Node-RED: A Live Demonstration of a Cross-Platform, Web-Based Visual Programming Environment

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Supervisory Control And Data Acquisition (SCADA)

- SCADA Systems Automate Control And Monitoring Of Critical Industrial Systems
  - Water treatment and distribution, oil and gas production and delivery, electric power generation and distribution
  - Manufacturing and process control of food, medicines, appliances, electronics
  - HVAC, lighting, and access control for office buildings, theme parks, ships, etc.
- SCADA Began With Mainframes And Evolved To Distributed Architectures
  - Programmable Logic Controllers (PLCs) and Remote Terminal Units (RTUs) connect to sensors and effectors
  - Supervisory computers aggregate information from one or more PLCs and RTUs
  - Algorithms are entered and progress monitored using a Human Machine Interface (HMI)
  - Devices are connected and may use MODBUS, TCP/IP, and other protocols

SCADA Is Not Appropriate For All Control Applications

Particularly Those With Lower Risk and Complexity

- SCADA Systems Can Be Very Expensive
  - They are scalable to handle hundreds or thousands of inputs and outputs
  - High-speed, closed-loop control requires fast, real-time processing
  - May require redundancy to survive single points of failure
  - Increasing emphasis on solutions hardened against cyber attacks
  - Sold by large companies like ABB, Emerson, GE, Honeywell, Rockwell, Schneider, Siemens
- Hobby And Low-End Applications Do Not Require Complex, Time-Tested Solutions
  - Home automation and security
  - Holiday lighting control
  - Consumer HVAC
  - Lawn and garden watering

Alternate Technologies

Courtesy of Moore's Law and Open-Source Communities

- PLC And RTU Functions Can Be Performed By Microcontrollers And FPGA's
  - There are dozens of low-cost hobby boards that offer GPIO, I2C, A/D, D/A, PWM, etc
  - Arduino Shields, BeagleBone Capes, Pi HATs, and other kits connect low-voltage I/O to larger systems
- HMI's Can Be Implemented Directly On Many Embedded Systems
  - Many low-end CPU's support LCD/OLED touchscreen displays and GPUs
  - Graphical Integrated Development Environments (IDE), free real-time OS's like FreeRTOS, graphical programming languages like Scratch, and familiar high-level languages like MicroPython lower costs and simplify programming
- There Are Many Widely Supported, Open Control And Status Protocols
  - AMQP, CoAP, HTTP/Restful, MQTT, RabbitMQ, STOMP, XMPP
  - All work over UDP or TCP/IP and supported physical and data link layers

