3: Building nodes (hardware)

Section	Length
1: Topic introduction	15 min
2: Hands-on and material exploration	40 min
3: Discussion and reflection activity	20 min
4: Wrap-up and week ahead	5 min
Workshop length	1:30 min

1: Topic introduction

- Break apart the mesh node into its base modules and brief overview of each module's role:
    - Single board computer
    - Storage (SD card) and software (OS)
    - Power supply
    - Radio (onboard and external)
    - Antennas
- Review Homework from Module 2 (radio waves)
- Introduce WiFi concepts as they relate to configuring the radio (frequencies, bands, bandwidth (40 MHz vs 20 MHz), SSID, etc)
- Touch upon licensed and unlicensed frequencies (900Mhz, 2.4Ghz, 5Ghz), how they change from jurisdiction to jurisdiction, and the CRTC as the governing body in Canada.

2: Hands-on and material exploration

Group activity to wirelessly mesh with other groups by configuring Raspberry Pis.

Objectives

- Learn to establish wireless links between nodes and manipulate the nodes' radio properties
- Understand the role that frequency, bands, bandwidth and SSIDs play in a wireless mesh
- Allow opportunity for students to tinker with the radios and create a mesh
- Discover first hand real-world problems with growing the mesh

Materials

- A Raspberry Pi 3 for each member labeled with the SSID for the node
- SD cards with pre-flashed images with all required software
- Laptops that can establish a SSH session to each Raspberry Pi (each running a Host AP with unique SSID)
- USB WiFi radio that is ad-hoc or 802.11s-capable (https://github.com/phillymesh/802.11s-adapters) for each Raspberry Pi 3

Format

- Pairs to start, then work toward establishing a class-wide mesh

Activity

- As a class review the purpose of each command in a sample starter script

```
ip link set dev wlan1 down
iw wlan1 set type mp
ip link set dev wlan1 up
iw dev wlan1 mesh join MY_MESH_NAME_HERE freq 2412
ip addr add 192.168.0.1/24 dev wlan0
```

- Break into groups of two
- Each group needs a pair of Raspberry Pis
- Each group will connect to their Raspberry Pi's Host AP and initiate a SSH session
- Use ifconfig to identify which wlan interface is which (Hint: look for 10.0.0.1)
- Use ifconfig and iw to create a mesh between the nodes with this sample starter script
- Use `iw wlan1 station dump` to see if connections are established
- Use `iperf3 -s` on one node and `iperf3 -c 192.168.1.x` on another node to test the speed across the link
- Once the nodes are properly meshed, have groups seek out another group that has finished
- Work together to integrate all 4 nodes into one mesh
- Encourage group to continue to merge meshes until all the groups are meshed into one
- End the group stage by discussing
    - Did you seek help with another group to mesh your first two nodes?
    - What where the barriers of connecting to another group?
    - How did you come to a consensus of mesh method, frequency, SSID, ip address schema? Build upon discussion in Module 2
    - Was it easier or harder to connect as the mesh got bigger?
    - Did we manage to mesh the whole class? Why, Why not?
    - Parallel the experience with the real world
        - Mesh locals working together
        - Coming to a consensus working in larger groups

3: Discussion and reflection activity

Q & A discussion around the different hardware we employ to build a network.

- Discuss alternative components that could be used in a node for different applications and environments
    - SBC (Orange Pi Zero, Rock64, ExpressoBin, Raspberry Pi, etc.)
        - Price point
        - Processing power
        - Power consumption
        - Features (10/100 Ethernet, mPci-e, USB ports, etc.)
    - Power Supply (wall wart, POE, battery, solar panel, lamp post)
    - Storage and OS (OpenWrt/Lede, LibreMesh)
    - Radios
        - 2.4 Ghz vs 5 Ghz

        - Ubiquiti proprietary protocols meshed over Ethernet

4: Wrap-up and week ahead

- Next session we will discuss important factors to consider for deployment and use a mapping activity of the nearby area for planning

Homework

- Watch Meta Mesh quick tour of a mesh networking installation (https://www.youtube.com/watch?v=aLusYsScrv0): https://www.youtube.com/watch?v=aLusYsScrv0 (https://www.youtube.com/watch?v=aLusYsScrv0) (4:03)
- Optionally read "Wireless Networking in the Developing World, Chapter 10: Deployment Planning (http://wndw.net/pdf/wndw3-en/ch10-deployment-planning.pdf)": http://wndw.net/pdf/wndw3-en/ch10-deployment-planning.pdf (http://wndw.net/pdf/wndw3-en/ch10-deployment-planning.pdf)
- Optionally watch
    - SmartrekTech How to install a Smartrek wireless mesh network for sugar making purposes (https://www.youtube.com/watch?v=eKkVEeVNhm8): https://www.youtube.com/watch?v=eKkVEeVNhm8 (https://www.youtube.com/watch?v=eKkVEeVNhm8) (4:31)
    - Rural Next Generation Broadband Project (https://www.youtube.com/watch?v=QM7MUWDcNxk): https://www.youtube.com/watch?v=QM7MUWDcNxk (https://www.youtube.com/watch?v=QM7MUWDcNxk) (6:12)