KubeSmith: A Framework for Hardenning Security Policies in Cloud-Native Environments

CHIHYEON CHO

Department of Computer Science & Engineering

Incheon National University

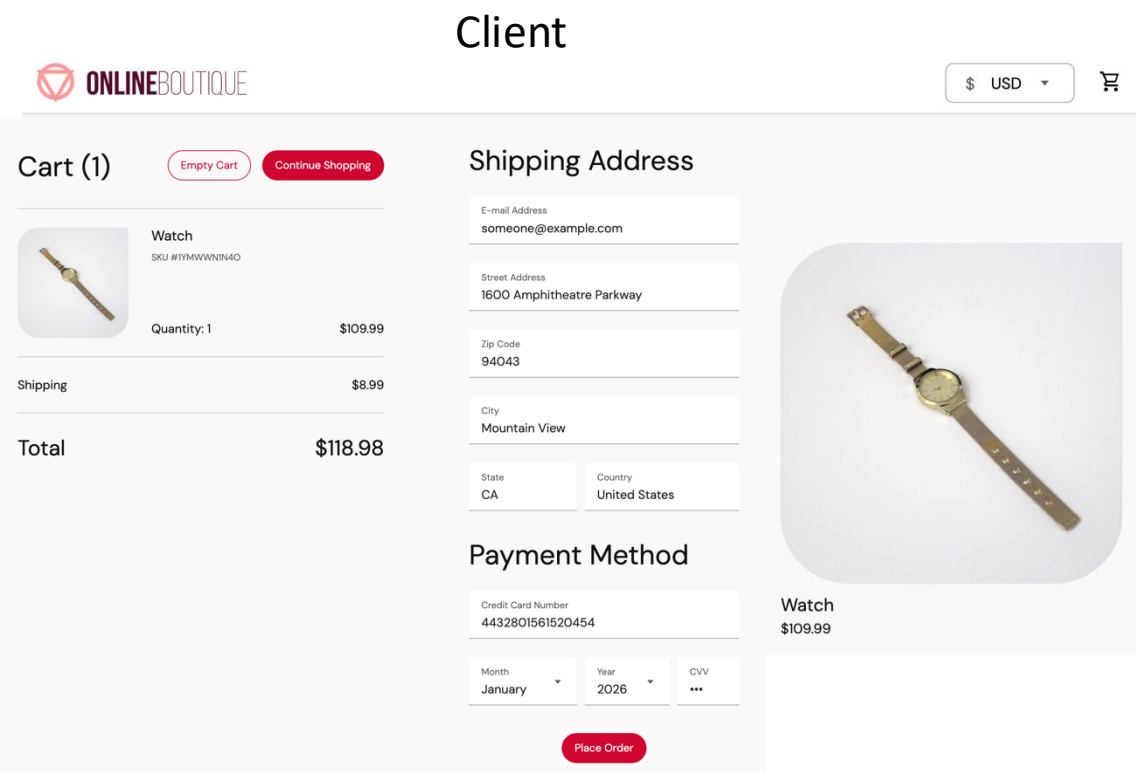
Subtitle

- Background
- Problem Statement
- Design
- Evaluation
- Conclusion and Future Work

