An Advanced Networking Outreach Activity for Kids

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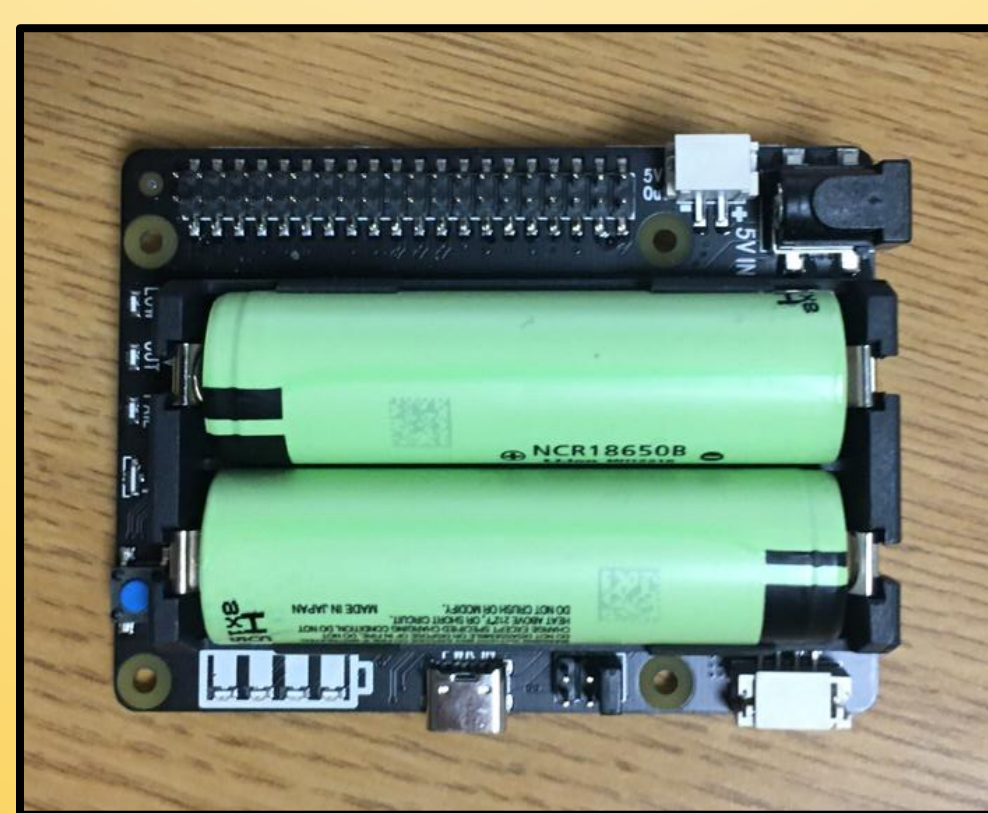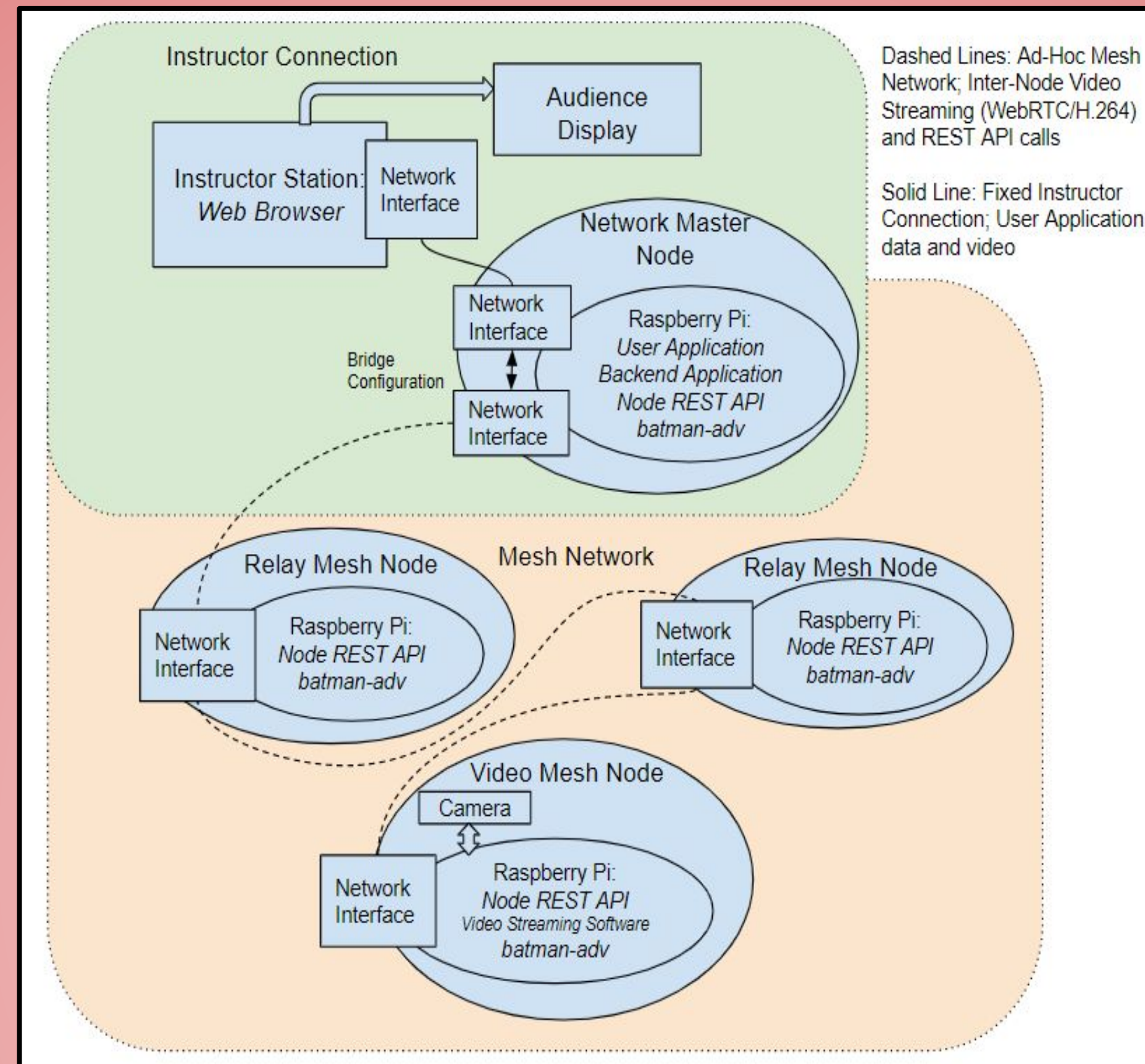Dr. Thomas Daniels

