// 3 THINGS EVERY DEVELOPER SHOULD KNOW ABOUT K8S SECURITY

JOHANNES SCHNATTERER

CLOUDOGU GMBH

@JSCHNATTERER

VERSION: 201909181109-A3A4A9D

Requirements for dev and ops

https://iso25000.com/images/figures/en/iso25010.png

End of Budget / Close to Deadline

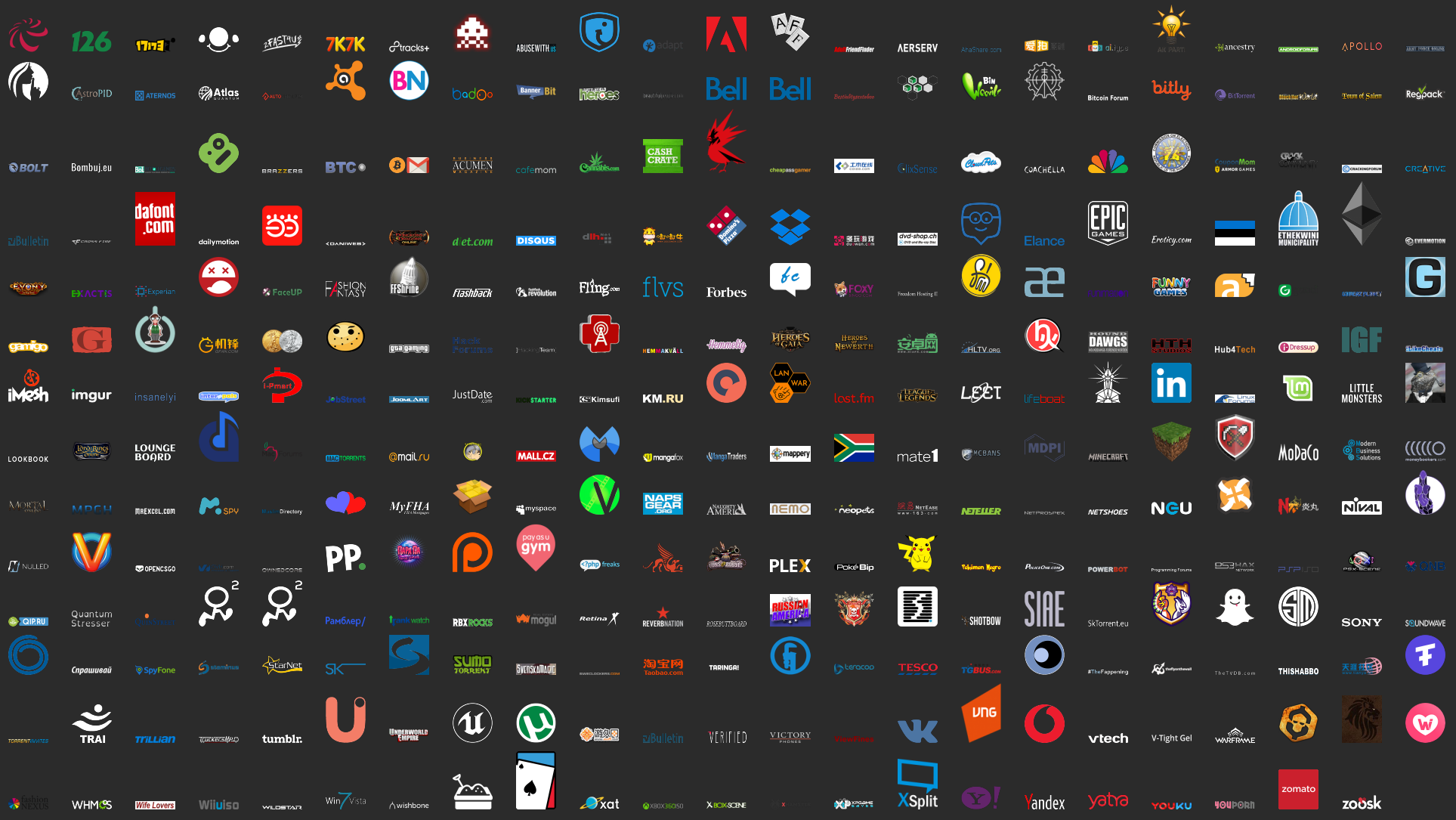
End of Budget / Close to Deadline

Don't try this at home!

Otherwise

You might make the news...

