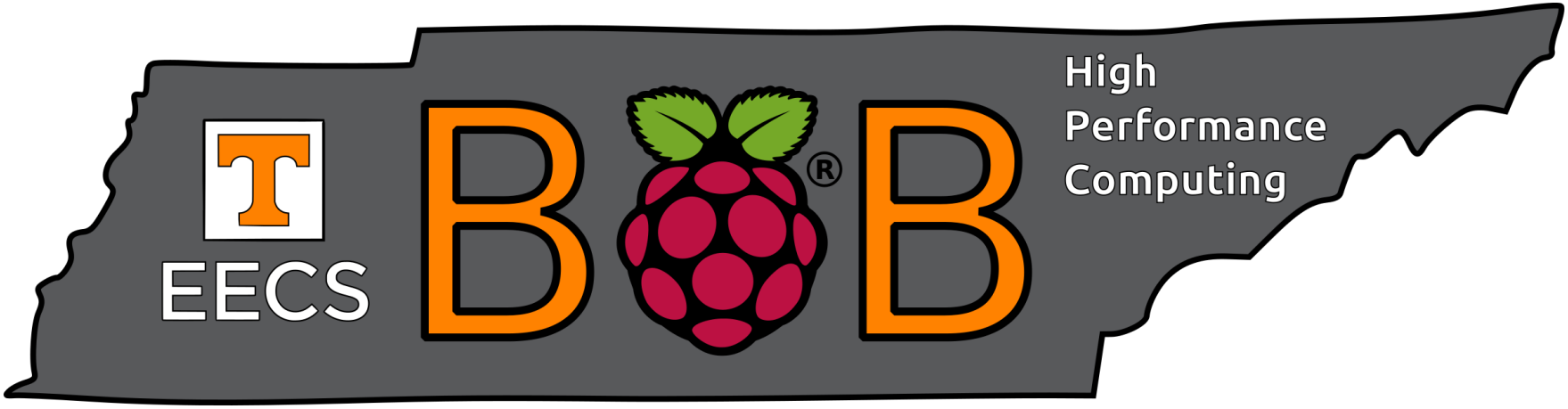
Big Orange Bramble



August 09, 2016

Overview

Raspberry Pi

Enclosure

Daughter Card

Monitor Node

Power Supply

LDAP

Slurm

NFS

OrangeFS

Hardware Overview

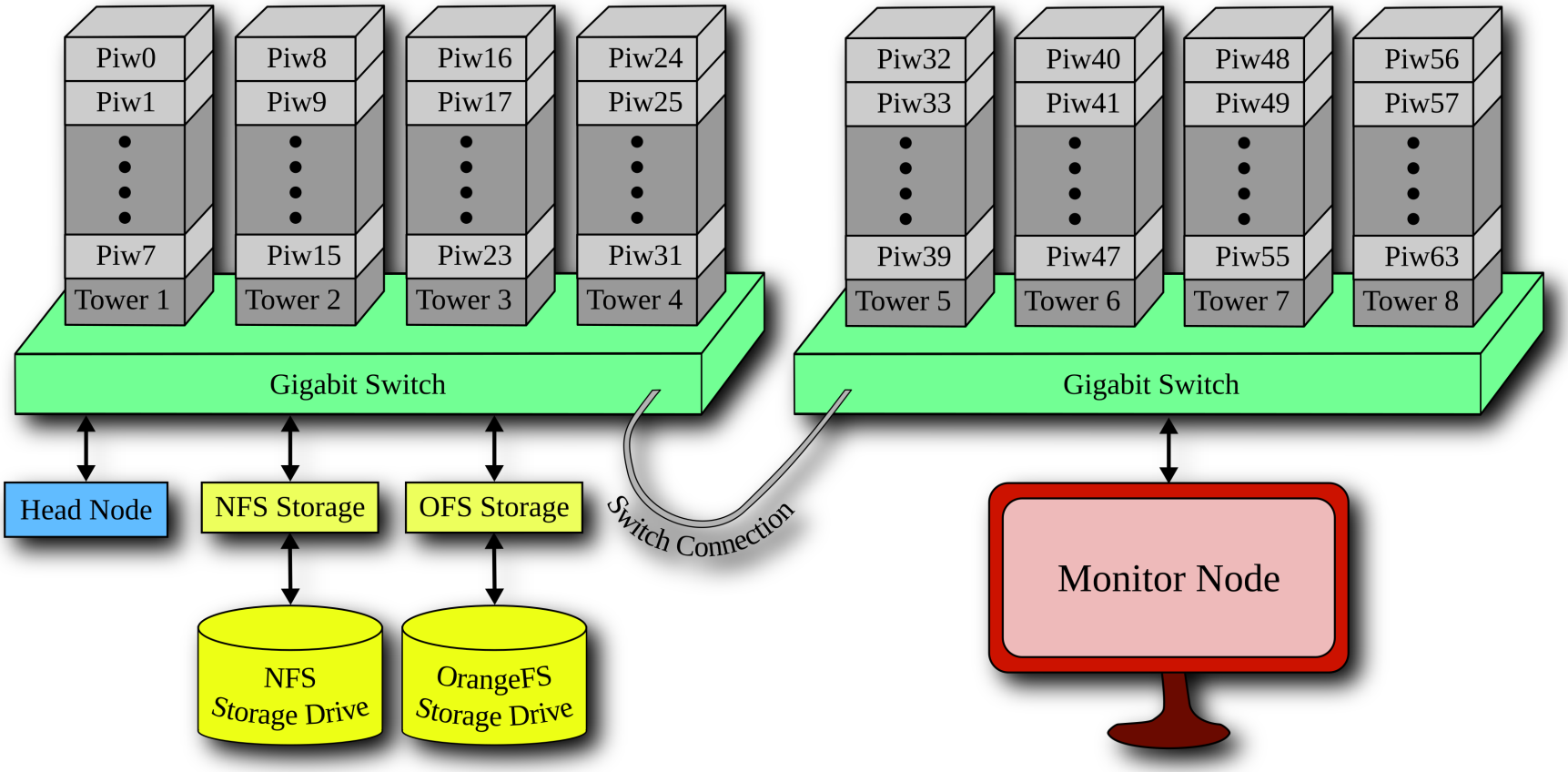


Figure 1: Hardware Diagram

Raspberry Pi 3

- Broadcom BCM28337 SOC
  - Quad Core Cortex A53 (AArch64, ARMv8 compatible)
  - VideoCore IV GPU
- 1GB LPDDR2 RAM
- 10/100 Ethernet, 4 USB 2.0 Ports

Figure 2: Raspberry Pi 3

Enclosure

- Rack Enclosure on Casters
- 2 custom Plexiglass boxes with 3D printed corner brackets house the worker nodes (dimensions: $17in \times 9.25in \times 8.75in$).
- Multiple rack shelves to hold switches and power supplies.
- Pull-out shelf for computer keyboard.

