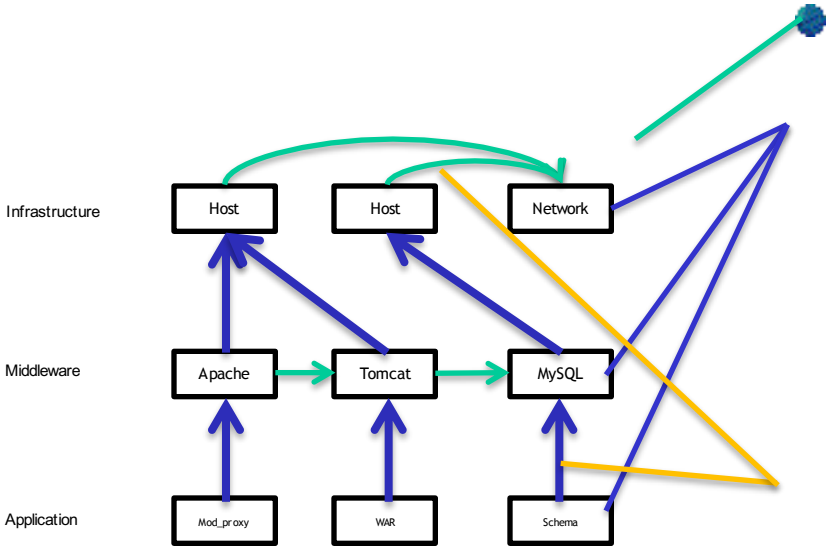
- An application topology
- 3 layers
  - Infrastructure (Cloud or DC objects)
  - Platform or Middleware (App containers)
  - Application modules, schemas and configurations
- Relationships between components:
  - What's hosted on what or installed on what
  - What's connected to what

Where Does IaC fit into?



- ***Many*** available formats (70+)*:
  - Saltstack
  - Kubernetes
  - CloudFormation
  - Cloudify
  - Ubicity
  - xOpera
  - HEAT
  - …

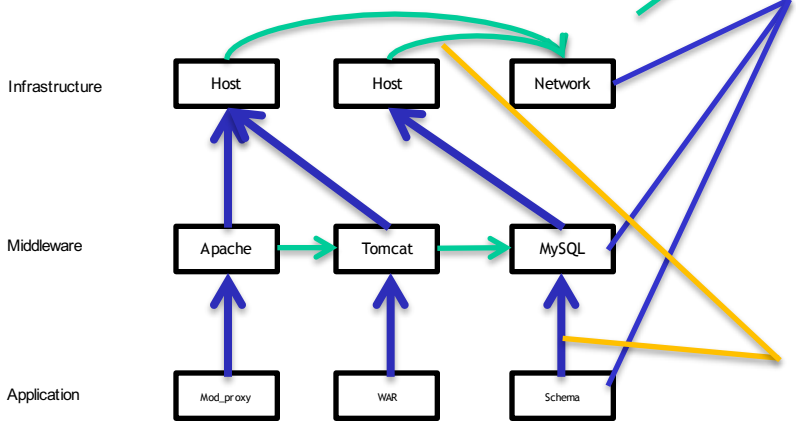
From IaC to TOSCA



TOSCA: "**T**opology and **O**rchestration **S**pecification for **C**loud **A**pplications"

- **Only ONE Standard!**

From IaC to TOSCA (cont'd)



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Where Does TOSCA fit into?

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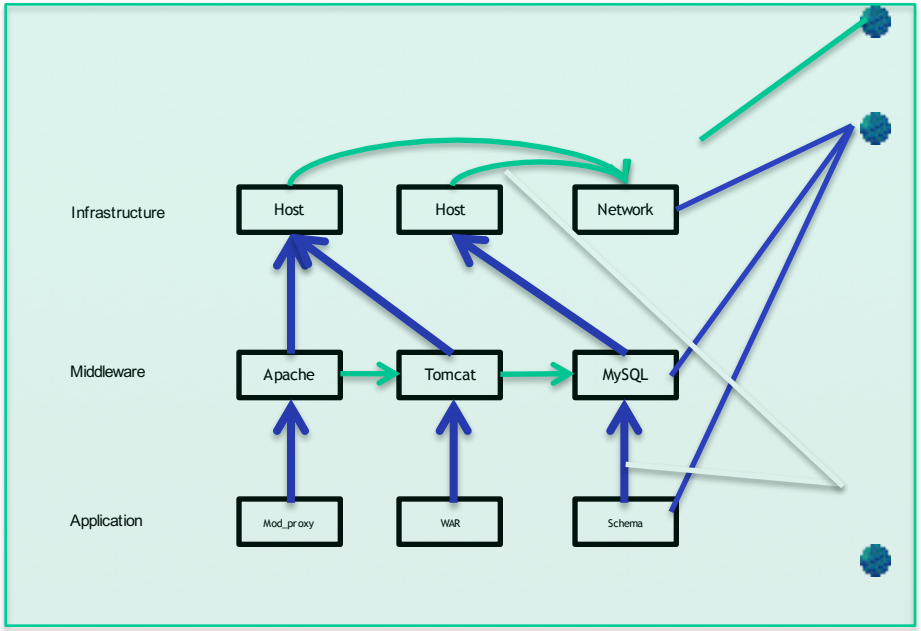
A single abstract language for IaC



TOSCA: "**Topology** and **O**rchestration **S**pecification for **C**loud **A**pplications"

An application topology

3 layers

- Infrastructure (Cloud or DC objects)
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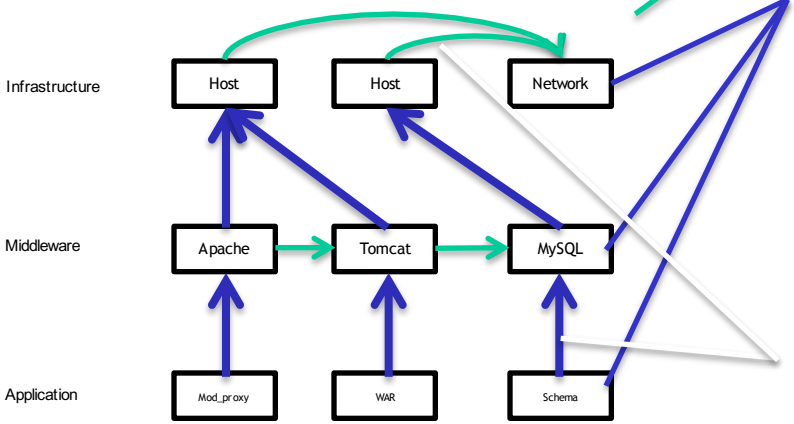

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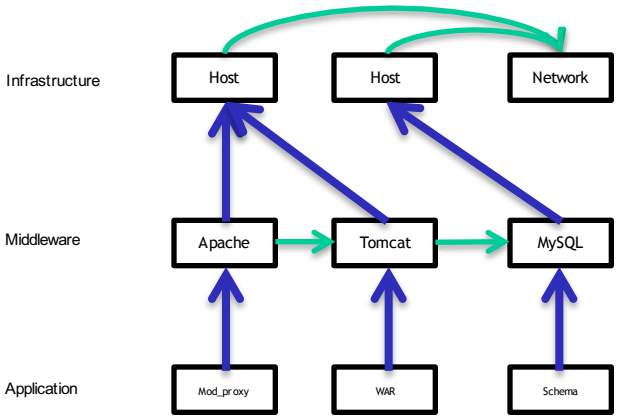

