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NSA/CISA Kubernetes Hardening Guidance and Beyond

Securing Kubernetes Container Platforms in 2022

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Reality check

Containers live in a world where...

- 56% of companies are **not vulnerability scanning**
- ~70% of companies will run containerized workloads in 2023
- **Misconfiguration** makes up 59% of Kubernetes security incidents

Uncomfortable question

What permissions have you given me

in your Kubernetes cluster if I manage

to hack into your application?

NSA/CISA Kubernetes Hardening Guid~~ance~~

Tech report from August 2021 (1.0) and updated in March of 2022 (1.1)

- Focused on Kubernetes **itself**
  - Detailed discussion of security-related configuration
  - Example code
- Mentions other security software (in passing)
- Focuses mainly on **hardening**, not *security as a process*

What's new in 1.1?

- "Threat Detection" section
  - What would some typical attacks look like to an operator?
- Discussion and suggestions for audit log levels
  - Avoid storing sensitive requests (e.g. Secrets)
- Remember the whole application context, including the cloud

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1.

Scan containers and Pods for vulnerabilities or misconfigurations

- Container images are **immutable**
  - Insecure code stays in time capsule
- Component stability: infrequent updates → worse security
- Scan images for known vulnerabilities
- Report: using an Admission Controller

🤓 Lars adds

- Daily scan all images that are in active use!

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2.

Run containers and Pods with the least privileges possible

- 😱 Containers run as “root” by default 😱
- Container file systems: read-only until need arises
- Use most restrictive Pod Security Policies (<= v1.21) or Pod Security Standard (>= 1.22)
- Avoid handing Default Service Account to Pods
- Limit kernel interactions using seccomp, AppArmor, or gVisor-like sandboxes

🤓 Lars adds

- ***Also*** encode your policies for automatic enforcement via Open Policy Agent

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3.

Use network separation for compromise damage control

- Separate control plane and worker node networks
- Default settings allow all Pods to network with all other Pods
  - Security is only as strong as the weakest point!
- Network Policies are Kubernetes-aware firewall rules
  - Specify rules for IP blocks or Kubernetes objects
  - Allow ***only*** “backend” to connect to “database” -- ***nothing else***

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4.

Protect confidentiality: firewalls and encryption

- Restrict access to Kubernetes core components
  - API server, etcd, Controller Managers

- Network traffic in Kubernetes clusters is unencrypted by default

🤓 Lars adds

- Use a networking provider with transparent encryption, e.g., Calico with WireGuard support

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5.

Limit attack surface: authn, authz, RBAC

- Enable authentication, authorization, and role-based access control

🤓 **Lars adds**

- Disable the **perpetual** admin token created during installation
- OpenID Connect for user and **group membership**
- **Disable anonymous access**
- **Restrict permissions** as much as possible with RBAC

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6.

Audit logging, log auditing

- Capture all logs from the entire environment, collect into single system
- All API calls can be logged for auditing purposes
  - Log at appropriate levels to avoid logging e.g. Secrets
  - Creates a huge amount of logs!
- Use an automated system for processing audit logs

🤓 Lars adds

- Falco can act as a simple Security Incident and Event Management (SIEM) system together with centralized logging, e.g., OpenSearch

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7.

Periodically scan, review, and patch Kubernetes

- Kubernetes has a new release ~3 times per year
  - N-3 security updates support (current and the two previous ones)
- Security features are typically opt-in, rather than opt-out
  - You need to opt-in as soon as possible
- Automated testing can help find insecure (default) settings

Are automated vulnerability tools sufficient?

- Kubescape, kube-bench
  - Investigate Kubernetes API (kubescape) or control plane host
- Low-hanging fruit of vulnerability scanning

🤓 Lars adds

- You **must do this** to not scream “insecure cluster over here!”
- **Limited** in what they can investigate, and always will be
- Encryption at rest storage, firewall rules, security policies encoded in other systems than Kubernetes, underlying operating system, third-party software...

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8 practical advice from Lars

Beyond the NSA/CISA recommendations

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1.

Prevent misconfiguration, don't just check for it.

- 2/3 of all insider incidents are due to negligence
- RBAC is great, but limited in what it can express:
  - "Lars" allowed to "modify configuration" in the "production" environment
  - ...but is he allowed to make any configuration change he pleases?
- Open Policy Agent to the rescue (again!)
  - Library and other third-party rules as inspiration

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2.

Any permission given to an application is also given to bad actors.

- Hacked applications have all the permissions that the application usually has
  - Third-party SaaS integrations
  - VPN-connected back-office locations
  - Databases
- Always restrict your app components as much as possible

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3.

Keep cloud resources, specifically, in mind, too.

