The newsletter of EPCC, the supercomputing centre at the University of Edinburgh

epcc news

Issue 88 WINTER 2020

Happy birthday, EPCC!

Celebrating 30 years since our foundation

EPCC's HPC Systems team and User Support team awarded Principal's Medal

EPCC's HPC Systems team and User Support team have both been awarded the University of Edinburgh's Principal's Medal for Exceptional Contribution.

The award was granted for "delivering exceptional service and demonstrating amazing commitment during the COVID-19 pandemic by developing the Edinburgh International Data Facility on time, and against all of the odds, supporting the Nightingale Hospital in London, and other ground-breaking COVID-19 research projects."

The Principal's Medal was first awarded in 2008 and is one of the most important ways in which the University recognises both professional services and academic colleagues or current students who have made outstanding contributions to both the University and wider communities, and consistently demonstrated the University's Values.

These awards are the highest bestowed upon students and staff in the University.

Principal's Medals recognise staff or students who have made a significant contribution to the University, and those who have made an impact in the wider community outside the University.

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EPCC is a supercomputing centre based at The University of Edinburgh, which is a charitable body registered in Scotland with registration number SC005336.

From our Director

2020 was going to be an important anniversary year for EPCC. We had already booked the venue for our "30 years old" event and were looking forward to an important year of celebration coupled to the arrival of ARCHER2 and the opening of the Edinburgh International Data Facility.

But as Robert Burns wrote in 1785, "The best-laid schemes o' mice an' men/Gang aft agley".

That 2020 went very awry is not news, but what may be news to some readers is that throughout the year EPCC has continued to operate all of its HPC and Data services from our ACF data centre and also transitioned to largely working from home. We have also continued to grow – we now have over 110 staff – some of whom I have never met in person. A strange year indeed – and very difficult for many people throughout society.

I have been incredibly proud of EPCC during this period. Many staff have been involved in COVID-19 related projects and the provision of data services. In particular we have worked with EPSRC and STFC to provide accelerated access to our HPC services for modelling of the virus, and the Scottish Government and Public Health Scotland for many projects within the National Safe Haven targeted on understanding the pandemic through public health and other public data. Within three weeks of the start of lock-down we had worked with eDRIS from Public Health Scotland to create a COVID-19 research data repository. This is now part of the UK's National Core Studies programme to develop UK-wide datasets for research purposes.

While there have been delays to ARCHER2, we are making progress and we now have an initial system installed onsite for early users, which is slightly larger than the current ARCHER system. We expect to install the remainder of the system in early 2021.

We will also take ownership of the new Computer Room 4 at the ACF in mid-December. That the building work has continued throughout the pandemic is down to the excellent management of the project by our builder – Robertson. This new room will hold the first full deployment of the Edinburgh International Data Facility infrastructure from early next year (see page 16). A key moment in our support of the Data-Driven Innovation programme of the Edinburgh and South-East Scotland City Region.

30 years ago, I do not think anyone could have dreamt that EPCC would have grown to the size and breadth it is today. I personally feel very privileged to be its Director during its 30th year and I look forward to many more years of success.

Mark Parsons, EPCC Director
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30 years at the leading edge

It gives me great pleasure to write this short review of the past 30 years and look forward to the future.

When I started as a PhD student, and subsequently a researcher, in the 1980s working on computational models of physical systems, I don't think that anyone would have foreseen the changes that would ensue. What we did appreciate was that simulation was the third methodology of science, complementing theory and experiment, that it was especially relevant in complex systems and that its usefulness was not confined to academia.

It was my privilege to be one of the founding members of EPCC and to become its Director in 1996. The next 15 years were one of the most exciting and rewarding periods of my working life. I felt very strongly that we were icebreakers in so many ways, bringing a new, entrepreneurial approach to academic practice and ensuring that the University was one of the first in the world to adopt computational science as a strategic objective.

More broadly, our "win-win-win" model, forging alliances with technology providers and end-users, was featured in the Government's "Realising our Potential" strategy for SET and has since become second nature in many areas.

The new millennium saw the emergence of data science to complement computation, and EPCC expanded its activities to embrace both, becoming a key player in the Data-Driven Innovation-focused, £1.3b Edinburgh and South East Scotland City Deal.

More generally, the Centre's expertise continues to enable us to support a broad portfolio of commercial clients from local, SMEs to multi-national blue-chips using truly world-class facilities.

In my current role, chairing EPCC's Board, I have watched with admiration the way that the organisation constantly evolves to meet new challenges. Looking forward in an area which is changing as rapidly as leading-edge computing is dangerous, nonetheless our 100+ staff have all of the skills, drive and ambition to enable EPCC to face the future with confidence – a future that has never looked so bright.

I am not a "petrolhead", but 30 years ago I could think of no better analogy for our operational model than the Ford Escort XR3i: fast, adaptable and perhaps a little cheeky. I am pleased to see that the characteristics that allowed us to break the mould then are still very evident. So, today's analogy? Surely it would have to be the Porsche Taycan: fast, green – and European!

Arthur Trew,
EPCC Director 1996–2010
Now EPCC Chairman

EPCC grew out of the pioneering work of many people but I would wish to single out David Wallace, Stuart Pawley and Roland Ibbett without whom EPCC would never have emerged as an entity, rather than as a collection of activities and projects.

Above: David Wallace with the Meiko Computing Surface.

Below: David Wallace (left), first Director of EPCC, beside Stuart Pawley. On the far right is John Burnett, then Principal of the University of Edinburgh. The group stands beside an International Computers' Distributed Array Processor (2x4,096 processors), which was installed at the University of Edinburgh in 1982.

At the centre of local, national and international data science

EPCC came into the world at roughly the same time I started lecturing in artificial intelligence (AI) at the University of Edinburgh but I had little awareness of it because research in AI and high-performance computing were distinct.

AI researchers were more interested in the maths of computation than in computational performance, and "high performance" of course wasn't anything like we have now. So much of foundational AI was invented mathematically and we built our own languages and systems to support ourselves. Meanwhile, EPCC inhabited the nascent world of raw compute power and placed Edinburgh's pin in the map for supercomputing centres. Then two things happened.

Science became compute and data intensive. We have seven Schools in Science & Engineering at Edinburgh and all needed faster computation and data at increasing volumes to keep at the leading edge of their disciplines. It wasn't just us; every research-intensive university took off in this direction and there was stiff competition to be in the international "club" of truly world-class supercomputing centres. EPCC got us into that club and kept us there, which is important because this shaped how we understand supercomputing systems.

EPCC also was a focus for raising our game computationally within our Schools. If you're (say) a chemical physicist who has a mathematical model of (say) molecular interactions then you know how the maths works but you need help to translate this into a computational algorithm and also, probably, to get the right algorithm: one that terminates in a day rather than several years of run-time. EPCC filled this gap for many of our scientists and has been a lynch pin of what was called "e-science". Now we just call it "science".

AI folk realised more data could be a very good thing. We stopped worrying so much about how to acquire scarce data and started building systems that exploited the sea of data becoming available from the sciences, humanities, and elsewhere. This meant that we had to intersect with the EPCC world of data-intensive computation. Others in computing science moved faster and intersected more fully (parallel computation is a good example) but we all drew closer together.

EPCC embraced this change and accepted the difficult challenge of working with a huge range of technical needs and differing approaches to system design. It also took industry seriously, and was a major part of the change we've seen (across the University but, I'd argue, especially in Science & Engineering) to bringing it into our research groups and developing the personal bonds that generate good and long-lasting applied research.

And now data science is ubiquitous across the entire University with EPCC at the centre of our local, national and increasingly international efforts in developing the infrastructure that we need for the many challenges we now face, in healthcare, finance, government, biotech, agritech, digital manufacturing... the list goes on. It is hard to think of an area where we couldn't potentially make a step change and, equally, it demands great foresight to choose which levers to pull to make the right changes happen.

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The 16,384-processor Connection Machine (CM-200) from Thinking Machines Corporation was the first system run by EPCC as a national supercomputing service for UK academia and industry.

Formally launched in February 1992, the CM-200 was the first Connection Machine system to be installed in the UK, and was at the time the most powerful, and most high-profile, computing facility in the country.

2002: Chancellor of the Exchequer Gordon Brown visits the National e-Science Centre, which was co-founded by EPCC.

