



The tech world's **BIG BOOST FROM BERKELEY**

by Dick Cortén

This is not a Cold War stereotype with impossible claims to breakthrough inventions. UC Berkeley has not felt the need, for institutional pride, to assert pioneering involvement in, say, the steam engine, the electric light, or the airplane.

However: Berkeley's role in advancing the computer, the transformative invention of our time, may not be widely understood.

First, the computer itself. While distantly related to the abacus — a calculator that predates our written numerical system and may be 2,400 years old — the computer, like a student, takes instructions. It's programmable. An early example of such instruction is Joseph Marie Jacquard's 1801 textile loom, which used punched paper cards to tell the device how to weave intricate patterns automatically. The 1890 U.S. Census used punched cards to count Americans in the first use of large-scale data processing, with machines made by a company that turned into IBM.

The conflicting priorities of World War II stepped up the evolution of the computer, mainly in Germany, the United Kingdom, and the U.S. (Encoding and decoding on the German side, code-breaking on Allied side, which enlisted English mathematician/logician/cryptographer **Alan Turing**, who is frequently seen as the father of modern computer science.)

The opposing sides used punched cards to tell mechanical devices employing vacuum tubes how to manipulate and extract data. These were analog computers. A Michigan-and-MIT alumnus named **Claude Shannon**, in what has been called the most important master's thesis of all time, essentially founded information theory and the theory behind the digital computer and digital circuit design. (He was 21 at that point.)

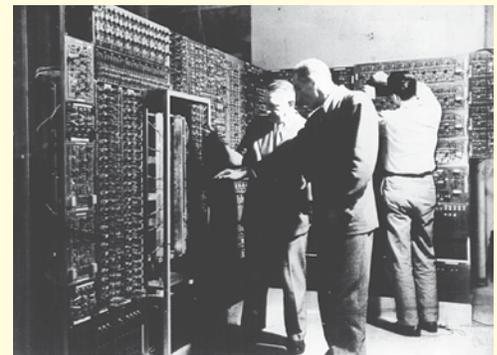
Transistors replaced vacuum tubes, and computers got smaller, faster, cheaper, and more reliable. In the 1970s, the integrated circuit did the same thing but more so, and the stage was set for computing power to move out of air-conditioned "computer rooms" and the sole control of the technical class and arrive in the hands and offices and homes of average citizens.

In the next steps of this revolution, nobody invented the personal computer, the operating system, or the mouse, much less the Internet, entirely alone.

But we wouldn't be where we are today without the major pieces UC Berkeley has placed solidly into those separate but intertwined jigsaw puzzles through the work — and inventive genius — of its faculty, its graduate students, and its undergraduate and graduate alumni.

What follows is a selection, not a complete list, of Berkeley-connected puzzle-solvers, with brief explanations of what they did. Names of Berkeley alumni are in **blue** in the narrative for ease of identification.

CALDIC:



the big, many-tubed instructional ground floor

Back in 1948, **Paul Morton** Ph.D. '43, a young associate professor of engineering, began work on a project called CALDIC (the California Digital Computer). Your wristwatch may have more



Photo courtesy of the Morton family

PAUL MORTON

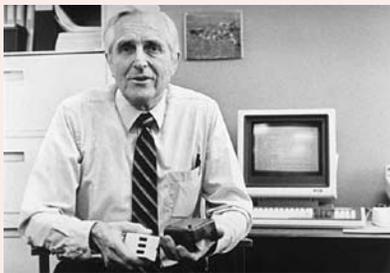
computing power now, but CALDIC was inexpensive and simple to operate for its day. Preceding transistors, it used more than a thousand vacuum tubes. Its memory unit was a rotating magnetic drum. It was a notable step in computer design, but it was far more important as an educational component for a generation of Cal master's and doctoral students, soon to be leaders in the computer industry. Morton developed Berkeley's first computer courses and set up the first computational service center on campus (with IBM punch-card machines). And Cal students went out to do their share of changing the world.

