The HPC Hardware Lab @Durham

Durham University

Alastair Basden, Peter Draper, Mark Lovell, Fawada Qaisir, Richard Regan, Paul Walker

COSMA

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DiRAC / Durham University

Durham
University
Institute for Computational
Cosmology

DiRAC
High Performance
Computing Facility

ExCALI8UR
10

- HPC Hardware Lab hosted by:
  - the COSmology MAchine
    - Est. 2001
    - The DiRAC Memory Intensive service
      - primarily covering STFC science
    - Alongside the 3 other DiRAC systems
  - 3 generations currently in operation
  - Newest being COSMA8
    - ~70k cores, 0.5PB RAM, 20PB storage, 26PB tape
    - Bespoke design appropriate for main workloads

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DiRAC

- Established 2009

- Provides HPC to the STFC theory community
  - Particle Physics, Astrophysics, Cosmology, Solar System and Planetary Science and Nuclear Physics

- Three services:
  - Extreme Scaling: Edinburgh (TURSA)
  - Data Intensive: Cambridge and Leicester (CSD3 and DiaL)
  - Memory Intensive: Durham (COSMA)

- Co-designed and tailored for specific workloads
  - Bespoke systems for the science being carried out

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HPC Hardware Lab @Durham

- Mission: Provide access to the latest HPC hardware to users and DRI/RTP professionals from across the UK

  - For code testing, performance tuning and debugging

  - To advise on purchase of future technologies

  - To allow informed decisions to be made whenever funding appears

- Accessible to all

  - Single authentication system to lots of novel hardware

- An emphasis on production/going live

  - No shelf-ware!

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Hardware Lab Components

- Two test clusters:
  - DINE: Durham Intelligent Networking Environment
  - DINE2: Durham Integrated Next-gen Environment
- CPU compute
  - X86, ARM
- GPU compute
  - NVIDIA, AMD, Intel
- Composability
- Networking
- Storage laboratory
- Environmental
  - Solar panel installation
  - Immersion cooling
  - Heat storage
 - Logging and awareness
- Quantum

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Accessing the hardware lab

- Sign up on SAFE:
  - safe.epcc.ed.ac.uk/dirac
- Apply to join an appropriate project code: (durham.readthedocs.io)
  - do009: General purpose
  - do015: Cerio compsable system
  - do016: NVIDIA GPUs
  - do017: Intel GPUs
  - do018: AMD GPUs
- And sign up for a lunch time tour!

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DINE

- Durham Intelligent Network Environment
  - A 24 node (initially 16) system for investigation of networking technologies
    - And other things
  - 32 cores and 512GB RAM per node, AMD ROME
- Has hosted (since 2019):
  - BlueField-1
  - BlueField-2 (host-separated and embedded modes)
  - Rockport 100G 6D Torus Ethernet network
- Investigating feasibility of charging by kWhr from April
- Funded by Durham, DiRAC, ExCALIBUR

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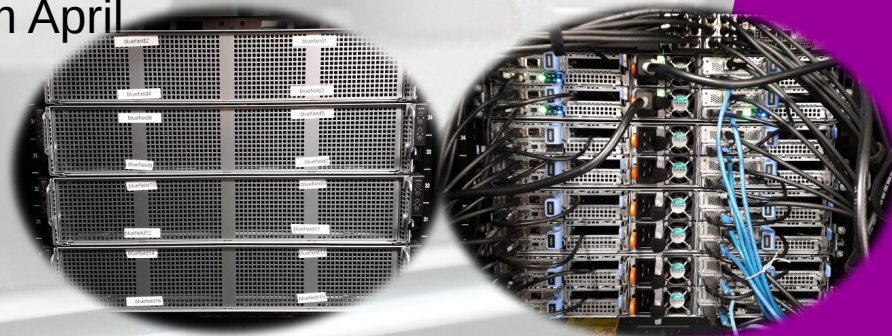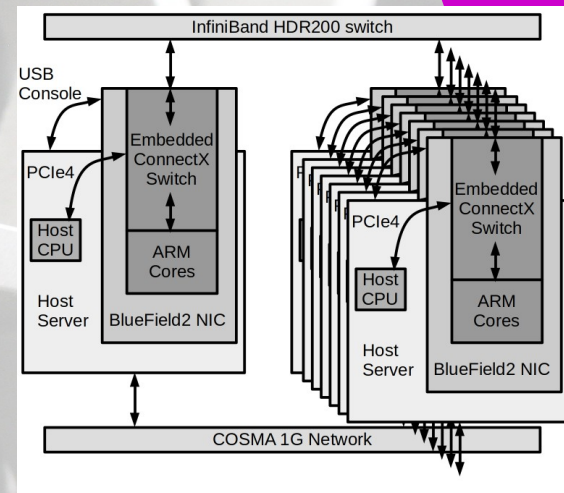
DINE-2

