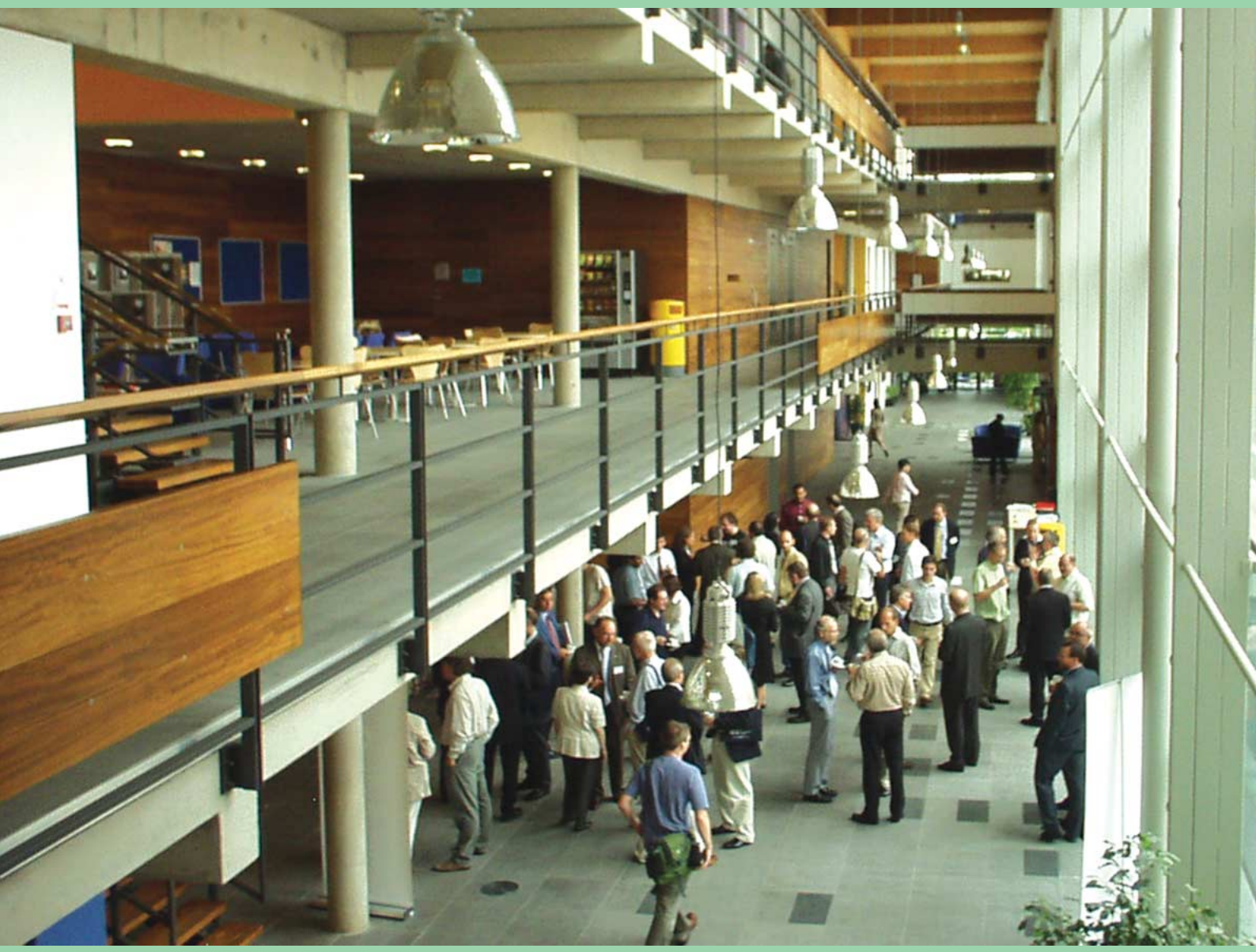
Computer Laboratory
University of Cambridge

Leaders in Computing Research and Teaching



William Gates Building
JJ Thomson Avenue
Cambridge CB3 0FD, UK
+44 (0)1223 763 500

http://www.cl.cam.ac.uk

The Laboratory

The Laboratory has been an international leader in Computer Science and Technology for more than half a century. The EDSAC 1, built by Maurice Wilkes and his team, came on stream in May 1949. This was the world's first complete and fully operational regular electronic digital stored program computer. Since then the Laboratory, under Wilkes and his successors as heads of department Roger Needham, Robin Milner and Ian Leslie, has continued at the forefront of research in computer systems and theoretical computer science. Its staff members have included two Turing Award winners, recipients of other international awards, Fellows of the Royal Society, the Royal Academy of Engineering, the British Academy and other academies and societies. Its students have become research leaders throughout the world and have established internationally successful businesses.

