Microsoft Research

Turning ideas into reality at Microsoft Research Cambridge

Microsoft Research CAMBRIDGE 10 year anniversary

Microsoft

Contents

Rick Rashid
Senior Vice President
Microsoft Research

'It is here at Microsoft Research that some of the most intriguing scenarios for information technology are being conceived and pursued. As demonstrated by hundreds of inventions that have advanced computer science and enriched Microsoft products, our team is rich with talent and widely recognised among our peers in academia and beyond.' — Rick Rashid

Microsoft Research around the world

The Cutting Edge of Innovation

Numbering more than 700 people at five laboratories on three continents, Microsoft Research has grown steadily since its founding in 1991. We are now one of the largest, most highly respected software research organisations in the world.

Backed by a steadfast corporate commitment to research, our mission is threefold: to advance the state of the art in our chosen fields of research, to contribute to the enhancement and evolution of Microsoft software, and to ensure that Microsoft has a vision for — and a role in — the future of technology.

Microsoft's research labs are unique among corporate research facilities, balancing an open and largely unconstrained research environment with an effective process for transferring the results of our work to product development. Our researchers have contributed to virtually every product the company has developed, from Windows Vista™ and the 2007 Office system to the Microsoft SQL Server™ database. They have been instrumental in the creation of software development tools for products such as Xbox®, MSN®, Tablet PC and SPOT. And they are breaking down barriers between people and technology through innovations in emerging product categories, such as the tabletop Surface computer. Through these products and many more, Microsoft Research is shaping the way the world works.

Our researchers are by no means walled off from the outside world. Through a variety of programmes, Microsoft Research collaborates with universities, industry and governments to support research in computing and computational sciences. One way we achieve this is through the creation of research institutes, each of which is focused on a specific area of investigation to help solve some of the toughest challenges in computing.

Microsoft researchers actively participate in external peer review, publishing prolifically and attending conferences to exchange ideas with researchers the world over. By conducting top-tier research and engaging with the broader research community, Microsoft Research prides itself on identifying key challenges, exploring possibilities and building a foundation for the future of computing.

Research Laboratories

China

- **Beijing** — Since its establishment in 1998, Microsoft Research Asia has attracted over 300 top-calibre researchers and scientists. The lab puts considerable resources towards cultivating new research talent in the Asia-Pacific region, through its large-scale PhD and post-doctoral programmes. Among the lab's key research areas are computer graphics, user interface, speech, multimedia and web search.

India

- **Bangalore** — Established in 2005, Microsoft Research India employs approximately 50 researchers and support staff, and a large number of interns. The lab focuses on six major areas of research: cryptography, security and algorithms; digital geographics; mobility, networks and systems; multilingual systems; rigorous software engineering; and technology for emerging markets.

United Kingdom

- **Cambridge** — Microsoft Research Cambridge was founded in 1997 and employs over 100 researchers. Strengths at the Cambridge lab include machine learning, security, information retrieval, operating systems, human-computer interaction, programming techniques and networking.

United States

- **Redmond** — Microsoft Research originated at the company's Redmond headquarters, near Seattle, in 1991, and today the Redmond lab boasts the largest concentration of researchers and breadth of research areas across the company. Microsoft was one of the first software companies to create its own computer-science research organisation, in pursuit of technical breakthroughs upon which future products — and technology-enabled lifestyles — would be built.

- **Silicon Valley** — Established in Mountain View, California, in 2001, this lab employs over 40 researchers who are advancing the state of the art in distributed computing and related fields. Areas of focus include web search, datacentre-scale computing, concurrent programming, security and privacy. Researchers at the Silicon Valley lab have made many significant contributions to MSN, Hotmail® and Windows Live™.

Andrew Herbert
Microsoft Distinguished Engineer and Managing Director Microsoft Research Cambridge

'Our priority at Microsoft Research Cambridge is technical excellence. By assembling a team of leading researchers in computer science, computational science, social science and mathematics, we have established an outstanding and highly productive European research centre.' — Andrew Herbert

Microsoft Research Cambridge

A World-Class Research Laboratory

One of Europe's renowned centres of higher learning, Cambridge, UK, is an appropriate setting for Microsoft's flagship research laboratory in Europe. Here, with nearly 100 researchers representing many nationalities, world-leading software research is taking place.

Our researchers are continually pushing the boundaries of computer science, in areas as diverse as bioinformatics, large-scale networks and applied games. Over time, the lab has created many technologies that the company has taken into new or enhanced products, or licensed to other companies.

We are in the business of innovation, and through both the talent of our researchers and our links with academic institutions, governments and industry partners across the region, we aim to create software technologies that improve the way the world works, plays and relaxes.

Advancing the State of the Art

One of the realities of software is that the underlying technology on which it runs is constantly evolving, and periodically goes through major revolutions. One such revolution is happening right now. For example, multi-core processing is becoming mainstream, practically everything is networked, and huge breakthroughs have occurred in display technology, computer vision and software verification to name just a few areas.

Opportunities for continued research and development are never-ending, which accounts, in part, for the steady growth of Microsoft Research in Cambridge and around the world. Just as the PC was a revolutionary step for computers in the age of mainframes, we're on the threshold of another set of transformations that govern what a computer is and the ways it can be used.

Christopher Bishop
Deputy Managing Director
Microsoft Research Cambridge

Ken Wood
Deputy Managing Director
Microsoft Research Cambridge

Top Minds Finding Technical Solutions

Microsoft Research Cambridge attracts some of the top minds in computing and related mathematical, technology and social science disciplines. The lab is a destination for emerging talent, a place where younger researchers can work with established figures in their field and contribute to meaningful research and product incubation that promises to benefit millions of people and businesses.