- Durham Integrated Next-gen Environment
  - 8 node Intel Sapphire Rapids system
    - 64 cores, 2TB RAM per node
  - Currently hosts a CerIO composable PCIe-5 fabric
    - 8x NVIDIA GPUs, assignable in any number to any host
  - 400G Ethernet fabric (800G switch)
- Also part of the kWhr charging/allocation study
- Funded by DiRAC, IRIS and SKA

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CPU compute

- Providing users with access to cutting edge CPU technologies:

- Coming soon: AMD Turin

- AMD Genoa and Bergamo

- NVIDIA Grace

- Intel Emerald Rapids, Sapphire Rapids, Ice Lake

- AMD Milan-X (extreme cache version: 768MB L3 cache)

- AMD Milan, Rome

- Intel Cascade Lake (with Apache Pass RAM, 6TB)

- Funded by OEMs, Intel, AMD, Dell, DiRAC, ExCALIBUR

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GPU Compute

- Access to small numbers of latest (and not-so latest) GPUs
- AMD MI300X
    - 8x MI300X, cache coherent global address space
- AMD MI300A
    - 4x MI300A, APU, global RAM
- AMD MI210, MI100, MI50
- NVIDIA H100 (Grace-hopper system)
    - PCIe version also coming soon, X86
- NVIDIA A100, A30, V100
- Intel Ponte Vecchio
- Direct ssh (including Jupyter) and queue-based access
- Funded by Dell, AMD, Intel, DiRAC, ExCALIBUR, IRIS

Credit: AMD

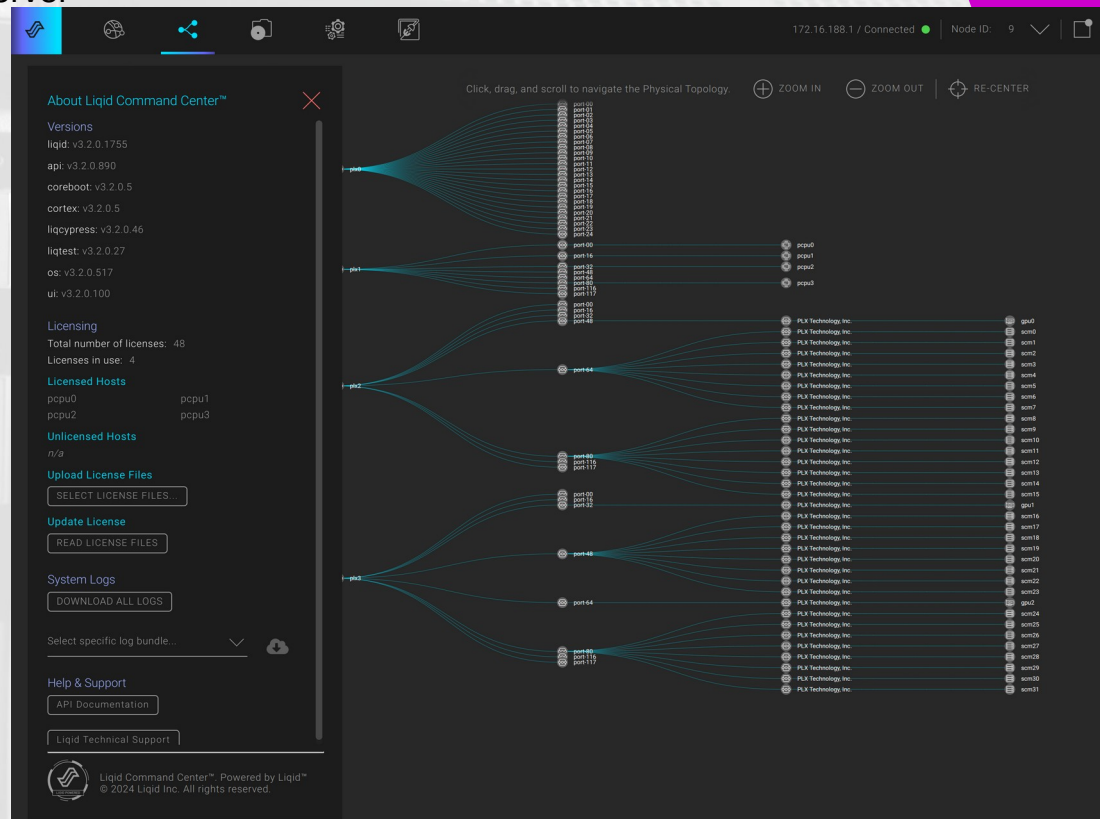Alastair Basden
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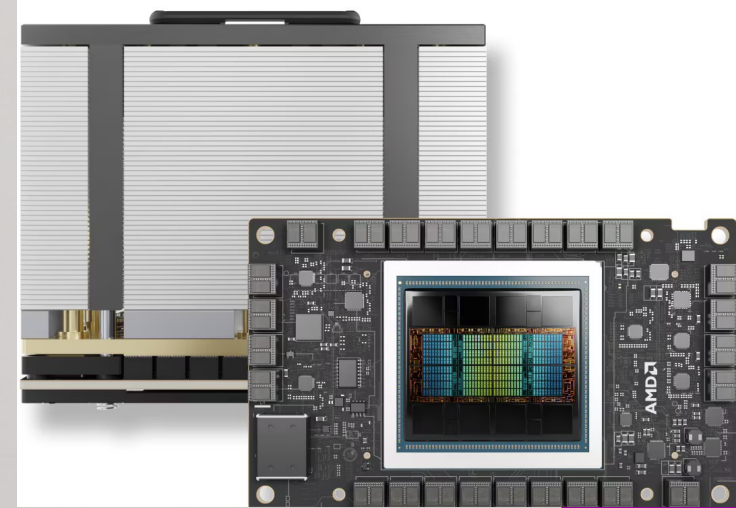
Composability

