PA200 - Cloud Computing

Lecture 10: Cloud software architecture and containers

by Ilya Etingof, Red Hat

Warm-up

Let's rehearse on the previous lectures...

Using OpenStack

- Spawn a single virtual machine
- Deploy the infrastructure

HEAT orchestration engine

- HOT templates render stacks
- Resources stack up to infrastructure
- HEAT takes HOT template(s) + environment

HOT resources

```
my_server:
  type: OS::Nova::Server
  properties:
    image: { get_param: image_id }
```

HOT parameters

```
parameters:

  key_name:
    type: string
    default: my_key

  instance_type:
    type: string
    default: m1.small
    constraints:
      - allowed_values: [m1.tiny, m1.small, m1.medium,
       m1.large, m1.xlarge]
```

Create the infrastructure

```
$ openstack --os-cloud muni-cloud stack create --wait \
        --template pa200.yaml pa200
$ openstack --os-cloud muni-cloud stack list
$ openstack --os-cloud muni-cloud stack show pa200
```

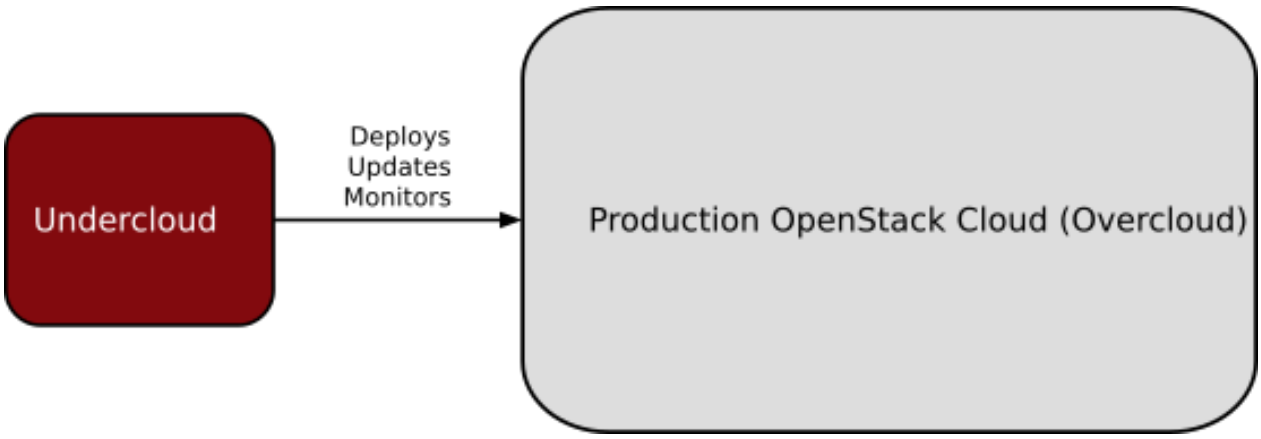
OpenStack administration

- PackStack, Fuel etc
- TripleO

OpenStack-on-OpenStack (1/2)

- Deployment cloud: Undercloud
- Workload cloud: Overcloud

OpenStack-on-OpenStack (2/2)



In this lecture...

- Cloud-naive software architecture
- Containers
- Container orchestration

On-premises applications (1/2)

- Monolithic
- Tied to the infrastructure
- Languages: a Visual Studio language, enterprise Java, Cobol
- Developed in a waterfall model

On-premises applications (2/2)

Problems:

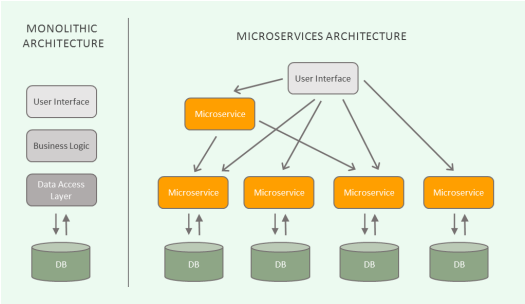
- Hard to scale, migrate, distribute
- Risky updates
- Low code reuse

Cloud-native applications

- Modular and stateless
- Shared resources
- Elastic and redundant by design
- Web-service architecture
- Rolling updates
- Agile, DevOps, CI/CD

