Disney World: The ARM Cluster

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Client

- Dr. Christer Karlsson

- Client Needs
  - Cluster of 6 – 12 single-board ARM computers
  - Benchmarked
  - Fastest and most efficient design

Project Overview

- Project
- Establish proof of concept
- Gather more LINPACK data
- Test new communication
  - GPIO
  - USB
- Test different topologies
  - Ring
  - Hypercube

Tools

- Linux
- Bash
- GitHub
- WiringPi
- C
- LINPACK
- OpenMPI, MPICH
- Python
- Pyplot
- Routing Tables
- USB to Ethernet

Deliverables

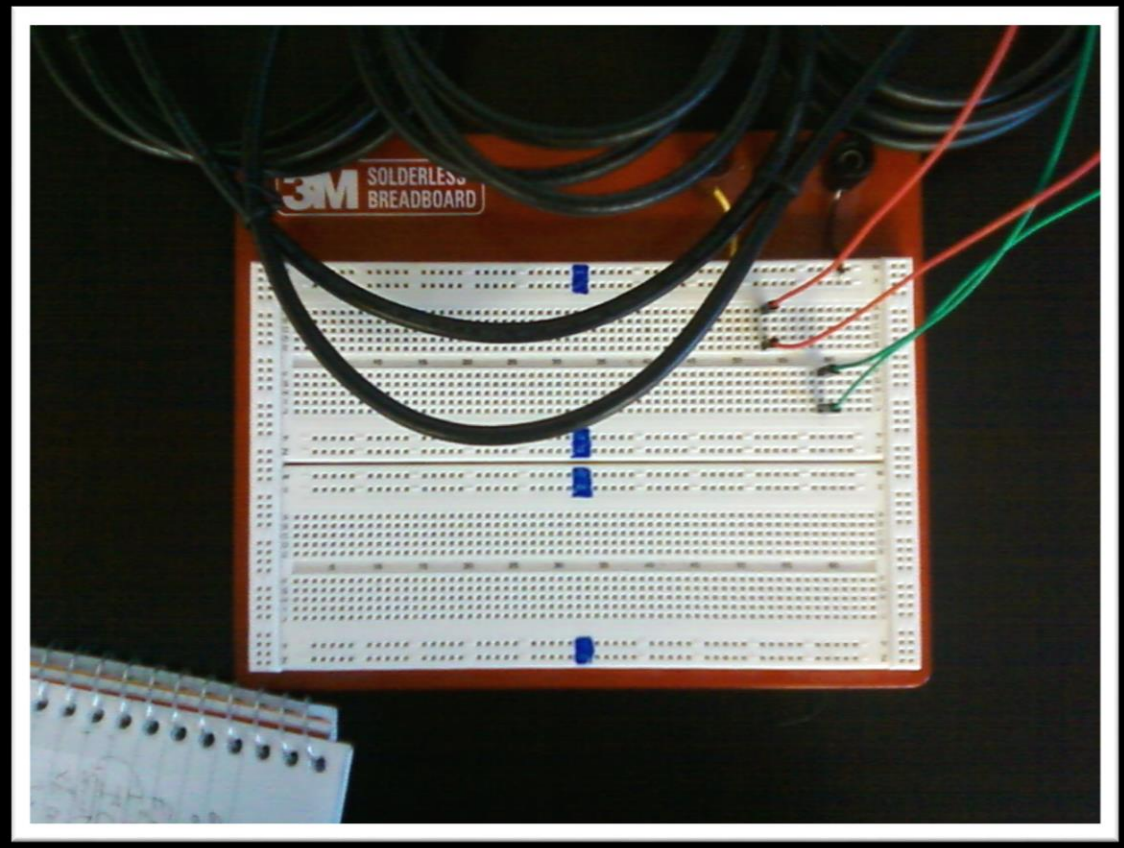
- Benchmark LINPACK on multiple number of devices
- Compared cluster to i7
- LINPACK Debian package
- USB and GPIO
  - Research on USB
  - Tests with GPIO
- Topology Design
  - Ring and hypercube
- Routing tables
- MICS Conference
  - Paper and abstract
- SDSMT Research Symposium
  - Abstract

ARM LINPACK

- Created Debian package of HPL
- Tuned to work on ARM
- Successfully installs on dwarfs with dpkg install command

