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

14th November 2022



in association with
**National Cyber
Security Centre**

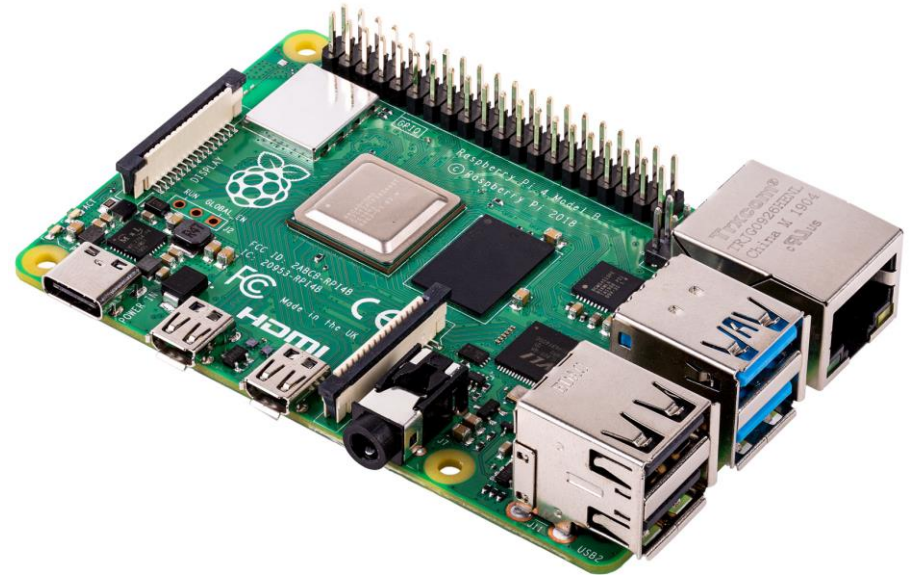


Department for
Digital, Culture,
Media & Sport

Academic Centre of Excellence in **Cyber Security Education**

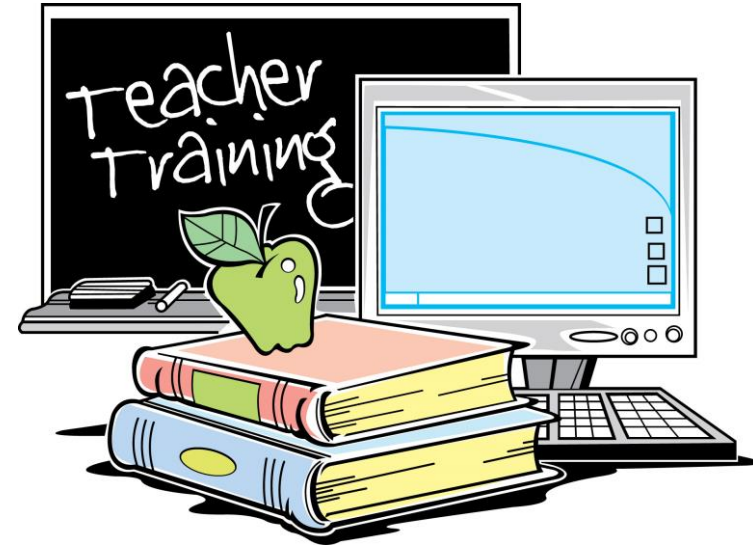
Overview

1. Problem statement
2. Proposed Pi Lab environment
3. Use case for teaching
4. Discussion and Conclusion



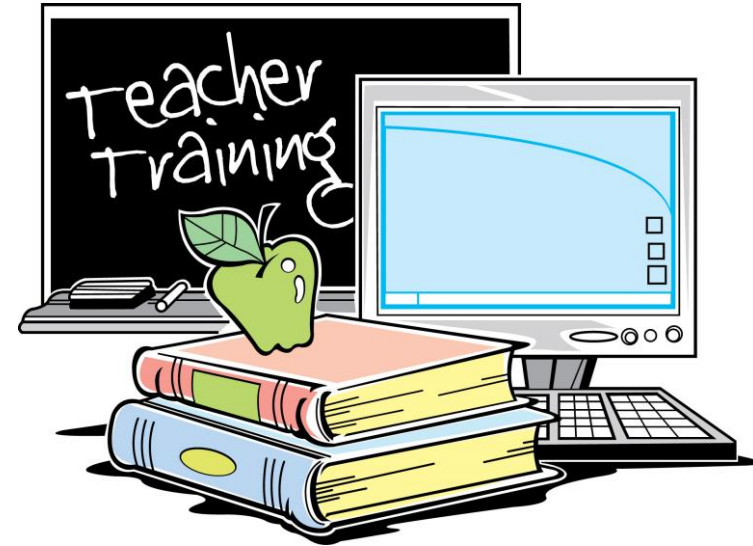
Problem Statement

- 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.

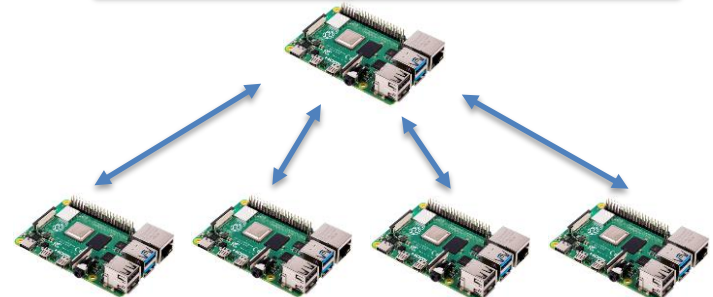


UWEcyber Pi Lab

- 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.



