

Microsoft<sup>®</sup>  
**Research** Silicon Valley

Advancing the State of the Art in Distributed Computing



“From the very beginning in 1991, the mission statement for MSR has been, first and foremost, to move forward the state of the art. That gets measured in publications and open interaction in the academic community, and that’s part of the values that we have. That’s been a very important part of what we do. The second part of the mission statement is to take those technologies that make sense and move them into products and into the world as quickly as we can.”

Rick Rashid, Microsoft Research senior vice president

# Corporate Research with a Difference

Established in 1991, Microsoft Research is recognized as one of the most successful non-academic research institutes in the computing field. Carrying out Microsoft Research's charter of exploring technologies that advance the state of the art for computing, six research facilities share the responsibility of covering a broad spectrum of topics. At Microsoft Research Silicon Valley, the focus is on distributed computing, and the lab currently addresses six areas, with work in each spanning a range from theory to practice.

- Algorithms and Theory
- Distributed Systems
- Security and Privacy
- Software Tools
- System Architecture
- Web Search and Data Mining

Although other companies depend on their research facilities to innovate, they generally expect labs to focus on results that directly benefit the business; consequently, they emphasize utility rather than innovation. Microsoft's long-term business success depends on new technology. Therefore, the company's research strategy is to foster innovation with the goal of creating technology that transforms the industry and ultimately enhances Microsoft's own products.

Such innovation requires not only a long-term commitment, but also a supportive work environment. From the outset, Microsoft Research Silicon Valley has created a workplace designed to encourage collaboration, creativity, and productivity. As a result, within a relatively short period, the lab has established a reputation as a premier research facility for distributed computing, delivering work that has been recognized by the academic community and used by Microsoft to deliver real-life benefits for computer users worldwide.

# Main Research Efforts at Microsoft Research Silicon Valley

Microsoft Research Silicon Valley's broad research agenda spans six interconnected areas of study, each with important implications for the future of distributed computing.

## Algorithms and Theory

Computing theory forms the mathematical foundation supporting all computer science. Algorithms represent concretely what a computing program can accomplish within the limits established by theory. Researchers working in this area are pursuing a range of projects that will, for example, lead to more efficient Web searches, richer social interactions in instant messaging, and faster and more accurate geographic mapping applications.

## Distributed Systems

Within the broader distributed-computing realm, researchers are striving to improve understanding of workloads, memory requirements, processing capabilities, and other variables involved in building larger, more geographically dispersed systems. Recent work will enable distributed computer networks to perform better while consuming less energy. Another current project will make it easy for software developers to create applications that run effectively in large-scale distributed environments.

## Security and Privacy

Researchers are exploring technological and theoretical foundations of security and privacy to help software developers design more effective protections into their products. Recent work includes the invention of new methods to help secure systems against malicious software and the creation of a mathematical framework that enables researchers to mine statistical databases, such as U.S. Census Bureau records, while preventing disclosure of individuals' confidential information.



### **Software Tools**

As software developers create increasingly sophisticated applications for distributed-computing environments, the complexity involved in writing and debugging this software code poses a growing challenge. Researchers are creating new development methods and programming languages that will help software programmers to express parallelism more effectively, recognize when they have set up parallel tasks incorrectly, prevent related errors, and more easily debug parallel and distributed code.

### **System Architecture**

Software developers need more advanced tools in order to write applications that run effectively on multicore processors and other distributed-system architectures. Researchers are exploring ways to design hardware systems and write software applications that can take advantage of the increased computing power, memory, speed, and parallel processing capabilities in these cutting-edge architectures.

### **Web Search and Data Mining**

Internet users are demanding faster, more accurate answers to their Web-search queries. When there is ambiguity—for example, does a search for “jaguar” mean the car or the cat?—today’s technologies fall short of expectations. Research projects in this area focus on making Web search engines more adept at recognizing patterns in search queries and at handling more sophisticated information requests. Researchers are investigating the impact of blogs on the Internet at large, evaluating methods of extracting insightful information about Web users’ interests from query logs, and looking closely at trends related to the evolution of the Web.

