Golfing with Dragons

Building Secure Environments for CTFs

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Agenda

- What's a CTF?
- Threat Modeling for CTFs
- Identifying & Implementing Controls
- Key Lessons Learned

DevSecOps & Capture The Flags Competitions

- Capture The Flag (CTF) competitions are prominent events in the Cyber Security field for contestants to demonstrate their technical skills for prizes, jobs and notoriety.

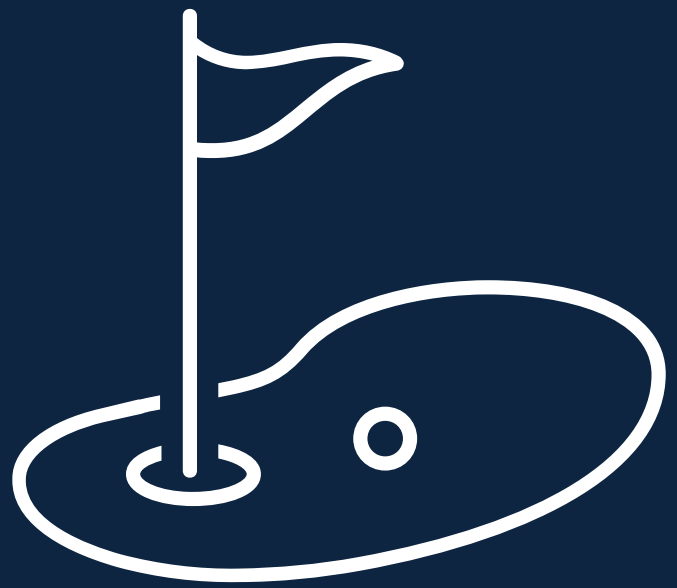
- These events range in variety, but popular categories include:
  - Jeopardy: Competitors download and solve a stand-alone challenge for points.
  - Attack/Defend: Competitors defend infrastructure while attacking others.
  - King of The Hill: Competitors attack infrastructure to place their “flag”, a unique identifier, in a specific file to score points.

Ghidra Golf – A Spin on Jeopardy Style CTF

- Ghidra Golf is **Reverse Engineering** CTF event with focus on Ghidra Script development.
  - Ghidra Scripts are **Java/Python Applications.**

- The contestant's goal is to develop Ghidra Scripts to identify, parse, decrypt/decode or otherwise accomplish a specific reverse engineering task.

- Contestants are provided with a binary to download, reverse engineer and to test their code against, before submitting their Ghidra Script for **automated evaluation**.



Ghidra Golf – A Spin on Jeopardy Style CTF

- “*Contestants are provided with a binary to download, reverse engineer and to test their code against, before submitting their Ghidra Script for **automated evaluation**.*”

- **Is a fancy way of saying….**
  - **Executing arbitrary Python/Java applications from strangers on the internet**

Threat Modeling: Identifying risks to the competition

Threat Modeling YOUR Competition


```
Program received signal SIGSEGV, Segmentation fault.
0x0000000000401116 in main ()
Missing separate debuginfos, use: dnf debuginfo-install
(gdb) disassemble
Dump of assembler code for function main:
   0x0000000000401106 <+0>:     push   %rbp
   0x0000000000401107 <+1>:     mov    %rsp,%rbp
   0x000000000040110a <+4>:     movq   $0x0,-0x8(%rbp)
   0x0000000000401112 <+12>:    mov    -0x8(%rbp),%rax
=> 0x0000000000401116 <+16>:    movl   $0x6c6f6c,(%rax)
   0x000000000040111c <+22>:    mov    $0x0,%eax
   0x0000000000401121 <+27>:    pop    %rbp
   0x0000000000401122 <+28>:    ret
```

Rogue Competitor

How do we minimize arbitrary code execution?

Infrastructure Availability

How do we recover from disaster?

How do we make our challenges available globally?

Broken Challenges

How do we Identify and recover from bugs?

Rogue Competitors – How to *safely* enable arbitrary code execution

- How could a competitor disrupt the environment for other competitors?
  - How do we limit this potential disruption?
- How do we scan submitted code to prevent undesired execution?
  - How do we become notified of “flagged” code?

Infrastructure Availability

- Most CTFs are run by volunteers in their free time.
  - Not everyone has a cloud budget.
  - How to enable remote access to volunteers?

- How do your leverage existing hardware to maximize reach to your competition?

