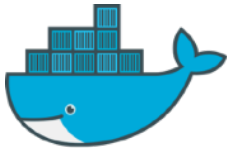
CS155: Infrastructure Security Building Blocks 🔒

@diogomonica



- Infrastructure Company
- Running on 10% of the internet
- Infra: Go, some python

- Mobile payments company
- Moving $60 billion annually
- Infra: Java & Ruby, some Go

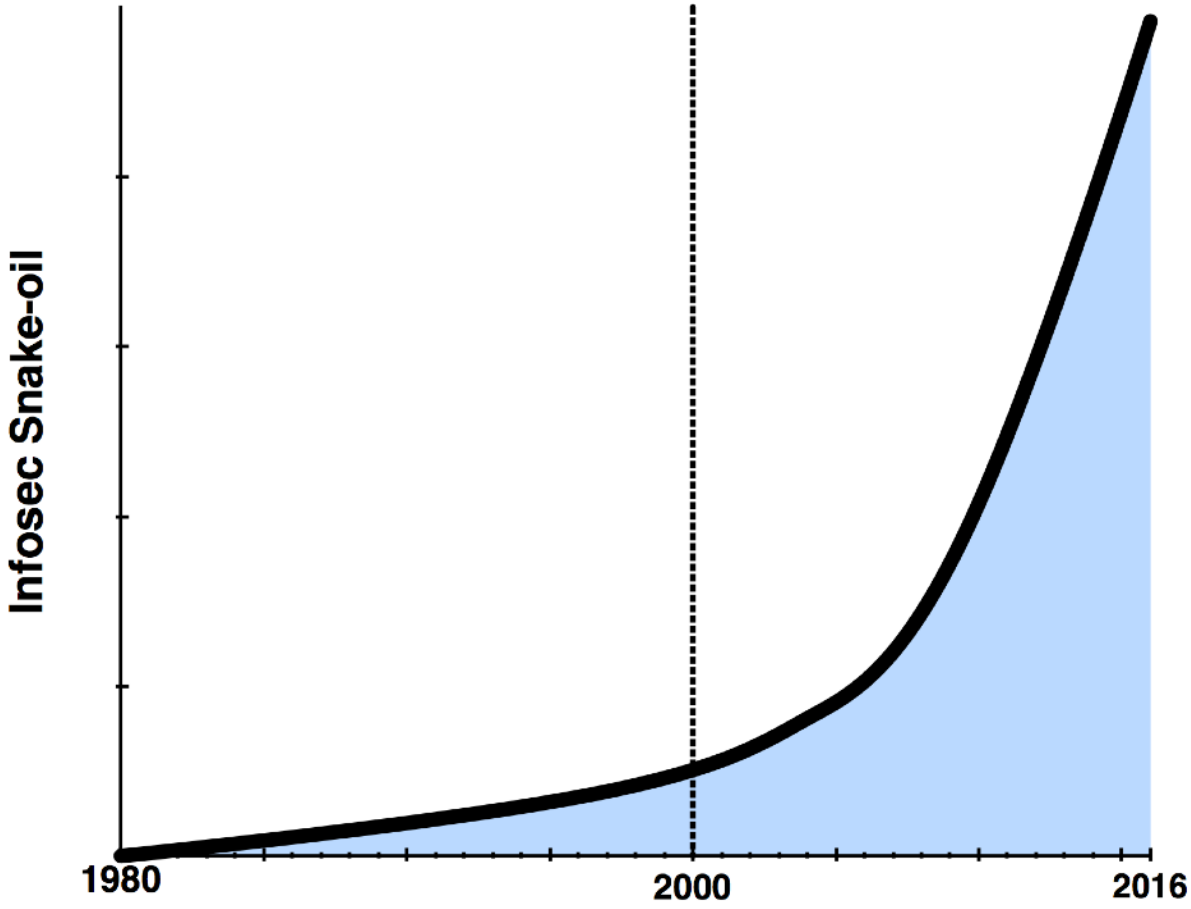
Agenda

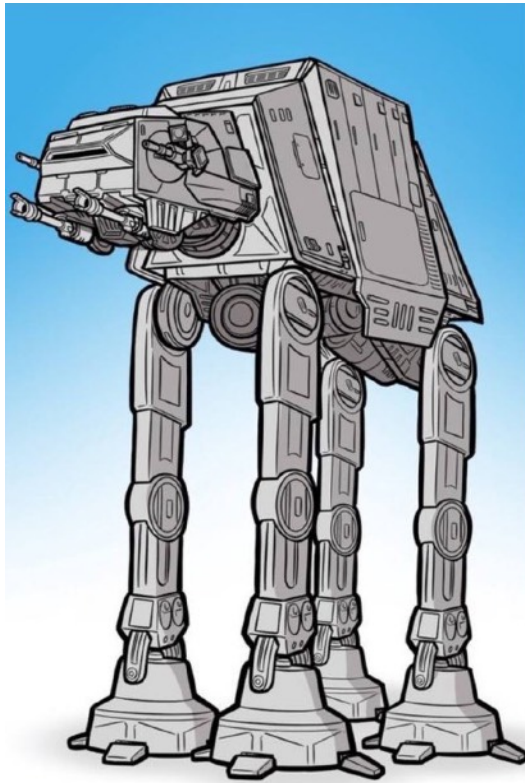
1. Why infrastructure security?
2. Biased timeline of how we got here
3. What is Docker
4. Docker security tetronimos
5. Demo

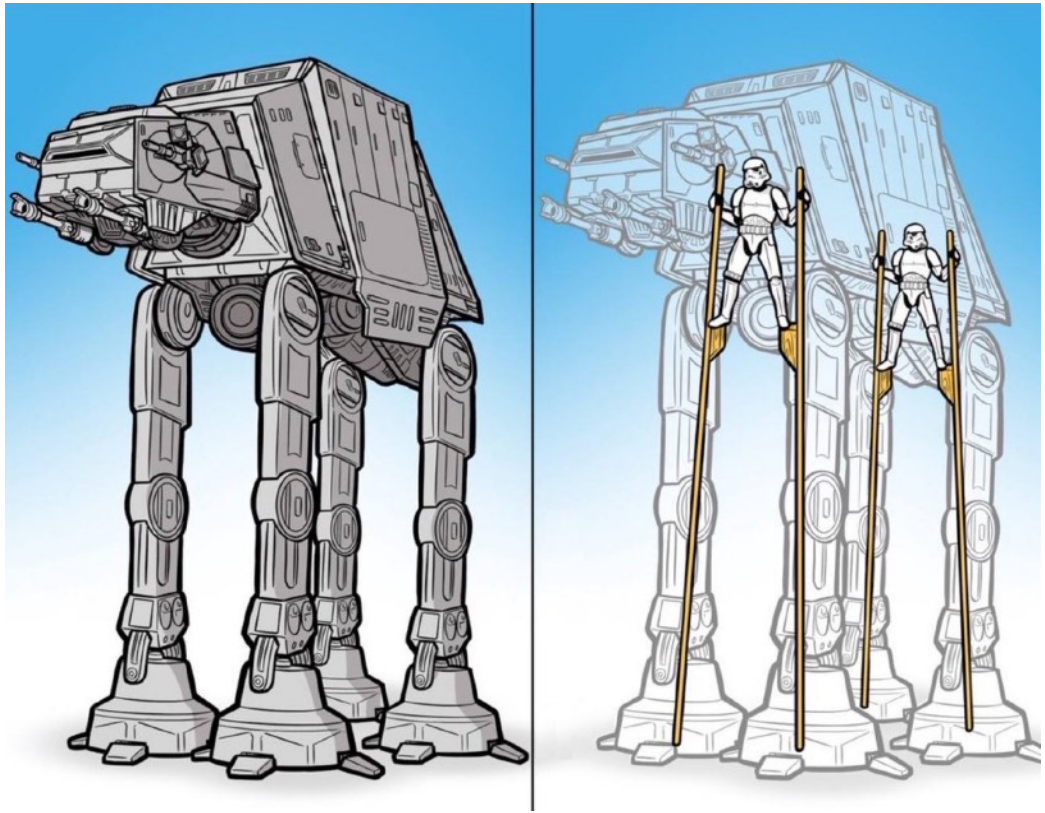
Why Infrastructure Security?

The Golden Ages

The Dark Ages

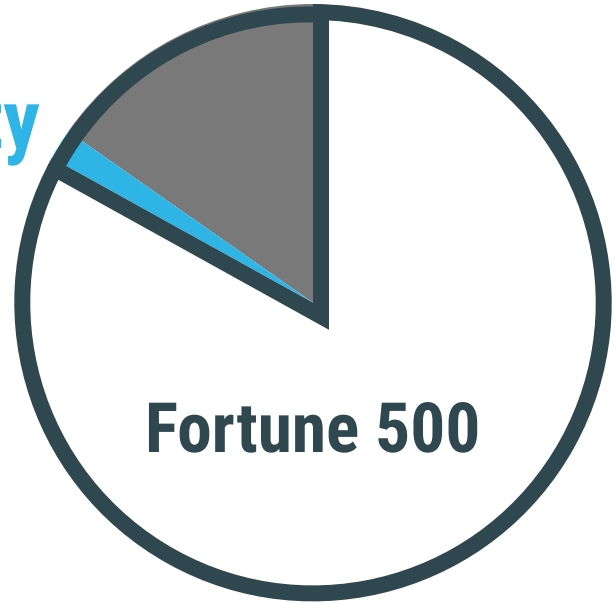

Infosec Snake-oil
1980
2000
2016

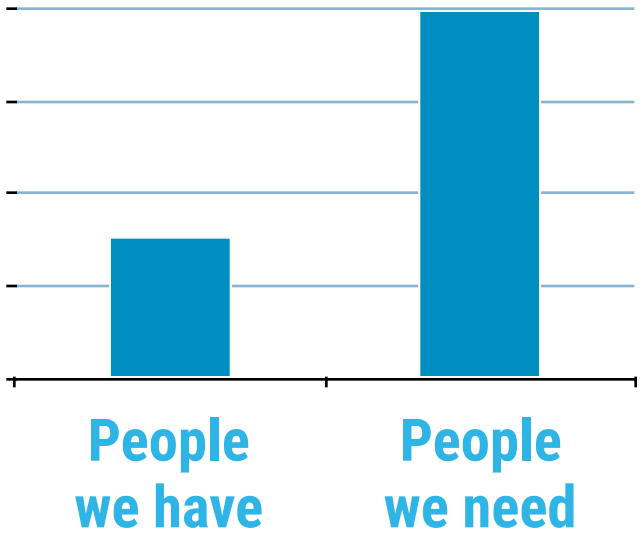




Tech Companies

Good at security

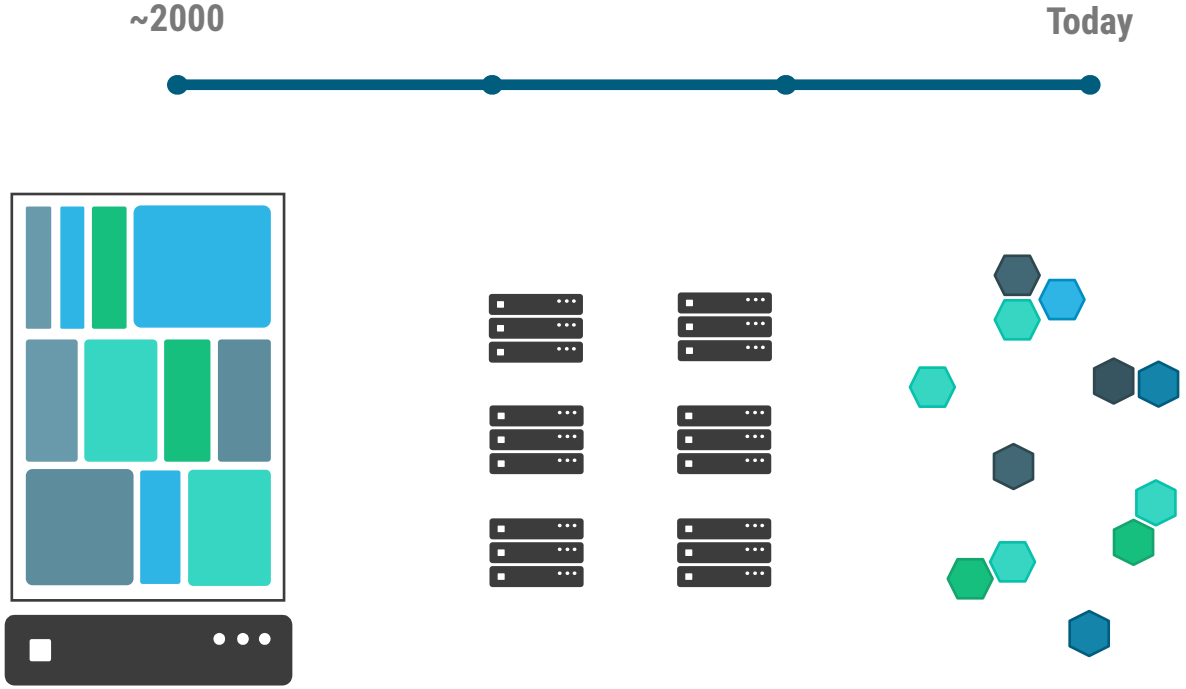



People we have
People we need

Building not breaking

If it doesn't come on by default, no one will use it

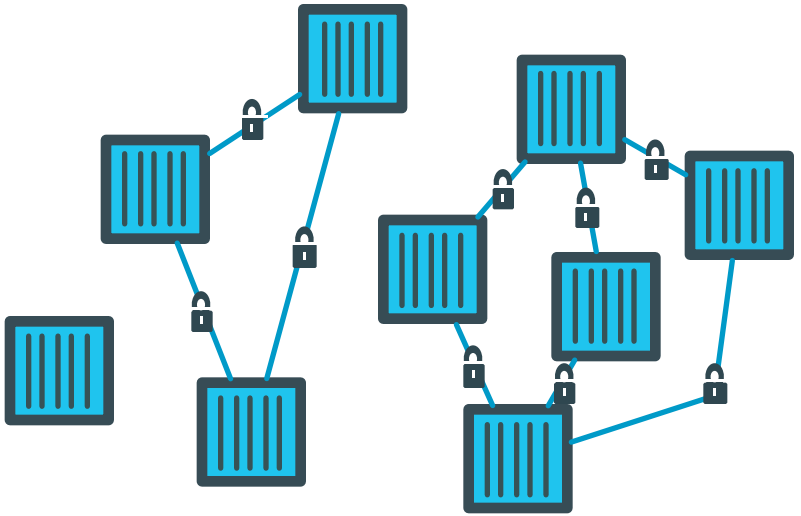
Biased Timeline of the Evolution of Security

