Kubernetes Security and Hardening

Cyber Protection Developer's Conference
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kubernetes

$ whoami - Orlix

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Agenda

- Cloud Native Computing Foundation and CNCF Bulgaria
- Short Intro to Kubernetes
- Container Security
- Kubernetes Security
- Demo – kube-bench/sonoboy
- Q&A

Goals of this talk

- Raise awareness of high-risk attacks possible in many installs
- Demonstrate few attacks
- Provide hardening methods
- Share additional hardening tips

CNCF - Who “Manages” Kubernetes?

CLOUD NATIVE
COMPUTING FOUNDATION

The CNCF is a child entity of the Linux Foundation and operates as a vendor neutral governance group.

kubernetes

CNCF - “few” other projects

Graduated

kubernetes
Orchestration

Prometheus
Monitoring

envoy
Service Proxy

Incubating

OPENTRACING
Distributed Tracing API

fluentd
Logging

GRPC
Remote Procedure Call

containerd
Container Runtime

rkt
Container Runtime

JAEGER
Distributed Tracing

notary
Security

Vitess
Storage

CoreDNS
Service Discovery

NATS
Messaging

LINKERD
Service Mesh

HARBOR
Registry

HELM
Package Management

CNI
Networking API

ROOK
Storage

etcd
Key/Value Store

TUF
Software Update Spec

kubernetes

CNCF Bulgaria

- 7 meetups
- +500 members(525 on 20.01.2019)
- Meetup: https://goo.gl/16bF3X
- YouTube: https://goo.gl/88yH4n
- CFP: https://goo.gl/TfVEMc

Vladimir Dimov

Spas Atanasov

kubernetes

Kubernetes 101
(or even shorter)

What Does “Kubernetes” Mean?

Greek for “pilot” or
“Helmsman of a ship”

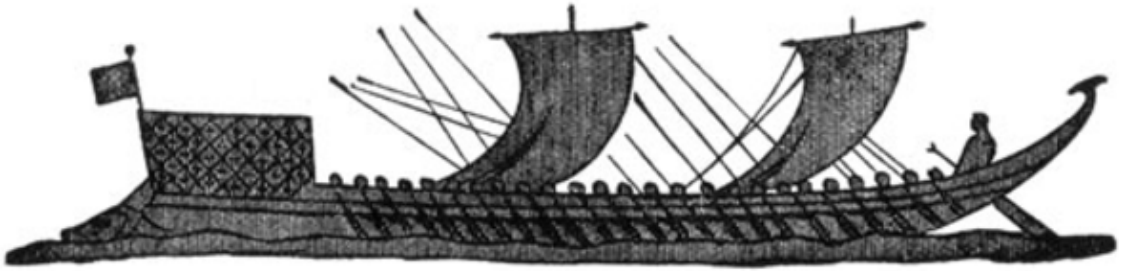

Image Source

kubernetes

What is Kubernetes?

- Project that was spun out of Google as an open source container orchestration platform.
- Built from the lessons learned in the experiences of developing and running Google's Borg and Omega.
- Designed from the ground-up as a **loosely coupled** collection of components centred around deploying, maintaining and scaling workloads.

Self Healing

Kubernetes will **ALWAYS** try and steer the cluster to its desired state.

- **Me:** “I want 3 healthy instances of redis to always be running.”
- **Kubernetes:** “Okay, I’ll ensure there are always 3 instances up and running.”
- **Kubernetes:** “Oh look, one has died. I’m going to attempt to spin up a new one.”

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Project Stats

- Over 42,000 stars on Github
- 1800+ Contributors to K8s Core
- Most discussed Repository by a large margin
- **50,000+** users in Slack Team

What can Kubernetes REALLY do?