GPIO

- WiringPi
- Pins connected
- Results



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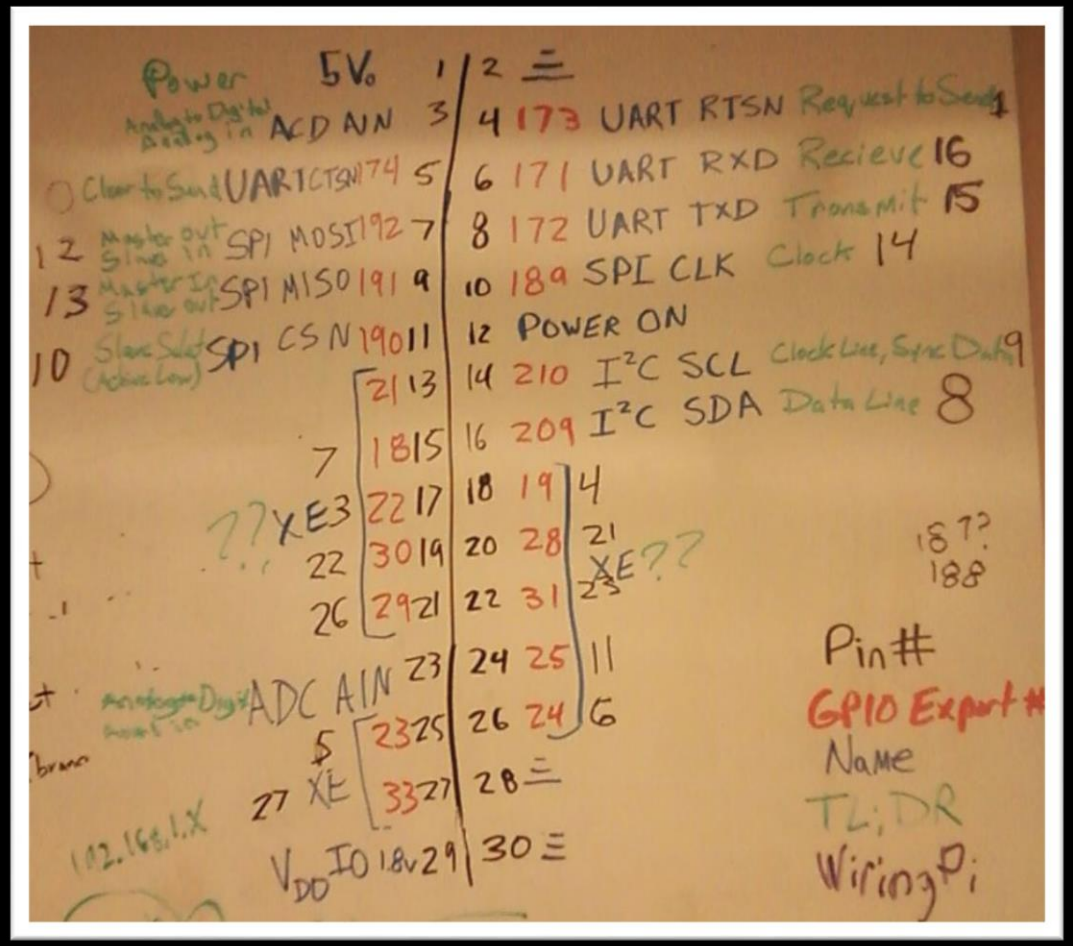
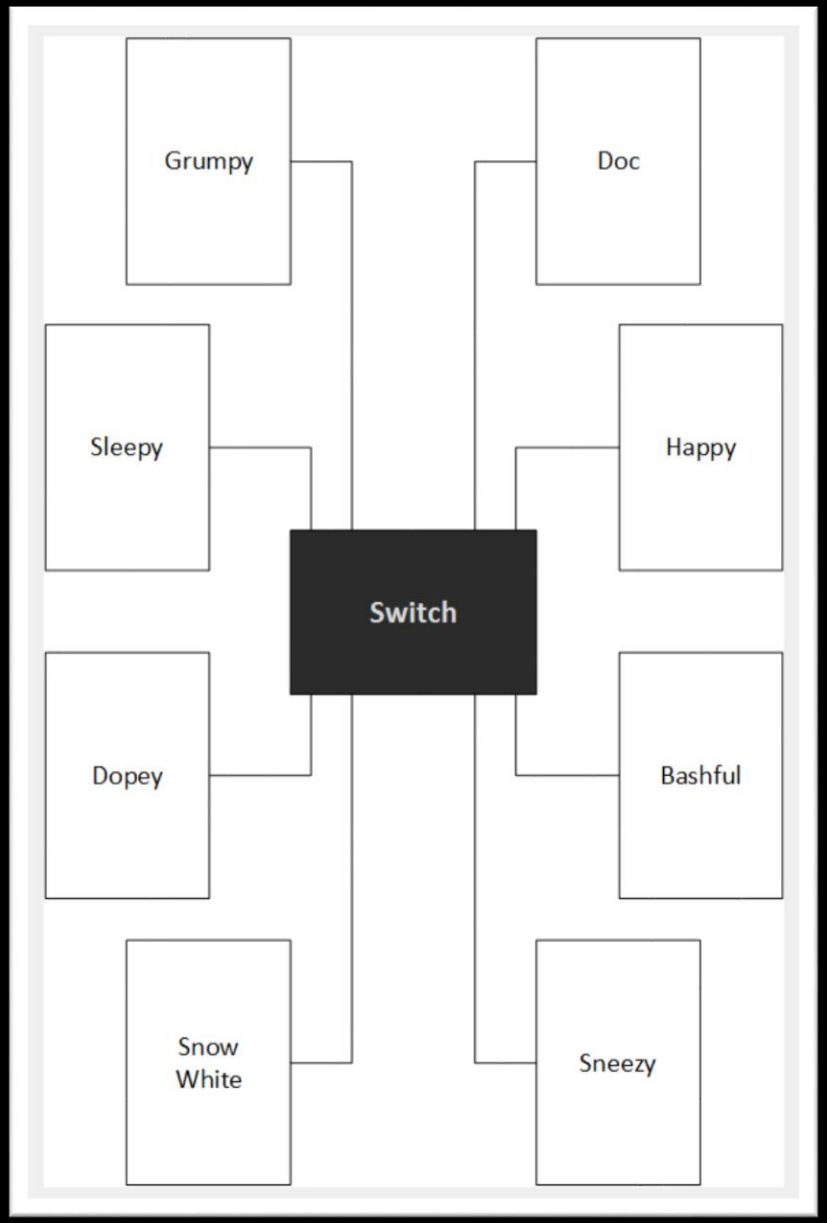