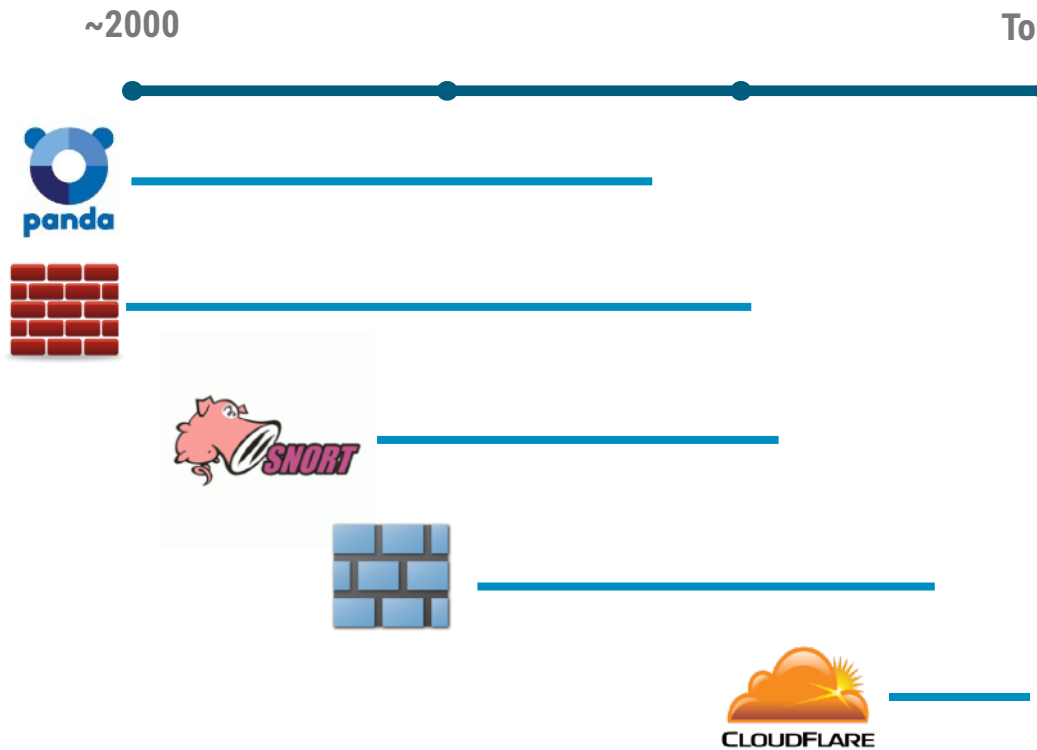

~2000
Today

Immutable Infrastructure

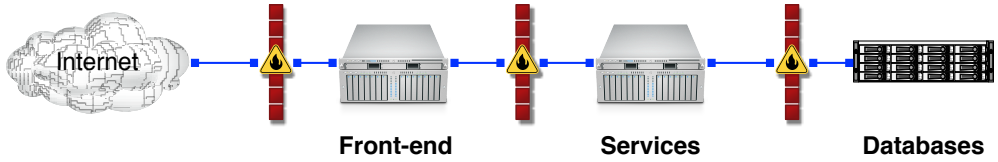
Application Containers

Decentralized Authorization

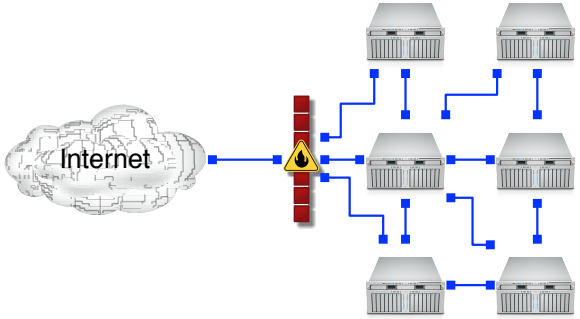



~2000
Today
panda
SNORT
CLOUDFLARE

Security boundary is the service



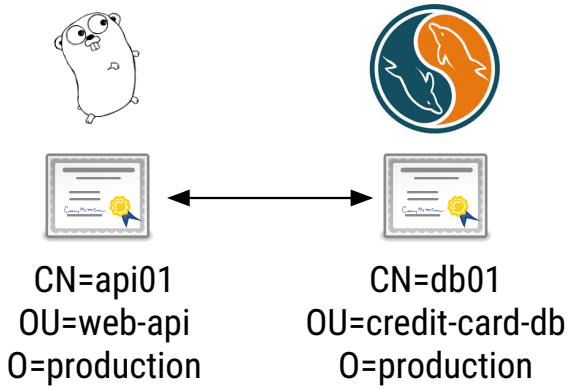
VS



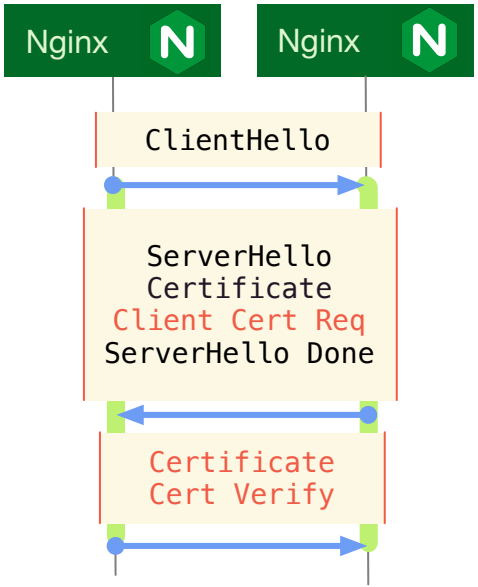
One App Instance, One ID

One Node,
One ID

Every service call is authorized and authenticated



mTLS


Nginx
Nginx
ClientHello
ServerHello
Certificate
Client Cert Req
ServerHello Done
Certificate
Cert Verify

mTLS - the good

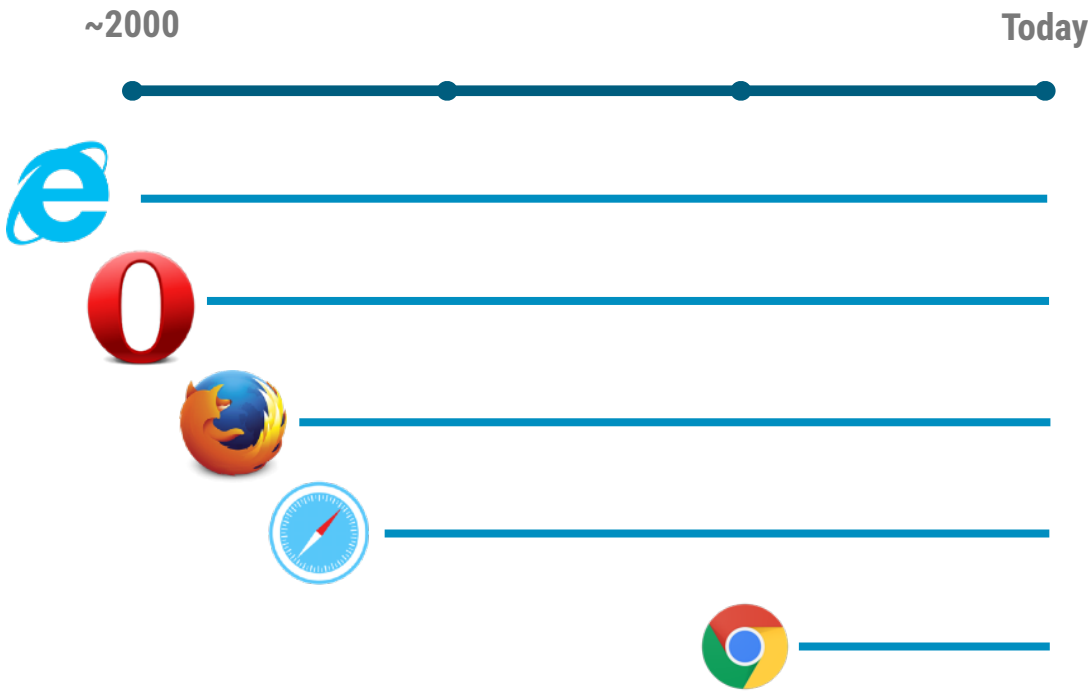
1. **Key-material stays secret**
2. **Supported everywhere**
3. **Authentication and Encryption**

mTLS - the bad

1. A LOT of certs
2. Confusing for developers
3. No good revocation story
4. Running a PKI is hard
5. Unforgiving

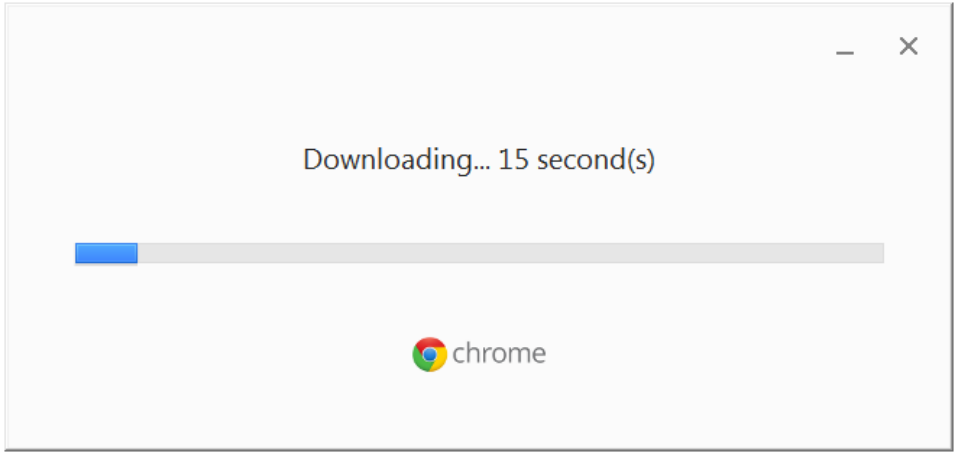
Least-privilege resource access

```
[ { "permission":
        { "method": "GET", "resource": "/user" },
    "allow": ["web", "fulfillment", "payments"] },

  { "permission":
        { "method": "POST", "resource": "/user" },
    "allow": ["signup", "web"] },

  { "permission":
        { "method": "DELETE", "resource": "/user/.*" },
    "allow": ["web"]
}]
```


~2000
Today

Sandboxing

Transparent Updates

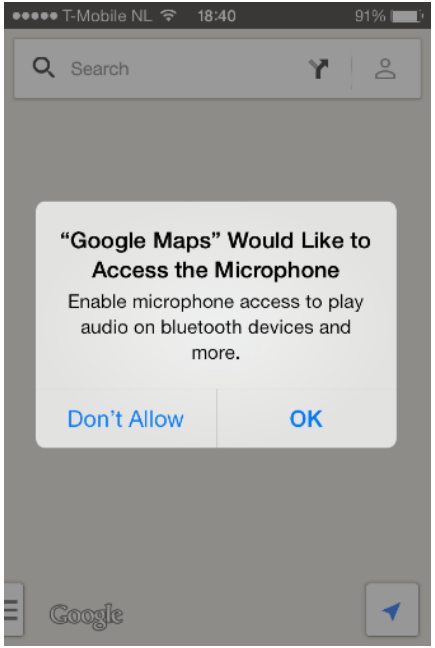


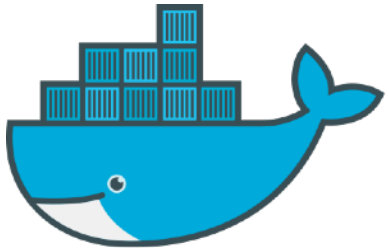
~2000

Today

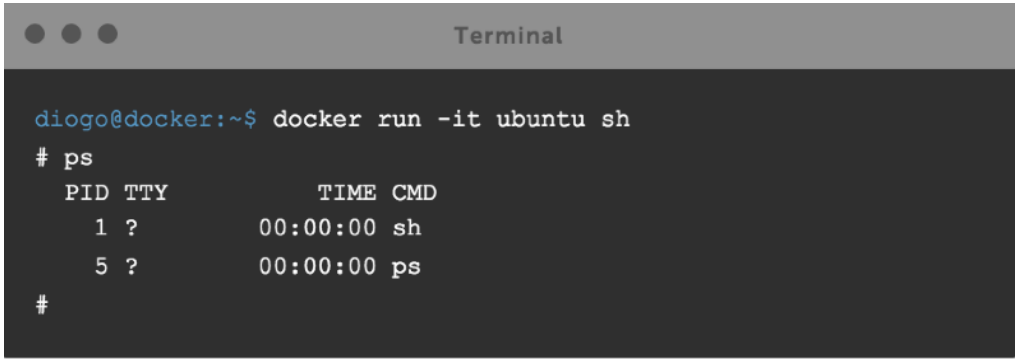
Application Whitelist

Usable Security

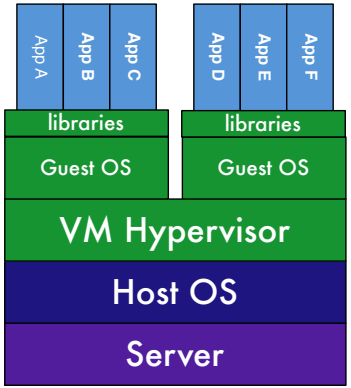


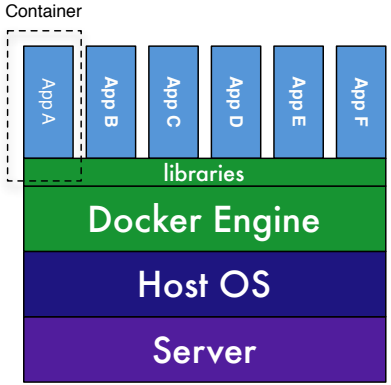


A container is isolated



Containers VS VMs

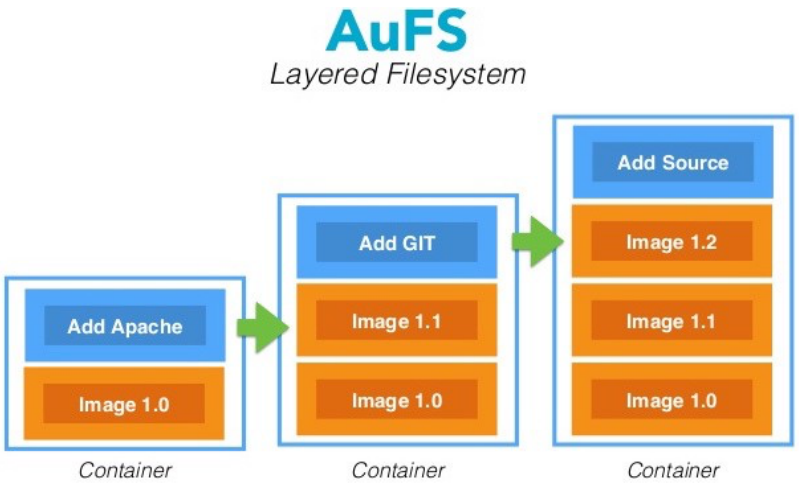




A container is a process

```
root@ubuntunew:/home/diogo# strace -c -f -p 6389
Process 6389 attached
Process 6476 attached
Process 6477 attached
Process 6479 attached
Process 6480 attached
Process 6481 attached
% time     seconds  usecs/call     calls    errors syscall
------ ----------- ----------- --------- --------- ----------------
 62.83    0.000747          68        11         6 wait4
  7.91    0.000094           6        17           lstat
  5.05    0.000060          15         4           getdents64
  3.45    0.000041           2        19           open
  3.20    0.000038           0       106           read
  2.61    0.000031          31         1           nanosleep
  2.02    0.000024           2        10           mprotect
  1.85    0.000022           1        38           rt_sigaction
  1.60    0.000019           0        43           ioctl
  1.43    0.000017           1        20           close
  1.26    0.000015           0        83           writev
```