The Laboratory, under its current head Andy Hopper, has 35 University teaching officers, 40 research staff, over 100 doctoral students in residence, and 350 students, mainly undergraduates, on taught courses.

The Laboratory's Vision of the Future

The development of computing, and information and communications technology as a whole, depends on reinvention and transformation to drive innovation. There is not just more of everything – more processors on a chip, more connections, more calculations, more data. Progress has also meant rethinking relations between different system elements, like hardware and software, or between different layers, like operating system and applications, or computer and network.

The Laboratory's research is committed to rethinking what computers are like, what they do, and how they do it. This involves work on formal theory and practical implementation, on system operation and user advantage, and on human-computer relationships. Our research vision for the future is focused on the idea of sustainable development, both technically in computing itself and for the world: making computer systems themselves sustainable because they are more flexible, more robust, and more adaptive; making computing applications more sustainable because they fit with the physical and social constraints imposed by their environments; and making societies and economies more sustainable by applying computers to the best use of natural, technical and human resources. Thus we are researching across the spectrum from hardware compilation to biological modelling.

The Laboratory is equally committed to ensuring that its students are fully informed about the current state of the art, and are thoroughly equipped to meet the challenges of the future. We will continue to ensure that they have a proper training in both principles and practice – for example in system theory, design and engineering – to contribute as computer science and technology professionals to all areas of employment where computing has or acquires a role. We will continue to educate our graduate students so that they will be the innovators of the future. We believe that by continuing at the forefront of computing and computer science research we will both advance the field itself and ensure that our teaching is forward-looking and of high quality, so that our graduates will meet the emerging technical, economic and social challenges that global-scale information and communications technologies bring.

The Laboratory's Research

The Laboratory's research is internationally recognised, and in the highest official UK rating class. The Laboratory is active in many interrelated areas that that are key to realising its vision of the future. This research, summarised below with some example funded projects, ranges over the whole computing field.

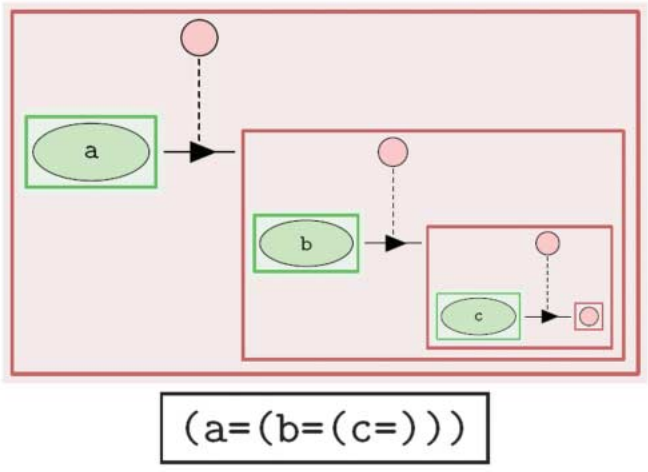
Systems and communications

Architectures for pervasive and mobile computing

How unobtrusive, efficient, and useful can having microdevices everywhere be? For what? For whom? We can envisage these devices, including sensors, and people linked in adaptive and personalised ways. We are working on chip designs for microdevices with, for example, low power consumption and high security, on program tools for handling device interactions in ubiquitous systems, and on generating user value from these systems.

Sentient computing

Secure systems using polysilicon TFTs on polymer substrates



Data storage architecture

Wireless engineering

What are the simplest and cheapest ways of connecting computers? Wireless communication is revolutionising the form and use of computing systems. We are working to model and manage complex wireless phenomena like propagation, interference, and space-time interaction so we can have effective and efficient network systems.

