// SECURE BY DEFAULT? PRAGMATICALLY IMPROVE APP SECURITY USING K8S BUILT-INS

Johannes Schnatterer

Cloudogu GmbH

@jschnatterer

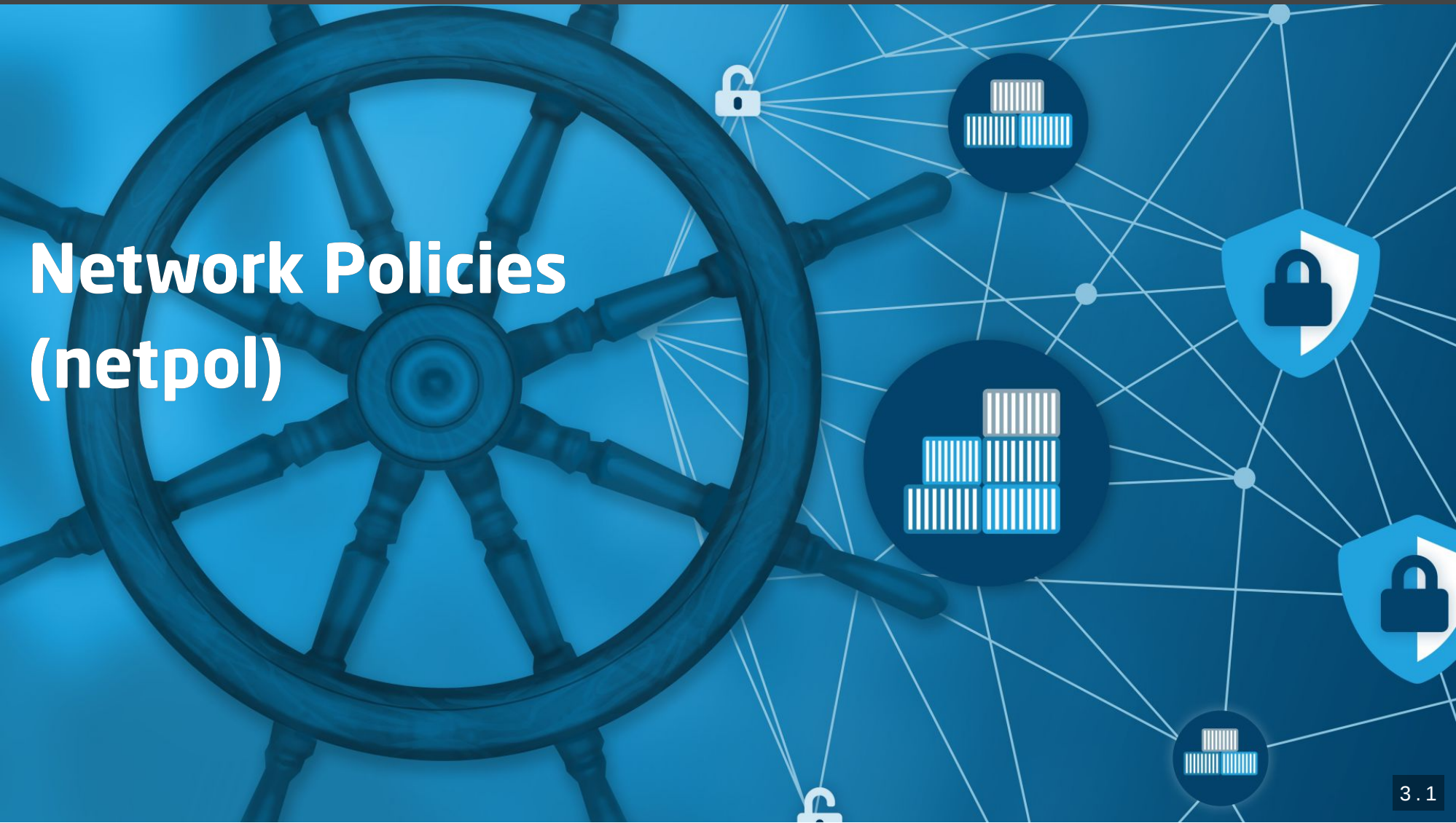
Version: 202010211357-b9d0614

K8s built-in security mechanisms

- Network Policies
- Security Context
- Pod Security Policies

Plenty of Options

- Secure by default?
- How to improve pragmatically?