The lab boasts three fellows of the Royal Society, four fellows of the Royal Academy of Engineering and two fellows of the Association for Computing Machinery (ACM). These honours, in addition to numerous awards held by the Cambridge staff, reflect the esteem by which our staff are held in the larger research community.

Freedom of Enquiry

Compared with the research arms of many companies, Microsoft Research has remarkable freedom to set its own agenda, which opens up our work to a broad set of topics. Our researchers work across more than 55 areas of research in an open and highly collaborative environment.

Our researchers subject their research to the rigours of external peer review. Microsoft Research Cambridge produces more than 70 papers per year, which are published in leading academic journals and at important conferences. In some research areas, such as computer graphics and computer vision, Microsoft is the leading contributor of new work.

Although most researchers at the lab pursue long-term goals that extend far beyond current product cycles, they also work closely with product development groups at Microsoft to help turn research discoveries into deliverable technology. And no matter how far-reaching or abstract their projects might be, they consistently strive for results that eventually provide practical benefit, solving some of the greatest challenges of computer science.

Sir Tony Hoare
Principal Researcher

'Up to now, the best research in computer science has been within the capability of a single scientist or small team. The subject has now reached a level of scientific maturity that it can benefit, like other branches of "big science", from wider and longer-term international collaboration. Microsoft Research has shown the way, triggering the most promising and most exciting forms of international collaboration.' — Sir Tony Hoare

Cultivating creativity and innovation

Sowing the Seeds of Future Products

Our ability to conduct industry-leading research would be severely limited if we worked in a vacuum. We therefore embrace a philosophy of collaboration with academic, government and commercial institutions on a broad range of research programmes.

Much of the work done at the Cambridge lab can be described as precompetitive research, in which the raw science is still being worked out, before the stage of commercialising particular inventions. This is when broad collaboration is most beneficial.

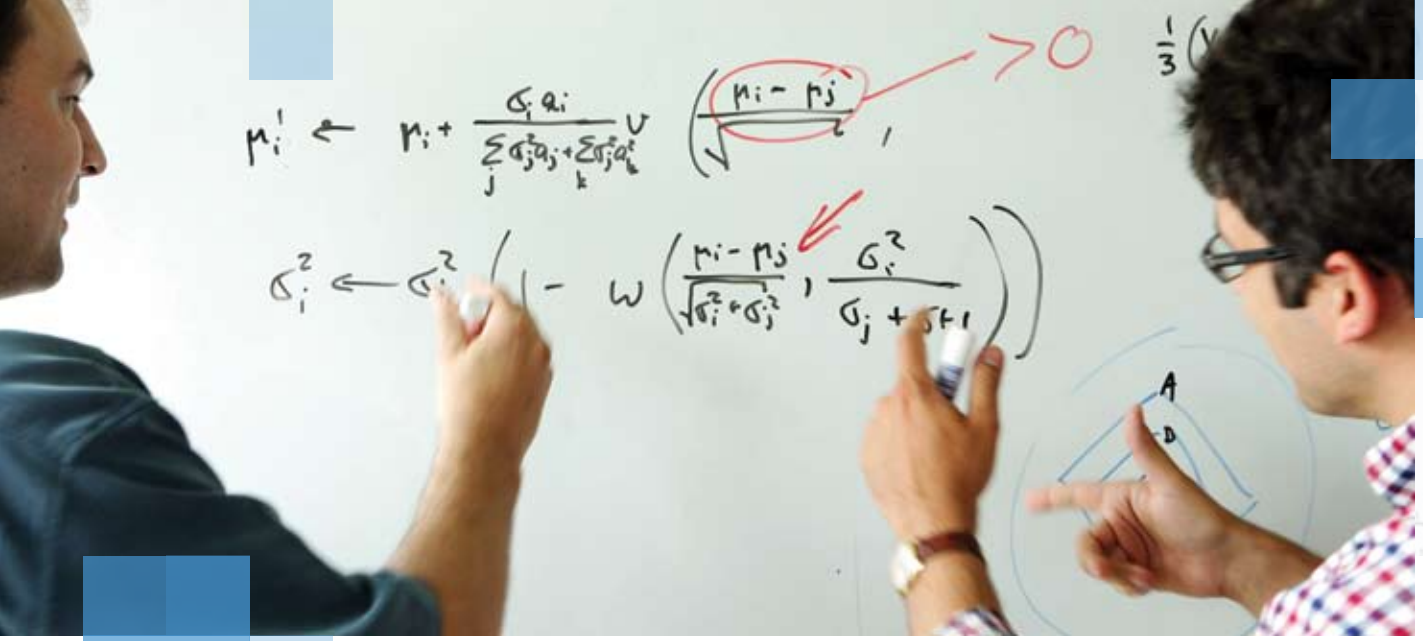
Microsoft also contributes by helping university researchers set the research agenda by communicating real-world issues and concerns, and by helping universities ensure they are providing relevant training that prepares students for the job market.

Joint Research Institutes

Microsoft Research has co-founded two research institutes in Europe that serve as centres of excellence in emerging areas of computational science.

- **Italy** — The Microsoft Research – University of Trento Centre for Computational and Systems Biology was established in collaboration with the Italian government and the Provincia Autonoma di Trento, with cultural and scientific contributions from the University of Trento. Research at the institute focuses on computational technology in the converging areas of IT, biotechnology and medicine.

- **France** — The Microsoft Research-INRIA Joint Centre was founded by INRIA (the French National Research Institute for Computer Science and Applied Mathematics), Microsoft France and Microsoft Research Cambridge. The objective of the institute is to pursue fundamental long-term research in formal methods, software security and the application of computer science research to science.



