2013

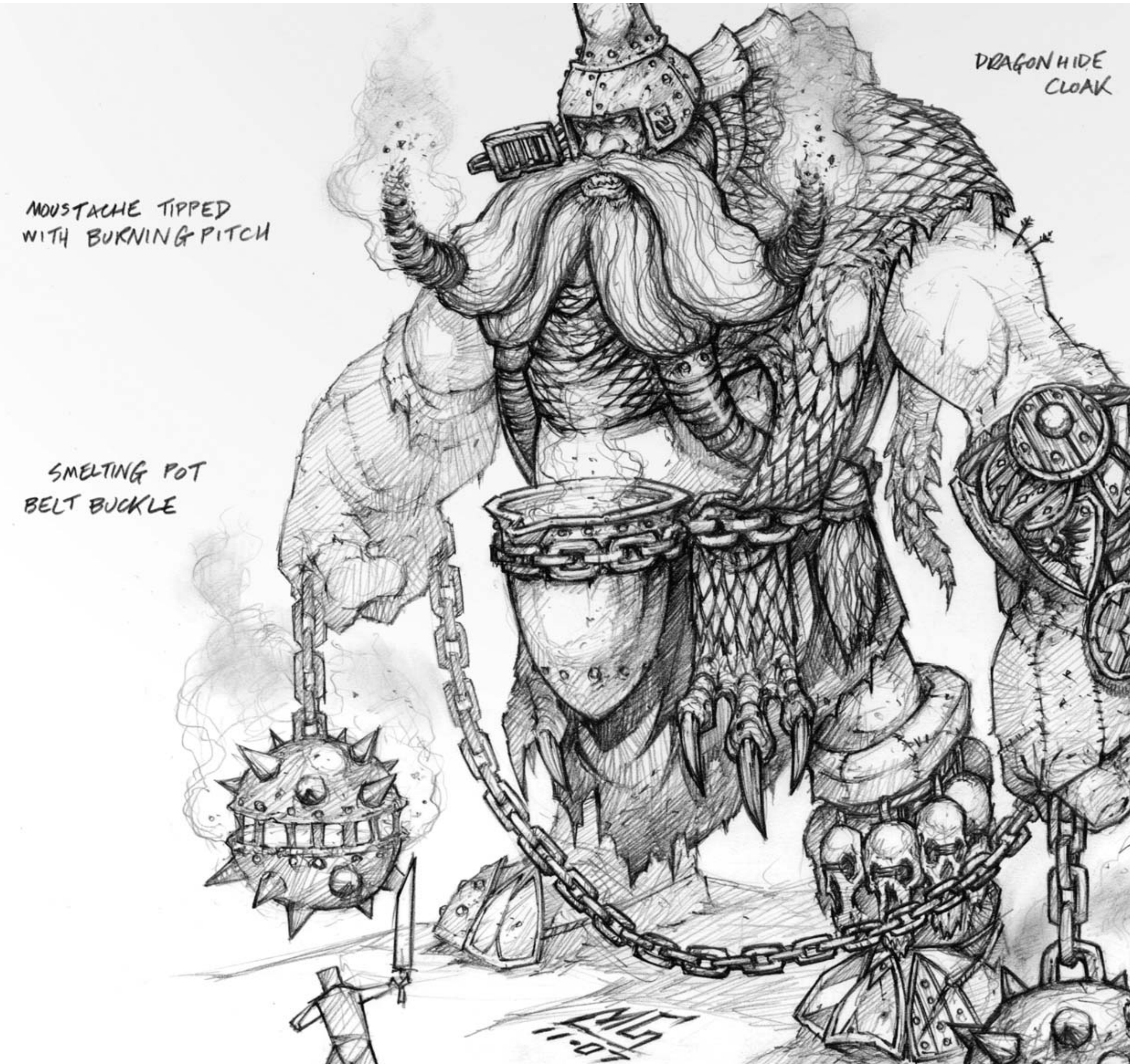
CORE

A Publication of the Computer History Museum

Make Software: Change the World!

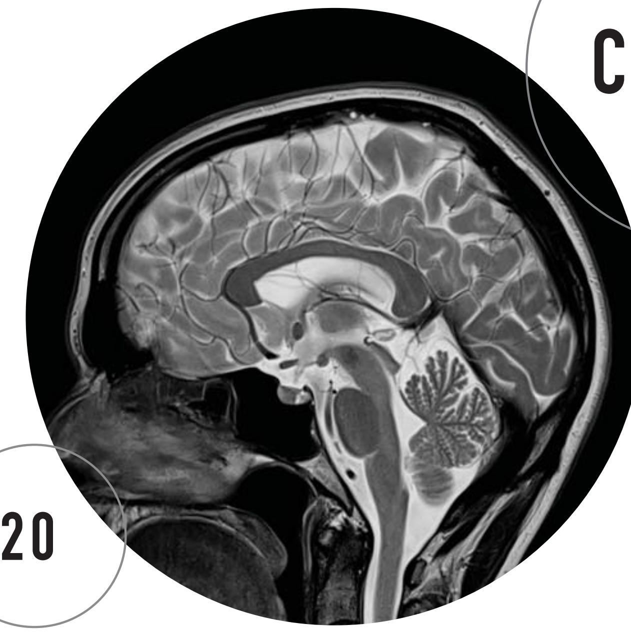
Software Archaeology: A Curator's Perspective

Where Wikis Come From



Cover: Concept art for a Fire Giant from *World of Warcraft*'s 2007 expansion pack, *Wrath of the Lich King* (p. 28). Inside cover: Tape of IBM's FORTRAN Scientific Subroutine Package for the System/360, software that is currently being preserved by the Museum (p. 30). Opposite: High-resolution MRI scan of the human brain (p. 20).

CORE 2013



SPECIAL SECTION: MAKE SOFTWARE

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John C. Hollar is President and Chief Executive Officer at the Computer History Museum. Hollar directs the Museum's strategic planning and operations. He is responsible for leading the Museum toward its goal of being the world's leading institution exploring the history of computing and its ongoing impact on society.

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CEO'S LETTER

WHY SOFTWARE IS EATING, AND CHANGING, THE WORLD

"Why Software is Eating the World" is the provocative title of an essay by Netscape co-founder and venture investor Marc Andreessen. He wrote it for *The Wall Street Journal* in 2011 and quickly found he had created a meme that swept—and continues to sweep—the Internet. Andreessen's thesis is simple, straightforward and, in the eyes of some, unassailable: the world is in the middle of a dramatic technological and economic shift in which software will take over the global economy.

In fact, much of that territory has already been taken. A JP Morgan Chase executive in 2012 described her company as an information technology business that happened to hold a banking license. At the height of its success, Kodak processed an estimated 150 million photographs a year; a recent MIT study estimated that 1.2 trillion digital photographs were taken by smartphones alone in 2011. GPS systems guide tractors sowing corn in the farms of the U.S. Midwest, and algorithms operate the implements dispensing the seeds and fertilizer according to instant analysis of soil content. As Andreessen explains, any entrepreneur can set up her business online in one day by leasing systems and storage in the Amazon cloud, setting up a payment account through PayPal, and marketing to a billion potential customers through Facebook.