- Autoscale Workloads
- Blue/Green Deployments
- Fire off jobs and scheduled cronjobs
- Manage Stateless and Stateful Applications
- Provide native methods of service discovery
- Easily integrate and support 3rd party apps

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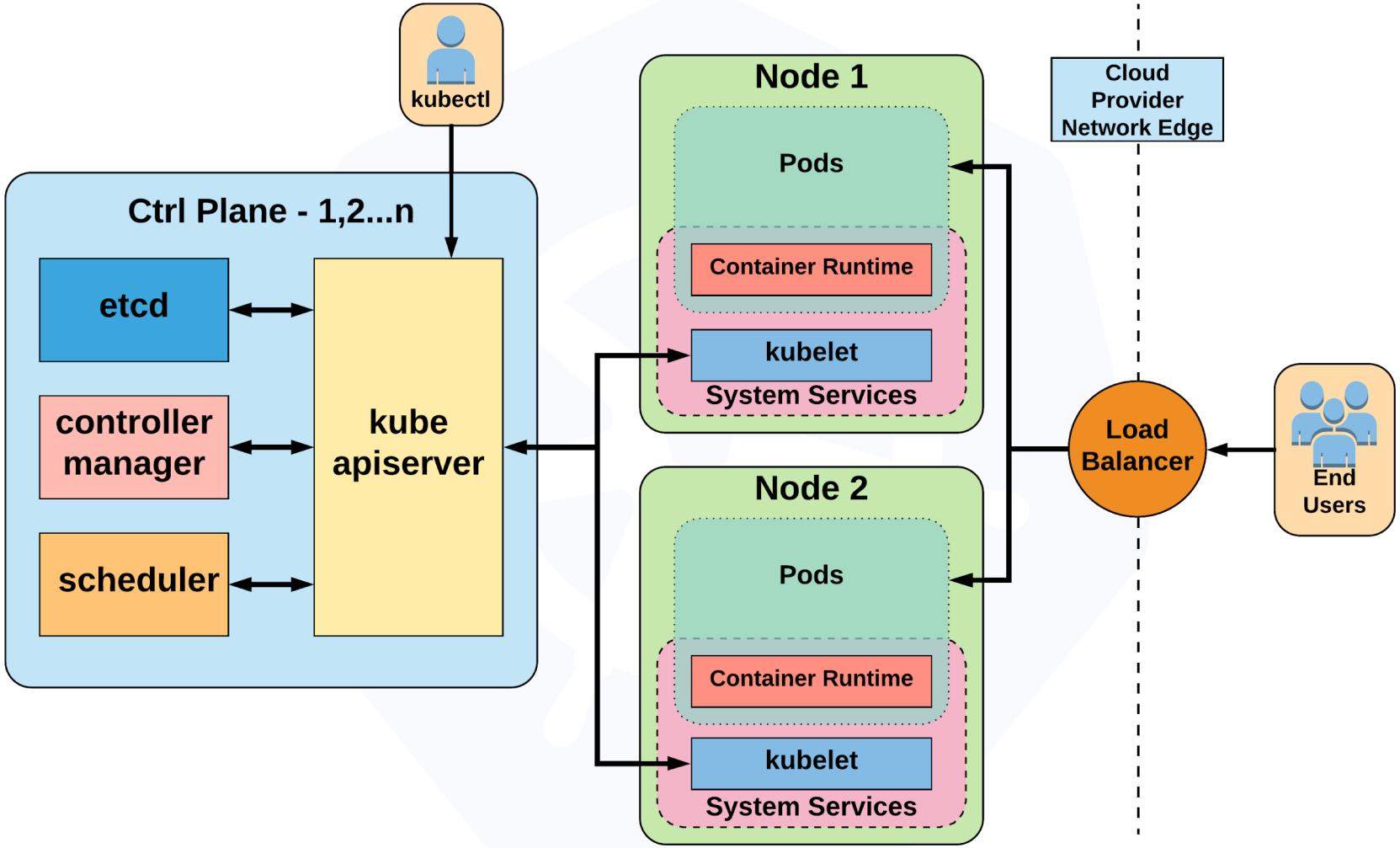
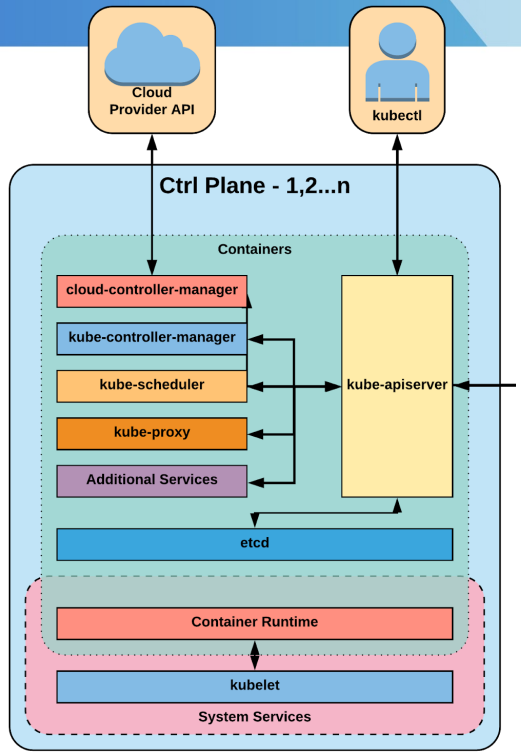
Architecture Overview