Like so many others



https://haveibeenpwned.com/PwnedWebsites

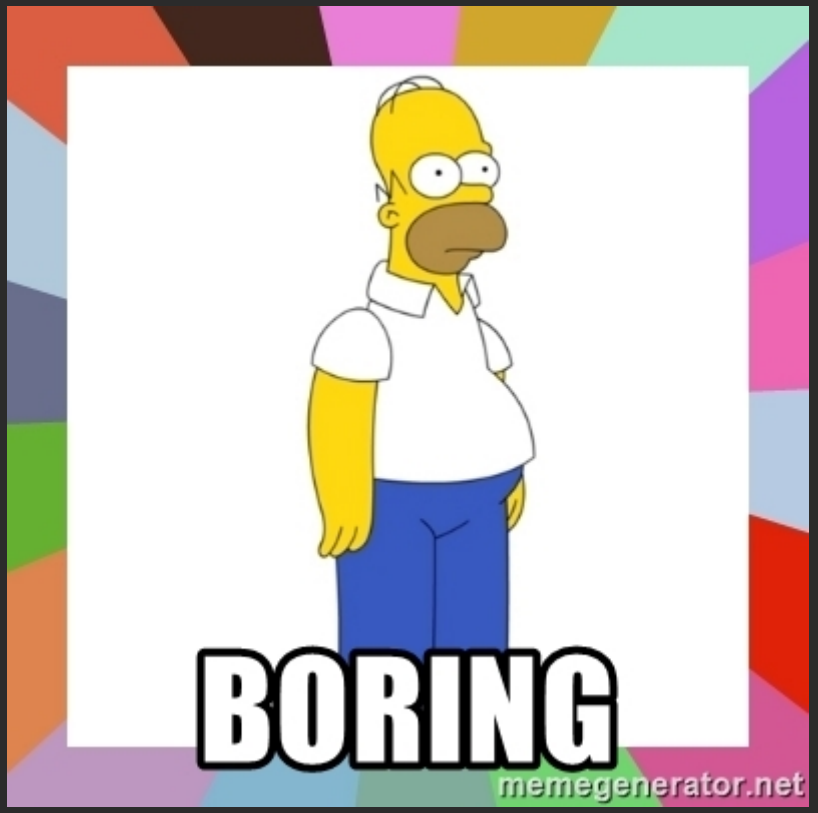
Plenty of security options


securityContextrunAsNonRoot
runAsUser
privileged
procMount
allowPrivilegeEscalation
readOnlyRootFilesystem
PodSecurityPolicy
RBAC
seccomp
Linux Capabilities
AppArmor
SELinux
Falco
Open Policy Agent
NetworkPolicy
gVisor
Kata Containers
Nabla Containers
Service Mesh
mTLS
KubeSec
KubeBench
kubetest
Clair
Vault
Grafeas
notary
Bastion Host
Certificate Rotation
Threat detection
SecOps

3 things every developer should know about K8s security

- a very opinionated list of actions that make a huge difference with manageable effort
- distilled from the experience of the last years developing and operating apps on k8s

1. RBAC



https://memegenerator.net/instance/83566913/homer-simpson-boring

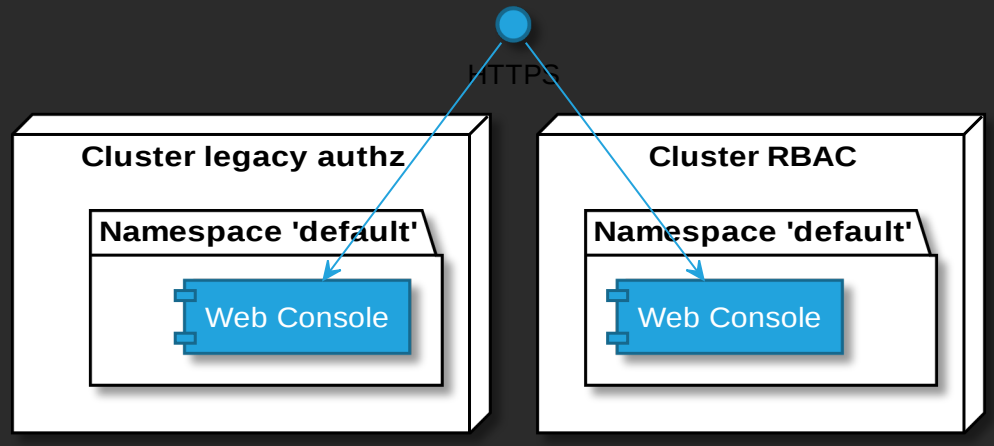
- RBAC active by default since K8s 1.6
- ... but not if you migrated!