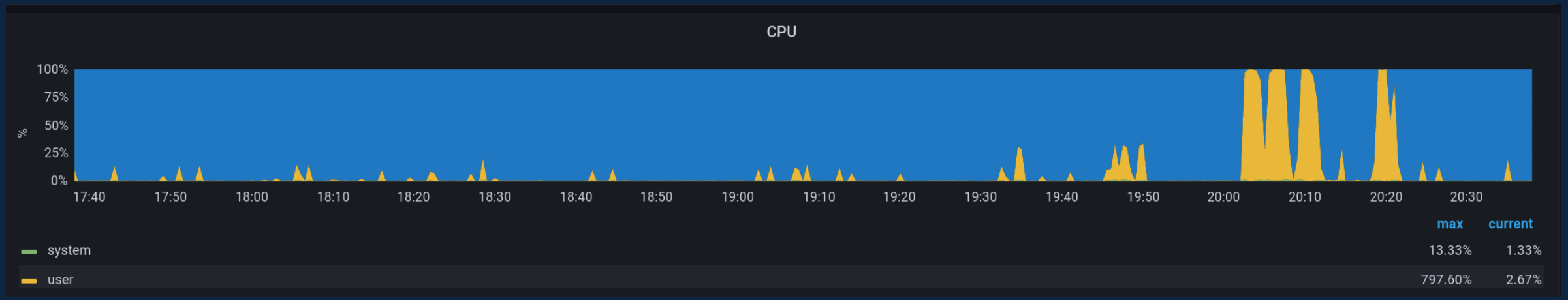
- How do you monitor for issues and respond accordingly?

Resolving Broken Challenges

- Software has bugs, CTF challenges have bugs.
- A competitor is spending their valuable conference/free time with you.
  - They are our customers.
  - Ensuring they have a positive experience is critical to continuing running these events
- Identifying ways to resolve, redeploy and reengage competitors is critical to a positive experience.

Implementing Controls to Reduce Risk

Infrastructure Monitoring – Identifying Broken Challenge



Implementing Controls Throughout the Competition to Reduce Rogue Competitor Impact

Application

DAST/SAST

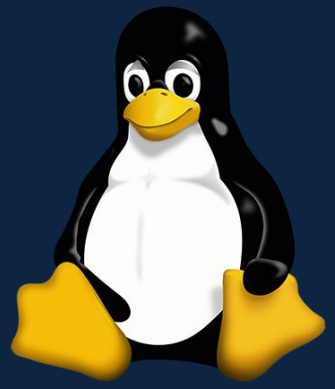
Scanning

Container

Image Scanning

&

Runtime Hardening

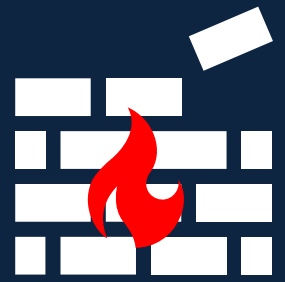


Host

Vulnerability Scanning

&

Hardening



Network

Firewalls/Isolation

Implementing Controls Throughout the Competition

Source Code Application Scanning to identify low hanging fruit.

Examples:

- YARA Rules, custom implementation
- Bandit, Open Stack's vulnerability Scanner for Python
- Integration opportunities:
  - CI/CD Pipelines
  - Git commit hooks
  - Ad hoc scans

Example – Bandit Scans

```
--------------------------------------------------
>> Issue: [B113:request_without_timeout] Requests call without timeout
   Severity: Medium   Confidence: Low
   CWE: CWE-400 (https://cwe.mitre.org/data/definitions/400.html)
   More Info: https://bandit.readthedocs.io/en/1.7.5/plugins/b113_request_without_timeout.html
   Location: GhidraGolf.py:168:16
167                    # post data to CTFd endpoint
                       requests.post(self.ctfd_endpoint,
169                                  json=submission_json)
170                    logging.critical(f"YARA rule hit: {yararetval} for submission {gsObj.sub_id}")

--------------------------------------------------
>> Issue: [B603:subprocess_without_shell_equals_true] subprocess call - check for execution of untrusted input.
   Severity: Low   Confidence: High
   CWE: CWE-78 (https://cwe.mitre.org/data/definitions/78.html)
   More Info: https://bandit.readthedocs.io/en/1.7.5/plugins/b603_subprocess_without_shell_equals_true.html
   Location: GhidraGolf.py:224:8
223                # Danger here!!! building execution script from user arguments!
                   subprocess.call(["/bin/bash", "-c", ghidra_runner])
225                return True

--------------------------------------------------
>> Issue: [B113:request_without_timeout] Requests call without timeout
   Severity: Medium   Confidence: Low
   CWE: CWE-400 (https://cwe.mitre.org/data/definitions/400.html)
   More Info: https://bandit.readthedocs.io/en/1.7.5/plugins/b113_request_without_timeout.html
   Location: GhidraGolf.py:246:26
245                    # post data to CTFd endpoint
                       results = requests.post(self.ctfd_endpoint,
247                                             json=submission_json)
248                    logging.info(results.text)
```