As the world speeds through this transition, we believe it's important to take stock of the history of software and the implications for all of us in the future. This year we are embarking upon a major initiative to do just that—a multi-platform content project that we call *Make Software: Change the World!* Our aim with *Make Software* is to explain the impact of software for visitors of all ages and geekiness levels. *Make Software* will focus on game-changing stories of breakthrough software applications that touch almost every facet of modern life, and the exhibit that is at the center of the project will open in a remodeled area of the Museum in 2014. The digital version will go live at the same time on computerhistory.org.

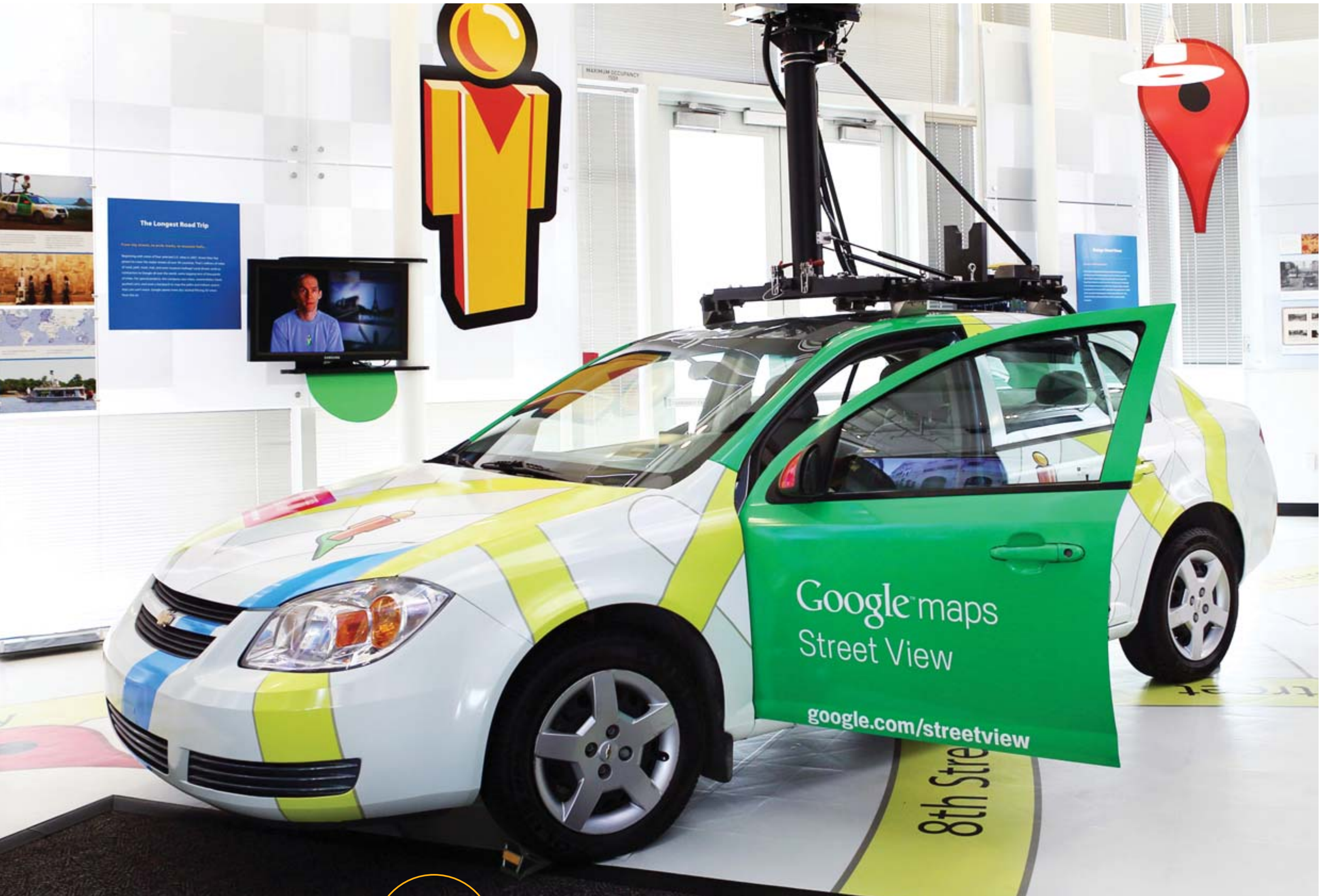
You'll read about *Make Software* in this issue of *Core* and also learn how much the Museum is doing to preserve the rich and complicated history of software in our archival and curatorial work. You'll discover the story of our new digital repository, which now holds more than two terabytes of vintage code and much of its related documentation—and so much more. And you'll sample a fascinating oral history of Ward Cunningham, who developed the wiki as a simple, ubiquitous publishing tool.

We're delighted to bring all of this and more to you in this edition of *Core*. Ideally, it will give your mind something to chew on as software continues to eat—and change—the world.

Yours sincerely,

JOHN C. HOLLAR
PRESIDENT & CHIEF EXECUTIVE OFFICER

Going Places: The History of Google Maps with Street View exhibit at the Computer History Museum.



MUSEUM UPDATES

GOING PLACES: THE HISTORY OF GOOGLE MAPS WITH STREET VIEW

BY MARC WEBER

THIS EXHIBIT IS MADE POSSIBLE THROUGH THE GENEROSITY OF GOOGLE, INC.

Since 2007, the Street View feature of Google Maps has transformed our ideas about going places, from faraway lands to a restaurant across town. In May 2012, the Museum launched a new temporary exhibit on the history of this and other "surrogate travel" systems. While computerized "movie maps" go back 35 years, today's connected computer power is turning tools that were once the province of artists and visionaries into a part of everyday life.

Visitors get to sit inside a Street View camera car and pedal a camera trike to activate their own big-screen tours. They can hear behind the scenes stories from the Google Street View team and see footage of vintage views, including a fateful tour of Market Street just days before the 1906 earthquake. There's also historic video from MIT's groundbreaking Aspen Interactive Movie Map project of 1978, which pioneered many of the features of modern street views using videodiscs and minicomputers. The exhibit shows how camera cars work, examines social impacts from privacy to tourism, and speculates about what the armchair traveler may see 35 years from now. There's even a full-sized Pegman costume on display in the Museum lobby.

Artists and filmmakers have long tried to immerse viewers in distant scenes, from cave paintings to early 3D movies. The exhibit traces how computers made this process interactive, with the groundbreaking movie maps of the 1970s, and how the modern Web let companies like Google scale it up to become so useful. We're the first generation to have ubiquitous access to those old dreams of "surrogate travel," from checking out a friend's new house to more safely rebuilding a city after a disaster.

The exhibit began when Google offered an early Street View car and a trike to the Museum for its collection. On a visit to look at the materials on offer with her staff, VP of Collections and Exhibitions Kirsten Tashev got intrigued with the idea of turning it into something more than a donation. The Google Street View team was in the process of marking the five year anniversary of the service, and was pleased to help out. For example, Google Street View engineers rigged up the special interactive trike and visitor-proofed the car.