Functional Requirements

- Nodes must support ad-hoc networking capabilities
- Nodes need to connect to one another automatically when within range
- If a node is moved out of range and then moved back into range, it must reconnect automatically
- Multiple networks of nodes should be able to coincide and stay independent
- The network must be able to communicate with the instructor's computer
- The user interface must be able to deliver statistics and data from the network

Constraints

- Interface must be understandable by grade school students and general educators
- System should be accessible without installing software onto instructor computer
- Individual nodes must be portable by hand

Non-Functional Requirements

- Nodes should have internal power supply providing at least two hours of use
- Hardware should be packaged in durable, drop-proof, and safe casing
- Batteries should be easy to access for recharging

Operating Environment

- Intended for indoor use and conditions
- Will be handled and carried by grade school students and instructors, rough handling likely
- Unlikely to be only wireless device in use, must not interfere with or be affected by other devices
- Size and layout of area not important, physical obstacles may aid in demonstrations
- At least one external device will be used to observe network with web GUI

Project Resources

- Budget for 6 nodes is about $960
- Nodes consist of a Raspberry Pi, an uninterruptible power supply with batteries, and a case
- Video Mesh Node consists of normal node hardware plus a camera module

Intro/Motivation

As technology becomes more commonplace, it also become more abstracted and less understood by users. This project hopes to solve this by providing kids with a mesh networking kit to learn how wireless networking works and how wireless signals interact with physical objects.

Design Approach

The Network Master Node acts as bridge between the mesh network and the User Application that runs on the instructor's device.

