Экскурсия по матрицам угроз для контейнеров и Kubernetes

Сергей Канибор

R&D/Container Security, Luntry

whoami

- R&D/Container Security в Luntry
- Специализируюсь на безопасности контейнеров и Kubernetes
- Багхантер
- Редактор Telegram-канала “k8s (in)security”
- Спикер: PHDays, OFFZONE, VK Kubernetes conf, Devoops, HackConf, CyberCamp, БеКон и др.

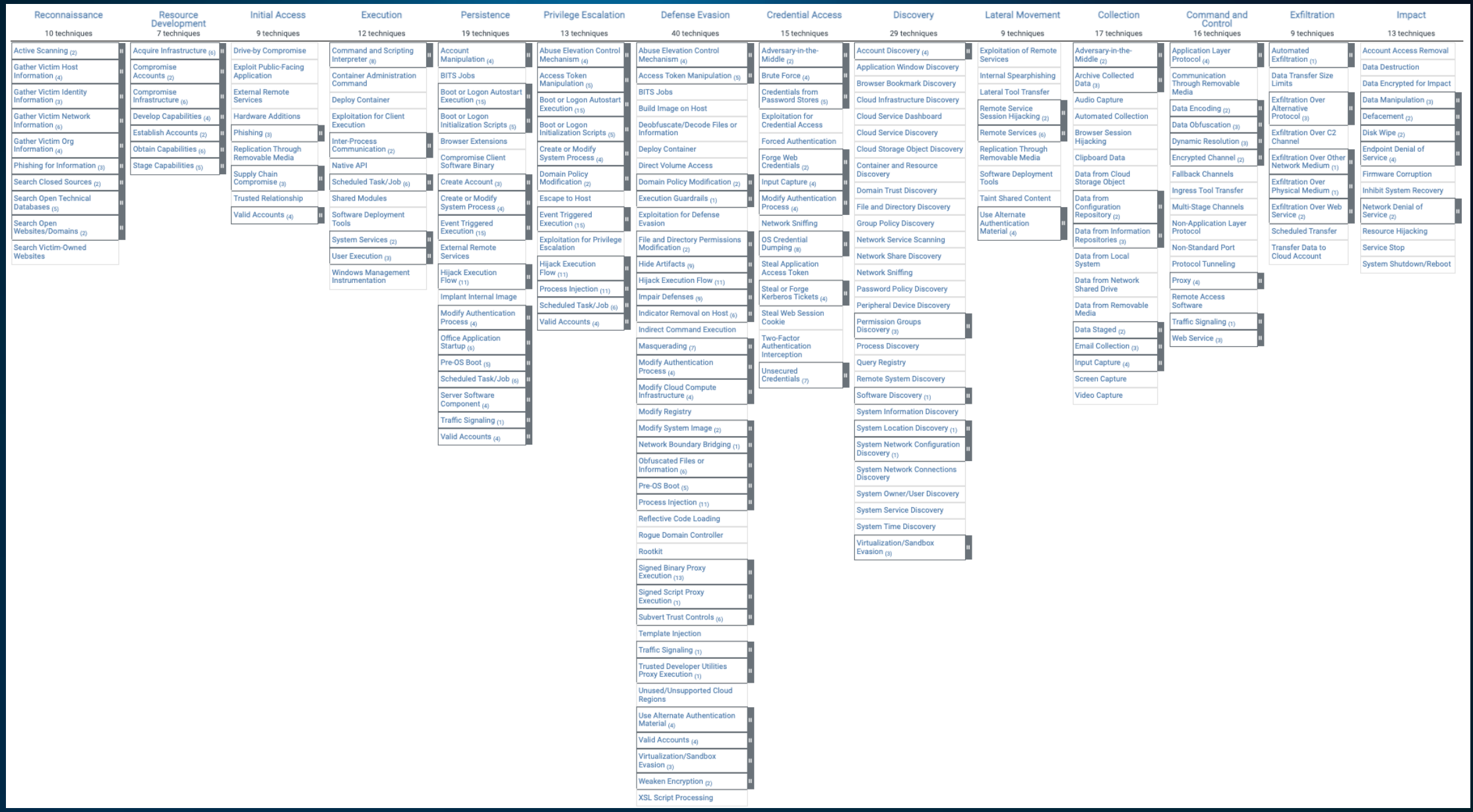
Agenda

- Зачем нам матрицы и какие они бывают?
  - MITRE ATT&CK Container Matrix
  - Microsoft Threat Matrix for Kubernetes
- Какой матрицей пользоваться?
- Раскладываем атаки по матрицам

Зачем нам матрицы и какие они бывают?

Что это такое и зачем нужно

- Матрица построена на реальных наблюдениях и примерах реальных инцидентов
- Это публичная база знаний, которая наполняется и поддерживается сообществом
- Помимо основной «большой» матрицы существуют матрицы-подразделы