THE MOUSE:



to the world from the mind of a Berkeley grad

The familiar computer mouse had an accurate but uncatchy name — “X-Y position indicator for a display system” — on the patent application **Doug Engelbart** filed in 1967 (after inventing the device in 1963). By the time he received patent number 3,541,541, he had gone with the “mouse” nickname, which arose from the wire that came, tail-like, out the end. (The prototype beast, mainly unrodentlike and cumbersome by current standards, was built primarily out of wood by Engelbart’s colleague William English.)



DOUG ENGELBART: the man behind the mouse — and far more

Engelbart had earned his 1952 B.S. and his 1955 Ph.D. in electrical engineering at Berkeley (working on CALDIC with Paul Morton and Al Hoagland B.S. ’47, M.S. ’48, Ph.D. ’54, who would become a pioneer in the magnetic disk drive industry, along the way), after which he soon joined Stanford Research Institute (the precursor of SRI International), where he not only did the mousework, but also, with his team, pioneered much of today’s human and computer interaction, online computing, and e-mail, including such things as bit-mapped screens, hypermedia, and what turned into the graphical user interface, or GUI, and onscreen video teleconferencing.

His computer mouse patent expired in 1987, before the mouse became the must-have input device of the personal computer revolution he envisioned, when most individuals were no longer kept away from computers. He never received royalties for the invention.

Engelbart received the Turing Award (often called “the Nobel Prize of computing”) in 1997 and the National Medal of Technology in 2000. Now 83, he directs his own company, the Bootstrap Institute, with one of his daughters, in Menlo Park. Richard Karp, long a Berkeley computer science and mathematics professor who is himself a Turing winner, says “Engelbart was ahead of his time in understanding how computers could augment human intellect.”

AN APPLE & A DESKTOP: making it easier and more fun

In 1972, handheld electronic calculators were available and all the rage, but not yet cheap. In the dorms at Berkeley, undergrad **Steve Wozniak**, who would later go on to co-found



Peg Skorpinski photo

STEVE WOZNIAK

Apple Computer, built and sold what he called his “blue box,” a tone generator that let people make free phone calls. That same year, ’72, **Butler Lampson**, who got his Ph.D. at Berkeley in 1967 wrote a now-famous memo to the home office at Xerox, parent company of the seminal Palo Alto Research Center (PARC), where he then worked. In it, he outlined a conceptual “architecture for information” from which grew many key elements of personal computing, including interfaces with windows and icons, on-screen full-page document creation (remember WYSIWYG?), laser printing, and more.

Lampson’s career work won him the Turing Award in 1992.

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Peg Skorpinski photo

BUTLER LAMPSON: he saw the elements of desktop publishing

UNIX:

You could take it with you. And change it.

Ken Thompson B.S. ’65, M.S. ’66 has been called “the most talented programmer the computer industry has ever seen.” After he left Berkeley, Thompson worked for over three decades at Bell Labs, where he was the principal inventor of UNIX, a computer operating system that even now, several decades later — an eternity in the computer world — is regarded, with its descendants, as among the best operating systems ever devised.

In the early ’70s, Thompson’s first public presentation about UNIX and his paper in a prestigious journal piqued interest about it in the academic community, including Berkeley. The first copy of the operating system was shipped here, and UC began using UNIX. Thompson returned to Berkeley in the mid-’70s as a visiting professor, and encour-



Peg Skorpinski photo

KEN THOMPSON: known simply as “ken” in hacker circles, co-created UNIX and, among other things, Belle, the first computer made solely for chess-playing.

aged changes in the operating system. UNIX soon had two leading developers — Bell Labs and Berkeley.