The early days

Above: Cray T3D (512 processors), installed at EPCC in 1994.
Below: an early weather simulation, produced using a Meiko system.

"I have the fondest memories of working with colleagues at EPCC, making connections early in my career with some wonderfully talented, diverse (and fun!) collaborators who were generous in extending the opportunity for me to grow and learn around the best programming and research talent in the world.

In the early days of big data science we were lucky both to have access to the hardware and industry partners for some wonderful projects in areas such as traffic prediction, medical visualisation and artificial intelligence.

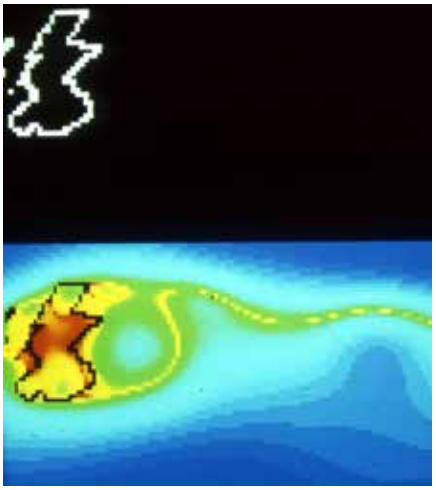
I was inspired daily at EPCC to take chances, and always supported by leadership and my peers in taking that risk. The sense that anything was in fact possible, has stayed with me through my career (a career that became possible through EPCC's desire to push boundaries with computer graphics and imaging, and its support of our team's efforts to connect).

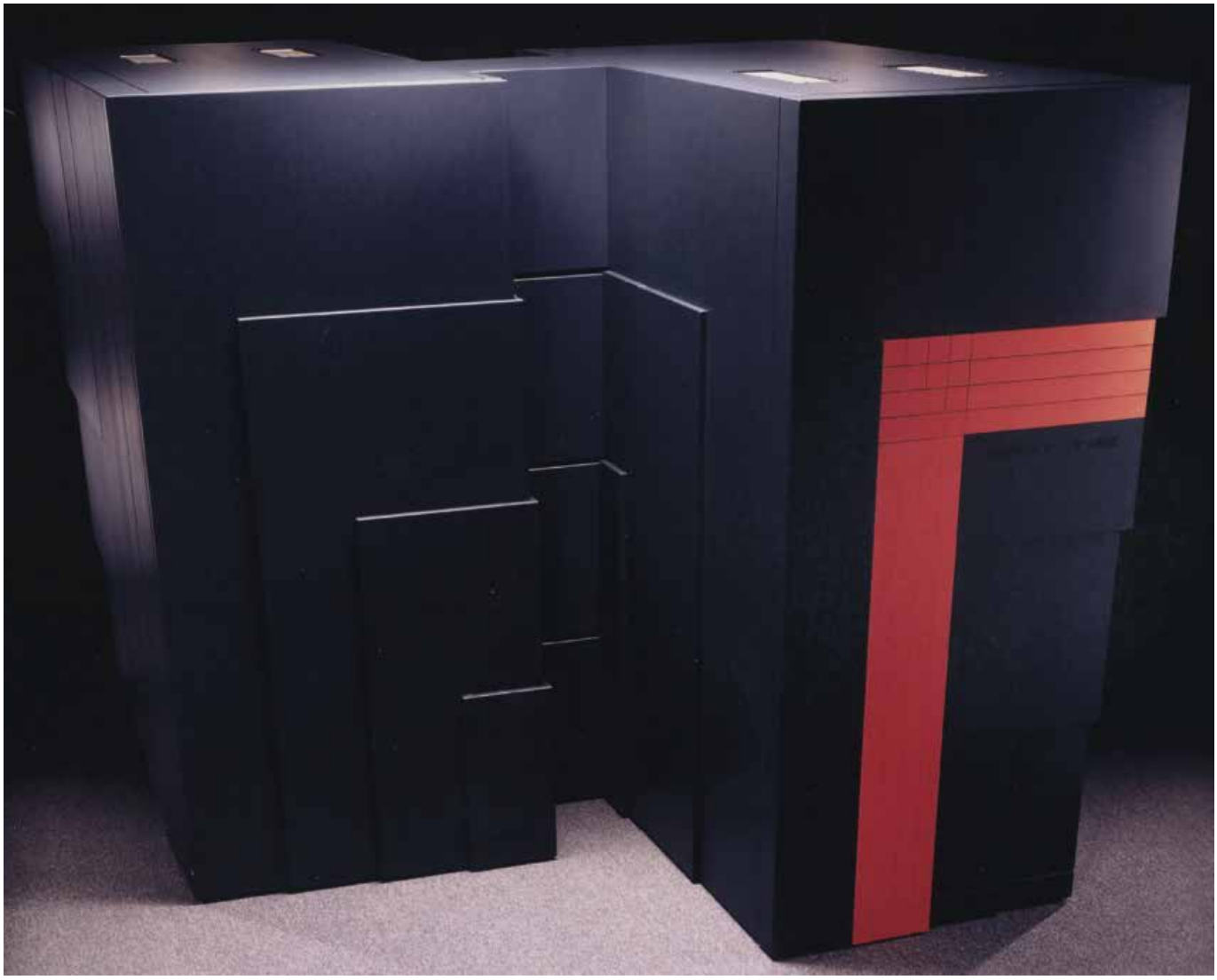
We were always encouraged to think beyond the walls of the University, to interact with others around the world, making crucial contributions to the fields, for example, of parallel programming with open source initiatives (Chimp! MPI!) and extending our reach into the scientific visualisation community with contributions of code, expertise and by presenting and publishing broadly.

I will never forget my years at EPCC, nor the people who inspired and challenged me daily - the experience is embedded within my DNA and I remain so very grateful for the existence of the institution, and its standing in the world.

Oh, and the Batman premiere with the team and altogether too much port was magnificent, but that's another story :)

Gordon Cameron
EPCC employee 1991–1994. Now Technical Supervisor at Pixar Animation Studios.





Above: Cray T3E (344 processors), installed at EPCC in 1997.
Below: Cray J90 (10 processors), installed at EPCC in 1996.

It has been 15 years already since I moved from EPCC, and yet the "EPCC culture" continues to represent the strongest and most positive influence on my professional life. Clearly working at EPCC was – and possibly still is – far more than "just a job".

Of course most of us in those days were taking great pride in being part of "the Premier HPC Centre in Europe", embracing a culture striving to the highest standards but also where everything was possible (even becoming experts in hybrid MPI-OpenMP programming overnight, after HPCx Phase 1 was commissioned). And of course there was a certain arrogance that came with it, which as a big fan of Eric Cantona was very appealing to me.

There was also a sense of eccentricity. Where else could you be one of the four horsemen of the apocalypse, or have a work session interrupted because the server you are programming on is being stolen by "someone with a baseball cap and a golden tooth"?

Above all I remember a workplace brimming with excitement, and a deep sense of camaraderie among staff.

EPCC? Surely one of Europe's best destination for ambitious young technologists. I wish EPCC and all its staff a very happy and successful 30 years ahead. And to all my friends still working there: I miss you!

JC Desplat
EPCC employee 1995–2005. Now Director of the Irish Centre for High-End Computing.

EPCC Advanced Computing Facility: how it all began

The Advanced Computing Facility (ACF) was born through necessity – but the opportunity was taken to create an expandable and highly-efficient facility that attracted future business including national computing services. Mike Brown, EPCC's Director of HPC Operations until 2017, gives an overview of the development of this unique building.

In 2000 all of the large-scale systems operated by EPCC (Cray T3E plus a number of SUN SPARC-based SMP systems) were installed in a computer room on the University of Edinburgh's Kings Buildings campus.

After a series of thefts across the UK of SUN CPU and memory parts, it became clear that a radical re-think of computer room provision for HPC-class systems was required – especially as we were planning to undertake a series of significant acquisitions such as the new system for UKQCD (which became QCDOC), the University's first-generation Storage Area Network (SAN), and the future IBM Blue Gene system. We were also starting to position ourselves for the next EPSRC-funded UK national service (which became HECToR).

The existing site could no longer offer the likely space, power, cooling, or the enhanced security and fire-suppression requirements. New-build was out of the question but fortunately the University's 1970s-era former computer centre was available.