As Web and Internet curator, I developed the content for the exhibit, which was designed by Tashev and Director of Media Jon Plutte. In less than three months "going places" had gone from an idea to a full physical exhibit with video and interactive features. ○

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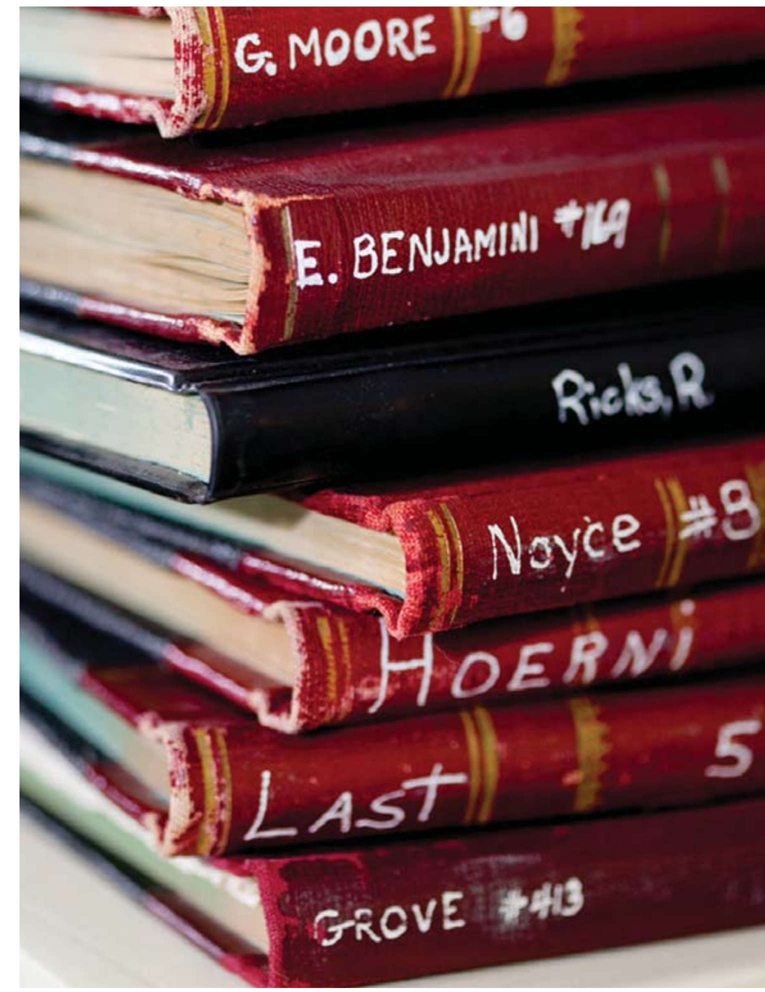
MUSEUM ACQUIRES THE "FOUNDING DOCUMENTS" OF SILICON VALLEY

BY DAVID LAWS

More than 1,300 historically vital Fairchild Semiconductor patent notebooks—many dating from the dawn of the integrated circuit—were donated to the Museum in July 2012. They represent the founding documents of Silicon Valley. *San Jose Mercury News* columnist Mike Cassidy has called them "the tech equivalent of the Magna Carta, the Declaration of Independence and the Constitution."

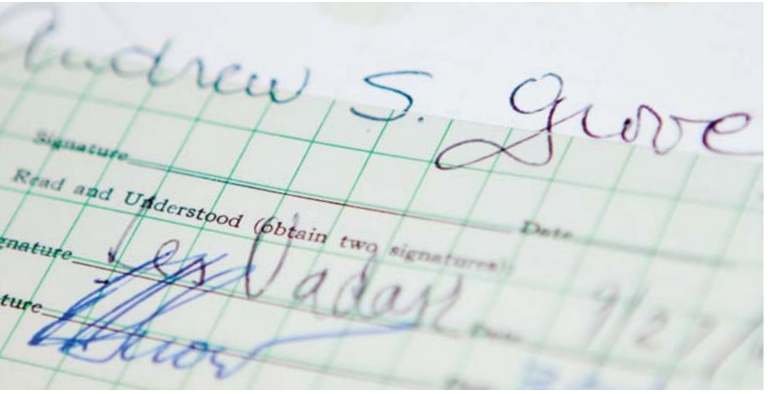
Created by engineers and scientists of the pioneering computer chip company, the notebooks provide an almost day-by-day account of work at Fairchild Semiconductor from 1957 to the 1970s—work that revolutionized the science and manufacturing of microelectronics and drove the explosive growth of the region we now know as Silicon Valley.

Fairchild was founded by Gordon Moore, Robert Noyce, Jean Hoerni, Julius Blank, Eugene Kleiner, Victor Grinich, Jay Last, and Sheldon Roberts. The history-making contributions of these entrepreneurs included building the first practical integrated circuits (ICs), the invention of the low power technology CMOS that enables



Fairchild Semiconductor patent notebooks that were donated to the Museum on July 2, 2012.

A disclosure in his patent notebook written by Andy Grove, Assistant Director of Fairchild Semiconductor Research & Development Laboratory, is witnessed by two of his colleagues, Les Vadász and Ed Snow.



every portable digital device today, and pioneering the development of semiconductor memory. All of these breakthroughs and many others critical to our modern technological society grew from ideas documented in these notebooks.

The notebooks formed part of a contribution of 115 boxes from Texas Instruments (TI) and were officially donated in a ceremony at the Museum on July 2nd. TI acquired the documents in 2011 when it purchased National Semiconductor, which had owned the notebooks since its purchase of Fairchild in 1987. John Hollar, Museum President and CEO, said, "We are proud to ensure they will be preserved for, and presented to future generations, and we are enormously grateful to TI for its generosity and vision in making this gift."

Highlights from the books include Hoerni's first description of his planar process that continues to provide the foundation for modern semiconductor manufacturing; Noyce's conception of the IC; Moore's work on metal deposition; and Andy Grove's research into reliable MOS technology.

The notebooks also frequently reveal the humorous sides of Fairchild's engineers. Eventual Nobel Prize winner Herbert Kroemer, for example, scrawled "What a blooper" beside an error in his computer program pasted into his notebook.

Conservation and processing of the notebooks by the Museum's curatorial and archival staff will take place over the next several years. These seminal documents will form the basis of future exhibitions, publications, and education programs at the Museum and are a critical resource for historians of Silicon Valley and the semiconductor industry. ○

SOVIET-ERA SEMICONDUCTOR PIONEERS: ORAL HISTORIES SERIES

BY ALEX BOCHANNEK

The Museum took a major step in its international expansion this year with a series of oral histories of information technology pioneers in Russia. The interviews, which focused particularly on semiconductor science and business in the former Soviet Union, follow a successful, similar project in Taiwan in 2011.

The history of semiconductors and microprocessors in the United States is quite familiar. The developments in the Soviet Union, however, are rarely considered in the Western literature. In 2009, I set in motion an outreach project with a focus on Russian computer history and have made annual research trips to Russia and Eastern Europe for the past three years. Following a meeting at the SoRuCom 2011 conference in Veliky Novgorod, Russia between former Svetlana Semiconductor executive Victor Tsvetov and me, the possibility of documenting this history became apparent.

Left to right: Alex Bochannek (CHM), Victor Tsvetov (former Svetlana engineer and executive), Rosemary Remacle (CHM), Vladimir Popov (Managing Director Svetlana Semiconductor).

The opportunity grew into an extended oral history project on-site in Russia with the help and support of longtime Museum Trustee Gardner Hendrie, who has been instrumental in many oral histories and, as a volunteer, chairs the Museum's Oral History Steering Committee. The Museum raised additional financial support from the Russia Venture Company and the Skolkovo Foundation. Rosemary Remacle, former staff director of the Museum's Semiconductor Special Interest Group—an industry veteran herself—set out to recruit the most important participants in Russia, plan the interviews, and work out the complicated logistics.

