The bridge to possible

Auditd for the recently threatened

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Background

- Why listen to me?
  - Designed and built detection capability for banks and telcomms
  - Assessed and provided input and training for OT developers, engineers and operators building, implementing and operating PLCs, HMIs etc
  - Responded to breaches on all manner of weird and wacky
- Recap from previous ATT&CK Community events
  - All of the threats - Intelligence, modelling, simulation and hunting through an ATT&CKers lens
  - The UNIX malware landscape - Reviewing the goods at MALWAREbazaar

Reacting to threats, both new and old

- New
  - T1036: Masquerading
  - T1070: Indicator Removal on Host
  - T1205: Traffic Signaling
- Old
  - T1005: Data from Local System
  - T1083: File and Directory Discovery
  - T1003: OS Credential Dumping
  - T1558: Steal or Forge Kerberos Tickets

Malware example

- BPFDoor
  - Writes a 0 byte file to /var/run
    - // /var/run/haldrund.pid
    - close(open(pid_path, O_CREAT|O_WRONLY, 0644));
  - Writes, executes and deletes from /dev/shm
    - // /bin/rm -f /dev/shm/%s;/bin/cp %s /dev/shm/%s && /bin/chmod 755 /dev/shm/%s && /dev/shm/%s --init && /bin/rm -f /dev/shm/%s
    - snprintf(cmd, sizeof(cmd), fmt, tmp, name, tmp, tmp, tmp, tmp);
    - system(cmd);
  - Time stomps /dev/shm/kdmtmpflush
    - utimes(file, tv);
  - Uses raw sockets
    - sock = socket(PF_PACKET, SOCK_RAW, htons(ETH_P_IP)
  - Sets a BPF filter
    - setsockopt(sock, SOL_SOCKET, SO_ATTACH_FILTER, &filter, sizeof(filter)
  - Executes commands
- Building detections
  - strace -f -o bpfdoor.out ./bpfdoor

File access

- egrep "/var|/dev" bpfdoor.out | egrep “access|open|unlink"
  - access("/var/run/haldrund.pid", R_OK) = -1 ENOENT (No such file or directory)
    - -w /run/haldrund.pid -p rwxa -k tb_run_haldrund_pid_bpfdoor
  - unlinkat(AT_FDCWD, "/dev/shm/kdmtmpflush", 0) = -1 ENOENT (No such file or directory)
  - openat(AT_FDCWD, "/dev/shm/kdmtmpflush", O_WRONLY|O_CREAT|O_EXCL, 0755) = 4
  - fchmodat(AT_FDCWD, "/dev/shm/kdmtmpflush", 0755) = 0
    - -w /dev/shm/kdmtmpflush -p rwxa -k tb_dev_shm_kdmtmpflush_bpfdoor

Command execution

- egrep "/var|/dev" bpfdoor.out | egrep “exec"
  - execve("/bin/rm", ["/bin/rm", "-f", "/dev/shm/kdmtmpflush"], 0x563147b63af8 /* 24 vars */ <unfinished ...>
  - execve("/bin/cp", ["/bin/cp", "./bpfdoor", "/dev/shm/kdmtmpflush"], 0x563147b63b00 /* 24 vars */ <unfinished ...>
  - execve("/bin/chmod", ["/bin/chmod", "755", "/dev/shm/kdmtmpflush"], 0x563147b63b00 /* 24 vars */ <unfinished ...>
  - execve("/dev/shm/kdmtmpflush", ["/dev/shm/kdmtmpflush", "--init"], 0x563147b63ad8 /* 24 vars */ <unfinished ...>
    - These are all a bit generic in this case, but in theory we could tap into the execve syscall
      - -a exit,always -F arch=b64 -S execve -k tb_exit_b64_execve_syscall_bpfdoor
        - Sadly we can’t filter on a0 etc as strings, but we could in the SIEM