Cloud-native: modularity

Microservices



Cloud-native: multitenancy

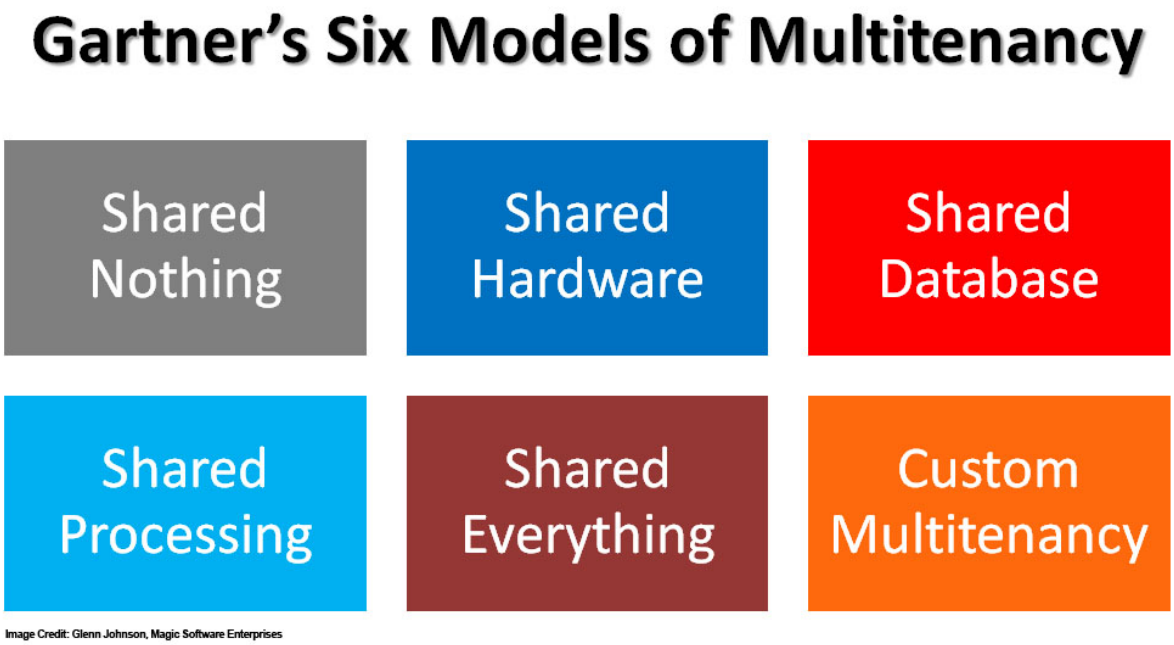


Image Credit: Glenn Johnson, Magic Software Enterprises

Cloud-native: elasticity and redundancy

- Services accommodate work load
- Services migrate towards the clients
- Service instances ensure redundancy

Cloud-native: application design

- Modular and task-specific
- Stateless - horizontally scalable
- REST API RPC
- Application databases
- Web-centric languages (Go, Python, Node.js, Ruby etc.)
- Configure from cloud

Cloud-native: rolling updates

- Frequent, minor per-service updates
- Redundancy to replace updating instances
- CI/CD automation to ensure code quality

Cloud-native: team changes

- Service-centric teams
    - Cross-team collaboration
- Agile, minimal viable product development
    - Software developers <-> customers
- Software development & IT operations (DevOps)
    - System administrators <-> software developers

Cloud-native: tooling

- Multiple teams - multiple tools
- Toolchains:
    - Source code management
    - Continuous integration and testing
    - Infrastructure as a code

Cloud-native: CI/CD

- Continuous integration
    - Test every change
- Continuous delivery
    - Stage every change
- Continuous deployment
    - Automatic release

Cloud-native challenges

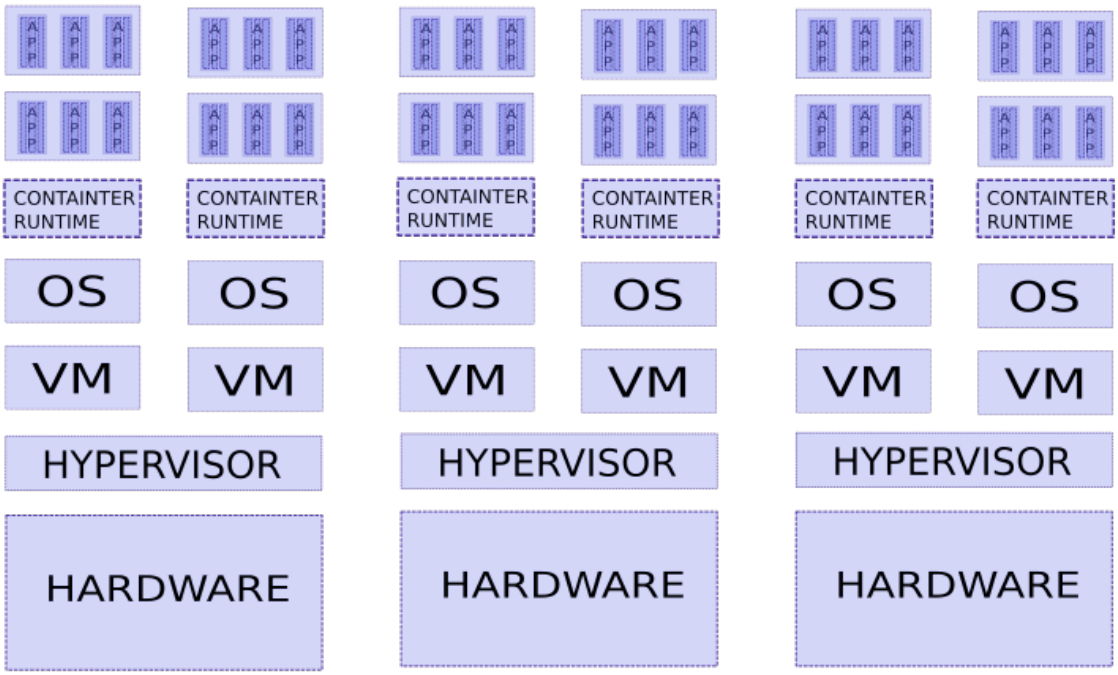
- Root cause analysis/debugging/testing
- Logging/monitoring
- Security
- Expensive changes to legacy apps & teams