Each node acts as a relay in the mesh network. Some nodes contain cameras and provide video feeds.

The Network Master Node hosts the User Application, which gives the users a way to view node data and video streams.

Video is streamed from the Pi camera to the User Application using the WebRTC protocol and H.264 video codec.

The Network Master Node also hosts the Backend Application, which interfaces between the User Application and the network.

Professional Standards

- Developing information for users in an Agile environment (ISO/IEC/IEEE 26515)
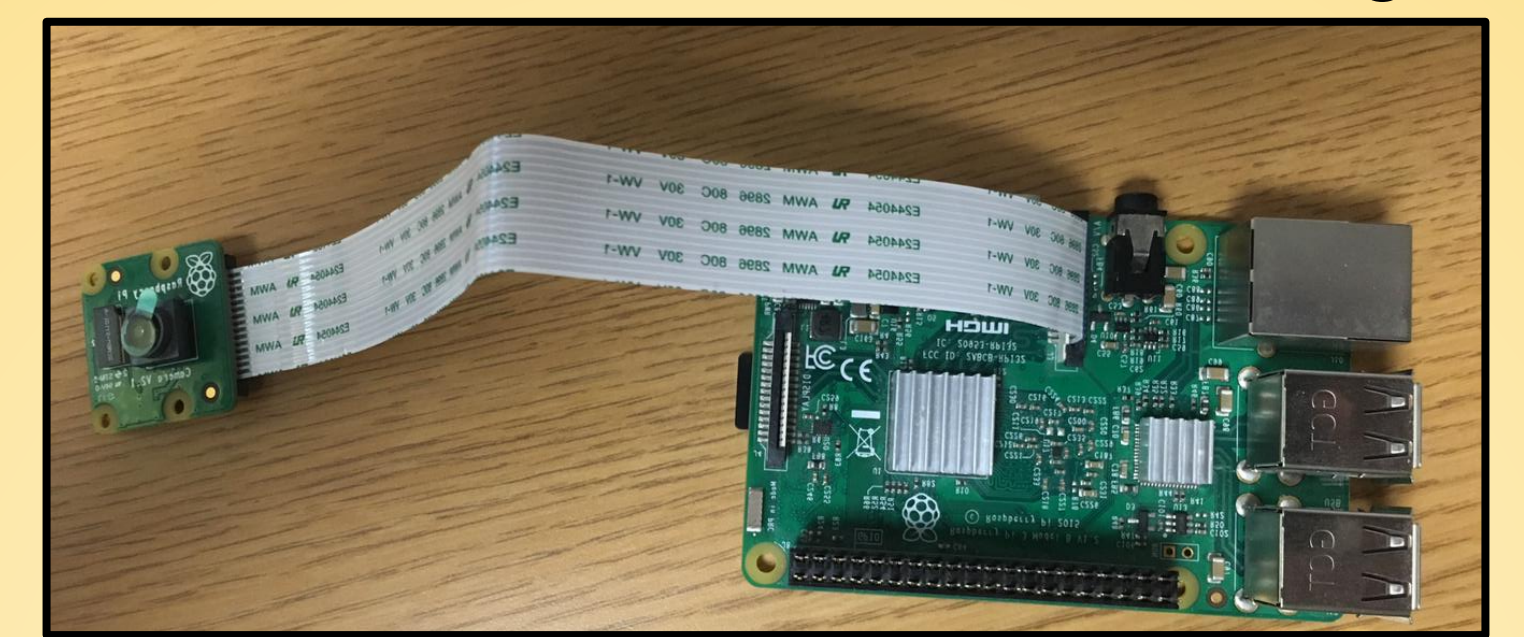- Quality management (ISO 9001)

