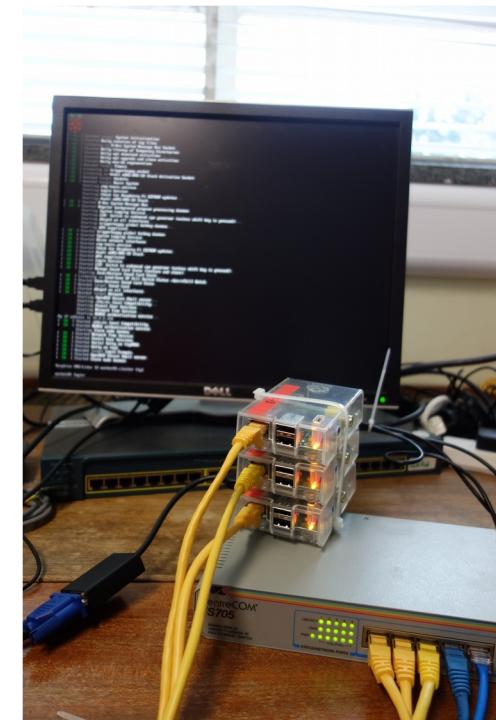


Introducing HPC with a Raspberry Pi Cluster

A practical use of and good excuse to build Raspberry Pi Clusters

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SUPERCOMPUTING WALES
UWCHGYFRIFIADURA CYMRU



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Overview

- About Me
- Inspirations
- Why teach HPC with Raspberry Pi?
- My Raspberry Pi cluster
- Experiences from teaching
- Future Work

About Me

- Research Software Engineer with Supercomputing Wales project
 - 4 university partnership to supply HPC systems
 - Two physical HPCs
- PhD in Robotics
 - Experience with Linux on single board computers
 - Lots of Raspberry Pi projects



Inspiration #1: Los Alamos National Laboratory

Los Alamos National Laboratory
Delivering science and technology to protect our nation and promote world stability

About Mission Business
search site

SCIENCE & INNOVATION COLLABORATION CAREERS COMMUNITY

Scalable clusters make HPC R&D easy as Raspberry Pi

It brings a powerful high-performance-computing testbed to system-software developers, researchers and others who lack machine time on the world's fastest supercomputers.



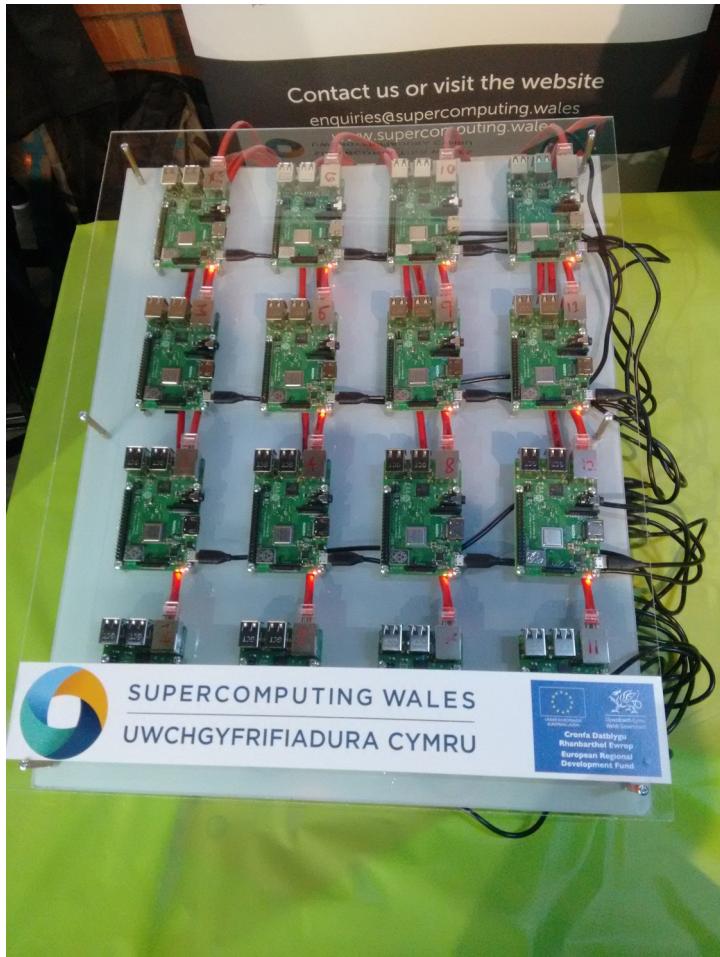
- 750 node cluster
- Test system for software development
- Avoid tying up the real cluster

Inspiration #2: Wee Archie/Archlet



- EPCC's Raspberry Pi Cluster
- Archie: 18x Raspberry Pi 2's (4 cores each)
- Archlet: smaller 4 or 5 node clusters.
- Used for outreach demos.
- Setup instructions:
https://github.com/EPCCed/wee_archlet

Inspiration #3: Swansea's Raspberry Pi Cluster



- 16x Raspberry Pi 3s
- CFD demo using a Kinect sensor
- Demoed at the Swansea Festival of Science 2018

Why Teach with a Raspberry Pi cluster?