“The best way to get a breakthrough research result is to empower smart, dedicated researchers to follow their technical instincts.”

Mike Schroeder,  
co-founder and assistant director,  
Microsoft Research Silicon Valley

“At any one time, researchers could be working on projects that are closely aligned with product groups as well as purely theoretical work. But even ‘blue sky’ work exists within a meaningful context.”

Frank McSherry, researcher



“It’s very important for me to have a voice regarding a potential future colleague. Not only are we making decisions about who will be our research collaborators, we are also defining the lab’s culture and image.”

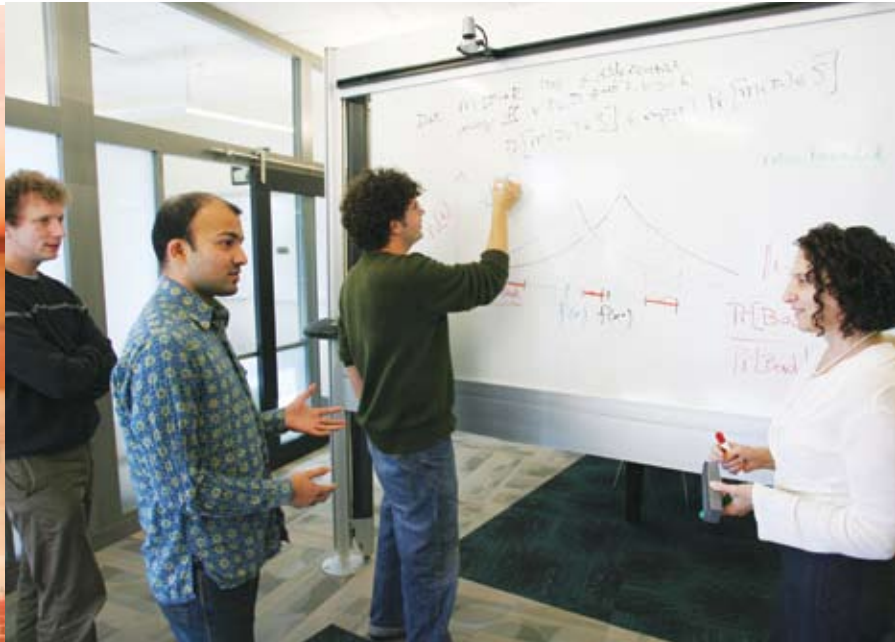
Yinglian Xie, researcher

## Attracting the Best Research Talent

At Microsoft Research Silicon Valley, having the best researchers in distributed computing contributes to high standards. It also helps attract the best talent; many recruits are excited by the prospect of working with well-known experts in the field. Candidates are attracted by the resources available at the lab and by the freedom to plan and pursue their own research agendas. Lab members receive strong support for publishing and value the opportunity to contribute to products at Microsoft.

The lab recruits internationally. The hiring process is highly selective, focusing on top Ph.D.s and researchers with strong track records. Ideally, each candidate should share an area of expertise with researchers and introduce new technical strengths. The right amount of overlap and new expertise stimulates collaboration while diversifying research perspectives.

It is critical that all lab members at Microsoft Research Silicon Valley are involved in the hiring process. Researchers attend candidate presentations, participate in one-on-one interviews, and contribute to the decision-making process.



## Encouraging Internal Collaboration

By design, Microsoft Research Silicon Valley is small enough to operate with a flat organizational structure. Apart from the lab's director and assistant director, there are no managers and no divisions within the research staff, either by specialty or seniority. Researchers therefore can work on projects driven by interest or by the direction their work is taking, unrestrained by any institutionalized unit. Each researcher can be part of several project teams. The absence of formal boundaries encourages dialogue between teams and creates opportunities for unexpected insights; sometimes, it takes a multidisciplinary approach to solve a problem or achieve a breakthrough.


One of the few regularly scheduled lab events is a weekly meeting during which researchers take turns presenting their current technical work, including work in progress. These presentations often lead to informal discussions that augment the ideas and can inspire others to join an embryonic research effort.