Software Research — What Is It?

All research begins with curiosity — the desire to understand. At Microsoft Research, our work results in ideas, technologies and, often, prototypes that demonstrate practical uses of our discoveries. What we do is called fundamental research, and it takes two forms.

Pure basic research is about improving understanding. It begins with open-ended questions such as: How can I use mathematics to model software and prove a program is correct? Why is voice recognition so difficult?

The other path is often referred to as **use-inspired basic research**. This approach starts with a more practical, user-focused problem for which a solution cannot simply be engineered: How can we reduce the cost of computing? What is the right model for computing in emerging economies? How can we build cars that don't crash, using software technology?

Researchers, through their training and skills, know how to pull apart questions like these. They think of reasons, conduct experiments and learn from them. They develop insights and eventually create technical building blocks. Then they consider the implications of their results for Microsoft products and strategies. Ultimately, they may create prototypes to establish proof-of-concept and assist software developers in preparing the technology for the marketplace — as a new product, or as a new feature within existing software.

A classic example of pure basic research is the work in nuclear physics in the mid-20th century, investigating the structure of the atom. At the time, nobody knew what the implications would be, but that research spawned advances including nuclear power and microelectronics. Louis Pasteur's investigation of germs and infectious diseases was use-inspired. He wanted to know why people die of diseases like cow pox. His research yielded the discovery of vaccination and modern medicine.

In contrast to the work we do here at Microsoft Research Cambridge, software development engineers use the insights, techniques, technologies and tools that have come out of research to build new products, which is why technology transfer is so important to Microsoft Research.

Abigail Sellen
Senior Researcher

'People used to talk about software design in terms of user-friendliness and making people productive and efficient. Our group recognises a more diverse set of human needs and values — using technology not so much to solve problems but to create new experiences that people find motivating and compelling.' — Abigail Sellen

Living with technology

Enhancing People's Everyday Lives

The Computer-Mediated Living group at Microsoft Research Cambridge investigates new kinds of hardware and software to enhance people's everyday lives. The group includes experts from the fields of psychology, sociology, design, computer science and hardware engineering.

Computer-Mediated Living has three component research teams, with complementary approaches to user-centred design:

- **Socio-Digital Systems**
- **Sensors & Devices**
- **Integrated Systems**

Socio-Digital Systems

The essence of Socio-Digital Systems (SDS) research is observing what people do in everyday life and considering how technology can enhance their experience, without taking it over. The SDS team brings together psychology, sociology, design, computer science and hardware engineering to explore the relationship between people and technology. This work is not anchored in metaphors (e.g., bringing the desktop to your computer screen), but focuses on the physical and social world to inform the design of new hardware and software systems that often result in entirely new kinds of artefacts. For example, SDS team members have created new twists on ordinary objects such as answering machines, shoeboxes of photographs, mirrors and kitchen calendars.

- **www.research.microsoft.com/cml**

HomeNote

HomeNote is a prototype device developed by the Socio-Digital Systems team at Microsoft Research Cambridge that displays messages received from mobile phones. It also allows users to write notes on the display screen with a stylus. We envision such a device being used by busy families in central places in the home, such as the kitchen. Long term testing of HomeNote in real households showed its value in supporting family awareness, and in allowing family and friends to send affectionate notes to one another. It also virtually replaced the use of paper notes for the family, acting as an electronic whiteboard for messages and reminders.

Sensors and Devices

The remit of the Sensors and Devices group is to conduct applied research into all aspects of embedded hardware. The team's interests are wide-ranging and include sensors, novel displays, wireless communications, and ubiquitous and mobile devices, as well as the systems issues that result as these are combined. Uniting technological expertise in hardware with sensitivities and insights into the use of the resulting technology, the Sensors and Devices group creates solutions that are of direct relevance to both end users and the research community.

One innovation developed by this group is SenseCam, a wearable digital camera that takes photos automatically. Originally conceived by former Microsoft researcher Lyndsay Williams as a personal 'black box' accident recorder, it became clear that SenseCam had potential as a powerful memory stimulant for people with severe memory loss. The group is running clinical trials of the technology in conjunction with Addenbrooke's Hospital Cambridge, and further developing the SenseCam hardware and software. To date, the trials have confirmed the potential of SenseCam as a memory aid for patients with conditions such as amnesia and Alzheimer's disease.

Integrated Systems

Computer systems and applications often comprise technologies that stem from multiple ideas and research areas, and these components require integration of algorithms, designs and technologies. Still, research projects that cross the boundaries of well-defined disciplines come about rather infrequently. The Integrated Systems team takes advantage of complementary research areas to achieve more effective and natural use of computer technology.

Their research includes design and technologies for supporting online communities and novel ways of communication across mobile and desktop devices. Content exchanged through blogs, discussion groups, or forums provides valuable information about individual and collective opinions of online communities. Applying text mining techniques to messages and analysing social structure of communities, Microsoft researchers can identify hot topics and visualise how they evolve over time. Furthermore, by exploiting rich feature sets of mobile devices and Web services, they created a highly personal and rich exchange of media messages. Through subtle and continuous communication, individuals can share and draw other people into their personal experience.

Rich Williams
Head of Computational Ecological and Environmental Sciences Group

'To respond effectively to the global environmental pressures we face today, a deeper understanding of the complex network of living systems on earth is essential. Progress will be underpinned by novel computational tools and techniques — from tools to integrate diverse sources of ecological data to new methods for modelling biological systems.' — Rich Williams

Accelerating new kinds of science

External Research Office

The External Research Office at Microsoft Research Cambridge is a new part of Microsoft Research established to lead the new challenge of creating, enabling and accelerating scientific and technological advances at the intersection of computing and the sciences, and in doing so make a valuable contribution to addressing some of the most important scientific and technological challenges and opportunities for the 21st century.