Enclosure

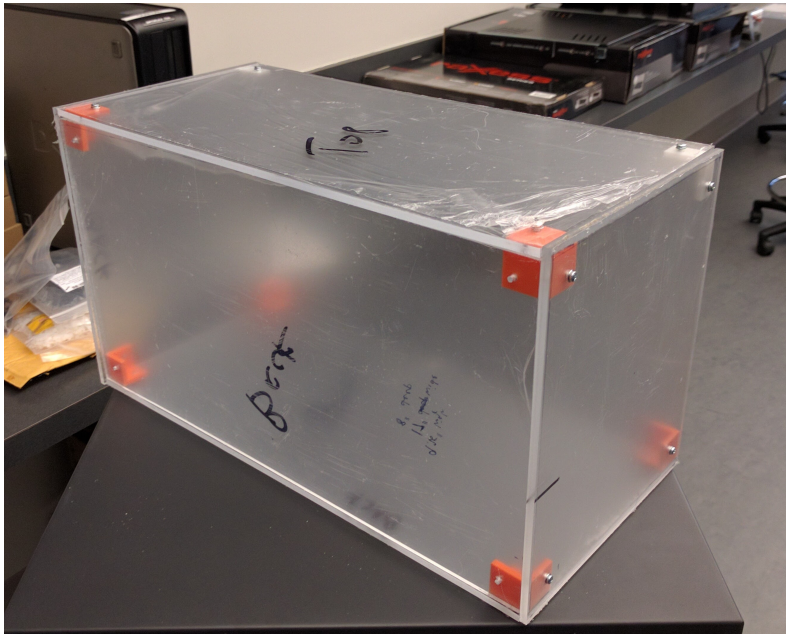
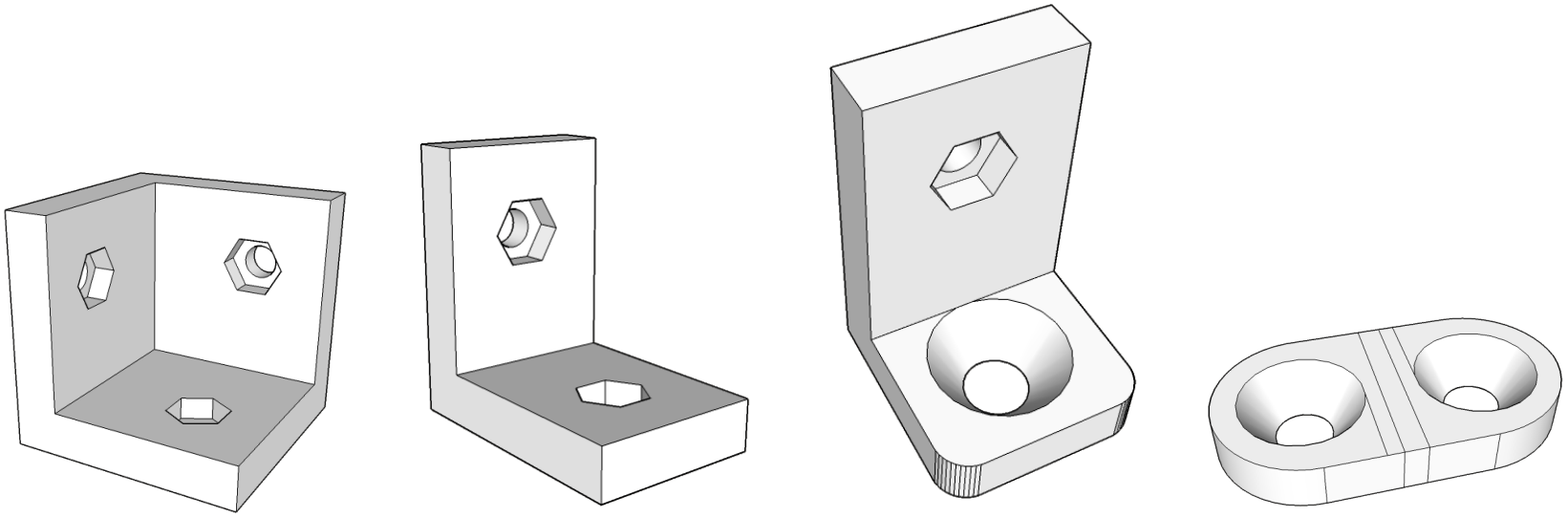


Figure 3: Custom Box

Figure 4: Rack with Casters

Enclosure



(a) Corner Brace (b) L Brace (c) Fan Brace (d) Fan Connector

Figure 5: 3D Printed Parts

Enclosure

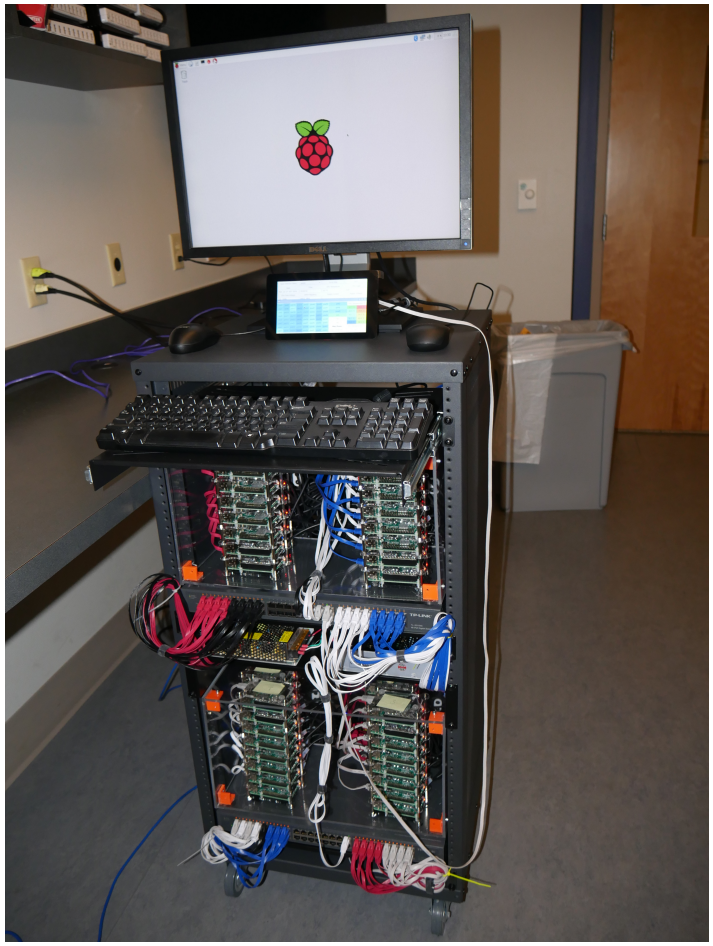


Figure 6: Filled Enclosure Front

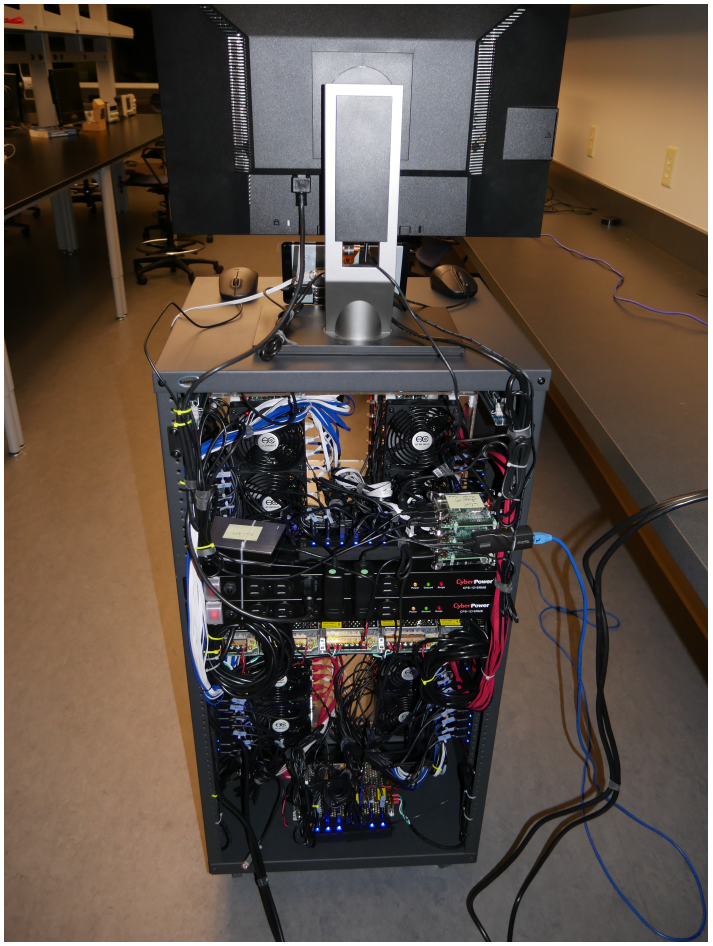


Figure 7: Filled Enclosure Rear

Daughter Card

- Needed a way to measure power input to nodes.
- Convert analog measurements to digital packets.
- Send information to a Monitor Node.