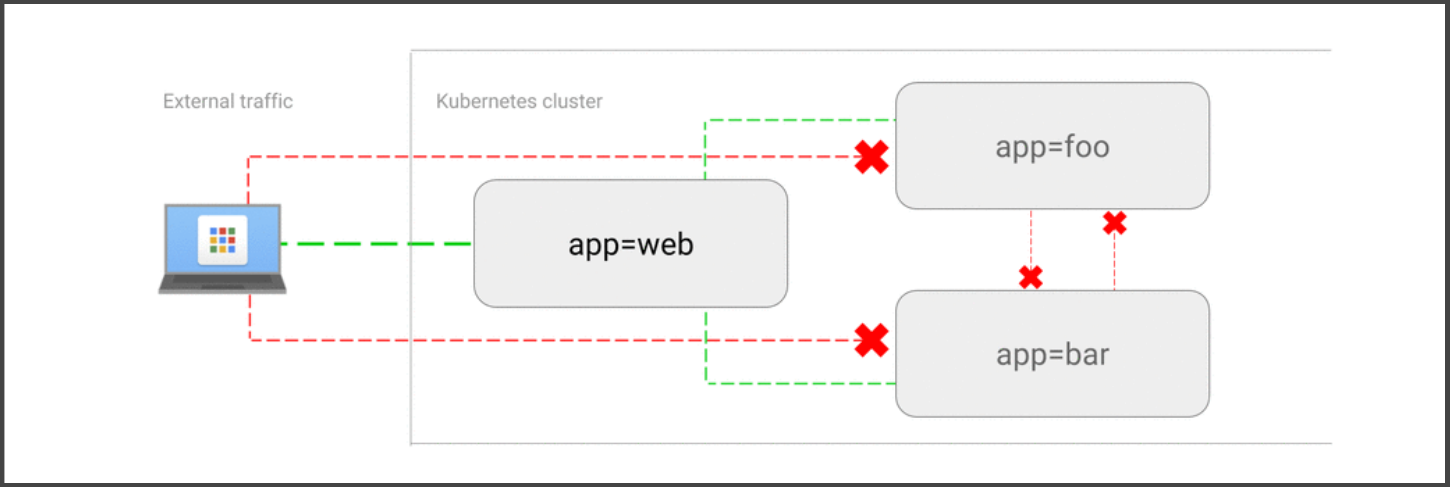


Network Policies (netpol)

A “firewall” for communication between pods.

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

📌 Helpful to get started



- https://github.com/ahmetb/kubernetes-network-policy-recipes
- Interactively describes what a netpol does:

```
kubectl describe netpol <name>
```

Recommendation: Restrict ingress traffic

In all application namespaces (not `kube-system`, operators, etc.):

- Deny ingress between pods,
- then allow specific routes only.

Advanced: Restrict egress to the outside

- Verbose solution:
  - Deny egress between pods,
  - then allow specific routes,
  - repeating all ingress rules. 🙄
- More pragmatic solution:
  - Allow only egress within the cluster,
  - then allow specific pods that need access to internet.

⚠️ egress target IP addresses might be difficult to maintain

Advanced: Restrict `kube-system` / operator traffic

⚠️ Might stop the apps in your cluster from working

Don’t forget to:

- Allow external ingress to ingress controller
- Allow access to DNS from every namespace
- Allow DNS egress to the outside (if needed)
- Allow operators egress (Backup, LetsEncrypt, external-dns, Monitoring, Logging, GitOps-Repo, Helm Repos, etc.)

Net pol pitfalls

- Allow monitoring tools (e.g. Prometheus)
- Restart might be necessary (e.g. Prometheus)
- No labels on namespaces by default
- Allowing egress to API server difficult

  https://stackoverflow.com/a/56494510/
- Policies might not be supported by CNI Plugin.

  Testing!