In 1983, Thompson and UNIX co-author Dennis Ritchie jointly received the Turing Award for their development of generic operating systems theory. In 1999, they both received the National Medal of Technology from President Bill Clinton for co-inventing the UNIX operating system and the C programming language, which have “led to enormous advances in computer hardware, software, and networking systems and stimulated growth of an entire industry.” On the day of the presentation, Bell Labs also paid tribute to their contributions: “Without operating systems, computer hardware is useless; before UNIX, operating systems were large, vendor-specific, and designed to cope with particular features of a given machine. UNIX was the first commercially important portable operating system, usable almost without change across the span of hardware from the smallest laptops to supercomputers. It embodies visionary ideas — deliberate generality and openness — that continue to be a strong force today. Many of its approaches and notations influence the entire span of operating systems.”

Thompson retired from Bell Labs in 2000 and now works at Google.

SENDMAIL: most e-mail gets where it's going because a Berkeley grad student solved a problem

When the UNIX source code became available at Berkeley, and could be modified, the local talents immediately started customizing it. One of these was **Eric Allman** B.S. '77, who was on his way to earning his master's degree, which he did in 1980. Working on an early (and later influential) relational database management system



Patti Meagher photo

that had defense applications, he was one of the few who had access to Arpanet, the U.S. Defense Department's network that linked academic researchers, which later evolved into the Internet. What we know today as e-mail was already happening in a limited way on Arpanet, but it was cumbersome and un-uniform. Allman simplified the process, in what he calls a quick hack that worked. On his own time, he improved his hack and

ERIC ALLMAN

distributed it free through Berkeley's Computer Systems Research Group. In 1981, the software product became known as **sendmail**. He continued supporting sendmail for free until 1998, by which time e-mail had become massively popular and he needed help, so he founded Sendmail, Inc. The company is headquartered in Emeryville, and Allman is its chief science officer, spending much of his time on authentication and encryption tools to protect electronic messages and discourage spamming, a use of e-mail unanticipated in the early days when the emphasis was on sharing. Now more than a quarter of a century old, sendmail at this point delivers more than 70 percent of the world's e-mail.

SUN: What's red and blue and extremely bright?

Sun Microsystems is a classic Silicon Valley business. Started in (cliché alert) a garage and now headquartered in Santa Clara, it's been powered since its early-'80s start by the brains and energies of Stanford and Berkeley. From a good idea and a modest start, it's grown massively, from a handful of employees to around 34,000 (in 2007), was hit by (but survived) the dot-com meltdown, and last year posted revenues

of almost \$14 billion.

Of Sun's founding fathers, three were from Stanford (an engineering Ph.D. student and a pair of 1980 M.B.A.s) and two left grad school at Berkeley early, all gambling on what seemed like a good idea at the time.

The Computer Science department lost **Bill Joy**, who had earned his M.S. in '79 and was on his way to the Ph.D.



Peg Skorpinski photo

BILL JOY: as an undergrad, he was fired from the International House of Pancakes. He's done better since.

before he signed Sun's articles of incorporation.

The other key player from Berkeley was **John Gage**, who became “employee 21” at Sun. Gage's econometrics studies involved huge sets of data. He needed computer time to analyze what he had, and Bill Joy was the helpful Evans Hall system administrator he went through. They talked beyond Gage's projects, about the future and a wide range of theory, and each liked the way the other's mind worked.



JOHN GAGE: at an earlier stage, he was a record-setting All-American swimmer for Cal.

They got together with the trio from Stanford and evolved what looked like a path to the way things should be: without mainframes, everyone with a machine and power to spare.

Joy already had a reputation as a UNIX guru. He was the primary author of a revision that took Ken Thompson's work even farther. It became known as Berkeley UNIX. As the first open-source operating system with built-in communications protocols, Berkeley UNIX became the backbone of the Internet,

which was then taking its baby steps.