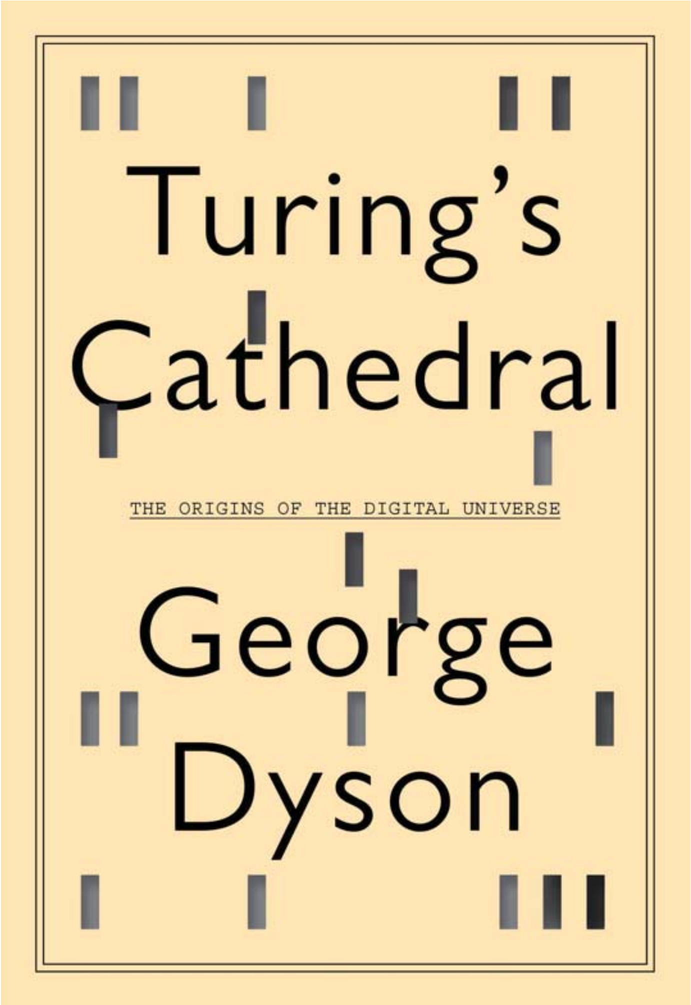
Remacle and I spent a week in St. Petersburg and Moscow in May 2012 conducting the oral histories and meeting with Russian experts. The interviews, conducted primarily by Remacle, ranged from semiconductor physicists like Nobel laureate Zhores Alferov, to representatives from manufacturing firms and government officials, to well-known supercomputer architect Boris Babayan, now an Intel Fellow in Moscow.

The interviews provided new insight into the state of semiconductor research and development, manufacturing, and applications in the Soviet Union. The interviewees offered a candid view of their experiences, often spanning more than half a century, especially when reflecting upon the breakup of the Soviet Union in 1991. The transition from a planned economy with great demands on development and manufacturing, particularly by the military, to a market economy proved to be dramatic to the industry.

While the interviews were very successful, much more remains to be done. The highly compartmentalized nature of industry and research in the former Soviet Union makes it difficult to get a comprehensive view of parallel developments. This challenge is magnified when considering work done in other Eastern Bloc states like East Germany, which also had a thriving microelectronics development program.

Exploring this rich history greatly strengthens the position of the Museum as an authoritative source of computing history that goes beyond the familiar—or the strictly American. ○

In *Turing's Cathedral*, author George Dyson introduces us to the remarkable engineers who were pioneering the development of computing after World War II.



IN THE BEGINNING WAS THE COMMAND LINE

A CONVERSATION WITH GEORGE DYSON, AUTHOR OF *TURING'S CATHEDRAL*
INTERVIEW AND EXCERPT BY JOHN HOLLAR

MAJOR FUNDING FOR THE *REVOLUTIONARIES* SERIES IS PROVIDED BY THE INTEL CORPORATION

The world inhabited at Princeton University by Alan Turing and John von Neumann more than seven decades ago seems distant and inaccessible in many ways. And yet George Dyson's brilliant book *Turing's Cathedral: The Origins of the Digital Universe* makes it as vivid and relevant as today.

The Museum is grateful to Dyson for taking the time on March 7, 2012 to discuss his fascinating biography of John von Neumann as part of our *Revolutionaries* program series and celebration of 2012 as the centenary of Alan Turing's birth. This edited excerpt is taken from the live conversation in Hahn Auditorium.

Hollar: *Turing's Cathedral* is a metaphor. Let's talk about the title of the book and how you came to it.

Dyson: One of the good things about Turing is that he left very few papers, so you can read everything he wrote. With von Neumann, it's hopeless to try and read everything he wrote. And in 1950 Turing wrote his tremendously famous paper—as famous as his 1936 paper on universal computation—about artificial intelligence. He made the statement that when we create intelligent machines, we are no more creating souls than we are in the process of procreating children. We are simply creating mansions for the souls that [God] creates. I love that phrase.

In 2005, when I visited Google, the engineers there gave me a very deep insight to what was going on there. When I walked out, I was astonished. They were really, truly doing everything that Turing had imagined—building a machine that sought to answer all the questions that anyone could ask in a non-deterministic way. And I thought, on one level, "This is not Turing's *mansion*. This is Turing's *cathedral*." And on a second level, the cathedral is built by large numbers of anonymous people whose names are not remembered, but the cathedral remains. So that became the title of the book.

Hollar: Turing and von Neumann did overlap at Princeton for two years while Turing was there doing his PhD. How much is known about their interaction?

Dyson: We know they interacted when they were there together during 1936 to 1938. Even though Turing was at Princeton University, and von Neumann was at the Institute [for Advanced Study], they shared office space. And that's where Turing corrected the final proofs of his great paper. He certainly had an influence on von Neumann.

Hollar: You cite several instances in the book where it's evident that von Neumann knows what Turing is working on. It seems that he was aware of Turing's theories as he was working on his own seminal paper.

Dyson: Yes. I decided to do a little physical research, rather than just speculation. So I went and found von Neumann's copy of Turing's paper. It's in the Institute library in one of those shelves that you have to turn the cranks to open. And there are all the volumes of the proceedings of the London Mathematical Society, and they're all there with perfect bindings, all intact. There's one volume, volume 42, with Turing's paper in it. If you take it out, all the pages fall out. It's completely disintegrated from being read so many times. I think that's pretty good evidence that they read that paper.

Hollar: Von Neumann's life—he's well educated in Budapest, goes to Berlin, joins the academy, is made a professor. The Nazis began to dismiss Jews from German academies. He resigns, leaves, and is appointed to the faculty at Princeton. He goes to the IAS and encounters a remarkable group who were already there and a remarkable intellectual atmosphere. Oppenheimer called it "an intellectual hotel." Talk a little bit about the IAS as von Neumann would have experienced it.

Dyson: Most people remember the Institute for Advanced Study because of Einstein and the nuclear physicists and the string theorists and the mathematicians. People forget the Institute also had a very strong school in the history of art, and a school studying Greek epigraphs, and a school of archeologists. So there was all this other culture there. He would have encountered people like Panofsky, and Homer Thompson, the model for *Raiders of the Lost Ark*.