Example – YARA Rule Implementation

```
rule cmdrules {
    meta:
        description = "detect submission script attempting to use command line tools"

    strings:
        // Shells
        $bash = "/bin/bash"
        $sh = "/bin/sh"
        $zsh = "/usr/bin/zsh"
        $chsh = "/usr/bin/csh"
        $sysexec = "system.exec"
        //$python = "python" // Should cover "python3" as well

        // Third Party Network Commands
        $curl = "curl "
        $wget = "wget "
        $ftp = "ftp "
        $netcat = "netcat "
        $ssh = "ssh "
        $scp = "scp "
        $telnet = "telnet "
        $nmap = "nmap "
```

https://github.com/ghidragolf/ctfd-ghidragolf/blob/main/conf/consumer/yara/rules/cmd_rules.yar

Implementing Controls Throughout the Competition

Image Scanning & Capability Enforcement

Examples:

- Trivy, Open-Source vulnerability scanner for containers
- Drop all capabilities
  - add only those that are needed
- OWASP Container Auditing

Example – Old Redis Images in CTFd's docker-compose

```
➜  ~ trivy image redis:4
2023-05-02T14:04:18.428-0400    INFO    Need to update DB
2023-05-02T14:04:18.429-0400    INFO    DB Repository: ghcr.io/aquasecurity/trivy-db
2023-05-02T14:04:18.429-0400    INFO    Downloading DB...
36.57 MiB / 36.57 MiB [---------------------------------------------------------------------------------------------------------------------------------------] 100.00% 10.26
2023-05-02T14:04:23.007-0400    INFO    Vulnerability scanning is enabled
2023-05-02T14:04:23.007-0400    INFO    Secret scanning is enabled
2023-05-02T14:04:23.007-0400    INFO    If your scanning is slow, please try '--scanners vuln' to disable secret scanning
2023-05-02T14:04:23.007-0400    INFO    Please see also https://aquasecurity.github.io/trivy/v0.41/docs/secret/scanning/#recommendation for faster secret detection
2023-05-02T14:04:24.985-0400    INFO    Detected OS: debian
2023-05-02T14:04:24.985-0400    INFO    Detecting Debian vulnerabilities...
2023-05-02T14:04:24.997-0400    INFO    Number of language-specific files: 0

redis:4 (debian 10.3)

Total: 188 (UNKNOWN: 5, LOW: 83, MEDIUM: 28, HIGH: 57, CRITICAL: 15)
```

Example – Hardening Runtime

deployments > ! path3.yaml

```yaml
version: '3'
name: path3
services:
  # Gateway service
  refresh:
    hostname: refresh
    build: challenges/refresh
    restart: unless-stopped
    user: user
    cap_drop:
      - ALL
    volumes:
      - .flags/refresh:/flags
    networks:
      - public
      - private

  # Hidden service
  dejavu:
    hostname: dejavu
    build: challenges/dejavu
    restart: unless-stopped
    user: user
    cap_drop:
      - ALL
    volumes:
      - .flags/dejavu:/flags
      - .keys:/home/user/.ssh:ro
    extra_hosts:
      - "disgusting-bovine.battle:192.168.129.200"
      - "poke-it.battle:192.168.129.201"
    # Only accessible from the first service
    networks:
      vagrant:
      private:
        aliases:
          - dejavu.${TLD}
```

Drop Extraneous Capabilities

Non-root user

Unique flag directory Per challenge

Read only mounts to prevent challenge tampering

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Implementing Controls Throughout the Competition

OS Scanning & Control Verification!