Other file operations

- egrep "/var|/dev" bpfdoor.out | egrep -v “exec|access|open|unlink"
  - utimensat(AT_FDCWD, "/dev/shm/kdmtmpflush", [{tv_sec=1225394236, tv_nsec=0} /* 2008-10-30T19:17:16+0000 */, {tv_sec=1225394236, tv_nsec=0} /* 2008-10-30T19:17:16+0000 */], 0) = 0
    - -a exit,always -F arch=b64 -S utimensat -F a0=AT_FDCWD -k tb_exit_b64_utimensat_syscall_bpfdoor
- But… -F can only take numbers for a0, a1, a2, a3
  - egrep -r "AT_FDCWD" /usr/include

Raw sockets

- egrep “socket|setsockopt” bpfdoor.out
  - socket(AF_PACKET, SOCK_RAW, htons(ETH_P_IP) <unfinished ...>
    - -a exit,always -F arch=b64 -S socket -F a0=AF_PACKET -F a1=SOCK_RAW -k tb_exit_b64_socket_syscall_bpfdoor
  - setsockopt(3, SOL_SOCKET, SO_ATTACH_FILTER, {len=30, filter=0x7fff628b97f0}, 16) = 0
    - -a exit,always -F arch=b64 -S setsockopt -F a1=SOL_SOCKET -F a2=SO_ATTACH_FILTER -k tb_exit_b64_setsockopt_syscall_bpfdoor
- Remember -F value should be number for a0 etc

Finalised rules to detect BPFDoor

```
-D

-w /run/haldrund.pid -p rwxa -k tb_run_haldrund_pid_bpfdoor

-w /dev/shm/kdmtmpflush -p rwxa -k tb_dev_shm_kdmtmpflush_bpfdoor

-a exit,always -F arch=b64 -S utimensat -F a0=-100 -k
tb_exit_b64_utimensat_syscall_bpfdoor

-a exit,always -F arch=b64 -S socket -F a0=17 -F a1=3 -k
tb_exit_b64_socket_syscall_bpfdoor

-a exit,always -F arch=b64 -S setsockopt -F a1=1 -F a2=26 -k
tb_exit_b64_setsockopt_syscall_bpfdoor
```

Evaluation and tuning

```
# auditctl -R audit.rules && ./bpfdoor && systemctl stop auditd

# grep bpfdoor /var/log/audit/audit.log | grep -v add | grep shm |
wc -l

9

# grep bpfdoor /var/log/audit/audit.log | grep -v add | grep run |
wc -l

1

# grep bpfdoor /var/log/audit/audit.log | grep -v add | grep
setsockopt | wc -l

1

# grep bpfdoor /var/log/audit/audit.log | grep -v add | grep socket |
wc -l

1
```

- tb_exit_b64_utimensat_syscall_bpfdoor
  - -F exe="/dev/shm/kdmtmpflush"
  - -F comm=“kdmtmpflush”
    - You could also potentially exclude known trustworthy processes
- tb_exit_b64_socket_syscall_bpfdoor
  - -F exe="/dev/shm/kdmtmpflush"
  - -F comm=“kdmtmpflush”
    - You could also potentially exclude known trustworthy processes
  - -F a0=3

Detecting forwards

Ideas for detecting forwards

- General
  - /dev
  - /tmp, /var/tmp, /dev/shm
  - /etc, /var writes from non-root
  - /proc, /sys writes from non-root
    - grep -r __SYSCALL /usr/include | cut -f 2 -d "(" | cut -f 1 -d, | sort | uniq | grep NR
      - ptrace()
      - set[ug]id()
      - *chown()
      - *chmod()
      - mmap()
      - mprotect()
      - memfd_*()
      - unshare()
      - Lots more…

- Daemons
  - write()
  - bind()
  - connect()
  - execve()
- Users
  - /etc/passwd
  - /etc/shadow
  - /etc/groups
  - /home/*/.ssh
  - /etc/sudoers
  - /etc/sudoers.d
  - execve() on GTFObins

Managing (technical) debt

How did I defend against it?