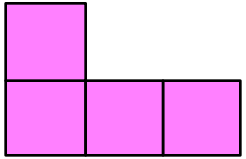
Copy-on-write FS

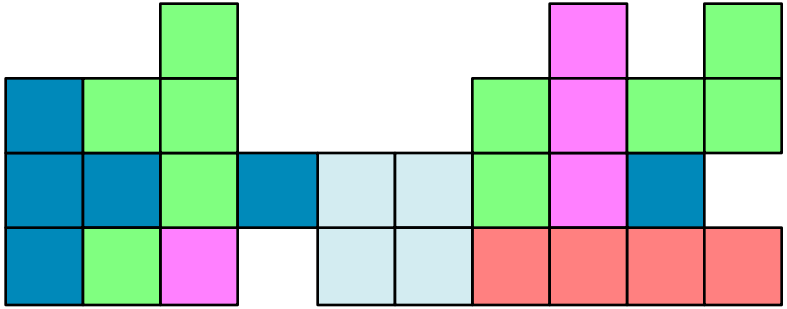


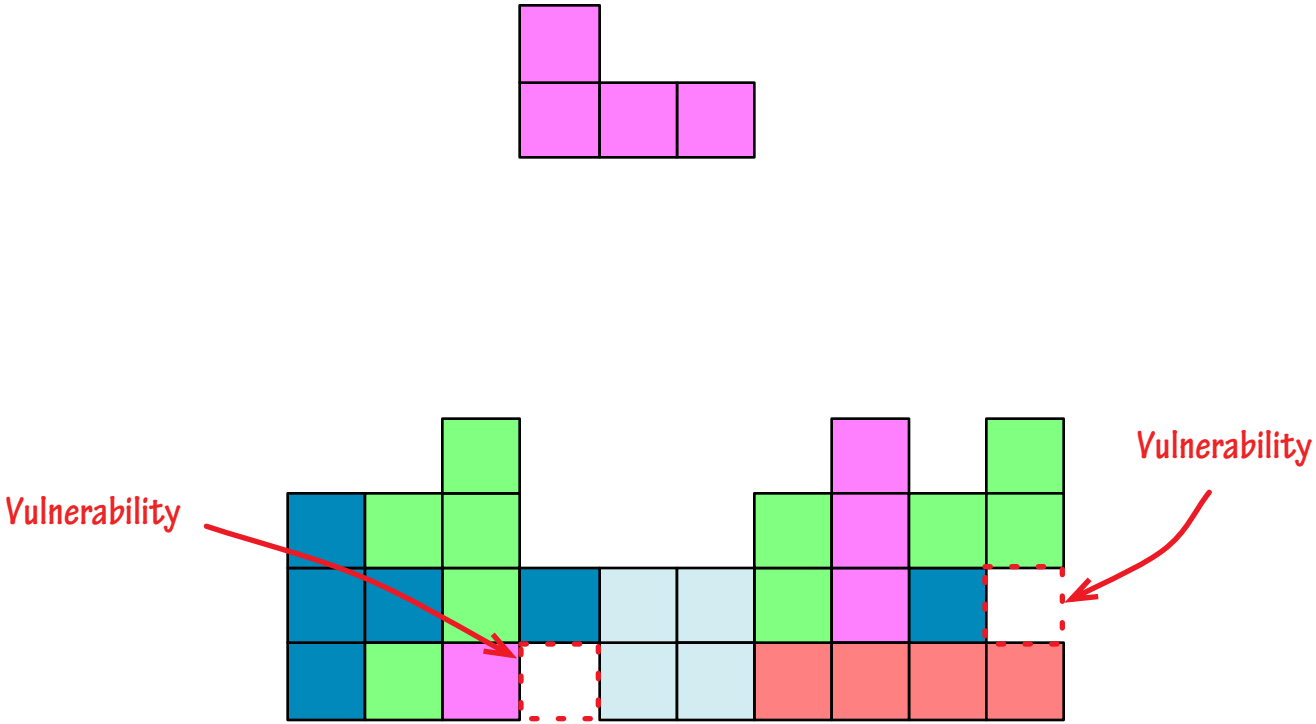
Key Security advantages

1. **Additional layer of isolation**
2. **Easier patch management, faster deployments, reduced risk**
3. **Better visibility into application behavior**

```
# docker stack deploy --stack-file docker-stack.yml my_app
Creating service my_app_frontend
Creating service my_app_backend
Creating service my_app_db
```

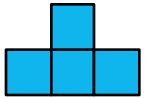




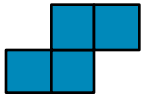

Vulnerability
Vulnerability

Security Tetrominos

runC

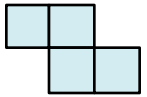


containerD

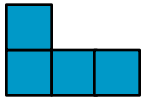


Docker

infraKit

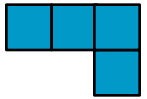


linuxKit



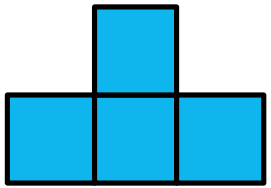
Notary

swarmKit



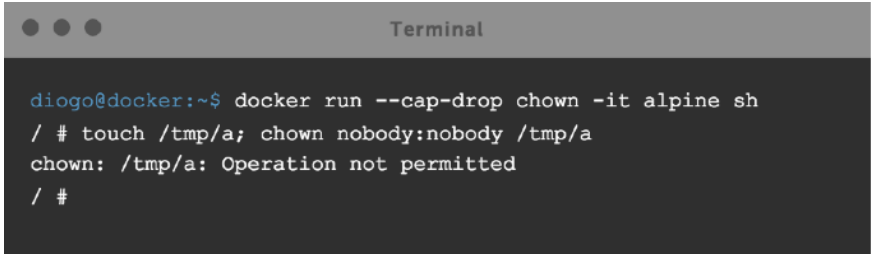
runC

Lightweight universal container runtime



runC

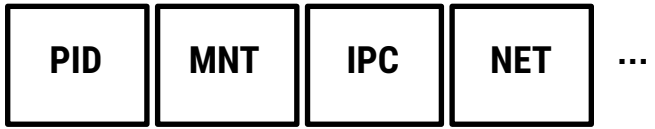
Capabilities



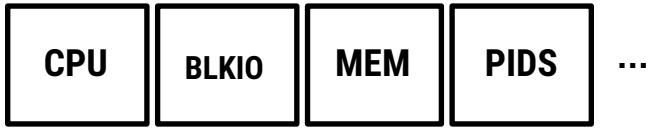
runC

- Namespace Isolation
- Cgroups

Namespaces



Cgroups



runC

Linux Security Modules

1. AppArmor
2. SELinux
3. Smack
4. TOMOYO
5. YAMA

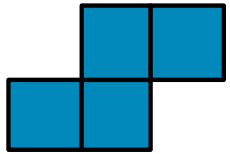
runC

Seccomp-bpf

```
{
    "defaultAction": "SCMP_ACT_ERRNO",
    "architectures": [
        "SCMP_ARCH_X86_64",
   ],
    "syscalls": [
        {
            "name": "accept",
            "action": "SCMP_ACT_ALLOW",
            "args": []
        },
        {
            "name": "accept4",
            "action": "SCMP_ACT_ALLOW",
            "args": []
        },
        ...
    ]
}
```

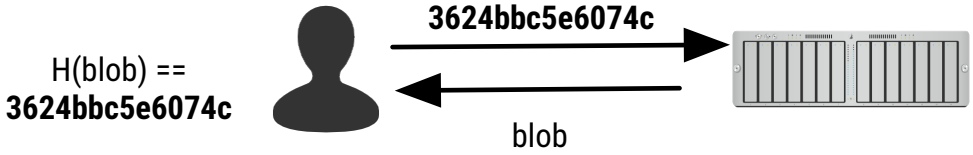
containerD

Container runtime supervisor



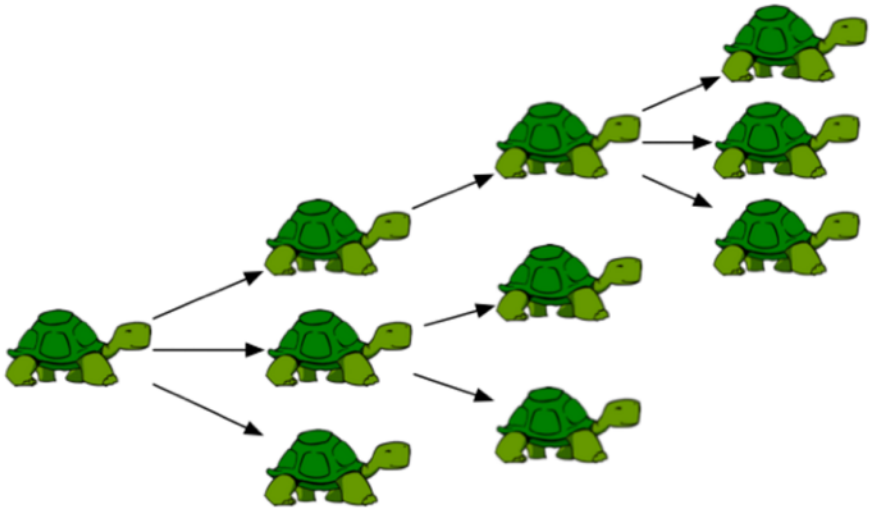
containerD

Content addressable images



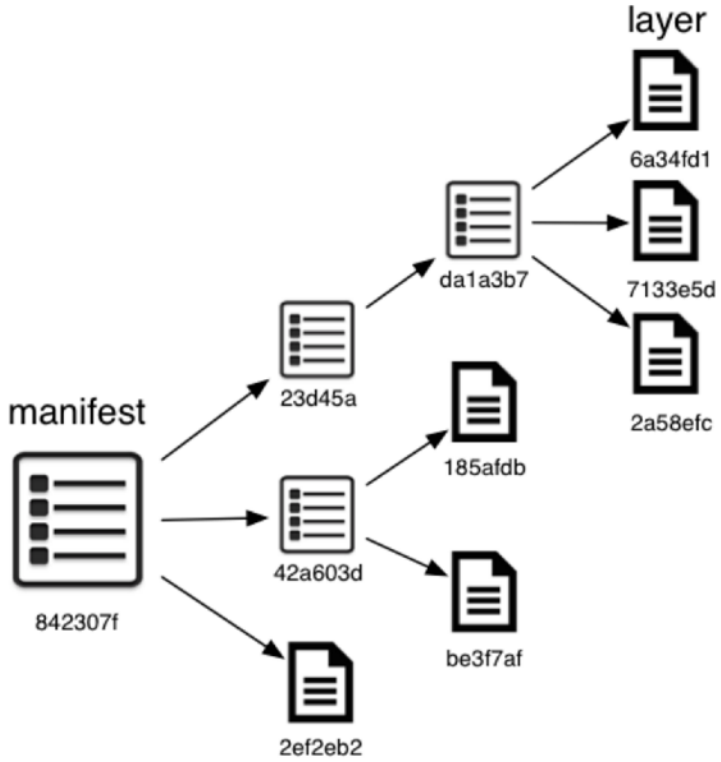
containerD

Turtles all the way down



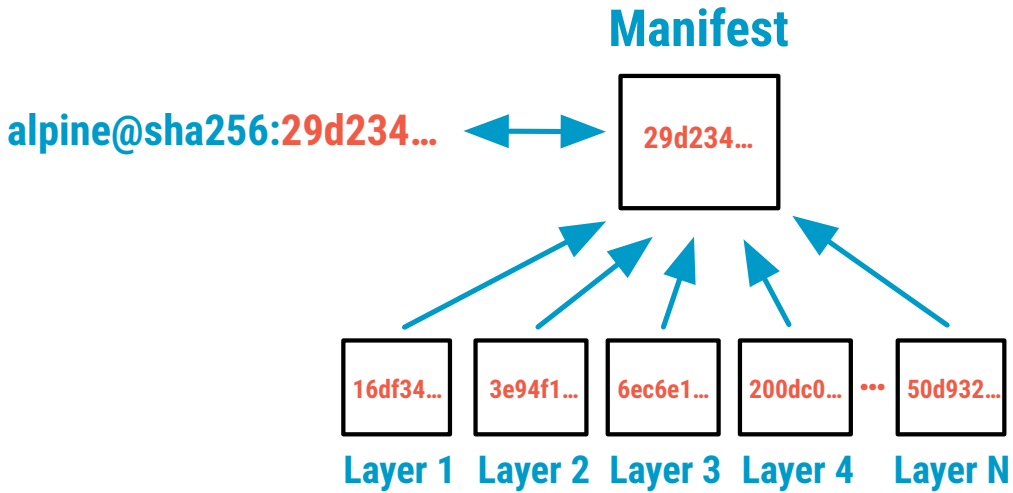
containerD

Images are Merkle DAGs of layers



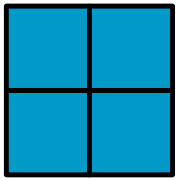
containerD

Content Addressable Image Pulls



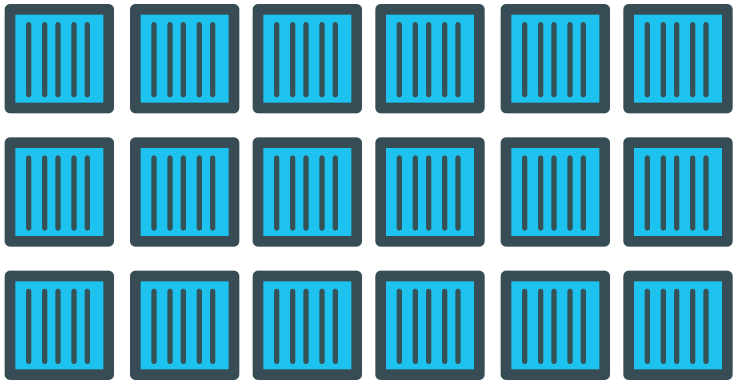
Docker

Secure-by-default software container platform



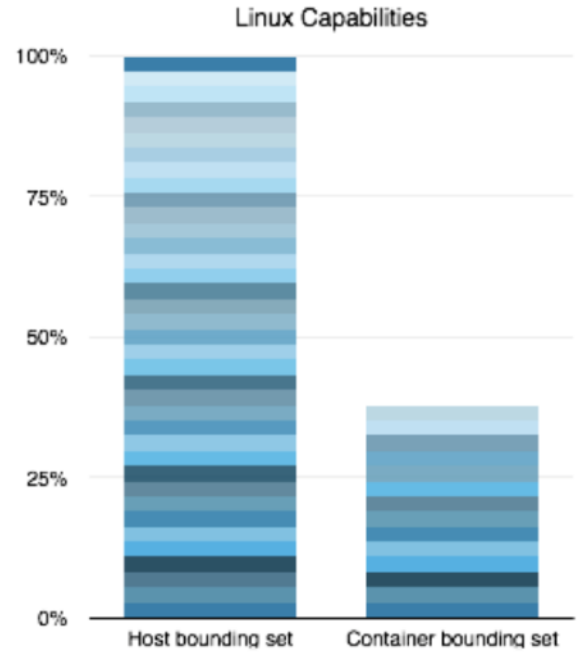
Docker

- SELinux & AppArmor
- Capability Whitelist
- Syscall Whitelist
- Copy-on-write
- No device access