- Infrastructure-as-a-service
  - The ultimate goal for commercial cloud-type systems
  - Is it relevant for HPC?
    - How does performance suffer?
    - Is it stable?
    - What are the use cases?
- 2 composable systems
  - And a Gen-Z test system
    - Defunct: technology transferred to CXL

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Liqid composable system
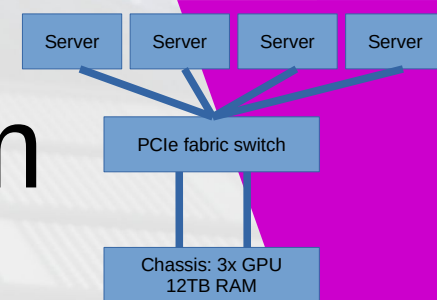
- Installed 2021

- A PCIe4-based composable fabric: 4 lanes to each server

- 3 A100 GPUs shared between 4 servers
  - Including a login node
  - GPUs per node can be changed in a few clicks

- 12TB RAM shared between these servers
  - Can be changed and reconfigured

- Positives: It works, can allow high RAM/GPU configs

- Negatives:
  - Bandwidth is shared
  - GPUs sometimes fail requiring a full stack reboot
  - RAM/kernel issues (and no Rocky9 support yet)
  - Rack-scale limitations
  - Bottlenecks

- ExCALIBUR funded

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Server   Server   Server   Server

PCIe fabric switch

Chassis: 3x GPU
12TB RAM

172.16.188.1 / Connected ●   Node ID: 9

Click, drag, and scroll to navigate the Physical Topology.   ⊕ ZOOM IN   ⊖ ZOOM OUT   RE-CENTER

About Liqid Command Center™

Versions
liqid: v3.2.0.1755
api: v3.2.0.890
coreboot: v3.2.0.5
cortex: v3.2.0.5
liqcypress: v3.2.0.46
liqtest: v3.2.0.27
os: v3.2.0.517
ui: v3.2.0.100

Licensing
Total number of licenses: 48
Licenses in use: 4

Licensed Hosts
pcpu0   pcpu1
pcpu2   pcpu3

Unlicensed Hosts
n/a

Upload License Files
SELECT LICENSE FILES...