And von Neumann didn't come alone. He came with Eugene Wigner. At that time, Princeton was not hiring Jewish professors, and so they couldn't really hire von Neumann flat out, but they found a loophole. They could hire two Hungarians half time. They couldn't hire one Hungarian full time, but they could hire two Hungarians half time. So, they offered Johnny von Neumann and Eugene Wigner this half a Princeton salary, which to them was ten times what you could make in Europe. And they both said yes.

Hollar: You made a crucial and startling discovery in the process of writing the book, didn't you?

Dyson: I discovered the most remarkable body of documents in [daughter] Marina von Neumann's basement. It was next to the water heater—the key filing cabinet is always next to the water heater. Von Neumann's known papers went to the Library of Congress, but

Top: Museum President and CEO John Hollar takes the stage to introduce author George Dyson. Bottom: John Hollar and George Dyson discuss Dyson's latest book, *Turing's Cathedral*.

BUILDING A DIGITAL FUTURE

BY PAULA JABLONER

Digital Repository core team from left to right: Ton Luong, Katherine Kott, Heather Yager, Paula Jabloner, Al Kossow, and Vinh Quach.

Building a robust and accessible digital collection is now as strategically important to the Museum as building our enormous and unique physical collection. In 2012, the Museum began serious work toward this ambition with the launch of a new digital repository.

The project came just in time. For 12 months, the Museum had been focusing on its own mini deluge of digital data. The Museum found itself at a preservation turning point. Our in-house produced high-definition oral histories, lectures, and exhibition videos were usurping our available server space at over 60 terabytes, with another 10 TB of historic digital artifacts including images and software.

To meet this challenge—with the clear recognition that digital assets will be a critical element of our future collection—the Museum organized a digital repository working group in late 2011. Our primary goal is to build a prototype digital repository with the proper hardware, software, and accessibility model. The work has been generously funded by a grant from Google.org.

Through the first nine months of 2012, the working group completed the planning and exploration phases. After months of study, we elected to build our own storage infrastructure using open source software and readily available components that are modular and extensible, allowing growth over time. To administer the metadata and other administrative functions, including migration and normalization, we will use *Archivematica*, an open source digital repository management system. We're currently in the throes of building and testing this system and firmly believe the straightforwardness of the infrastructure will guarantee the sustainability of the digital artifacts entrusted in its care.

The working group is excited about the possibilities the new digital repository represents for expanding our digital collection while putting the Museum in the forefront of peer cultural institutions creating digital repositories.

The tragedy of von Neumann's early death is that he was very interested in artificial intelligence, but he didn't want to publish anything until he had a complete theory of it, and he never got there.

this filing cabinet didn't go. In the bottom drawer was all the handwritten correspondence between von Neumann and Klari, his [second] wife, from 1937 to 1957. The papers give you a day by day, firsthand picture of what people were really thinking at the time.

Hollar: Was he using that as a means of getting the information out?

Dyson: It was like email is to us. He would have a full day of meetings and solving problems, and still write 16 pages in fountain pen to Klari at night. They had a difficult marriage. They were always in different places because she was doing some of the coding for early bomb calculations. So, she might be working on the ENIAC in Aberdeen [Maryland]. And he would be in Los Alamos [New Mexico] or Oak Ridge [Tennessee]. And these letters went back and forth. And they were half in Hungarian, but I have friends who translated all the interesting Hungarian.

Hollar: Did you know that this secret trove of letters and this documentation existed?

Dyson: I had no idea. I couldn't have imagined it. To me the most interesting period of American history is that period from just before World War II until Sputnik. After Sputnik, we have a very good record, but there's a period there where it's really not clear what people said. The Oppenheimer trial is pretty good on some of the things surrounding von Neumann's work at Los Alamos because they had people under oath, and they got everybody to testify, but that's still not what people were really thinking at the time. In her letters, for example, Klari describes that day on which they closed the mousetrap on Oppenheimer and what everybody's reactions were. You're not going to get that anywhere else.

Hollar: How did you come upon that filing cabinet?

Dyson: It was thanks to Marina von Neumann, who knew through Charles Simonyi that I was doing this project. One day she said, "Maybe you should come to Ann Arbor and look at this stuff." It was awkward for her, because this is the woman that her father left her mother [Mariette Kövesi] for. She didn't really want to look at these very, very personal letters. But she trusted me to go through them and take out what was useful for the history of computing. And it brings the book to life. I don't think there would be a book that's as alive without her voice.

Hollar: You used the phrase "a deal with the devil" a minute ago talking about Los Alamos and the atomic bomb. There was another deal with the devil made for the computer that von Neumann wanted to build after the war, wasn't there, in the design of the hydrogen bomb?

Dyson: Yes, and I feel this is a fable for the future, and a metaphor, but the deal was that the devil could have this weapon, the hydrogen bomb, that could destroy all life on Earth. And von Neumann and the scientists asked to design it would get this computer that would reveal all knowledge. It was this incredible trade, sort of like a "give me everlasting life and I'll give you my first born child" sort of thing. And we think that we won that deal, because we survived—we don't really worry about those bombs like we used to. But I think what you have to remember is that computers could be equally threatening. Maybe the devil is out there saying, "I didn't really want the bombs. I wanted the computers." That's what I think we need to be watchful for—that we do not let this global computing network that is so beautiful—it is a cathedral—become the tool of some totalitarian maniac.

Hollar: Another note on von Neumann and Turing: you write, "When von Neumann spoke of computers, he never talked about artificial intelligence, and Turing talked of little else." Please talk about that dichotomy.

Dyson: I'm more on the Turing side. I love speculating about artificial intelligence, but von Neumann was very reserved on it. He never published anything until it was perfectly proved. He spoke in perfect complete sentences. Turing was very much the other way—just wrote and said what he thought, and so they were just very different characters. The tragedy of von Neumann's early death is that he was very interested in artificial intelligence, but he didn't want to publish anything until he had a complete theory of it, and he never got there. Turing died at age 41, and von Neumann at age 53.

Hollar: Is what we're seeing today the approximation of artificial intelligence as Turing might have thought of it?

Dyson: I think it's oddly close. People remember Turing's 1950 paper, the one with the imitation game, and they remember his 1936 paper on the universal machine. The one that I think is equally important, but less remembered, is his 1938–39 PhD dissertation at Princeton on nondeterministic machines that he called Oracle machines. These are machines that are deterministic, but every once in a while they just take a jump like we do in thinking. We may think very logically, and then do something illogical, but we put it together, and that's intelligence. Turing, in fact, believed that he had proved that a machine that never makes mistakes can never be intelligent.