  https://www.inovex.de/blog/test-kubernetes-network-policies/

  https://github.com/inovex/illuminatio

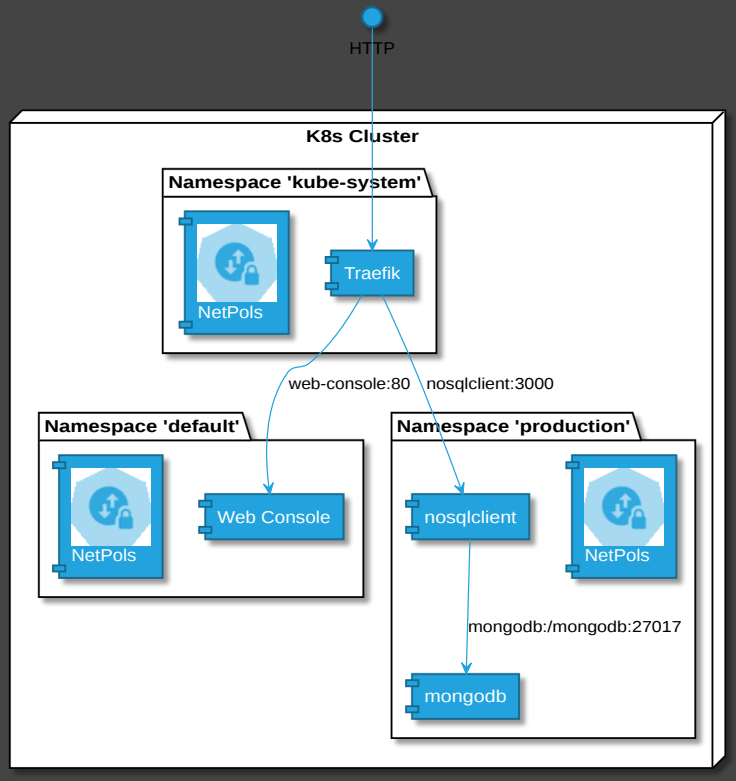
More Features?

- Proprietary extensions of CNI Plugin (e.g. cilium or calico)
- Service Meshes: similar features, also work with multiple clusters

  ➡️ different strengths, support each other (ISO/OSI Layer 7 vs 3/4)