It has begun with a strong focus on the following areas:

- **Computational Biology**
- **Ecological and Environmental Sciences**
- **Biological Computation**

- **www.research.microsoft.com/ero**

Computational Biology

Despite over a century of intense scientific activity that has created astounding advances in molecular biology, scientists are still far from having a full understanding of complex living systems. Indeed, we still do not know how a living cell works. As a consequence, we have a long way to go in understanding the aetiology of disease, and therefore how to best treat and beat common diseases — from cancer to dementia to malaria. Complex biological systems have refused to reveal their most detailed workings through traditional, well established scientific approaches, and radically new scientific methods and tools are needed to fully understand biology and disease. The Computational Biology group at Microsoft Research Cambridge is exploring new ways in which to study, model and understand complex living systems. Specifically, we are investigating new kinds of conceptual and technological methods and tools that can underpin fundamental advances in understanding complex living systems. Our research is already creating exciting and highly promising insights into immune system function, metabolic pathways and the cell cycle in collaboration with leading research laboratories worldwide.

Towards 2020 Science

In the summer of 2005, Microsoft Research Cambridge brought together some of the world's leading scientists to think about how science can better help address our most urgent and important global challenges and what needs to happen in science in order to do so. The result of this group's considerations, analysis and assessment was a vision and roadmap for science and computer science towards 2020. This work was published as Towards 2020 Science, which sets out what is needed to accelerate scientific advances through enabling what could even be called 'new kinds' of science emerging at the intersection of traditional scientific disciplines, and at the intersection of computing and science, creating entirely new approaches, methods and conceptual and technological tools in science.

The Towards 2020 Science report has become a highly influential and widely read publication, cited and used by scientists, policy makers and students worldwide as a valuable guide and source of information for new directions in science and computing.

Ecological and Environmental Sciences

The Earth's biosphere is undergoing rapid change. Understanding these changes, their consequences and how to prevent the loss of our life-support system is probably the most important global challenge for the 21st century. But we currently have only a partial understanding of the nature, scale and consequences of changes already happening to the Earth's climate, food systems, biodiversity and ecosystems. And we understand even less about future changes from increasing human activities and their impact. To help address this challenge, the Ecological and Environmental Science group is pioneering, in collaboration with leading scientists worldwide, new scientific and technological approaches, and novel computational tools and methods to better understand the changes occurring to the Earth's biosphere, and to provide information urgently needed by policy makers to devise effective strategies in response.

Biological Computation

How biology 'does' information processing is a question not just of interest to biologists. Challenges for future computing systems have elegant analogies and solutions in biology, such as complexity, evolution, resilience, fault tolerance, adaptation and learning. It is therefore of increasing interest in computer science. In fact, it is possible that fundamental, paradigm-shifting innovations in computing and information technology might stem from lessons computer scientists can learn from the way biology does it — how nearly 4 billion years of nature's own R&D created such impressive computation and information processing systems. In the long term, it might be possible not only to build far more powerful computers using some of the lessons learned from biological systems, but to do computing using biological material, creating entirely new kinds of computers that are capable of performing computations and information processing that we can only dream of today with silicon and software. We are starting to explore some of these long-term but extremely exciting possibilities.

Antonio Criminisi
Researcher

'By helping machines to see and learn by themselves, all kinds of scenarios for computer-assisted living open up — blind people who walk more safely in cities, machines that learn their operators' likes and dislikes, cameras that take the perfect shot in all conditions, security cameras that detect suspicious behaviour and alert the police. All of these will one day become reality.' — Antonio Criminisi

Helping computers perceive and react

Machine Learning and Perception

The Machine Learning and Perception group at Microsoft Research Cambridge conducts research in four closely related areas:

- **Applied Games**
- **Machine Learning**
- **Computer Vision**
- **Information Retrieval**

Applied Games

The more that computer-based games are able to reflect human behaviour, the more engaging, challenging and immersive they can be. Enabling game characters and virtual environments to react in the way players would expect is the central focus of the Applied Games group at Microsoft Research Cambridge. The team is developing advanced applications to improve game play, player ranking and analysis in video games (such as Xbox) and traditional games (such as Go) to create more competitive environments.

- **www.research.microsoft.com/mlp**

Machine Learning

Many computer tasks, such as recognising objects in an image or identifying subtle relationships within large data sets, can be too complex to solve directly. Instead, we employ statistical techniques which allow the computer to learn an appropriate solution automatically. The Machine Learning group at Microsoft Research Cambridge has particular strengths in the Bayesian approach to machine learning and in the use of techniques based on graphical models. Much of the group's research is concerned with new algorithms for machine learning, and with the efficient implementation of these algorithms in flexible software environments.

As well as being an important research field in its own right, machine learning also plays an important role in several other areas of the lab's research. For example, the group is using machine learning techniques to analyse, understand and model biological systems, with specific emphasis on the function of the human genome and its relation to common diseases, in order to aid medical research and treatment.

AutoCollage

Digital cameras and modern computers allow people to take and store digital photos easily. However, as photo collections grow, so does the need to summarise, visualise and browse through such collections in a user-friendly way. AutoCollage is a novel framework for creating a photomontage automatically from a large collection of different input images. The collage can be used as a smart thumbnail viewer of the photo collection or for image retrieval.

The aim is for the resulting collage to be representative of the collection, summarising its main themes. It is constructed from informative input image regions, where the term informative is defined by state-of-the-art scene understanding. The composition of the collage is cast as an energy minimisation problem, which is solved using latest technology such as graph cuts, constraint satisfaction and Poisson Image Blending.

