Teaching Internet of Things Concepts with the Raspberry Pi

Brian Nelson
Professor, Computer Information Technologies
Lansing Community College

Bill Saichek
Professor, Computer Science and Information Systems
Orange Coast College

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Why the Internet of Things Is Important to Teach

- The IoT Industry is still advancing at an extremely fast rate.
  - There are HUNDREDS of new devices being released all the time
  - The leveraging of “standard” protocols has been accelerated
  - The security issues are just beginning to be addressed
  - Privacy issues are becoming more of a concern
    - Many of the low end consumer devices are cloud based (whose cloud?)

Teaching the Internet of Things

- IoT has a number concepts that need to be taught
  - Networking Protocols
    - Traditional Ethernet and Wifi
    - TCP, UDP (especially)
    - PoE and Powerline networking
    - Zigbee and Zwave
    - MQTT
  - Security
    - Wireless Security
    - VPNs
    - VLANs
    - Secure Web Access
    - Password and Authentication Practices
  - Automation
    - Sensors
    - Outputs and Actuators
    - Design of Automations
      - If This Then That programming (IFTTT)

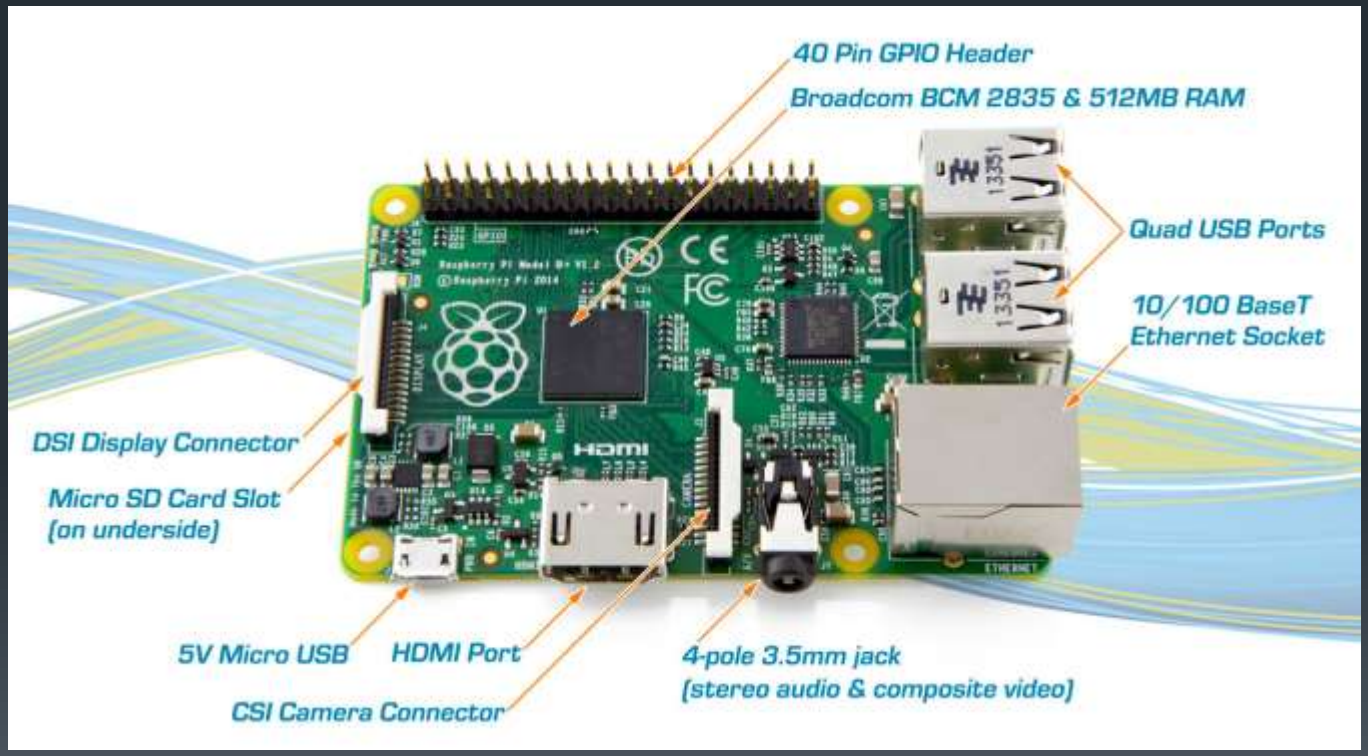
Teaching the Internet of Things

- These Concepts can be taught using commercially available equipment for popular IoT applications
  - Commercial and Residential
    - HVAC Systems
    - Lighting Controls
    - Media Distribution
    - Surveillance
    - Access Controls
    - Environmental Monitoring
- It would be very desirable to have a single platform to cover all the concepts and equipment

The Raspberry Pi

- These small computers make an ideal platform for IoT instruction
  - Inexpensive ~ $60 - $70 each (system cost)
  - Readily available
  - Large user base
  - Zero software cost – quality Open Source titles abound
  - Reasonably powerful
  - Linux based
  - Can be used for more than IoT classes