- Various Controllers and Operators in the community offer cloud integrations.
  - How seriously do they take cloud security?
- Reject ones without configurable/restrictive permissions

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4.

Does your app **unintentionally** have permissions in your cloud?

- Beware of “instance profiles” that your cluster VMs may have ability to modify
  - DNS records,
  - autoscaling groups,
  - load balancers…
- …because all applications can also get those permissions!
  - Just call the cloud’s metadata service and get a token with permissions
  - Applications are also “the VM” to the cloud

✨ Added in 1.1

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5.

Do this daily!

Regularly scan all your deployed container images, not just when they are new.

- To get up to date security scans, you just need to:
  - loop through all your Pods that are deployed,
  - determine which container images are in active use, and
  - scan those images.
- More secure than “scan on push” or “scan on deployment”
- “Zero trust”: scan, sign, verify, enforce policies with private registries

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6.

Foster a security-first mindset

Regularly have **your own staff** security test your entire system.

- Building is hard, breaking is easy (and fun!)
- Your engineers have access to source code, hacker's don't
- Let your engineers try to break your application
- Better if they find errors, than if hackers do!

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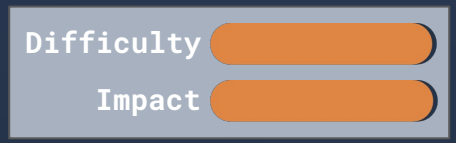
7.

Disaster Recovery != “backups”

Have a **Disaster Recovery** (DR) plan, and actually practice it.

- Disaster could be “entire cloud region outage”...
- ...or “we need to go back in time to five hours ago, before this attack started”

How quickly can you destroy your entire infrastructure and get it back again?



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8.

IDS & SIEM

Use an Intrusion Detection System **and** a Security Information and Event Management.

- Intrusion Detection System (IDS) verifies that applications behave “normally”
- Security Information and Event Management (SIEM) searches through logging systems to find and flag abnormal events
- Could be false positives, but could also be indications of incidents!
- Falco is an IDS and can also be a simple SIEM

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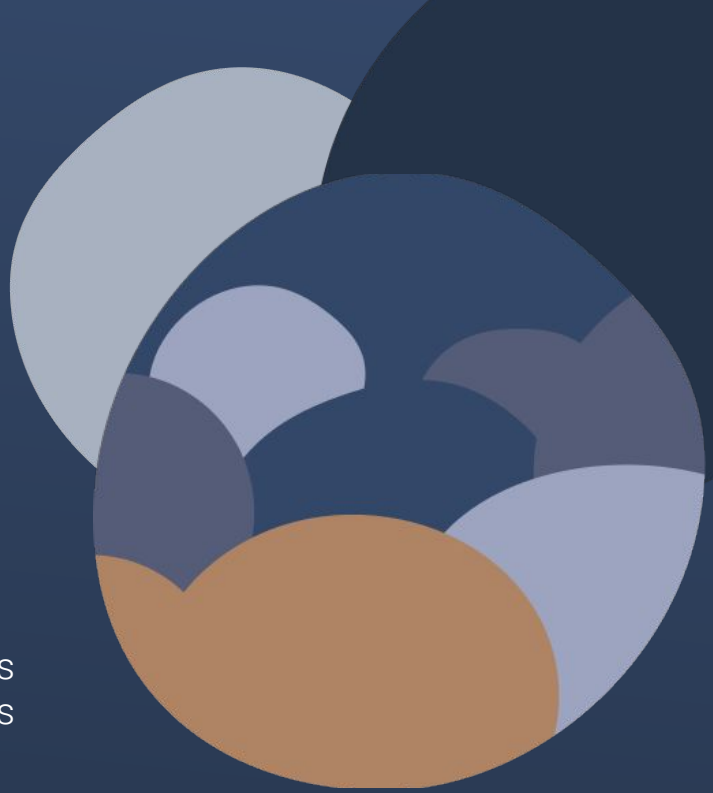
Summary

Kubernetes is neither safe by default, nor by itself.



- Restrict access (network, users, machines) and privileges
- Periodically use tools to assess current security practices
- Prevent misconfiguration, don’t just check after the fact
- Cloud resources and permissions: be mindful!
- Security-conscious engineering culture
- Disaster Recovery applies also to security breaches

Uncomfortable question

What permissions have you given me

in your Kubernetes cluster if I manage

to hack into your application?

Appropriate Answer

No more than **absolutely** needed!

And you will see that I am there, because you have automated systems that both limit what I can do, and raise an alert when I make the application behave in ways it doesn’t normally do.

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Do you have a question? Fire away!

or via linkedin.com/in/llarsson/