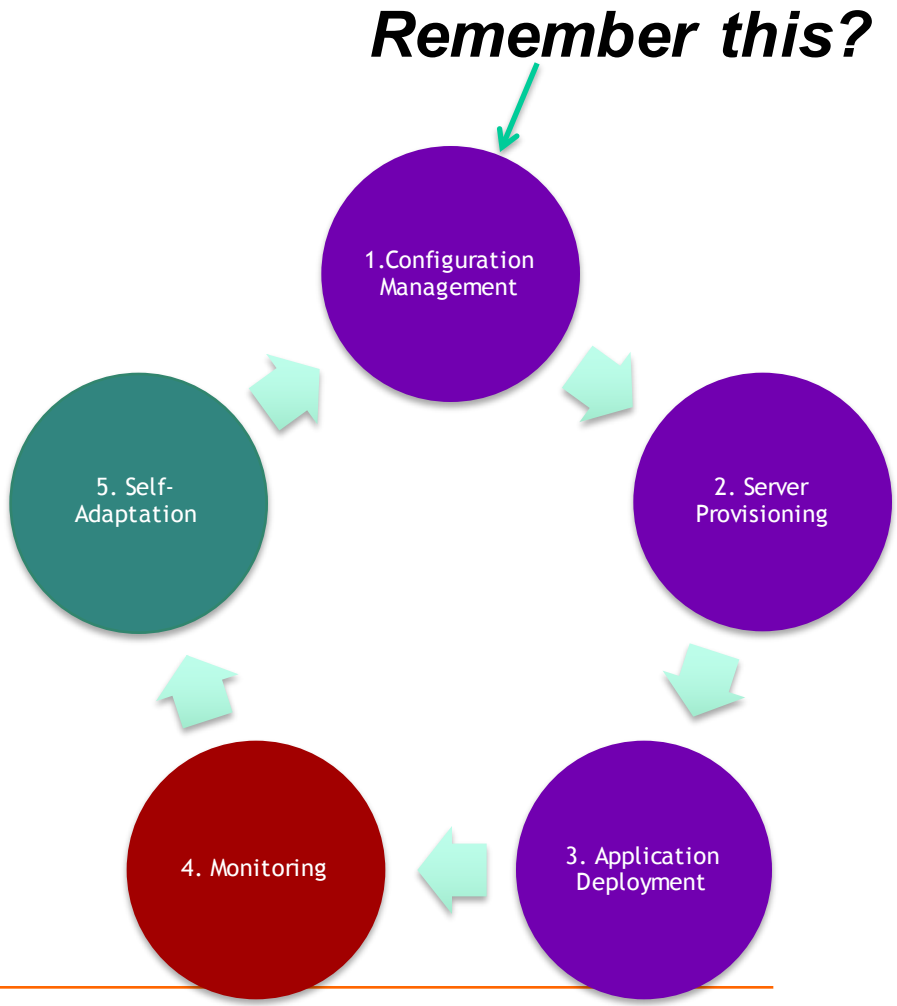

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Where Does IaC and TOSCA fit into?

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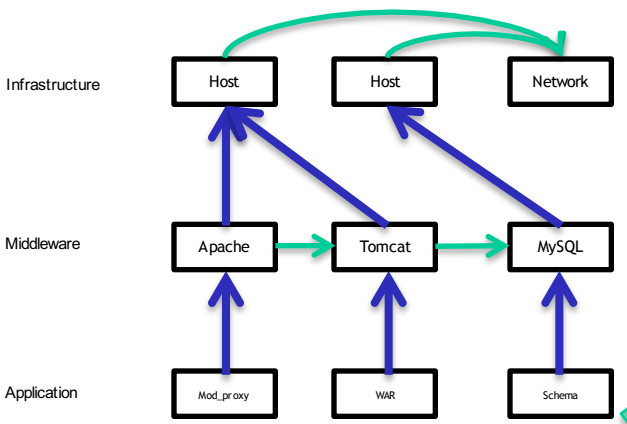
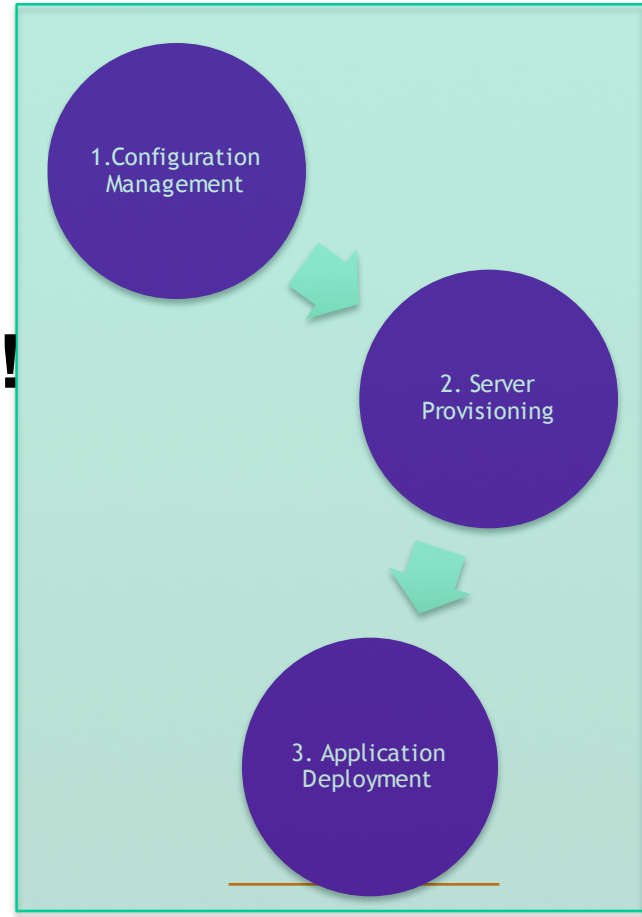
A single abstract language for IaC



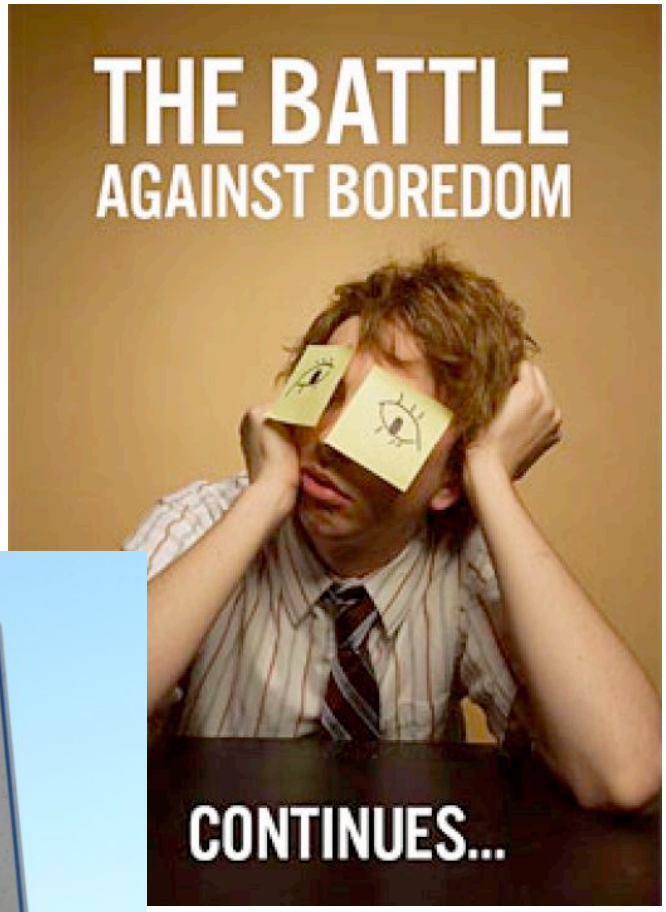
Orchestration!