- Every Container is mounted the token of its service account at `/var/run/secrets/kubernetes.io/serviceaccount/token`
  - With RBAC the default service account is only authorized to read publicly accessible API info
  - ⚠️ With legacy authz the default service account is cluster admin
- You can test if your pod is authorized by executing the following in it:

```
curl --cacert /var/run/secrets/kubernetes.io/serviceaccount/ca.crt \
  -H "Authorization: Bearer $(cat /var/run/secrets/kubernetes.io/serviceaccount/token)" \
  https://${KUBERNETES_SERVICE_HOST}/api/v1/secrets
```

- If a pod does not need access to K8s API, mounting the token can be disabled in the pod spec: `automountServiceAccountToken: false`

Demo



- legacy-authz
- RBAC

2. Network Policies (`netpol`)

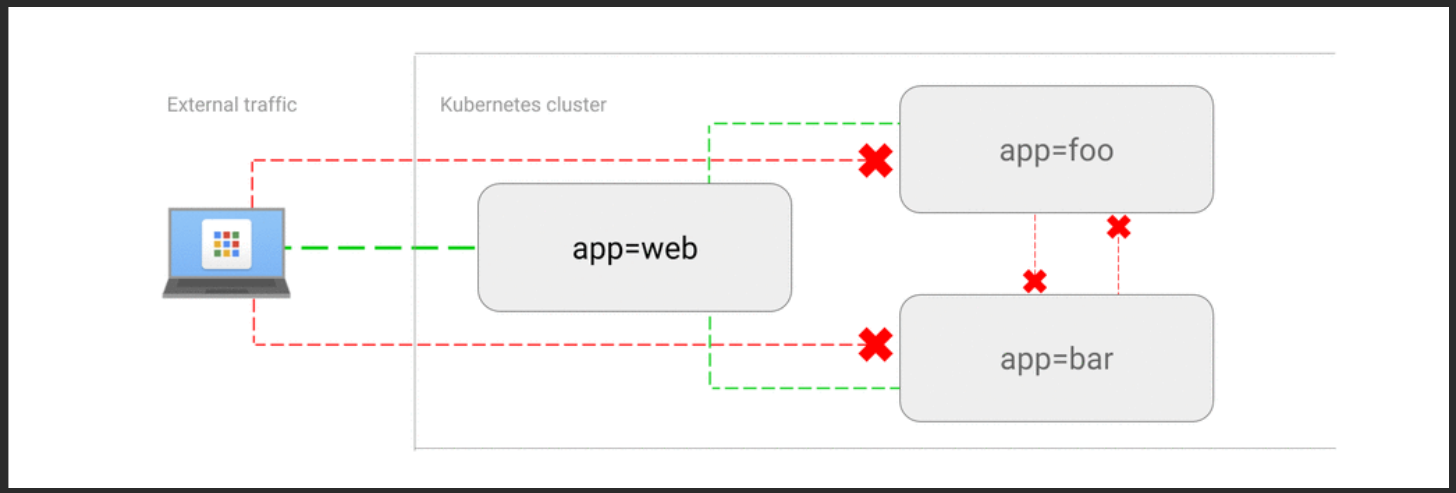
A kind of firewall for communication between pods.

- Apply to pods (`podSelector`)
  - within a namespace
  - via labels
- Ingress or egress
  - to/from pods (in namespaces) or CIDRs (egress only)
  - for specific ports (optional)
- Are enforced by the CNI Plugin (e.g. Calico)
- ⚠️ No Network Policies: All traffic allowed

Recommendation: Whitelist ingress traffic

In every namespace except `kube-system`:

- Deny all ingress traffic between pods ...
- ... and then whitelist all allowed routes.



https://github.com/ahmetb/kubernetes-network-policy-recipes

See also: Securing Cluster Networking with Network Policies - Ahmet Balkan
https://www.youtube.com/watch?v=3gGpMmYeEO8

Advanced: ingress to `kube-system` namespace

⚠️ You might stop the apps in your cluster from working

For example, don't forget to:

- Allow external access to ingress controller
  (otherwise no more external access on any cluster resource)
- Allow access to kube-dns/core-dns to every namespace
  (otherwise no more service discovery by name)

Advanced: egress

- Verbose solution:
  - Deny all egress traffic between pods ...
  - ... and then whitelist all allowed routes...
  - ... repeating all ingress rules. 😕
- More pragmatic solution:
  - Allow only egress traffic within the cluster...
  - ... and then whitelist pods that need access to the internet.