kubectl
Ctrl Plane - 1,2...n
etcd
controller manager
scheduler
kube apiserver
Node 1
Pods
Container Runtime
kubelet
System Services
Node 2
Pods
Container Runtime
kubelet
System Services
Cloud Provider Network Edge
Load Balancer
End Users

Control Plane Components

- kube-apiserver
- etcd
- kube-controller-manager
- kube-scheduler



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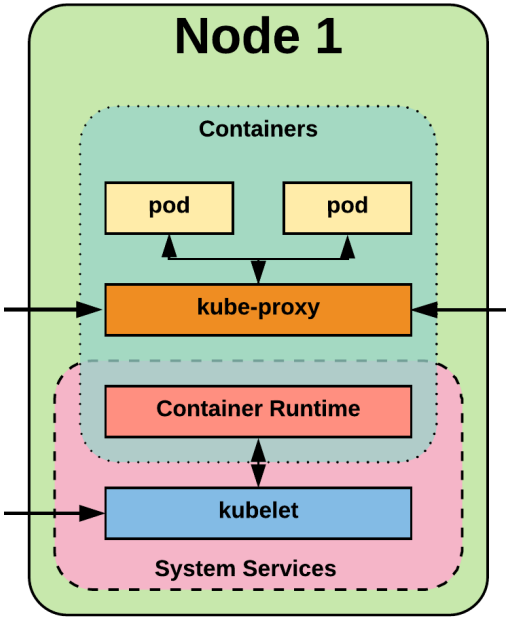
Node Components

- kubelet
- kube-proxy
- Container Runtime Engine



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A Couple Key Concepts...

Kubernetes Objects

Basic:

- Pod
- Service
- Volume
- Namespace

More:

- ReplicaSet
- Deployment
- StatefulSet
- DaemonSet
- Job
- ….

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Namespaces

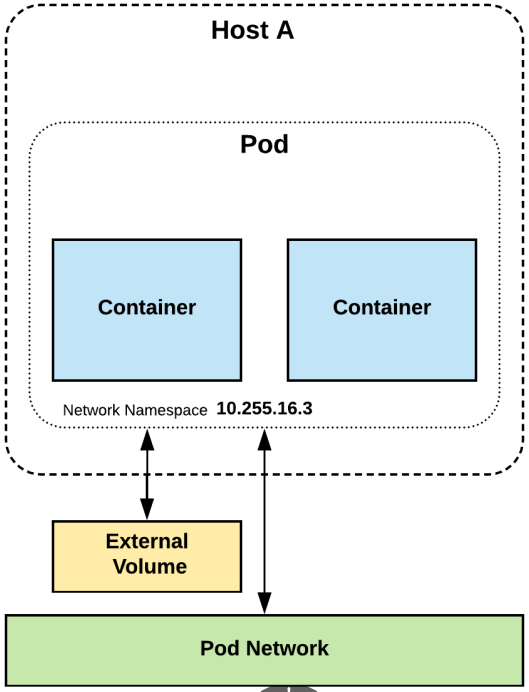
Namespaces are a logical cluster or environment, and are the primary method of partitioning a cluster or scoping access.

```yaml
apiVersion: v1
kind: Namespace
metadata:
  name: prod
  labels:
    app: MyBigWebApp
```

```
$ kubectl get ns --show-labels
NAME        STATUS   AGE    LABELS
default     Active   11h    <none>
kube-public Active   11h    <none>
kube-system Active   11h    <none>
prod        Active   6s     app=MyBigWebApp
```