Computer Vision

Vision is the study of how computers can be programmed to understand and react to images and video. At Microsoft we take an approach that spans the range from theory to practice. Theoretically we are interested in questions such as how different types of texture in images can be captured, synthesised and distinguished; how three-dimensional structure can be recovered from stereoscopic images or from video; and how the characteristics of objects can be captured and recognised. A distinguishing feature of the work at the Cambridge lab is that probabilistic inference and learning permeates all of our modelling work, and we have been in the vanguard of the move towards thinking of visual processes in probabilistic terms.

Theoretical insights from this kind of study feed into practical inventions: the modelling of texture has led to image editing tools that remove unwanted details from an image, progress on object recognition is taking practical shape in the form of a camera system that labels objects in real time, and ideas on three-dimensional structure have led to a new kind of webcam that reacts to the subject in a scene while ignoring the background.

Information Retrieval

Information retrieval research involves the use of machine learning and techniques such as Bayesian inference to develop more accurate, fast and advanced information retrieval and search techniques for a variety of applications. Information retrieval and analysis is concerned with core search processes such as term weighting, document scoring and ranking algorithms and combinations of evidence from different sources. These are studied both theoretically, through the use of formal models and statistical methods including machine learning, and experimentally, through activities such as the Text Retrieval Conference (TREC) and with internally generated evaluation sets. The group, with its Keenbow evaluation environment, has had some excellent results at TREC. The group's work has a strong influence on Microsoft search technologies.

Byron Cook
Researcher

'The ultimate goal behind automated software verification is to remove the uncertainty we feel when using software. Software should not crash, and it should not hang. It should be reliable and always available to respond to events. If software 'just works', then it will have an exponentially more profound impact on our society and economy.' — Byron Cook

Better tools for software development

Programming Principles and Tools

The Programming Principles and Tools group develops techniques and models for understanding programs, programming abstractions and languages. The group also develops advanced techniques and tools for software development. Research areas for this group include automated testing and analysis of software for bugs, new programming languages that better harness the power of advanced computing, and developing more secure software through programming techniques and tools for analysing security.

Specific research areas include:

- **Programming Languages**
- **Formal Software Verification**
- **Concurrency**
- **Security**

- **www.research.microsoft.com/ppt**

Programming Languages

Software developers use a variety of programming languages to create modern software systems, and the design and implementation of those languages has a large impact on developers' productivity. Researchers who specialise in programming languages are investigating new language features, new language paradigms, efficient implementation (including complete compilers) and various tools for reasoning about program correctness.

Formal Software Verification

In addition to programming languages, software developers rely on tools to ensure their software satisfies all of the expected requirements. The current approach to testing, while useful, is inadequate as it cannot prove that a system does not have a defect. Formal software verification uses formal specifications and reasoning principles to establish correctness. Research in this area ranges from work on new formal models to automated and semi-automated tools to assist programmers.

Theorem Proving

Theorem provers are necessary tools in formal software verification, and Cambridge lab researchers are doing fundamental research in theorem-proving. As part of this research, one theorem — the Four-Colour Theorem — was proven entirely by formal methods for the first time. First conjectured in 1852, the theorem states that any planar map, such as a political map of the world, can be coloured using only four colours in such a way that neighbouring countries are always a different colour. The machine-checked formal proof is 60,000 lines long.

Concurrency

Concurrency is an important factor in the behaviour and performance of modern code. Concurrent programs are difficult to design, write, reason about, debug and tune. Furthermore, concurrency can significantly affect the meaning of virtually every other construct in the language (beginning with the atomicity of assignment), and can affect the ability to invoke libraries. Nevertheless, most popular programming languages treat concurrency not as a language feature, but as a collection of external libraries that are often under-specified.

Security

Programming secure systems is difficult, and application developers don't have adequate tools to help them understand and reason about security. Cambridge lab researchers are studying various aspects of security in relation to computer systems. These include the design and analysis of cryptographic protocols (especially authentication), the design of secure systems, the relationship between security and privacy, and the usability, evaluation and certification of security products.

Peter Key
Principal Researcher

'Networks have always been about creating connections that enable communication, rather than the underlying technology itself. The tremendous popularity of internet-based social networks has re-emphasised the value of networks as enabling technologies. Our work involves getting systems and networks to work more intelligently, unseen by the user, making new forms of communication and applications possible.' — Peter Key

Optimising large-scale systems

Cambridge Systems and Networking

The research of the Cambridge Systems and Networking group covers a wide range of practical computer science disciplines, ranging from improving the performance of individual computers through to designing novel distributed systems that can scale to hundreds of thousands of hosts. We are a broadly-based group that designs and builds systems, analyses them, and uses them.
Specific research areas include:

- **Distributed Systems**
- **Networking**
- **Operating Systems**
- **Concurrency and Multicore Computing**
- **Constraint Reasoning**

Distributed Systems

We have active research areas centred around peer-to-peer systems including distributed hashtables (DHTs), key-based routing (KBR), distributed databases and social networking systems. The team is also interested in Byzantine fault-tolerance in distributed systems.

One objective of the research is to improve the robustness of peer-to-peer systems as a vehicle for distributing content. The group has developed special coding techniques in which both the servers and the peers publish encoded blocks that are unique. The codes are such that the receiver does not need to care about which blocks they receive, as long as they receive enough of them.