Star Topology

- Initial setup
- Each dwarf connected to an unmanaged switch

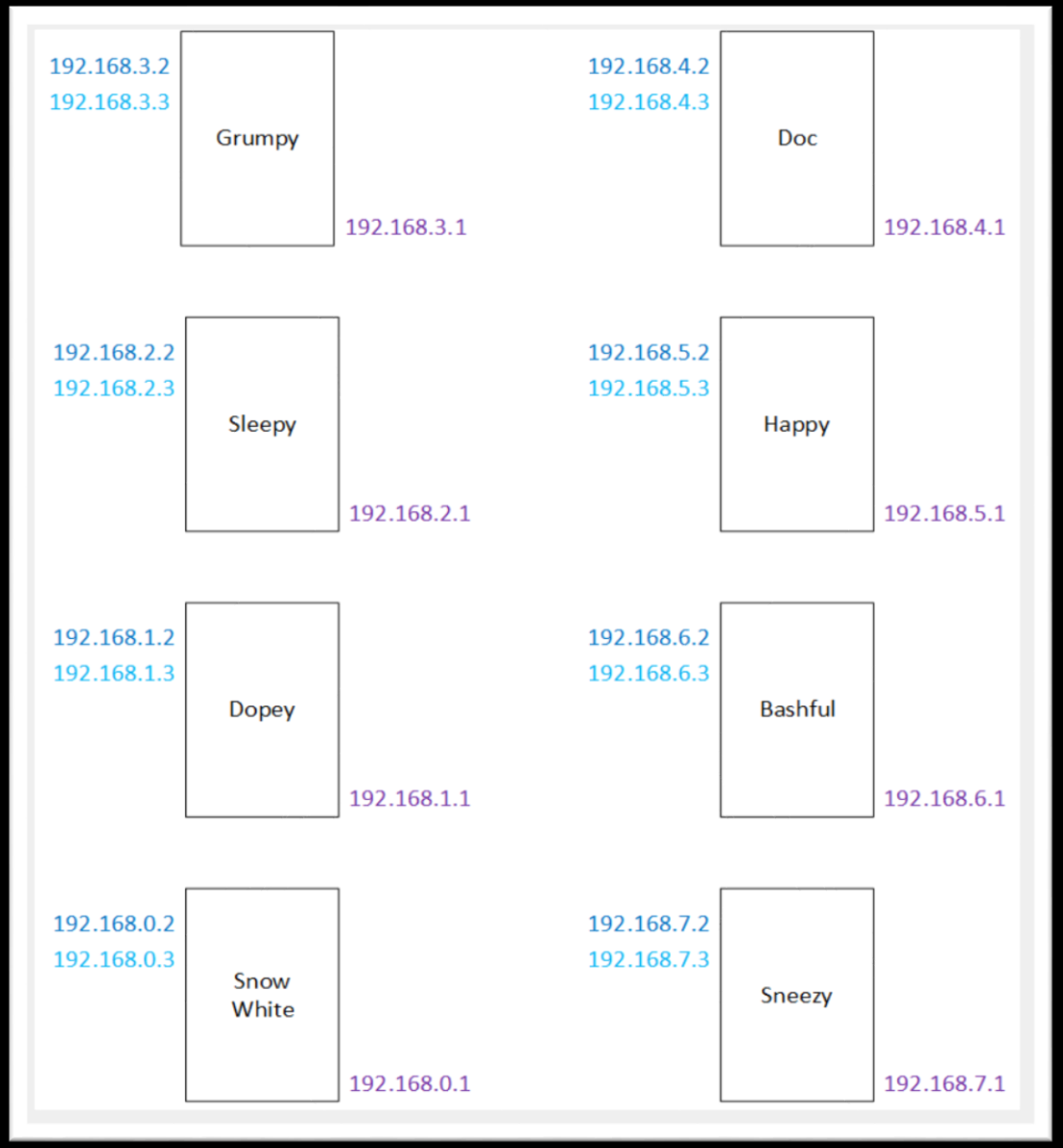


Routing Table

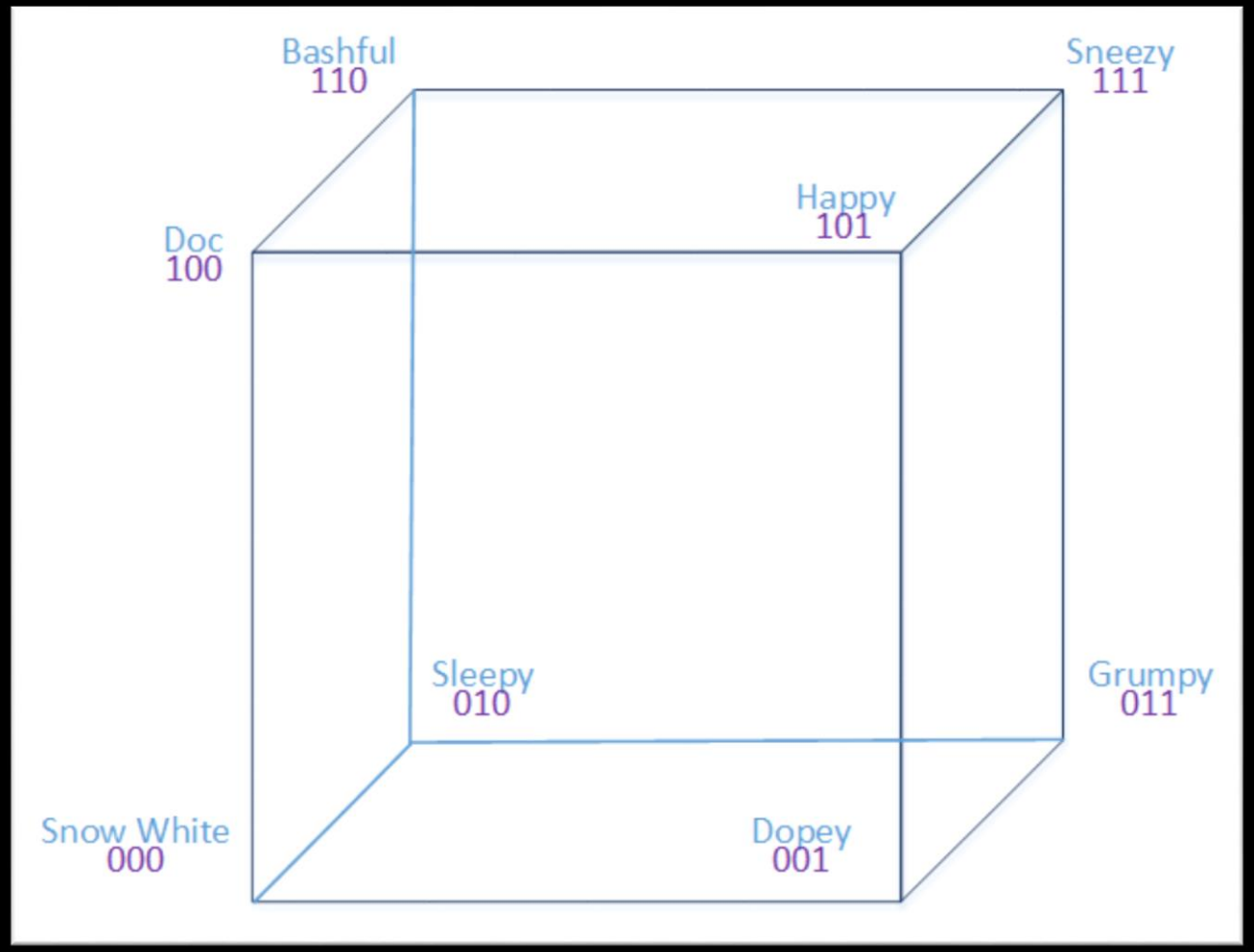
```
# interfaces(5) file used by ifup(8) and ifdown(8)
# Include files from /etc/network/interfaces.d:
source-directory /etc/network/interfaces.d

auto eth0
iface eth0 inet static
    address 192.168.0.11
    netmask 255.255.255.0
    up route add -net 192.168.0.10 netmask 255.255.255.255 gw 192.168.0.11
    up route add -net 192.168.0.9 netmask 255.255.255.255 gw 192.168.0.11
    up route add -net 192.168.0.8 netmask 255.255.255.255 gw 192.168.0.10
    up route add -net 192.168.0.7 netmask 255.255.255.255 gw 192.168.0.10

auto eth2
iface eth2 inet static
    address 192.168.0.12
    netmask 255.255.255.0
    up route add -net 192.168.0.13 netmask 255.255.255.255 gw 192.168.0.12
```