Reconnaissance
10 techniques
Active Scanning (2)
Gather Victim Host Information (4)
Gather Victim Identity Information (3)
Gather Victim Network Information (6)
Gather Victim Org Information (4)
Phishing for Information (3)
Search Closed Sources (2)
Search Open Technical Databases (5)
Search Open Websites/Domains (2)
Search Victim-Owned Websites
Resource Development
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Compromise Accounts (2)
Compromise Infrastructure (6)
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Establish Accounts (2)
Obtain Capabilities (6)
Stage Capabilities (5)
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External Remote Services
Hardware Additions
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Supply Chain Compromise (3)
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Boot or Logon Initialization Scripts (5)
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Compromise Client Software Binary
Create Account (3)
Create or Modify System Process (4)
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External Remote Services
Hijack Execution Flow (11)
Implant Internal Image
Modify Authentication Process (4)
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Pre-OS Boot (5)
Scheduled Task/Job (6)
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Traffic Signaling (1)
Valid Accounts (4)
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Abuse Elevation Control Mechanism (4)
Access Token Manipulation (5)
Boot or Logon Autostart Execution (15)
Boot or Logon Initialization Scripts (5)
Create or Modify System Process (4)
Domain Policy Modification (2)
Escape to Host
Event Triggered Execution (15)
Exploitation for Privilege Escalation
Hijack Execution Flow (11)
Process Injection (11)
Scheduled Task/Job (6)
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Abuse Elevation Control Mechanism (4)
Access Token Manipulation (5)
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Hijack Execution Flow (11)
Impair Defenses (9)
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Obfuscated Files or Information (6)
Pre-OS Boot (5)
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Signed Script Proxy Execution (1)
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Traffic Signaling (1)
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System Owner/User Discovery
System Service Discovery
System Time Discovery
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9 techniques
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Exfiltration Over C2 Channel
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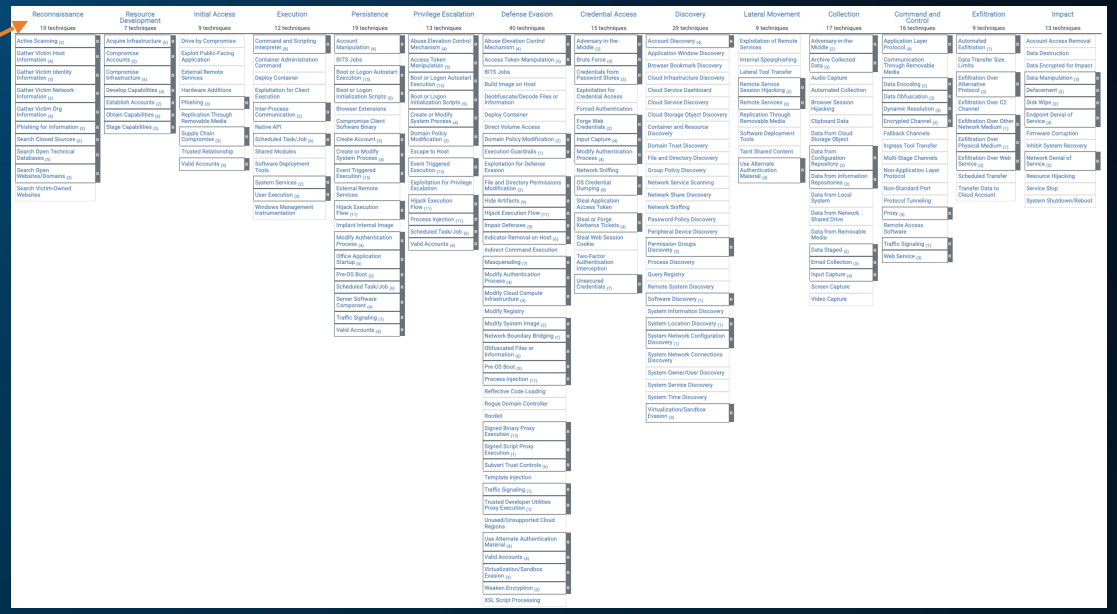
Network Denial of Service (2)
Resource Hijacking
Service Stop
System Shutdown/Reboot