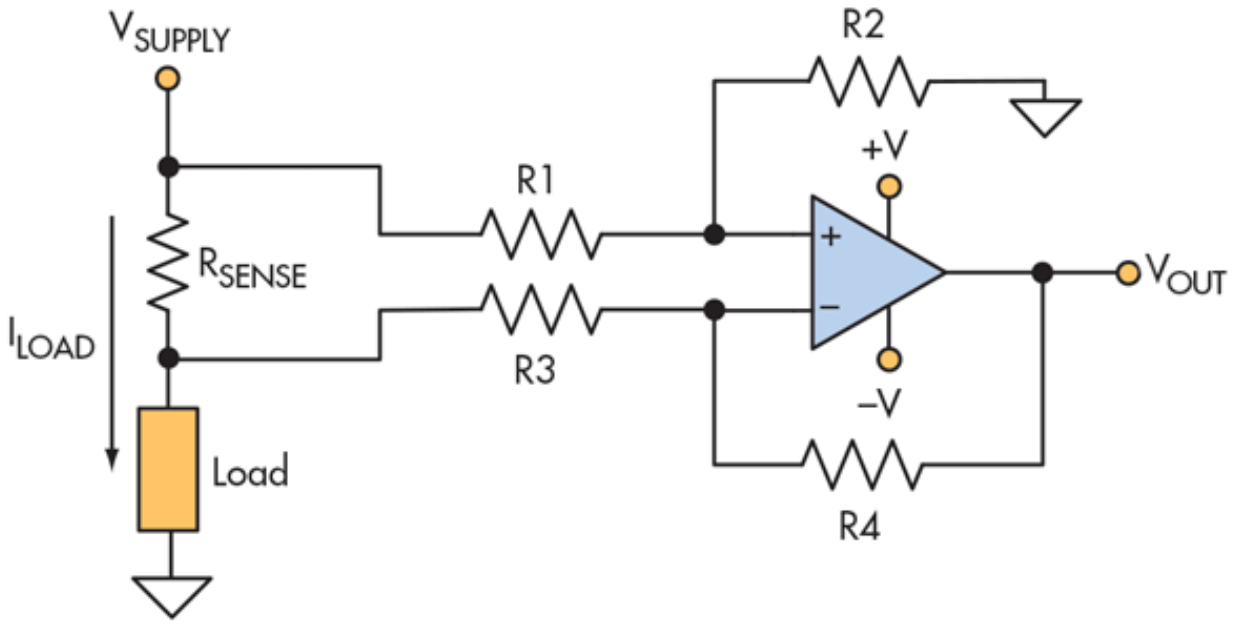


Figure 8: Current Sense Technique

Daughter Card

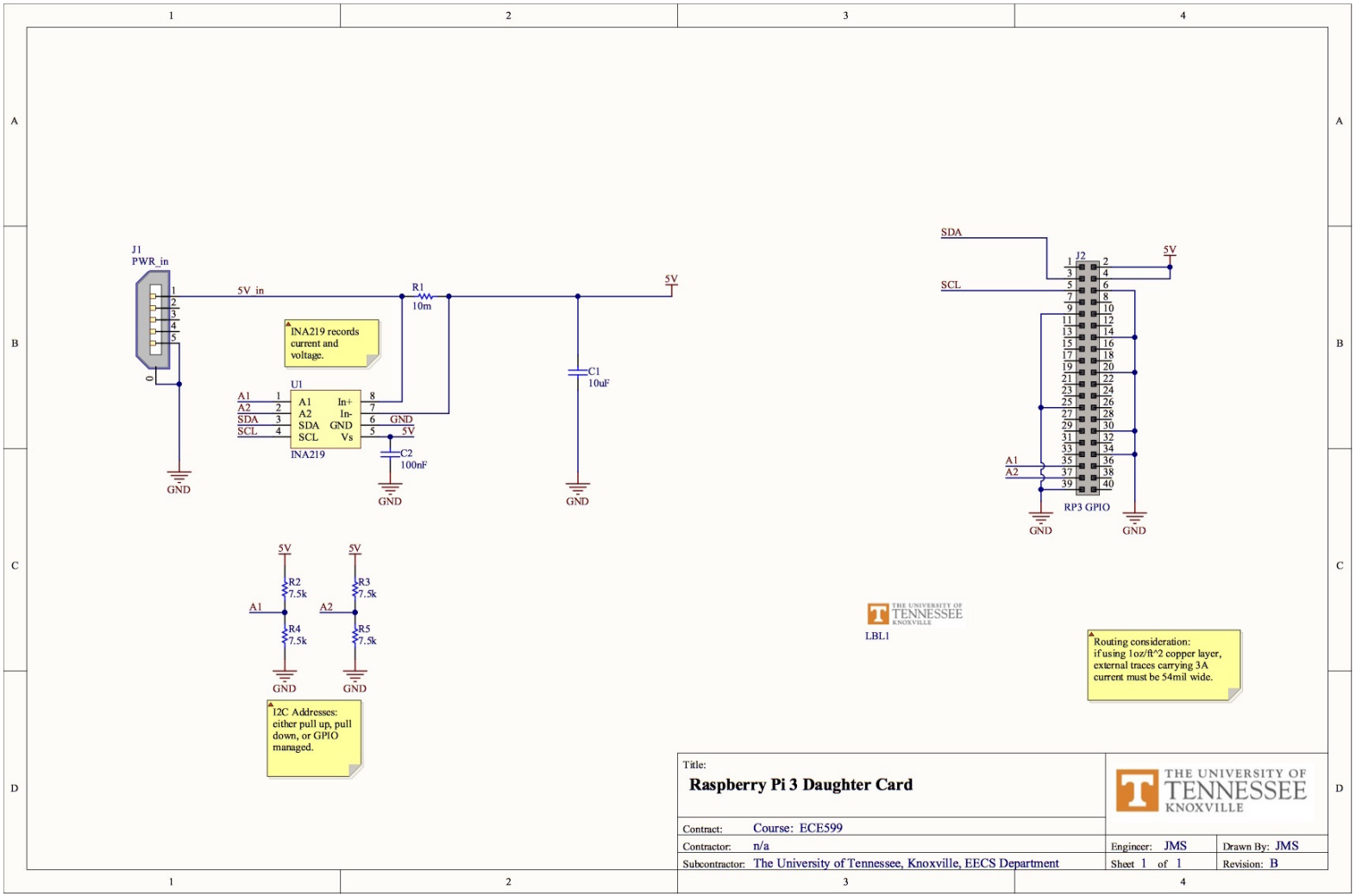


Figure 9: Daughter Card Schematic

Daughter Card

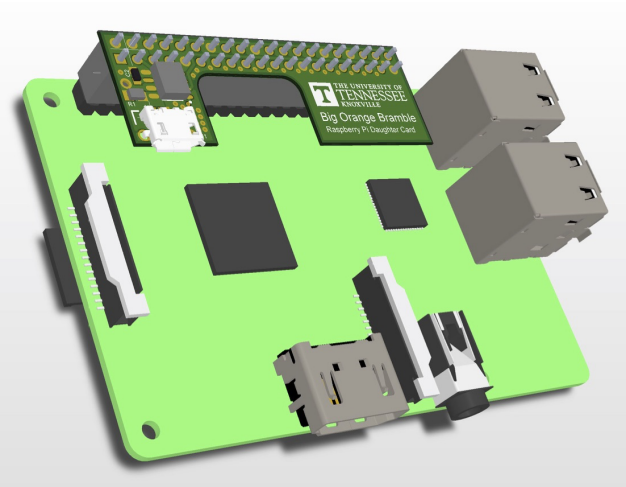


Figure 10: Daughter Card 3D Render

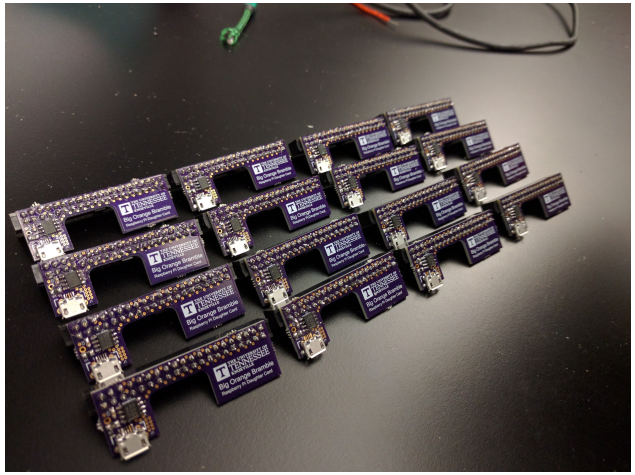


Figure 11: Sixteen Populated Daughter Cards

- Altium Designer
- OSH Park
- Tweezers and Patience

Daughter Card

- Adafruit has a C++ library for the INA219 that was originally used
- Someone had created a Python port that was much easier to integrate into our usage scenario
  - getShuntVoltage_mV()
  - getBusVoltage_V()
  - getCurrent_mA()
- Originally daughter cards connected through Python Paramiko library ssh connections for ease of access
  - This was slow and not the most easily expandable solution
- Now the monitor node handles communication with all daughter cards