Update License
READ LICENSE FILES

System Logs
DOWNLOAD ALL LOGS

Select specific log bundle...

Help & Support
API Documentation

Liqid Technical Support

Liqid Command Center™. Powered by Liqid™
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CerIO composable system

- Installed 2024
- PCIe5-based fabric
  - No central switch: Uses a flit-based torus topology
  - Full data centre scalability
  - 200Gb/s to nodes
  - 300Gb/s inter-card bandwidth
- 8 compute nodes, 8x A30 GPUs, 16TB RAM
- IRIS/SKA/ExCALIBUR/DiRAC

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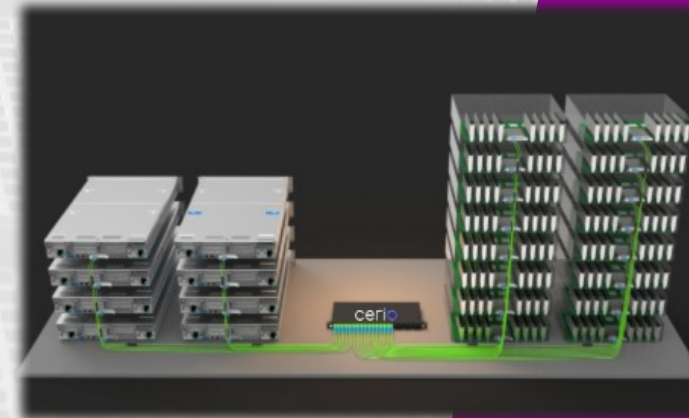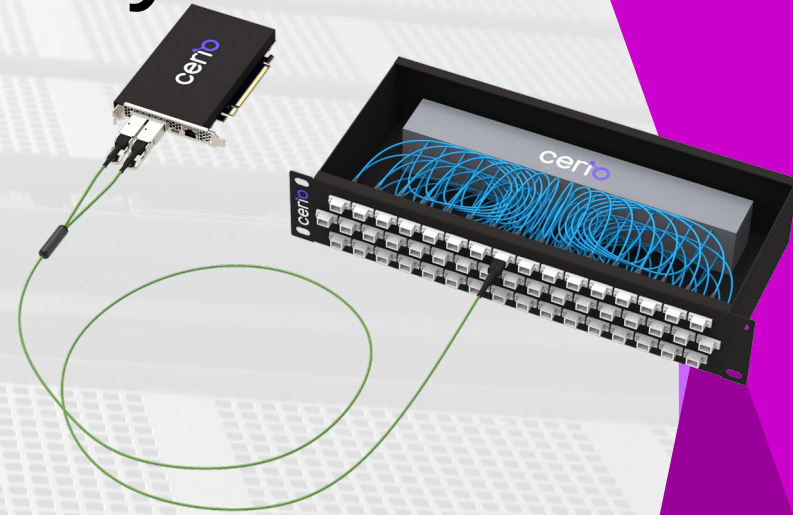
Network fabrics

- Rockport 6D Torus network
  - A "switchless" fabric for 100G Ethernet
  - Trailed on DINE in 2021
  - Installed on COSMA7 in 2022
    - 224 nodes (half the cluster) replaced IB
    - Allows direct comparison of fabrics
    - At full HPC problem-size scale
  - Works well
    - Performance comparable to InfiniBand
    - For real workloads
    - Handles congestion well
  - ExCALIBUR/DiRAC funded