The building and facilities at Microsoft Research Silicon Valley provide the most visible evidence of the lab's commitment to a support system that fosters collaboration, creativity, and productivity. Lab members have access to state-of-the-art computing resources and tools, libraries and databases, and flexible working hours.

The lab also recognizes that the right architecture and workspace encourage the cross-connection of ideas. While each researcher has a private office space and each floor of the building contains a number of meeting rooms, the common areas best represent the culture of the lab.

Each common area is designed for relaxation, dining, or games, but whiteboards and monitors lie within immediate reach. These informal workspaces maximize interaction between lab members outside of their research projects and encourage potential new avenues of research. Thus, when casual conversation over coffee turns serious, it is easy for participants to sketch and develop ideas without leaving the space.



The background of the slide is a whiteboard with various handwritten notes and diagrams. At the top, there are some faint notes including "3 + D" and "A | B | C | D". Below this, there are several lines of text and some small diagrams, including what looks like a flowchart or a list of items. The whiteboard is slightly out of focus, giving it a soft, artistic feel. The text on the whiteboard is in blue and black ink.

"It is common for good ideas to gain traction in hallway conversations or over coffee; this kind of casual validation often leads interested researchers to form a project team to work together on an idea. We consider this the best possible way to staff a project."

Roy Levin, co-founder and director,  
Microsoft Research Silicon Valley

## Staying Current with Developments in the Field

Any research lab must stay current with the state of the art and assess the quality of its work with feedback from the outside world. Microsoft Research emphasizes publication by researchers in the professional literature. Acceptance by peers constitutes validation that the work advances the state of the art. Since its inception, Microsoft Research Silicon Valley has maintained a strong presence in leading publications and conferences.

Interaction with external developments goes beyond attending conferences. Of particular significance are researchers' relationships with the academic world and with Microsoft's product groups.

Every major practical advance in computing over the last four decades has involved both the university and corporate sectors. Microsoft Research Silicon Valley sponsors an extensive summer intern program, and the lab's population grows by more than 50 percent while graduate students work with researchers on specific projects. Sometimes researchers and students continue to collaborate beyond the internship. Microsoft Research also encourages researchers to teach courses and seminars at local universities, another way to interact with graduate students.

Collaboration between Microsoft Research personnel and university faculty members is also common, coalescing on topics of mutual interest. Faculty members can spend weeks to months to an entire sabbatical as visiting researchers at Microsoft Research; this type of collaboration almost always results in jointly authored papers that extend Microsoft's reach into areas that researchers might not otherwise have explored. Microsoft Research also provides grants to faculty members to support specific research projects.

Microsoft Research encourages collaboration among its labs. Each lab pursues a variety of research areas, and there is often value and synergy in working together to solve complex problems that involve multiple technical disciplines.



*“By describing your problem in one domain to a specialist in a different domain, you often end up seeing the problem differently and that leads to new possibilities.”*

*Ollie Williams, researcher*



## Making the Connection Between Research, Technology, and Product

Microsoft Research's success depends on some of its research results being adopted by Microsoft's businesses. A researcher often does not know which product group would benefit the most from his/her work. Therefore, Microsoft Research employs program managers (PMs) to help labs expose their work to relevant internal audiences at Microsoft.

The Microsoft Research PM team helps create connections with Microsoft product groups, understanding when in each development cycle they would be most open to adopting new technology. The connection is bi-directional, because product groups within Microsoft also approach Microsoft Research PMs for help in solving technical problems. Informed by the product groups' longer-term needs and experiences, collaboration between Microsoft Research and product groups often forms the basis for new research directions.

Since these managed connections may not identify all possibilities for technology transfer, the annual Microsoft Research TechFest provides a less structured setting for direct contact between researchers and product groups. This event is a multi-day showcase of research projects from all Microsoft Research labs, attended by thousands of Microsoft employees. At TechFest, the goal is to foster unanticipated connections between research and product development, leading to novel technology applications.