Intended Users

The objective of this project is focused on providing a learning opportunity to kids primarily in middle school and high school. There are two kinds of users:
- Instructor: Can be any adult and is not expected to be technically inclined.
- Children: The main users that will be handling the nodes and completing activities.
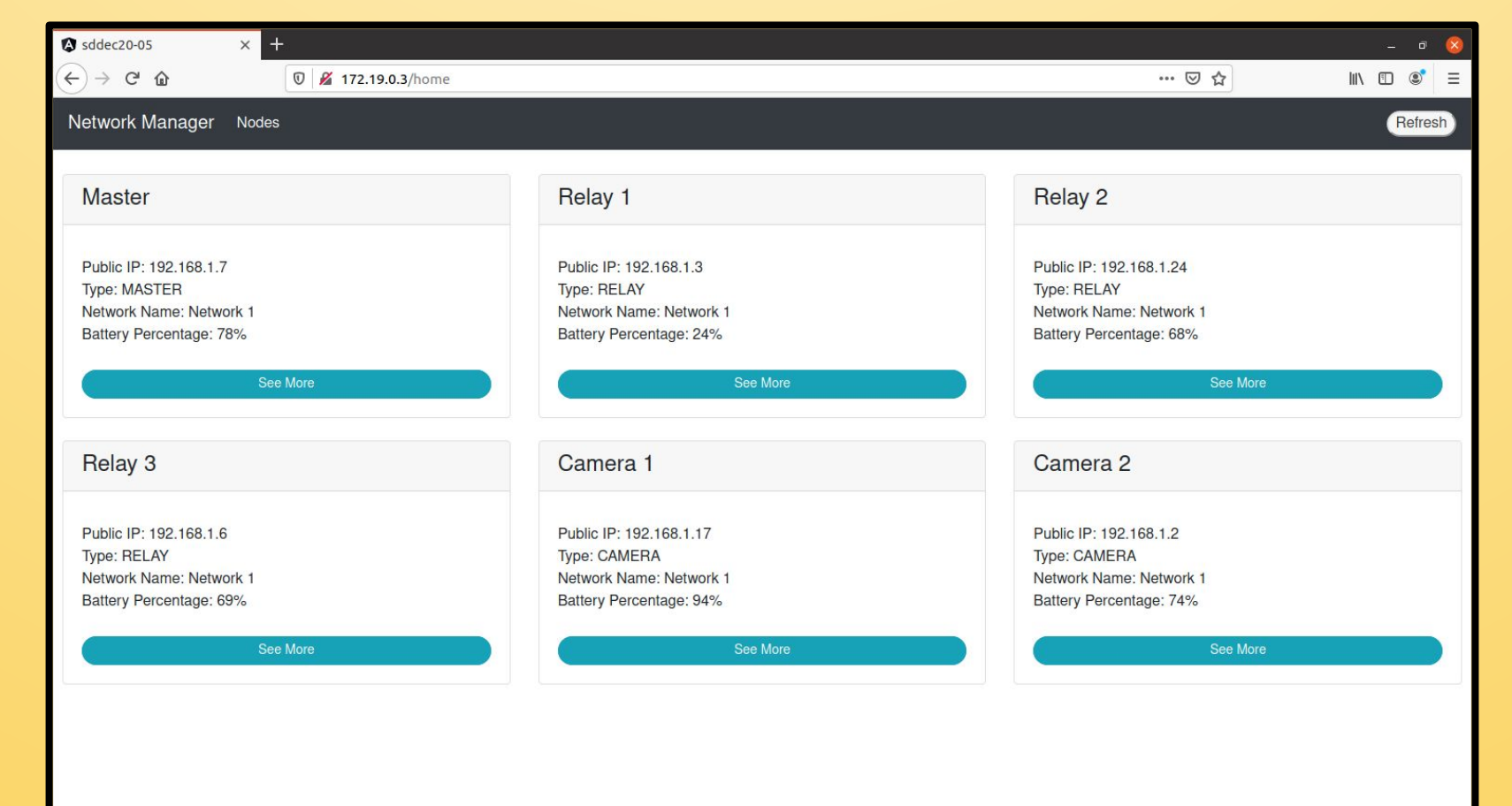
Tech Details

Hardware
- Raspberry Pi based nodes
- Mesh networking using external wireless adapters and built-in chips
- Pi camera used for video streaming