IP Addresses

192.168.Dwarf.Port



Hypercube

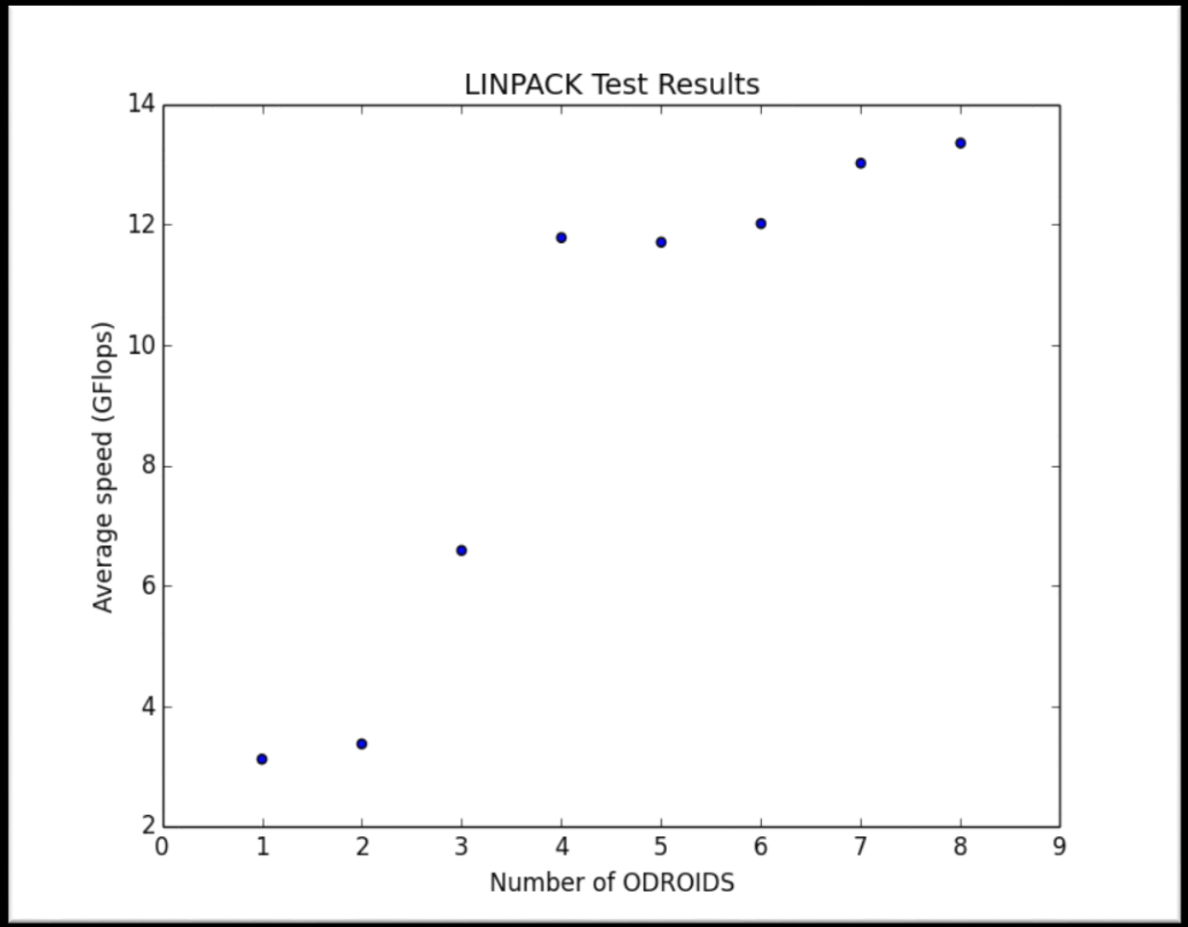

Bashful
110
Sneezy
111
Happy
101
Doc
100
Sleepy
010
Grumpy
011
Snow White
000
Dopey
001

Results

- Gigaflops per number of devices
- USB not practical
- GPIO with WiringPi slow
- Routing tables, ring topology functional