Тактика

То, как злоумышленник действует

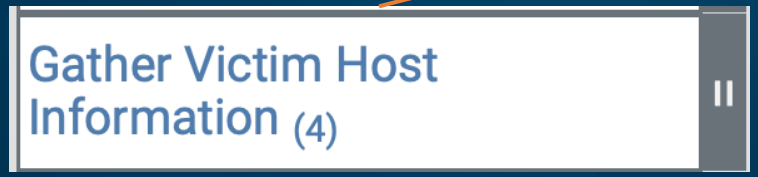
Reconnaissance

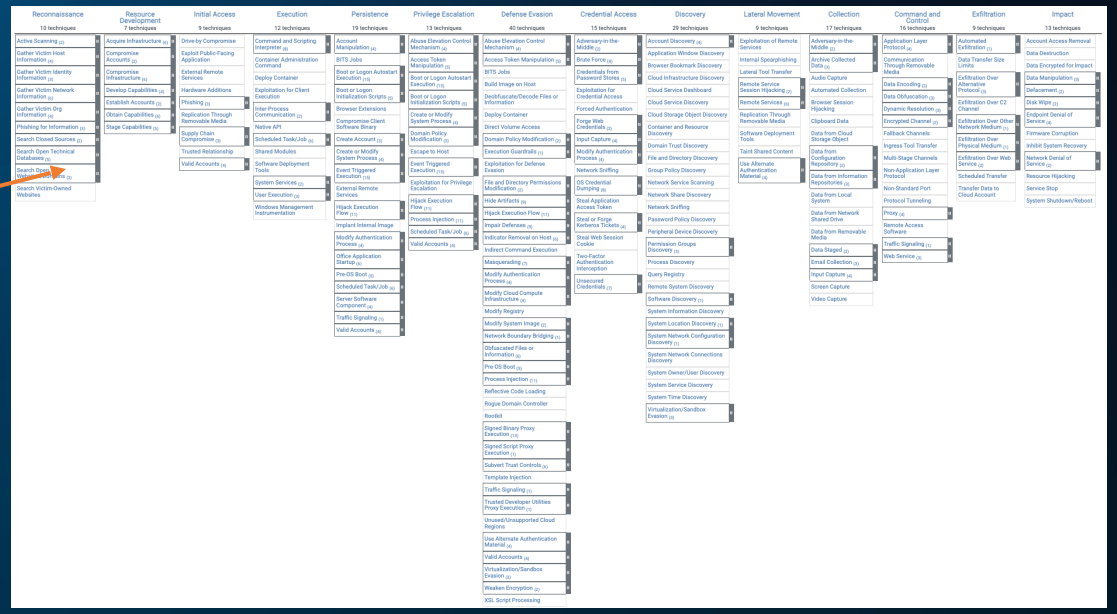
10 techniques



Техника

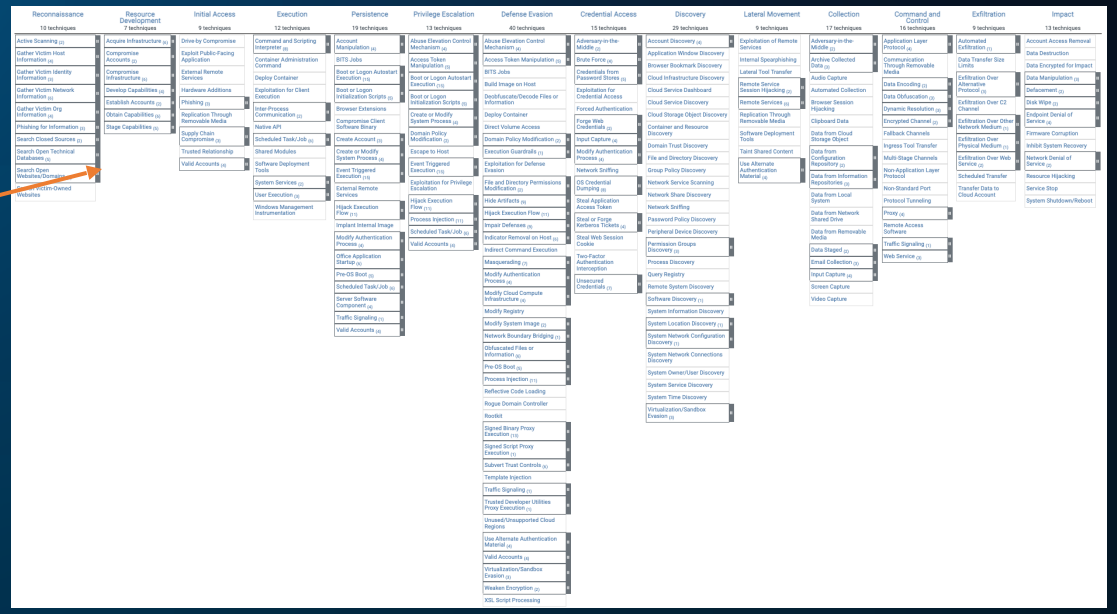
То, как злоумышленник достигает цели

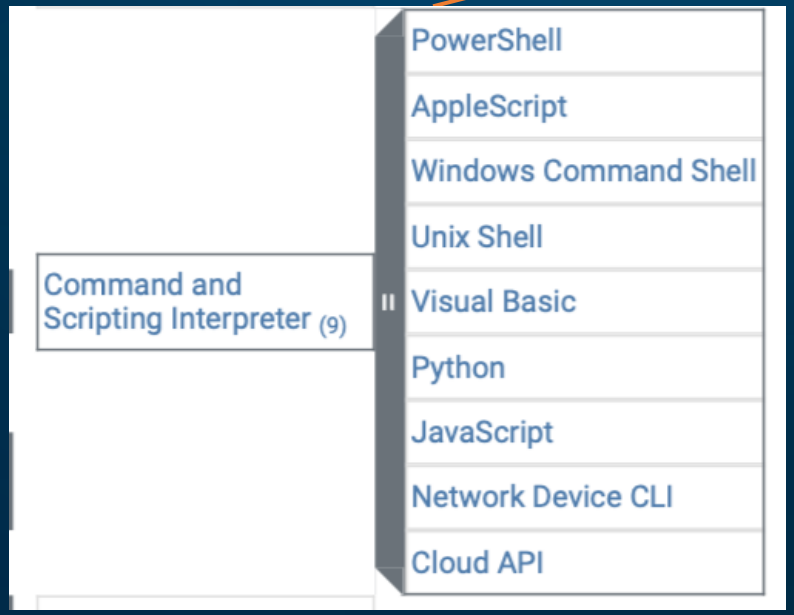




Процедура

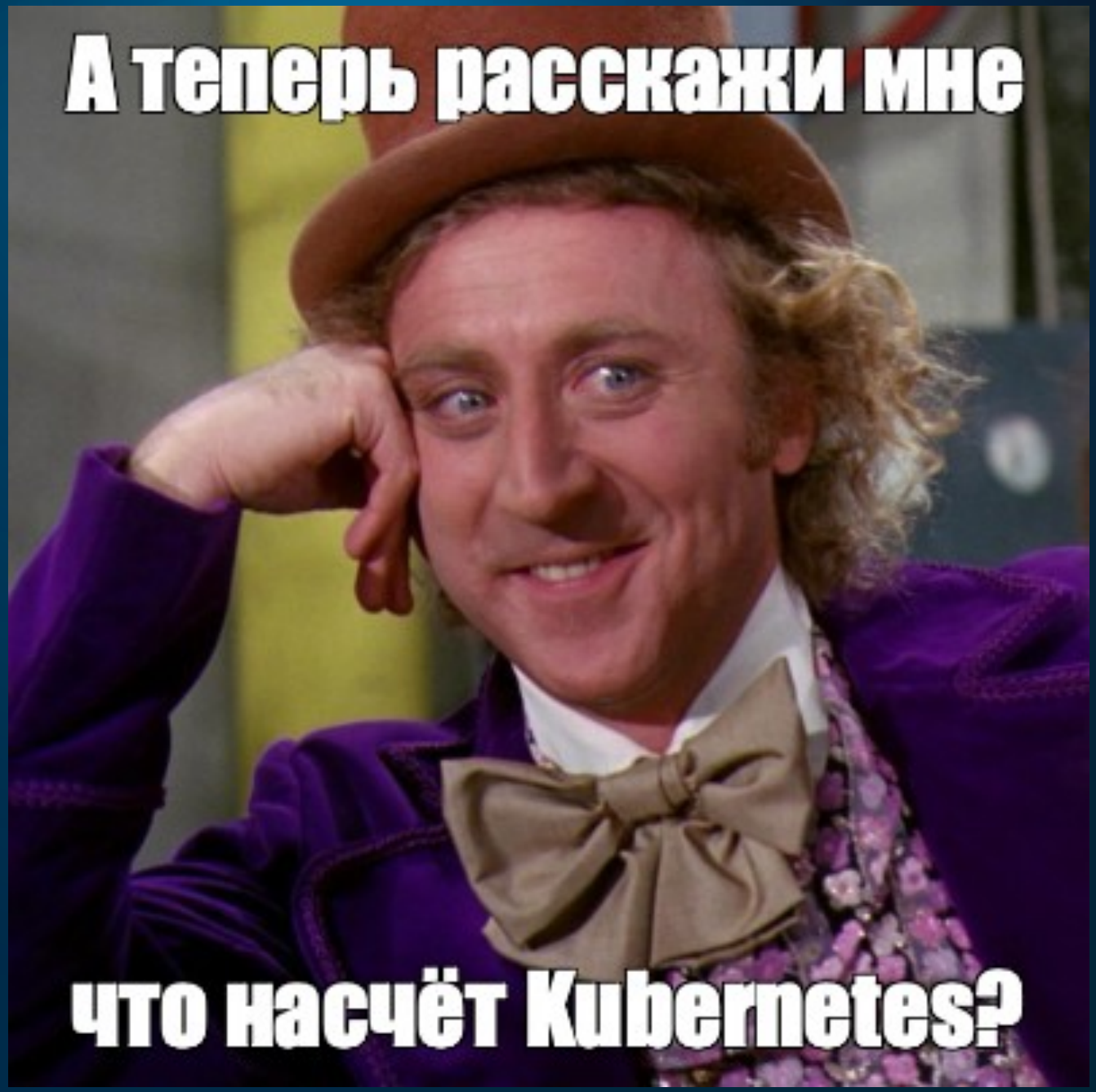
То, как эта техника выполняется и для чего