TOSCA: "**T**opology and **O**rchestration **S**pecification for **C**loud **A**pplications"

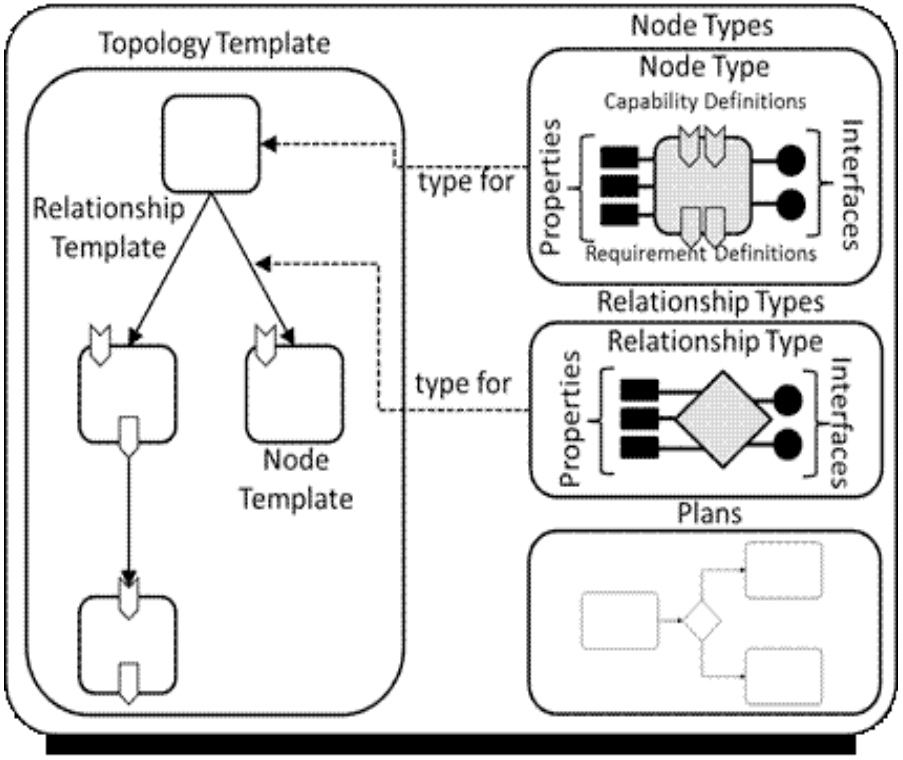
Bored yet?

- 10 min Break?



Coming up next... TOSCA, IaC Explained!

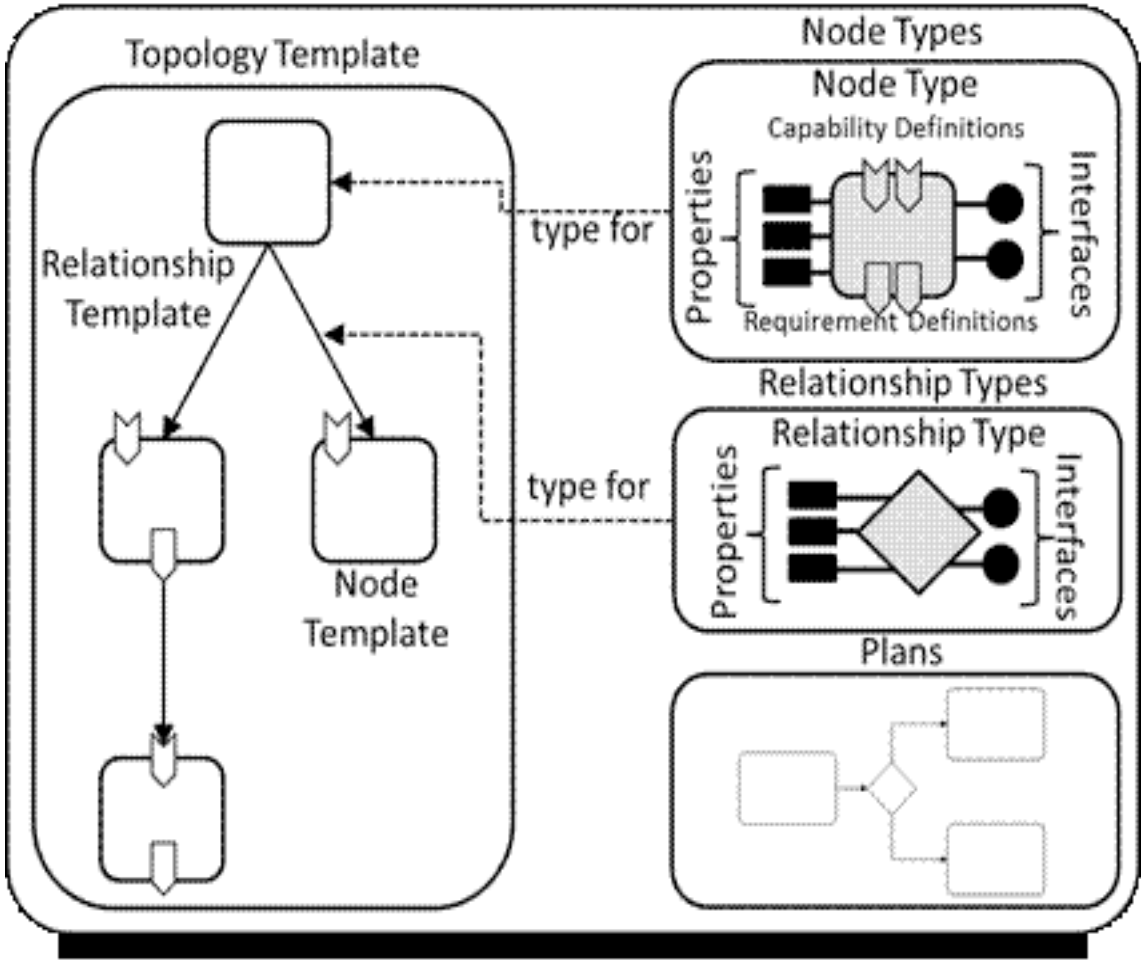
What's in a TOSCA Topology?