- Avoid loading real clusters doing actual research
 - Less fear from learners that they might break something
- Resource limits more apparent
- More control over the environment
- Hardware less abstract
- No need to have accounts on a real HPC

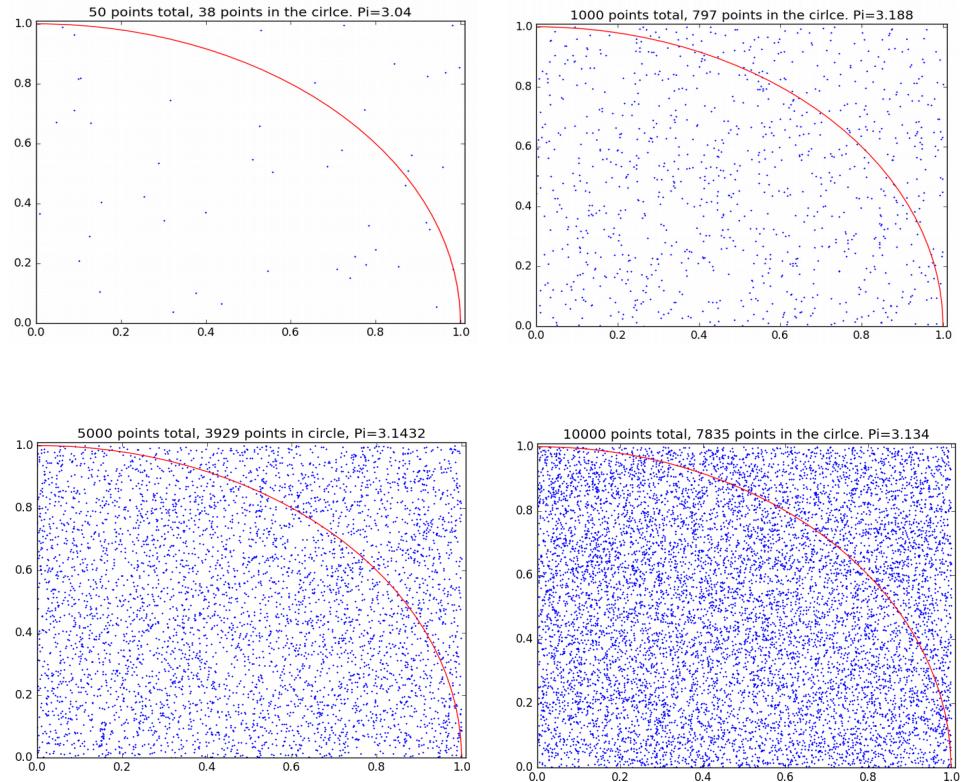
My Cluster



- “Tweety Pi”
 - 10x Raspberry Pi model B version 1s
 - 1x Raspberry Pi 3 as head/login node
 - Raspbian Stretch
- Head node acts as WiFi access point
 - Internet via phone or laptop

Demo Software

- British Science Week 2019
 - Simple Pi with Monte Carlo methods demo
 - MPI based
 - GUI to control how many jobs launch and show queuing
- Swansea CFD demo
 - Needs more compute power
 - 16x Raspberry Pi 3 vs 10x Raspberry Pi 1
- Wee Archie/Archlet Demos
 - Many demos available
 - I only found this recently
 - https://github.com/EPCCed/wee_archie



Making a realistic HPC environment

- MPICH
- Slurm
- Quotas on home directories
- NFS mounted home directories
- Software modules
- Network booting compute nodes

Network booting hack

- No PXE boot support on original Raspberry Pi (or Raspberry Pi B+ and 2)
- Kernel + bootloader on SD card
- Root filesystem on NFS
 - Cmdline.txt contains:
 - console=tty1 root=/dev/nfs
nfsroot=10.0.0.10:/nfs/node_rootfs,vers=3 ro ip=dhcp
elevator=deadline rootwait
- SD cards can be identical, small 50mb image, easy to replace

Teaching Materials

- Based on Introduction to HPC with Super Computing Wales carpentry style lesson:
 - What is an HPC?
 - Logging in
 - Filesystems and transferring data
 - Submitting/monitoring jobs with Slurm
 - Profiling
 - Parallelising code, Amdahl's law
 - MPI
 - HPC Best Practice