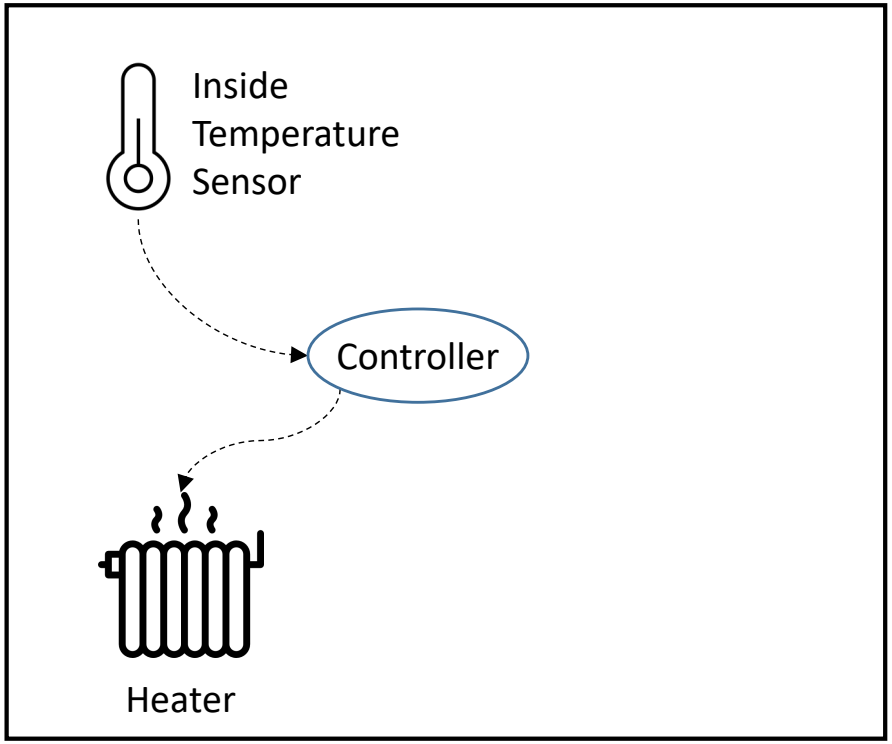
Node-RED

Project Homepage: https://nodered.org/

- Node-RED Is A Web-Based Visual Programming Environment
  - It is available for Windows, Mac, Linux, Raspberry Pi, BeagleBone, and more
  - It is based on configurable function blocks called “nodes”
  - Output from a node can be “wired” to the input to one or more others creating “flows”
  - The graphical editor simplifies the creation and maintenance of complex control logic
- It Is Well Suited For Many Personal And Some Industrial Control Applications
  - Flow visualizations emphasize sensor inputs, control algorithms, and effector outputs
  - Included nodes process data and interface with common I/O and common Internet services
  - New nodes are easily created using HTML and Javascript (based on Node.js package manager ”npm”)
  - It can perform functions of PLC’s, RTU’s, and HMI’s
  - Hardened, commercially supported implementations are available