Background

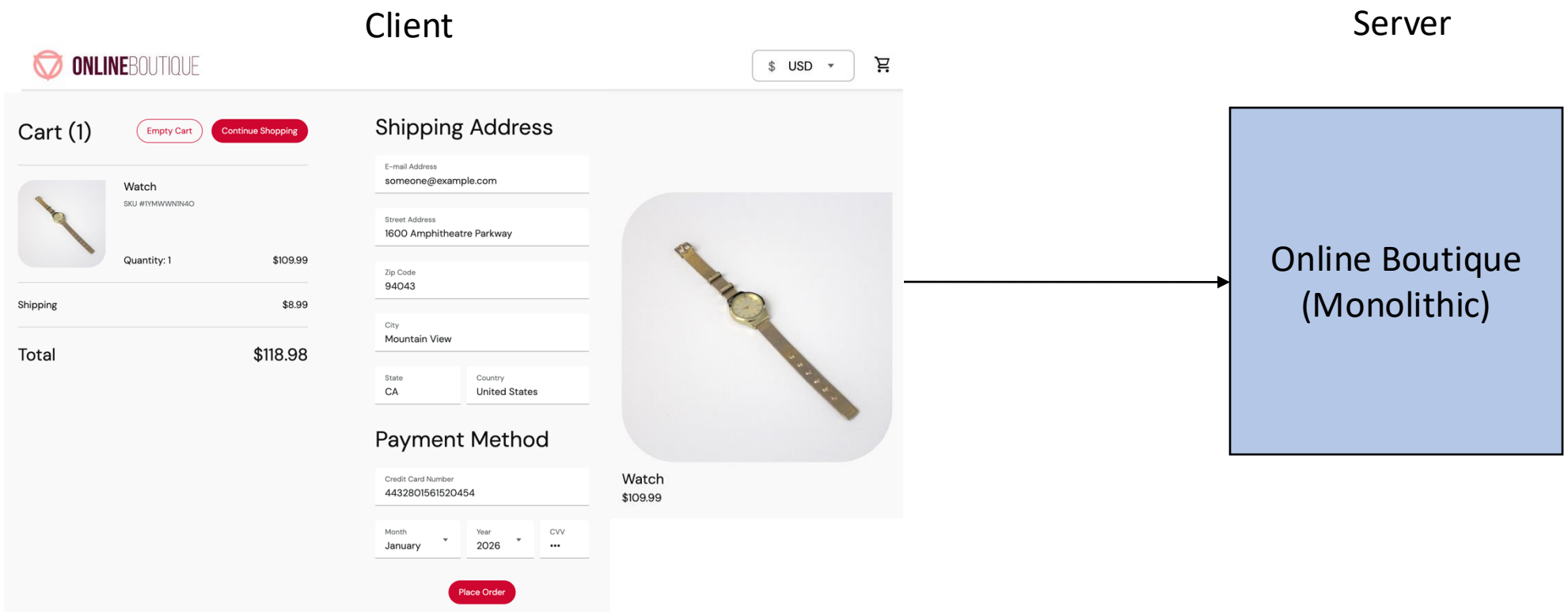
Microservice

- The most widely used **architecture** to practically implement the characteristics of Cloud Native