Monitor Node Backend

- Separate Raspberry Pi with Touchscreen
- Python monitoring script runs as a service on each node
- Each node sends:
  - CPU temperature
  - CPU load
  - CPU frequency
  - SoC core voltage
- Nodes with daughter cards also send:
  - Supply current
  - Supply voltage
- Information is sent via UDP packets
- Information sent from nodes every 2 seconds

Monitor Node GUI

- Monitoring GUI implemented in Python and GTK and Glade
- GUI can show a map of any of the monitored metrics
- Shows min/max of the measurement metrics

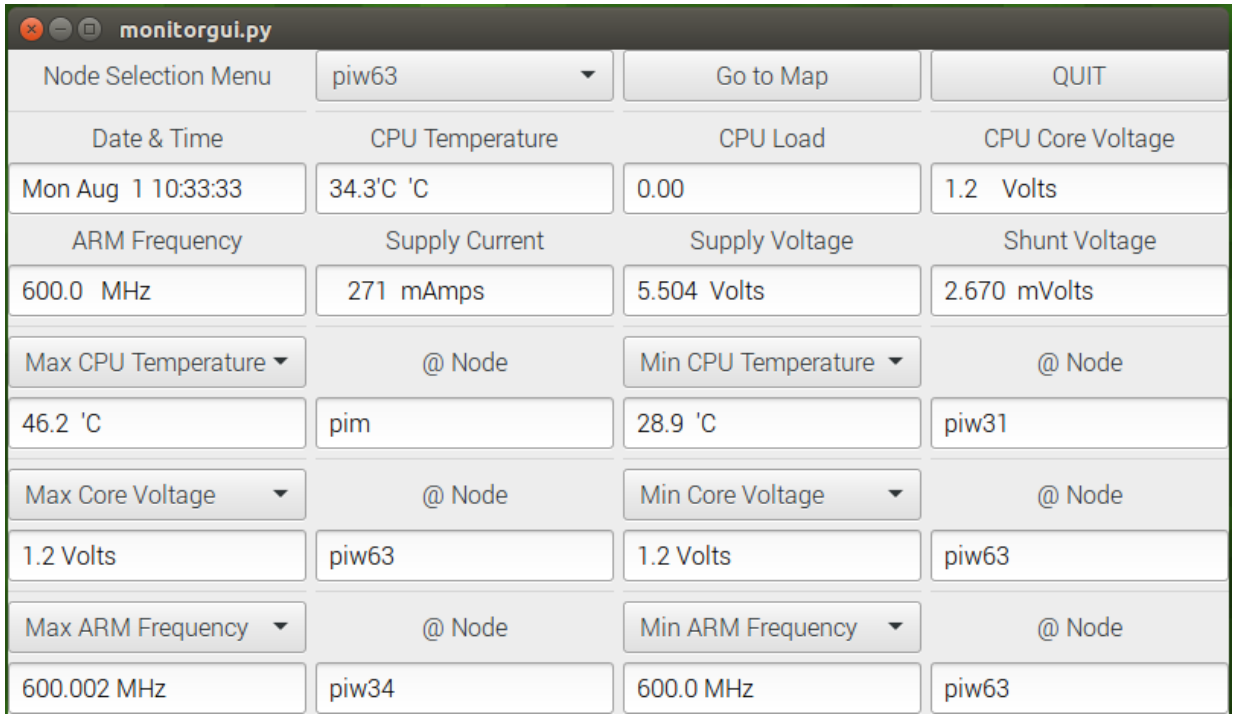


Figure 12: Monitor Gui

Monitor Node GUI

- Monitoring GUI implemented in Python and GTK and Glade
- GUI can show a map of any of the monitored metrics
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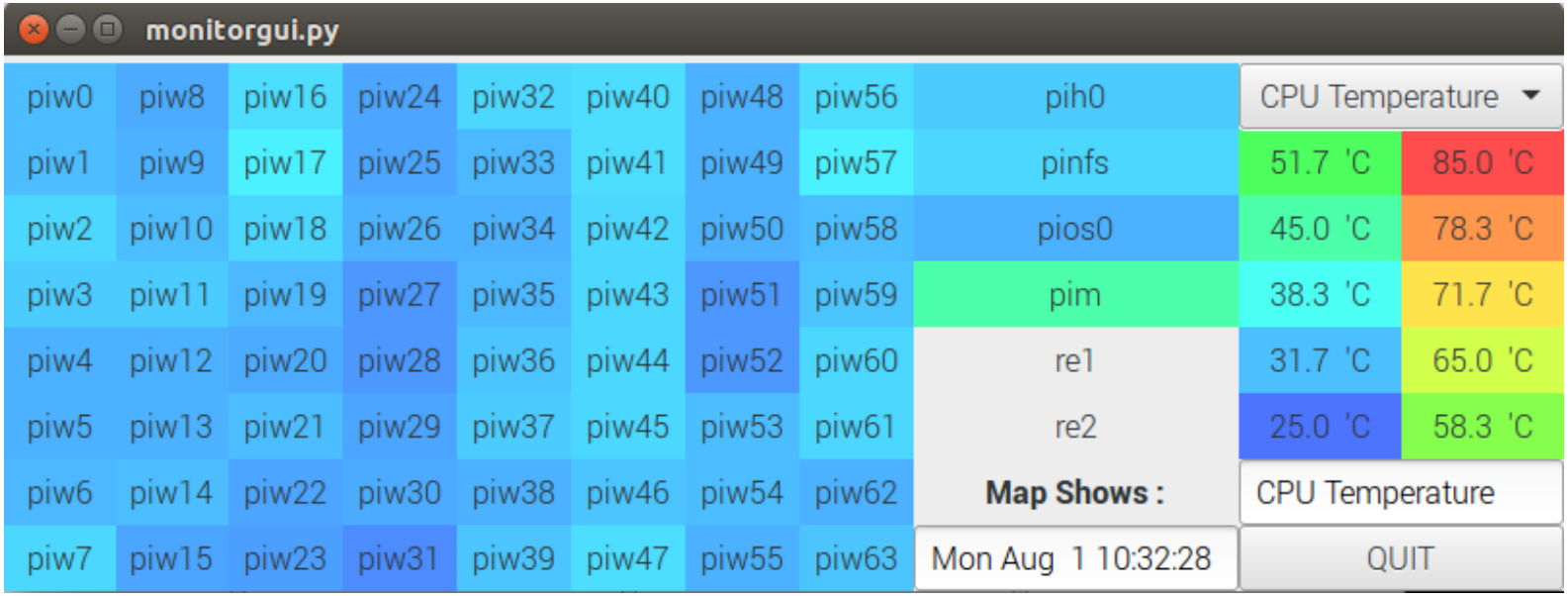