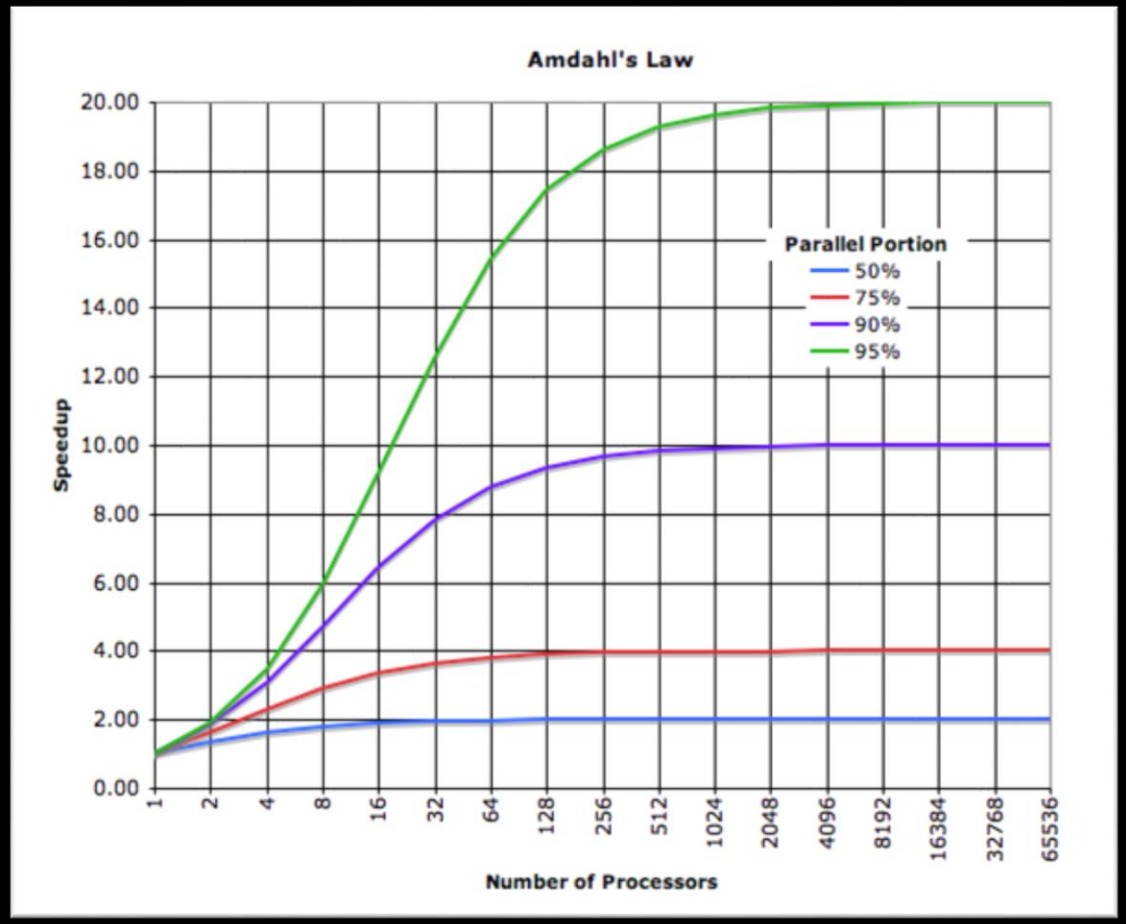
Speedup

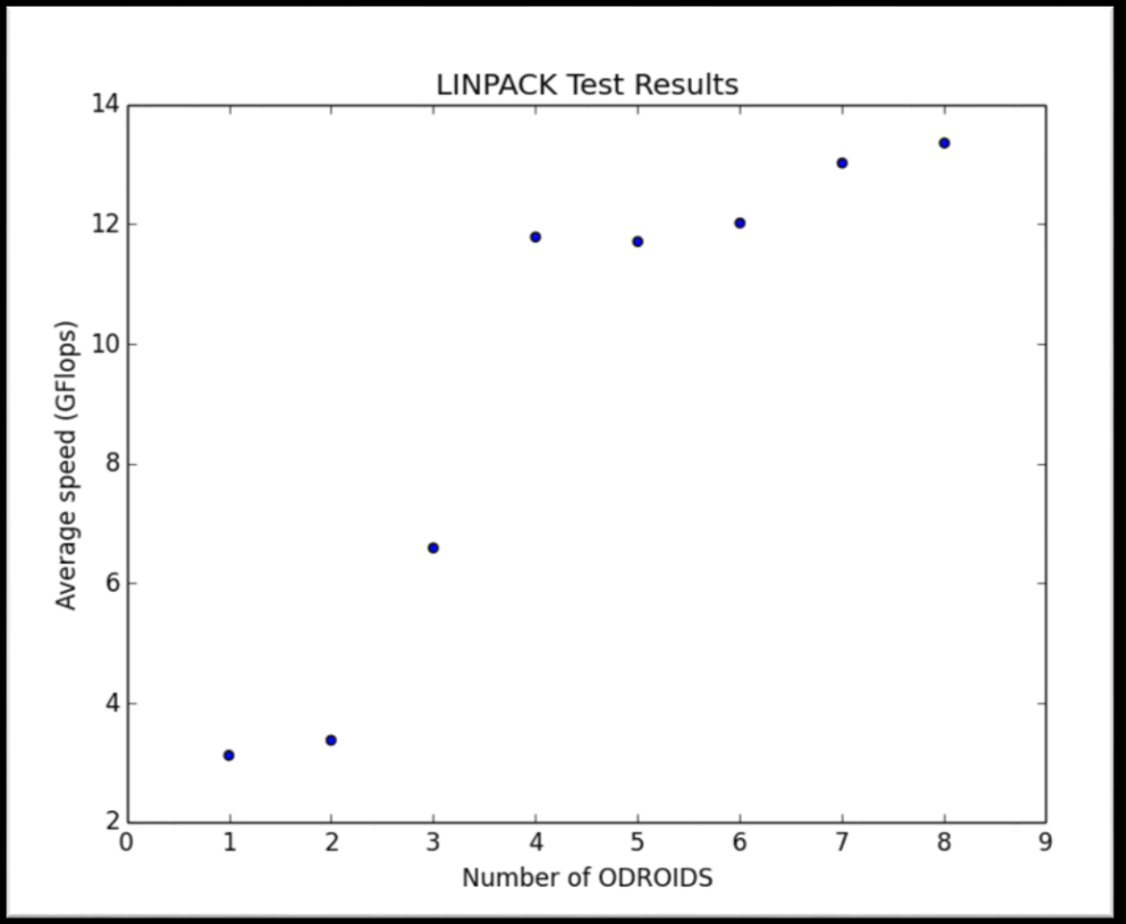
- 1 → 2 devices = 1 speedup
- 2 → 3 = 4
- 3 → 4 = 5
  - Max speedup
- 4 → 5 = 1
- 5 → 6 = -1
- 6 → 7 = 2
- 7 → 8 = 1