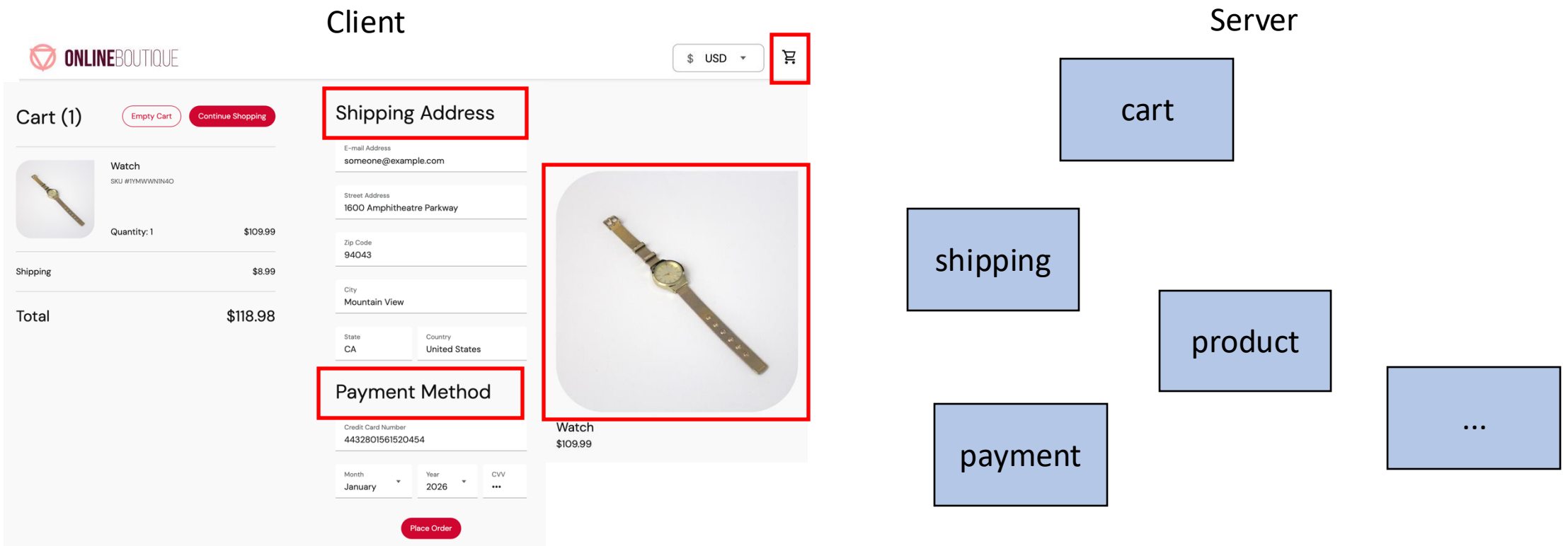
Microservice

- Past - Monolithic



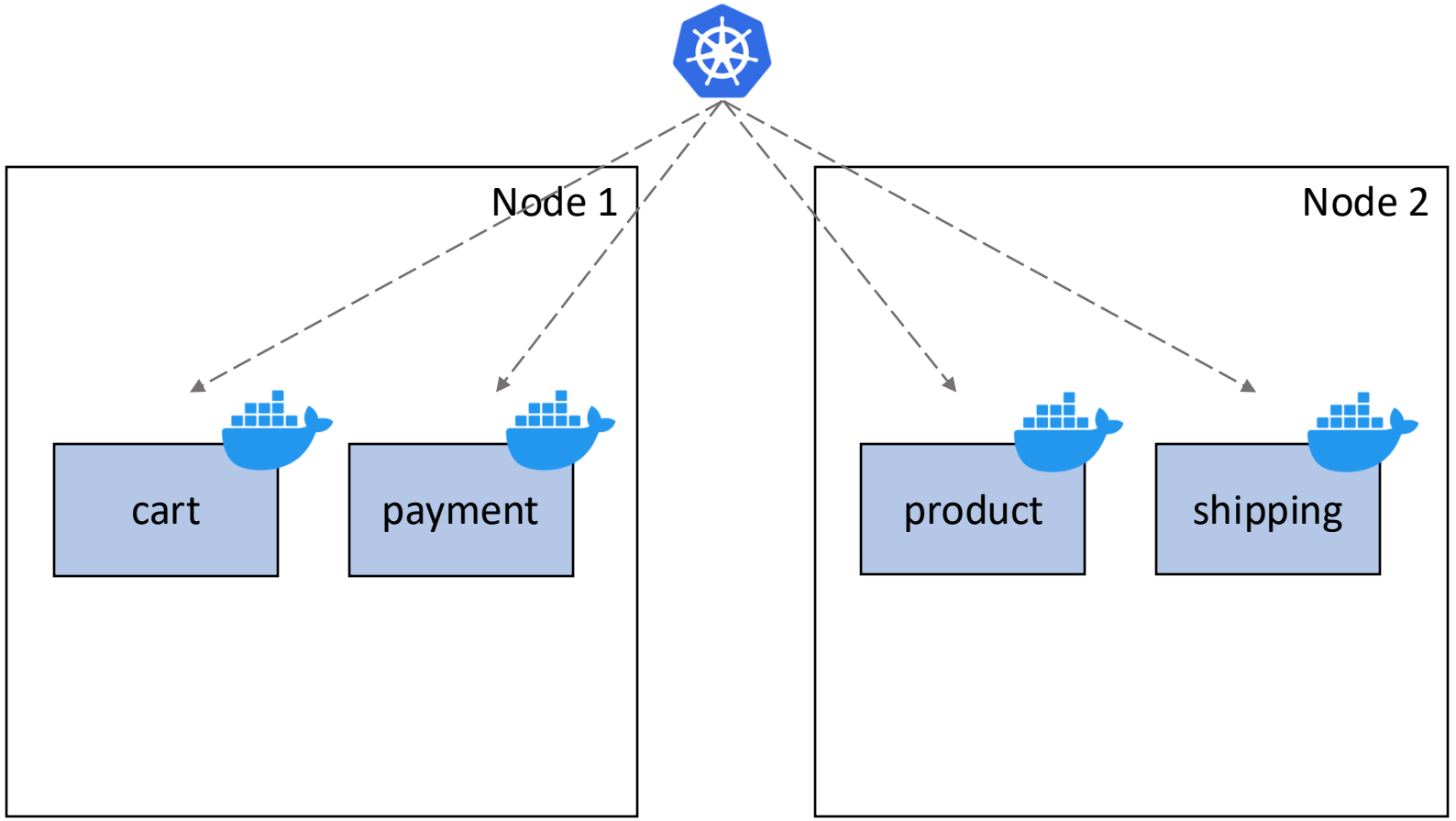
Microservice

- Cloud Native - Microservice



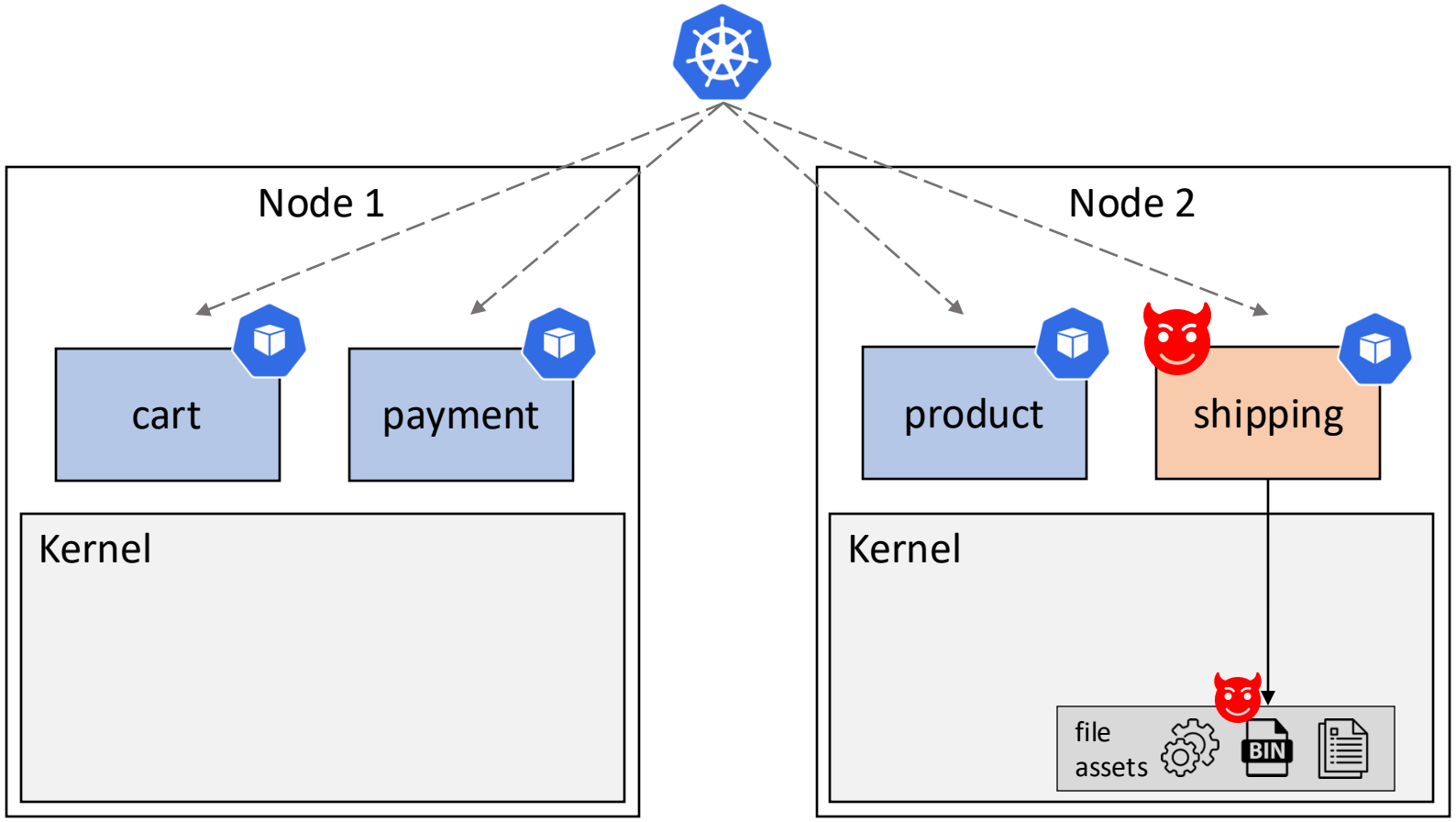
Container and Kubernetes

- Container Orchestration