If you look at, for instance, what Google is doing, it's a million perfectly predictable deterministic Turing machines in the classical sense. Yet they're connected by these nondeterministic links, which are the people doing the searches. Every time you're given 10 search results and you click on one, that's a nondeterministic process, and then the deterministic machine incorporates that nondeterministic leap into the state of the deterministic machine. Google can get you those results in a millisecond, because it knows other people have found meaning in them. You can't imagine a more perfect blueprint for an Oracle machine. It's not scary—we love it. We couldn't live without it now. ○

The full interview is available on the Museum's YouTube channel: youtube.com/computerhistory

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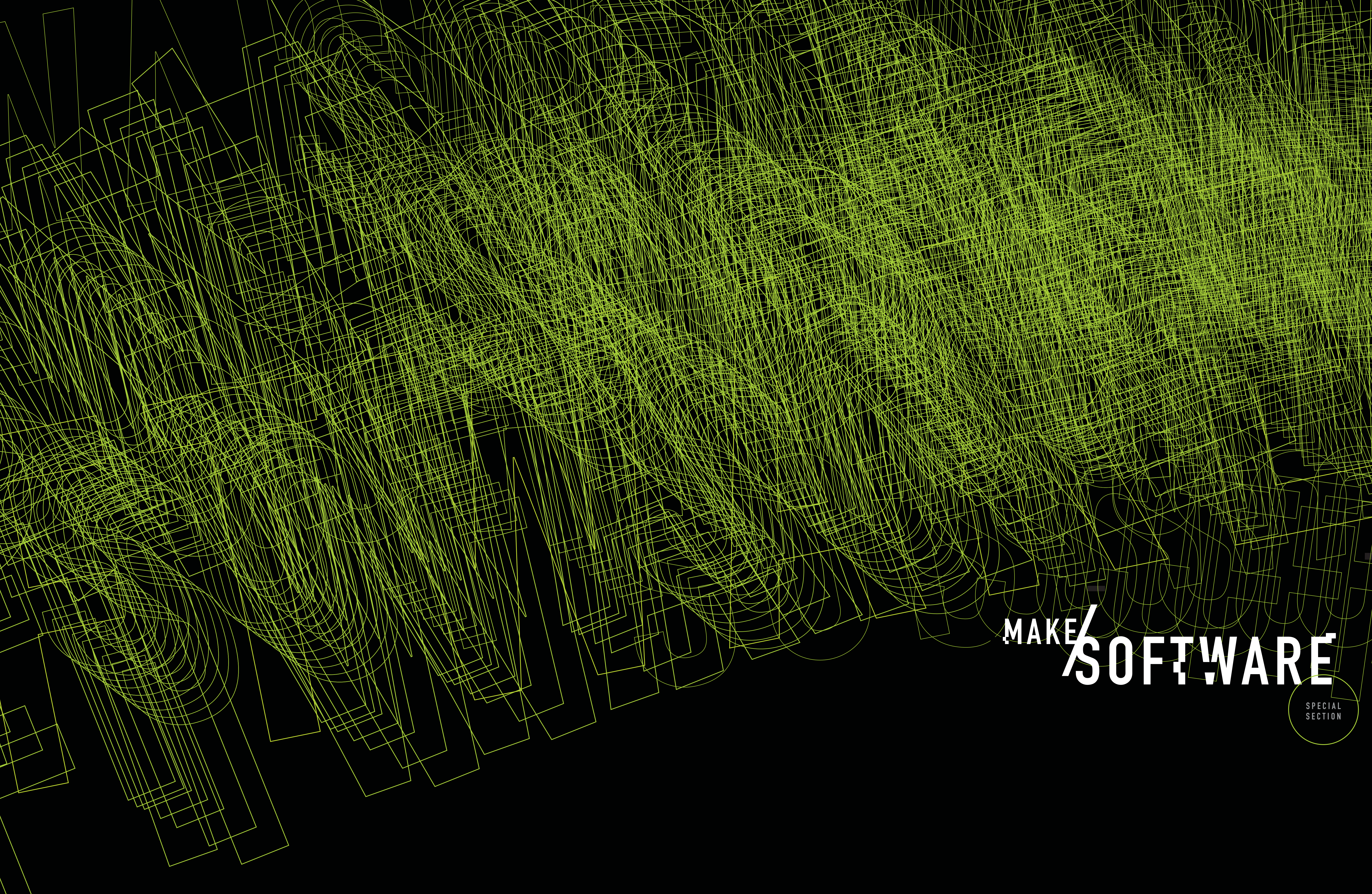
HELPING STUDENTS GET INVESTED

BY LAUREN SILVER

The Museum is in its second year of an exciting new education program for high school students. Funded in part by a grant from the HP Catalyst Initiative, *Get Invested: Case Studies in Innovation* immerses underserved students in creative inquiry and problem solving through the application of STEM (Science, Technology, Engineering, and Math) skills and principles. Starting in August 2011, students from Central County Occupational Center in San Jose, CA, and from two high schools affiliated with the University of Monterrey, Mexico, worked to identify social challenges which they believed could be addressed through innovative technological solutions, and to create formal proposals for their ideas. Students explored our permanent exhibition, *Revolution: The First 2000 Years of Computing*, to learn how successes and challenges from the past could apply to their own innovations for the future, and they developed skills in entrepreneurship, ultimately presenting their proposals to venture capitalists who provided them with marketing and business feedback.

A formal evaluation of *Get Invested* revealed increases in students' interest in STEM learning, confidence in themselves as innovators, and ambitions towards careers in technology; teachers gained insights about teaching through their collaboration with Museum Education staff and volunteers. As we move into our second year, *Get Invested* continues to grow and garner attention: the Museum recently received a STEM Innovation Award from the Silicon Valley Education Foundation, honoring *Get Invested* for exemplary education in engineering. With these early successes as our base, the Museum is on its way to making major contributions to STEM education in Silicon Valley and beyond.

Students from the Central County Occupational Center, San Jose, CA, and the University of Monterrey, Mexico, present their projects to Silicon Valley venture capitalists at the Museum on March 9, 2012.


MAKE/SOFTWARE
SPECIAL SECTION

INTRO

WHY SOFTWARE HISTORY MATTERS

BY DAG SPICER

SPECIAL SECTION

Software. What is it? You can't taste it, smell it, feel it, or do much of anything with it by itself. But connect that software to a computer and magic happens. The computer is the ultimate machine—"ultimate" because it is a universal machine. The same physical computer can perform thousands of different tasks—from guiding a robot surgeon to tweeting—simply by changing its software. This marks the computer—and software—as utterly unique in the history of technology. For as long as humans have been making things, nothing has had the universality of the computer.

Given this universality, it's perhaps not surprising that we interact with software every day, nearly all day, whatever our walk of life. Today, a child born in a modern hospital will be scanned within minutes of birth, his critical medical information stored in a massive database where it will be used to track his health. By the time he dies, he will have had millions of individual interactions with a computer.

While software is considered a highly technical field, creating software is equal parts art, science, politics, economics, and marketing. Sometimes the "best" software loses in the marketplace while a mediocre competitor thrives. As in other forms of creative expression like music, art, or literature, there is both good and bad software. Whatever its inherent quality, however, all software provides us with a lens through which to examine the technoscientific foundations of our modern world; software is a part of our built world as much as skyscrapers and bridges, both liberating us and constraining what we can do in our daily lives. While we may not understand the technical details of software, its effects are certainly easy to understand and knowing a bit about the process of its creation may give people the confidence to effect change in this *software-built* world.

Why software is part of the Museum's mission

The Museum collects software because it is the "sheet music" to the computer's "piano." To collect only the hardware artifacts of computing would be to collect only half the story, perhaps less. A Steinway piano is a beautiful instrument but without the music "software," it is mute and hardly fulfilling its intended purpose.

To give visitors an appreciation for how complex, beautiful, and interconnected our world is through software, the Museum is launching a new exhibit in 2014. Entitled *Make Software: Change the World!*, the exhibit will be unique in the world and has several important goals in mind for the visitor.