TTP

- Kill Chain – модель (последовательность TTP), определяющая последовательность действий, ведущих нарушителя к цели
- Если рассматривать реальный киллчейн, совсем необязательно чтобы в нём последовательно присутствовала каждая тактика


А теперь расскажи мне
что насчёт Kubernetes?

Linux, Kubernetes или Cloud?

Очень много техник, в основном можно отнести к Node
В большинстве своём нивелируется использованием Container OS

https://clck.ru/36Lheh

Контейнер без контекста особо не интересен

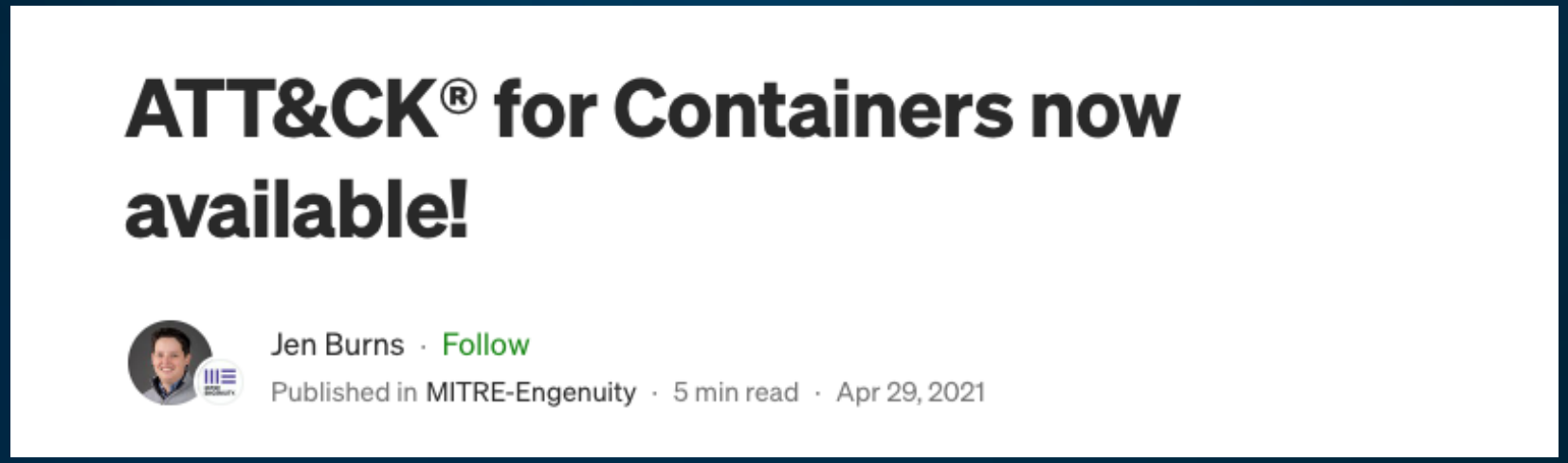
https://clck.ru/36LhhK

Актуально, если используете Managed Kubernetes

https://clck.ru/36Lhk7

MITRE ATT&CK Container Matrix

- Опубликована в 2021 году
- Одно из ответвлений матрицы Enterprise
- Как и в любой другой MITRE матрице есть маппинг процедур на реальные APT
- Есть описание Mitigations и Detections



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MITRE ATT&CK Container Matrix – Data Source

- Container и Pod в качестве Data Source

Data Components

Container: Container Creation

Initial construction of a new container (ex: docker create)

Domain	ID	Name	Detects
Enterprise	T1610	Deploy Container	Monitor for newly constructed containers that may deploy a container into an environment to facilitate execution or evade defenses.
Enterprise	T1611	Escape to Host	Monitor for the deployment of suspicious or unknown container images and pods in your environment, particularly containers running as root.
Enterprise	T1053	Scheduled Task/Job	Monitor for newly constructed containers that may abuse task scheduling functionality to facilitate initial or recurring execution of malicious code.
	.007	Container Orchestration Job	Monitor for newly constructed containers
Enterprise	T1204	User Execution	Monitor for newly constructed containers that may use an existing, legitimate external Web service to exfiltrate data rather than their primary command and control channel.
	.003	Malicious Image	Track the deployment of new containers, especially from newly built images.

Container: Container Enumeration

An extracted list of containers (ex: docker ps)

Domain	ID	Name	Detects
Enterprise	T1613	Container and Resource Discovery	Monitor logs for actions that could be taken to gather information about container infrastructure, including the use of discovery API calls by new or unexpected users. Monitor account activity logs to see actions performed and activity associated with the Kubernetes dashboard and other web applications.

Container: Container Start

Activation or invocation of a container (ex: docker start or docker restart)

Domain	ID	Name	Detects
Enterprise	T1610	Deploy Container	Monitor for activation or invocation of a container that may deploy a container into an environment to facilitate execution or evade defenses.
Enterprise	T1204	User Execution	Monitor for the activation or invocation of a container (ex: docker start or docker restart)
	.003	Malicious Image	Monitor the behavior of containers within the environment to detect anomalous behavior or malicious activity after users deploy from malicious images.

