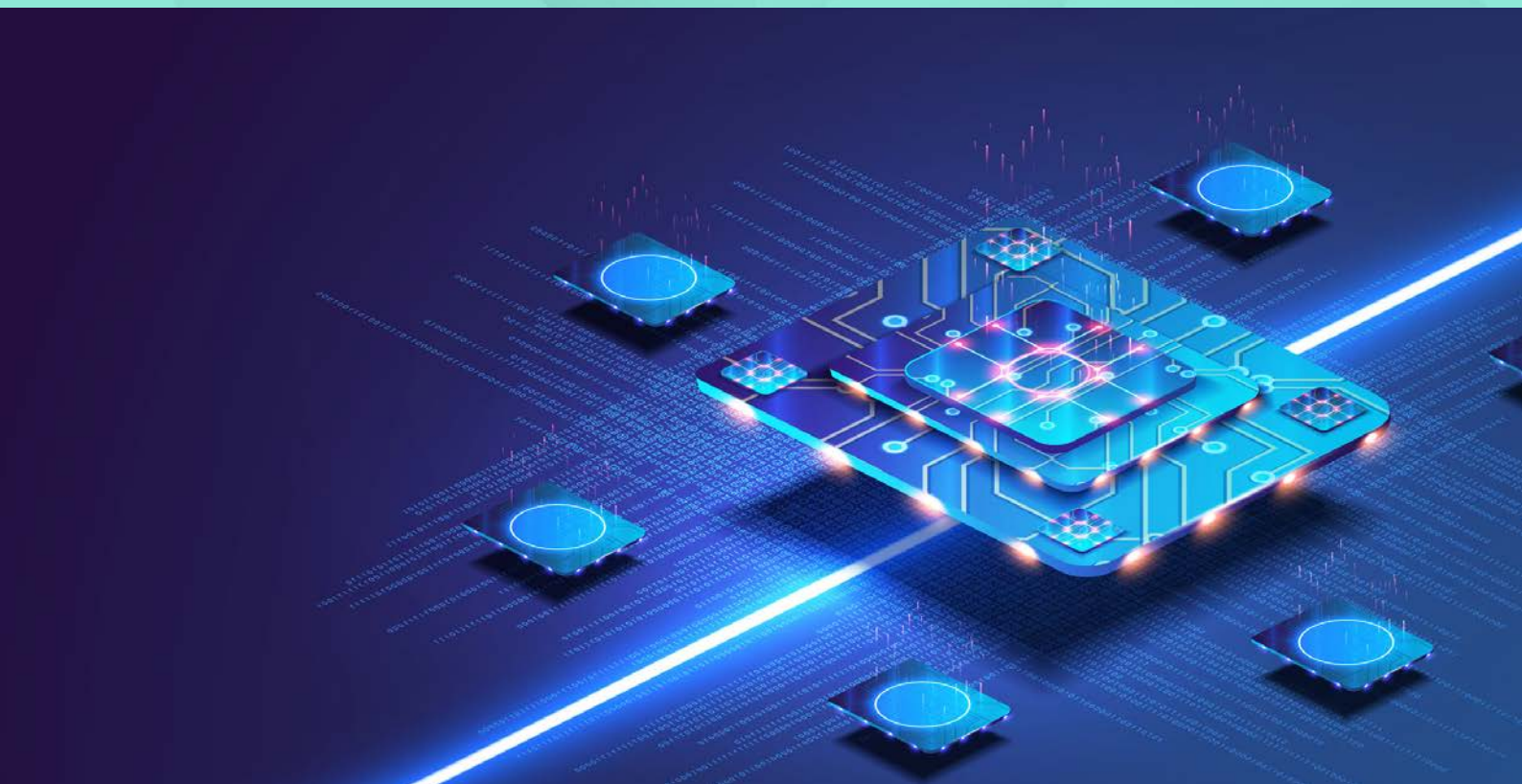
UNIVERSITY OF CAMBRIDGE

Proposal for a Computer Architecture Research Centre

@ Department of Computer Science and Technology, University of Cambridge



“Members of the Computer Architecture group have a wide range of work experience, expertise and skill sets.

As a PhD student in the group (researching near-memory processing for low-precision deep neural networks), I found this made for an enriching and dynamic learning environment where even a casual conversation about the latest technology news could yield really valuable insights.

I’m planning to go into industry, aiming to apply my knowledge to tangible and impactful projects.”

Aida Miralaei

“My research focuses on speculative parallelisation inside a processor (i.e. how hardware can find and exploit mostly independent computations beyond standard out-of-order techniques).

Working in the Computer Architecture group with skilled colleagues and an industrial partner has been ideal as it has given me both the freedom to explore my own ideas and access to feedback and guidance when needed.