Networking

Researchers in this group are investigating network and systems management, in areas ranging from theoretical modelling of transmission control protocol (TCP), wireless Media Access Control protocols and worm epidemics, to practical topics in overlay networking, file swarming, topology discovery, bandwidth probing and network management. The team aims to build an enterprise network management platform based around two main components: endsystem flow monitoring, providing the inputs to the system; and monitoring of network routing protocols, providing current system configuration. By aggregating and querying these data sources in a distributed fashion, the platform will enable network management applications to provide tools for visualisation, what-if analysis and control of the network.

- **www.research.microsoft.com/camsys**

Network Map

Windows Vista includes new features that make networking easier, safer and more reliable for users — whether at home, at a small business or in a large enterprise. Developed at Microsoft Research Cambridge, the network map in Windows Vista simplifies connectivity so people can quickly and easily visualise and use their network connections. The network map makes it easier for Vista users to connect wirelessly to the company network, share printers and a high-speed Internet connection, copy files between PCs and enjoy their favourite online entertainment at home.

Operating Systems

We are interested in a variety of low-level operating-systems topics, including virtualisation, many-core, automatic worm containment, performance analysis/prediction and future operating systems architectures. The team is also studying how existing operating systems behave in the field, to identify major causes for the failure of client and server systems, and the clustering of failures within major server farms. Via statistical mining of operating system and application defect data, it is possible to understand the relationship between the way software is developed and how it behaves in the field.

Concurrency and Multicore Computing

Silicon chip technology has reached the physical limit of what a single-core microprocessor can do, or nearly so, and further improvements to system performance will require better use of parallel processing to increase computation speed. In addition, better use of input/output devices is needed to reduce the impact that high-latency disk requests and network round trips have on application performance. Complementing the research being done by the Programming Principles and Tools group at the lab, this team is investigating how changes to programming languages, runtime systems and operating systems can help address these problems. For example, the team's work on atomic blocks and transactional memory shows a promising approach for building scalable shared-memory data structures for multicore machines.

Constraint Reasoning

Future generations of software applications will increasingly rely on automated reasoning technologies. Central to these applications is the ability to search through a large set of possibilities (schedules, plans, program executions, etc.) and to find the ones that optimally match the requirements of the user. The goal of the Constraint Reasoning group is to develop the next generation of optimisation technology to accompany the development of these new applications. To improve automated reasoning usability, we develop new optimisation algorithms which can autonomously adapt their problem-solving strategy to the application domain. To improve scalability, we develop algorithms that are able to seamlessly exploit multiple computing resources like multicores and distributed computing facilities.

Fabien Petitcolas
Head of Intellectual Capital and Development

'Without excellent people, we cannot do world-leading research. So Microsoft Research has a vested interest in helping universities cultivate new talent and inspire the best young minds. We do this through scholarships, sponsorships and recognition programmes and, importantly, we give students a view into the workings of a corporate research lab.' — Fabien Petitcolas

Expanding the pool of scientific talent

Inspiring Tomorrow's Scientists

Research at our Cambridge lab represents but a small fraction of the need for advanced software research. In some areas, research is urgently needed to help address the broad social and environmental challenges that we all face. Other areas are driven by the continual evolution of computing, which demands new approaches to product development and offers endless possibilities for business as well as personal expression and enjoyment.

It is therefore essential to inspire and educate the scientists of tomorrow — talented young people who will expand and strengthen innovation in Europe, the Middle East and Africa and, at the highest level, ensure continued economic growth and competitiveness for the future of the region.

Microsoft Research Cambridge invests in numerous programmes that recognise and support top talent, from graduate students through to leading international scientists:

- **Scholarships for PhD students**
- **Awards and fellowships**
- **Support for visiting lecturers and faculty**
- **Sponsorship of international conferences and workshops**

- **http://research.microsoft.com/ero**

Summer School in Cambridge

One way that the Microsoft Research lab in Cambridge is helping to cultivate the next generation of researchers is through its annual Summer School for PhD students. Over a week in July, students are invited to Cambridge to attend a series of talks as well as a posters session, in which they are given the opportunity to present their work to Microsoft researchers and Cambridge academics. Lectures cover topics such as entrepreneurship, presentation skills, applying for funding and 'productising' research.

The 2007 Summer School was organised in partnership with the Cambridge University Computer Laboratory and the Cambridge Centre for Entrepreneurial Learning. Students invited to participate included all first year PhD students of the Computer Laboratory and all Microsoft Research 2006 PhD Scholars. The lectures and posters sessions were open to faculty members and research students from the University of Cambridge.

Supporting Achievement in IT Research

We run several programmes aimed at developing intellectual capital across Europe, the Middle East and Africa:

- **European PhD Scholarship Programme** — Microsoft Research supports nearly 100 of Europe's brightest scholars in taking research positions at some of Europe's leading academic institutions. In addition to funding, students are invited to events at the Cambridge laboratory, where they can share and discuss ideas with researchers from Microsoft.
- **European Science Award** — This prestigious annual award, presented by the Royal Society and the Académie des Sciences, recognises scientists who have made a major contribution to the advancement of science through the use of computational methods.
- **Fellowship for early-career scientists** — Through this fellowship, highly promising early-career scientists who are establishing a track record of top research in emerging science and technology are receiving support and funding of up to 250,000 euros.
- **Student project prizes** — To encourage innovation among students, we offer prizes in several computer science departments at universities across Europe, recognising the best projects completed during undergraduate studies.
- **Conference support** — Each year, we sponsor a number of the leading academic conferences in our chosen areas of research.
- **Inspire programme** — Inspire is a unique programme that encourages education and achievement in computer science in developing economies. The programme offers lecturers and researchers from Europe and the US the opportunity to teach computing and train teachers in developing countries. Microsoft Research manages the programme and offers a travel stipend to some of the volunteers, while the host university provides accommodation. The programme also includes a research summer school for students, including workshops, lectures and tutorials involving internationally renowned speakers. In addition, to encourage final-year undergraduate students to carry on towards a masters or doctoral degree, Microsoft is awarding up to 2,000 euros for as many as 100 promising final-year undergraduate students.