- ACLs and auditing
- Scripting the generation of an auditing policy and bespoke ACLs based on the output of `find’
- Detection
  - DS0017: Command
  - DS0009: Process

Preparing for Black Hat

How should you defend against it?

- Check the syscalls
- Check file access
  - -a always,exit -F dir=/var/lib/sss/db -F perm=rwxa -k linikatz-sss
- Look for static numeric values to match on
  - Constants
  - Size parameters
  - -a always,exit -F arch=b64 -S connect -F a2=0x2f -k linikatz-vas
- Detection
  - DS0017: Command
  - DS0022: File
  - DS0009: Process

Conclusions

Auditd crib sheet

- A subset of events will be generated without configuration
  - Don't mistake this for a useful configuration
- Protect the daemon
  - -e 2
- What happens in kernel stays in kernel
  - *entry* && exit
- There may be event subsets you don't care about
  - always || never && exclude
- Pick the real path for file system operations
  - Operations on files beneath a symlink won't be logged

- Fine tuning (-F) can help
  - Consider architecture
    - -F arch=b32 vs -F arch=b64
  - Watch by user, process
    - -F auid=<uid>
    - -F pid=<pid>
    - -F ppid=<ppid>
    - etc
  - Sadly you can't match on strings
    - Filenames, syscall specific constants and length arguments may still be useful
- Combine rules where you can
  - The filesystem rules for BPFDoor for example
- Tag your rules (-k) to help your analysts

Questions?

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The bridge to possible

Bonus material

Why look at Auditd?

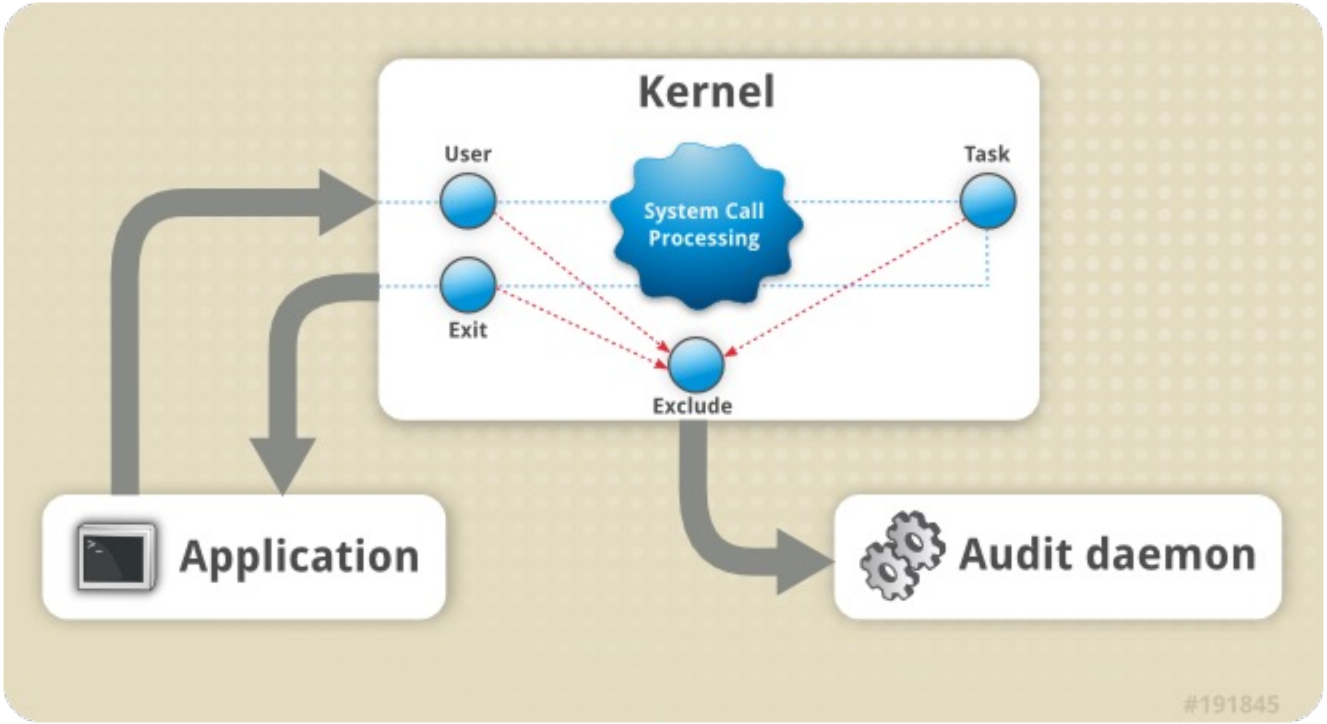
- Reticence to deploy EDR to more interesting systems
- But also…
  - EDR platforms are moving to eBPF but…
    - https://cve.mitre.org/cgi-bin/cvekey.cgi?keyword=eBPF
      - 14 vulnerabilities
    - Broadly, eBPF doesn't really work for end-users
  - Auditd is mainline
    - May already be there
    - Could do a lot more than many will realise