Attack Types & Techniques

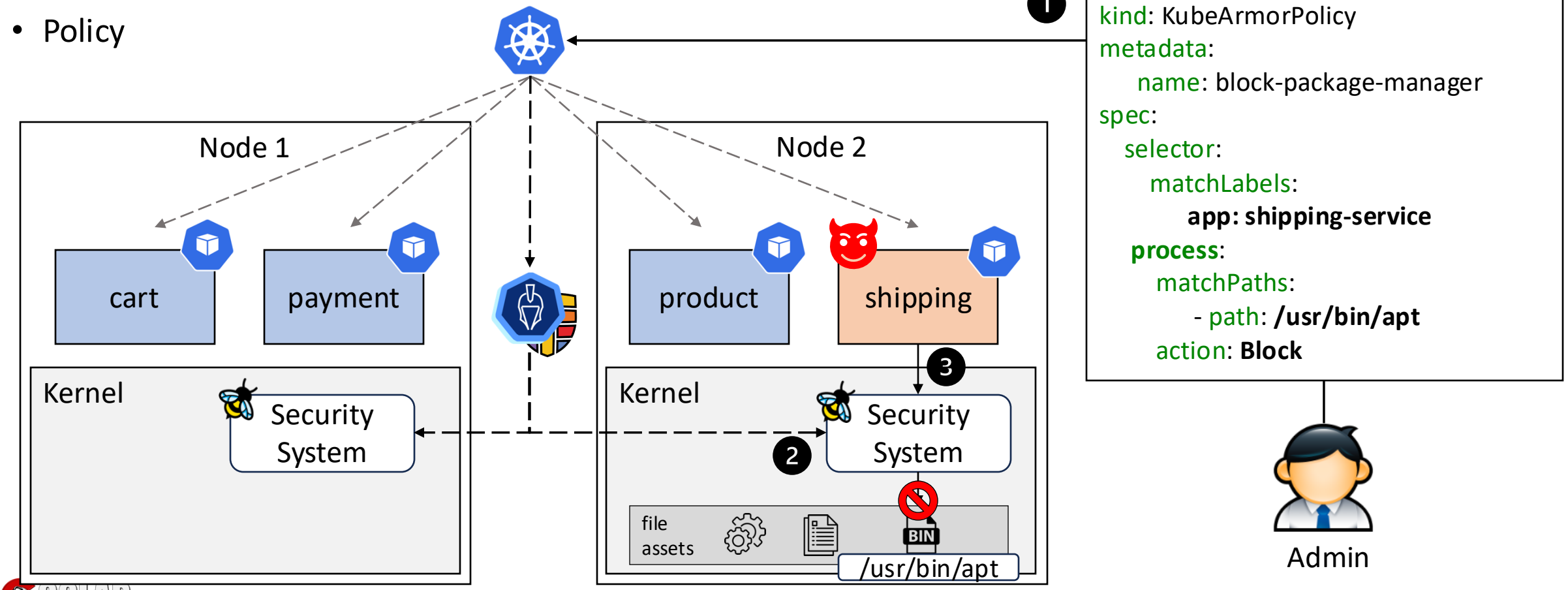
- Compromise the container



Attack Type	Attack Techs
Disclose credential Information	filesystem access
	file name access
Execute Arbitrary Code	Command and Scripting Interpreter