After my PhD, I’m planning to apply for a postdoctoral position to continue this research.”

Márton Erdős

Why we need a new research centre

Computer architecture is a critical area of computing that underpins today's technologies and drives the next generation of computing systems. We define computer architecture broadly, encompassing the design and optimisation of general-purpose microprocessors, specialised accelerators, on-chip interconnect and memory systems, along with verification, compilation and networking.

As the National Semiconductor Strategy lays out, the UK is a leader in this field and yet there is a lack of investment nationally, despite high demand from industry. To maintain our position at the forefront of research in computer architecture we must invest in building capacity now to ensure a pipeline of leaders for tomorrow.

Cambridge is the ideal place to do this. The Department of Computer Science and Technology was the first such department in the country and has been a pioneer for over 80 years. Our research helped lay the foundations of modern computing – building the first programmable computer to come into service and leading early development of programming languages and operating systems – and continues to advance the field today in areas from AI and machine learning to quantum computing.

Our staff and alumni have set up more than 300 companies, and their contributions to computer science include the Raspberry Pi (the most successful computer ever to come out of the UK) and metaverse unicorn, Improbable Worlds.

This strong track record of innovation is evident in computer architecture too, where our collaboration with world-leading, local microprocessor company Arm on the Capability Hardware Enhanced RISC Instructions (CHERI) cyber security technology leads the UK Government's £200+ million *Digital Security by Design* programme. This was cited as a case study in the National Semiconductor Strategy as an example of 'Building on our hardware strengths to improve cyber security'.

Among the hundreds of companies to come out of the Department are the open-source hardware company lowRISC, along with dividiti, Ellexus, Embecosm, Tenison Technology EDA and KRAI, all of which are directly related to the Department's Computer Architecture group.

This combination of academic expertise and industrial links means that we are exceptionally well situated to build on the UK's strengths by training the next generation of engineers and seeding the entrepreneurs of the future.

The Computer Architecture Research Centre

As a University we attract the best and brightest students from across the world and our intellectual powerhouse is embedded within the Cambridge Cluster of over 5,000 knowledge-intensive companies. Capitalising on our uniquely fertile environment for innovation, our plan for the Department is to create a new, dedicated centre for 30–40 PhD students: the Computer Architecture Research Centre.

Our popular undergraduate degree, attracting 1,800 applications for around 130 places, combined with our Master's cohort of 100 students annually, lay the foundations of the subject for the brightest young computer scientists. The new Computer Architecture Research Centre will provide a pathway into research for these students, as well as those who have studied at other leading universities from across the globe. PhD students will be admitted either to an MPhil + PhD or direct to the PhD programme.

Our aim is for the Centre to become a locus for collaboration between companies, generating pre-competitive open-source artefacts and driving development of novel computer architectures.

We intend to establish this exciting initiative by seeking funding through unrestricted donations. In keeping with our ethos, all outputs will be open source, in order that they are maximally useful and can be developed and maintained transparently within the computing community.

A Cambridge Computer Architecture PhD has been the springboard to careers in a wide range of industries. Former students of ours have gone on to work in:

- the semiconductor industry (including AMD, Arm, Imagination Technologies, NVIDIA, SiFive and STMicroelectronics) and as part of the collaborative open-silicon engineering initiative, lowRISC
- global tech firms (Google, Meta, Microsoft)
- the financial technology sector (online bank Monzo and capital markets firm Citadel Securities)
- academia (taking up lectureships at the Universities of Bristol and Edinburgh, and Imperial College London)
- the public sector (for the UK Government's Defence Science and Technology Laboratory).

And some entrepreneurial graduates have founded their own companies, such as Azuro (now part of Cadence) and Ellexus (acquired by Altair).

Centre director and research areas

The new Centre will be directed by Timothy M Jones, Professor of Computer Architecture and Compilation within the Department of Computer Science and Technology, and a Fellow at Gonville and Caius College.

Tim's research spans computer architecture, compilers and binary modification tools, often working across different system layers. His particular focus is on extracting parallelism to improve performance, reliability and security. He has supervised 9 PhD students, and a further 5 are currently studying with him. Graduated students have found positions in academia and industrial research and production settings.

Tim has published over 70 peer-reviewed papers in the top conferences and journals in the field. He regularly serves on tier-1 conference programme committees, is Associate Editor for *IEEE Transactions on Computers* and co-editor of the Computer Architectures column in *IEEE Computer*. His research has been recognised through publication in *IEEE Micro*'s 'Top Picks from the Computer Architecture Conferences' and a recent Best Paper award at the International Symposium on Microarchitecture (MICRO) 2023.