Phase 1: Computer Room 2

Funding for refurbishment of the building was secured in early 2003, with work completed in August 2004. The building had one 285m² computer room (CR2) fitted out, a second (CR1) empty in reserve, and a 250m² plant room for mechanical and electrical services. CR2 was fitted out principally for air-cooling, but with dedicated cooling water supplies for QCDOC (installed by the end of 2004). By year end about 50% of the space was occupied – with the SUN SAN, QCDOC, SUN 15K SMP system and the dedicated storage systems for QCDOC, while the Blue Gene/L system arrived shortly afterwards.

Mike Brown was EPCC's Director of HPC Operations until he left the University in 2017. Associated with the support and delivery of HPC services at the University (from the ICL DAP in 1982 until the Cray XC30) as a Chartered Engineer, his principal interest was in the provision and operation of the support infrastructure with an emphasis in maximising operational efficiency.

Opposite: IBM Blue Gene L.
Above: Linda Dewar with QCDOC. Linda is now HPC Systems Programme Manager at EPCC.
Below and bottom: HECToR Phase 3.
Below, opposite: cooling system on the ACF roof, 2007.

The facility was officially opened by His Royal Highness, Prince Philip, Duke of Edinburgh, in the summer of 2005.

Phase 2: Computer Room 1

Occupancy continued to increase, and by 2006 planning for the potential arrival of the EPSRC-funded HECToR national service was underway. Installation at Edinburgh was confirmed in November and we then had a very short period to undertake a significant expansion of the facility.

Due to its physical size, and power and cooling requirements, the initial Phase 1 system (60-cabinet Cray XT4) required the fit-out and commissioning of the reserve CR1 – and the construction of the 475m² Plant Room B to service it. All infrastructure was commissioned in July 2007 – just six months after the ground was cut in January.

In August the Cray XT4 was installed in CR1 while most of the peripheral equipment (front-ends and support nodes, discs, plus a stand-alone XT4 test and development system) were installed in CR2.

The HECToR service was opened by the then Chancellor of the Exchequer, Alistair Darling, in January 2009.

The HECToR service went through two principal upgrades: the first in Q2/2010, which reduced the XT4 to a 30-cabinet system while 20×XE6 liquid-cooled cabinets were installed alongside, and the second in Q4/2011 when the XT4s were removed and the XE6 expanded to 30 cabinets. The installation of the fully liquid-cooled system enabled the plant to exceed its planned levels of operating efficiency.

The University of Edinburgh's Information Services began to

Continues on next page.

Left: His Royal Highness Prince Philip, then Chancellor of the University of Edinburgh, at the opening of the Advanced Computing Facility in 2005.

Below: General view of Plant Room C showing the HV area (L), electrical services for plant (centre), and mechanical services (right).

Opposite page: HECToR Phase 1.

install some of its large-scale systems (the ECDF cluster and follow-on generations of the original SAN) at the ACF, and by 2009 CR2 was full.

Phase 3: Computer Room 3

The second major expansion occurred in 2012 after the ACF had been selected to house the EPSRC ARCHER service. Groundworks started in April 2012 for an expansion that included the 550m² Computer Room 3 and 750m² Plant Room C.

Despite one of the wettest summers on record, the build was completed ahead of schedule with full completion in February 2013.

The Cray XE30 was not installed until Autumn 2013, but the plant and systems were functional from handover in February, with the first installation (the moving of the RDF (Research Data Facility and associated hardware from CR2) in the spring.

The ACF is in a pleasant rural location, which can present operational challenges in winter. The severe winter of 2009 brought a record low temperature of -14°C, while in 2010 more than 450mm of snow fell in the carpark. However operations were maintained throughout, with the site only closed early for bad weather twice – once for snow and once when 90mph+ winds caused widespread damage in the area, including blocking the access road with fallen trees.

The building is not an architectural gem – it has been likened to a concrete bunker in the middle of a sheep-field but it is functional, secure, efficient and has proven to have been a highly cost-effective investment by the University and the Research Councils.

EPCC Advanced Computing Facility: planning for future growth

Since 2005, the Advanced Computing Facility (ACF) has housed all the major systems managed by EPCC. It has expanded and evolved since its creation, becoming one of the most innovative and efficient facilities of its kind in the world.

The building and its internals have changed greatly since I started in February 2018, as part of a drive to ensure that our wider master planning for the site is reflected in what visitors see. This includes a video wall using Raspberry Pi's and PiWall software to allow us demonstrate HPC visualisations to visitors.

We are developing a site-wide Data Centre Infrastructure Management (DCIM) approach which allows us to view real-time data or room and system performance on screens outside of different rooms and on our video wall.

In addition, as described by Mike Brown on page 8, the ACF has had significant investment over the years, most recently with the creation of Computer Room 4, the home of the new Edinburgh International Data Facility (EIDF).

We also host and support a number of other HPC systems at the ACF, including the National Tier-1 and Tier-2 systems, ARCHER and Cirrus. The first phase of the next UK national supercomputing service, ARCHER2, has also been recently installed.

Cooling systems

Each of the ACF's four computer rooms hosts specific HPC equipment and is supported by associated plant rooms that provide dedicated power and cooling infrastructure. We have several pieces of equipment and racks at our site which are "traditionally" air cooled, but the majority of our equipment and speciality high-performance computers are water cooled. As water is a significantly more effective coolant than air alone, the ACF is an extremely efficient data centre.

Paul Clark
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Above: ACF plant room.

Previous page: Taking delivery of the initial four-cabinet ARCHER2 system during the UK's first COVID-19 lockdown.

Thanks to the Scottish climate, for much of the year the ACF benefits from free cooling. The water which supports our cooling infrastructure is pumped to our roof-mounted dry air cooling towers and back again, allowing the lower outside temperature to cool our water as it passes through the towers. It is only on extremely warm summer days that there is no free cooling and we then use our large-scale mechanical chillers to cool the water circuits.

Edinburgh International Data Facility

EPCC plays a major role in the Data-Driven Innovation (DDI) Programme of the Edinburgh and South East Scotland City Region Deal. At the heart of this programme is the EIDF (see page 16), which will be housed in the ACF's new Computer Room 4 (cr4).

This high-resiliency room provides the state-of-the-art computing and data-storage infrastructure needed to develop the technologies that will enable data-driven innovation. cr4's cutting-edge networking advancements, which will underpin the EIDF, are among the fastest available while its innovative cooling solutions make it one of the most efficient computer rooms possible.

We have run the National Safe Haven for several years and we are building on this deep expertise to provide a secure data-hosting and analytics infrastructure for the EIDF service. EIDF will hold unique datasets and allow approved, authorised users to find innovative solutions to novel questions. cr4 will be capable of hosting up to 270 cabinets, giving EIDF and the DDI programme a platform on which to grow over the next 10 years.

ARCHER Tier-2 National HPC Facility
www.archer2.ac.uk

Cirrus Tier-2 National HPC Facility
www.cirrus.ac.uk

Data-Driven Innovation Programme
ddi.ac.uk

Edinburgh International Data Facility
www.ed.ac.uk/edinburgh-international-data-facility

National Safe Haven
www.isdscotland.org/Products-and-Services/eDRIS/Use-of-the-National-Safe-Haven/

ARCHER2: the UK's next national supercomputer

In June 2020, EPCC was awarded the two support contracts for the ARCHER2 HPC service: the Service Provision, and Computational Science and Engineering contracts. The system is supplied by Cray/HPE and is being hosted at EPCC's Advance Computing Facility.

Since then it has been a busy time. Once complete, ARCHER2 will be an HPE Cray EX supercomputing system with an estimated peak performance of 28 PFLOP/s. The machine will have 5,848 compute nodes, each with dual AMD EPYC Zen2 (Rome) 64 core CPUs at 2.2GHz, giving 748,544 cores in total.

However the system is arriving in a phased manner, with a four-cabinet system being built first. Once this system is stable, the current ARCHER service will be switched off and the remaining 19 cabinets built. Finally the four cabinets will be integrated with the main system to form the final 23-cabinet system.

First shipment

The four-cabinet system was shipped from the US in July. Leaving Chippewa Falls, Wisconsin, they flew from Chicago to Luxembourg, before being transported by road to London Heathrow, then Prestwick and finally to Edinburgh. While this sounds logistically demanding, COVID considerations meant that the biggest challenge was bringing the Cray/HPE engineers from the US to Edinburgh.