Cloud Native Runtime Security Enforcement System

- KubeArmor, Tetragon
- Mandatory Access Control (LSM, eBPF)
- Policy



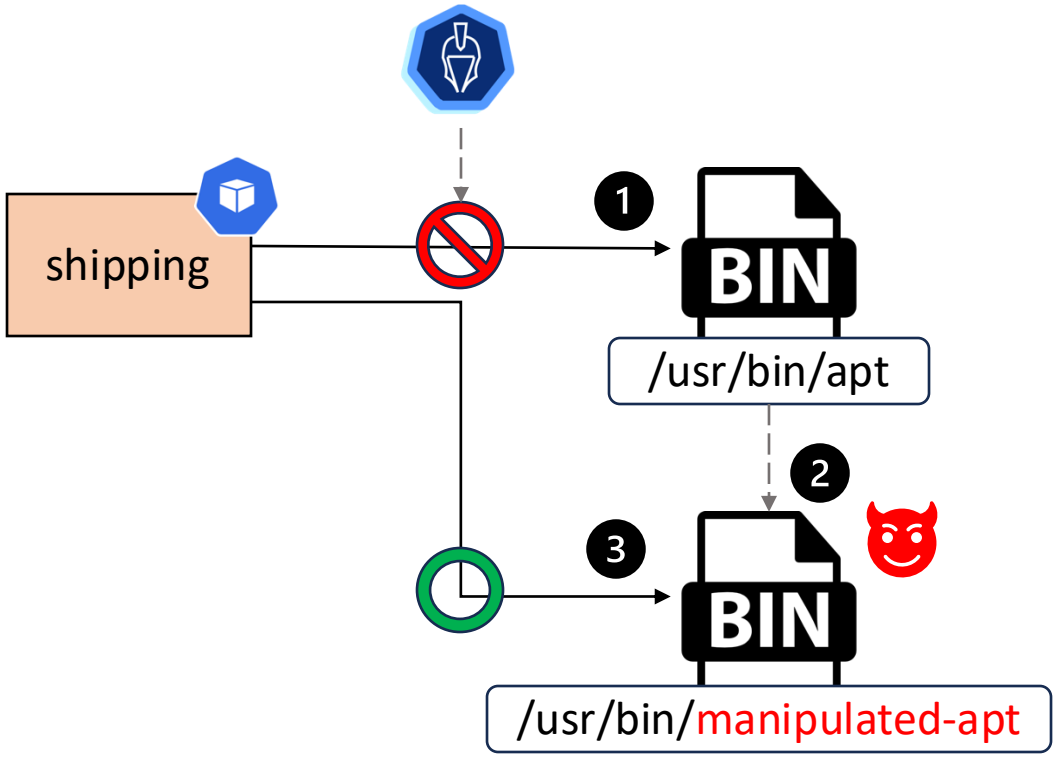
Problem Statement

Problem Statement - Overview

- Bypass of the security policy
  - Path Manipulation
  - Misconfiguration

Bypass of security policy (1) – Path Manipulation

- Path Manipulation



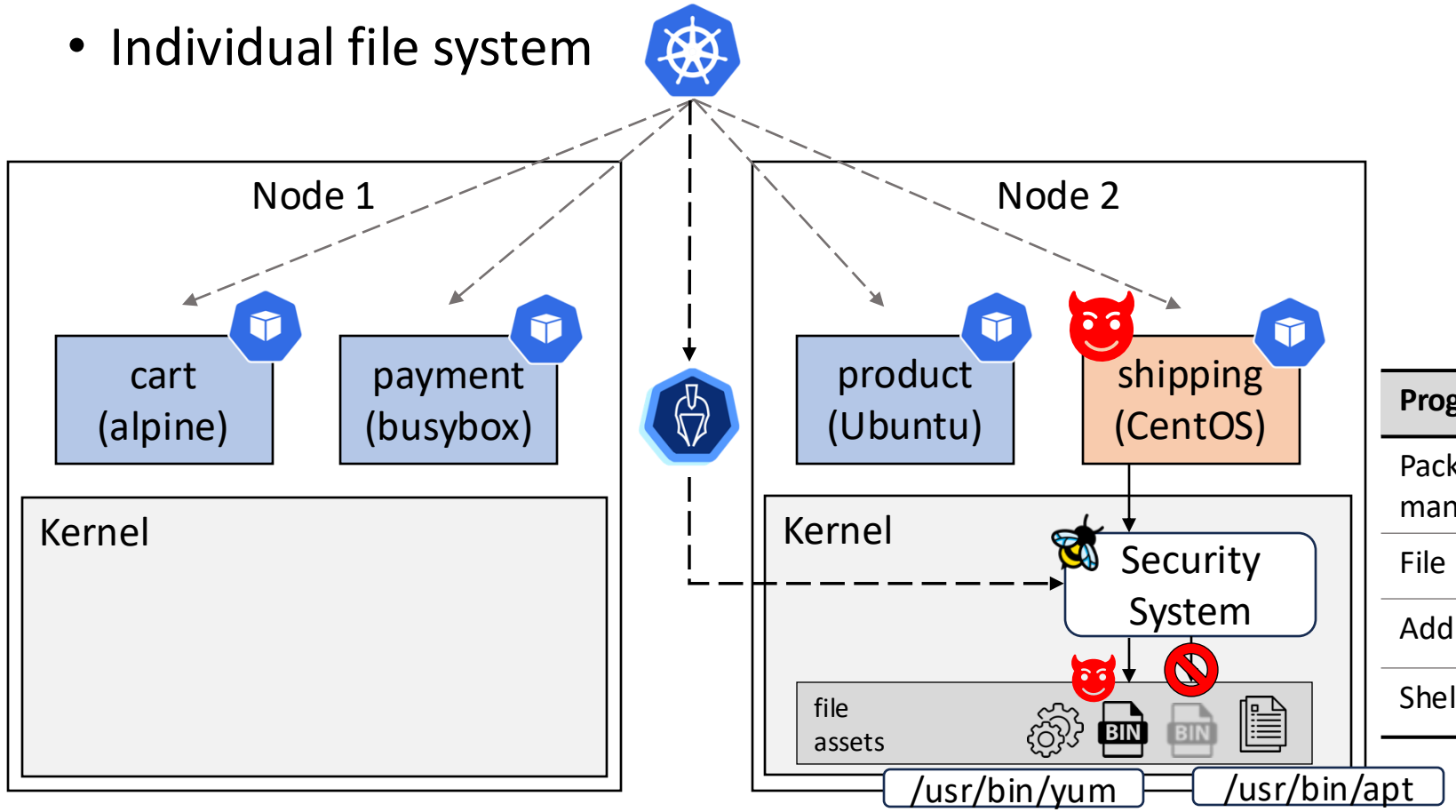
(1) Path Manipulation

Manipulation Type	Command (linux)