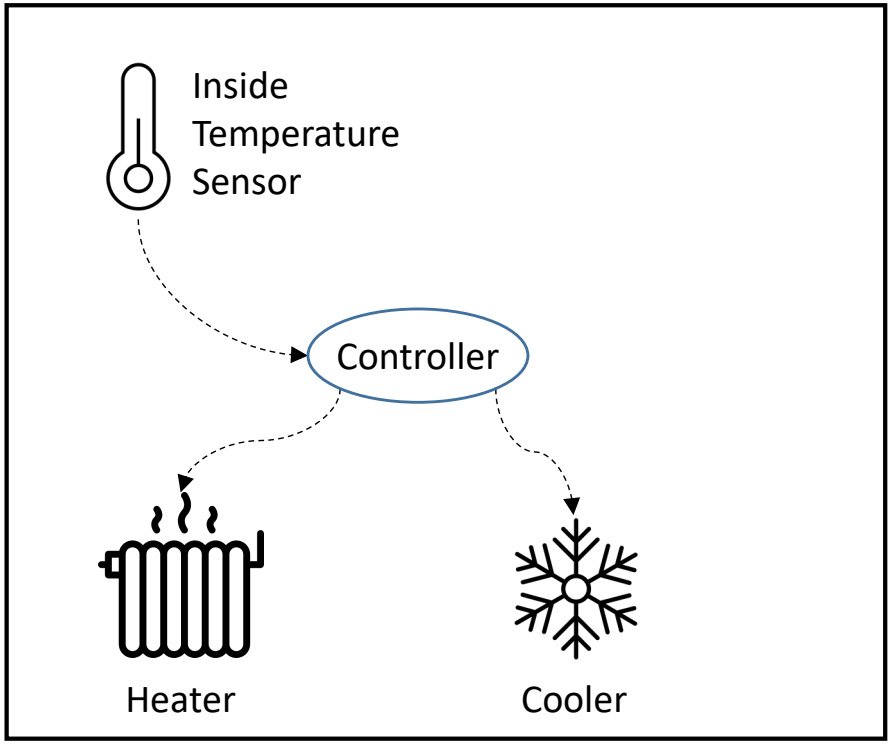
Today's Demo: Part 1

Maintain Inside Temperature At Least 68 °F



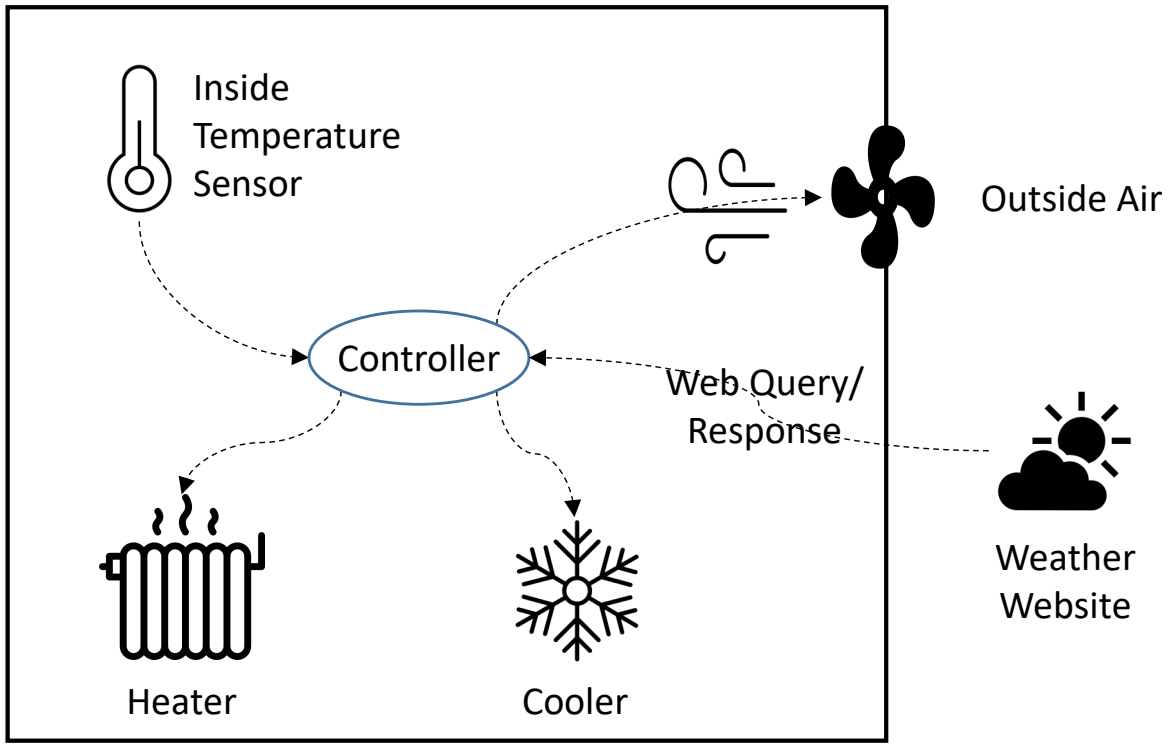
Today's Demo: Part 2

Maintain Inside Temperature Between 68 and 72 °F



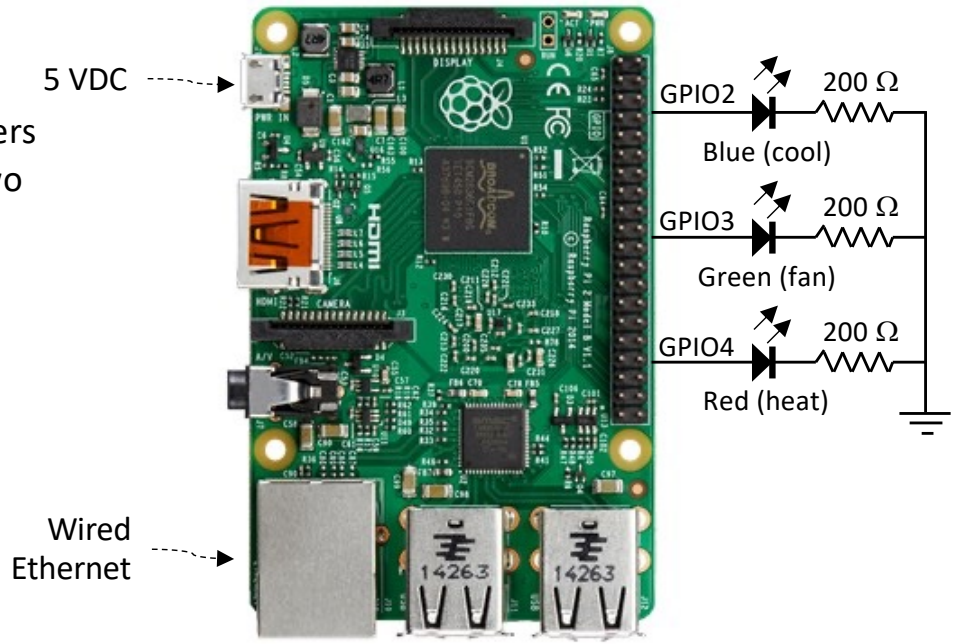
Today's Demo: Part 3

Efficiently Maintain Inside Temperature Between 68 and 72 ℉



Demo Platform

- Raspberry Pi 2
  - Relatively inexpensive family of computers
  - Sufficient speed and memory despite two generations behind current model
  - Many general Purpose I/O pins
- 16 GB Class 10 MicroSD Card
- Raspberry Pi OS Lite
  - Debian-based native OS w/o X-Windows
  - Plenty of online help and support
- Note: No Onboard WiFi
  - Add w/USB dongle or use Pi 3 or 4

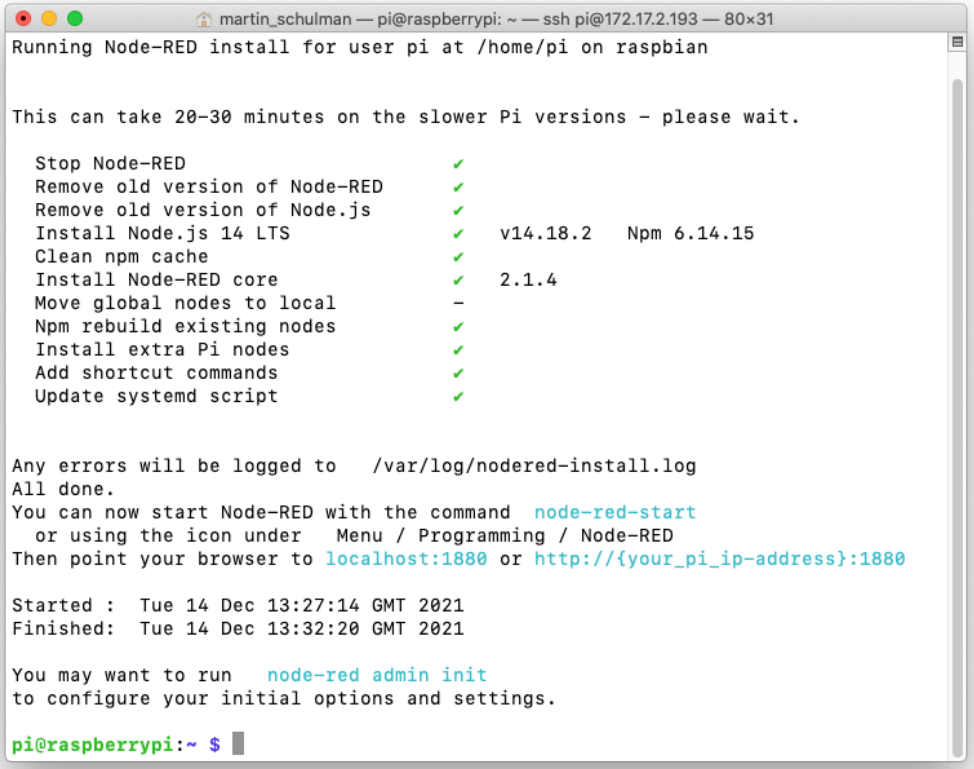


Prepare The Raspberry Pi Operating System

- Installing And Setting Up The OS
  - Takes too long to do during this presentation - there are many online resources for getting started
  - If you're new, start here: https://www.raspberrypi.com/software/
- Initial Housekeeping Tasks
  - Use the "Raspberry Pi Imager" to load Raspbian on SD card
  - Username is "pi", change password from "raspberry"
  - Change the keyboard to US (defaults to British)
  - Update Raspian
  - Connect to wired network or WiFi and view address with "ip addr"
  - Enable SSH for remote command line access if needed
  - Use the "pinout" command to see a map of the I/O pins
  - Wire and test LED outputs, i.e. https://www.ics.com/blog/control-raspberry-pi-gpio-pins-python