- 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

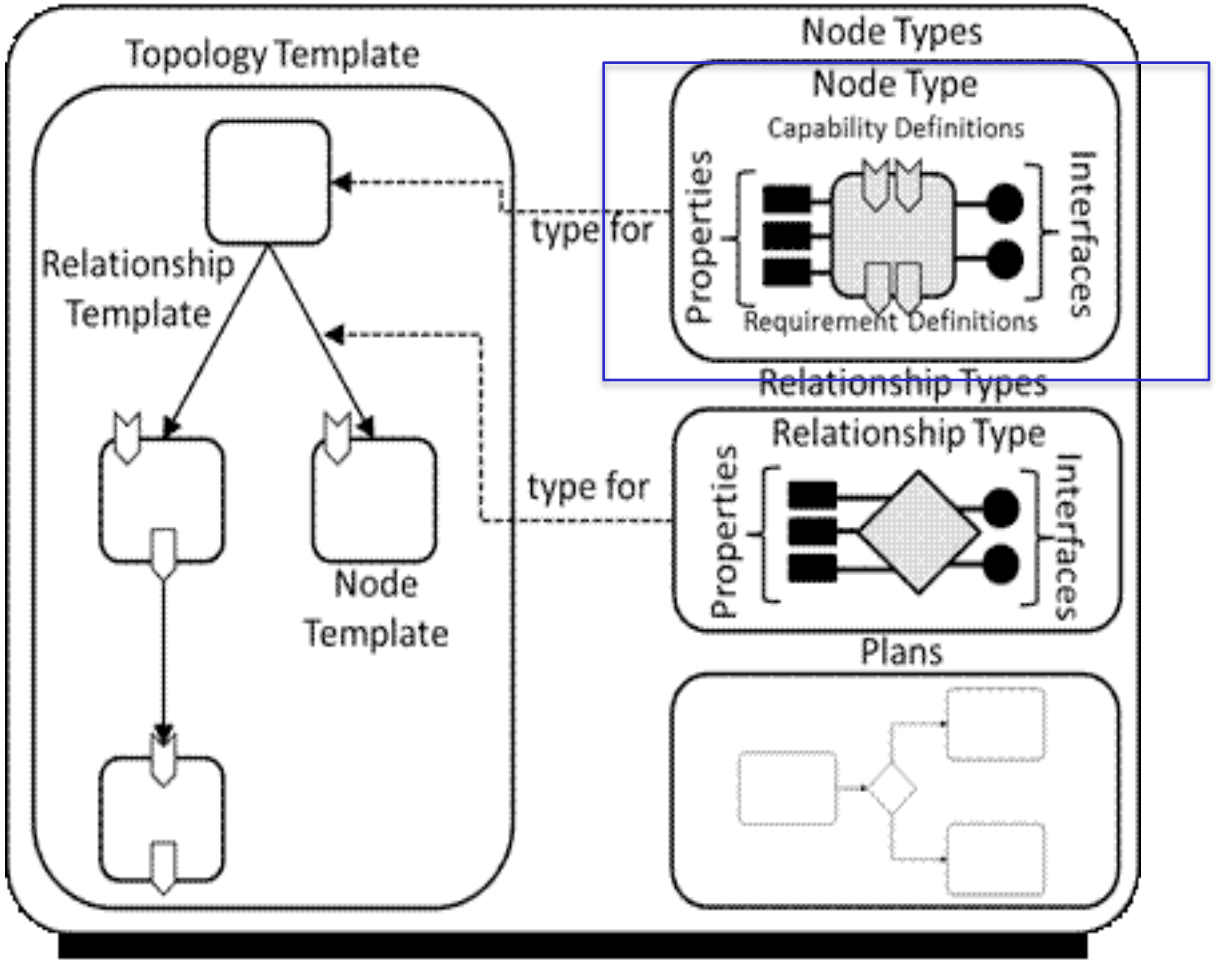
TOSCA, IasC Standard

TOSCA Service Template [7]



TOSCA Core Ingredients

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 ]
```

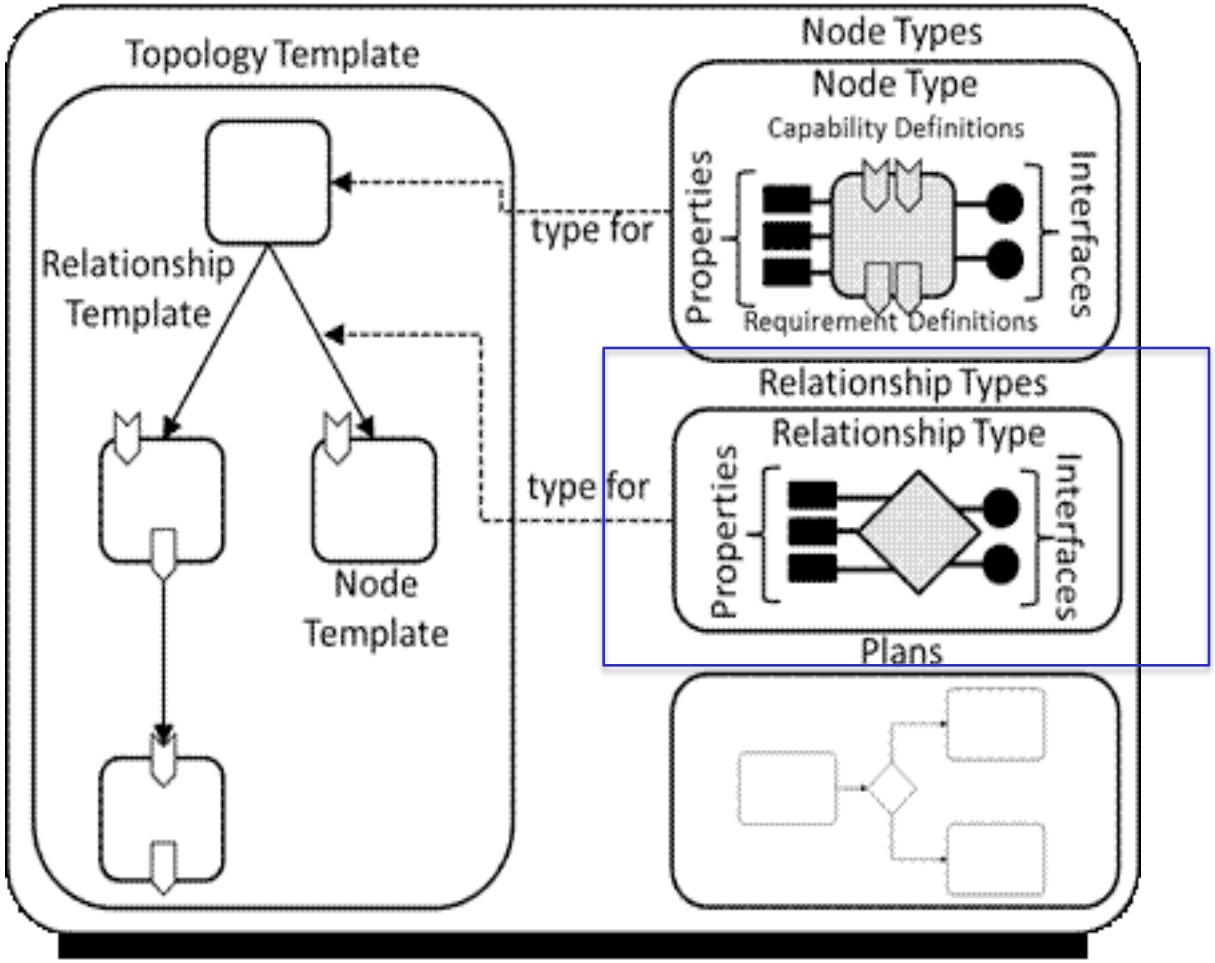
Node Type (cont.)

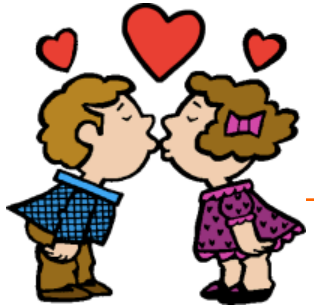
- Might define requirements (what it needs from other nodes)

```
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 Core Ingredients

TOSCA Service Template





Relationship Type

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- 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

Relationships (cont.)

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- 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**

Node Templates

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- 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)