Path Modification	mv
File Duplication	cp
Hardlink	ln

(2) Manipulation Type

Bypass of security policy (2) – Misconfiguration

- Misconfiguration
- Individual file system

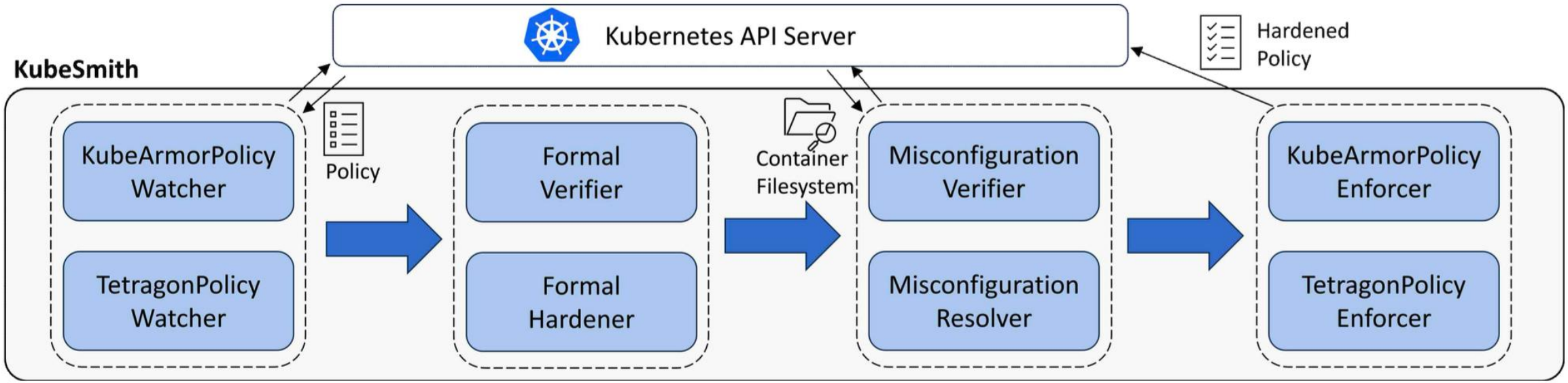


Program Type	Ubuntu	CentOS
Package manager	**/usr/bin/apt** /usr/bin/apt-get	**/usr/bin/yum** /usr/bin/rpm
File Editor (vim)	/usr/bin/vim.basic	/usr/bin/vi
Add User	/usr/sbin/useradd	/usr/sbin/adduser
Shell	/usr/bin/dash	/usr/bin/bash