Pod

- **Atomic unit** or smallest "*unit of work*"of Kubernetes.
- Pods are **one or MORE containers** that share volumes, a network namespace, and are a part of a **single context**.
- **Ephemeral**



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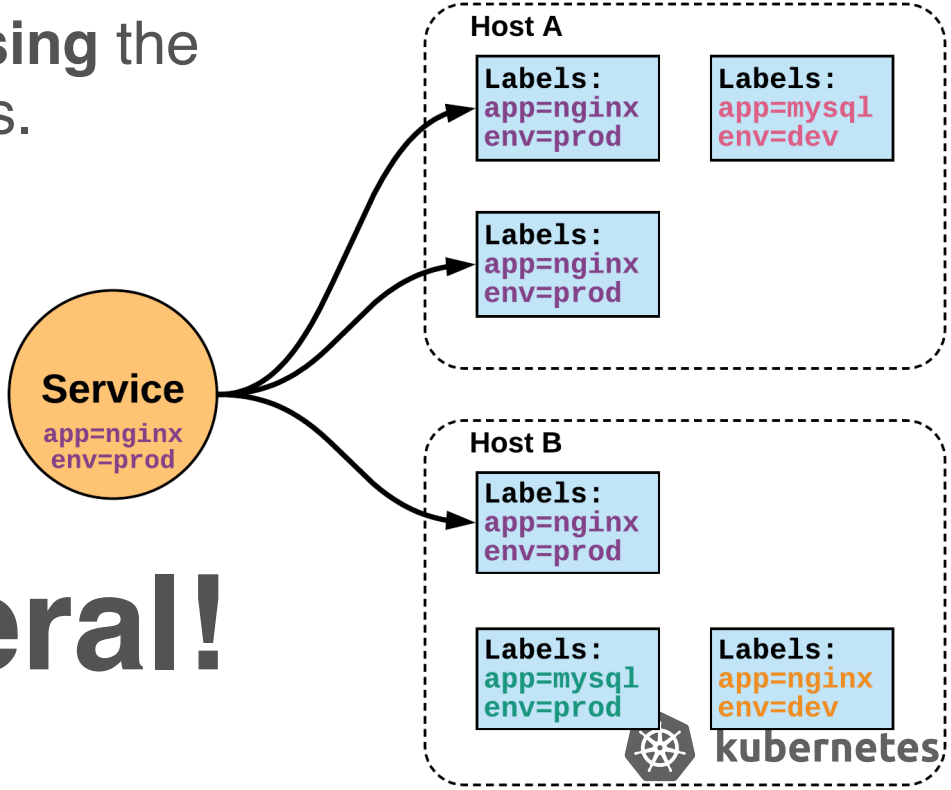
Services

- **Unified method of accessing** the exposed workloads of Pods.
- **Durable resource**
  - static cluster IP
  - static namespaced DNS name



NOT Ephemeral!