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```
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:
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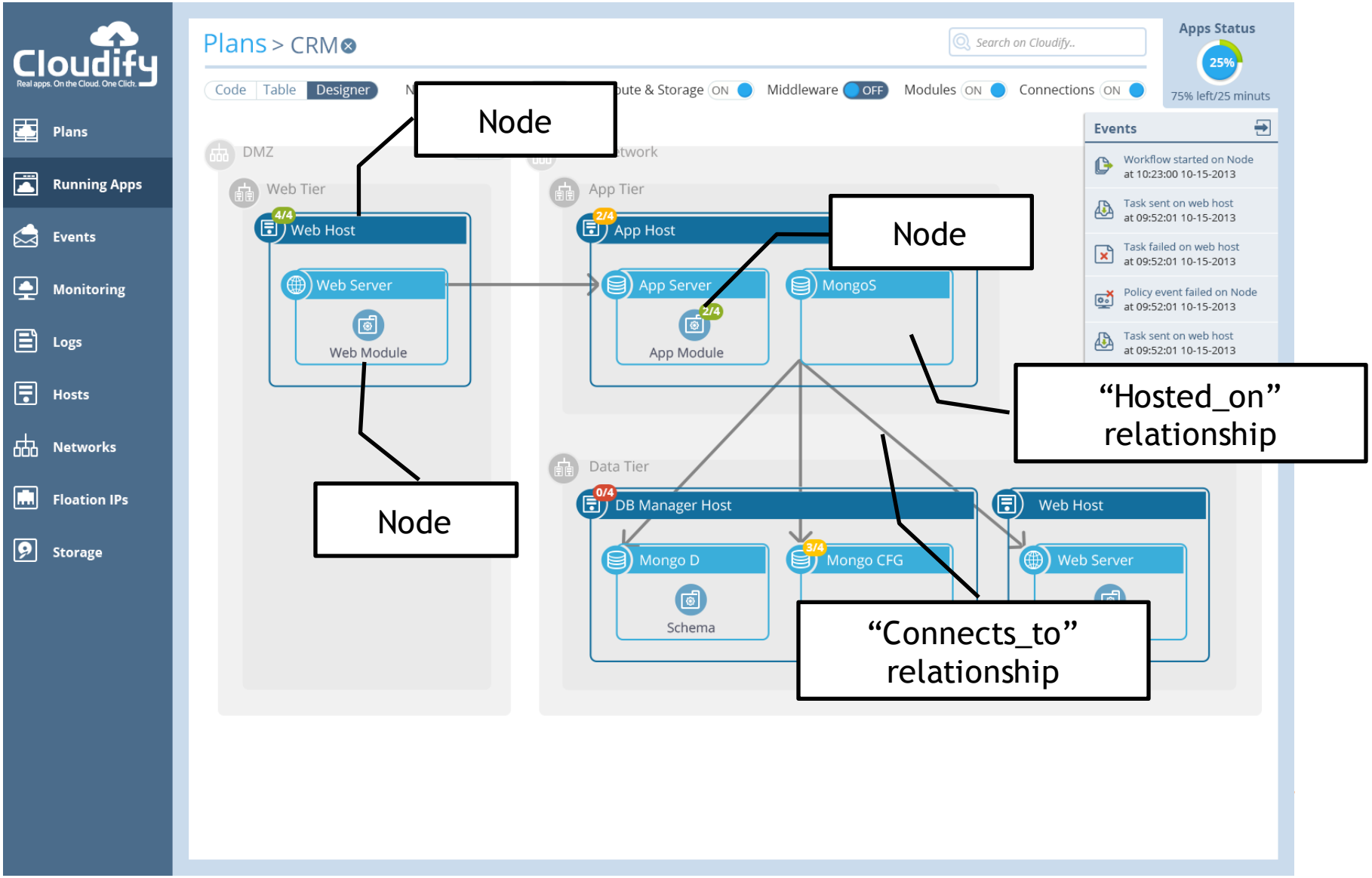
    properties:
      # omitted here for sake of brevity
    requirements:
      - host: apache
      - database: wordpress_db
        relationship_type: my.types.WordpressDbConnection
```

Translated to TOSCA



Workflows

- 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)*

Policies

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- 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

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Event Type

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

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>:
```

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)*

TOSCA Policy Example – Entities that compose Policy (Event, Condition, Action) model

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Event Type

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

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>:
```

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)*

Example Senlin "scaling_out_policy_ceilometer.yaml"

using the Kubernetes "redis" example

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

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"*

TOSCA Policy