KubeSmith Design

KubeSmith Overview

- Verification and Hardening **Policy**
- Watch → Verify & Harden → Enforce



Path Manipulation – Formal Verifier & Hardener

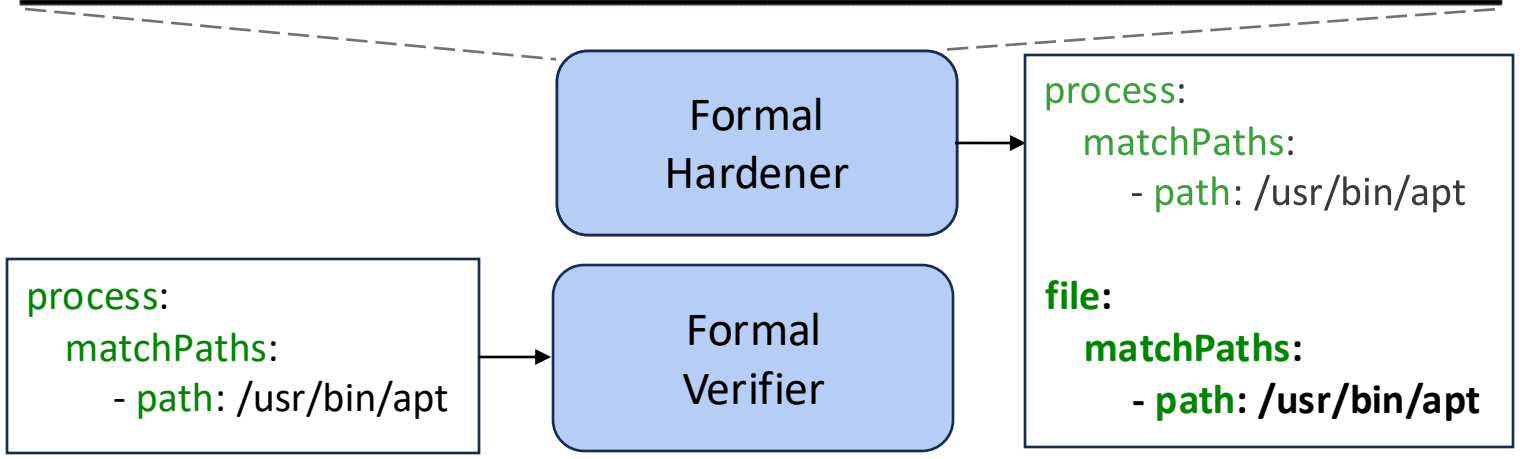
Identification of potential **path manipulation** in policies and hardening through **policy modification**

(1) Manipulation type – Response Mapping

Manipulation type	LSM Hook	KubeArmor rule	Tetragon rule
Path Modification	path_rename	File	-
File Duplication	file_open		hook: "file_open"
Hardlink	path_link		-

(2) Identify security policy

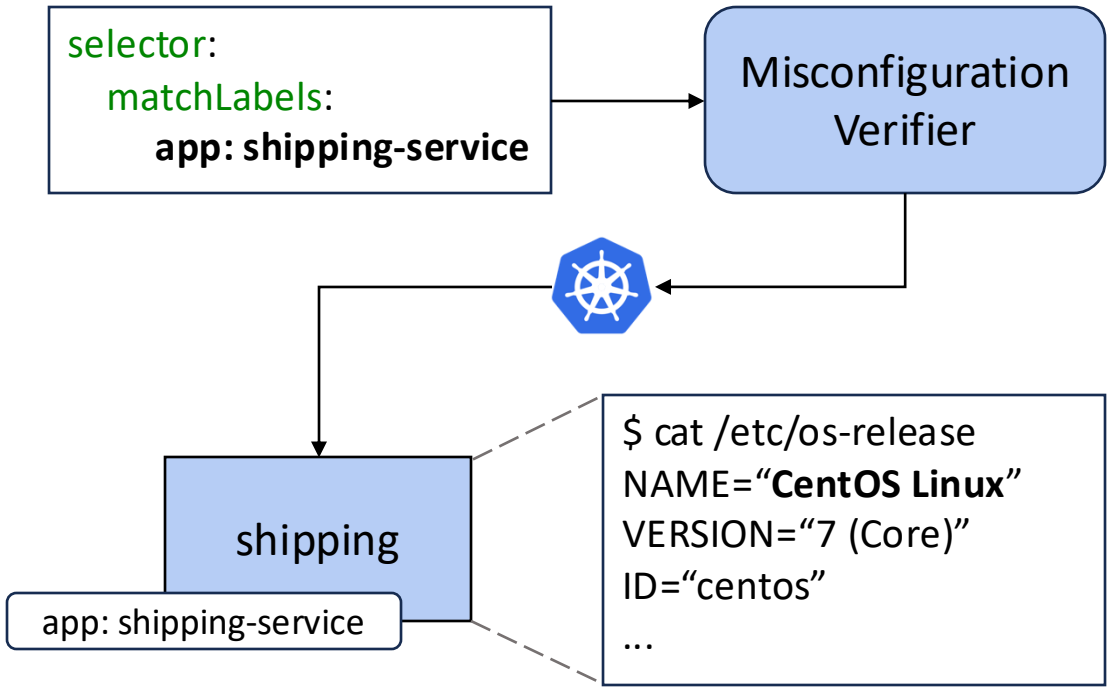
(3) Harden security policy



Misconfiguration – Misconfiguration Verifier & Resolver

Identify **misconfigurations** between policies and the actual container environment, and **resolve** them

(1) Extraction container filesystem information



Misconfiguration – Misconfiguration Verifier & Resolver

Identify **misconfigurations** between policies and the actual container environment, and **resolve** them

(2) Matching the container – program

```
process:
  matchPaths:
    - path: /usr/bin/apt
```

```
NAME="CentOS Linux"
VERSION="7 (Core)"
ID="centos"
...
```

You are a Linux system binary mapper.
Your task is to identify equivalent command-line binaries across Linux distributions.

binary: **{binary name}**

Your job: Search within the **{image}** and list the binary (or binaries) that serve the same purpose as the input binary.