Figure 13: Monitor Map

Power Supply

- Discovered power delivery issue when HPL tests showed CPU frequency throttling
- Voltage dropout was primarily due to cable loss from cables and board-level power management devices (up to $1.5\,\Omega$)
- Power distribution system has 10 Switch Mode Power Supply (SMPS) units rated at 20 A current capacity at 5 V (100W)
- Each SMPS drives a single 7-port USB hub, modified to accommodate approximately 4A per port.

USB Hub Mods

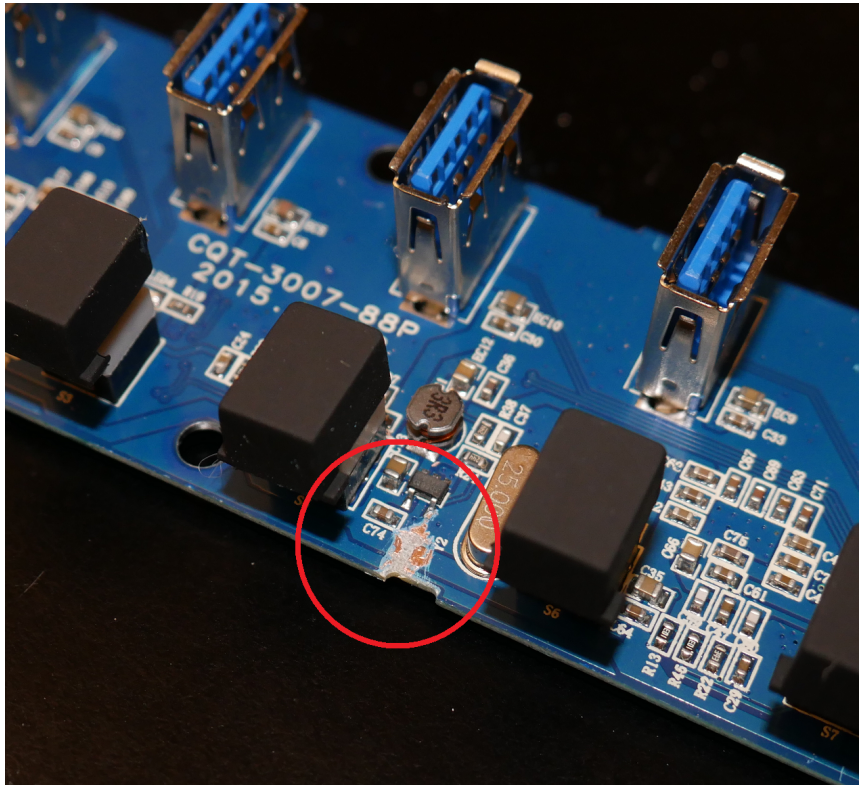


Figure 14: Sliced Power Bus

- 100mil trace only sufficient for up to 4A current load.
- Find optimum location to split trace in order to fan out current load.
- Slice trace with repeated scoring of Exacto-knife.

USB Hub Mods

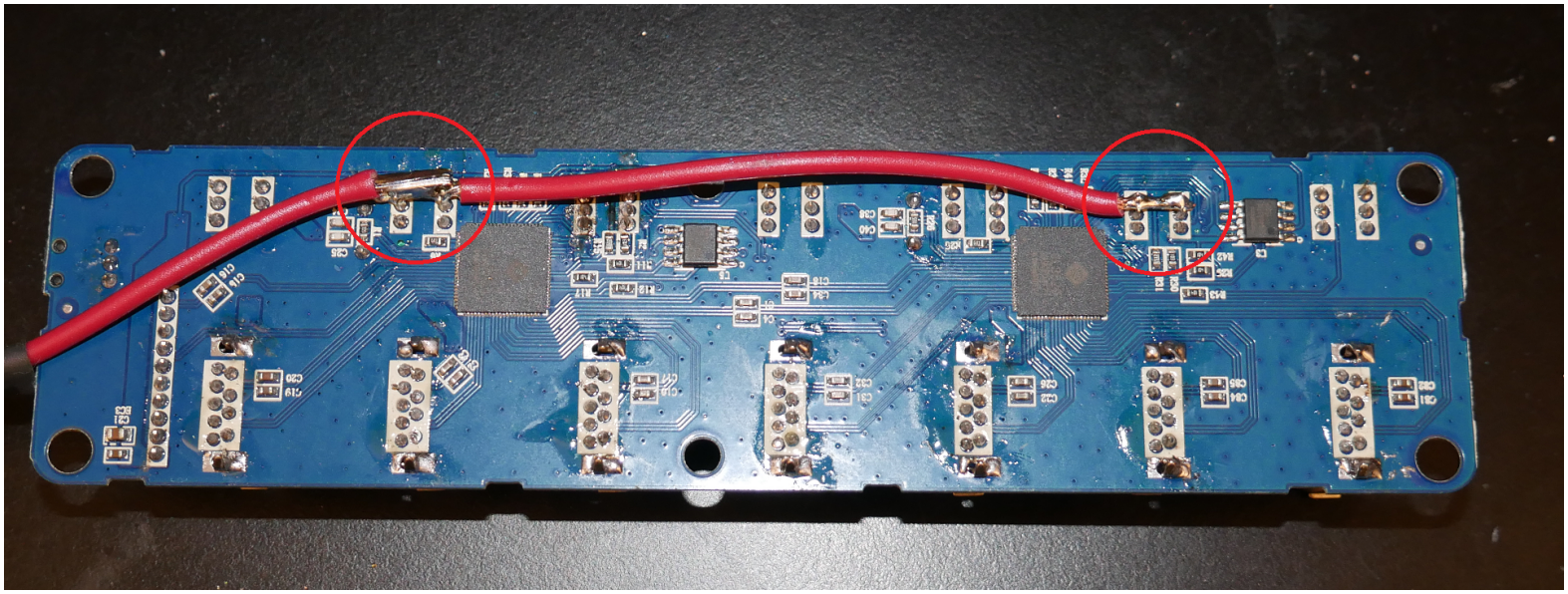


Figure 15: Power Rail Connections

- Choose fanning locations and solder 16AWG stranded wire to points.