```
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>
```

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)

Describe NODE to attach an alarm | alert | event to

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

TODO:
Need a % data type for TOSCA

List optional input parms. here

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

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```
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
  insatlled 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

TOSCA YAML IasC Examples

- WordPress+MySQL
- NodeJS App+MongoDB

WebServer-DBMS-1: WordPress - MySQL

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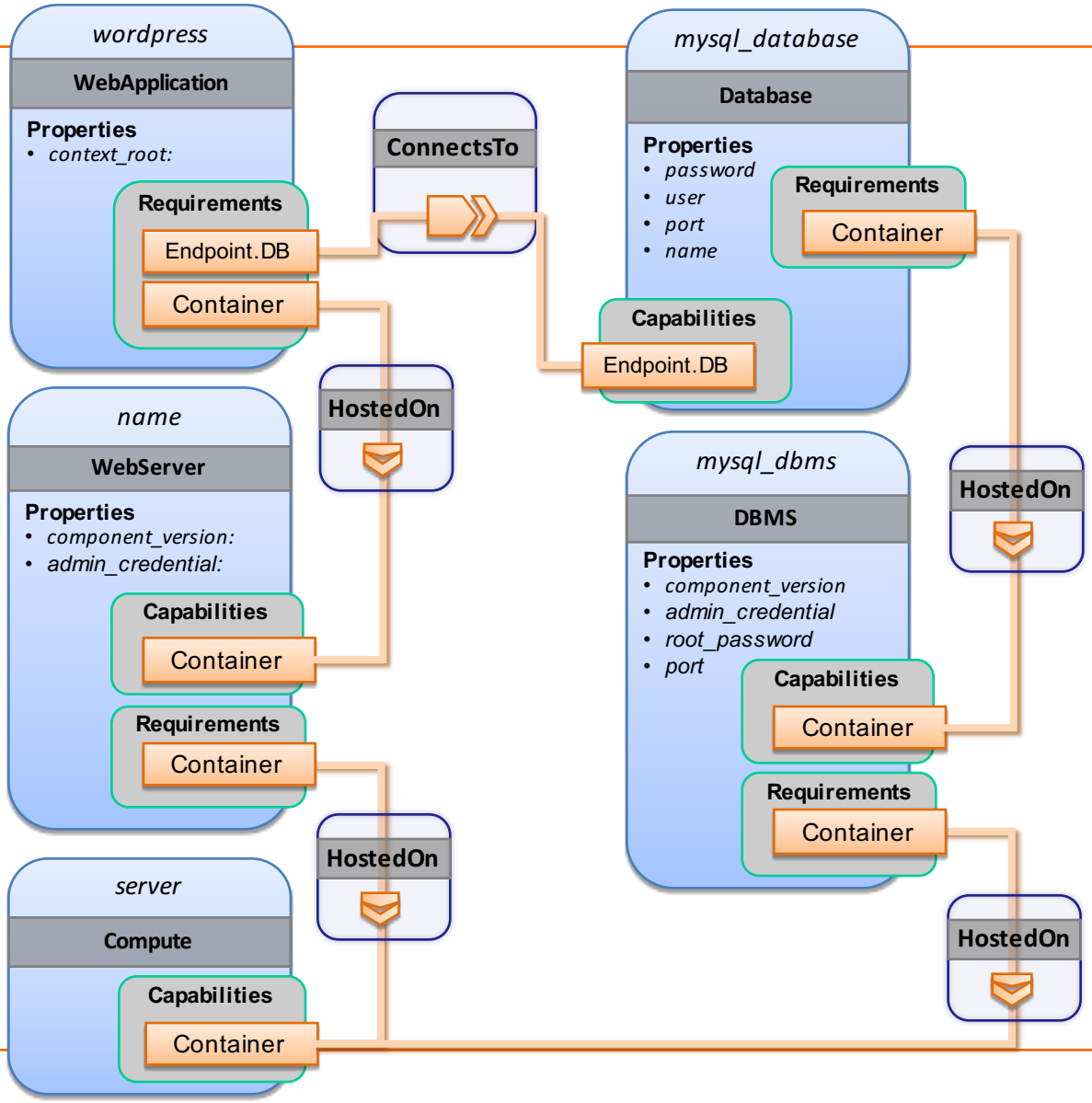
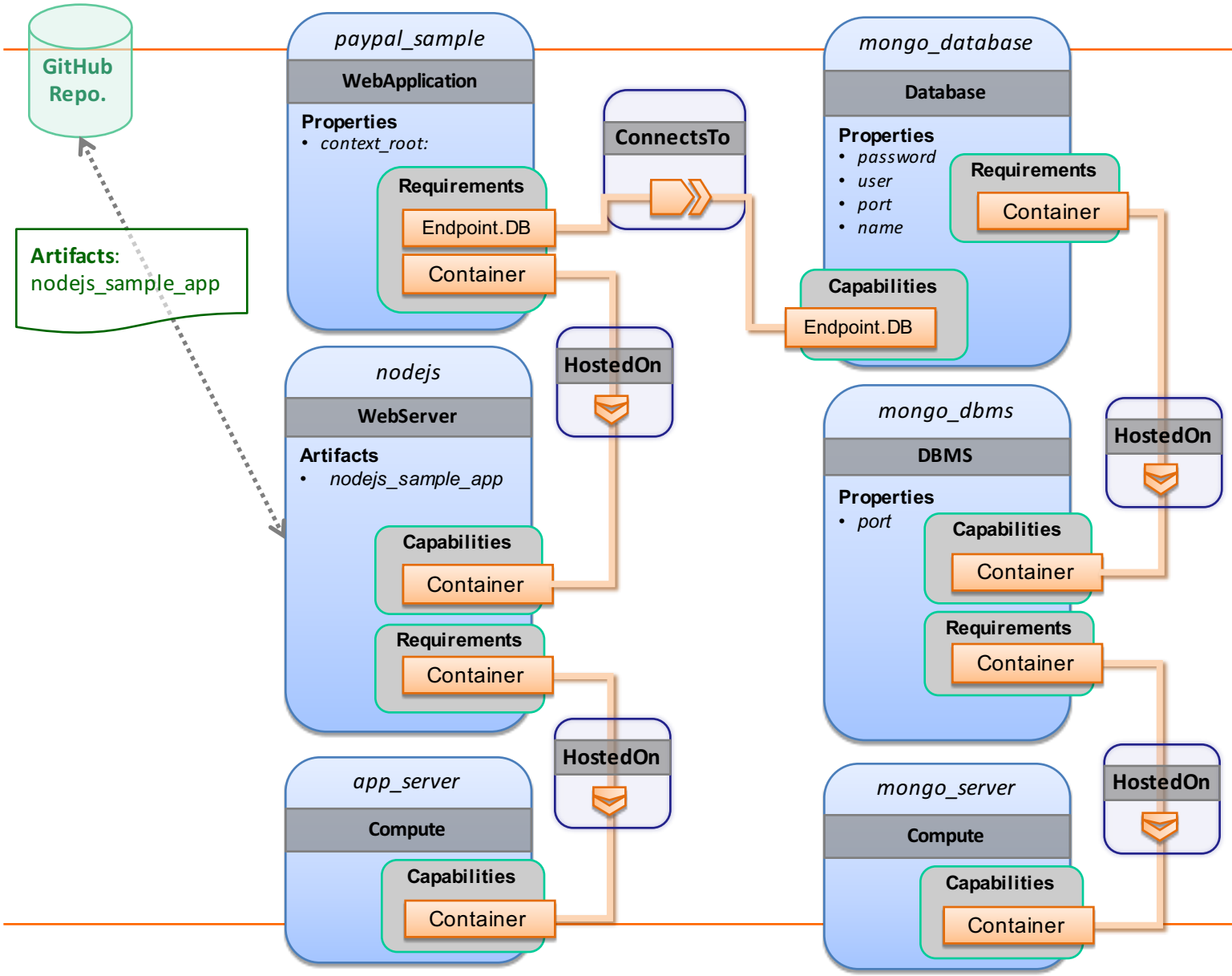
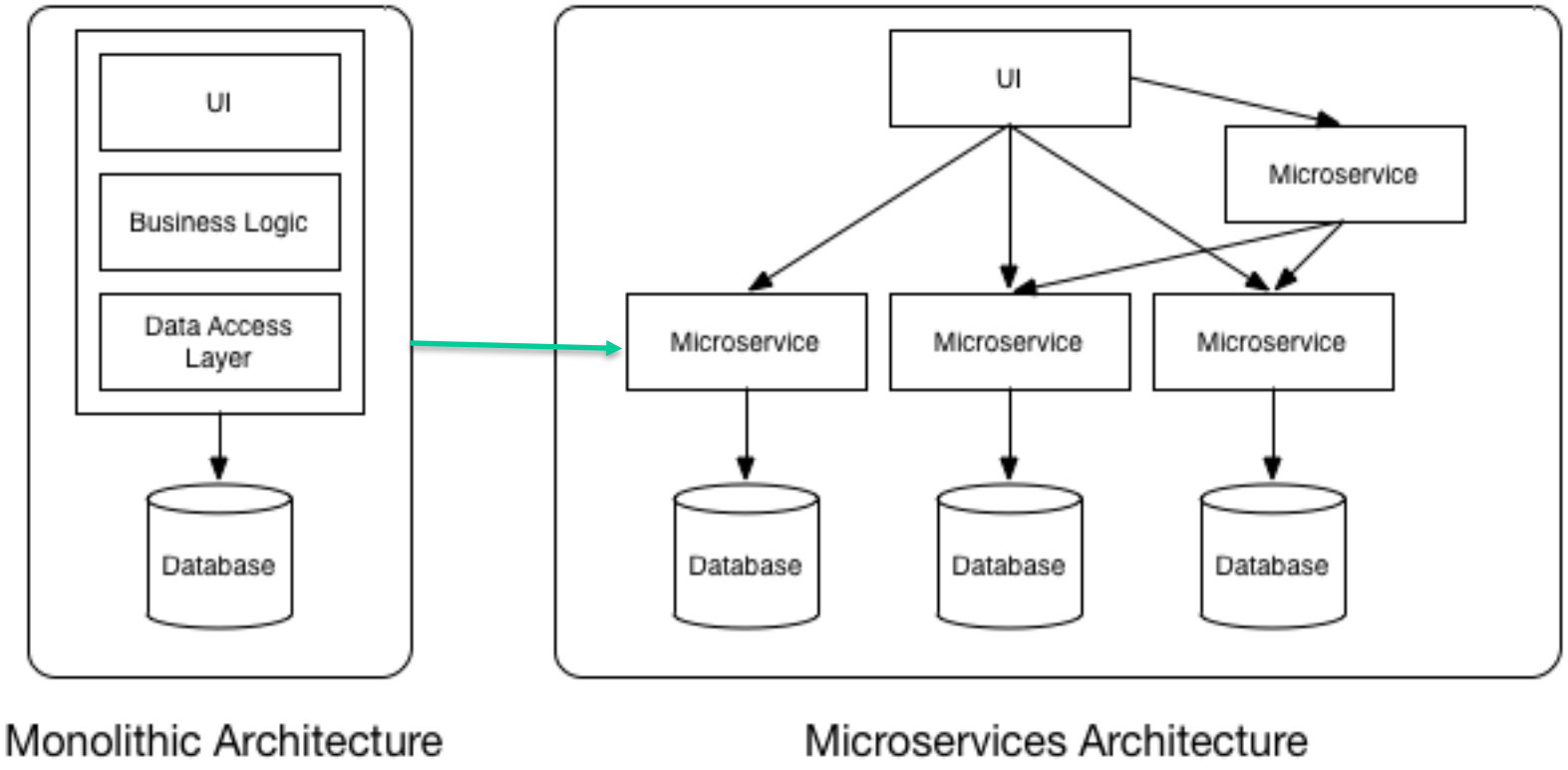


WebServer-DBMS-3:
Nodejs - MongoDB



IaC in action: Continuous Architecting & Microservices



Microservices

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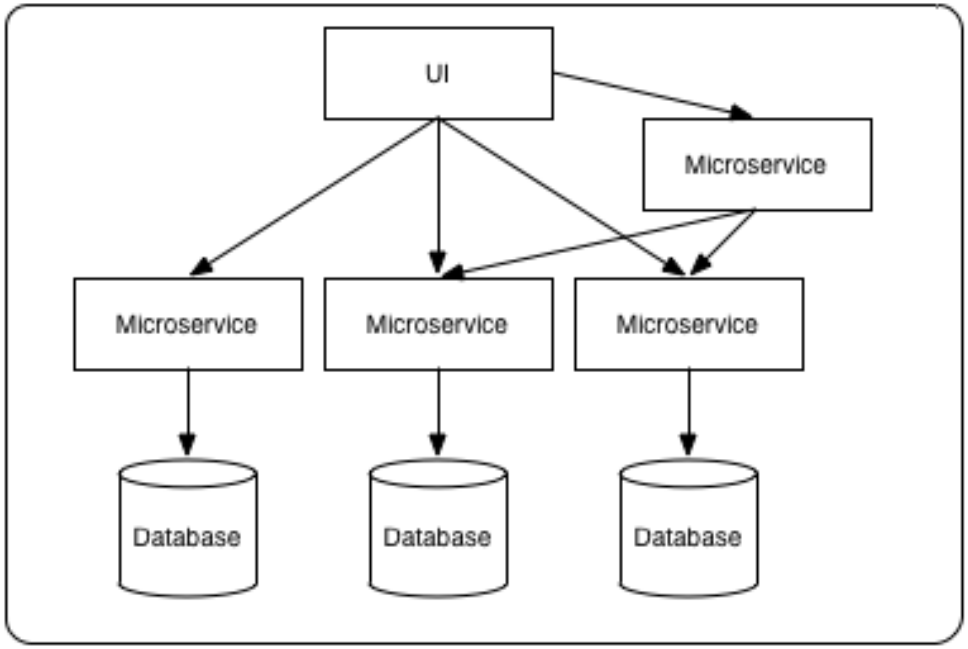
Architecture Principles:

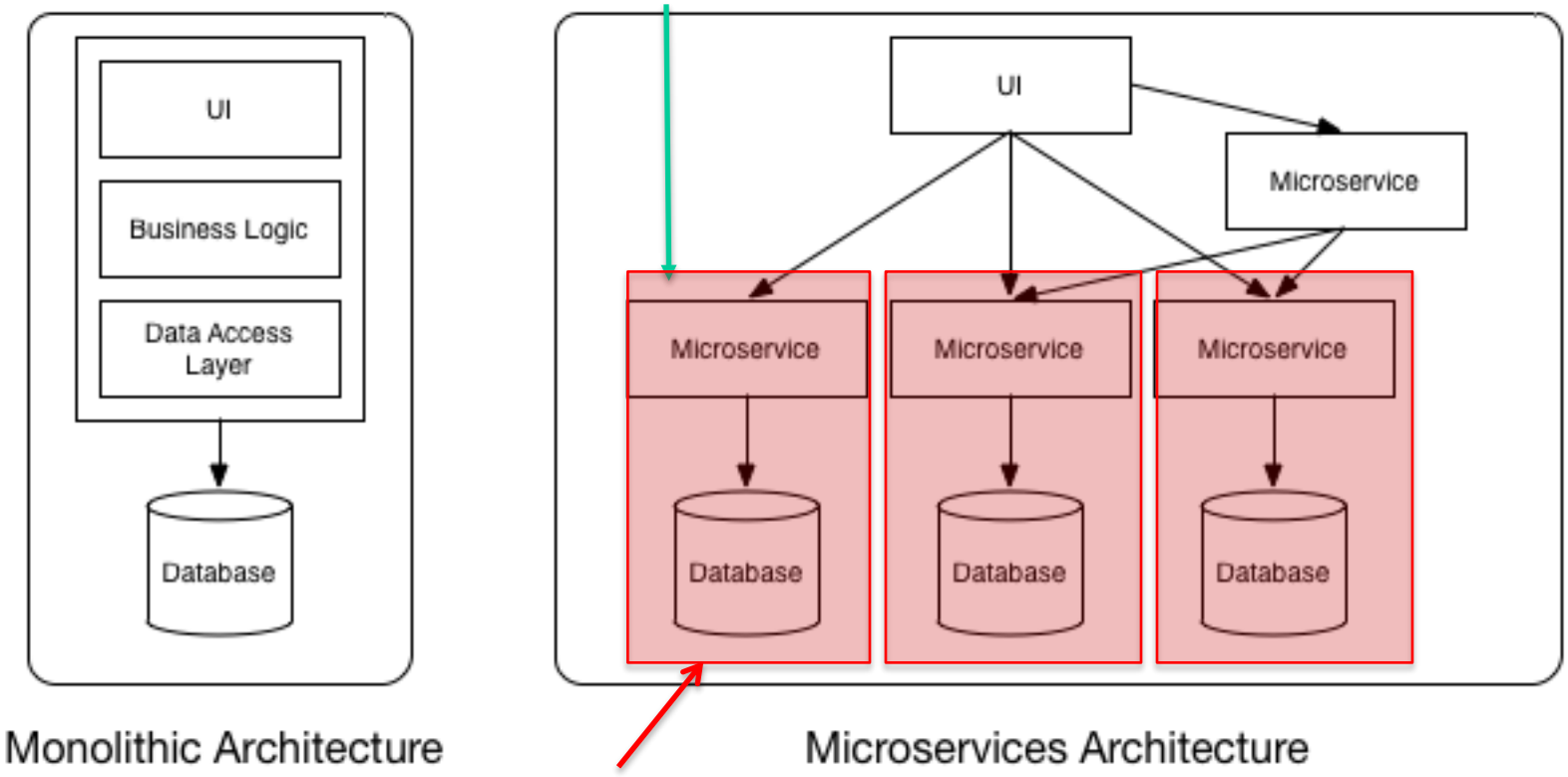
- Statelessness
- Available in multiple copies
- No data sharing among peers
- Each microservice its own DB
- Data-Intensive Message Brokering
  - Message queues



Microservices Architecture