- 800G Ethernet fabric
  - 400G to nodes
 - On the DINE2 cluster

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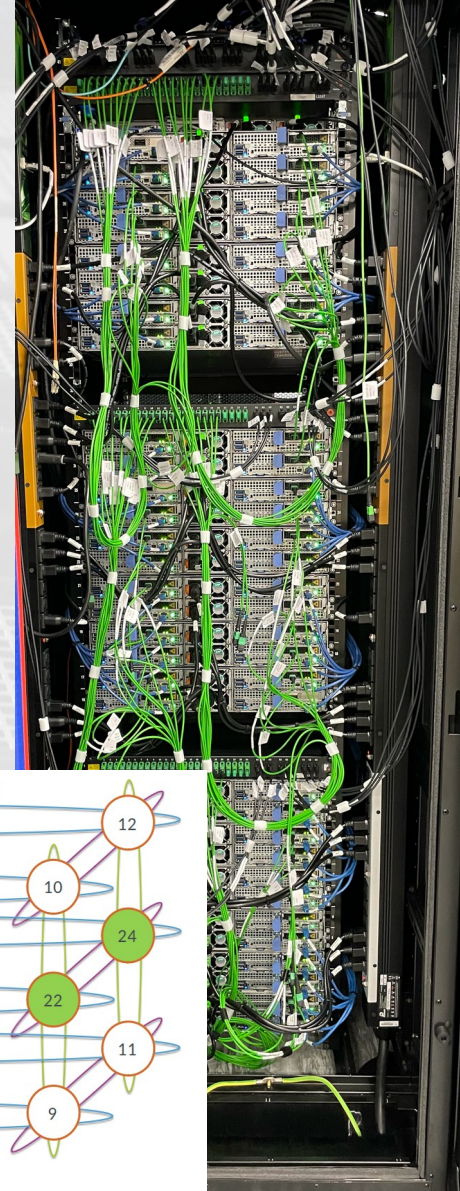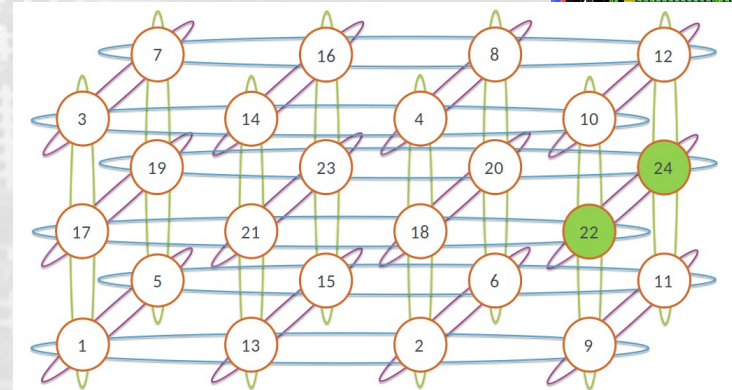
Storage sub-lab

- Various different storage technologies
- High-performance scratch Lustre (NVMe)
- DAOS (NVMe)
- Ceph
- StorJ private cloud
- VAST (NVMe)
- Globus (data transfer)
- Lustre (efficient bulk storage)
- Tape: Atempo Miria
- NVMe RAID test systems
- Funded by DiRAC/IRIS/SKA/ExCALIBUR

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Environmental-related

- HPC is a huge energy user
  - COSMA ~1MW at peak
    - (~5GWh/year, ~120T CO2, 70 people crossing the Atlantic and back)
  - Responsibility to keep this as low as possible
- 2023: Installation of ~£1m solar panels
  - Funded by DiRAC
 - Investigation into the interplay between supply and demand
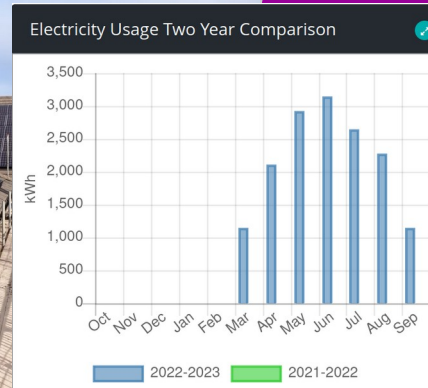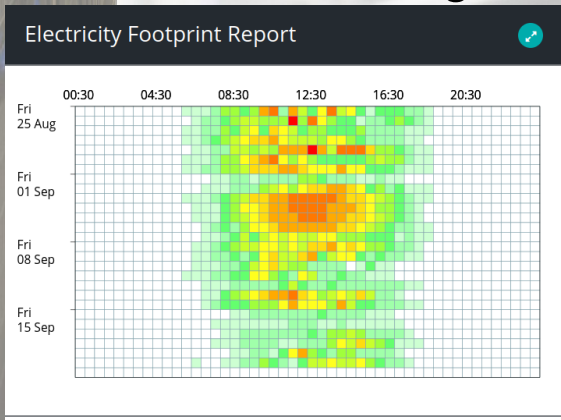
Cooling sub-lab