Capacity and throughput improvement techniques for broadband fixed wireless access systems

Network structures and modelling

How should networks be modelled, concurrent processes be managed, reliability be achieved? As networks become ever more heterogeneous we need better ways of monitoring, pricing and routing traffic flows. We are working on methods of managing networks when, as now, there cannot be global control of where data is kept or computation done and when large processes have to be boot-strapped from local communications.

Futuregrid – a programme for long-term research into grid systems

Operating systems

What should operating systems for today's distributed and even virtual machines be like? As computer systems embrace ever more varied devices or data types like multimedia, and spread over networks, operative systems have to be more powerful but also more flexible. We are working on operating systems that can monitor and manage, in a coherent and seamless way, anything from smart input and output devices through multiple real-time high-volume data stream to global networks.

Design and implementation of virtual machines

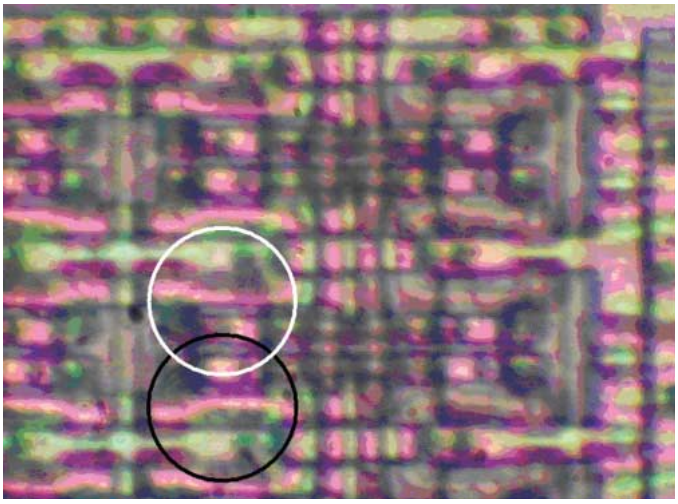
IPV4 and IPV6 performance and QoS – 46PAQ

Widely distributed applications

How can distributed resources be reached and utilised, user access be facilitated but security maintained? What's needed for good middleware to support large applications like health data systems? We are working with general notions like policy, event, role and metadata as effective ways of organising multiple processes, defining user access, and maintaining data for use and reuse.

TIME-EACM – a transport information monitoring environment: event architecture and context management

CareGrid – autonomous trust domains for healthcare applications



Undermining static RAM security

Security and cryptography

What do we mean by secure systems, and how can we make sure supposedly secure systems are actually secure? How can we build systems that protect transaction integrity, safety and privacy in the face of human failings, but are also practical, convenient to use and easy to maintain? Security devices and processes are becoming ubiquitous. We are developing methods and tools for testing security components ranging from smart cards to user interfaces, for integrating components into complete systems, and for modelling system-wide security in economic and policy terms.

The security of crypto APIs

Formal models, languages and methods

Theory and semantics

What are good concepts and formal, mathematical foundations for large heterogenous systems, for micro mobile agents, for computing per se? Can we apply existing mathematical approaches and logics, or does computing need new ones? We are exploring models of computation, ways of characterising algorithms and the combinatorial implications of complex processes. We are working on the semantics of programming languages so we can reason about program behaviour and data structures, and building formal tools for system understanding and checking from low-level operations through policy applications to the global activity of interacting networks.

NetSem – rigorous semantics for real systems

Domain theory for concurrency – new categorical foundations

Automated reasoning

Given system specifications in principle and system implementations in practice, how can one prove they are correct and consistent? How can one reason effectively about the behaviour of populations of computational agents, or about system behaviour together with human interaction? Do we want more features or better ways of capturing the user's intentions? We are applying automatic and interactive theorem-proving tools to show that programs meet their specifications and that crucial components like security protocols are soundly implemented; and we are examining human problem solving as a means of enhancing formal provers.

Formal specification and verification of ARM-based systems

Automation for interactive proof

Programming languages and processes

How should the tools for software and the languages on which this depends be viewed, designed, and implemented? Do we want ever more features, or better ways of capturing the user's intentions? We are working on algorithms and data structures for more efficient and powerful compilers, interpreters and other tools that can be applied, in software and hardware, to build programs.