MITRE ATT&CK Container Matrix – Data Source

- Container и Pod в качестве Data Source

Data Components

Pod: Pod Creation

Initial construction of a new pod (ex: kubectl apply|run)

Domain	ID	Name	Detects
Enterprise	T1610	Deploy Container	Monitor for newly constructed pods that may deploy a container into an environment to facilitate execution or evade defenses.

Pod: Pod Enumeration

An extracted list of pods within a cluster (ex: kubectl get pods)

Domain	ID	Name	Detects
Enterprise	T1613	Container and Resource Discovery	Monitor logs for actions that could be taken to gather information about pods, including the use of discovery API calls by new or unexpected users. Monitor account activity logs to see actions performed and activity associated with the Kubernetes dashboard and other web applications.

Pod: Pod Modification

Changes made to a pod, including its settings and/or control data (ex: kubectl set|patch|edit)

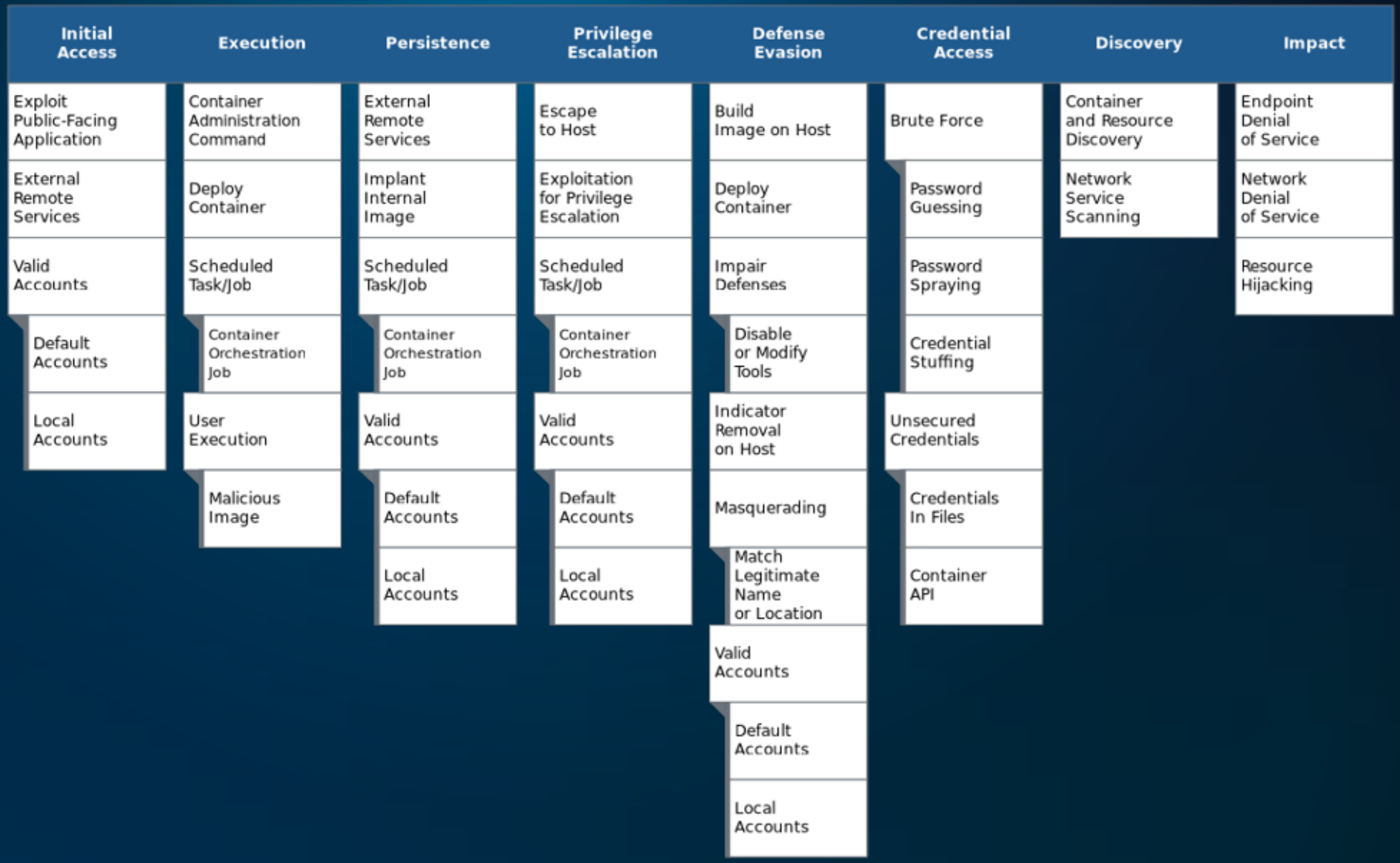
Domain	ID	Name	Detects
Enterprise	T1610	Deploy Container	Monitor for changes made to pods for unexpected modifications to settings and/or control data that may deploy a container into an environment to facilitate execution or evade defenses.