- A sequence of technologies:
  - Hot aisle (2006?)
  - Passive cooled rear doors (pre 2010)
  - Active cooled rear doors (2018)
  - Direct liquid cooling (2020)
  - Immersion cooling (2025)
    - As a national object-of-study
    - Support for visits to Durham for operators to learn this technology
    - Reduced operational and embodied CO_2
    - Talk on Wednesday, 11am, Paul Walker
- Free air coolers: 12kW to cool 800kW load
  - Dependent on external temperature

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Mine water heat storage

- The ICHS project
  - Talk on Wednesday, 11am, Paul Walker


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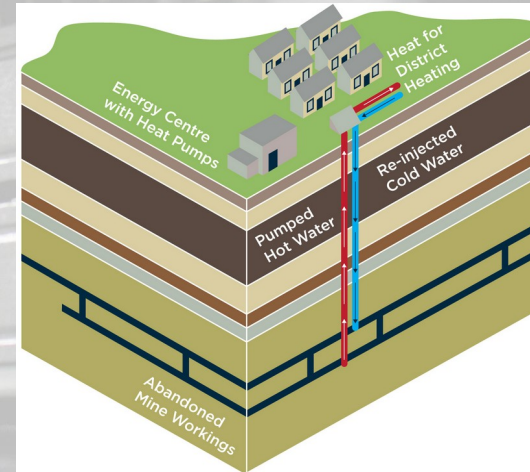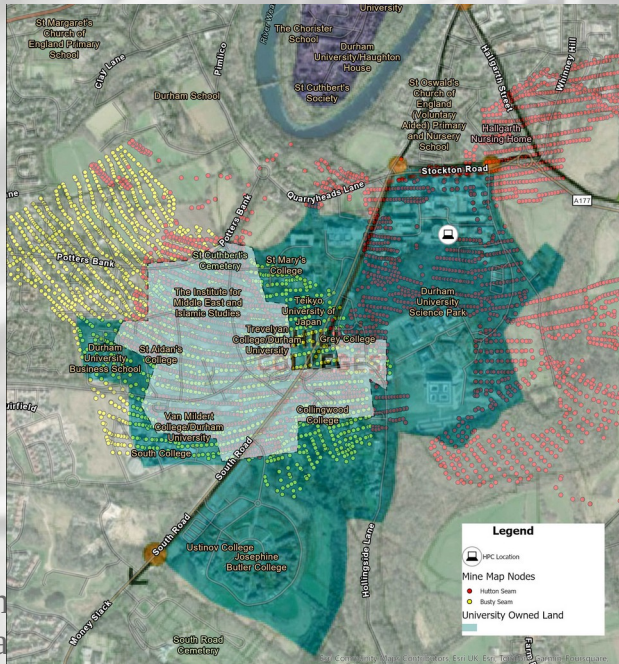
Energy awareness

- Quarterly reporting to users around energy usage
  - Ability to query energy usage for each submitted job
- Monitoring of power on a node, rack, room and system scale
- Power-down of unused nodes
  - On quieter systems

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Quantum computing

- No quantum compute in Durham (yet)
- However, the hardware lab administers national access to:
  - DWAVE quantum annealer (expired)
  - QuEra neutral atom quantum computer
- ExCALIBUR funded

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quantumcomputinguk.org
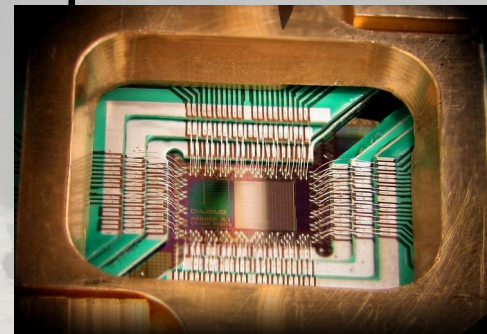
Hardware Lab Outputs

- Key outputs from the hardware lab are:
  - Up to date knowledge of performance on new technologies
  - Experience profiling and optimising codes
  - Code preparation for future systems
  - Training on new technologies and tools
  - User awareness
  - Input into future system design

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Future plans*

- UntetherAI card
- Turin CPU system
- CXL composable systems
  - Large shared-memory fabrics
- Ultra-Ethernet fabric

* dependent on funding!

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Conclusion

- The Durham HPC Hardware Laboratory
  - Accessible for UK researchers
    - Account creation on SAFE
    - Single login
    - HPC environment
  - Cutting edge technologies
  - Let us know if there is something of particular interest
    - Always happy to host!
  - A steady funding line would be a good thing!

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