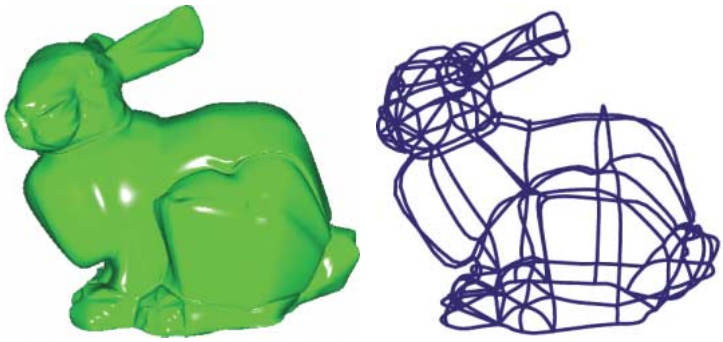
Higher-level languages for network processors

Language and vision, communication and interaction

Intelligent systems, learning systems

How can patterns be identified in noisy data? How can systems learn from their experience and the masses of data to which they are exposed? What computational models are there for animate behaviour that can be used to inform system design, extend machine capabilities or understand biological agents? Our research on pattern analysis and automated learning underpins practical applications to images, as in iris coding, and work on interpreting biological data, processes and organisms.

Iris recognition



Approximating smooth curves

Natural language information processing

Can computers respond to, or deploy, language in ways that help humans gather, manage, or produce information? How can texts be summarised, facts extracted from them, or questions answered? We are applying robust processing tools like statistically-based parsers to extract information nuggets from complex scientific text, and exploring the ways text is organised to present and signal important content.

ACLEX – accurate and comprehensive lexical classification for natural language processing applications

Extracting the science from scientific publications

Graphics, visualisation and designing systems for people

What makes visual displays well engineered for humans and for machines? What methodologies and technologies promote good system design and hence effective system use? We are studying both surface modelling and human behaviour data to get better images and animation. We are exploiting both graphical presentation techniques and other information, for example about human emotions, to enhance human-computer interaction for individuals and in group collaboration. We are also developing more general design principles and methods, drawing on social science insights, for building practical and usable application technologies and systems.

Geometry-sensitive subdivision schemes for three-dimensional modelling

Facial affect inference

The Laboratory's Teaching, Students and Alumni

The Laboratory's teaching quality is officially rated excellent. The main undergraduate course is a three-year honours degree in Computer Science. It covers all major areas of the subject in both theory and practice, and includes both group and individual projects. Current graduate courses include the long-standing Diploma in Computer Science and the MPhil in Computer Speech, Text and Internet Technology. An optional fourth year in Computer Science, leading to an MPhil is being introduced, intended as a preliminary training for research. Recent national award winners for undergraduate dissertations include

Hanna Wallach: Visual representation of computer aided design constraints

James Murphy: Modelling smoke in computer graphics

Cambridge graduates in Computer Science are eminently employable, and past students are to be found throughout the world in ICT and ICT-related technical and management positions like

Staff position at Barclays Bank

Technical/management job at John Lewis

Staff post at the Royal Society

and some have set up companies soon after on graduating, for example

Jagex

Azuro, Mountain View CA

Hardware lab

The Laboratory's doctoral research has been at the forefront of the field since its first PhD students helped to build the EDSAC 1. Recent theses include

Joe Hurd: Formal verification of probabilistic algorithms

Christopher Town: Ontology based visual information processing

and a British Computer Society Distinguished Dissertation

Keir Fraser: Practical lock-freedom

The Laboratory's postgraduates have continued to leading academic positions, and to academic, public, commercial and industrial research, for example

Researcher at Google Headquarters

Senior manager at IBM TJ Watson Laboratories

Managing Director, Microsoft Research Ltd

Head of Bibliotheca Alexandria IT Department

Holder of EPSRC Advanced Research Fellowship

The Laboratory has a flourishing Graduate Association, the Cambridge Computer Lab Ring.

The Laboratory's Collaborations and Projects

Since its beginning the Laboratory has interacted with other universities and with companies, and has collaborated both nationally and internationally in many different projects, as well as in interdisciplinary work within Cambridge itself. Current work includes joint research with many colleagues throughout Europe, in Japan and in the USA, for instance through the Cambridge-MIT Initiative projects.