With COVID numbers relatively low during this period, the engineers were able to fly to Edinburgh and install the systems over a period of three to four days, following strict health guidelines to keep everyone safe.

Since then the Computational Science and Engineering (CSE), and Service Provision (SP) teams have been working on porting, testing and documenting the four-cabinet system.

First users

Recently we have been able to

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Training programme

Our online training programme has proved popular with high attendee numbers across all courses, including our series of introductory courses:

- Package Use of ARCHER2
- Development of ARCHER2
- Data Science on ARCHER2.

These are available to book via the ARCHER2 website.

Upgrading the high-speed internal network of the initial ARCHER2 four-cabinet system.

allow a group of early users on the system. This group covers a broad spectrum of science areas and consortia, and their input has been invaluable as they have been porting, testing and benchmarking their applications, providing feedback and improvements around the environment and documentation.

This is a very new system and we are seeing a range of fixes and enhancements that are required before full user service can commence. However early results show good performance across a range of applications and we hope to commence user service soon.

Things are changing rapidly around the ARCHER2 hardware. Keep up to date through our regular blog article series. For example there is an interesting blog around early experiences with GROMACS on the system.

eCSE programmes

While the new hardware is being installed, our training programme and embedded Computational Science and Engineering (eCSE) programmes are up and running.

eCSE provides funding to support research software engineer effort embedded within research groups to enhance the ARCHER2 software base. This is well worth investigating.

Finally, it is worth mentioning the original ARCHER service, which continues to provide a significant resource for the UK HPC community and we continue to support users on this service.

Having worked on this service since it was commissioned in November 2013, I will be sad to see it finally switched off and decommissioned.

archer2

More details on training, the eCSE programme, blog posts, and other aspects of the service can be found on the ARCHER2 website.

www.archer2.ac.uk

Edinburgh Internationa
Hitting key milestones

Work on the Edinburgh International Data Facility passed three key milestones this autumn, bringing the infrastructure that will underpin the £600m Data-Driven Innovation Programme significantly closer to reality.

Firstly, and perhaps most importantly, EIDF's home, Computer Room 4 (cr4) at the University's Advanced Computing Facility, completed its main construction phase at the end of the third quarter of 2020 and cr4 has entered its commissioning and fit-out phase. If everything goes to plan, we will start to build infrastructure in the room from January 2021 (see p12).

Phase 1 hardware

Perhaps wheel-in ready is a better description, given the size of some of the equipment now on its way from hardware partner HPE.

EIDF Phase 1 hardware will include 30 HPE ProLiant and Apollo servers, 20 Nvidia GPUs and 46 PB of storage capacity, plus two HPE SuperDome Flex supercomputers each with 18 TB memory. The bulk of this has been arriving throughout October and November, passing the second of our milestones. One of the SuperDome Flexes will replace our aging Ultra supercomputer and the servers will form the bedrock of EIDF's data science cloud. The storage systems will underpin the new Research Data Facility service for UKRI as well as providing user workspace for both the National Safe Haven and the data science cloud.

Data science cloud

The completion of the data science cloud's software base hit our third milestone of the quarter. The data science cloud is the new virtual machine-based computing service that will give users their main window into EIDF.

Based on the OpenStack open-source cloud software, the data science cloud will offer a rich array of tools and services on full Linux virtual desktops accessible through a standard web browser.

Over the last few months we've successfully hooked all the moving parts together with SAFE, EPCC's service management software stack, laying solid foundations for

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We are working right now with colleagues across the University on plans to provide the right kinds of data and compute environments for projects from epidemiology to manufacturing supply chains, from social care to infrastructure planning and recovery in the local economy.

al Data Facility: to completion

the launch of this new service early next year.

Data research projects

It's been a great summer of progress on the new EIDF service, and this has been on top of our continuing development and support for COVID-19 research projects on our existing data facilities.

Within the highly secure National Safe Haven infrastructure, the **Scottish COVID-19 Research Database** is in active use by more than 30 projects under the governance of Public Health Scotland.

Alongside that, our work with the **ISARIC4C consortium** is bringing the power of the 8 TB-memory Ultra system to bear on the marriage of clinical trial data from the University of Oxford with genomic data from the Roslin Institute.

The National Safe Haven has also been key to our work with the new **Global Open Finance Centre of Excellence**, partnering with a major UK financial institution and local fin-techs on modelling the economic consequences of the pandemic. The demands of these projects are helping shape our plans and designs for the new EIDF hardware – for us, necessity really has been the mother of invention over the last few months.

Next stages

Looking ahead to the start of 2021, we'll be launching the first services on EIDF in April, and we expect some of the first users to come from the programme of COVID-19 response and recovery projects for the City of Edinburgh region, funded recently by the Scottish Funding Council.

Never has the need for better machinery to support critical decision-making been so acute. We'll be doing all we can to ensure that EIDF can rise to the challenges ahead.

Data-Driven Innovation Programme
ddi.ac.uk

Edinburgh International Data Facility
www.ed.ac.uk/edinburgh-international-data-facility

Global Open Finance Centre of Excellence
https://bit.ly/31nnx3A

ISARIC: Understanding behaviour and spread of COVID-19 in the UK
www.nhsresearchscotland.org.uk/coronavirus/COVID-19-research

ISARIC4C consortium
https://isaric4c.net

How we work with business

Since its foundation, EPCC has partnered with local, national and multi-national companies to help them achieve their business objectives.

EPCC continues to support industry in these challenging times, leveraging the Centre's three key foundations:

- The hosting, provision and management of high-performance computing (HPC) and data facilities for academia and business.
- Research and project support to optimise the computing activities of those organisations.
- Our unique project-based Applications Group, which provides bespoke novel and high-performance software solutions.

Our bespoke project activity continues apace with new and ongoing collaborations with a variety of organisations, including software and architecture development for **Apropos**; enhanced CFD modelling via on-demand HPC for **Eberspaecher** and **ICON Energy**, and data architecture support to **Jearni**, an educational technology startup that is focused on the development of advanced digital technologies.

Data projects

The development of key early-adopter commercial projects for the Edinburgh International Data Facility (EIDF) and the Data-Driven Innovation Programme continues. Our collaborations with the **National Collection of Aerial Photography** (NCAP) and **Albyn Housing Society** are expected to come on stream in early 2021. NCAP will use the Edinburgh International Data Facility to enhance its capacity to process digital imagery and provide research access to a growing library of datasets, while Albyn will

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Work with us!

Our facilities and expertise are unmatched in Europe. Get in touch to discuss how we can help your business: t.blyth@epcc.ed.ac.uk

utilise EIDF to store and manage datasets from smart homes for subsequent data science analytics and modelling to improve its residents' quality of life.

Cirrus: a Tier-2 resource for industry

With respect to the provision of HPC and data facilities, Cirrus, a national Tier-2 system hosted by EPCC, was recently upgraded via a £3.5m funding award from EPSRC. This included the addition of 144 NVIDIA V100 GPUs to the system and a 256TB high-performance storage layer for the most demanding data streaming applications.

Cirrus is available to industry on a pay-per-use basis, and is regularly used to solve CFD and FEA simulation and modelling problems in sectors such as automotive, aerospace, energy, oil and gas, general engineering, life sciences, and financial services.

The additional 144 GPUs provides a key resource for users to explore programming frameworks and accelerated versions of existing applications, in addition to supporting the exponential growth in artificial intelligence and machine-learning data science projects. Through a simple internet connection, users gain cost-effective access to Cirrus and can run their own codes as well as accessing a range of commercial software tools.

Costs for industrial users of Cirrus are:

- CPU £0.0369 per core hour used.
- GPU £2.0357 per GPU hour used.

Disk storage up to 1 TB is provided at no cost.

Cirrus at EPCC:
www.epcc.ed.ac.uk/facilities/demand-computing/cirrus

Data-Driven Innovation Programme:
ddi.ac.uk

Edinburgh International Data Facility
www.ed.ac.uk/edinburgh-international-data-facility

The National Collection of Aerial Photography's collaboration with EIDF
www.epcc.ed.ac.uk/blog/2020/05/05/enabling-research-access-historic-geospatial-data-places-around-globe

The Machine Intelligence Garage: AI and machine learning for business

EPCC is a founding partner of the Machine Intelligence Garage, which helps businesses access the computation power and expertise they need to develop and build machine-learning and artificial intelligence solutions.