USB Hub Mods

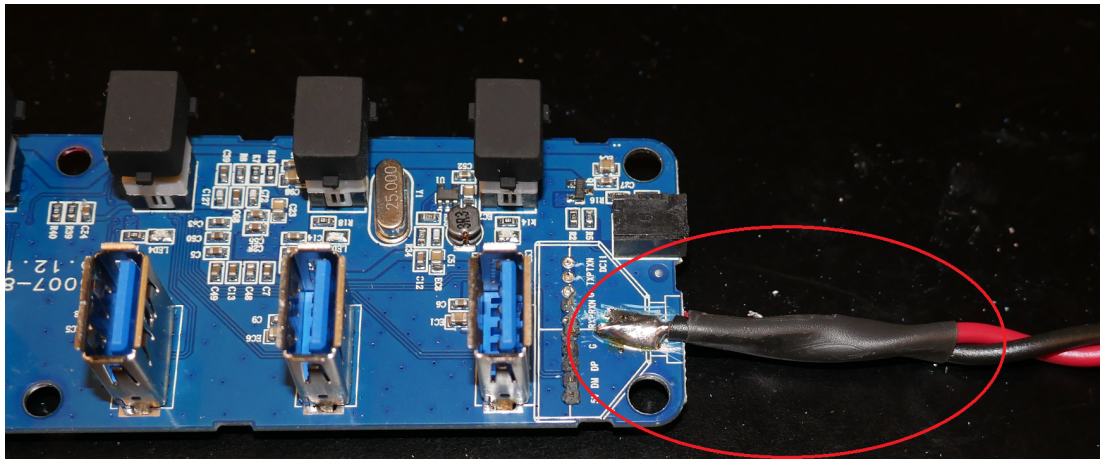


Figure 16: Ground connection and Heat-shrink

- Remove solder mask by scoring from Printed Circuit Board (PCB) to reveal Ground (GND) Plane.
- Solder 16AWG stranded wire to exposed GND plane.
- Twist pairs to establish electromagnetic coupling between transmission and return path.

USB Hub Mods

Success!