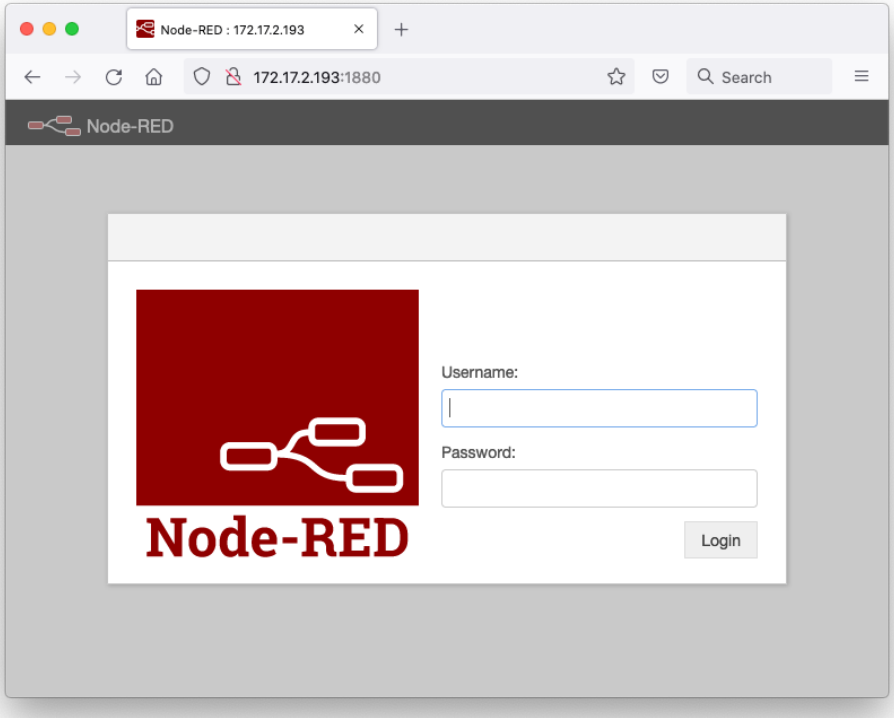
Install Node-RED

- Use installation script method at https://nodered.org/docs/getting-started/raspberrypi
- Include Pi-specific nodes
- Allow 20-30 minutes
  - May depend on Pi version, SD card speed, network speed, and server load
- Installs Version 2.1.4
  - As of December 2021



Configure And Run Node-RED

- Initialize Configuration
  - Run “node-red admin init”
  - Recommend enabling user security, accept other defaults
- Run Node-RED Service
  - Start manually with “nohup node-red-pi --max-old-space-size=256 &” or enable as service
- Browse To http://<ip_addr>:1880/
  - Login if user was configured



Live Demo

Extra Credit

- How Would You Modify This Demo To…
  - Use heat/cool AND fan if the temperature is far out of range?
  - Revert to only heat or cool if the outside temperature changes?
  - Add humidity control?
  - Send email notifications?
  - Log data?
- Features We Did Not Explore
  - Executing operating system commands
  - Alternate I/O: serial, I2C
  - Loading additional nodes
  - Saving nodes to libraries
  - Storing data in a database
  - Creating a dashboard and graphing data

Summary

- Node-RED Is A Web-Based Visual Programming Environment
  - It provides a No-Code or Low-Code solution for many personal control and monitoring applications
    - Pay attention to the message objects passed between nodes
  - It can leverage low-cost compute and I/O hardware
  - It offers some of the capabilities of SCADA systems for much less
  - It can be fun to use!
- More Information At https://nodered.org/

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Thank You

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