Examples:

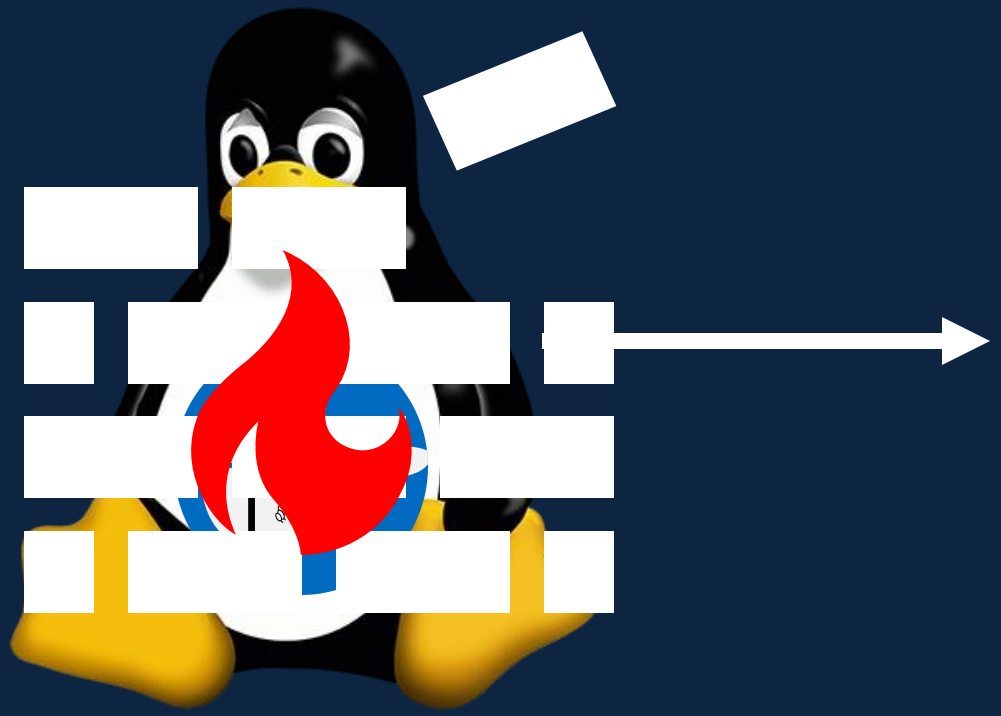
- **LinPEAS**, Open-Source reconnaissance script that audits common vulnerabilities/suggests breakouts.
- **OpenSCAP**: Open-Source vulnerability scanner with reasonable defaults!

Example – Privilege Escalation Opportunities in Images

```
╔══════════╣ Container & breakout enumeration
╚ https://book.hacktricks.xyz/linux-hardening/privilege-escalation/docker-breakout
╠═╣ Container ID ..................... 16d7cf7556a8╠═╣ Seccomp enabled? ..............
╠═╣ AppArmor profile? ............... system_u:system_r:container_t:s0:c233,c423╠═╣ U
      0        1000           1
        1      524288       65536
╠═╣ Vulnerable to CVE-2019-5021 .... No

╠═╣ Breakout via mounts
╚ https://book.hacktricks.xyz/linux-hardening/privilege-escalation/docker-breakout,
sitive-mounts
╠═╣ /proc mounted? .................. No
╠═╣ /dev mounted? ................... No
╠═╣ Run ushare ...................... Yes
╠═╣ release_agent breakout 1........ No
╠═╣ release_agent breakout 2........ No
╠═╣ core_pattern breakout .......... No
╠═╣ binfmt_misc breakout ............ No
╠═╣ uevent_helper breakout ......... No
╠═╣ is modprobe present ............. No
╠═╣ DoS via panic_on_oom ............ No
╠═╣ DoS via panic_sys_fs ............ No
╠═╣ DoS via sysreq_trigger_dos ..... No
╠═╣ /proc/config.gz readable ........ No
╠═╣ /proc/sched_debug readable ..... No
╠═╣ /proc/*/mountinfo readable ..... Yes
╠═╣ /sys/kernel/security present ... Yes
╠═╣ /sys/kernel/security writable .. No
```