Containers: agenda

- Concurrency and isolation
- OS-level virtualization
- Container orchestration

Concurrency and isolation

Multiple systems, VMs, containers, processes, threads



Containers vs VMs

- Containers: share kernel
- VMs: share physical hardware

Linux containers

Based on kernel features:

- Namespaces present resources to process
- Cgroups govern resource isolation and usage
- Container is temporary and transient, much like a process

Examples: LXC, Docker, OpenVZ

Docker to manage containers

Docker concepts

- Dockerfile to build Docker image
- Docker image to run the container(s)
- Containers are live image instances

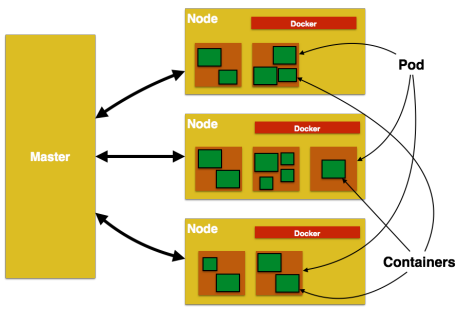
Docker features

- Container is temporary and transient, but it can be
  - deployed, suspended, replicated, moved, backed up etc.
- Docker Hub shares Docker images
- Docker Compose hitches containers on the same host
- Docker Swarm orchestrates multi-node deployments
  - Clustering, redundancy, load-balancing etc.

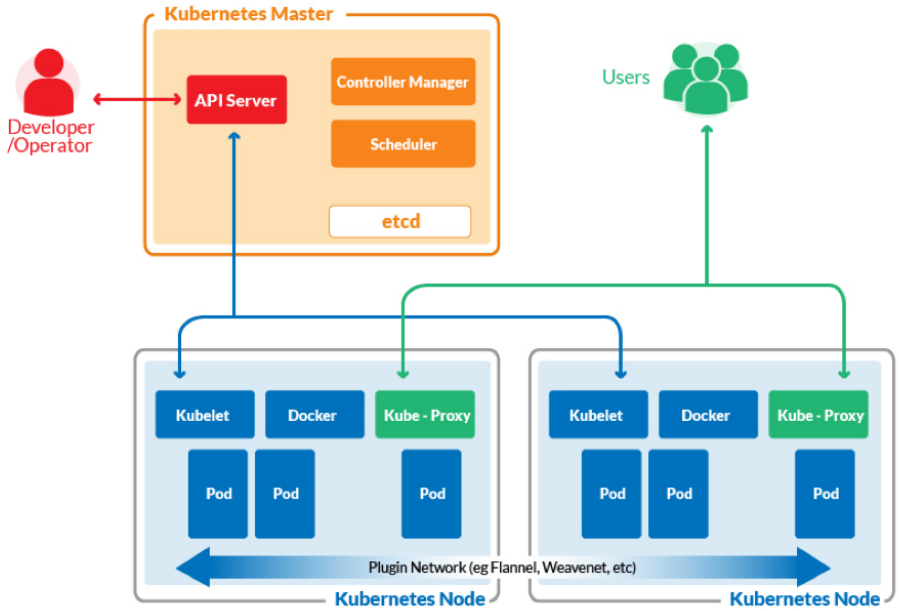
Container orchestration: Kubernetes (1/3)

- Cluster
  - master + nodes (on bare metal or VMs)
  - nodes run pods
- Pods
  - Pod contains one+ containers
  - Application runs in its pod
- Controllers
  - Pod management logistics (e.g. Deployment, StatefulSet)
- Services
  - Represent application to the world

Container orchestration: Kubernetes (2/3)



Container orchestration: Kubernetes (3/3)



Kubernetes pros&cons

- Automates application maintenance
    - Deployment (e.g. Helm), health, balances load, resilience
- Simplifies management of shared resources
    - Storage, secrets etc.
- Utilizes hardware resources
    - Soft & hard limits per-app
- Learning curve is high

Kubernetes vs Docker

- Docker (prior to Swarm) builds and run containers locally
- Kubernetes orchestrates multiple nodes
- Docker and Kubernetes may or may not be used together

The alternatives

- Alternatives to Docker
    - rkt, LXC etc.
- Alternatives to Kubernetes
    - Docker Swarm, Apache Mesos etc.

Containers are on the rise

- Facilitates microservices design
- Portability
- Composability and throttling
- Easy scaling

Containers challenges

- Keeping software up to date is difficult
- Isolation can be insufficient
- Overhead can be noticeable

Recap: cloud software architecture

- Requires changes in software design towards:
    - Modularity
    - Statelessness
    - Automatic testability
- Requires changes in team work
    - Team focusing on service
    - Agile, MVP
    - DevOps

Recap: containers

- Container for concurrency and isolation
- Docker for container lifecycle automation
- Kubernetes for container-based clouds

Questions

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