Joy's prowess as a programmer was already legendary, and at Sun he extended it. Under the title chief scientist, he led hardware and software architecture and came up with the idea for Java, a platform-independent programming language that helped web browsers explode with audio, animations, and real-time interactivity. Joy was also, initially, Sun's external spokesman. The holder of more than 40 patents, these days Joy is a partner at Kleiner Perkins Caulfield and Byers, perhaps Silicon Valley's premier venture capital firm. When he was on campus in 2005 being honored by the College of Engineering, Joy said the ideas and interactions of his seven years at Berkeley were exciting and set the stage: "In many ways, I spent the next 30 years finishing things we thought of here."

Because somebody had to do it, John Gage was Sun's original salesman. "The things basically sold themselves," he told *Wired* magazine in 1996, "— a \$30,000 machine that took the place of a million-dollar mainframe."

Still at Sun today, wearing the title Chief Researcher and Director of the Science Office, Gage has become an eclectic influential globe-trotting evangelist for all things computer (especially networks and Sun) and a social activist on a wide front.

According to the job description Gage wrote when he created the position, his duties are: "Find the world's smartest people, talk to them about what they're doing, and see how Sun can help." Sun engineer James Gosling, principal author of the code in Java, says Gage has "a thousand fingers, stuck into a thousand pies."

THE PALM: handy and brainy

Jeff Hawkins was, in a way, a re-entry, and then a de-entry, grad student at Berkeley. He had become interested in biophysics in high school, got his bachelor's in electrical engineering from Cornell in 1979, and went to work in the computer industry. Ever more curious about intelligence



Jeff Kubina photo

JEFF HAWKINS: fascinated with intelligence, human and machine

and the brain, he veered away from his career in 1986 and came here to study neuroscience. The way he wanted to do this didn't mesh with the academic structure, and he left in 1988. The upside was that another bit of writing he did in that period, for a pattern classifier program, ultimately became the hand-printed-character recognizer that became a

central element in the Palm operating system.

He's been busy ever since. He created the first commercially successful handheld computer, co-founding Palm Computing and Handspring (which introduced the PalmPilot and Treo product lines), which helped stimulate, and satisfy, the world's sudden hunger for Personal Data Assistants. Those enterprises provided the financial wherewithall for Hawkins to keep going in neuroscience. In 2002 he endowed a new research center at Berkeley — the Redwood Center for Theoretical Neuroscience, which will operate within the Helen Wills



Brusselsshrek photo

PALM TX: one of many steps that hastened the advent of devices like today's iPhone

Neuroscience Institute — to develop mathematical and computational models of how the brain works. His endowment is designed, in part, to provide graduate student support and fund seminars and conferences.

In 2004, *On Intelligence*, the book Hawkins wrote with science writer (and Berkeley alumna) **Sandra Blakeslee** '65, was published. It outlines his theory of how the brain works.

And in 2005, based on that theory, he founded a new company called Numenta, where he and his team are creating an artificial intelligence program that may be the first software truly based on the principles that operate the human brain. Their first product, NuPIC, is now available in "research release" for the Macintosh, Linux, and Windows platforms.

POWERPOINT: About 30 million presentations a day, give or take

The world's most pervasive software program for presentations, PowerPoint, was co-created (with Dennis Austin) by **Robert Gaskins**, who did graduate work at Berkeley in the 1970s. The program was released in 1987, initially for the Macintosh platform, back when "desktop publishing" was a new concept, always in quotes. It allowed people to quickly and

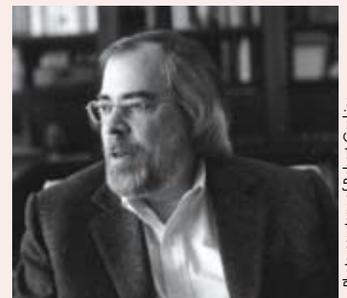


Photo courtesy of Robert Gaskins

BOB GASKINS: veteran of too many manually-created slides and flipcharts, he came up with a better way

easily crank out text-and-graphics slide pages for overhead transparencies, spurring the sales of overhead projectors, and then, with the advent of laptop computers and digital projection, gutting that same market. Microsoft, which bought the program (and, of course, the company) soon after the launch, has estimated that at least 30 million PowerPoint presentations are made every day. Some believe the program has well over 90 percent of the presentations-software market.