Natasa Milic-Frayling
Senior Researcher

'Microsoft technology can only progress if we understand the long-term aspirations of our customers. When our researchers engage with the innovators inside these companies and partner organisations, we gain early insight into fundamental research issues. At the same time, we impart our knowledge and the spirit of exploration and pursuit that encourages further innovation.' — Natasa Milic-Frayling

Sharing our knowledge

Facilitating Collaboration

The Research Partnership Programme is a channel for sharing Microsoft Research insights with large enterprises, governments and other public-sector organisations such as national libraries and archives. The programme offers the benefits of Microsoft Research expertise and the latest academic thinking in support of customer and partner projects.

The team engages with customers and partners to discuss their project strategies and consider opportunities for applying specific technologies or strategies. Input from Microsoft Research typically includes information on leading-edge research, identification of opportunities to apply it, and advice on technical methodologies.

The exchange of information, although initiated by the customer's need, is two-way. In addition to strengthening Microsoft's customer relationships, the Research Partnership Programme gains a direct understanding of the issues facing specific industries and business sectors. This intelligence gives Microsoft product teams valuable knowledge that shapes future enhancements of Microsoft products.

Importantly, Microsoft Research is an impartial counsellor, as it does not offer paid services or deliver products or prototypes, but instead works in partnership with other Microsoft groups to ensure they have informed access to state-of-the-art technology and thinking.

- **www.research.microsoft.com/rpp**

Preserving Digital Content

The Research Partnership Programme is currently involved in the EU-sponsored PLANETS project led by the British Library. The project involves a consortium of 16 European libraries, national archives, universities and industry partners pursuing technologies and strategies for long-term preservation of digital content. This is of the greatest importance for preserving Britain's national heritage. Within the project, Microsoft Research is investigating the use of the Microsoft Office Open XML file format for the preservation of Microsoft Office documents.

Lynne Brindley, CEO of the British Library, said: 'European national libraries and archives are uniquely positioned to lead on this digital preservation initiative, having the legal responsibility and the legislative framework to safeguard digital information. A consortium such as PLANETS allows us to address a challenge the scale of which goes far beyond the capabilities of any single institution.'

Knowledge Exchange and Research Collaboration

Cambridge lab researchers engage with Microsoft customers and partners in various ways:

- **Technology briefings** — Working closely with Microsoft account managers and consultants, the Research Partnership Programme hosts technology briefings at the Cambridge facility. These sessions give clients an opportunity to have deep discussions with researchers knowledgeable in particular areas of interest. Through presentations and brainstorming, participants exchange knowledge and identify opportunities for innovation in a particular industry segment. The ideas are then taken further with Microsoft account management teams and clients' R&D teams.
- **Workshops and seminars** — In some instances, an area of research — such as methods for investigating the impact of mobile technologies on individuals and the society — is of interest to several groups within or outside of Microsoft. In order to stimulate dialogue and discuss the key issues, the team organises focused workshops and seminars to identify common aspirations and outline possible directions for innovation.
- **Strategic research projects with industry partners** — If a problem area is of strategic importance to Microsoft and its partners, Microsoft research may join a consortium of organisations to tackle the challenges. For example, long-term preservation of complex scientific workflows may require both the customisation of existing Microsoft technology and fundamentally new models to represent, store and search data generated from scientific workflows. Microsoft researchers would work closely with partner groups and Microsoft teams.

The Research Partnership Programme also works with organisations in and around Cambridge that run programmes for entrepreneurial learning and innovative design. By promoting creativity and entrepreneurship, we support Microsoft's continuous effort to promote innovation across industry and public sectors.

Mitch Goldberg
Director of Technology Transfer and Incubation

'Our researchers have the freedom to pursue their passion and maintain their standing in the wider research community. At the same time, the reach of Microsoft products makes it possible for their research to impact millions of users. That really motivates people here, and you can't get that anywhere else.' — Mitch Goldberg

Ideas into reality: technology transfer

Contributing to Leading-Edge Products

A goal of every researcher is for his or her work to be put to use, either inspiring further lines of inquiry or, in the case of software, leading to products that solve problems and enhance people's lives. Likewise, organisations that fund research expect an eventual return on their investment.

When we have great ideas that work at Microsoft Research, we look to move those ideas and technologies into Microsoft products as rapidly as we can. The process of taking ideas, technologies and prototypes out of the realm of research and into product development is called technology transfer. And it happens on many levels, from simply informing a product group about a new idea, through to working closely with them to get what has been created into a form that can be incorporated into a product.

Microsoft's technology transfer programme provides a unique opportunity for ongoing relationships between research and the product development teams. It also finds a balance between the innovations developed in Microsoft Research and the pragmatic engineering that the product teams do. Strong, collaborative partnerships between researchers and the product teams fulfil a shared vision: to get great technologies and innovations into Microsoft products. As a result of the relationships, communication and trust that have developed between researchers and product teams, we are able to bring cutting-edge technology to our products faster and at less cost to the company and consumers. From the original Answer Wizard in Office 95 to more than 75 innovations in the 2007 Microsoft Office system and Windows Vista, the success of this partnership continues to grow.

- **www.research.microsoft.com/aboutmsr/overview/tech2006.aspx**

Licensing Intellectual Property

Sometimes research yields a viable prototype with market potential, but it isn't picked up for product development within Microsoft. Microsoft has begun, in recent years, to license such intellectual property (IP) with increasing frequency.