During the past year EPCC has increased its engagement with the Machine Intelligence Garage, a UK Government programme that supports innovative startups which make use of machine-learning techniques and artificial intelligence (AI). Part of its remit is to enable technical support, such as HPC services, which is provided by various partners. Industrial partners of the Machine Intelligence Garage include AWS, Google Cloud, and NVIDIA. EPCC also offers support and potential collaboration for interested startups.

Startups

Machine Intelligence Garage works with startups across a range of industries that are developing products in many different fields, with the unifying factor the technologies with which these companies work.

For example, the current cohort contains startups operating in neuro-linguistic programming and fintech, as well as those working on hardware development. This presents the potential for interesting collaborations with EPCC, working with companies developing new techniques, as well as for us to play a part in introducing HPC systems to interested parties.

Our collaborations

Following an introductory presentation by EPCC at the start of this year, a diverse group of Machine Intelligence Garage startups expressed interest in working with us. The broad expertise available within EPCC

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The Machine Intelligence Garage is a programme of the UK Government's Digital Catapult centre, which designs and delivers specialised innovation programmes to drive UK leadership and economic growth.

Image: Additive Flow
www.additiveflow.com

proved to be a particularly important draw for these potential collaborators.

Two of these newly established connections illustrate the range of projects, as well as the service, that EPCC can provide.

Our collaboration with **Additive Flow** focuses on optimisation for additive manufacturing (3D printing). The company wanted to increase the computational scale of its material modelling and we were able to provide access to Cirrus, a national Tier-2 HPC system, as well as support in switching software to an HPC architecture.

We undertook a different type of engagement with **Sundance Microprocessor Technology**. Sundance works on the application of FPGAs for a variety of different tasks, including running AI. The company has many years' experience in hardware development and sought out EPCC to explore a collaboration that would combine both organisations' expertise.

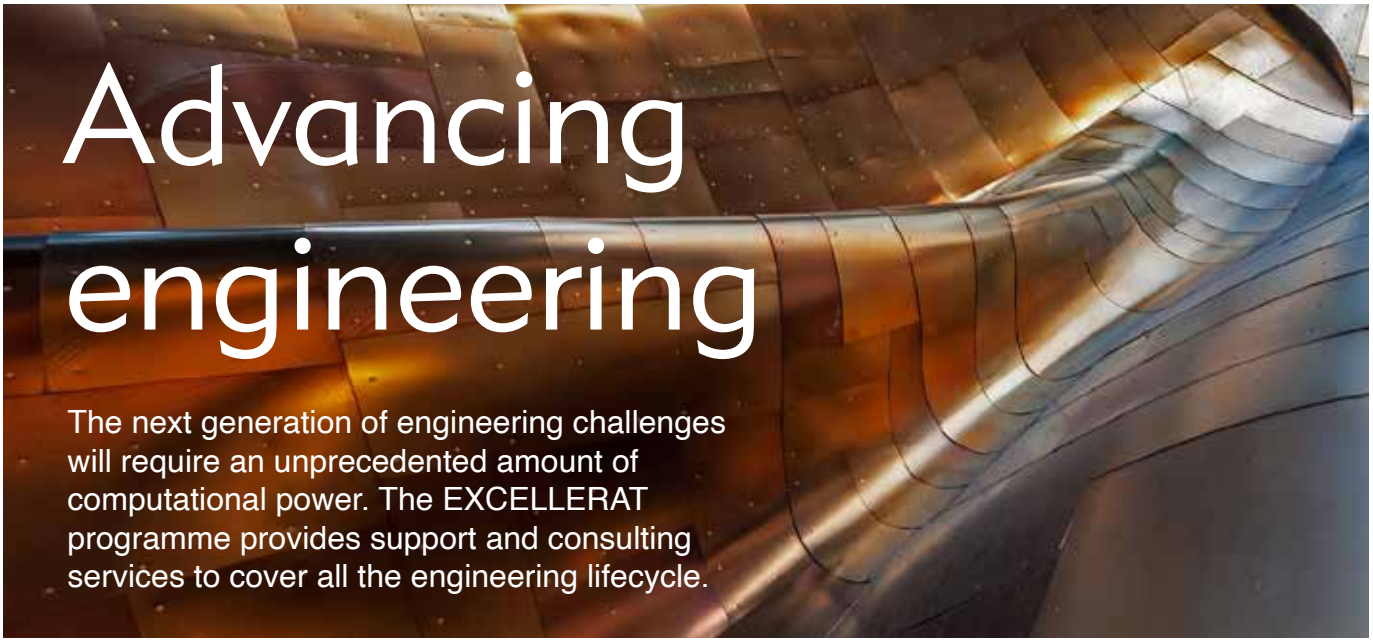
After working with EPCC's Dr Nick Brown, Sundance is now able to expand its hardware capabilities using an HPC system, and is planning to work with one of EPCC's MSc students on a research project in the coming year.

Each annual cohort of Machine Intelligence Garage startups will be introduced to EPCC, providing the possibility of further collaborations in the future.

MACHINE INTELLIGENCE GARAGE

Find out more

www.migarage.ai/



Advancing engineering

The next generation of engineering challenges will require an unprecedented amount of computational power. The EXCELLERAT programme provides support and consulting services to cover all the engineering lifecycle.

The European Centre of Excellence for Engineering Applications (EXCELLERAT) enters its third year in December. The Centre aims to be a single point of access for expertise on how data management, data analytics, visualisation, simulation-driven design and Co-design with high-performance computing (HPC) can benefit engineering.

Engineering is one the most important industrial sectors in Europe and it can benefit greatly from the use of high performance computing (HPC). The European engineering supply chain ecosystem consists of over 100,000 companies providing more than 10 million jobs. Engineering is seen as one of the areas in which Exascale computing can have the most significant impact.

Exascale potential

The EXCELLERAT Centre of Excellence (CoE) brings together Europe's leading HPC centres, application specialists, and supporting partners who have worked with and offered their expertise and knowledge to engineering companies and researchers from across industry and academia for the past three decades.

Services

EXCELLERAT offers a variety of tailored services for different users:

End-users. EXCELLERAT can develop solutions for challenges along the entire Exascale engineering cycle, eg simulations.

Code developers. EXCELLERAT provides expertise to code developers to help them to evolve engineering software packages towards extreme-scale applicability.

Reference applications

The CoE is using six reference applications as a focus for its work. These have been chosen for their potential as Exascale applications and for their industrial relevance. By studying these applications and how they can be adapted for Exascale, the CoE partners will learn valuable lessons and develop new approaches and technologies that can be applied to other software applications.

The CoE is running an outreach programme so that the results of the work can be taken up by the wider industrial engineering community.

The final year of EXCELLERAT will be devoted to establishing a sustainable basis for the CoE. A service-based approach is being planned, with a Service Portal already in place to enable access to the nascent services that are being developed, along with training, knowledge base and good practice guides.

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EXCELLERAT Service Portal

By presenting a wide variety of resources in an easily-accessible format, the Portal will play an essential role in EXCELLERAT's mission to create a Centre of Excellence in Engineering. The Portal offers separate dashboards tailored towards engineers, software developers, and the general engineering community.

EXCELLERAT

EXCELLERAT European Centre of Excellence:
www.excellerat.eu

EXCELLERAT Services Portal
https://services.excellerat.eu

Annual ISO 27001 Information Security and ISO 9001 Quality audits

We have passed our annual external ISO 27001 Information Security and ISO 9001 Quality audits with flying colours.

EPCC recognises the importance of a process-led approach to the delivery of National Tier-1 and Tier-2 services such as ARCHER, ARCHER2 and Cirrus. The implementation of an ISO 9001-based Quality Management Systems has provided a framework to ensure that the services delivered meet user and customer requirements. It requires that service improvements are identified and the impacts of their implementation tracked, ensuring that the improvement is effective.

The effectiveness of this approach can be seen through the scenario tests used by EPCC to test service resilience to major incidents and disasters. The impact of this work can be demonstrated in the current ability of the services to be delivered successfully with staff working remotely from home.