Gaskins worked for Microsoft for nearly six years, direct-

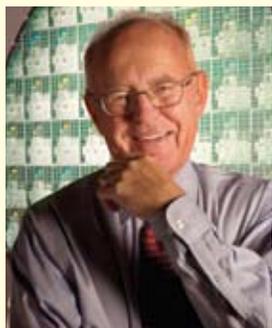
ing its business graphics unit, after which he and his wife moved to London, restored an 1890 Victorian “mansion flat,” and he became seriously interested in the concertina (“the only native English musical instrument,” according to his website). In 2001, they moved back to San Francisco, where he lives and creates “authoritative websites about concertina history.”

At Berkeley, Gaskins had earned an M.A. in 1973, and most of a Ph.D. in computer science, linguistics, and English, with the help of a fellowship from the Ford Foundation.

INTEL:

Everything will get smaller, faster, and cheaper. It's the law.

Intel Corporation was founded by two scientists, MIT physics Ph.D. **Robert Noyce** — who co-invented the integrated circuit, also known as the microchip, which fueled the personal computer revolution and gave Silicon



GORDON MOORE

Valley its nickname — and chemist/physicist **Gordon Moore**, who did his undergrad work at Cal (B.S. '50), then went to CalTech for his Ph.D. Intel's third employee was **Andrew Grove**, who was born in Hungary and emigrated to the U.S. in the mid-1950s. He earned his Ph.D. in chemical engineering from Berkeley in 1963.

All three served lengthy stints as CEO, and wore various other top titles as well. Grove is remembered as the chief strategist during the company's period of greatest growth. He was named *Time* magazine's Man of the Year in 1997.

Intel is now the world's largest semiconductor corporation. Moore is most famous for promulgating **Moore's Law** — the semiconductor industry's guiding



ANDREW GROVE

axiom for delivering smaller, ever-more-powerful chips while making the electronics cheaper. Noyce died in 1990; both Moore and Grove are retired from the company but are highly active as philanthropists and industry advisers. **Paul Otellini** M.B.A. '74 has been CEO since 2005.



PAUL OTELLINI

GOOGLE'S CEO:

Stanford lads search the world, find Schmidt

The late-'90s startup Google had been the search-engine research project of the Stanford Ph.D. students **Larry Page** and **Sergey Brin**. It became one of the greatest dot-com success stories ever.

Cal's main solace in this saga is that in 2001, Page and Brin needed some Berkeley sensibility to help guide Google's path and they recruited **Eric Schmidt**, who earned his M.S. in '79 and Ph.D. in '82 here in EECS, to be their chairman and CEO. (He had been CEO of Novell and chief technology officer of Sun, and reportedly was the only candidate who had been to Burning Man — a definite plus in the eyes of Google's young founders.)

His advice certainly hasn't hurt. Google is now the stock everyone wishes they'd bought, like IBM before the split, and Schmidt has hopped firmly onto the Forbes list of the world's richest people.



ERIC SCHMIDT: chatting in his company's HQ, the Googleplex

*The "Nobel Prize of computing,"
given by the Association for Computer Machinery (ACM)*

TURING AWARD WINNERS

at or from Berkeley, 1966–2007

- 1983 Ken Thompson* B.S. '65, M.S. '66
- 1984 Niklaus Wirth* Ph.D. '63
- 1985 Richard M. Karp** (faculty)
- 1989 William (Velvel) Kahan** (faculty)
- 1992 Butler W. Lampson* Ph.D. '67
- 1995 Manuel Blum** (faculty; left UCB in 1999)
- 1997 Douglas Engelbart* B.S. '52, Ph.D. '55
- 1998 Jim Gray* B.S. '66, Ph.D. '69

* = alum ** = faculty