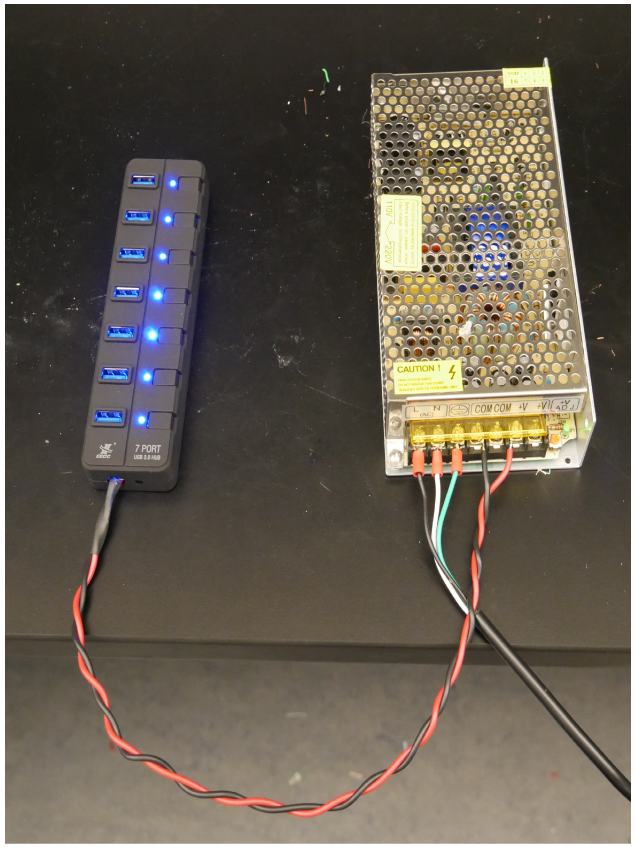


Figure 17: Power Supply

Software Overview

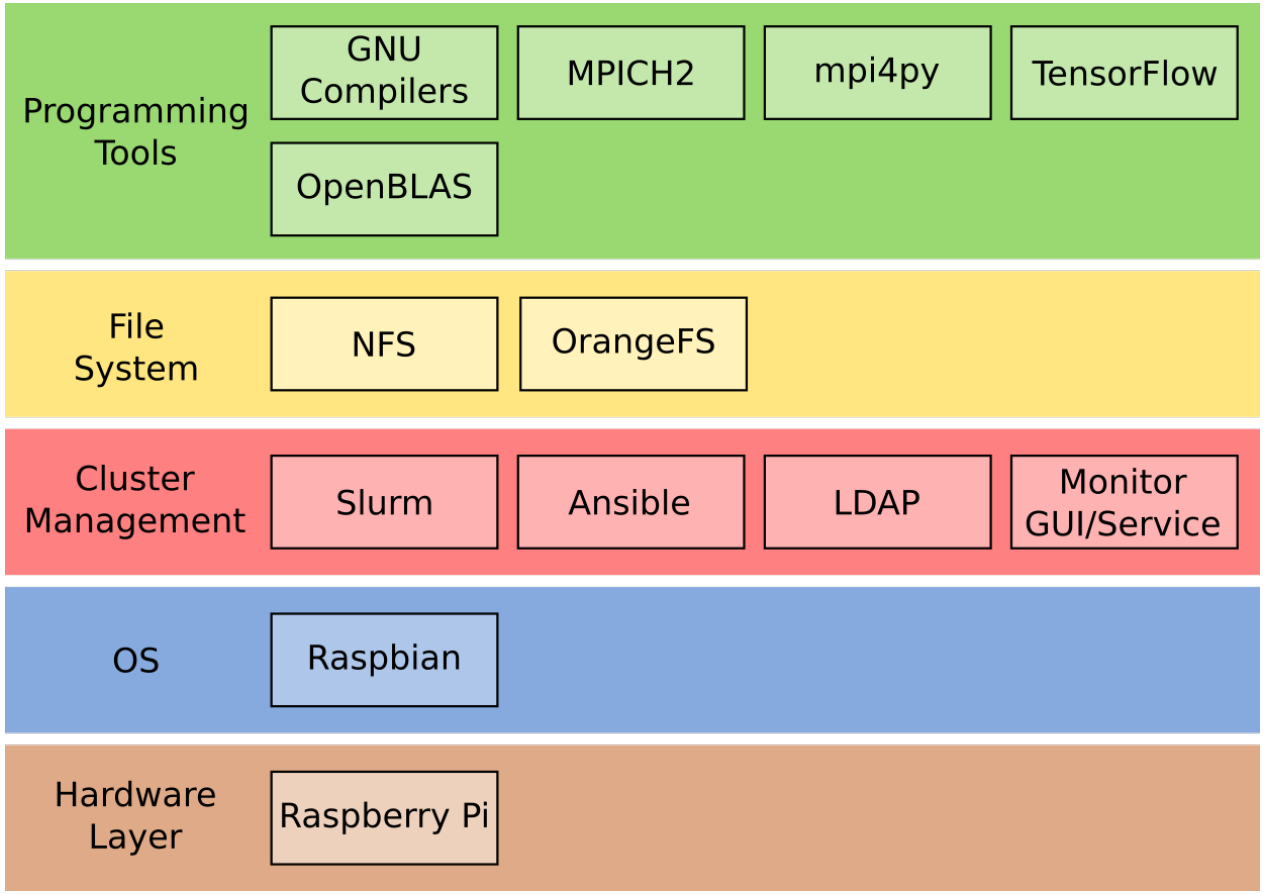


Figure 18: Software Stack

LDAP

- Used to store Users and Groups
- Made easier to use with LDAP Scripts

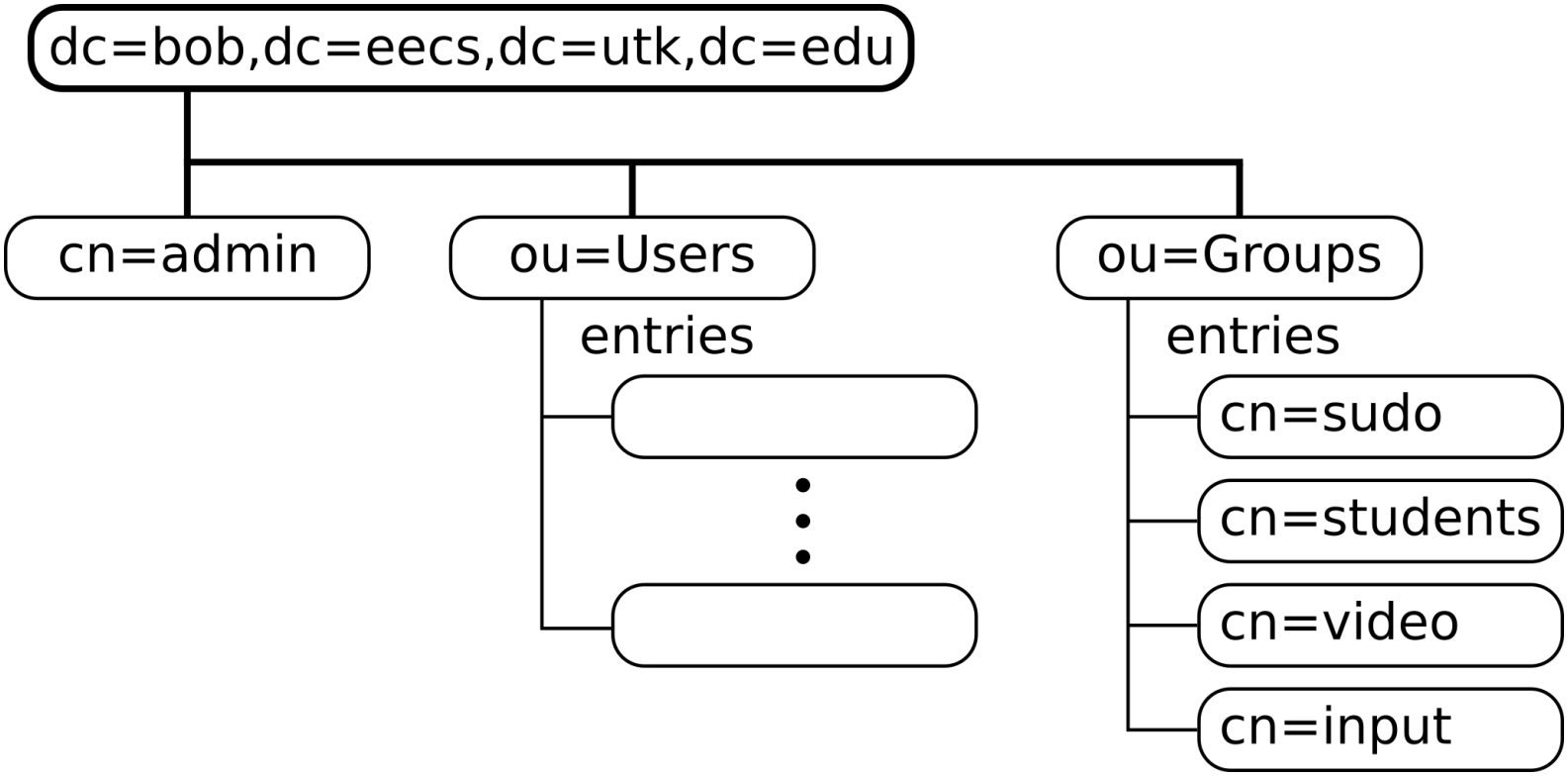


Figure 19: LDAP Structure

Slurm

- Used for resource management

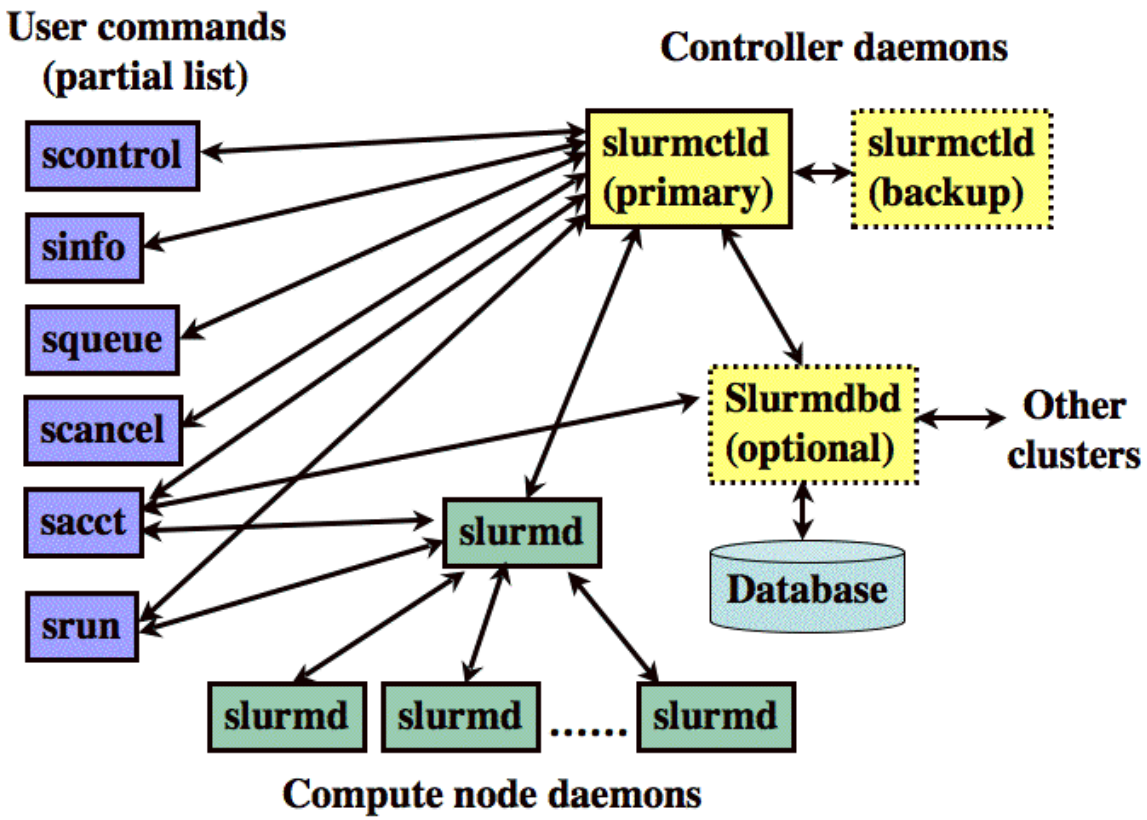


Figure 20: Slurm Architecture

NFS

- Network File System
  - Distributed file system Protocol
- Native component of the Linux Kernel
  - Current version NFSv4
- MPI and NFS
  - Message Passing Interface only supported under no attribute caching disabled
- NFS on BOB
  - Only used for storing users home directories
  - does not support MPI

What is OrangeFS?