MITRE ATT&CK Container Matrix – первый черновик

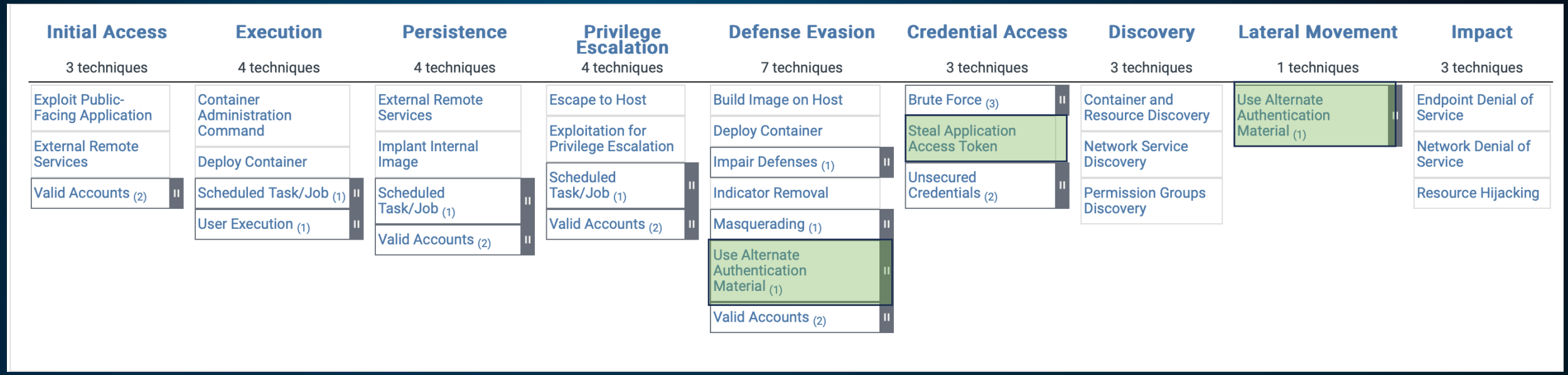
Initial Access	Execution	Persistence	Privilege Escalation	Defense Evasion	Credential Access	Discovery	Impact
Exploit Public-Facing Application	Container Service	Implant Internal Image (NAME CHANGE)	Escape to Host	Build Image on Host	Brute Force	Container Resource Discovery	Endpoint Denial of Service
External Remote Services	Deploy Container	Scheduled Task/Job	Scheduled Task/Job	Deploy Container	Brute Force: Password Guessing		Network Denial of Service
Valid Accounts	Scheduled Task/Job	Scheduled Task/Job: Container Orchestration Job	Scheduled Task/Job: Container Orchestration Job	Masquerading	Brute Force: Password Spraying		Resource Hijacking
Valid Accounts: Local Accounts	Scheduled Task/Job: Container Orchestration Job	Valid Accounts	Valid Accounts	Masquerading: Match Legitimate Name or Location	Brute Force: Credential Stuffing		
	User Execution	Valid Accounts: Local Accounts	Valid Accounts: Local Accounts	Valid Accounts	Unsecured Credentials		
	User Execution: Malicious Image			Valid Accounts: Local Accounts	Unsecured Credentials: Credentials in Files		
					Unsecured Credentials: Container API		

Proposed new techniques and sub-techniques

MITRE ATT&CK Container Matrix – первый релиз



MITRE ATT&CK Container Matrix

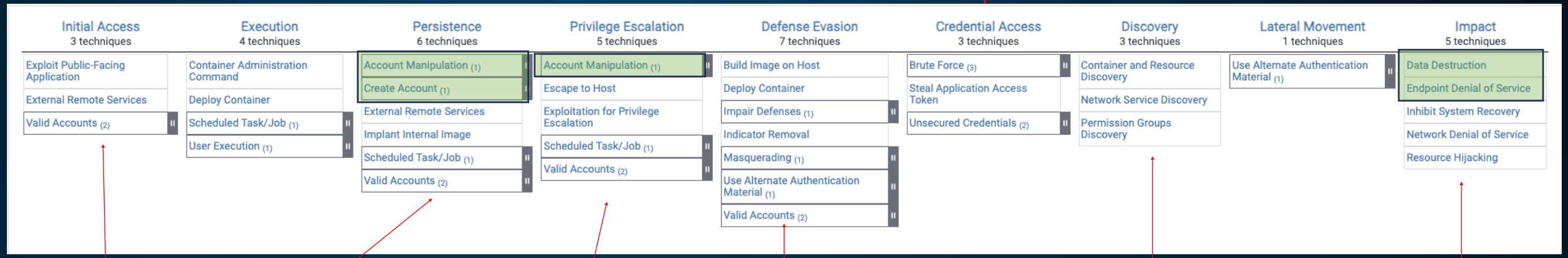


MITRE ATT&CK Container Matrix – апдейт октябрь 2023

SSH server running inside container

List K8s secrets
Malicious Admission Controller

ARP poisoning and IP spoofing



Compromise image in registry

Static Pods

Access cloud resources

Shadow Kubernetes API server

Install discovery tool outside container

Data manipulation

Помните: матрицы всегда отстают и всегда не полны!

MITRE ATT&CK Container Matrix – недостатки

- Правки и изменения вносятся достаточно долго
- В реальном мире бывает достаточно сложно определить к какой стадии kill chain относится та или иная процедура
- Техники довольно абстрактны и не сильно погружены в контекст Kubernetes
- Самих техник сильно меньше по сравнению с другими матрицами
- Это скорее инструмент, с помощью которого можно узнать об определенных процедурах

Microsoft Threat Matrix for Kubernetes

- Первая версия вышла в апреле 2020
- Наверное, одна из самых удобных матриц для контейнеров и Kubernetes
- Есть маппинг на техники, описанные в MITRE
- Понятные и хорошо описанные техники в контексте Kubernetes
- Mitigations на уровне Kubernetes

Microsoft Threat Matrix for Kubernetes – первый апдейт

Initial Access	Execution	Persistence	Privilege Escalation	Defense Evasion	Credential Access	Discovery	Lateral Movement	Collection	Impact
Using Cloud credentials	Exec into container	Backdoor container	Privileged container	Clear container logs	List K8S secrets	Access the K8S API server	Access cloud resources	Images from a private registry	Data Destruction
Compromised images in registry	bash/cmd inside container	Writable hostPath mount	Cluster-admin binding	Delete K8S events	Mount service principal	Access Kubelet API	Container service account		Resource Hijacking
Kubeconfig file	New container	Kubernetes CronJob	hostPath mount	Pod / container name similarity	Access container service account	Network mapping	Cluster internal networking		Denial of service
Application vulnerability	Application exploit (RCE)	Malicious admission controller	Access cloud resources	Connect from Proxy server	Applications credentials in configuration files	Access Kubernetes dashboard	Applications credentials in configuration files		
Exposed Dashboard	SSH server running inside container				Access managed identity credential	Instance Metadata API	Writable volume mounts on the host		
Exposed sensitive interfaces	Sidecar injection				Malicious admission controller		Access Kubernetes dashboard		
							Access tiller endpoint		
							CoreDNS poisoning		
							ARP poisoning and IP spoofing		

= **New technique**

= **Deprecated technique**

Microsoft Threat Matrix for Kubernetes

Tactics

Помните: матрицы всегда отстают и всегда не полны!