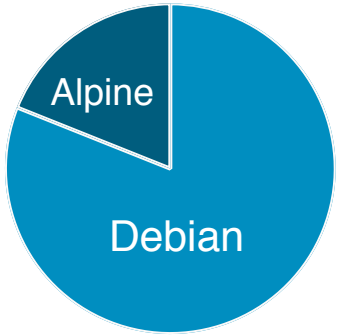
Docker

Less than half the default capabilities



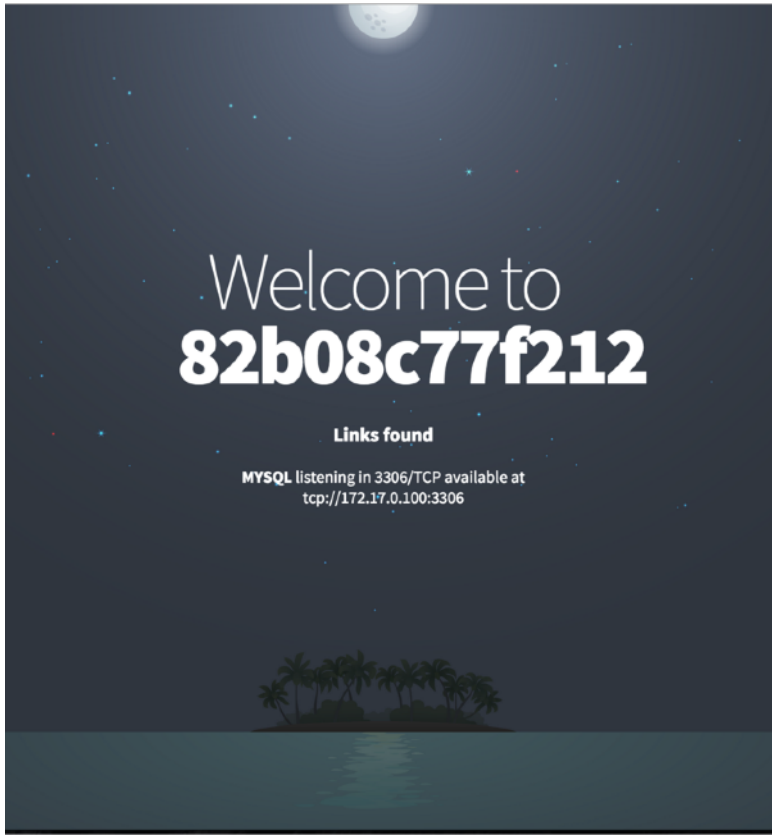
Docker

Minimal Distros



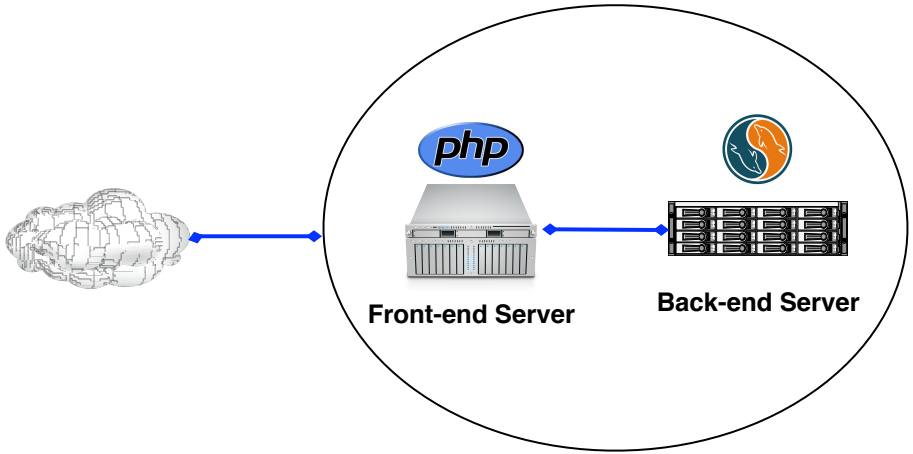
Demo

Our new website



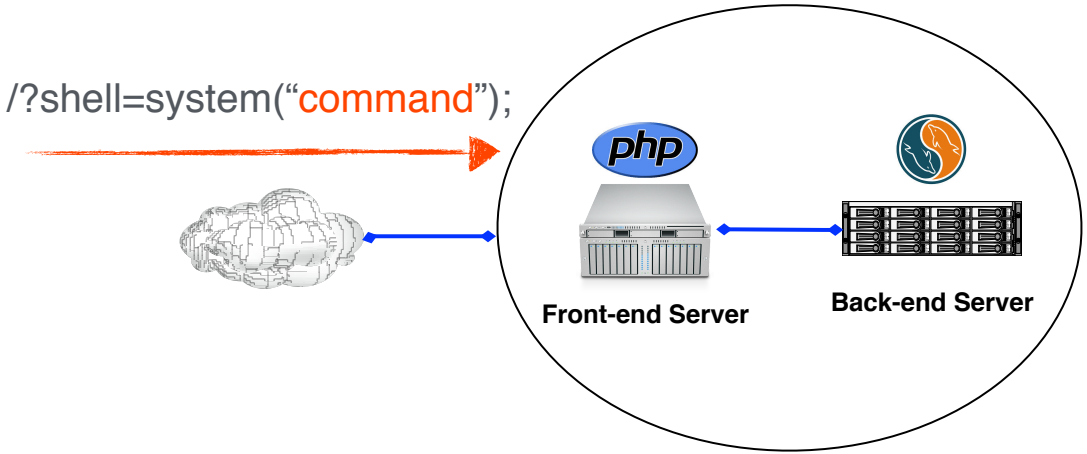
Demo

Our new architecture



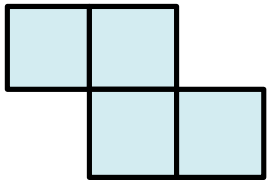
Demo

Our new backdoor



infraKit

Infrastructure independent machine management



infraKit

Platform Agnostic

infraKit

Declarative Updates

```
# infrakit group commit moby.json
Performing a rolling update on 5 instances
```

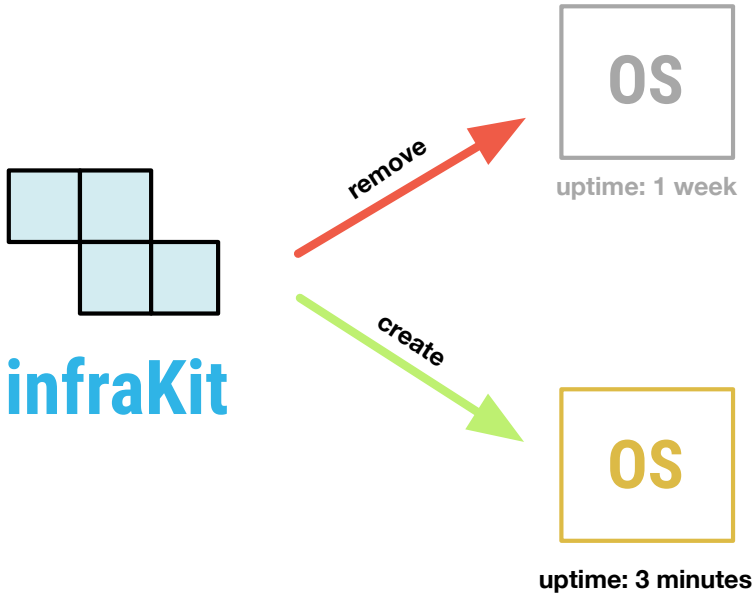
infraKit

Reverse Uptime

10:00

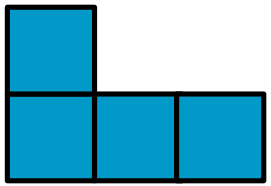
infraKit

Rolling Deploys



linuxKit

A secure OS builder for your containers



linuxKit

Immutable Linux
OS builder

```
kernel:
  image: "linuxkit/kernel:4.9.x"
  cmdline: "console=ttyS0 page_poison=1"
init:
  - linuxkit/init:1b8a7e394d…
onboot:
  - name: dhcpcd
    image: “linuxkit/dhcpcd:7d2b8aaaf…
    command: ["/sbin/dhcpcd", “--nobackground" ]
trust:
  org:
    - linuxkit
```

linuxKit

Minimal Base

linuxKit

Type-safe
System
Daemons

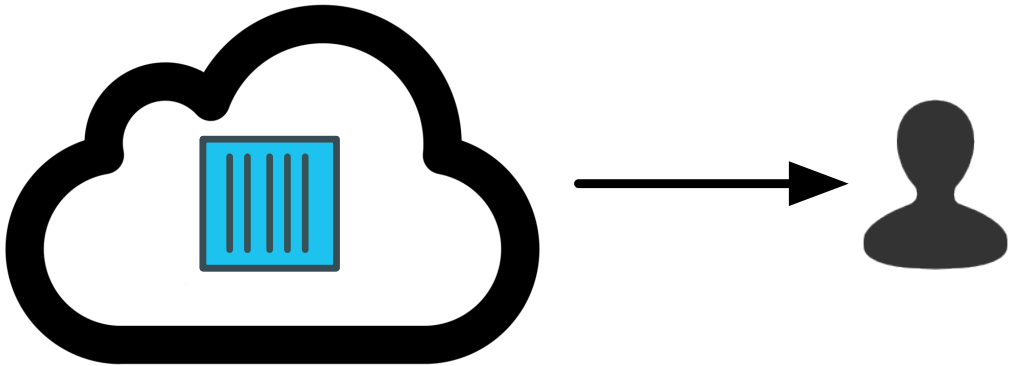
linuxKit

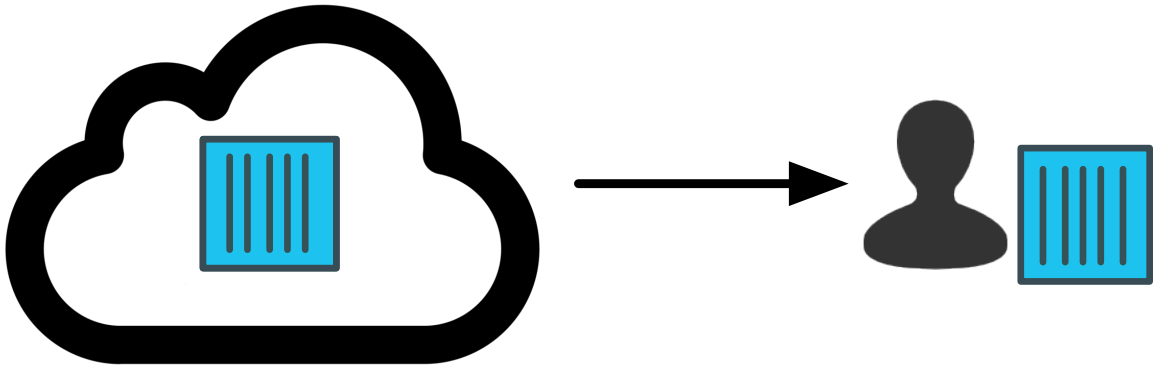
Hardening the kernel

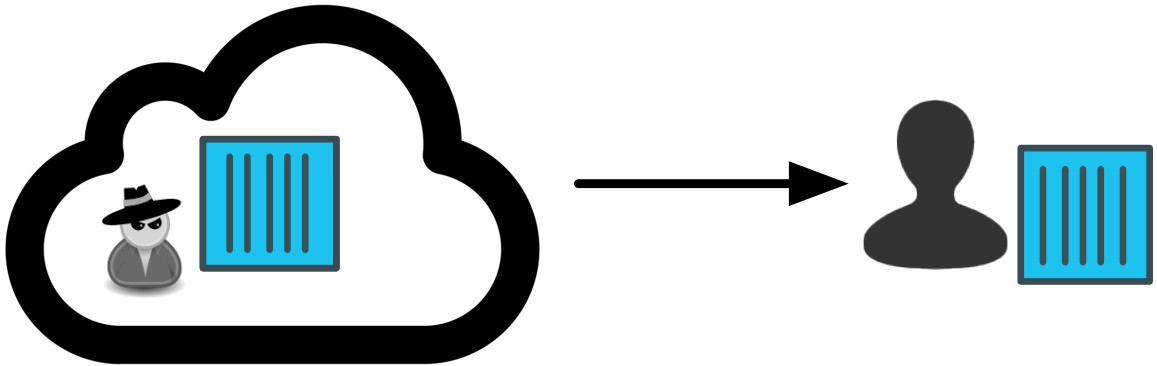
Notary

Trusted software delivery

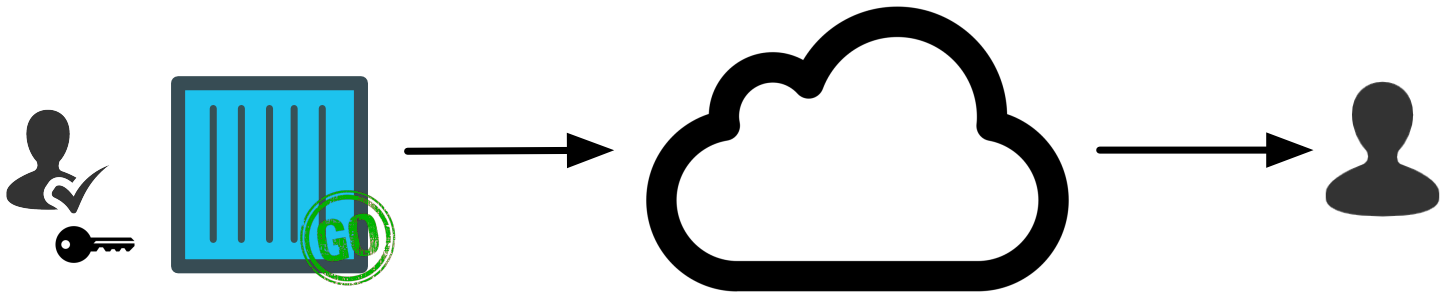
Isn’t HTTPS enough?