Lessons learnt

- https://github.com/timb-machine/linux-malware
  - Yes, there is interesting malware
  - No, we don’t do enough to protect ourselves
    - I actually spotted my first bit of malware derived from our research ☹
- Vertical specific systems often don’t have sufficient monitoring
  - Banking systems of record
  - Telecomms OSS/BSS
  - Retail payment platforms
  - Operational technologies
  - Etc

Tracing all the things with Auditd

- Syscalls
  - *entry*, task, **exit**, **user**, exclude, **filesystem**
    - -a exit,always -F arch=b64 -S all -k tb_exit_b64_all_syscall
    - -a exit,always -F arch=b32 -S all -k tb_exit_b32_all_syscall
    - -a user,always -F arch=b64 -S all -k tb_user_b64_all_syscall
    - -a user,always -F arch=b32 -S all -k tb_user_b32_all_syscall
- File systems
  - **read**, **write**, **execute**, **attribute** operations
    - -w / -p r -k tb_read_all_files
    - -w / -p w -k tb_write_all_files
    - -w / -p x -k tb_execute_all_files
    - -w / -p a -k tb_attribute_all_files


Kernel
User
Task
System Call Processing
Exit
Exclude
Application
Audit daemon
#191845

A dirty script

```
find /opt/component -name –perm -o+w | while read filename
do
        printf -- "-w %s -p r -k flag-%s-r\n" “${filename}” “$(printf ”%s” "${filename}" | tr \"/\"
\"_\")”>>/etc/audit/rules.d/honeypot-component-dynamic.rules
        printf -- "-w %s -p w -k flag-%s-w\n" “${filename}” “$(printf ”%s” "${filename}" | tr \"/\"
\"_\")”>>/etc/audit/rules.d/honeypot-component-dynamic.rules
        printf -- "-w %s -p w -k flag-%s-x\n" “${filename}” “$(printf ”%s” "${filename}" | tr \"/\"
\"_\")”>>/etc/audit/rules.d/honeypot-component-dynamic.rules
        printf -- "-w %s -p a -k flag-%s-a\n" “${filename}” “$(printf "%s” "${filename}" | tr \"/\"
\"_\")”>>/etc/audit/rules.d/honeypot-component-dynamic.rules
done
```

Useful links

- Auditd documentation
  - https://access.redhat.com/documentation/en-us/red_hat_enterprise_linux/8/html/security_hardening/auditing-the-system_security-hardening
- A decent blog post on Auditd for detection
  - https://izyknows.medium.com/linux-auditd-for-threat-detection-d06c8b941505
- Upstream rules
  - https://github.com/linux-audit/audit-userspace/tree/master/rules
- ATT&CK aligned rules
  - https://github.com/bfuzzy/auditd-attack
- UK HMG rules
  - https://github.com/alphagov/chef-auditd
- A decent blend
  - https://github.com/Neo23x0/auditd