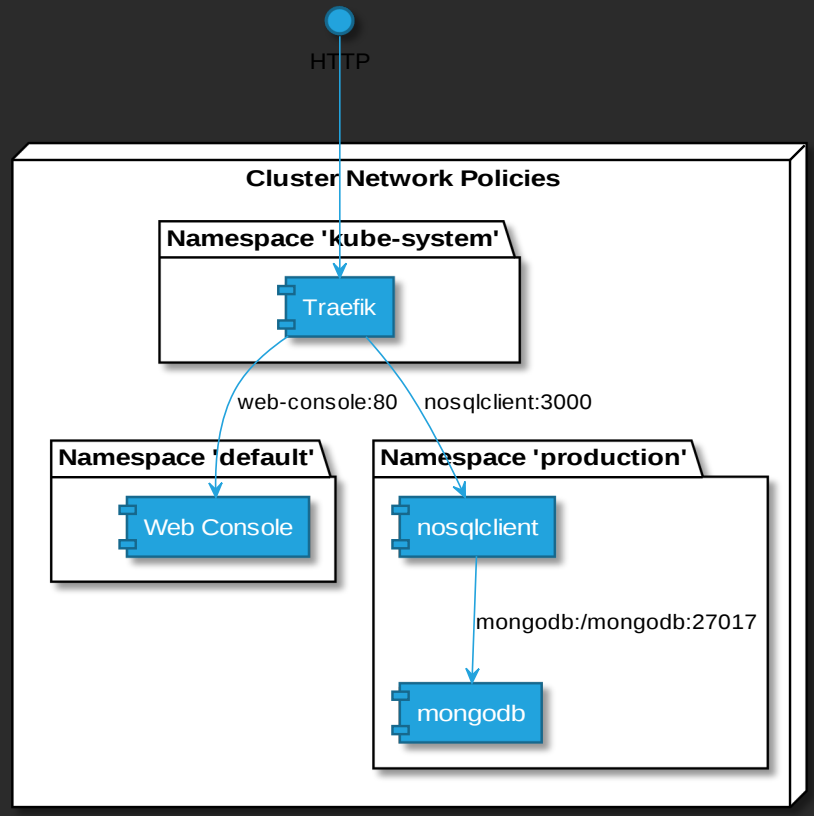
Net pol pitfalls

- Don't forget to whitelist your monitoring tools (e.g. Prometheus)
- A restart of the pods might be necessary for the netpol to become effective (e.g. Prometheus)
- In order to match namespaces, labels need to be added to the namespaces, e.g.

```
kubectl label namespace/kube-system namespace=kube-system
```

- Matching both pods and namespace is only possible from k8s 1.11+
- Restricting `kube-system` might be more of a challenge (DNS, ingress controller)
- `egress` rules are more recent feature than `ingress` rules and seem less sophisticated
- Policies might not be supported by CNI Plugin.
  Make sure to test them!
  https://www.inovex.de/blog/test-kubernetes-network-policies/
- On GKE: "at least 2 nodes of type n1-standard-1" are required

Demo



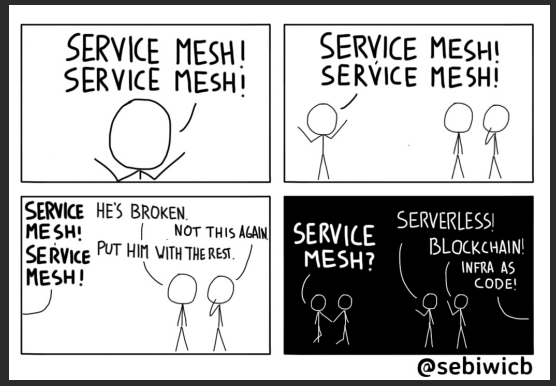
- nosqlclient
- web-console

🎁 Wrap-Up: Network Policies

- My recommendations
  - Definitely use DENY all ingress rule in non-`kube-system` namespaces
  - Use with care
    - rules in `kube-system`
    - `egress` rules
- 📌 Helpful to get started - describe what a netpol does:
  `kubectl describe netpol <name>`
- Limitations:
  - netpols will not work in multi-cloud / cluster-federation scenarios
  - Service Meshes provides similar features and work also work with multiple clusters