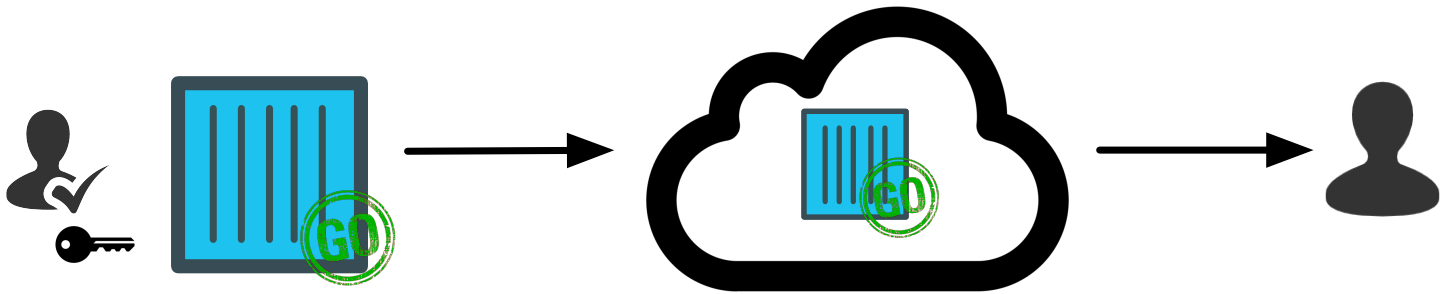




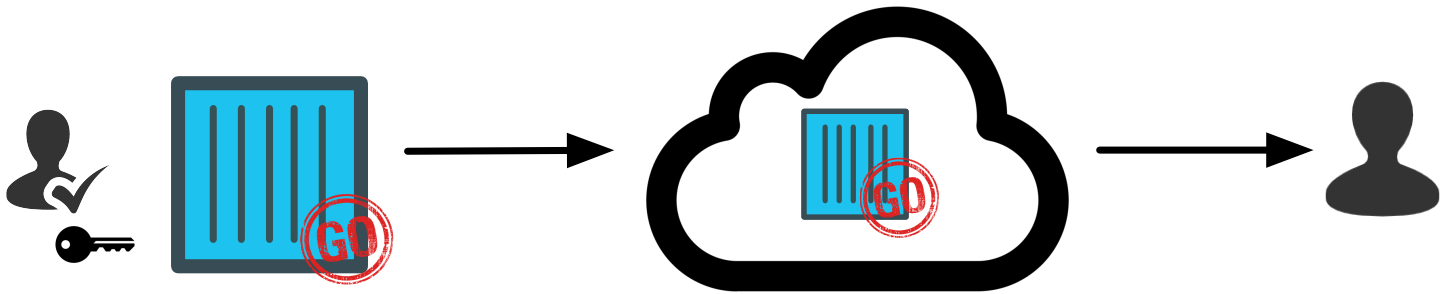


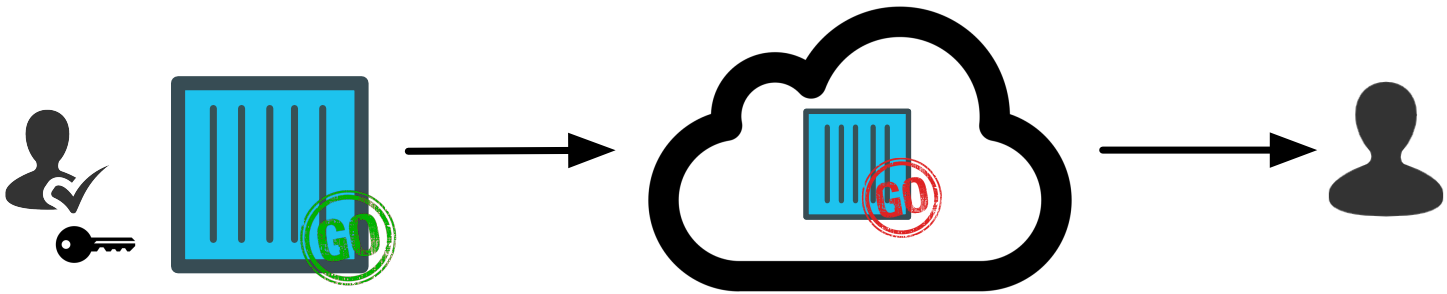
What about GPG?

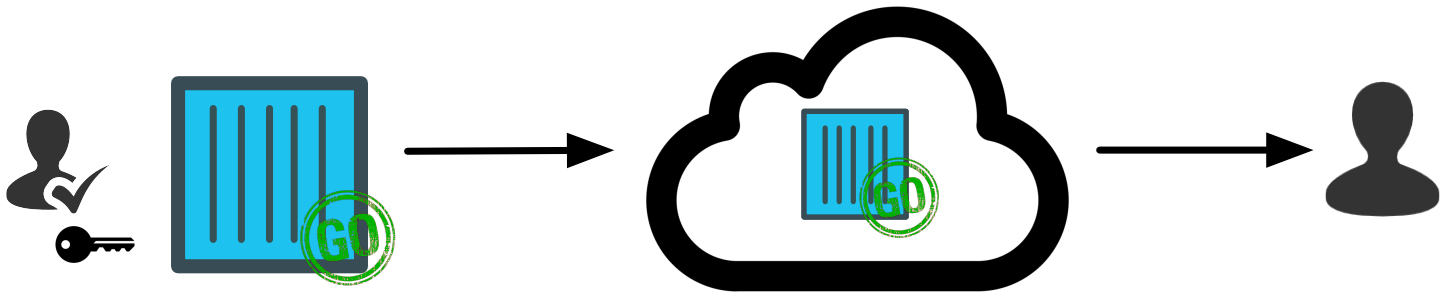

GO

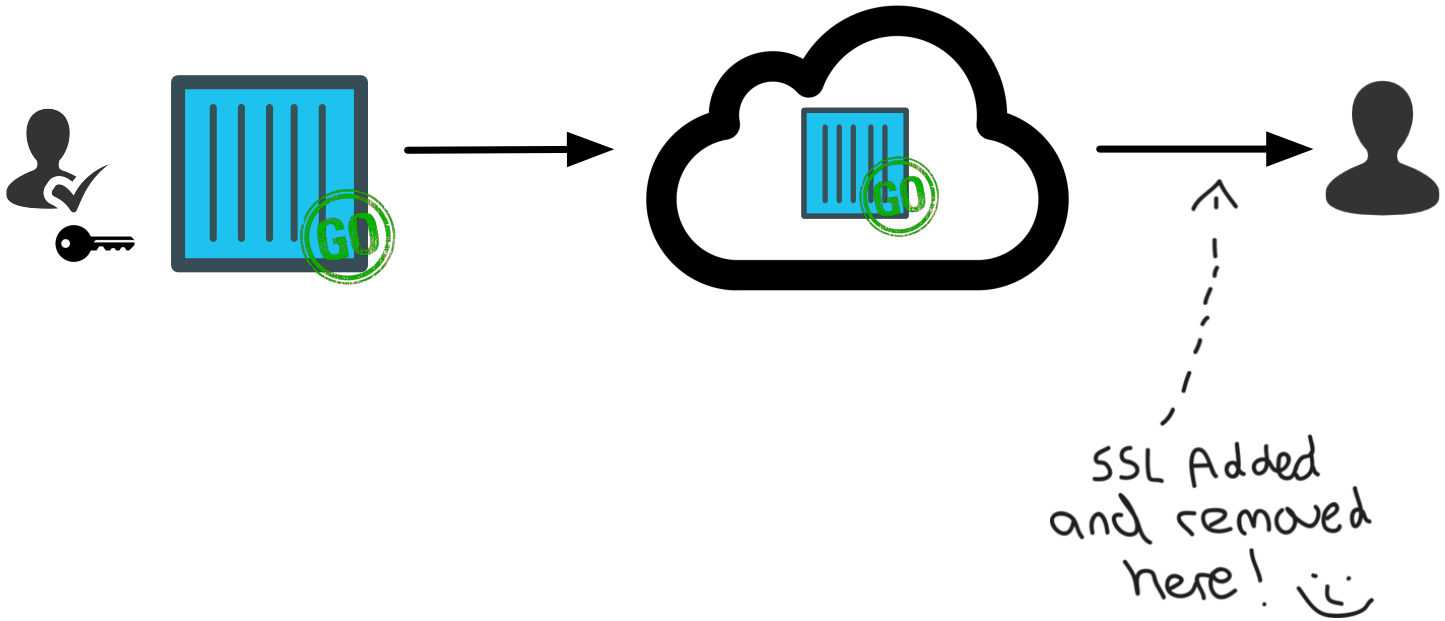

GO
GO

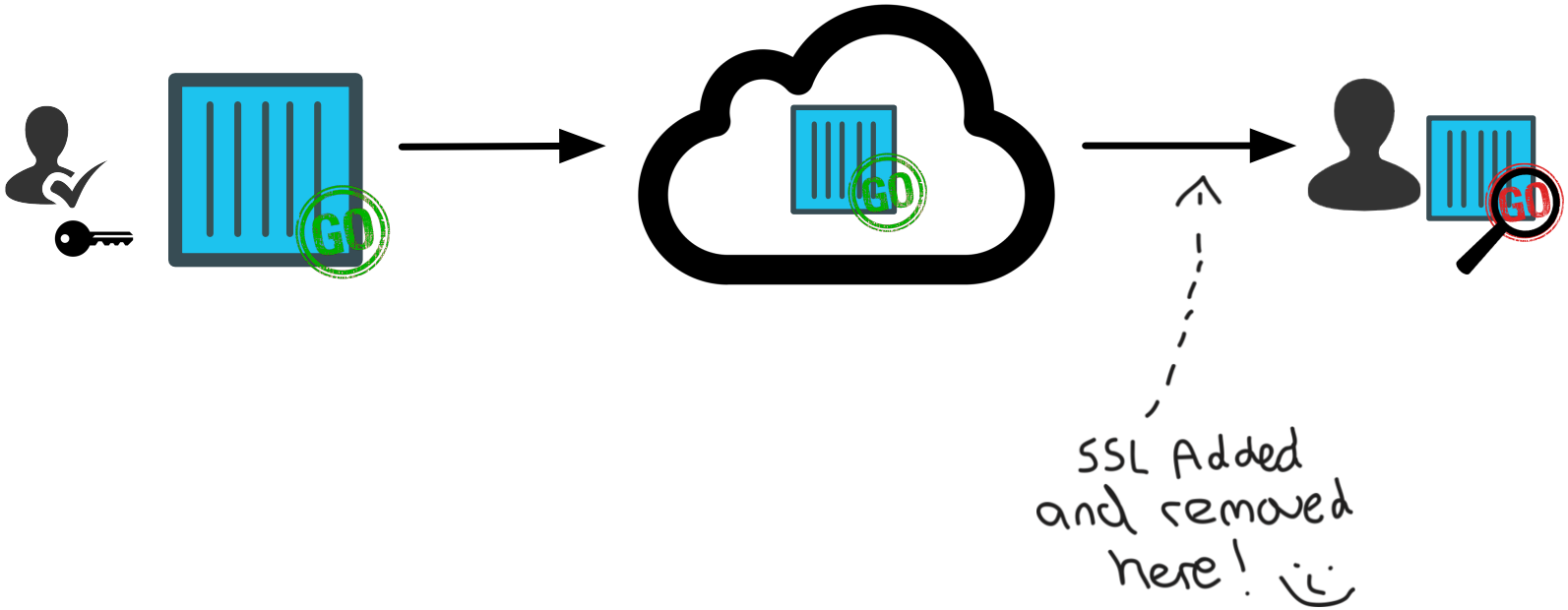
GO
GO
GO


GO
GO
3 months later…


GO
GO


GO
GO


GO
GO
SSL Added
and removed
here!


GO
GO
GO
SSL Added
and removed
here!

Secure Software Distribution is Hard!
arbitrary software
extra dependencies
slow retrieval
indefinite freeze
malicious mirrors
wrong software
rollback
endless data
mix-and-match
key compromise
Secure Software Distribution is Hard!
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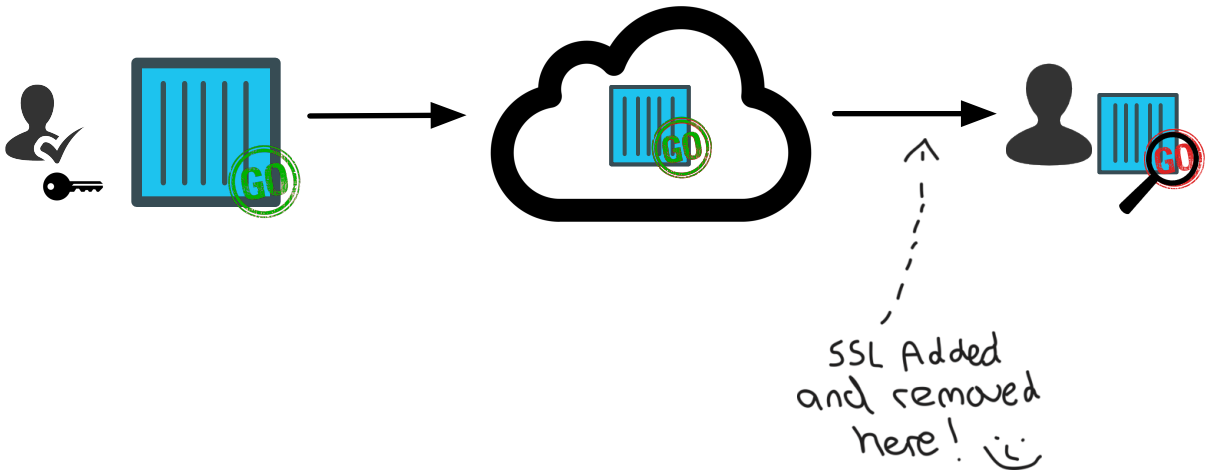
endless data
mix-and-match
slow retrieval
key compromise
indefinite freeze

“A software update system is secure if it can be sure that it knows about the latest available updates in a timely manner, any files it downloads are the correct files, and no harm results from checking or downloading files.”