Why Micro-?

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



Container!

Maintenance Challenges

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

Intermezzo: Containerization!

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- Terms & Definitions
- Examples & Use-cases

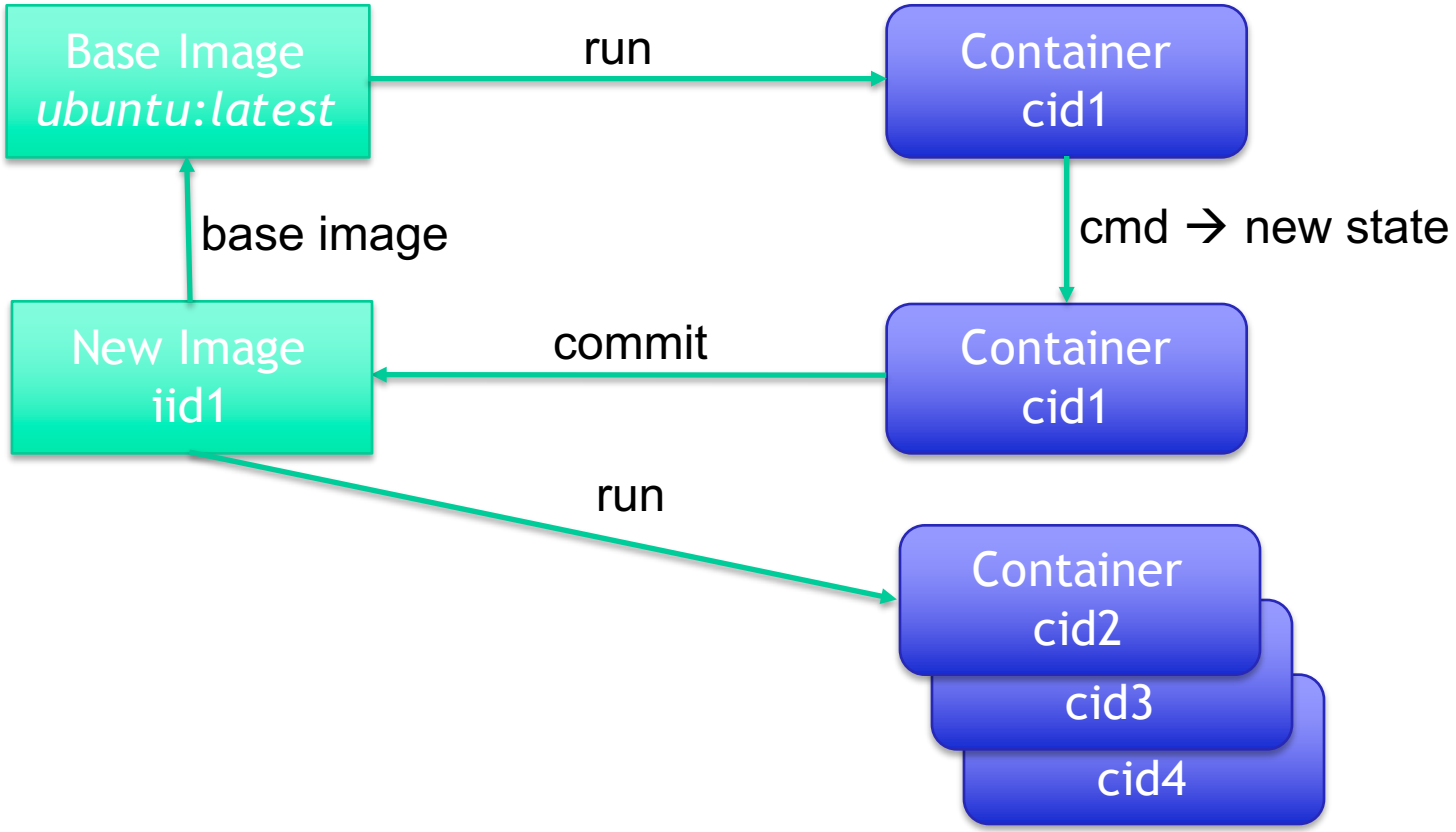
Terminology - Image

- 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

Terminology - Container

- 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

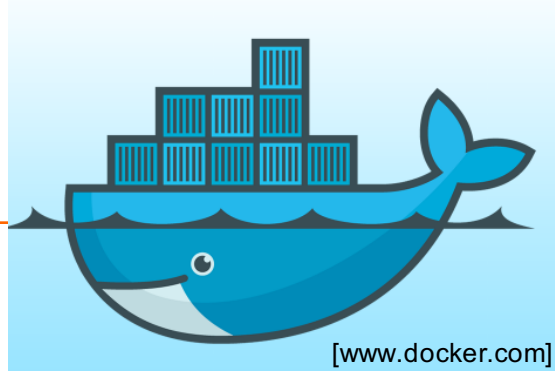


Example: Docker

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

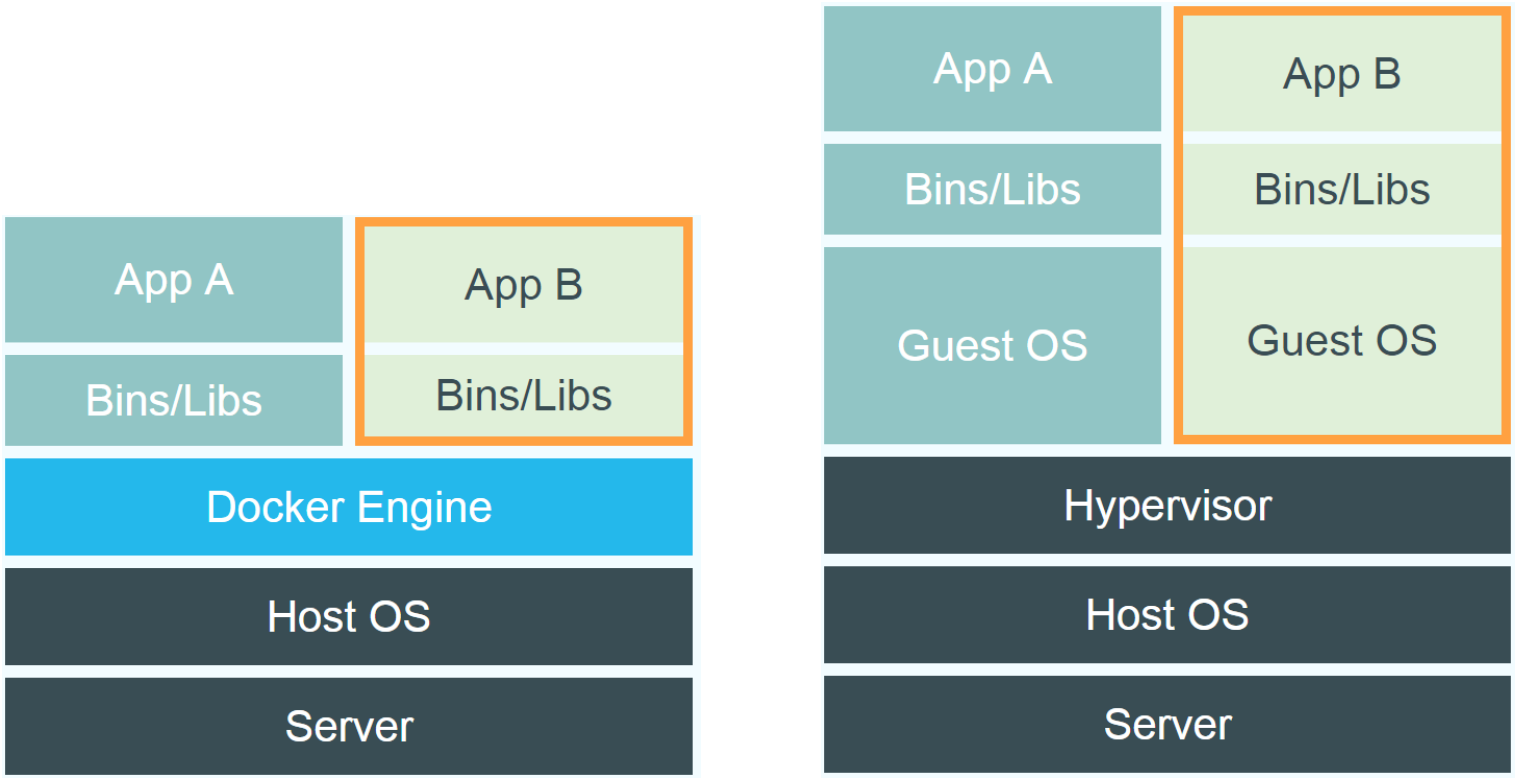


docker [naut.]: der Dockarbeiter, der Hafenarbeiter

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, ...

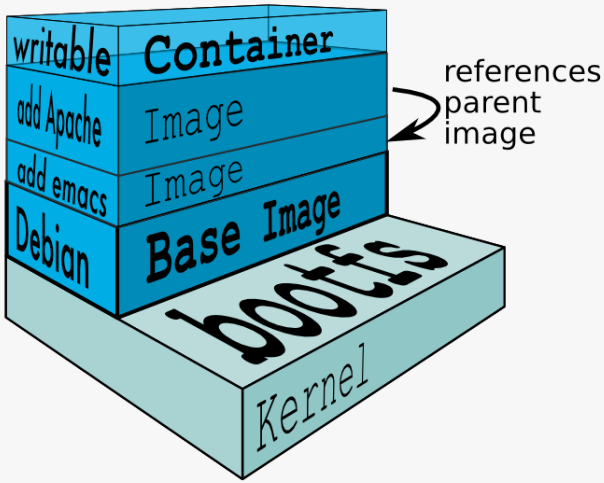
Docker vs. Virtual Machines



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



[Source: https://docs.docker.com/terms/layer/]

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

Hello World

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Simple Command - Ad-Hoc Container

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

Container ➔ Dockerfile

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- 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

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- Dockerfile:
  - ```
    FROM ubuntu
    ENV DOCK_MESSAGE Hello My World
    ADD dir /files
    CMD ["bash", "someScript"]
    ```
- `docker build [DockerFileDir]`
- `docker inspect [imageId]`
    ```

Docker Hub

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- 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

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- 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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Hold on… what is *serverless*?

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

Basic Idea

- 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;

Conclusions

- DevOps is a set of tactics that accellerate 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;

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    default_instances: 3
    increment: 1
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  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:
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List optional input parms. here

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!

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Any Questions?

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