Implementing Controls Throughout the Competition

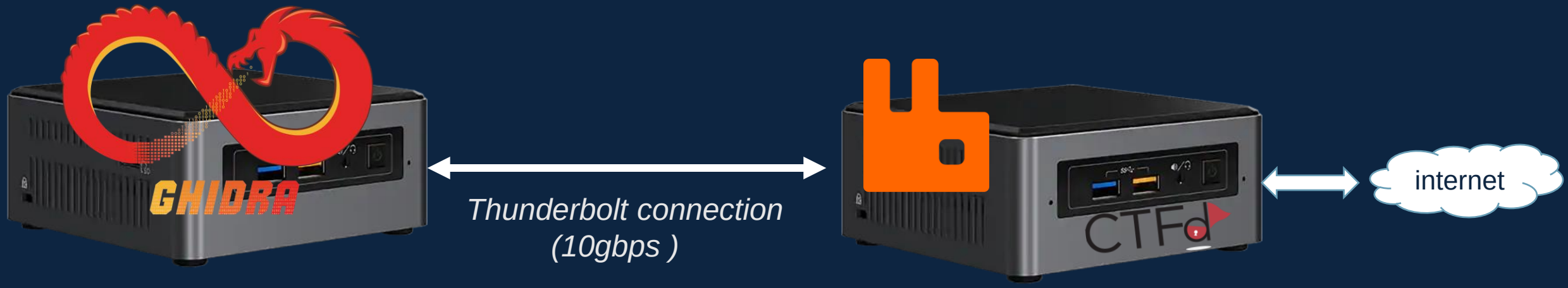


Isolation & “Zero Trust”

Examples:

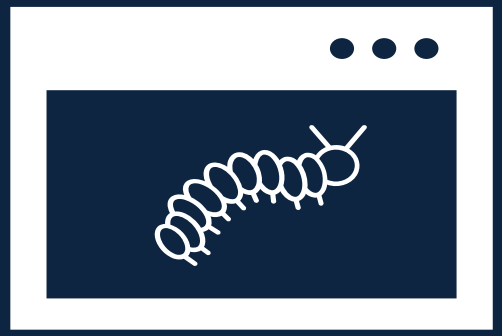
- **Cloudflare Tunnels – enable remote access behind unknown conference network**
- **Isolated high-risk containers on host (Ghidra Runner) without direction internet connection**

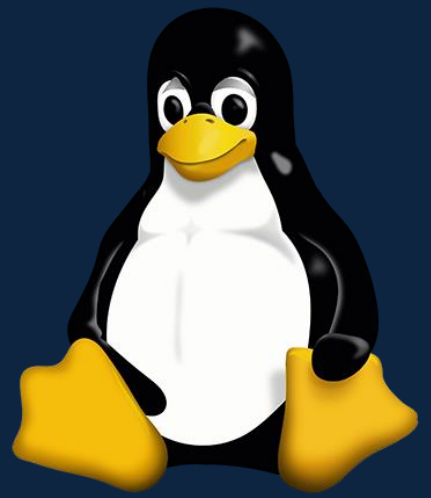
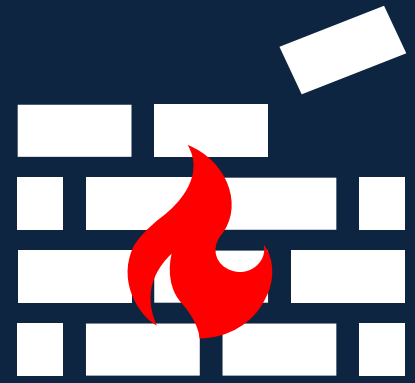
Isolated Host– Container Overlay Networks