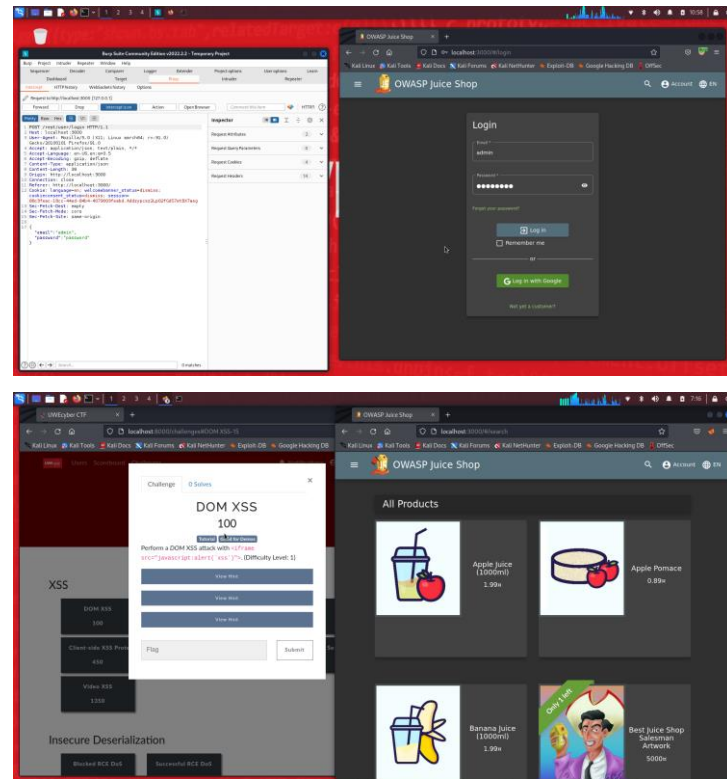
Wireless Access Point PiLab Image



Multiple Student PiLab Images

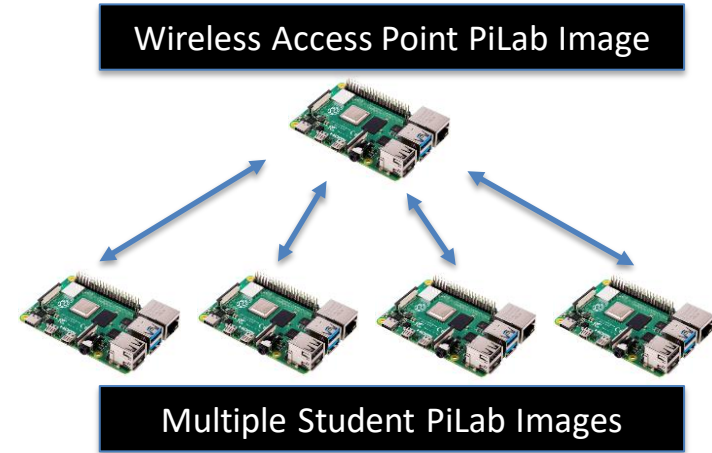
UWEcyber Pi Lab – Pre-install

- 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



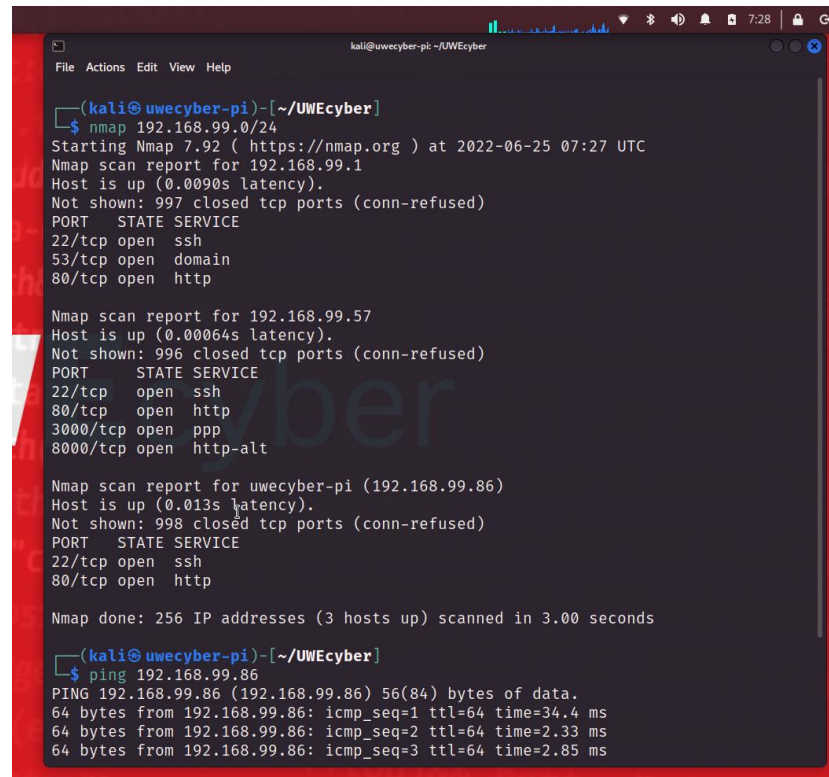
Multi-machine case study