Initial Access	Execution	Persistence	Privilege Escalation	Defense Evasion	Credential Access	Discovery	Lateral Movement	Collection	Impact
Using cloud credentials	Exec into container	Backdoor container	Privileged container	Clear container logs	List K8S secrets	Access Kubernetes API server	Access cloud resources	Images from a private registry	Data destruction
Compromised image In registry	bash/cmd inside container	Writable hostPath mount	Cluster-admin binding	Delete K8S events	Mount service principal	Access Kubelet API	Container service account	Collecting data from pod	Resource hijacking
Kubeconfig file	New container	Kubernetes CronJob	hostPath mount	Pod / container name similarity	Container service account	Network mapping	Cluster internal networking		Denial of service
Application vulnerability	Application exploit (RCE)	Malicious admission controller	Access cloud resources	Connect from proxy server	Application credentials in configuration files	Exposed sensitive interfaces	Application credentials in configuration files		
Exposed sensitive interfaces	SSH server running inside container	Container service account			Access managed identity credentials	Instance Metadata API	Writable hostPath mount		
	Sidecar injection	Static pods			Malicious admission controller		CoreDNS poisoning		
							ARP poisoning and IP spoofing		

Collecting data from Audit Log file

Malicious Pause Container

Bypass PolicyEngine

Придумайте сами ;)

Microsoft Threat Matrix for Kubernetes – недостатки

- Правки и изменения вносятся достаточно долго
- Есть небольшой акцент на Managed Kubernetes
- Как и в любой другой матрицу, атакующий всегда на шаг впереди

Сравнение матриц

MITRE ATT&CK Container Matrix	Microsoft Threat Matrix for Kubernetes
Является частью большой Enterprise матрицы	Ориентирована на K8s
Ориентирована на контейнеры	Есть связь с MITRE матрицей
Мапится на конкретные APT	Mitigations ориентированы на Kubernetes
Большинство техник заимствовано с «большой» матрицы	

Раскладываем атаки по матрицам

Модели нарушителя

Kubeflow Pipelines campaign – внешний нарушитель

- Kubeflow это фреймворк для запуска ML тасков в K8s
- Можно взаимодействовать через CRD или через dashboard
- В некоторой конфигурации, Kubeflow не требует аутентификации
- Если dashboard торчит наружу, это позволяет получить полный доступ к интерфейсу Kubeflow

Kubeflow Pipelines campaign

- Этот пример относится к внешнему нарушителю
- Kubeflow это фреймворк для запуска ML тасков в K8s
- Можно взаимодействовать через CRD или через dashboard
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Kubeflow Pipelines campaign

- В мае 2021 масштабная кампания затронула торчащие наружу Kubeflow
- Злоумышленники использовали открытую dashboard для деплоя вредоносного Kubeflow Pipeline
- Kubeflow Pipeline это сервис для создания ML pipelines, основанный на Argo Workflow
- Kubeflow это фреймворк для запуска ML тасков в K8s
- Можно взаимодействовать через CRD или через dashboard
- В некоторой конфигурации, Kubeflow не требует аутентификации
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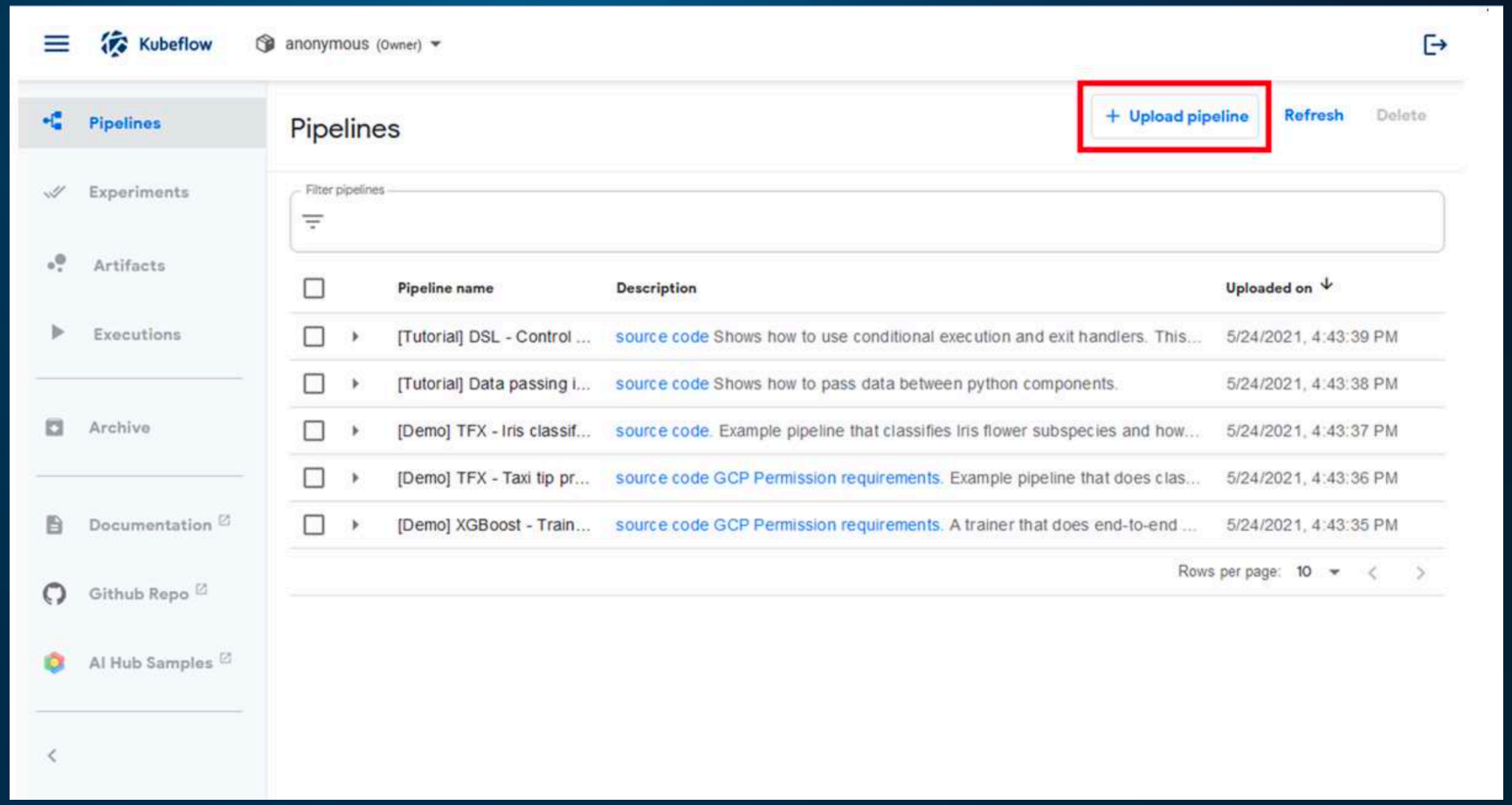
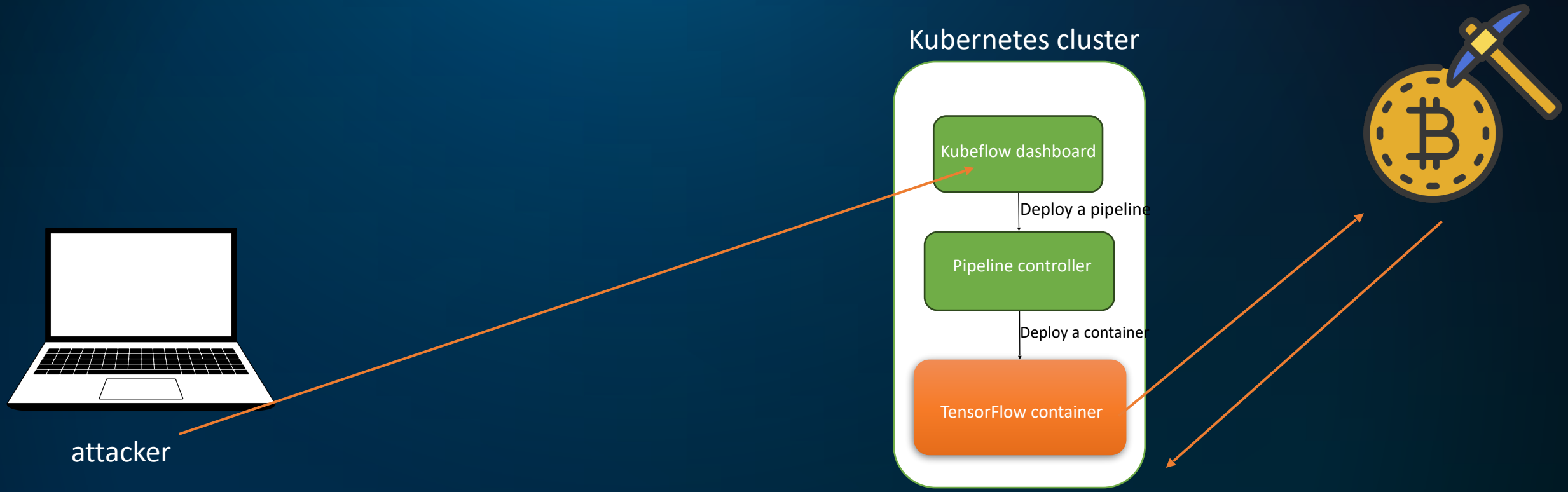
Kubeflow Pipelines campaign