Tim's research has been funded through grants from research councils and industry amounting to over £9 million for him as Principal Investigator. He has previously held two 5-year Fellowships from EPSRC and the Royal Academy of Engineering. He obtained his PhD from the University of Edinburgh, was Visiting Researcher at Harvard and has collaborated widely with academics and industry on joint projects, publications and PhD supervision.

The new Centre boasts a range of internationally leading academics, including Professor Simon Moore (computer architecture and security), Professor Robert Mullins (machine learning and open-source hardware), Dr Tobias Grosser (compilation and language design) and Dr Prakash Murali (quantum architecture and compilation).

Further Department research leaders with expertise in this area can be found on our website using this QR code:

Professor Timothy Jones

"The Computer Architecture Research Centre will draw on the breadth of supervisor experience from across the Department.

This will allow students freedom to explore the areas of the subject that they are most passionate about, while addressing industry-relevant research.

Alongside traditional computer architecture and microarchitecture of general-purpose cores and accelerators, we have expertise in compilers and toolchains, hardware security, applied semantics, networking, AI and quantum computing.

The students will benefit from working alongside and with each other as an integrated cohort dedicated to computer architecture."

Next steps

We are now seeking industrial supporters to fund the Centre's research via donations and to offer input on the Centre's research directions.

We invite industrial supporters to interact with the Centre in a range of ways, including:

- attending research showcase and networking events
- joining annual discussions with other supporters and faculty about future research areas and projects at the Centre
- receiving regular reports on the students' research
- offering, where appropriate, internships for students, guest lectures and workshops.

We hope that our industry supporters will form a peer group to share experiences of working with the Centre and the students.

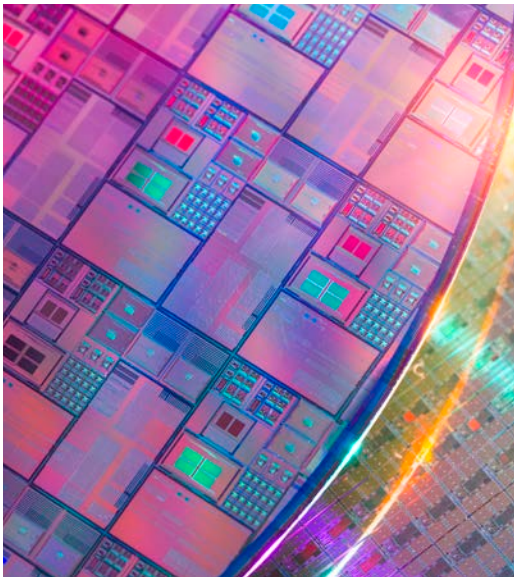
MPhil and PhD students typically apply in the autumn for entry the following year and we are planning for our first cohort to take up their places in the new Centre in the 2025–26 academic year. We are therefore seeking funding pledges now from existing and new supporters.

Funding opportunity

We are seeking funding primarily for PhD studentships. £210,000 will cover one student's fees and maintenance for up to 4 years, while £1.3 million will endow a studentship in perpetuity. In order to foster collaboration between the PhD students, we would aim for a cohort of at least 6–8 students per year, for a minimum period of 5 years. We are hoping to work with a range of industry supporters and individuals who would like to invest in our new Centre by funding PhD students.

We would also like to recruit additional postdoctoral research associates to work with the principal investigators and the students. This will increase the depth of the student-led projects through collaborations between students and research associates, and provides role models for the students to learn from and a path for advancement once their PhDs are finished.

We would be delighted for you to be involved at the beginning of this exciting new initiative.



"Computer architecture is a widely researched field at Cambridge, and being able to work with experts in so many different sub-areas has been very inspirational.

The end of my PhD seems some way off, but I'm already thinking about going into teaching. As a PhD student here, I can both discuss the latest developments with experts in the field and supervise undergraduate students – great preparation for such a career path."

Karl Mose

"I research the development of efficient binary techniques to ensure an all-encompassing security protection for applications. Being part of the Cambridge Computer Architecture group has been very valuable: I've found friendly and supportive peers and mentors whose guidance and support has helped me both personally and professionally.

As a world-leading research and technology hub, Cambridge offers a unique blend of academic and industrial perspectives, exposing me to cutting-edge research and industry trends.

After my PhD, I plan on pursuing a research role, either in industry or academia."

Mahwish Arif

"While I'm researching ways to enforce security between host computers and peripheral devices, others in my group are working on the pioneering cyber security project CHERI. They have been offering me invaluable insights into how I can make my work better while still keeping it practical.

Once I finish my PhD, I plan to go into hardware R&D in industry."

Samuel Stark

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If you would like to discuss this opportunity further please contact:

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More information about the Centre can be found on our website using this QR code:

The proposals set out in this document are indicative only and they are not intended to form the basis of a legally binding contract.