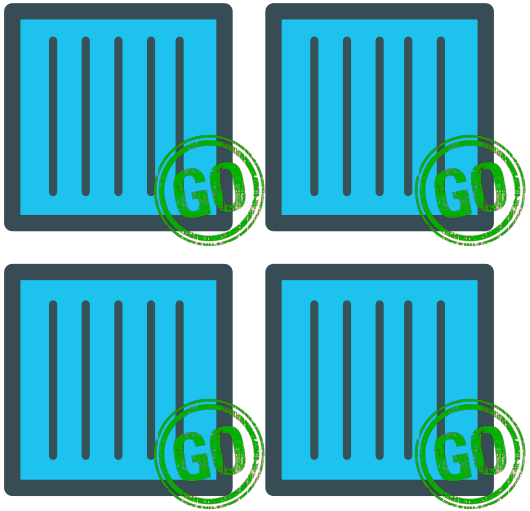
- The Update Framework

1. Freshness
2. Signed Collections
3. Key Hierarchy
4. Transparent Key Rotation
5. Threshold Signing

Freshness



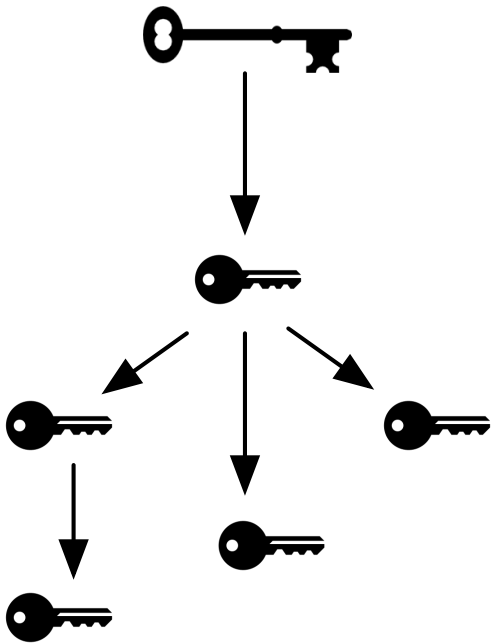
Signed Collections



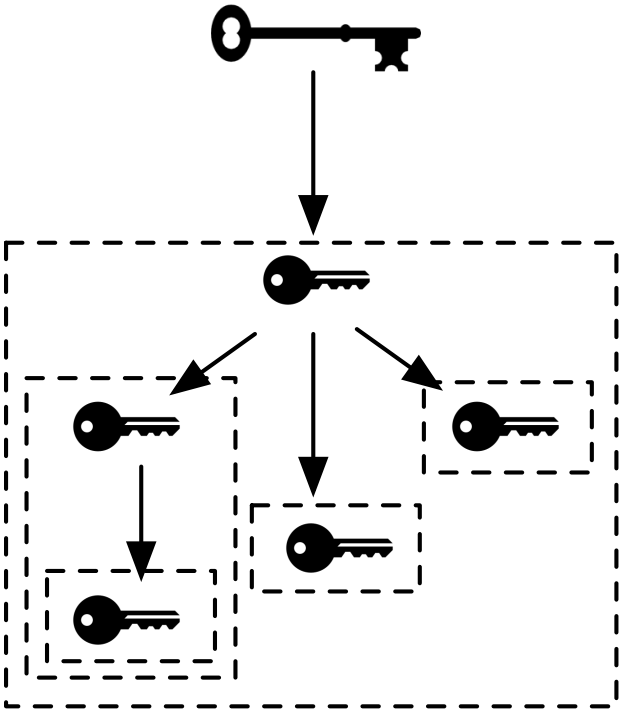
Signed Packages

Signed Collection

Key Hierarchy



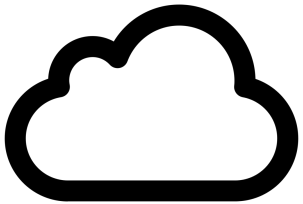
Key Hierarchy



Key Hierarchy

Short Expiry

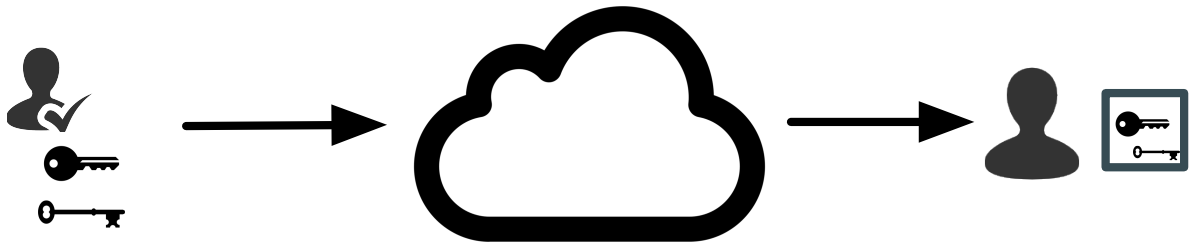
Long Expiry



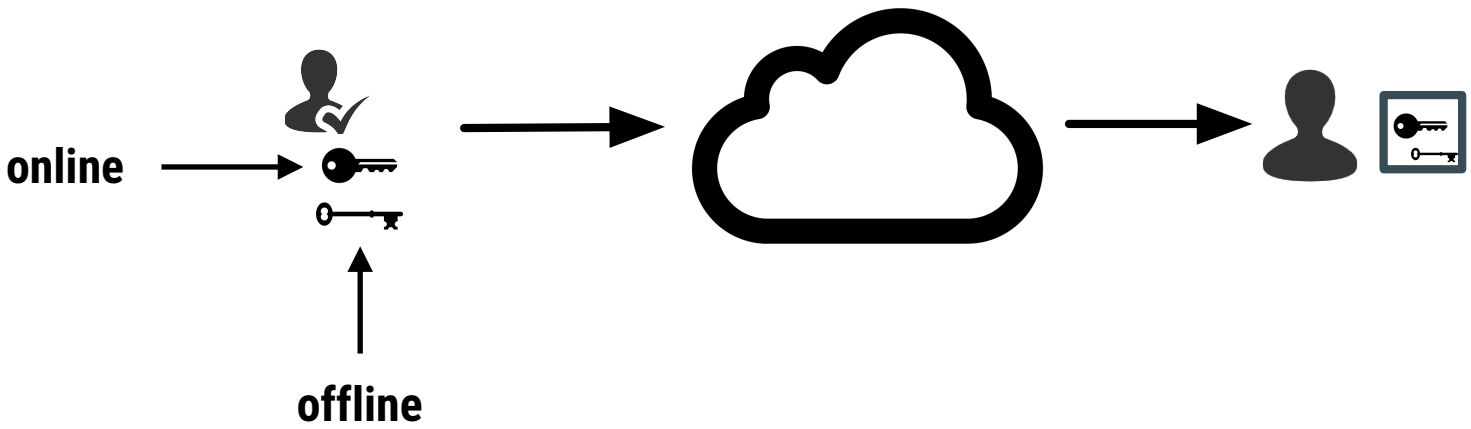
Less Sensitive

More Sensitive

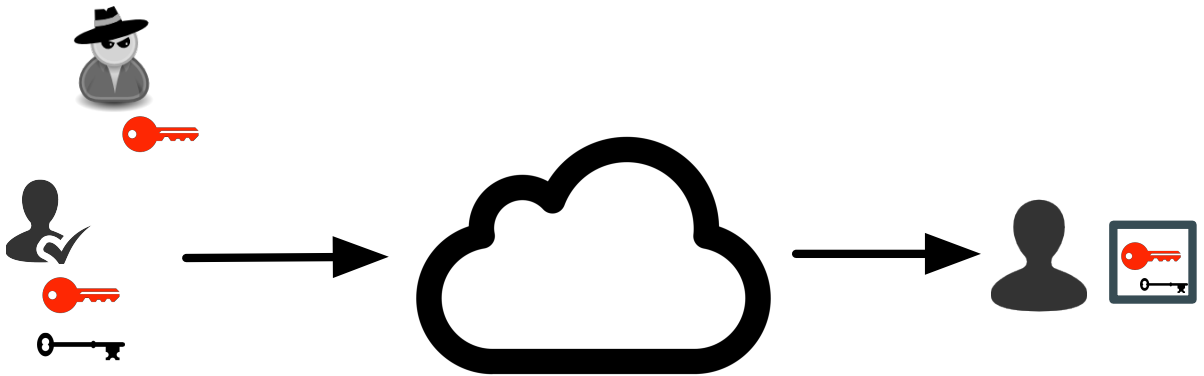
Transparent Key Rotation



Transparent Key Rotation

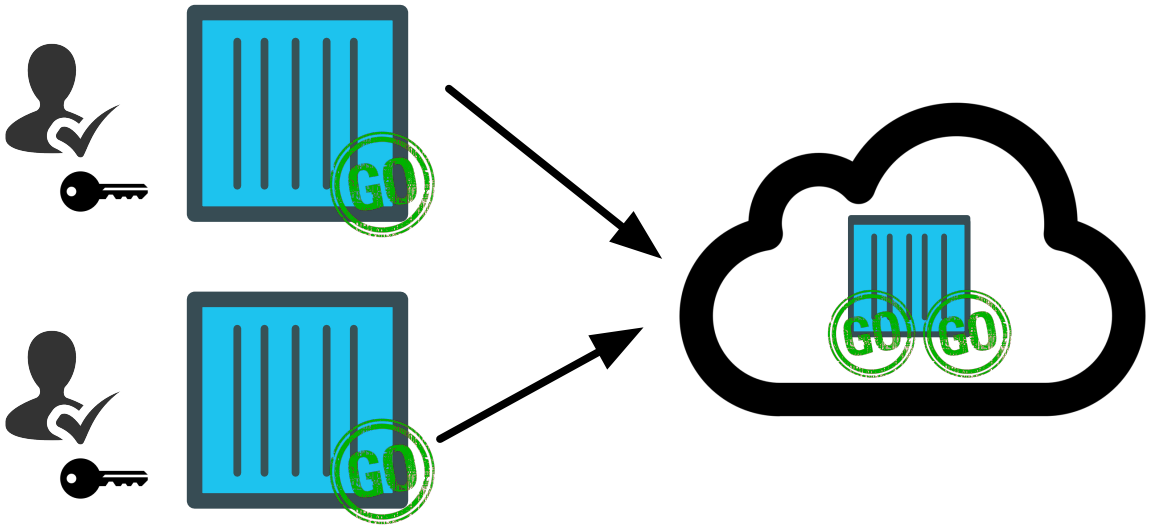


Transparent Key Rotation

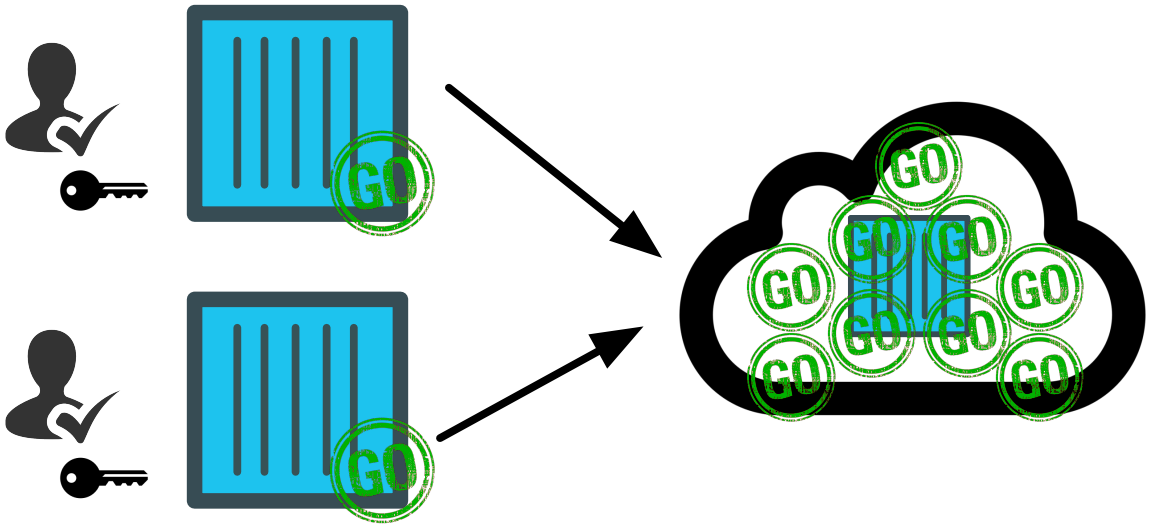


Transparent Key Rotation

Threshold Signing



Threshold Signing



The Update Framework (TUF)

theupdateframework.com

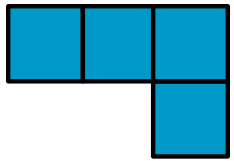
Notary

Cryptographic
Name Resolution

swarmKit

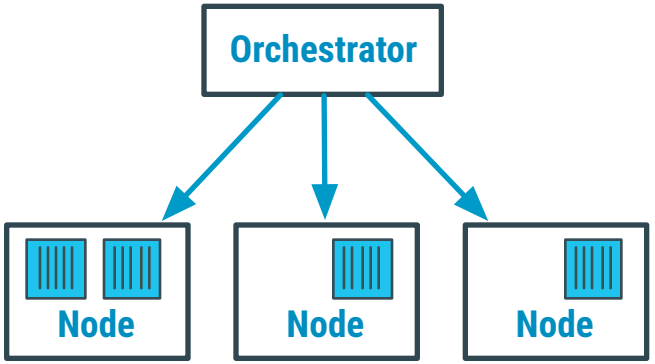
Least-privilege

container orchestrator



swarmKit

Multiple
nodes

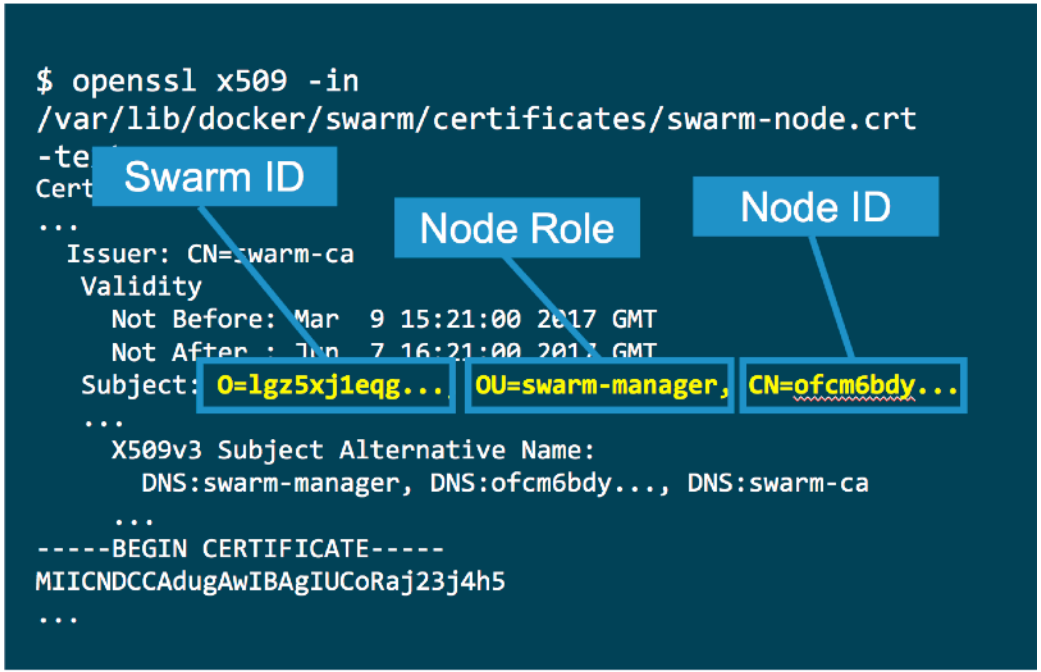


swarmKit

Secure Node Introduction

swarmKit

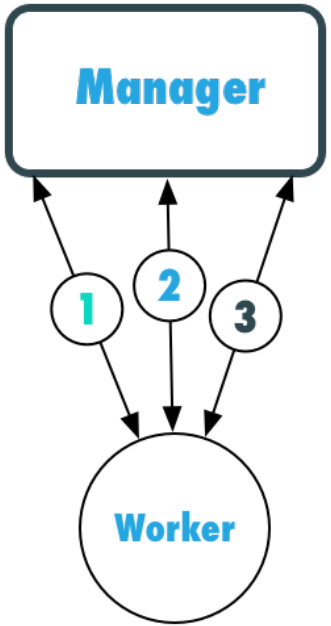
Cryptographic
Node Identity



swarmKit

Bootstrap

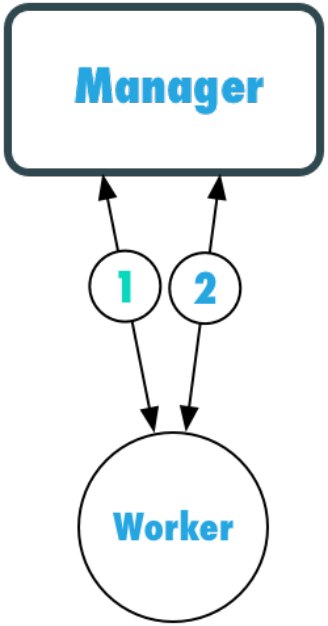
1. Retrieve and validate Root CA Public key material.
2. Submit new CSR along with secret token.
3. Retrieve the signed certificate.