Amdahl's Law

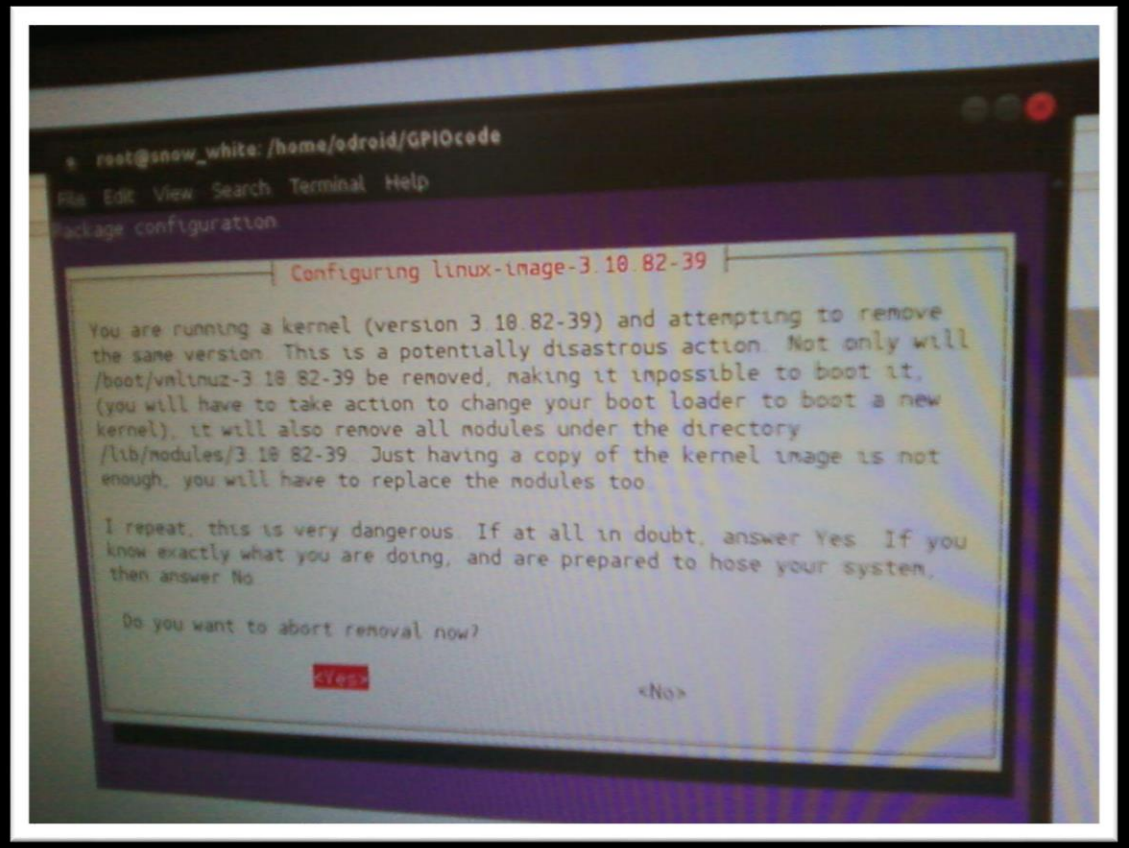
- $speedup \leq \frac{1}{S + \frac{(1-S)}{N}}$
  - S = portion serial
  - N = number of cores
- Unsure of portion sizes
- If all parallel
  - $speedup \leq N$
- All serial
  - $speedup \leq 1$
- Increasing the number of cores
  - $\lim_{N \to \infty} = \frac{1}{S}$
  - Speedup will not achieve more than $\frac{1}{S}$


Amdahl's Law
Speedup
Number of Processors
Parallel Portion
50%
75%
90%
95%
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
1
2
4
8
16
32
64
128
256
512
1024
2048
4096
8192
16384
32768
65536


LINPACK Test Results
Average speed (GFlops)
Number of ODROIDS
14
12
10
8
6
4
2
0
1
2
3
4
5
6
7
8
9

Issues

- WiringPi
  - Updating the kernel
  - GPIO pin numbers to physical numbers
- Topologies
  - Create appropriate network
  - Access devices through others
- LINPACK
  - Testing on ring topology



Education Tool

- Answering questions:
  - How computer work?
  - How do we build and setup networks?
  - How do we communicate between computers?
  - How do we benchmark it?

Budget

- MICS Registration
  - $35.00
- Miscellaneous
  - $25.00
- Acrylic board
  - $25.00
- Replacement ORDOID-XU4
  - 2 at $76.00 each
- ODROID-XU4
  - 8 at $76.00 each
- Memory
  - 8 at $38.00 each
- Power Unit
  - $49.99
- Ethernet cables
  - 8 at $2.99 each
- Switch
  - $39.99

Remaining Backlog

- LINPACK over ring and hypercube
- SDSMT Symposium
- MICS Symposium
- Design Fair
- Design Documentation