First, we hope to show seven special stories about software that are both relevant and impactful—relevant in the sense of something you might use yourself (or at least know about), and impactful in the sense of the software affecting the lives of millions of people, usually on a global scale.

The exhibit's other goals include explaining what software is, how it works, and how it is made. These goals mesh with the exhibit's approach of balancing both maker (creator) and user perspectives—i.e. how is it made and what was it like to use it?

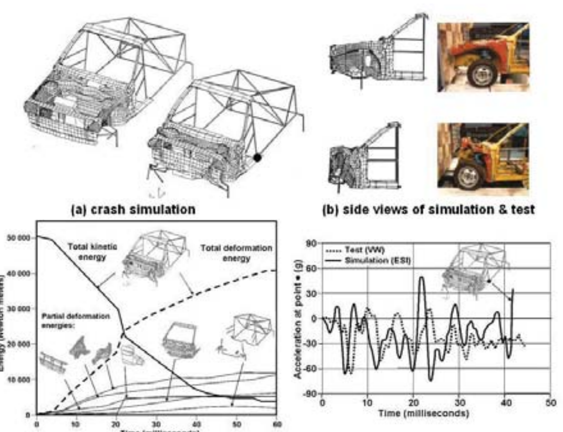
The seven software impact stories in the exhibit are: Car Crash Simulation; MP3 and iTunes; Magnetic Resonance Imaging (MRI); Photoshop; Texting; Wikipedia, and *World of Warcraft* (a massively multiplayer online game featuring role-playing). Not all of us have been involved in running car crash simulation software, but we all benefit from it. The same is true for MRI diagnosis. Texting, while a convenience in western countries, is an absolute lifeline for many parts of the developing world. And while we may not know how to use Photoshop ourselves, we are immersed in its effects throughout our global culture (as when "Photoshopped" models with impossible blemish-free skin coax us to buy). Some of the technologies we look at have deep historical antecedents—when Twitter launched, people described it in terms quite similar to those describing the first telegraph message. And doctoring photographs has been a part of photography since its beginnings in the mid-nineteenth century.

Finally, the exhibit will feature a "software lab," in which visitors can learn about the creation of software, what it is, how to program a computer, and how software is made as a product. This area will serve as a conceptual hub for *Make Software: Change the World!*, as well as a jumping off point for the seven impact stories. We are excited to bring this software exhibit to the general public. It represents an opportunity for the Museum to interpret software for a broader audience in an authentic, engaging and interactive way. ○

Software. What is it? You can't taste it, smell it, feel it, or do much of anything with it by itself. But connect that software to a computer and magic happens.

THE EVER SAFER VEHICLE?

BY ALEX BOCHANNEK



Top: Crash test of a 1999 Subaru Forester conducted by the Insurance Institute for Highway Safety. Bottom: Comparison of simulated and physical crash test results of the 1986 VW Polo simulation.

© TIM WRIGHT/CORBIS / VW POLO: COURTESY OF VOLKSWAGEN AG & ESI GROUP

Motor vehicle crashes are the leading cause of death among Americans ages 3–34. However, even as the population continues to grow and the number of miles traveled increases, the number of deaths has declined 47 percent from 1975 to 2009. Many factors contribute to this, but changes to vehicle design play a major role. Computer-simulated crash tests enable car manufacturers to respond quickly and economically to evolving regulations, and to build safer cars.

Crash-Testing Cars

During the development of the Ford Mondeo in the 1990s, Ford crashed 150 prototypes over five years. Each of these prototypes cost roughly $250,000. As the cost for prototypes goes up and the cost for computing goes down, simulation becomes an appealing alternative: it allows for quick iterations of designs and more models can be tested than could be constructed for physical tests. Simulation also allows the engineers to ask new questions. For example, they can investigate causes of deformations—why a car's body shape is changing in response to a collision—rather than just the effects.

The Finite Element Method

Different techniques are employed for simulating different aspects of a car's design. In the Finite Element Method (FEM), the shape of the car is modeled as a mesh of interconnected elements. The equations representing the interaction of the elements are solved for each step in time. The more elements there are in the mesh, the more accurate the simulation of the deformation becomes. The software used for this analysis is called a finite element solver.

Most commercially available FEM solvers for car crash simulation have their roots in the DYNA3D software developed in 1976 by John Hallquist at Lawrence Livermore National Laboratory. The project for which the software was written was for simulating a specific type of nuclear bomb. While other FEM solvers existed, none had the specific capabilities that DYNA3D offered. DYNA3D was shared with other organizations and Hallquist founded Livermore Software Technology Corporation (LSTC) in 1989 to commercialize DYNA3D as LS-DYNA.

1986: 5,661 Finite Elements in Four Hours

One of the earliest full vehicle crash simulations took place in 1986. A VW Polo was modeled with 5,661 elements, and the simulation of a 60 ms impact took four hours on a Cray-1 S supercomputer. While experiments with crash simulations had been done since the 1970s, the supercomputers available by the mid-1980s, together with sophisticated solver code, usually written in Fortran, gave the engineers the required accuracy and the efficiency necessary to integrate car crash simulation into their toolkit.

By about 1990, crash simulation had become part of the development process. By the 2000s, virtual crashes outnumbered physical tests by orders of magnitude. As computing power increased, so did the complexity of simulation models. The number of elements for a typical simulation increased from 15,000 in 1990 to 1.5 million in 2005 to 10–15 million elements in 2012. The limiting factor is the simulation turnaround time; the longest acceptable wait time for the engineers is usually overnight.

The Limitations of Simulation

Car crash simulation has limitations, and questions about its accuracy remain. How much trust should the mechanical engineer put into the software engineers who created the simulation codes? This is not a problem specific to automotive engineering; many areas of science and engineering have long tried to identify the role of the computer as an instrument for inquiry.

In practical terms, virtual simulations are limited not just by computational power, but also more importantly by their models. As new materials gain wider acceptance in passenger cars, the models need to be adapted for their new failure modes.

Different Safety Goals

The goal of producing safer cars is shared by manufacturers, customers, consumer advocates, insurance companies, and regulatory agencies. The overall intention is the same—the reduction of serious injuries or death—but the motivations differ. The customers want to reduce their own risk. Reducing costs motivates the insurance companies and manufacturers. The regulatory agencies respond to this dynamic by introducing rules and regulations to which the manufacturers need to respond.

Regardless, increasing crashworthiness has had a dramatic impact on the reduction of automobile occupant deaths, and car crash simulation has played a significant role since the 1990s. ○

MP3 AND THE ITUNES MUSIC STORE 2

ONE MILLION SONGS IN SIX DAYS

BY ALEX BOCHANNEK

Six days after the April 28, 2003 launch of the Apple iTunes Music Store, users had downloaded and legally paid for one million songs—well ahead of Apple's own projection (Apple believed it would hit the million-song milestone in six months). By 2010, 10 billion songs had been downloaded and Apple had become the number one retailer of music in the world.

How did this shift from brick-and-mortar record stores to a world with near instantaneous access to music come about? It's the story of a clever algorithm, a shifting business model, and consumers who above all value ease of use.

The Creation of MP3

In 1986, a German graduate student was approached by his thesis advisor with the challenge of how to transmit high-quality music over digital phone lines. After one week of late-night work on this difficult problem, Karlheinz Brandenburg had developed the foundation for what was to become MP3.