Communications Research Network

MINGLE (Multiresolution in geometric modelling) Network

Cambridge Computational Biology Institute

Companies involved in recent and current funded projects include Boeing, BT, IBM, Intel, NTT, Sun and Thales.

The Laboratory has been notably successful in winning research support from many funding agencies for innovative projects from the foundational to the 'ready to go'. Recent cases include

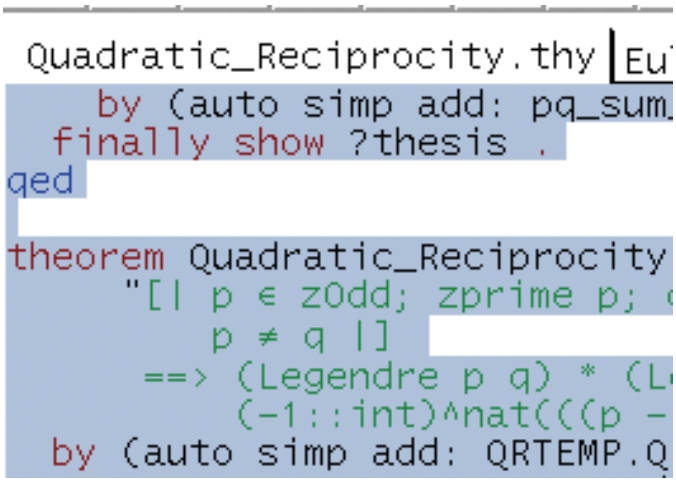
Verifying electronic commerce protocols

Personal projected displays

The Laboratory's Entrepreneurship and Company Connections

The Laboratory has long been at the heart of the Cambridge Phenomenon, as a major player in the Cambridge high-tech area. Laboratory graduates have founded over 120 companies, and the Laboratory has many connections with international and national companies extending far beyond specific funded projects. Companies founded by Laboratory members in the last twenty-five years include

Apama, APM, Applied Generics, Artimi, Bango.net, Blue Compass, Cedalion, Codian, CPLANE, Creature House (Hong Kong), Curious Software, Electronic Share Information, Envisional, Equisys, FORE, Greenstreet Software, Iridian Technologies, Jawasoft (Jakarta), Level5 Networks, Linguamatics, MessageLabs, Metrica Systems, Muscat, Nemesys, Patientline, Ncipher, nGame, Operis Group, Questionmark, Real VNC, Sophos, SoftForum (Seoul), Tenison Technology, Tideway, Virata, XenSource, Zeus



Theorem proving tool

The Laboratory intends to continue at the leading edge in Computing and Computer Science research.

For this, support for PhD students is essential

Our Appeal: The 2009 Computer Laboratory Research Students Fund

PhD students are vital to the Laboratory's research. They are the creative base on which it is built. As they develop and test new ideas, PhD students stimulate the Laboratory's larger research effort and contribute to the advance of the field we aim to achieve.

As a major research department we attract applications from the best students, worldwide, who want to work at the leading edge in computer science and technology. We cannot fund enough of them. We have enterprising research staff wanting to take on more students, the space to house them, and the technical facilities for their work. But we need money to support more of the top-flight doctoral students who seek to come here.

Funding from external sources is variable and often limited. We need to be able to offer our own student funds to the best students from here and elsewhere, to give them, and us, the freedom to develop new research areas. PhD students currently cost, in fees and living expenses, about £25,000 per annum. With half a million pounds capital we can provide full support for one student, or material support for three, making it easier for the students we want to come here.

We want to build our Research Students Fund to celebrate the 70th anniversary of our foundation, in 1937, as the Mathematical Laboratory, as well as to mark the University's 800th Anniversary in 2009. Help us to ensure that the Laboratory remains at the forefront of the field, so that Computer Science and Technology get the top-quality players they need.

FOR FURTHER INFORMATION ABOUT GIVING, CONTACT

Professor Andy Hopper
Computer Laboratory
Tel: +44 (0)1223 334 607
Email: appeal2009@cl.cam.ac.uk

The Laboratory's Appeal is one of the projects in the University's 800th Anniversary Campaign portfolio. Support for students is a major theme in the University's Anniversary Campaign.

Printed by Cambridge University Press. www.cambridge.org/printing
December 2006