- **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

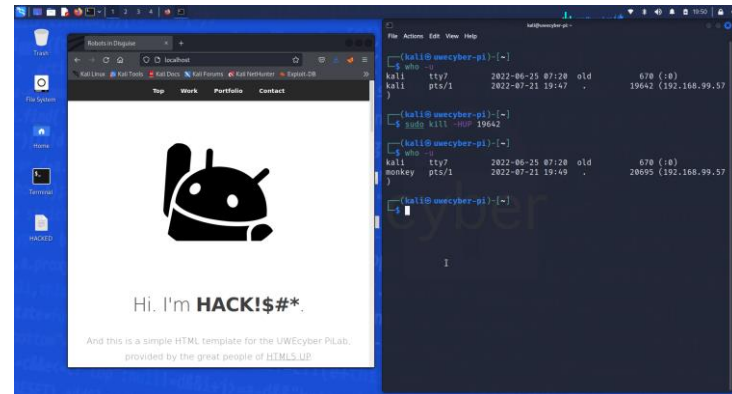
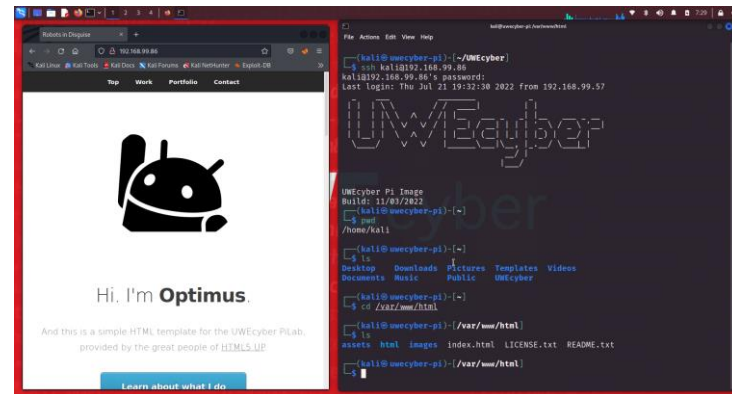
Nmap scan report for uwecyber-pi (192.168.99.86)
Host is up (0.013s latency).
Not shown: 998 closed tcp ports (conn-refused)
PORT      STATE SERVICE
22/tcp    open  ssh
80/tcp    open  http