Example – Github Accounts for SSO

Clear Communication & Responsibilities

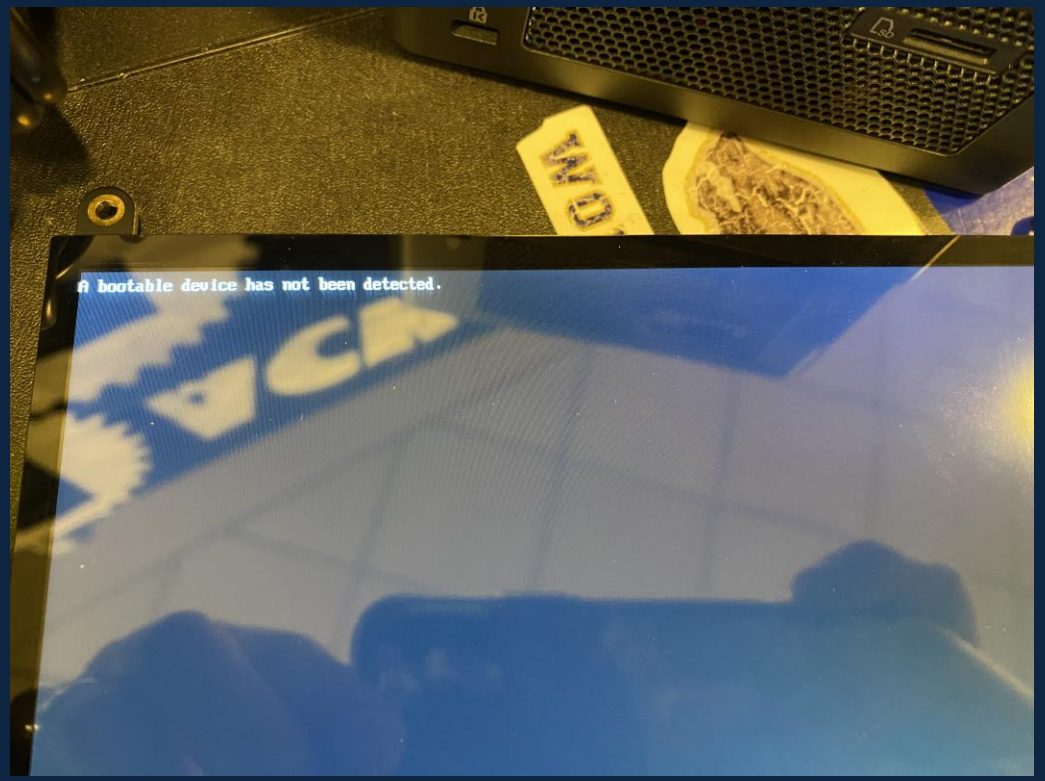


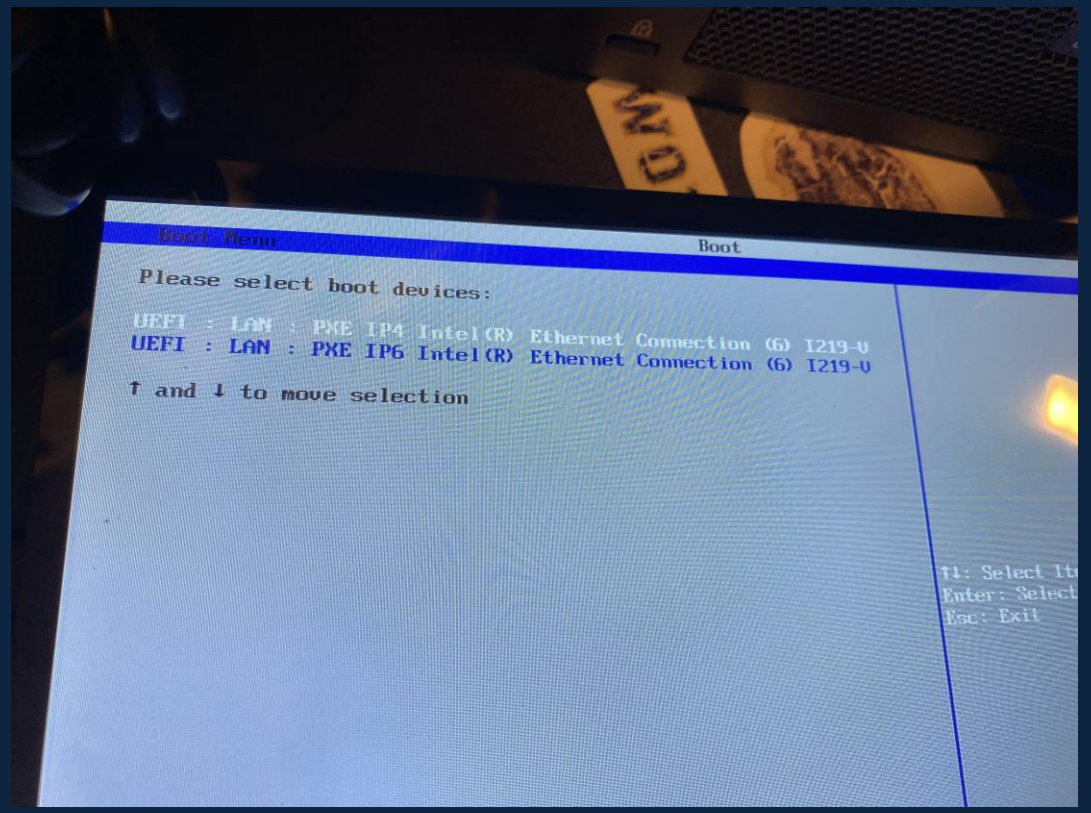



Identify who is responsible for each layer



Identify communication platform for incidents





Have a plan for failure

Interested in Learning More?

- https://ghidra.golf
- https://battleofthebots.net

- https://github.com/ghidragolf
- https://github.com/battleofthebots

- Code available on Github!