swarmKit

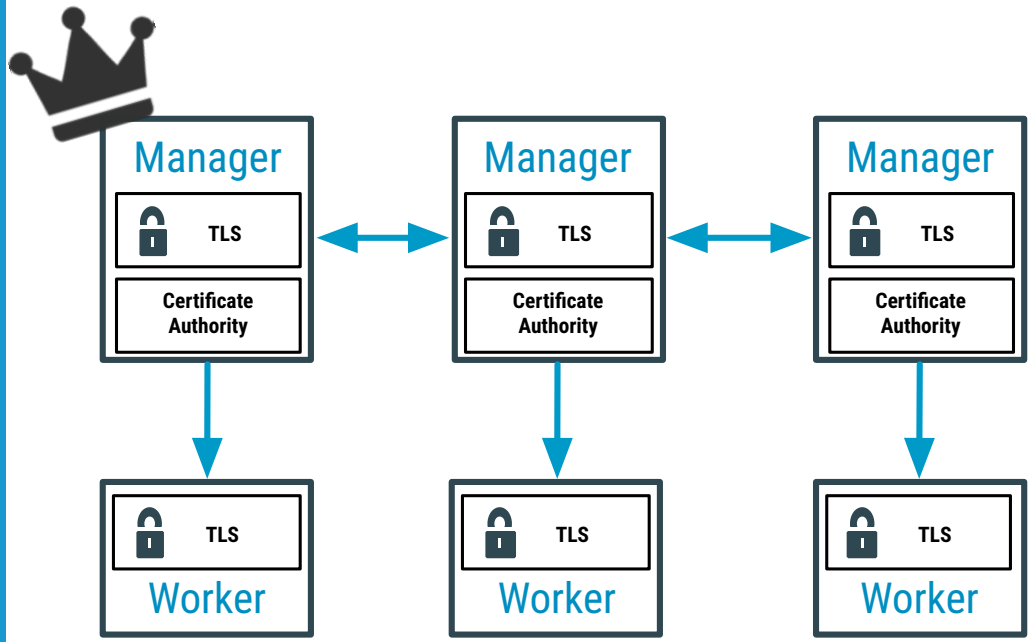
Automatic Certificate Rotation

1. Submit new CSR using old key-pair.
2. Retrieve the new signed certificate.



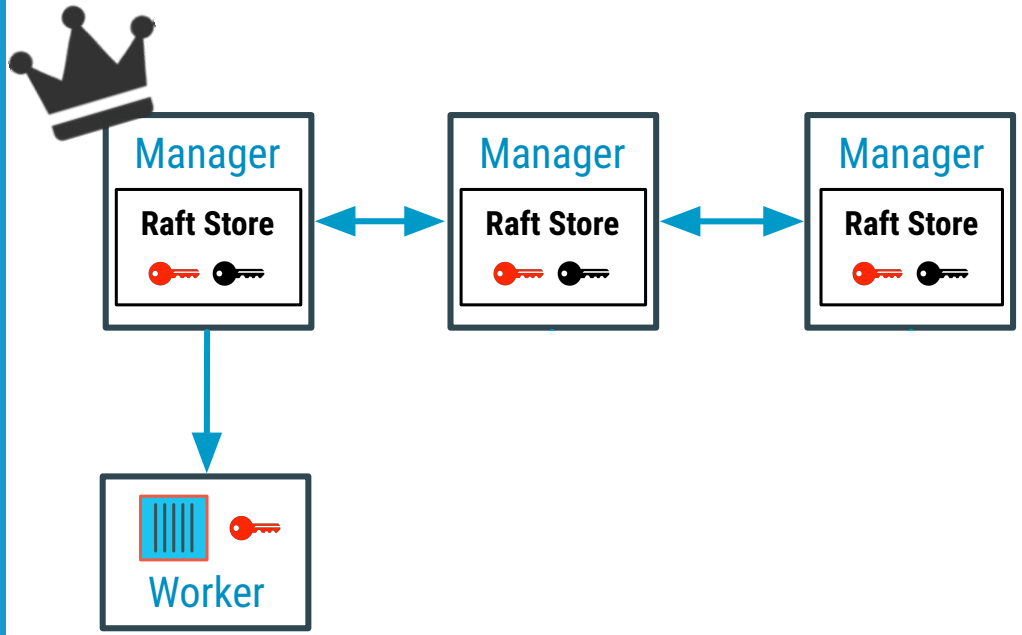
swarmKit

MTLS Between
All Nodes



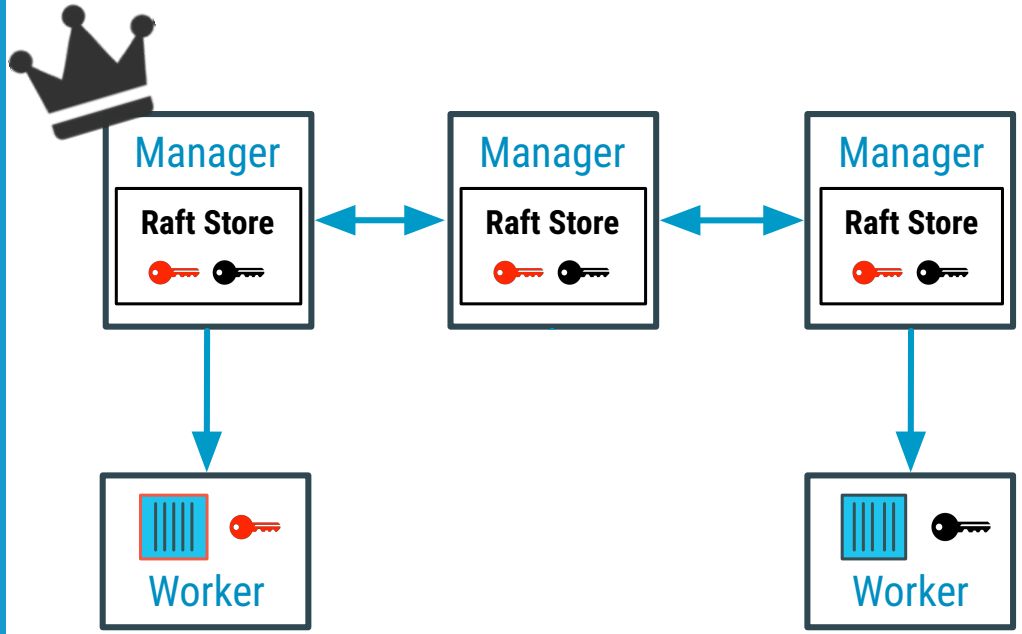
swarmKit

Least-privilege
Secret
Distribution



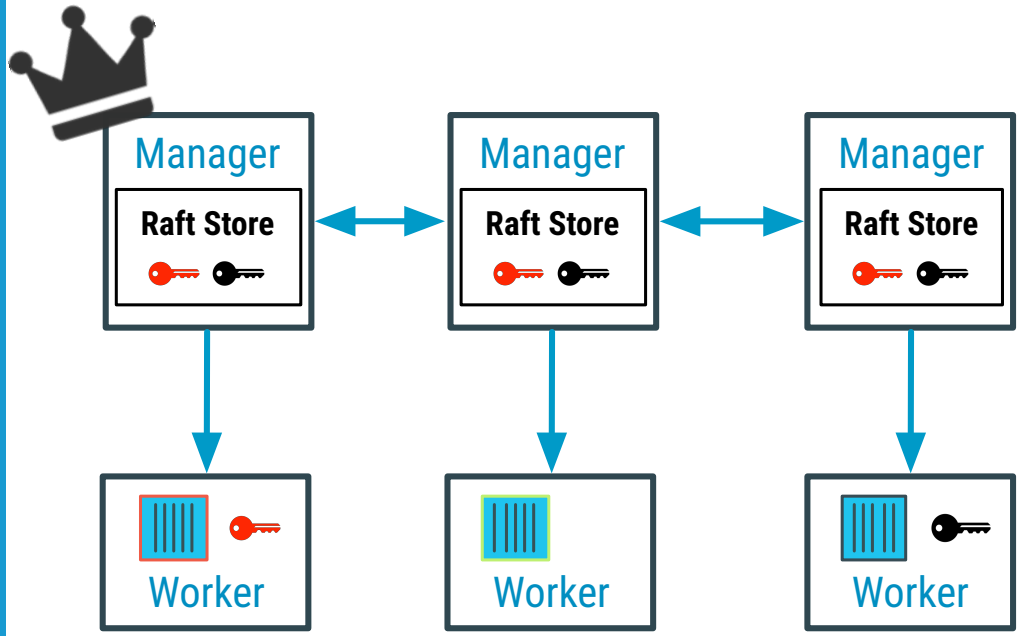
swarmKit

Least-privilege
Secret
Distribution



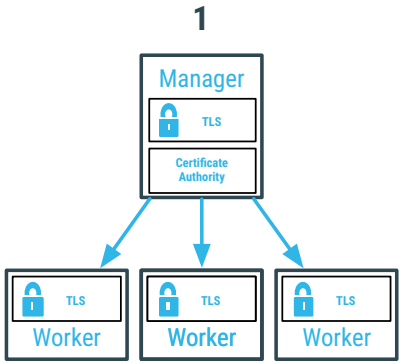
swarmKit

Least-privilege
Secret
Distribution



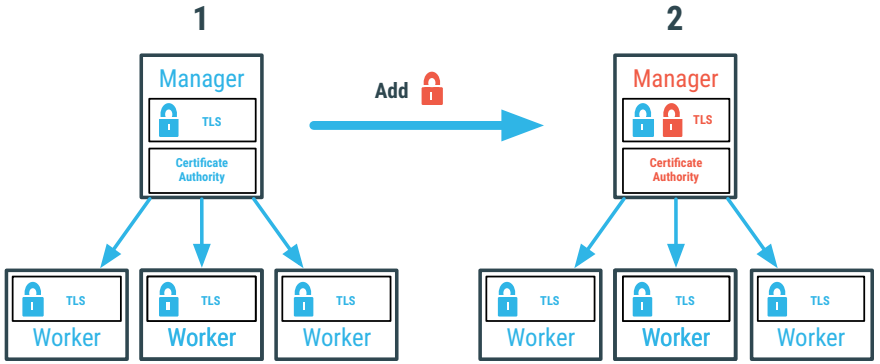
swarmKit

Transparent
Root Rotation



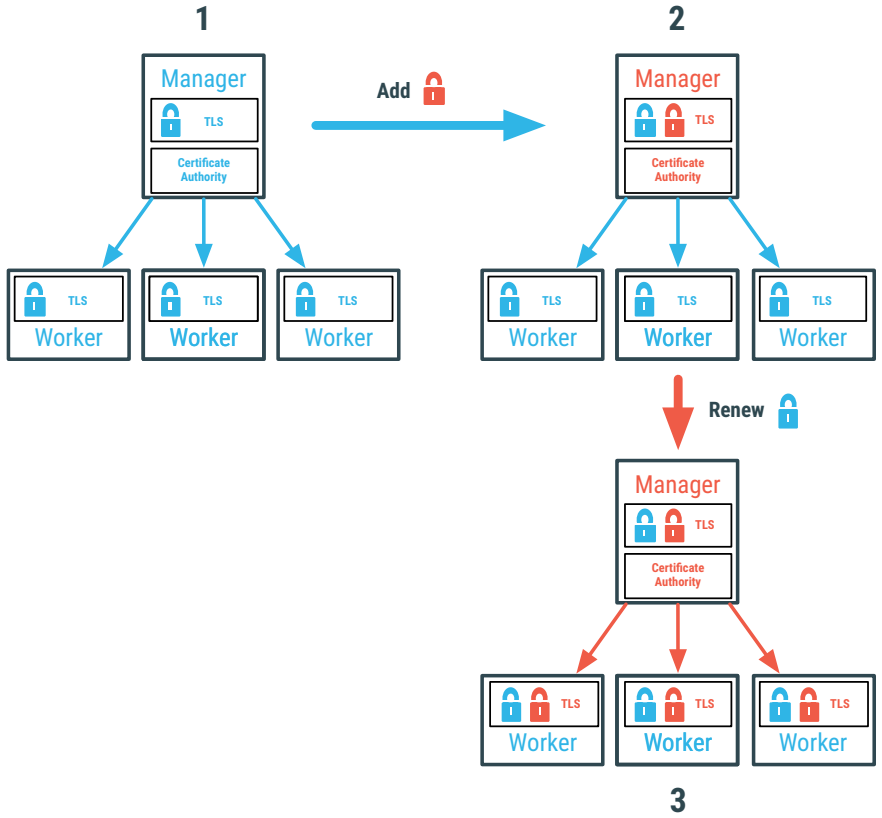
swarmKit

Transparent Root Rotation



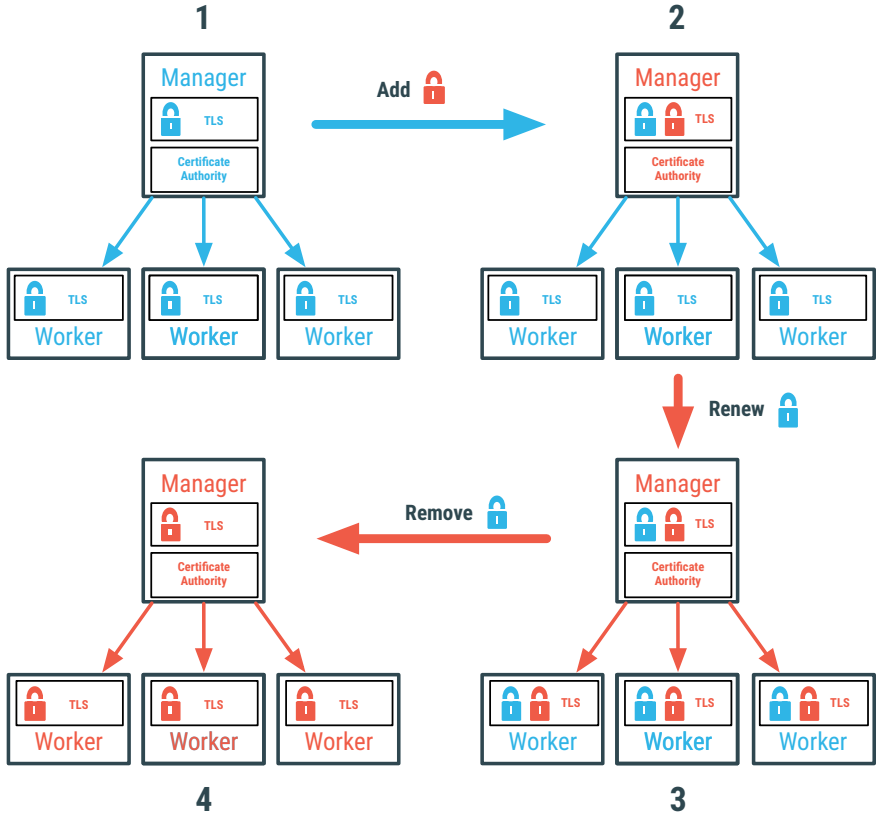
swarmKit

Transparent Root Rotation



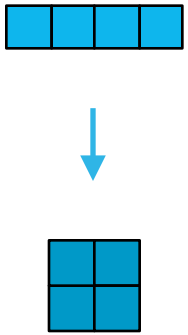
swarmKit

Transparent Root Rotation

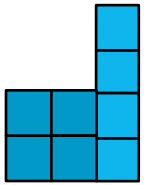


Bringing it all together

Notary for Docker image name resolution

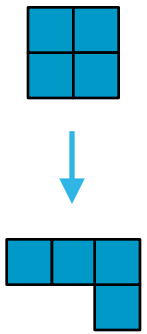


Notary for Docker image name resolution

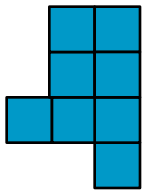


Cryptographically Verified Pulls

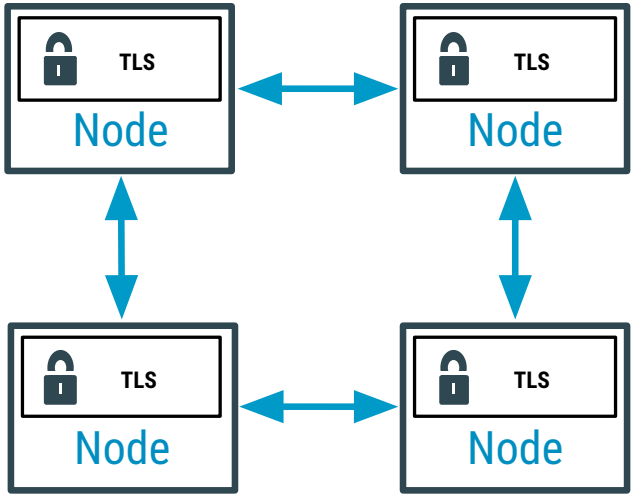
swarmKit delivered Docker containers



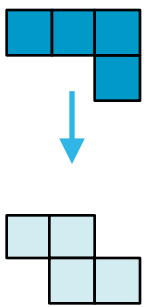
swarmKit delivered Docker containers



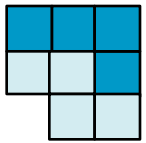
Authorized,
Authenticated,
Encrypted delivery
of Resources



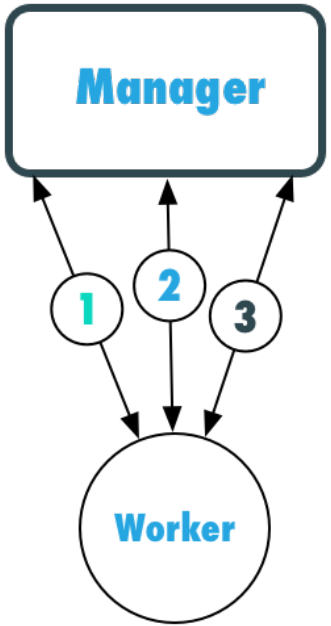