  🌐 https://istio.io/blog/2017/0.1-using-network-policy/

Demo

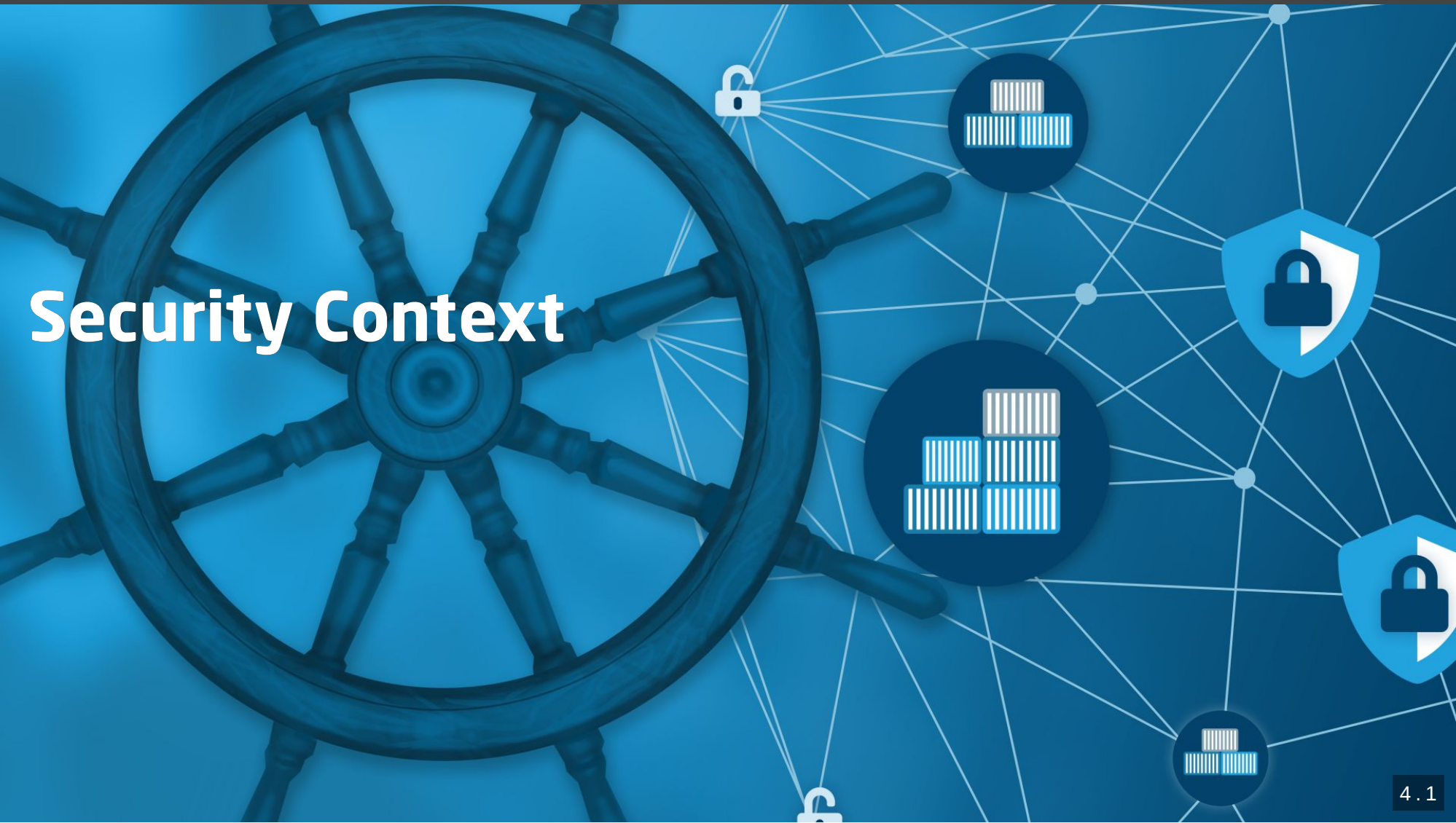


- nosqlclient
- web-console

🎁 Wrap-Up: Network Policies

My recommendations:

- In all application namespaces: restrict ingress traffic
- Use with care
  - restricting `egress` for cluster-external traffic
  - restrict traffic in `kube-system` and for operators



Security Context

- Security Context: Defines security parameters *per pod/container*
  ➡️ container runtime
- ↔️ Cluster-wide security parameters: See Pod Security Policies

Recommendations per Container

```yaml
apiVersion: v1
kind: Pod
metadata:
  annotations:
    seccomp.security.alpha.kubernetes.io/pod: runtime/default # k8s <= 1.18
spec:
  containers:
  - name: restricted
    securityContext:
      runAsNonRoot: true
      runAsUser: 100000
      runAsGroup: 100000
      allowPrivilegeEscalation: false
      readOnlyRootFilesystem: true
      seccompProfile: # k8s >= 1.19
        type: RuntimeDefault
      capabilities:
        drop:
          - ALL
  enableServiceLinks: false
  automountServiceAccountToken: false # When not communicating with API Server
```

Recommendation per Container in Detail

Enable seccomp

- Enables e.g. docker's seccomp default profile that block 44/~300 Syscalls
- 🔥Has mitigated Kernel vulns in past and might in future 🔮
  🌐 https://docs.docker.com/engine/security/non-events/
- See also k8s security audit:
  🌐 https://www.cncf.io/blog/2019/08/06/open-sourcing-the-kubernetes-security-audit/

Run as unprivileged user

- `runAsNonRoot: true`
  Container is not started when the user is root
- `runAsUser` and `runAsGroup` > 10000
  - 🔥 Reduces risk to run as user existing on host
  - 🔥 In case of container escape UID/GID does not have privileges on host
- 🔥 E.g. mitigates vuln in `runc` (used by Docker among others)
  🌐 https://kubernetes.io/blog/2019/02/11/runc-and-cve-2019-5736/

No Privilege escalation

- Container can't increase privileges
- 🔥 E.g. `sudo`, `setuid`, Kernel vulnerabilities

Read-only root file system

- Starts container without read-write layer
- Writing only allowed in volumes
- 🔥 Config or code within the container cannot be manipulated

Drop Capabilities

- Drops even the default caps:
  🌐
  https://github.com/moby/moby/blob/3152f94/oci/caps/defaults.go
- 🔥 E.g. Mitigates `CapNetRaw` attack - DNS Spoofing on Kubernetes Clusters
  🌐 https://blog.aquasec.com/dns-spoofing-kubernetes-clusters

Bonus: No Services in Environment

- By default: Each K8s service written to each container's env vars
  ➡️ Docker Link legacy, no longer needed
- 🔥 But convenient info for attacker where to go next

Bonus: Disable access to K8s API

- SA Token in every pod for api-server authn

```
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/
```

- If not needed, disable!
- No authentication possible
- 🔥 Lesser risk of security misconfig or vulns in authz

Security context pitfalls

Read-only root file system

Application might need temp folder to write to

- Run image locally using docker, access app
  📌 Run automated e2e/integration tests
- Review container's read-write layer via

```
docker diff <containerName>
```

- Mount folders as `emptyDir` volumes in pod

Drop Capabilities

Some images require capabilities

- Find out needed Caps locally:

```
docker run --rm --cap-drop ALL <image>
# Check error
docker run --rm --cap-drop ALL --cap-add CAP_CHOWN <image>
# Keep adding caps until no more error
```