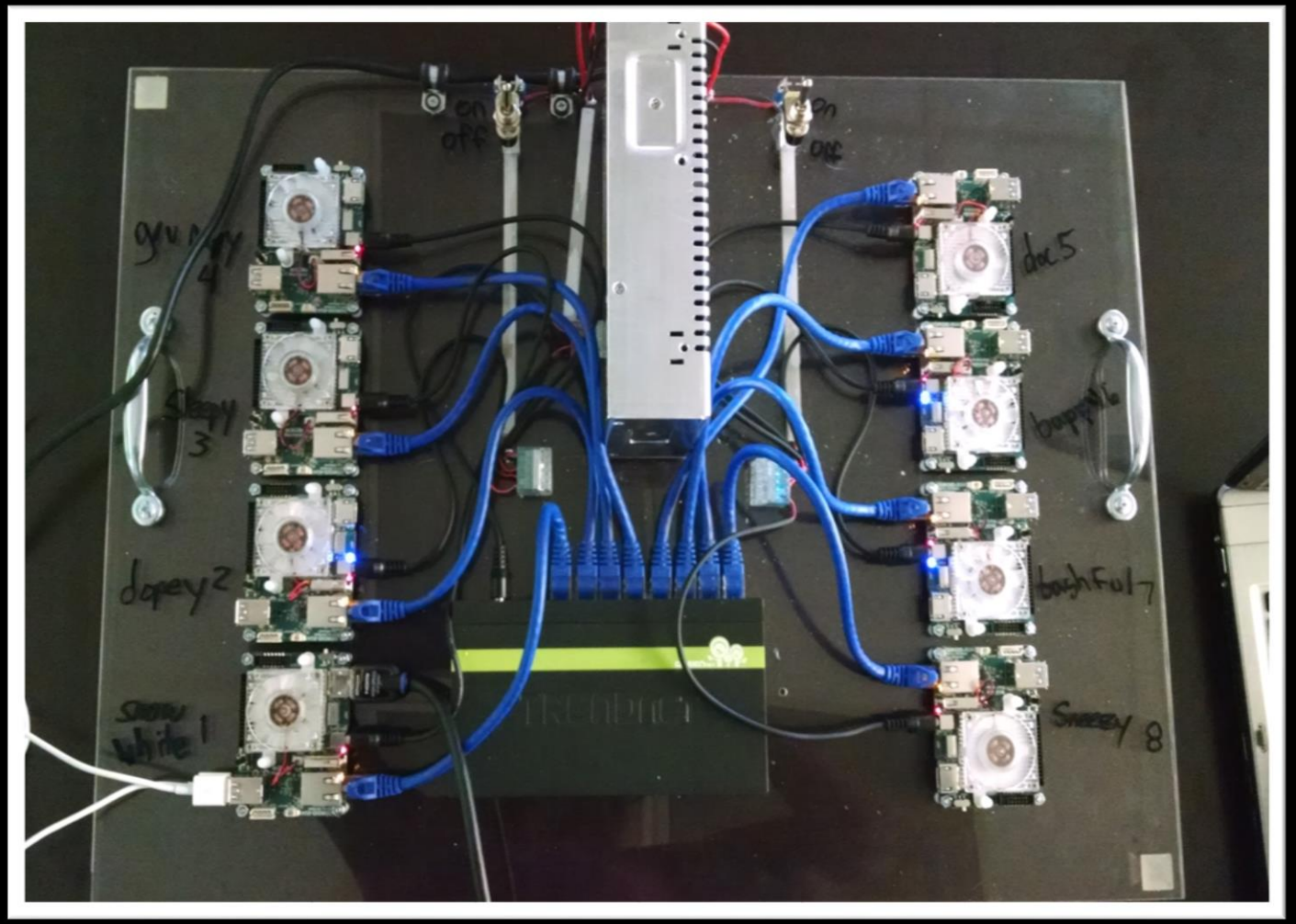
Revised Goals

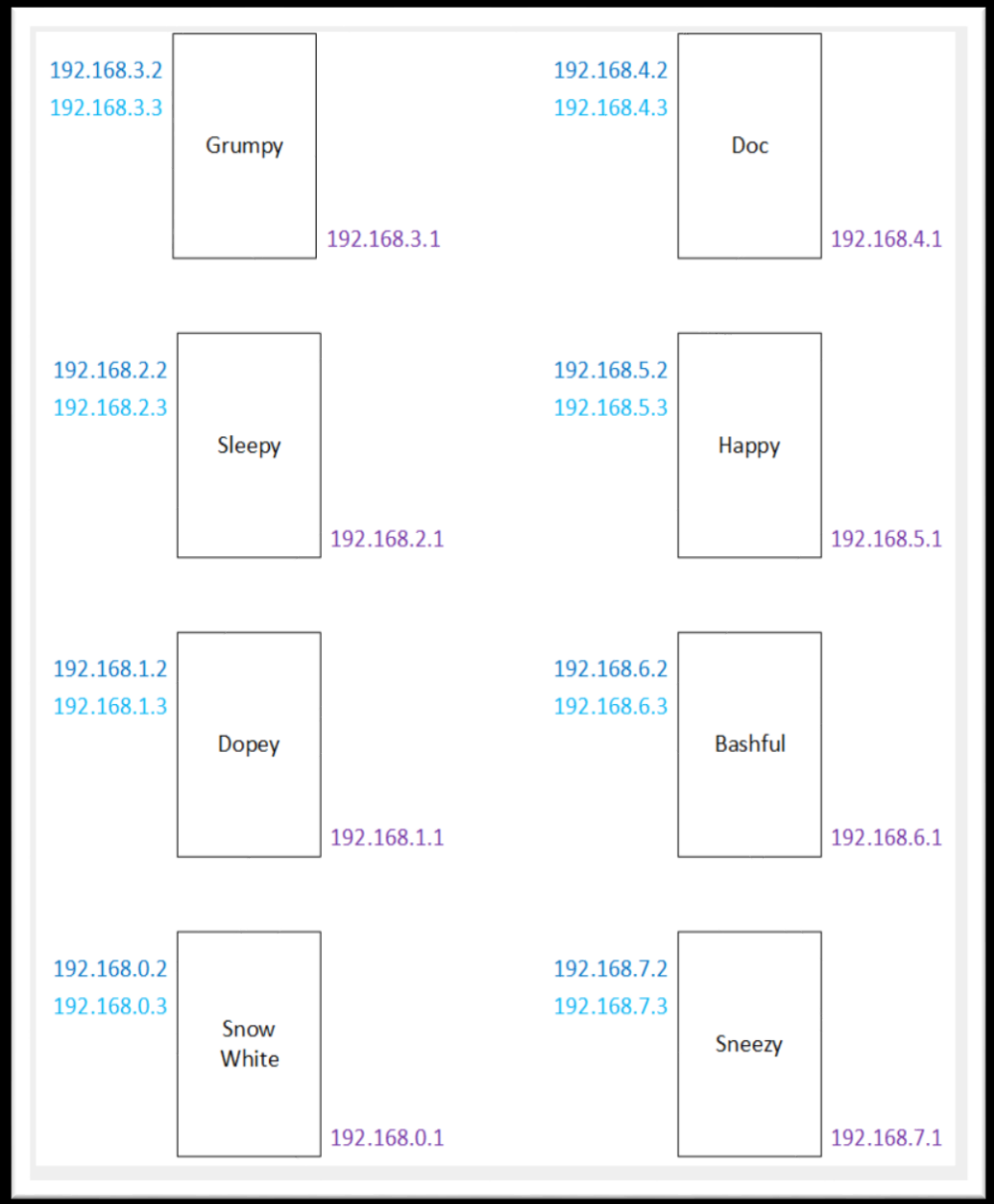
- Debug LINPACK
- SDSMT Symposium

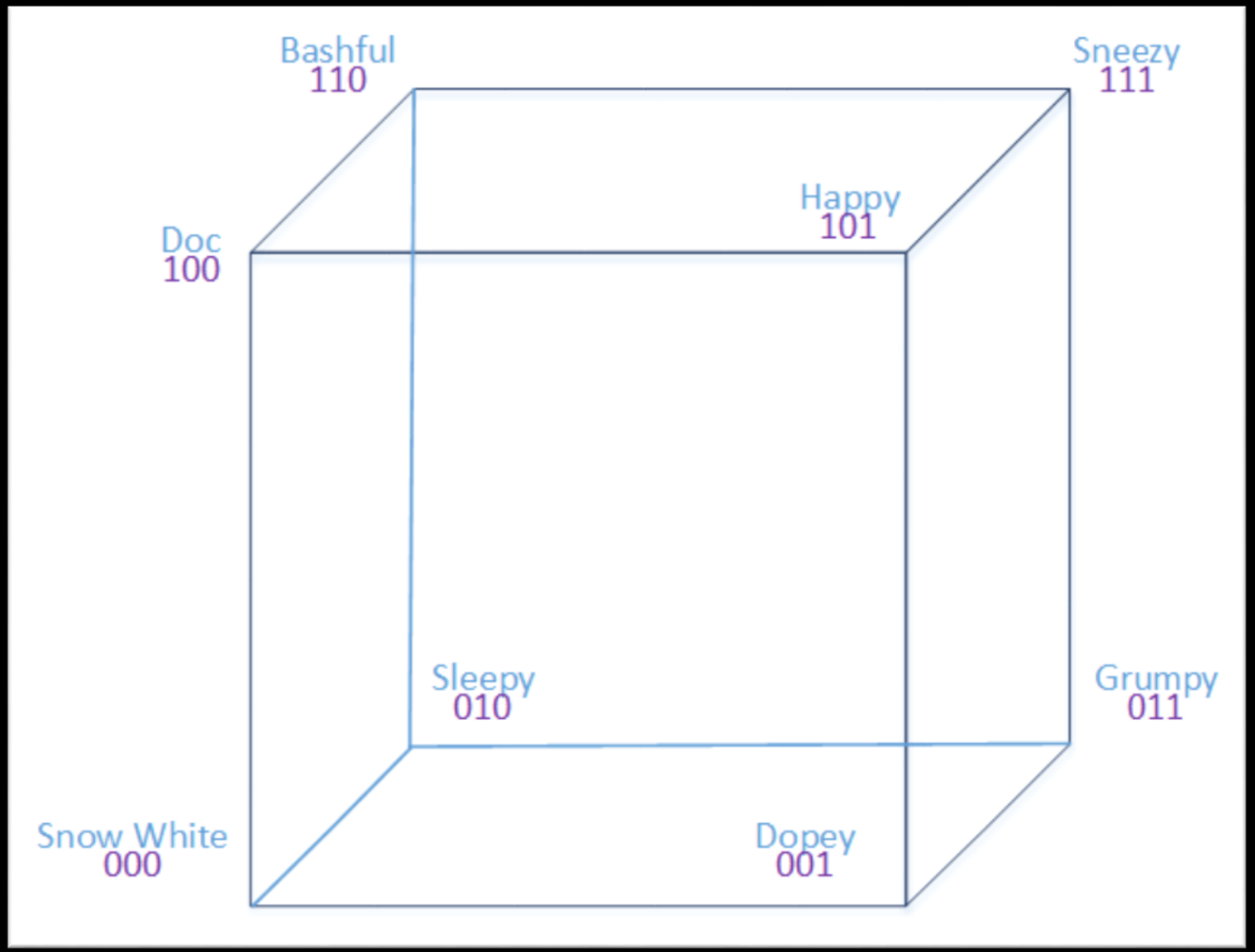
Schedule

- Sprint 6: 3/21/16
  - Documentation
  - Presentation preparations
- SDSMT Research Symposium: 4/7/16
- Design Fair: 4/19/16
- MICS: 4/23/16

Prototype




192.168.3.2
192.168.3.3
Grumpy
192.168.3.1
192.168.4.2
192.168.4.3
Doc
192.168.4.1
192.168.2.2
192.168.2.3
Sleepy
192.168.2.1
192.168.5.2
192.168.5.3
Happy
192.168.5.1
192.168.1.2
192.168.1.3
Dopey
192.168.1.1
192.168.6.2
192.168.6.3
Bashful
192.168.6.1
192.168.0.2
192.168.0.3
Snow White
192.168.0.1
192.168.7.2
192.168.7.3
Sneezy
192.168.7.1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Questions?