infraKit for swarmKit Bootstrap



infraKit for swarmKit Bootstrap



Secure Node Cluster Introduction



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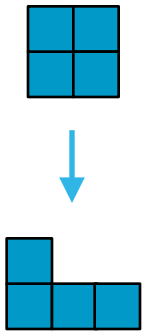
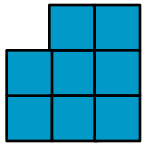
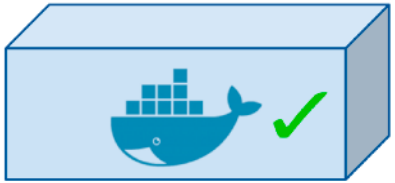
linuxKit as the base OS builder



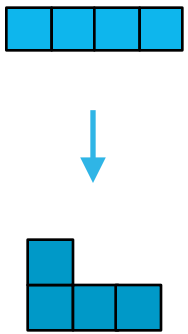
linuxKit as the base OS builder



Hardened Configuration



Notary for secure dependency resolution



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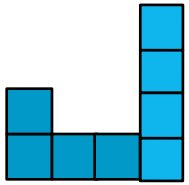
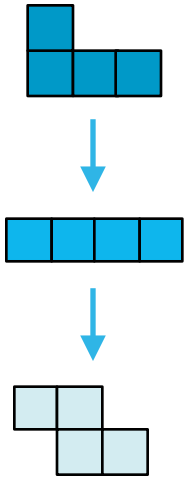
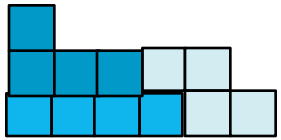


Cryptographically Verified Build

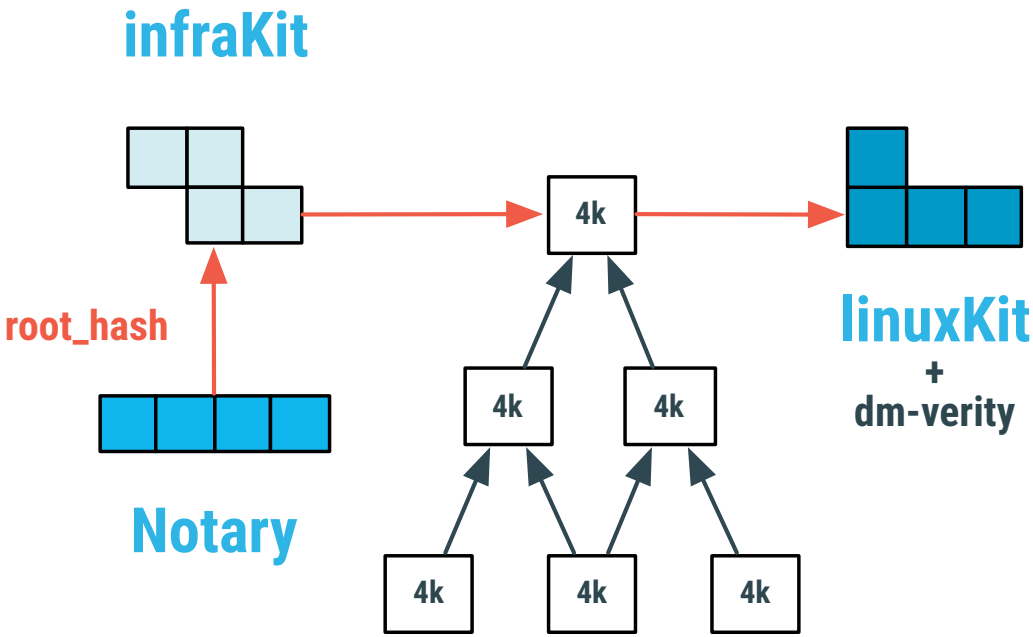
infraKit plus Notary for trusted OS Provisioning

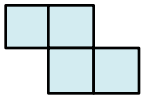


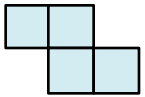
infraKit plus Notary for trusted OS Provisioning

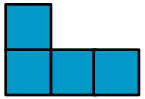


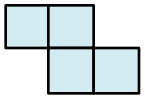
Cryptographically Verified Boot

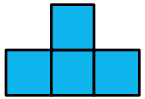


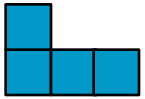


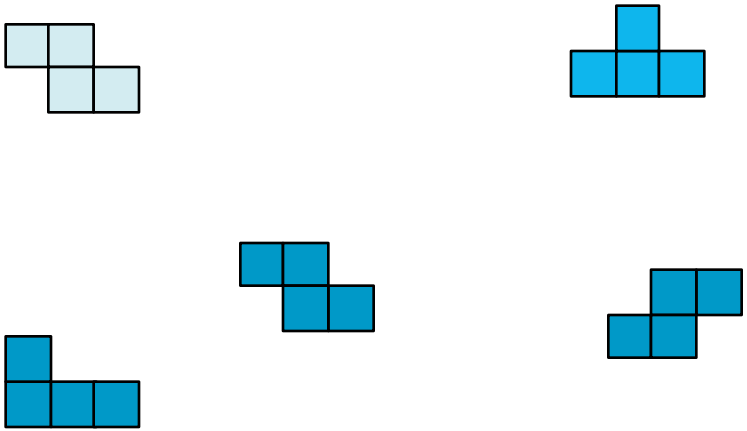


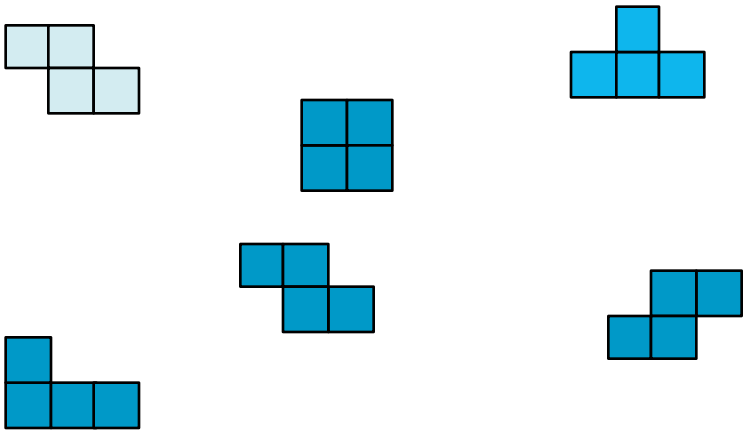


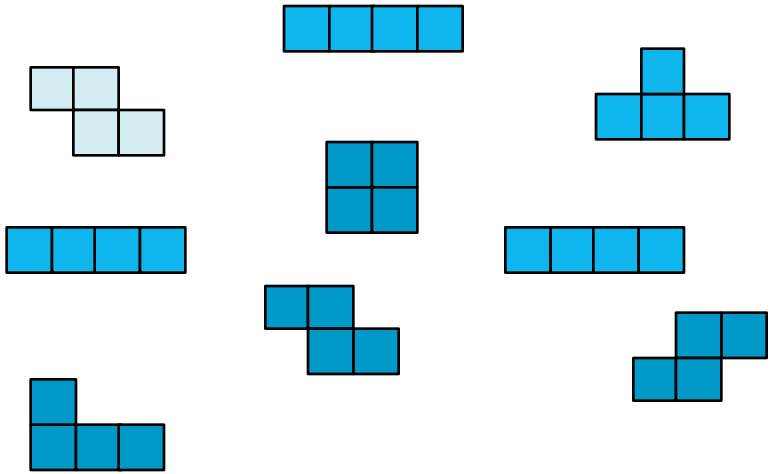


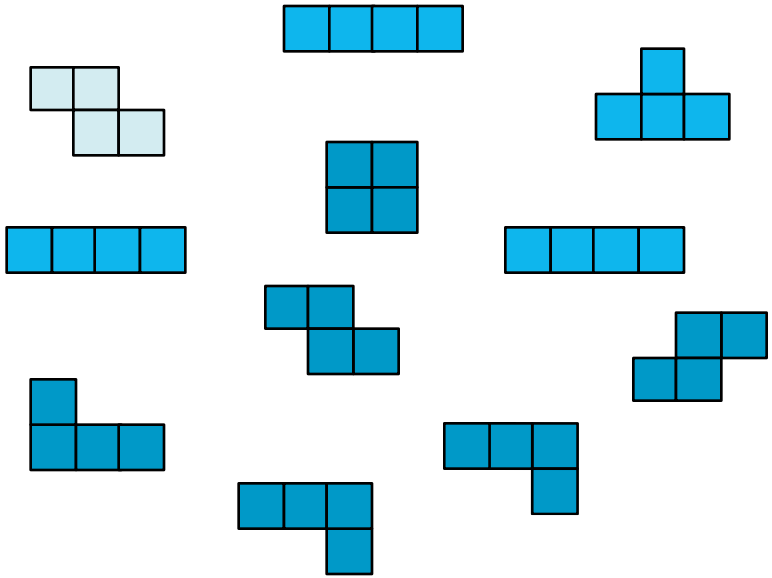


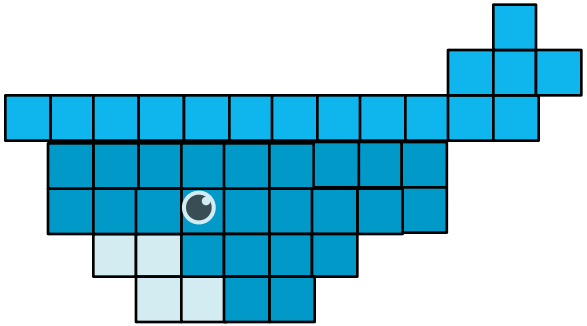


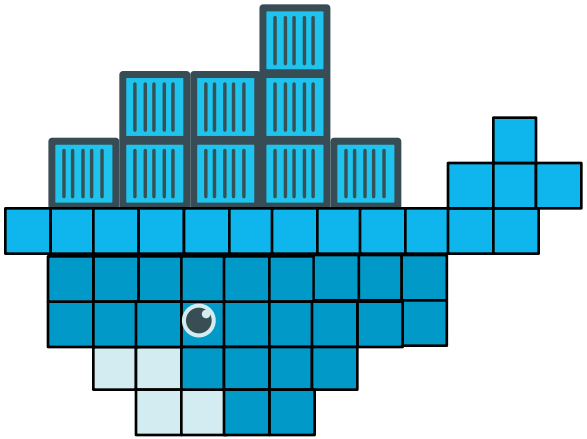












Thank you!