🎁 Wrap-Up: Network Policies

- My recommendations
  - Definitely use DENY all ingress rule in non-`kube-system` namespaces
  - Use with care
    - rules in `kube-system`
    - `egress` rules
- 📌 Helpful to get started - describe what a netpol does:
  `kubectl describe netpol <name>`
- Limitations:
  - netpols will not work in multi-cloud / cluster-federation scenarios
  - Service Meshes provides similar features and work also work with multiple clusters



🌐 https://twitter.com/sebiwicb/status/962963928484630530

3. Security Context

> Defines privilege and access control settings for a Pod or Container

https://kubernetes.io/docs/tasks/configure-pod-container/security-context/

Recommendation per Container

- `allowPrivilegeEscalation: false`
  - mitigates a process within the container from gaining higher privileges than its parent (the container process)
  - E.g. `sudo`, `setuid`, Kernel vulnerabilities
- `runAsNonRoot` - Container is not started when the user is root
- `readOnlyRootFilesystem: true`
  - Mounts the whole file system in the container read-only. Writing only allowed in volumes.
  - Makes sure that config or code within the container cannot be manipulated.
  - It's also more efficient (no CoW).

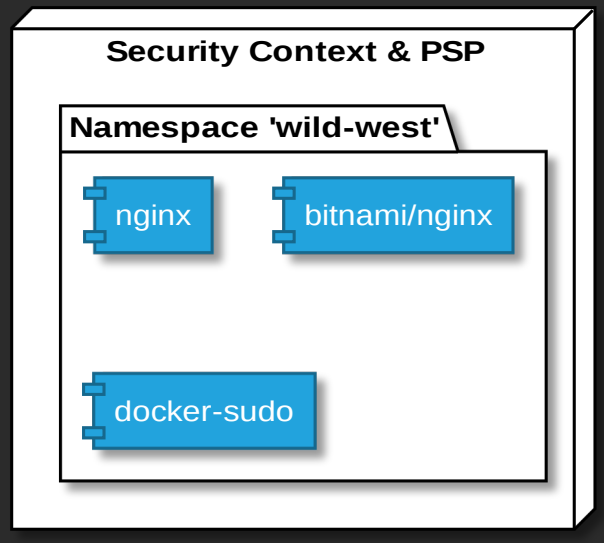
```yaml
apiVersion: v1
kind: Pod
#...
spec:
  containers:
  - name: cntnr
    securityContext:
      runAsNonRoot: true
      allowPrivilegeEscalation: false
      readOnlyRootFilesystem: true
```

There is also a `securityContext` on pod level, but those settings cannot be applied there.

Security context pitfalls

- `readOnlyRootFilesystem` - most applications need temp folders to write to
  - Run image locally using docker, access app (📌 run automated e2e/integration tests)
  - Then use `docker diff` to see a diff between container layer and image
  - and mount all folders listed there as `emptyDir` volumes in your pod
- `runAsNonRoot`
  - Non-root verification only supports numeric user. 😕
    Either set e.g.
    - `runAsUser: 1000` in `securityContext` of pod or
    - `USER 1000` in `Dockerfile` of image.
  - Some official images run as root by default.
    Possible solutions:
    - Find a **trusted** image that does not run as root
      e.g. for nginx, or postgres: https://hub.docker.com/r/bitnami/
    - Derive from the original image and create your own non-root image
      e.g. nginx: https://github.com/schnatterer/nginx-unpriv

Demo


Security Context & PSP
Namespace 'wild-west'
nginx
bitnami/nginx
docker-sudo

🎁 Wrap-Up: Security Context

My recommendations

- Security Context
  - Start with `readOnlyRootFilesystem`, `runAsNonRoot` and `allowPrivilegeEscalation: false`
  - Only differ if there's absolutely no other way
- BTW - you can enforce Security Context Settings by using Pod Security Policies.
  However, those cause a lot more effort to maintain.

Summary

IMHO ever person working with k8s should *at least* adhere to the following:

- Enable RBAC!
- Don't allow arbitrary connection between pods.
  (e.g use Network Policies to whitelist ingresses)
- Don't allow privilege escalation via the security context of each container
- Try to run your containers
  - as non-root user and
  - with a read-only file system.

Johannes Schnatterer

Cloudogu GmbH

https://cloudogu.com/schulungen

https://cloudogu.com/blog

@jschnatterer

@cloudogu

Demo Source: https://github.com/cloudogu/k8s-security-demos