Raspberry Pi 3 Connections



The Raspberry Pi as a Lab Platform

- Let's take a look at using the Raspberry Pi for Labs
- … for general networking as well as IoT
  - Advantages:
    - Use of Open Source Software eliminates licensing issues
    - Easy to leverage existing lab equipment (such as a generic desktop/laptop computers and inexpensive routers/switches/APs)
    - Costs are low enough to purchase additional hardware
      - Students work in smaller groups
      - Capability to do more labs
  - The next slides will show some labs that can be done using the Pi for your labs
    - Sensor Actuator I/O w/Automation
    - Zigbee, Z-Wave and WiFi Interfacing
    - Presence Detection
    - Surveillance
    - VPN setup
    - Radius server

Sensor Actuator I/O Lab

- Home Assistant on a Raspberry Pi used as a Microcontroller
- An inexpensive temperature/humidity sensor and LED are interfaced via the GPIO connector
- Students add the configurations for the devices by programming the Home Assistant's main configuration file (***config.yaml***)
- Once the devices are functional the students can write simple automations around the devices using IFTTT (*if this then that*) statements
  - For example:

    If the temperature is >x, turn on the LED, if the temperature is <y turn off the LED
- The lab will also serve as a springboard for additional Home Assistant based labs

Zigbee, Z-Wave and Wifi Device Labs

- Home Assistant on a Raspberry Pi used as a Microcontroller
- “Off the shelf “Zigbee, Z-Wave and WiFi devices are paired with Pi
  - Zigbee and WiFi Light Bulbs
  - Z-Wave and WiFi Switches
  - Z-Wave and WiFi Motion Sensors
- Students add the configurations for the devices by programming the Home Assistant’s main configuration file (***config.yaml***)
  - Care must be taken so that no more than one student team are configuring Zwave and Zigbee devices (lesson learned)
  - For WiFi devices make sure they are supported by Home Assistant
- Once the devices are functional the students can write simple automations around the devices using IFTTT
  - For example:

    If the time = x then turn on a Zigbee light bulb

    If the contact sensor = open then turn on a WiFi light bulb to color = red

    If motion detected = TRUE then turn on WiFi light bulb for 1 second, then turn off for 1 second and repeat 20 times

Presence Detection Lab

- Home Assistant on a Raspberry Pi used as a Microcontroller
- Home Assistant has several ways to determine if a person is “home” (at least if their phone is) using *ping*, *nmap* or even *communication with a router*
- Students add the configurations for the devices by programming the Home Assistant’s main configuration file (***config.yaml***) adding the configurations for their phones

  … which will need static IP addresses
- Once they get Home Assistant to detect the presence of the phone the students can add customized icons for each person to display
- The students can write simple automations around who is present
  - For example

    If student X is home turn on a specific bulb

Video Surveillance Lab

- Home Assistant on a Raspberry Pi as a Microcontroller
- Home Assistant can support a number or security cameras … including webcams.
  - Note: not all cameras work well and integrate with Home Assistant (Foscam seems to be the go to camera)
- Home Assistant can use cameras as motion detectors, send snapshots and even integrate with 3rd party surveillance platforms (iSpy … open source video surveillance)
- Students add the configurations for the devices by programming the Home Assistant's main configuration file (***config.yaml***) adding the configurations for the cameras

VPN Lab

- Only requires:
  - Raspbian on a Raspberry Pi running OpenVPN
    - Both OpenVPN and Raspbian (the Pi's version of Debian) are open source … therefore free
  - Inexpensive Router/Switch/AP (DLink, Asus, Netgear, etc)
  - A desktop or laptop on "both sides" of the router
- Students install the OpenVPN software on the Pi
- … and then configure an RSA self-signed certificate for encryption and authentication

- The students get invaluable understanding and practice a critical piece of network security while demonstrating that you don't need a complex infrastructure to provide this valuable service.

RADIUS Lab

- Only requires:
  - Raspbian on a Raspberry Pi running FreeRADIUS (and other stuff)
    - Both FreeRADIUS and Raspbian (the Pi's version of Debian) are open source … therefore free
  - Inexpensive Router/Switch/AP (DLink, Asus, Netgear, etc)
  - A desktop or laptop on "both sides" of the router
- Students install FreeRADIUS and other required service software on the Pi
- … and then configure FreeRADIUS authentication
- … and then configure the router to forward RADIUS packets to the Pi

- The students get invaluable understanding and practice a critical piece of network security while demonstrating that you don't need a complex infrastructure to provide this valuable service.

- *One note … this lab is far more complex than any of the other labs mentioned. FreeRADIUS requires many additional servers and services … such as MySQL … be installed and configured. Consider this lab for a more advanced networking class.*

In Conclusion

- The Raspberry Pi provides a flexible , low cost IoT lab platform
- Many important concepts can be demonstrated
- It’s applicability is made possible by the numerous open source software packages available
- Lab possibililties are endless