With the increasing importance of data analytics and data science, we have a long-term aim of becoming a leader in the secure hosting and management of huge and varied datasets to support data research. Key to the success of EPCC in providing data services is trust from our customers that we provide best practice in information security and data handling. ISO 27001 certification provides a framework to deliver this best practice.

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Scenarios of working remotely following a building fire, and of having the service team numbers decimated by a food poisoning outbreak, were enacted and improvements identified were documented as part of the service delivery processes.

EuroCC: new network of national HPC competence centres

EuroCC will raise participating countries to a common high level in high-performance computing (HPC), high-performance data analytics (HPDA), and artificial intelligence (AI).

National Competence Centres (NCCs) will be responsible for surveying and documenting the core HPC, HPDA, and AI activities and expertise in each participating country. The ultimate goal is to make HPC available to different users from science, industry, public administration, and society.

EPCC will work in collaboration with the Hartree Centre to implement the UK NCC and to coordinate services such as business development, application support, technology transfer, training and education, and access to expertise. Researchers from academia and industry both benefit from this competence concentration, and more efficient research ultimately benefits state and national governments and society as a whole.

CASTIEL and EuroCC

CASTIEL, the Coordination and Support Action (CSA) closely associated with EuroCC, combines the EuroCC National Competence Centres into a pan-European network. As a hub for information exchange and training, CASTIEL promotes networking among NCCs and strengthens idea exchange by developing best practices.

The aggregation of HPC, HPDA, and AI competencies demonstrates the global competitiveness of the EU partners. The two activities are the beginning of a strategic positioning of the European HPC competence and will contribute to the comprehensive independence of these technologies in Europe.

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Funded jointly by the European Commission and national governments, the network was launched in September 2020.

www.hartree.stfc.ac.uk/
www.eurocc-project.eu/

Extreme-scale precision imaging in radio astronomy

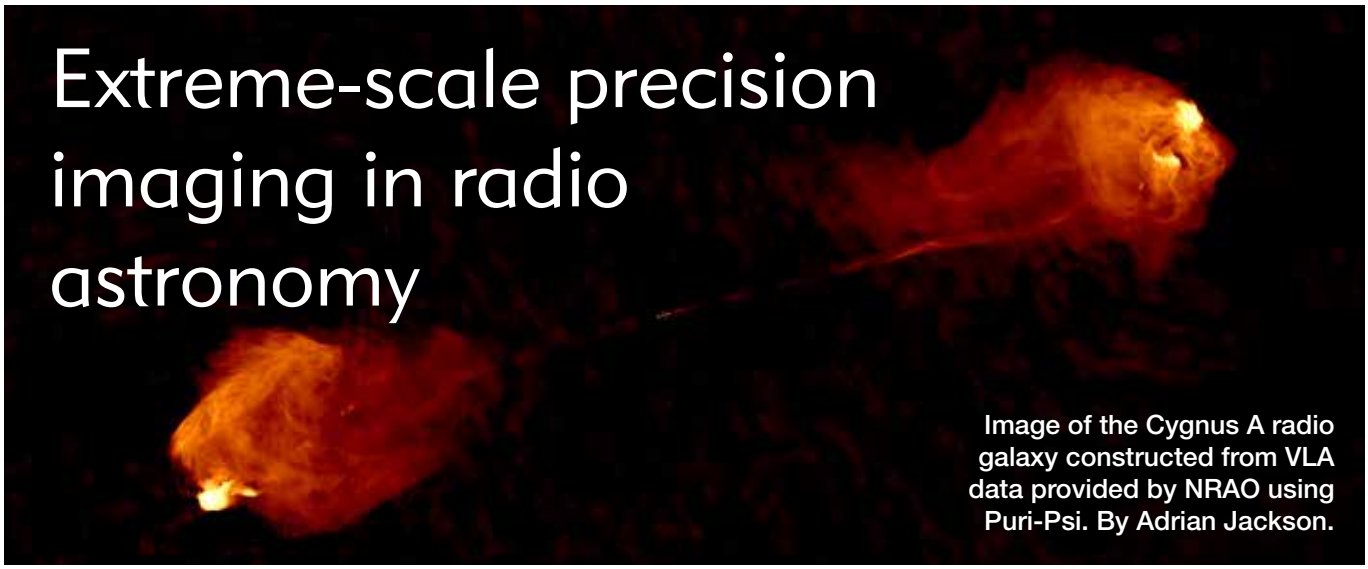

Image of the Cygnus A radio galaxy constructed from VLA data provided by NRAO using Puri-Psi. By Adrian Jackson.

In September EPCC embarked on a new collaboration with Prof. Yves Wiaux (Heriot-Watt University) to advance algorithms for high-precision and high-sensitivity computational imaging.

The EIRA (Extreme-Scale Precision Imaging in Radio Astronomy) collaboration will focus on radio astronomy, which uses radio telescopes to collect data. This allows observation of the sky with antennae arrays at otherwise inaccessible angular resolutions and sensitivities. Algorithms being developed at Heriot-Watt University will address the challenges of building images from these incomplete linear data sets.

Extreme data sets

In particular, next-generation radio telescopes such as the Square Kilometre Array (SKA), which is capable of imaging the sky at much higher resolution than current instruments, will generate Exabyte data volumes. This data can be used to construct image cubes (consisting of images across a wide number of frequencies) that will exhibit rich structure and reach sizes between 1 Terabyte (TB) and 1 Petabyte (PB). Imaging algorithms, and the applications that implement them, need to parallelise efficiently and scale up to large amounts of computational resources to handle these extreme data sets.

Better, more reliable images

The EIRA project will extend imaging algorithms to significantly improve the achievable resolution and dynamic range of the constructed images to include the calibration functionality that is needed to correct for instrumental and ionospheric effects on the data, as well as providing methodology for quantifying the uncertainty around the constructed image.

Together these new features will enable high-resolution images with uncertainty quantification information, giving researchers confidence in the features that are present in the images created by the programs that EIRA will develop.

Parallelisation of algorithms

The parallelisation of these algorithms is one of the key aspects that EPCC is focusing on, and we will be building on an existing collaboration where the Puri-Psi and Psi codes were developed to provide wide-band parallel imaging functionality.

Extending these applications to include calibration and uncertainty quantification, and developing novel domain decomposition techniques for this new set of functionality, will enable Puri-Psi and Psi to be utilised by the radio astronomy community for a wide range of imaging applications.

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Medical imaging

Radio astronomy imaging algorithms are also applicable to medical imaging, where magnetic resonance imaging (MRI) and ultrasound systems utilise a similar approach to data collection and image construction as radio telescopes. We will extend our applications into a proof-of-concept implementation for 3D MRI and ultrasound devices once the applications have been tested in radio astronomy.

Further information

EIRA is funded by EPSRC:
https://gow.epsrc.ukri.org/NGBOViewGrant.aspx?GrantRef=EP/T028270/1

Puri-Psi
github.com/basp-group/Puri-Psi

Psi
github.com/basp-group/Psi

Exploring Fujitsu's A64FX CPU

The release of Fujitsu's A64FX CPU has been a high point in an otherwise disappointing year. This next-generation CPU is the brain in Fugaku, the supercomputer at RIKEN in Japan, which was number one in the June 2020 TOP500 list.

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Since February, Fujitsu has given EPCC access to a development A64FX machine as part of an early-access programme. We have been exploring the performance of this technology applied to numerous HPC workloads.

The A64FX is very special. Not only is it a high-performance ARM-based CPU with 48 physical cores, but it also contains numerous technology advances such as ARM's Scalar Vector Extensions (SVE), and the use of HBM2 high bandwidth memory.

The high floating point and memory performance could be revolutionary for HPC, providing at or near GPU performance but still within a familiar CPU environment and without the need to rewrite codes.

Furthermore, Fugaku also contains Fujitsu's proprietary torus fusion (tofu) interconnect, which promises very low latency/high bandwidth communications, potentially significantly improving node-to-node communication performance. The early-access machine we used contained 48 nodes connected by this same tofu interconnect, and felt like a mini Fugaku.

To explore the potential of the machine we focused on a variety of benchmarks, mini-apps, and full applications which included HPCG, Nekbone, Minikab, COSA, and OpenSBLI, CASTEP. These were run on the A64FX early-access machine and then compared against some of our own machines in EPCC, including our ARM machine with Marvell ThunderX2 CPUs, and NextGenIO with Xeon Platinum Cascade Lake. Generally speaking, performance was very good, and for some of our codes the A64FX performed extremely well against the other existing CPU technologies.

