
layout: page
title: "Building nodes (hardware)"
module: "3"
contents:

- [_articles/module-3/presentation.md](#)
 - [_articles/module-3/pdf-assets.md](#)
following: [_articles/module-3/presentation.md](#)
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Module 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 \(https://github.com/phillymesh/802.11s-adapters\)](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 wlanX down
iw wlanX set type mp
ip link set dev wlanX up
iw dev wlanX mesh join MY_MESH_NAME freq 2412
ip addr add 192.168.0.Y/24 dev wlanX
```

- 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 wlanX station dump to see if connections are established
- Use iperf3 -s on one node and iperf3 -c 192.168.0.Y 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 were 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> (<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> (<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> (<https://www.youtube.com/watch?v=eKkVEeVNhm8>) (4:31)
 - [Rural Next Generation Broadband Project](https://www.youtube.com/watch?v=QM7MUWDcNzk) (<https://www.youtube.com/watch?v=QM7MUWDcNzk>): <https://www.youtube.com/watch?v=QM7MUWDcNzk> (<https://www.youtube.com/watch?v=QM7MUWDcNzk>) (6:12)