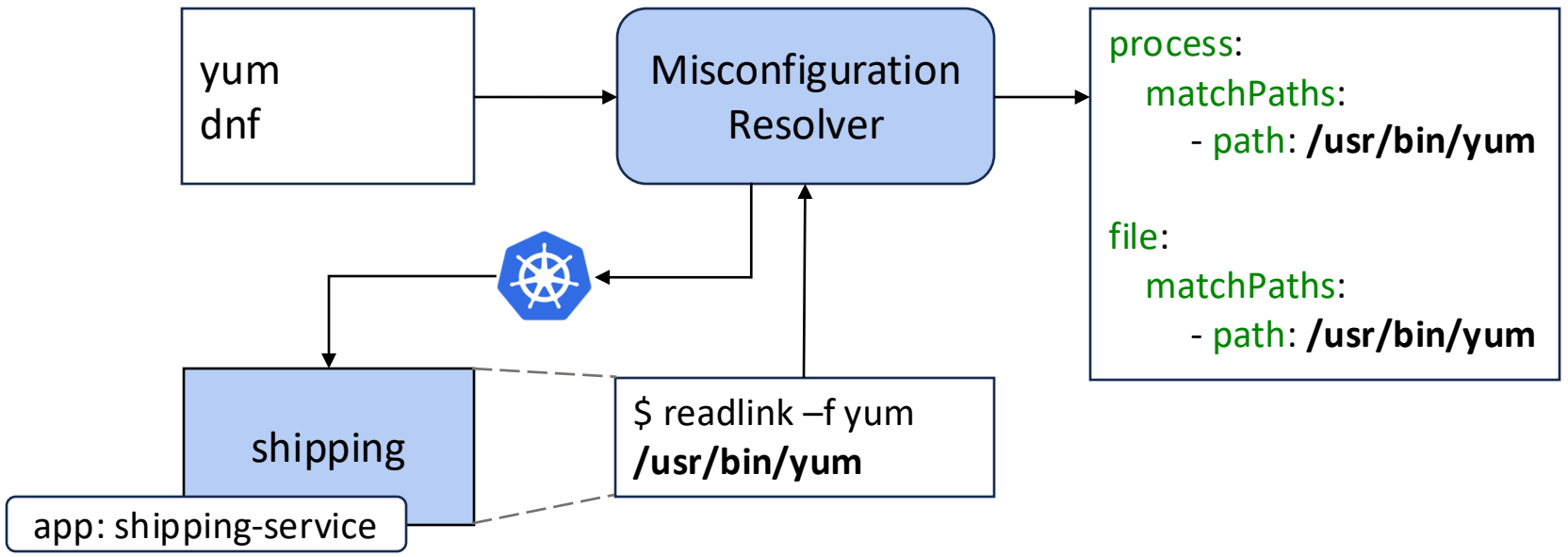
Constraints:
- Output only actual binary names as they appear
- No explanation, no code blocks, no formatting
- ...

yum
dnf

Misconfiguration – Misconfiguration Verifier & Resolver

Identify **misconfigurations** between policies and the actual container environment, and **resolve** them

(3) Path correction based on filesystem lookup



Evaluation

Evaluation – Formal Verifier & Hardener

- Evaluate whether all three types of manipulable paths can be blocked
  - KubeArmor – All
  - Tetragon – only file duplication

without – (A)

```
root@target-pod:/# apt update
bash: /usr/bin/apt: Permission denied

root@target-pod:/# mv /usr/bin/apt /usr/bin/manipulated-apt
root@target-pod:/# manipulated-apt update
Get:1 http://deb.debian.org/debian bookworm InRelease [..]
Get:2 http://deb.debian.org/debian bookworm-updates InRelease [..]
...
```

with – (B)

```
root@target-pod:/# apt update
bash: /usr/bin/apt: Permission denied

root@target-pod:/# mv /usr/bin/apt /usr/bin/manipulated-apt
mv: cannot move '/usr/bin/apt' to '/usr/bin/manipulated-apt':
Permission denied
```

(1) Use case

Manipulation type	LSM Hook	KubeArmor rule	Tetragon rule
Path Modification	path_rename	File	-
File Duplication	file_open		hook: "file_open"
Hardlink	path_link		-

(2) Coverage

Evaluation – Misconfiguration Verifier & Resolver

- 5 example policies from the KubeArmor repository
- 3 containers, each using a different image
- Policy Example
  - /usr/bin/apt, /usr/bin/apt-get

Program Type	Ubuntu	CentOS	Busybox
Package Manager	/usr/bin/apt /usr/bin/apt-get	/usr/bin/yum	-
File Editor	/usr/bin/vim.basic	/usr/bin/vi	/bin/vi
Add User	/usr/sbin/useradd	/usr/sbin/adduser	/bin/adduser
Shell	/usr/bin/dash	/usr/bin/bash	/bin/sh

(1) Program name

Program Type	Ubuntu		CentOS		Busybox	
	w/o	w/	w/o	w/	w/o	w/
Package Manager (apt)	2/2	2/2	**0/1**	**1/1**	-	-
File Editor (vim)	**0/1**	**1/1**	**0/1**	**1/1**	1/1	1/1
Add User (adduser)	1/1	1/1	1/1	1/1	**0/1**	**1/1**
Shell (sh)	**0/1**	**1/1**	1/1	1/1	1/1	1/1

(2) Coverage

Conclusion

Conclusion and Future Work

Conclusion

- Bypass of security policy
- KubeSmith

Future Work

- White list policy generation