Microsoft IP Ventures licenses Microsoft Research technology to start-ups, venture capitalists, entrepreneurs and governmental agencies from around the world, fostering new product development and opportunity for others, while realising a return on its research investment.

One such example is with a form of peer-to-peer networking invented by Microsoft researchers here in the UK that is highly scalable, easy to manage and high-performance. This technology was licensed to a young company called Skinkers, and the IP was exchanged for an equity stake and royalty share. The Skinkers technology is being developed for two quite different scenarios: enabling enterprises to push important messages and content to employees' computer screens, and for real-time television programme distribution over the internet.

Competitive Matchmaking

TrueSkill™ is a ranking and matchmaking system premiering in the Xbox 360 Live services. It uses a mathematical model of uncertainty to address weaknesses in existing ranking systems such as ELO. Bayesian techniques enable the TrueSkill ranking system to identify player skill with near-optimal speed. For example, a new player joining million-player leagues can be ranked correctly in fewer than 20 games. It can predict the probability of each game outcome, which enhances competitive matchmaking, making it possible to assemble skill-balanced teams from a group of players with different abilities. The TrueSkill ranking system is now used in over 150 titles for the Xbox 360.

A Track Record of Innovation

Microsoft Research contributes to every product that Microsoft ships. In partnership with product teams, we contribute new core technologies, provide new algorithms, develop and share code, design new user interfaces, create better software development tools and contribute in a host of other ways. To highlight just a few technology transfers:

- **Ease of networking** — Technology designed for home and small office networks running on Windows Vista was developed at the Cambridge lab, to reflect the fact that these kinds of users rarely have expensive managed-network switches that automatically identify a computer's switches and hubs, to make networking easier.
- **Performance modelling** — Modelling systems is complex but provides invaluable insight to the performance of future system configurations. The Cambridge lab's 'Indy' helps size and plan deployments of Microsoft Exchange Server and Microsoft Operations Manager by providing tools and guidance for efficient deployment.
- **Stronger type systems** — Adding generic types to C# and the .NET Common Language Runtime makes programs more robust and supports code re-use. This innovation is used in a host of applications, including Visual Studio, SQL Server and Visual Basic.
- **Web services security** — Cambridge researchers created formal theorem-proving tools for analysing the security of web services specifications, implementations and deployments. Versions of this technology have been developed for several platforms, including Microsoft .NET, Windows Vista and Web Service Enhancements 3.0.

Careers and contact information

Research Positions

Microsoft Research is a magnet for some the world's top computer scientists, leaders in their field who are working to advance the state of the art and make an impact on Microsoft products and services. At Microsoft Research Cambridge, the research environment is friendly and informal, yet focused and intense. Your primary responsibilities will include conducting basic and applied research on the most challenging computer science problems.

We are always looking for candidates who have a PhD and a well-established research track record, demonstrated by journal publications and conference papers, as well as participation on programme committees, editorial boards and advisory panels. Additional requirements include outstanding communication skills and the ability to develop original research agendas.

Post-Doctoral Opportunities

A post-doc position at Microsoft Research Cambridge is a great opportunity for you to work with some of the best researchers, and the strongest teams, in a whole range of areas of computer science and information engineering. These are two-year, salaried positions for researchers who have a strong record of publication and who have completed the requirements for a PhD, including submission of their thesis, prior to joining Microsoft Research.

Post-doc researchers are invited to define their own research agenda and demonstrate their ability to drive forward an effective programme of research. These posts offer an opportunity to develop your career, with the potential to have your research realised in products and services that will be used worldwide. Successful post-doc researchers may be invited to apply for permanent positions towards the end of their two-year term.

- **research.microsoft.com/aboutmsr/jobs**

Internships

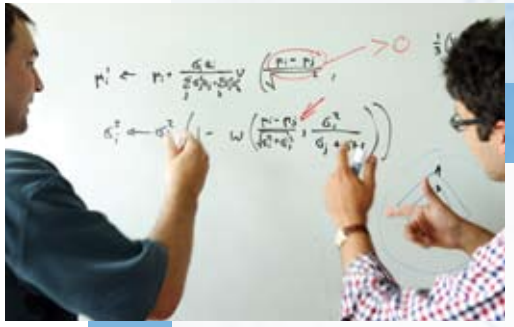
Microsoft Research is a great place to do an internship to expand your research horizons and get a taste of industry research. Internships normally last 12 weeks and most commonly occur over the summer. As an intern at Microsoft Research Cambridge, you will be given the same job responsibilities as a full-time researcher. You will be given real work with real problems to solve working alongside one of our full-time researchers as your mentor. In return for your valuable contribution, we will pay you a competitive salary. A number of our most successful interns have subsequently joined the full-time staff of the Cambridge lab or other Microsoft Research labs.

Internships are offered to graduate students on PhD programmes relevant to all of our areas of research. We prefer candidates to have had two or three years of practical PhD-level research experience.

We are always looking for exceptional researchers, post-docs and interns. For more information about a career at Microsoft Research Cambridge, please visit Microsoft Research Careers at www.research.microsoft.com/aboutmsr/jobs/.

Microsoft Research Ltd
7 J J Thomson Avenue
Cambridge, CB3 0FB
United Kingdom

Tel: +44 (0)1223 479 700
Fax: +44 (0)1223 479 999
Email: cambhr@microsoft.com
Web: research.microsoft.com



Microsoft Research 10 year anniversary CAMBRIDGE

Microsoft Research Ltd
7 J J Thomson Avenue
Cambridge, CB3 0FB
United Kingdom