“For many of us, the wealth of real-world data available from Microsoft is a resource we would not have in an academic environment. It is immensely useful to have models proven out with real data.”

Michael Isard, researcher

## The Results: Innovation and Success

The proof of Microsoft Research Silicon Valley's success as a quality research organization lies in external validation by peers in the field that the work advances the state of the art. The lab has seen significant success, from publication in professional, peer-reviewed journals to awards recognizing professional excellence. In addition to numerous "best paper" awards, three of Microsoft Research Silicon Valley's researchers' papers received the SIGOPS Hall of Fame Award, given for the most influential operating systems papers that have stood the test of time.

The Microsoft Research Silicon Valley staff includes:

- Three winners of the IEEE John von Neumann Medal for outstanding achievements in computer-related science and technology.
- Two winners of the ACM Edsger W. Dijkstra Prize in Distributed Computing for papers that have stood the test of time.
- Two winners of the ACM SIGSAC Outstanding Innovation Award for contributions to the field of computer and communication security that have had lasting impact.
- Four ACM Fellows and five National Academy of Engineering members.

Other awards earned by lab members include:

- The SIGGRAPH Computer Graphics Achievement Award.
- The NAE Charles Stark Draper Prize.
- IEEE Emanuel R. Piore Award.
- The NIST/NSA National Computer Systems Security Award.



Recognition by the professional community is one source of validation for Microsoft Research Silicon Valley's work; the other is the extent to which the lab's research has been adopted by business units within the company. Working in collaboration with product development groups, the lab has made significant contributions to Microsoft products, including:

- Address-space randomization security feature in Windows.
- Low-cost, searchable, highly available, and reliable storage platform for MSN Hotmail and Spaces.
- Major contributions to the core index-serving implementation for Live Search.
- Folder-synchronization design for SQL Server and Windows Live.
- Landmarks-based shortest-path algorithm to improve computation of driving directions in Europe for maps.live.com.
- Filter for detecting dynamic IP addresses as part of the Windows Live mail service.
- SAT solver in the Windows Static Driver Verifier.

# Microsoft Research Around the World

With 800 researchers at six laboratories on three continents, Microsoft Research has grown steadily since its founding in 1991. We are one of the largest, most highly respected software research organizations in the world.



## **Microsoft Research Redmond**

Microsoft Research originated at the company's headquarters, near Seattle, in 1991. Today, the Redmond lab boasts the largest concentration of researchers and the most breadth of research areas across the company. Being near the product teams at Microsoft proved valuable in the early days, and that remains true today.



## **Microsoft Research Cambridge**

Founded in 1997 in the United Kingdom, Microsoft Research Cambridge employs more than 100 leading researchers from around the world across various disciplines. The lab works hard to provide a world-class academic environment that promotes creativity and independent thinking while providing a challenging and open work environment.



## **Microsoft Research Asia**

Microsoft's basic research arm in the Asia Pacific region, Microsoft Research Asia, founded in Beijing, in 1998, has attracted top-caliber researchers and scientists from all over the world, supplemented by a postdoctoral research center and more than 200 visiting researchers and students.



### **Microsoft Research India**

Established in Bangalore in 2005, Microsoft Research India employs about 50 scientists and support staff and hosts a large number of interns each year. The lab conducts long-term basic and applied research in cryptography, security, and algorithms; digital geographics; mobility, networks, and systems; multilingual systems; rigorous software engineering; and technology for emerging markets.

### **Microsoft Research Silicon Valley**

Established in Mountain View, Calif., in 2001, Microsoft Research Silicon Valley employs approximately 50 researchers working to advance the state of the art in distributed computing and related fields while strengthening the architecture and technology of Microsoft products.

### **Microsoft Research New England**

Established in Cambridge, Mass., in 2008, Microsoft Research New England builds on Microsoft's commitment to collaborate with the broader research community and to advance the state of the art in multiple areas of computing research. The lab pursues new, interdisciplinary areas of research that bring together core computer scientists and social scientists to understand, model, and enable the computing and online experiences of the future.

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