Software
- User Application
  - Angular web application
  - Containerized with Docker
- Backend Application
  - Spring Boot REST server
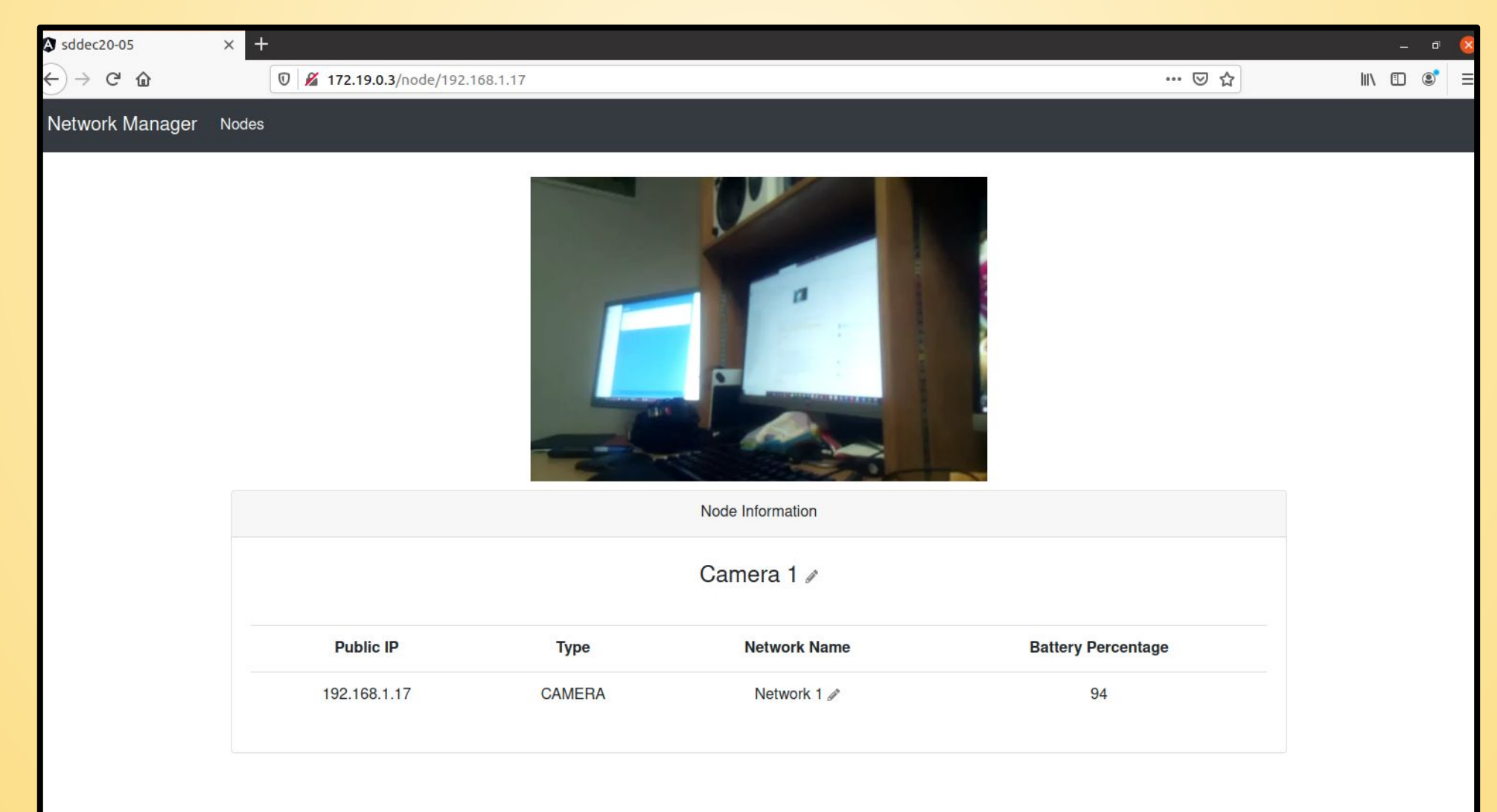 - Containerized with Docker
- Node REST API
  - Python REST API

Testing Details

Unit Tests
- Confirmed the Backend Application can list the nodes in the network

Integration Tests
- Backend Application passes requested data to the User Application
- Video can be streamed from the Pi camera to the User Application

System Tests
- Ensure all Mesh Nodes connect automatically to the Network Master Node
- Ensure all nodes are indicated as available in the User Application