Containers and Kubernetes Security and Benchmarking

Goals of this talk

- Raise awareness of high-risk attacks possible in many installs
- Demonstrate few attacks
- Provide hardening methods
- Share additional hardening tips

Possible Attack Surface

Launch too many pods / high consume CPU/RAM/ Disk

Malicious Image, Compromised Container

Escape the container

Service Account Tokens

Dashboard Access

Direct Etcd Access

Kubelet Exploit

Application Tampering

Metrics Scraping

Metadata API

Underlying Infrastructure (On-Prem or Public Cloud)

Host security(OS)

Docker daemon security(or containerd, rkt, CRI-O …)

Container security

kubernetes

Container Security

- Container Runtime - Least Privileges
- Base Image
- Image Builder/Maintainer
- Image Scanning
- Image Signing
- do not run as root in container

```
RUN useradd -r -u 1001 -g appuser appuser
USER appuser
```

Few Kubernetes Security Aspects

- Kubernetes security:
  - Properly configured RBACs
  - Secrets
  - Pod Security Policy
  - Network Policy
  - Admission Controllers
  - etc…

  - If running in Public Cloud - protect Metadata API

Kubernetes RBAC

- enabled in kube-api : —authorization-mode=RBAC
- Role and ClusterRole
- RoleBinding and ClusterRoleBinding
- ServiceAccounts

Tips

- use audit logs to monitor activities

Role and RoleBinding

```yaml
kind: Role
apiVersion: rbac.authorization.k8s.io/v1
metadata:
  namespace: default
  name: pod-reader
rules:
- apiGroups: [""] # "" indicates the core API group
  resources: ["pods"]
  verbs: ["get", "watch", "list"]
```

```yaml
kind: RoleBinding
apiVersion: rbac.authorization.k8s.io/v1
metadata:
  name: read-pods
  namespace: default
subjects:
- kind: User
  name: jane # Name is case sensitive
  apiGroup: rbac.authorization.k8s.io
roleRef:
  kind: Role #this must be Role or ClusterRole
  name: pod-reader #must match name
  apiGroup: rbac.authorization.k8s.io
```

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Kubernetes Secrets

- A Secret is an object that contains a small amount of sensitive data such as a password, a token, or a key.
- base64ed
- consumed within a pod as volumeMounts
- secrets used to keep docker login information for private registry
- use secrets instead of writing sensitive data in the containers

```
apiVersion: v1
data:
  .dockerconfigjson: eyJhdXRocyI6eyJk...(long base64)
kind: Secret
metadata:
  name: regcred
  namespace: secconf
type: kubernetes.io/dockerconfigjson
```

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PodSecurityPolicy

- Enforced by the PodSecurityPolicy admission controller enabled on kube-api
- PSP is an ClusterLevel resource
- Set of conditions which allows a pod to be run
- some examples
  - privileged
  - runAsUser
  - hostPID
  - volumes

Tips:

- create PSP before enabling PSP admission controller
- PSP are applied alphabetically

```
apiVersion: policy/v1beta1
kind: PodSecurityPolicy
metadata:
  name: privileged
  annotations:
    seccomp.security.alpha.kubernetes.io/allowedProfileNames: '*'
spec:
  privileged: true
  allowPrivilegeEscalation: true
  allowedCapabilities:
  - '*'
  volumes:
  - '*'
  hostNetwork: true
  hostPorts:
  - min: 0
    max: 65535
  hostIPC: true
  hostPID: true
  runAsUser:
    rule: 'RunAsAny'
  seLinux:
    rule: 'RunAsAny'
  supplementalGroups:
    rule: 'RunAsAny'
  fsGroup:
    rule: 'RunAsAny'
```

Usage via RBAC with ClusterRoles and ClusterRoleBindings to ServiceAccount or User

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Network Policy

A network policy is a specification of how groups of pods are allowed to communicate with each other and other network endpoints.

Uses labels to select pods and define rules.

NetworkPolicy needs network plugin which supports it.(calico/weave..)

By default, if no policies exist in a namespace, then all ingress and egress traffic is allowed to and from pods in that namespace.