- Add necessary caps to k8s `securityContext`
- Alternative: Find image with same app that does not require caps, e.g. `nginxinc/nginx-unprivileged`

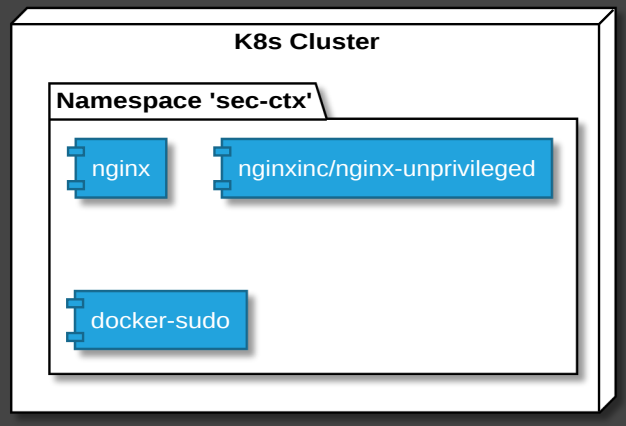
Run as unprivileged user

- Some official images run as root by default.
  - Find a **trusted** image that does not run as root
    e.g. for mongo or postgres:
    https://hub.docker.com/r/bitnami/
  - Create your own non-root image
    (potentially basing on original image)
    e.g. nginx: https://github.com/schnatterer/nginx-unpriv

- UID 100000 might not have permissions. Solutions:
  - Init Container sets permissions for volume
  - Permissions in image ➡️ `chmod`/`chown` in `Dockerfile`
  - Run in root Group - `GID 0`

    🌐 https://docs.openshift.com/container-platform/4.3/openshift_images/create-images.html#images-create-guide-openshift_create-images

Demo


K8s Cluster
Namespace 'sec-ctx'
nginx
nginxinc/nginx-unprivileged
docker-sudo

🎁 Wrap-Up: Security Context

My recommendations:

- Start with least privilege
- Only differ if there's absolutely no other way


Pod Security Policies
(PSP)

- enforces security context settings cluster-wide
- additional options enforcing secure defaults
- more effort than security context and different syntax 😕
- future from K8s 1.22 vague 😟

  https://github.com/kubernetes/enhancements/issues/5

➡️ Still only built-in solution for cluster-wide security settings

Recommendation

https://github.com/cloudogu/k8s-security-demos/blob/master/4-pod-security-policies/demo/01-psp-restrictive.yaml

Too much ground to cover for 45 min!

- 🎥 https://youtu.be/YIvdFE1RsmI?t=3092 🇩🇪 including Demo
- 🌐 https://cloudogu.com/en/blog/k8s-app-ops-part-5-pod-security-policies-1 🇬🇧 🇩🇪

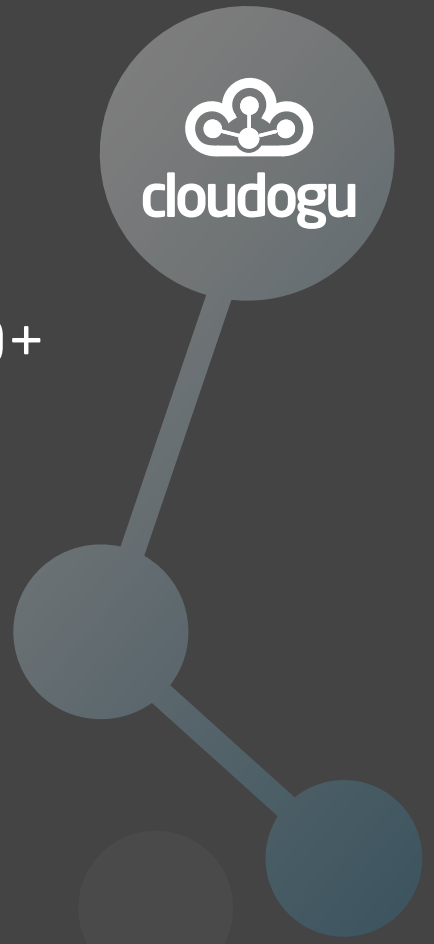
Summary

- Don’t allow arbitrary connections between pods, e.g. via NetPols
- Start with least privilege for your containers
  - using either Security Context or
  - PSP

Johannes Schnatterer

Cloudogu GmbH

cloudogu.com/schulungen



K8s AppOps security series on JavaSPEKTRUM 05/2019+

See also cloudogu.com/blog/tag/k8s-security

@cloudogu
@jschnatterer

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