However, performance characteristics are not the same across all the codes we tested on the A64FX processor, with a number of benchmarks exhibiting slightly worse performance. To some extent, this is the interesting part, and identifying what does not run quite so well, and why, is the point of the early-access programme.

It is important to highlight that to date we have focused on compiling and running directly, rather than any architecture-specific optimisations, aside from using the provided compilers and associated libraries, and as such there is likely significant opportunity to further tune applications to the A64FX.

Having played with the A64FX all year, we think this is an impressive piece of technology. The fact that it is so easy to get applications running on it, without requiring any specific code-level changes, demonstrates the high level of readiness of the overall system platform surrounding the CPU.

With Fujitsu making the A64FX more widely available and Cray supporting it in their platforms, this product and the associated technology such as SVE has an important future enabling the next generation of scientific workloads.

The early-access machine used Fujitsu's specialist compilers and, apart from having to ensure you were referencing the English rather than Japanese version of the manuals, was a really pleasant environment to use.

Published paper

We published a paper about our experiences in the EAHPC-2020 IEEE Cluster 2020 Workshop, with a pre-print available at: https://arxiv.org/pdf/2009.11806.pdf

A64FX details

www.fujitsu.com/global/products/computing/servers/supercomputer/a64fx/

Three decades of education and training at EPCC

Right from its inception in the early 90's, education and training in HPC methods was a key component of EPCC's mission to "facilitate the effective exploitation of HPC throughout academia, industry and commerce".

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This started with courses on general parallel methods, but was further strengthened in 1993 when funding from JISC (the UK organisation for digital services and solutions) made EPCC a national HPC Training and Education Centre. This lead to the development of a range of training material, freely available to all academics, including the first version of our long-running course "Message-Passing Programming with MPI".

The launch of the Cray T3D national supercomputer service in 1994 led to a rapid expansion in the range and number of courses offered. This was largely born out of necessity: parallel programming was completely new to almost the whole UK computational science community, and delivering a comprehensive training programme was the only way to support such a large number of new users.

Masters programmes

We were unsuccessful in bidding to run the subsequent HPC97 service, but used this as an opportunity to develop and launch our MSc in HPC with the support of an EPSRC Masters Training Programme grant. Extending our existing base of HPC training courses, the MSc took its first intake in 2001 and is still running successfully today. We extended our offering in 2014 by adding a programme in HPC with Data Science, and to date almost 400 students have graduated from our Masters programmes, which are delivered under the School of Informatics at the University of Edinburgh.

Training in UK & Europe

The training for the HPCx service in the mid-2000s was also delivered by EPCC. UK training for the subsequent HECToR service was delivered by NAG, which we took as an opportunity to become a PRACE Advanced Training Centre and so began delivering training at a pan-European level.

The training pendulum swung back again with ARCHER, and we provided 446.5 days of training over more than six years of the service. Bucking the historical see-saw trend, we are also responsible for training for ARCHER2, so our national HPC training programme continues uninterrupted.

Online training

Over the years we have increased the amount of online training we provide. This started way back in 1997 with an online version of the MPI course, using technologies that

Our students' communal work space in EPCC's offices in the Bayes Centre.

Left: Teaching staff and some of the class of 2019.
Above: TeamEPCC, winners of the ISC High Performance's 2014 Student Cluster Competition's "Highest Linpack" award.

Below: 15 state-of-the-art Sun Ray 150 terminals were installed in EPCC's first teaching room in 2001.

were novel in their time to support interactive supervision and parallel programming via a browser. Under ARCHER we introduced "Virtual Tutorials", interactive webinars delivered using Blackboard Collaborate, and we also delivered entire MPI and OpenMP courses online using the same technology.

In addition to live delivery, we were funded by PRACE to develop an introductory "Supercomputing" MOOC using the FutureLearn platform. Over 1000 people completed this five-week course, supported by experienced tutors, and it is now available on-demand as an "unfacilitated" MOOC.

We have also expanded our MSc programmes online. Starting in 2015 by contributing introductory HPC and Data Science courses to the University of Edinburgh's online MSc in "Data Science, Technology and Innovation", we now offer complete versions of both our on-campus MSc programmes for part-time study online.

We always planned more online courses under ARCHER2, continuing the successful virtual tutorials and live-broadcast training and extending it with online "self-service" versions of the OpenMP and MPI courses. These courses draw on our experience from the online MSc and should both be available early in 2021.

COVID-19 challenges

With the advent of the COVID-19 pandemic we have had to move all teaching online at quite short notice. The challenge is always to maintain interaction with attendees when the delivery is not face-to-face.

Modern Virtual Learning Environments such as Collaborate allow screen-sharing and private breakout rooms, both of which go some way to reproducing the hands-on assistance that is the focus of our standard classroom-based courses. Together with embracing the Carpentries "tutor-led" methodology for hands-on, practical-based training, we hope to make these online courses every bit as interactive as their face-to-face counterparts.

Over the past three decades our training programme has evolved to react to new opportunities and challenges. It remains at the core of EPCC's activities and we hope to be able to offer a wide range of courses, in a variety of formats, to the UK HPC community and beyond for decades to come.

Although delivering all training online is not ideal, there are advantages. Compared to face-to-face teaching, courses can be more easily delivered over an extended period, and it is easier to record sessions for later use. It also offers a lower barrier to entry, requiring no travel and hence less time and money, and reducing potential overheads such as arranging childcare.

Find out more

www.epcc.ed.ac.uk/education-training

Meshing for Exascale: ELEMENT workshop

ELEMENT is one of eight “high priority use case” projects that recently received funding from EPSRC as part of the UK’s ExCALIBUR Exascale programme. ELEMENT is led by EPCC and is run in partnership with the University of Cambridge, Imperial College London, the University of Exeter, and Swansea University.

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Michèle Weiland, EPCC
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One of the key objectives of these new projects is to build communities around specific challenges that need to be addressed as we move towards the next generation of supercomputers. For ELEMENT, the high priority use case is that of “meshing”.

Virtual workshop

As part of our community-building effort, we held our first (virtual) workshop in October to discuss all aspects of meshing as we approach the Exascale era. The topic proved extremely popular, with a final registration count of 276 attendees signed up (and a consistent attendance rate of around 100 across all the sessions)!

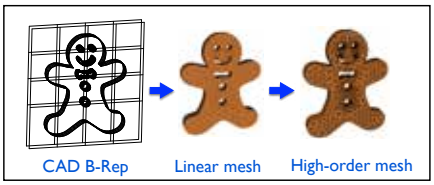
The first day focused on what changes might be coming in terms of hardware architecture and how parallelisation may be used to address challenges in generating meshes for Exascale-type problems. On the second day, topics examined the user experience of meshing software, and how this software interacts with our CAD models and adapts to our solutions. A full list of speakers and titles can be found on the ELEMENT website - select slides and video recordings have also been made available.

Each session was concluded by breakout groups to discuss the topics and seek feedback from the community to be fed directly into the ELEMENT project. This also enabled us to emulate the kind of interactions that would occur at in-person meetings whilst (unfortunately) running the meeting entirely remotely.

Although no video calls can truly replace face-to-face interaction, we had lively discussion throughout. In fact, an unforeseen benefit of conducting a workshop like this remotely was that we were free to invite industrial and academic experts and attendees from across the globe, with attendees outside Europe from Japan, China and India to Brazil, Mexico, Canada and the US.

Some of our presenters had to get up very early to deliver their talks (with only one presentation in pre-recorded format because the time difference was too great), so we are extremely grateful for their efforts.

Immediate feedback from attendees suggests they found the workshop highly enjoyable and useful. However it was only the first step in an effort to bring the community around meshing closer together. There will be more events (some of them in-person, we hope) in the next year, culminating in a paper detailing our strategic vision for Exascale meshing.



From boundary representation to higher-order meshes: the increasing power of supercomputers is enabling greater accuracy in simulation. Image: Joaquim Peiro, Imperial College London

ELEMENT

See the ELEMENT website for workshop materials

https://epcced.github.io/ELEMENT/workshops.html

Some of TAM2020's participants.
Image: Alexey Cheptsov, HLRS.