NetworkPolicy example

```yaml
apiVersion: networking.k8s.io/v1
kind: NetworkPolicy
metadata:
  name: test-network-policy
  namespace: default
spec:
  podSelector:
    matchLabels:
      role: db
  policyTypes:
  - Ingress
  - Egress
  ingress:
  - from:
    - ipBlock:
        cidr: 172.17.0.0/16
        except:
        - 172.17.1.0/24
    - namespaceSelector:
        matchLabels:
          project: myproject
    - podSelector:
        matchLabels:
          role: frontend
  ports:
  - protocol: TCP
    port: 6379
  egress:
  - to:
    - ipBlock:
        cidr: 10.0.0.0/24
  ports:
  - protocol: TCP
    port: 5978
```

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CIS Kubernetes Benchmark

- 200+ pages of best practices and tests
  https://www.cisecurity.org/benchmark/kubernetes/
- Tests for workers, masters and federated nodes

- **kube-bench** (Aqua Security)
  - 1265 stars on GitHub
  - ~30 contributors
  - https://github.com/aquasecurity/kube-bench

more tools

- **sonobuoy**(heptio)
  - 1141 stars on GitHub
  - 33 contributors
  - https://github.com/heptio/sonobuoy
- **kubeaudit** (shopify)
  - 306 stars on GitHub
  - 16 contributors
  - https://github.com/Shopify/kubeaudit
- **k8guard**
  - 122 stars on GitHub
  - 8 contributors
  - https://github.com/k8guard/k8guard-start-from-here

Demo

Demo 1 - scraping unsecured metrics
Demo 2 - exploiting misconfigured taints for master
Demo 3 - exploiting the lack of PSP

aliases:
k = kubectl
kdp = kubectl describe pods
kep = kubectl edit pod
kgn = kubectl get nodes —show-lables -o wide
lp = kubectl get pods
lpa = kubectl get pods —all-namespaces
kshell = kubectl exec -it $$ bash
kn = kubens

General Guidance

1. Verify that all your security settings properly enforce the policy
2. Use the latest stable K8s version possible to gain the latest security capabilities and fixes
3. Audit the OS, container runtime, and K8s configuration using CIS Benchmarking and other tools like kube-auto-analyzer and kube-bench
4. Log ***everything*** to a location outside the cluster

Image Security

1. Use private registries, and restrict public registry usage
2. Scan all images for security vulnerabilities continuously. E.g CoreOS Clair or Atomic Scan
3. Decide which types/severity of issues should prevent deployments
4. Maintain standard base images and ensure that all workloads use them
5. *Do NOT run containers as the root user*

K8s Components Security

1. API Server *authorization-mode=Node,RBAC*
2. Ensure all services are protected by TLS
3. Ensure *kubelet* protects its API via *authorization-mode=Webhook*
4. Ensure the *kube-dashboard* uses a restrictive *RBAC* role policy and v1.7+
5. Closely monitor all *RBAC* policy failures
6. Remove default *ServiceAccount* permissions

Network Security

1. Filter access to the cloud provider metadata APIs/URL, and Limit IAM permissions
2. Use a CNI network plugin that filters ingress/egress pod network traffic
   a. Properly label all pods
   b. Isolate all workloads from each other
   c. Prevent workloads from egressing to the Internet, the Pod IP space, the Node IP subnets, and/or other internal networks
   d. Restrict all traffic coming into the kube-system namespace except kube-dns
3. Consider a Service Mesh!

Hardening Tips (Continued)

Workload Containment and Security

1. Namespaces per tenant
2. Default network “deny” inbound on all namespaces
3. Assign CPU/RAM *limits* to all containers
4. Set *automountServiceAccountToken: false* on pods where possible
5. Use a *PodSecurityPolicy* to enforce container restrictions and to protect the node
6. Implement container-aware malicious activity / behavioral detection

Misc Security

1. Collect logs from all containers, especially the RBAC access/deny logs
2. Encrypt the contents of *etcd*, and run *etcd* on dedicated nodes
3. Separate Cloud accounts/VPCs/projects/resource groups
4. Separate clusters for dev/test and production environments
5. Separate node pools for different tenants

Resources and goodreads

- https://github.com/kelseyhightower/kubernetes-the-hard-way
- https://github.com/hardening-kubernetes/from-scratch
- https://github.com/cncf/presentations/tree/master/
- https://goo.gl/TNRxtd

Q&A