- Parallel Virtual File System
- Object based design
- Client/Server Architecture
- Metadata and data services
- BMI - TCP/IP network communication

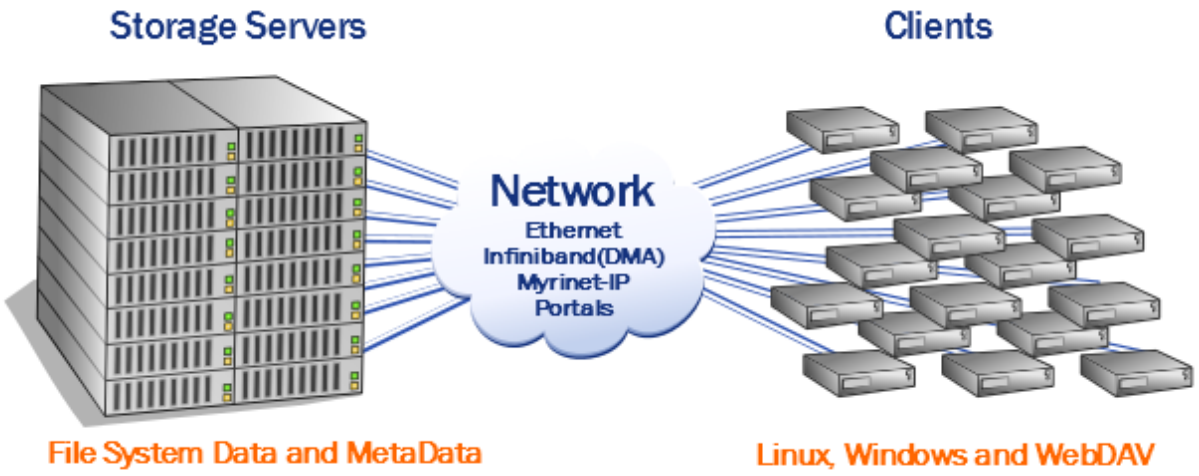


Figure 21: File Distribution

How OrangeFS Works

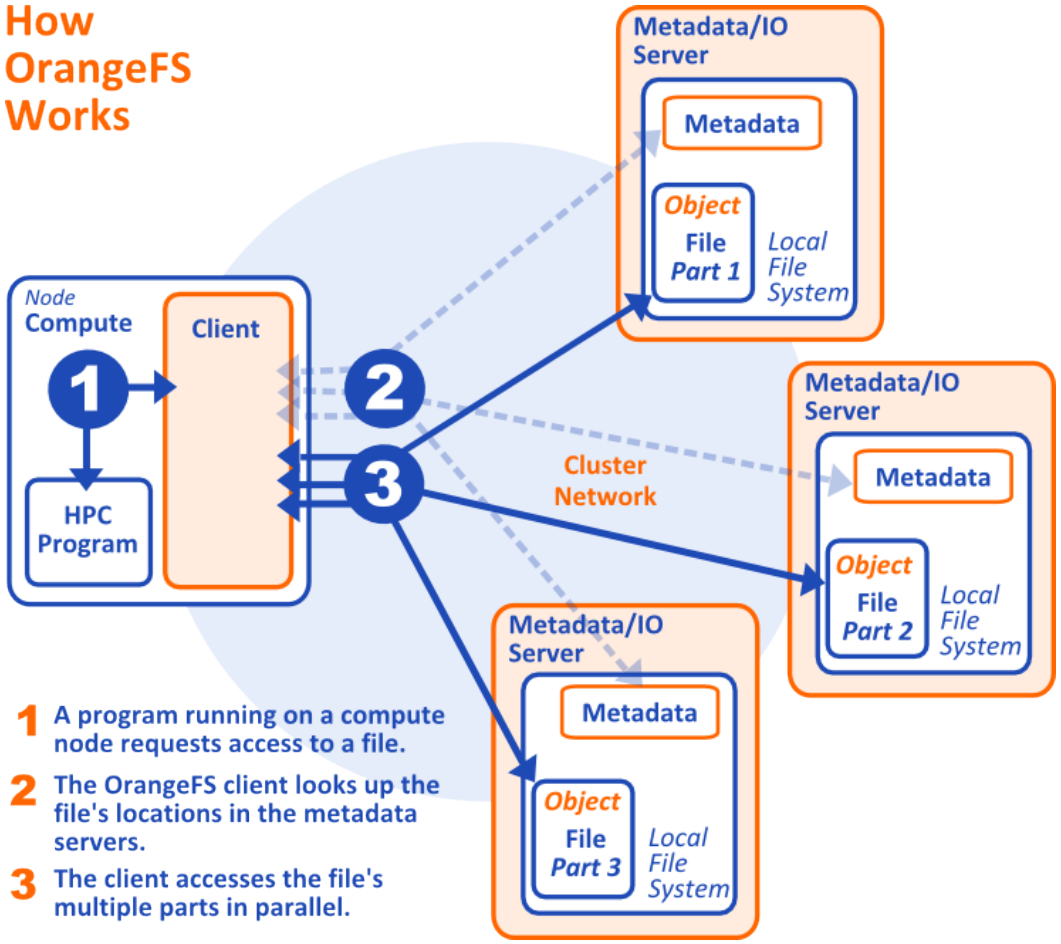


Figure 22: File Distribution

OrangeFS on B.O.B.

- 1 Server
  - Mounted to 4 TB external hard drive
  - Provides highest throughput given 100Mbit/s Ethernet
  - 3 more servers available to integrate
- 64 clients
  - FUSE
  - MPICH2
  - 262,144 Byte transfer buffers with 8 buffers per bulk transfer
  - Metadata and data files synchronized with every write operation
  - Uses a thread based implementation of Asynchronous IO
  - Additional 64 GB of unused storage space available on SD card of each client
- Provides no methods of security

OrangeFS vs NFS

5.6 GB file, 1 MB block, 8 Nodes/32 Tasks, POSIX API

Xfer Size	NFS	OFS
10 KB	10.41	10.78
100 KB	9.16	11.46
1 MB	9.65	11.12

Table 1: Read Rate (MB/s)

Xfer Size	NFS	OFS
10 KB	11.42	9.73
100 KB	11.25	11.31
1 MB	11.34	11.44

Table 2: Write Rate (MB/s)

5.6 GB file, 1 MB block, 64 nodes/256 tasks, POSIX API

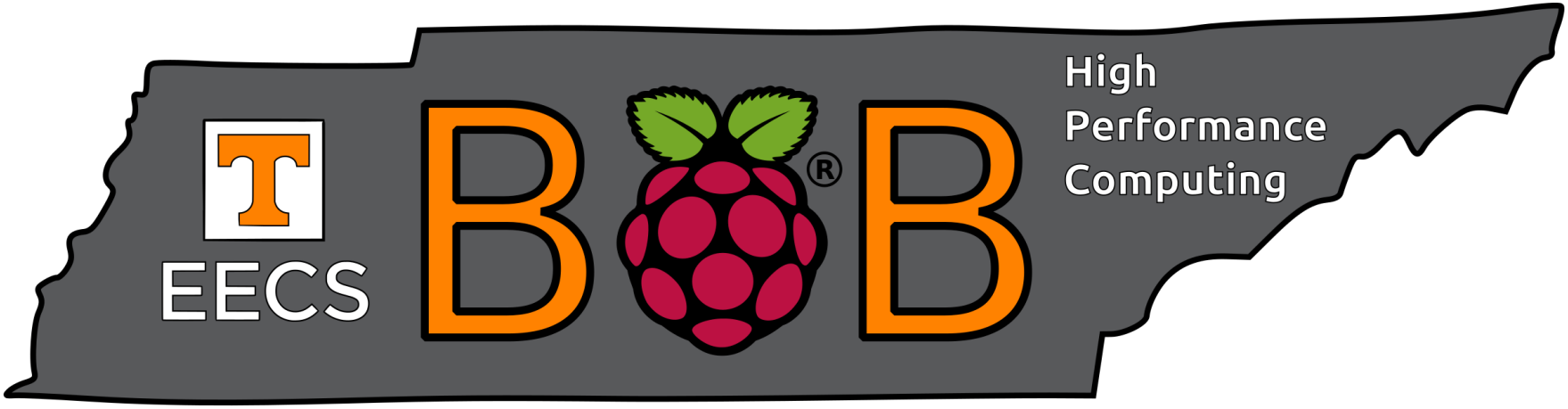
Xfer Size	NFS	OFS
10 KB	8.4	5.64
100 KB	8.7	6.96
1 MB	8.5	7.85

Table 3: Read Rate (MB/s)

Xfer Size	NFS	OFS
10 KB	11.59	10.05
100 KB	11.57	11.51
1 MB	11.64	11.54

Table 4: 6Write Rate (MB/s)

Big Orange Bramble



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