https://clck.ru/36LxFg

Kubeflow Pipelines campaign

- Используя Kubeflow pipelines, злоумышленники задеплоили в кластере вредоносные контейнеры
- Эти контейнеры использовались для криптомайнинга в кластере (с использованием как CPU, так и GPU)
- Вредоносная нагрузка запускалась поверх легитимного образа TensorFlow



Оцениваем покрытие

Initial Access	Execution	Persistence	Privilege Escalation	Defense Evasion	Credential Access	Discovery	Lateral Movement	Collection	Impact
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Exposed sensitive interfaces	SSH server running inside container	Container service account			Access managed identity credentials	Instance Metadata API	Writable hostPath mount		
	Sidecar injection	Static pods			Malicious admission controller		CoreDNS poisoning		
							ARP poisoning and IP spoofing		

Внутренний нарушитель

- Отсутствие сегментации позволило попасть на Node
- В Pod использовался высоко привилегированный ServiceAccount
- Используя Bad Pods злоумышленник делает Container escape на мастер ноду (PolicyEngine были, но не настроены до конца)
- Полный захват кластера

Оцениваем покрытие

Initial Access	Execution	Persistence	Privilege Escalation	Defense Evasion	Credential Access	Discovery	Lateral Movement	Collection	Impact
Using cloud credentials	Exec into container	Backdoor container	Privileged container	Clear container logs	List K8S secrets	Access Kubernetes API server	Access cloud resources	Images from a private registry	Data destruction
Compromised image In registry	bash/cmd inside container	Writable hostPath mount	Cluster-admin binding	Delete K8S events	Mount service principal	Access Kubelet API	Container service account	Collecting data from pod	Resource hijacking
Kubeconfig file	New container	Kubernetes CronJob	hostPath mount	Pod / container name similarity	Container service account	Network mapping	Cluster internal networking		Denial of service
Application vulnerability	Application exploit (RCE)	Malicious admission controller	Access cloud resources	Connect from proxy server	Application credentials in configuration files	Exposed sensitive interfaces	Application credentials in configuration files		
Exposed sensitive interfaces	SSH server running inside container	Container service account			Access managed identity credentials	Instance Metadata API	Writable hostPath mount		
	Sidecar injection	Static pods			Malicious admission controller		CoreDNS poisoning		
							ARP poisoning and IP spoofing		

Скомпрометированный разработчик

- Злоумышленник получил доступ к аккаунту разработчика
- Есть возможность запускать нагрузки и пушить образы в registry
- У разработчика есть возможность создавать Admission Controller
- Admission Controller патчит каждую новую задеплоенную нагрузку и добавляет к ней вредоносный контейнер

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Выводы

1. Kubernetes постоянно развивается
2. Вместе с тем развиваются и угрозы
3. Не стоит целиком и полностью полагаться на матрицу, но учитывать её необходимо

Кураторство и помощь в исследованиях Kubernetes от Luntry

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