TAM2020: HPC-Europa3 Transnational Access Meeting

The HPC-Europa3 Transnational Access programme funds short collaborative research visits for computational scientists working in any discipline which can use HPC.

Former HPC-Europa visitors are invited to attend the Transnational Access Meeting (TAM), to present the results of their visits. With approximately 40% of visitors being postgraduates, for many it also provides a supportive environment for their first conference presentation.

The second HPC-Europa3 TAM was held in October 2020. Like so many other events this year, it was initially rescheduled due to the coronavirus pandemic and then changed to an online event.

While an online event does not allow the same networking opportunities as a face-to-face meeting, it can be opened up to many more attendees. Over 100 people registered, while attendance would normally be limited to around 40. The attendees included visitors to each of the nine Transnational Access partner centres, as well as host researchers and members of the selection panel.

The TAM began with a very interesting keynote talk from John Davis of the European Laboratory for Open Computer Architecture (LOCA), a new venture which aims to develop energy-efficient high-performance computing chips for future Exascale supercomputers.

Over the two days, 21 former visitors gave talks, and a further nine presented posters. The range of topics covered in the presentations reflected the multidisciplinary nature of the programme, and included:

- Unveiling tropical forests: new approaches using 3D terrestrial LiDAR
- The effect of unsteady blade row interactions on performance of multi-stage turbomachines
- Machine-learning interatomic potential for W-Mo alloys.

First post-lockdown HPC-Europa3 visitor arrives in Edinburgh

In October, EPCC welcomed the first HPC-Europa3 visitor to arrive in Edinburgh since February.

Sudip Kumar Mondal of the Jadavpur University Geodynamics group (Kolkata, India) will spend three months working on his project in collaboration with Dr Andreas Hermann of the School of Physics and Astronomy, University of Edinburgh.

HPC-Europa3 is funded by the EU.

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"Prior to my visit, email conversations with the HPC-Europa3 team at EPCC led to a hassle-free experience organising everything. After reaching Edinburgh, setting up a Cirrus account also went smoothly, thanks to Dr William Lucas of EPCC and my host Dr Andreas Hermann, who both helped me via Skype meetings during my self-isolation period."
Sudip Kumar Mondal, our first HPC-Europa3 visitor since March.

TAM2020 material:
www.hpc-europa.org/2ndTAM.

Above: the class of 2018/2019, including Holly Judge (front row, second from left), now at EPCC.

Below: Liang Liang.

Bottom: Iñaki Abadia Osta and Linda Koletsou, part of TeamEPCC at the 2018 Student Cluster Competition.

What our MSc students say

"I decided to apply to the MSc in HPC for two reasons. First, I knew that continuing my education in the UK would bring me closer to many engineering opportunities. Second, the fact that it's taught by EPCC staff gave me the confidence to decide this was the best opportunity for me.

"Today, two years after graduating, I'm grateful I made that choice. Everything I learned and all the great people I met still have an impact on my day to day work."

Iñaki Abadia Osta
MSc student 2017/2018. Now working as an engineer at Arm, Performance Modelling, CPU Group, Cambridge, UK.

"I dare not imagine I could be admitted into my current PhD programme without the knowledge and experiences from comprehensive HPC lectures, hands-on lab sessions, and the dissertation project provided by EPCC.

"With one of the most experienced teaching and research staff, combined with its cutting-edge supercomputers, EPCC enabled me to establish the fundamentals of HPC and Data Science and to build a solid base for my further academic pursuit.

"EPCC can always offer you the most enabling mentoring and guidance. As the saying goes, "life is a manifestation of where your energy is flowing". EPCC can always surround you with enthusiasm, wisdom and support to bring your career to the next level."

Liang Liang
MSc student 2019/2020. Now a PhD student at Imperial College London, focusing on Spatial Data Processing on HPC.

"The MSc in High Performance Computing course had a really good practical focus which allowed me to develop my HPC programming skills and get hands-on experience working on applications.

"I am now an HPC applications consultant at EPCC. I am currently working on scientific software development and performance benchmarking, using the skills I learned during the MSc on a daily basis."

Holly Judge
MSc student 2018/2019. Now an Applications Developer at EPCC.

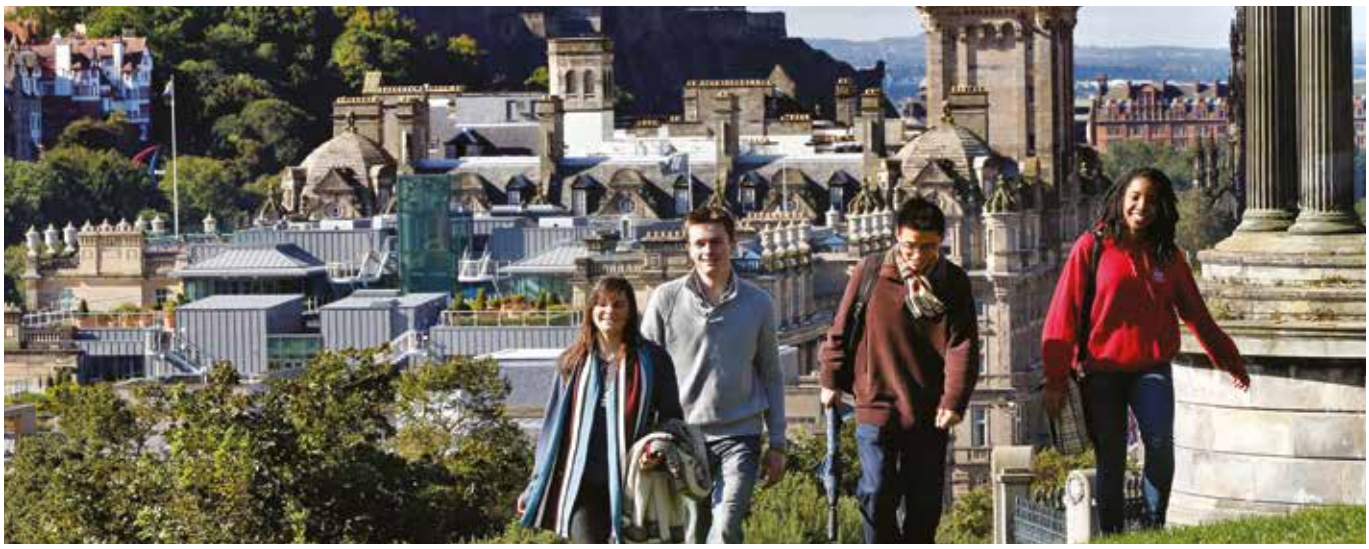

Image: Paul Dodds

Study HPC with us

Master's degrees in High Performance Computing (HPC) and in HPC with Data Science

EPCC is the UK's leading supercomputing centre. We are a major provider of HPC training in Europe, and have an international reputation for excellence in HPC education and research.

Our MSc programmes in High Performance Computing (HPC) and HPC with Data Science have a strong practical focus and provide access to leading edge systems such as ARCHER2 (the UK's National HPC Service), and Cirrus (an EPSRC Tier-2 National HPC facility including over 150 GPUs).

MSc students have the opportunity to undertake their dissertations as an industrial project, building on EPCC's strong business links. Recent project partners range from start-ups to multinationals.

Optional course choices include modules from the School of Informatics and the wider College of Science and Engineering.

Our graduates are in high demand in both academia and industry in the UK and abroad.

The University of Edinburgh is ranked in the top 30 universities in the world by both Times Higher Education World University Rankings 2021 and QS World University Rankings 2021.

"Studying the MSc in HPC at EPCC has given me the benefit of a thorough practical grounding in supercomputing and the once-in-a-lifetime opportunity to participate in the Student Cluster Competition at ISC High Performance 2018, alongside the wider opportunities afforded by the student experience at the University and in the city of Edinburgh."
Wilson Lisan, 2017/18 MSc in HPC student

"Modules covered the full range of HPC and Data Science skill sets from core 'best-practice' ways of working to the latest technologies. These were well-structured and delivered at a good pace by lecturers who were more than happy to engage in discussion in response to questions."
Dr Andy Law, Roslin Institute,
2017 MSc in HPC with Data Science graduate

www.epcc.ed.ac.uk/msc