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
```

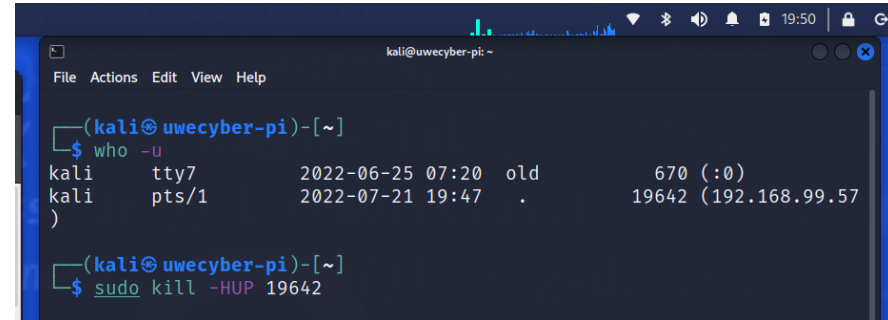
Multi-machine case study

- **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.



The screenshot shows a Kali Linux terminal window titled 'kali@uwecyber-pi: ~'. The terminal displays the output of the 'who -u' command, which lists active users and their connections. The output is as follows:

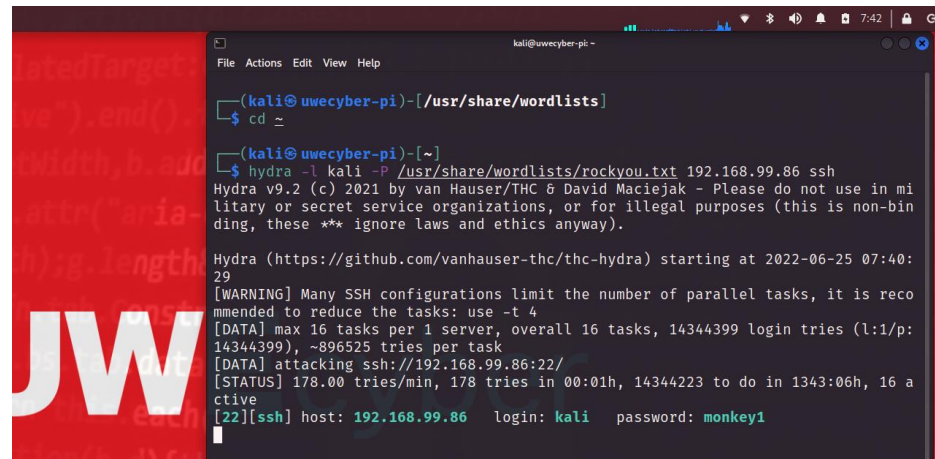
User	Terminal	Local Address	Remote Address	Session ID
kali	tty7	2022-06-25 07:20	old	670 (:0)
kali	pts/1	2022-07-21 19:47	.	19642 (192.168.99.57)

Below the table, the terminal shows the command 'sudo kill -HUP 19642' being entered, which is used to terminate the SSH session for the user 'kali' with PID 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



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

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