Experiences from Teaching – STFC Summer School

- New PhD students in solar physics
 - Not registered at universities yet, no academic accounts
- 15 people each time
 - 1st time using HPC for many
 - Most had some Unix experience
- Subset of Super Computing Wales introduction to HPC carpentry lesson



Feedback

- Very Positive
- A lot seemed to enjoy playing around with SSH/SCP
 - First time using a remote shell for some
 - Others more adventurous than they might have been on a real HPC
- Main complaint was lack of time (only 1.5 hours)
 - Only got as far as covering basic job submission
 - Quick theoretical run through of MPI and Amdahl's law
 - Probably have 3-4 hours of material
- Queuing became very apparent
 - 10 nodes, 15 users
 - “watch squeue” running on screen during practical parts

Problems

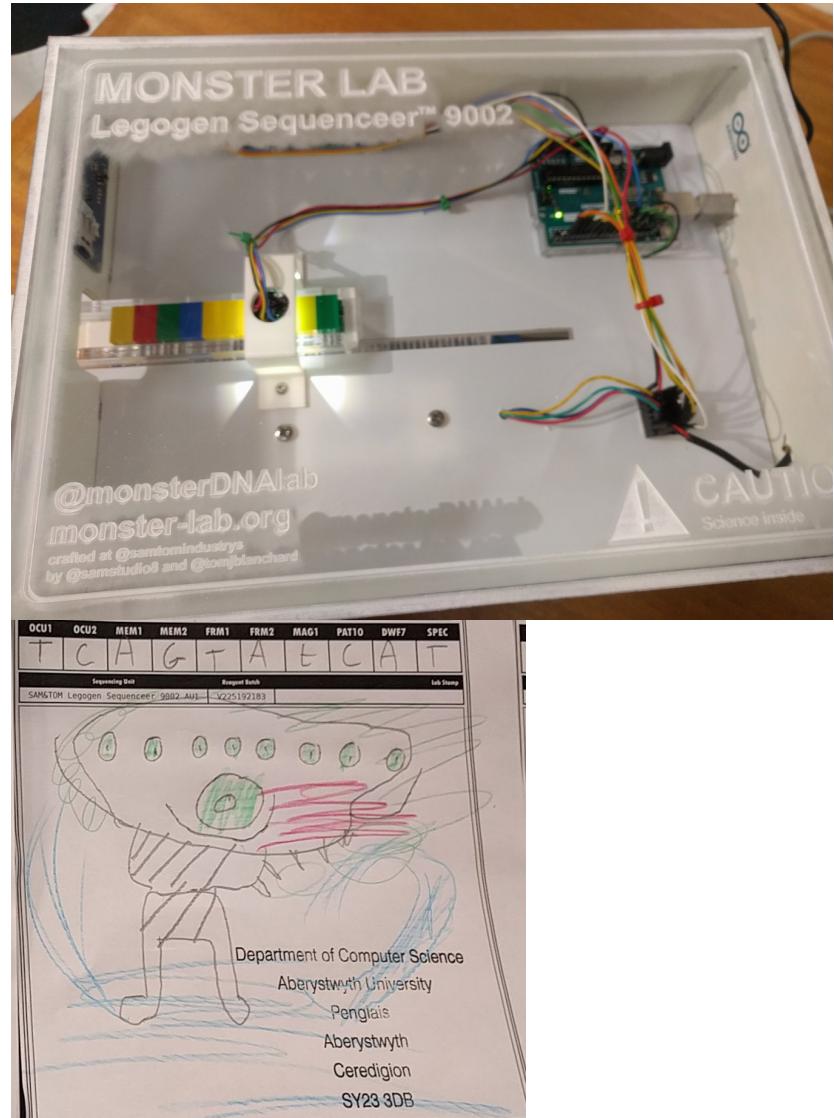
- Slurm issues on day 1
 - Accidentally overwrote a system user when creating accounts
- WiFi via Laptop/phone slow
 - When users connect to the cluster its their internet connection too
 - Relied on this for access to course notes

Experiences from teaching – Supercomputing Wales Training

- Approximately 10 people
 - Mix of staff and research students
 - Mixed experience levels
 - All intending to use a real HPC
- Simultaneously used Raspberry Pi and real HPC
 - Same commands run on both
- Useful backup system for those with locked accounts
- Feedback good
 - Helped make HPC more tangible

Future Work

- Configuration management tool (Ansible/Chef/Puppet/Salt etc) instead of script for configuration
- CentOS/Open HPC stack instead of Raspbian
- Public engagement demo which focuses on our research
 - Analysing satellite imagery
 - Simulate the monsters from MonsterLab (<https://monster-lab.org/>)



More Information

- Setup instructions and scripts -
https://github.com/colinsauze/pi_cluster
- Teaching material -
<https://github.com/SCW-Aberystwyth/Introduction-to-HPC-with-RaspberryPi>
- Email me: cos@aber.ac.uk