Brandenburg's approach for digitally encoding music was unusual. Instead of encoding the sound as it was produced, he decided to only process what the human ear could actually hear, discarding what could not be heard, and yet still create music perceived as high quality. Testing went well and by 1988 his refined software could indeed transmit high-quality music over digital phone lines.

When standardization efforts for digital video encoding were progressing within the Moving Picture Experts Group (MPEG), digital audio received increased attention. Brandenburg's work was considered as a third alternative to two other audio encoding. His Audio Layer III became part of the MPEG standard in 1992.

MP3 Becomes a Standard for Internet Audio

Initially, there was little industry interest in MPEG Audio Layer III, but its creators saw an opportunity to establish it as the de facto audio standard for the Internet. They announced the format and its new *.mp3* filename extension on July 14, 1995.

Many computer users started filling their music libraries with illegal copies of CDs available on the Internet. The culmination of this development was the Napster file sharing platform in 1999 that allowed users to exchange MP3s without any consideration of copyright.

The Napster platform shook the record industry, which had reacted to MP3 with complacency. Legal action resulted in the shutdown of Napster in 2001, but an estimated 25 million people had already accessed 80 million songs globally.

Apple Changes the Business of Music

Portable MP3 players like the Rio PMP300 were already available in 1998, but it was Apple's attention to a well-thought-out user experience that made the iPod a success. Apple combined several acquired technologies and tied them together in the iconic all-white device designed by Jonathan Ive. Apple released the first iPod in 2001.

As the music companies struggled to cope with the tectonic shift in their industry, Steve Jobs looked at ways to make it simple and legal for iPod users to download music.

The iconic silhouetted figure ads were introduced by Apple for the third generation iPod in 2003.

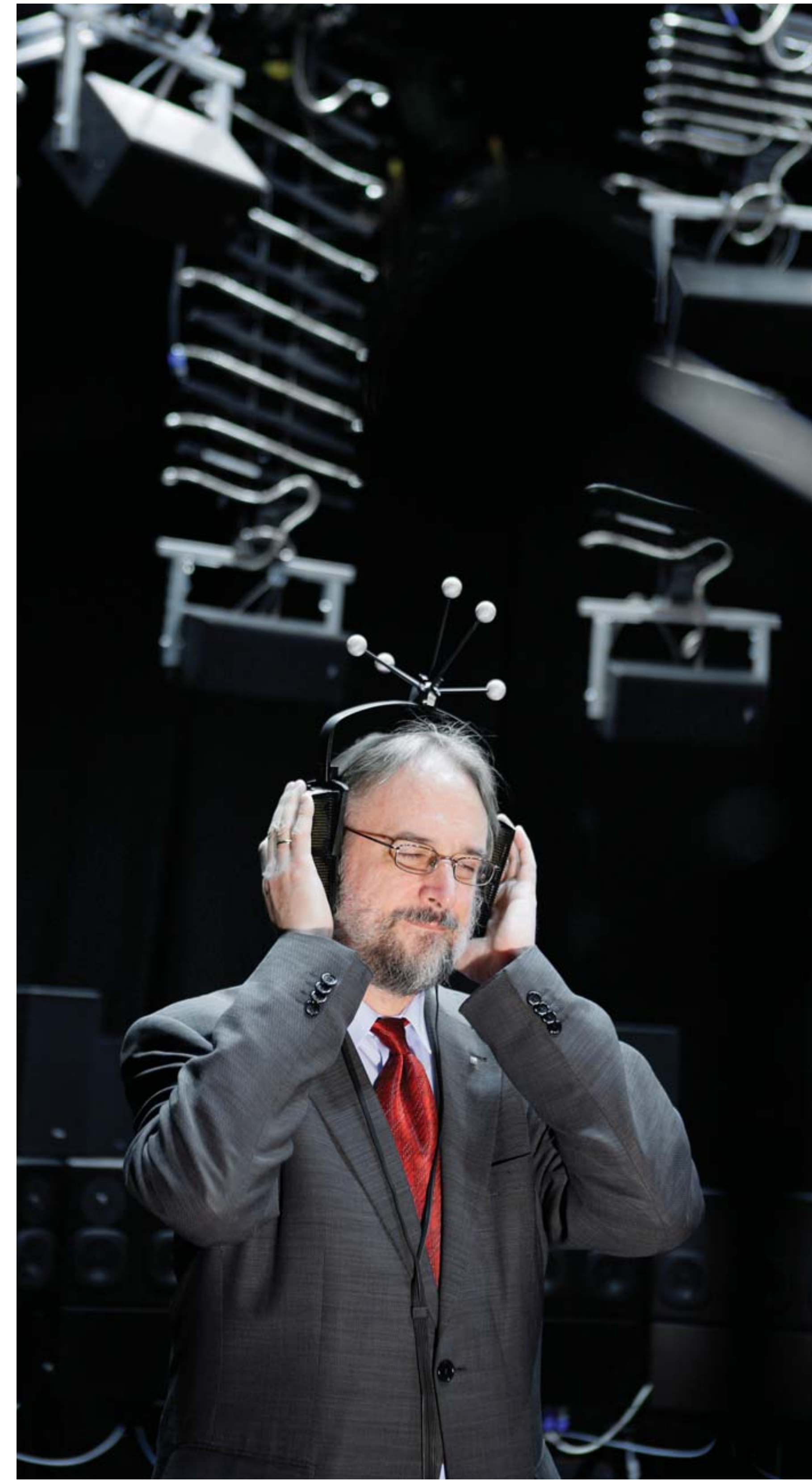
Jobs, with the Macintosh's small market share as his bargaining chip, was able to persuade the record labels to offer songs at 99 cents each when the iTunes Music Store launched in 2003. Its FairPlay digital rights management software was unobtrusive enough for the customer, but satisfied the music industry's concerns about protecting its copyrights.

The success of iTunes forced Apple to open its music store to Windows users—a major change for the record companies, who had relied on their music only being available to the relatively small Macintosh market.

iPod Culture

MP3 and iPod are terms that have entered the general vocabulary. White earbuds are part of today's visual culture. The way music is purchased and consumed has fundamentally changed. Apple has successfully broadened the iTunes Store offerings to become an increasingly comprehensive reference library. Musicians can also more easily self-publish in the MP3 format and distribute their music over the Internet. To the buyer of music, the ritual trip to the record store has all but disappeared and the easy availability of tens of millions of songs from any genre, time period, or geography has flattened out the musical landscape. There is no longer a difference between a new song and an old song. Both are just a mouse-click away. ○

Karlheinz Brandenburg, originator of the MP3 audio compression method, in his audio laboratory.



MAGNETIC RESONANCE IMAGING 3

High-resolution MRI scan of the human brain.

SIEMENS AG, MUNICH/BERLIN

SEEING THE INVISIBLE

BY DAG SPICER

Today, magnetic resonance imaging, more commonly known as MRI, is one of the leading tools doctors have for diagnosing and treating disease. MRI can actually refer to a variety of different procedures, depending on the settings of the scanner and the software used. These different approaches are called *studies* and highlight different features of the human anatomy. Another common use for MRI is for surgical planning, including radiation therapy if required. The ability for surgeons to know ahead of time exactly what anatomical features they will encounter while operating has dramatically improved patient safety and surgical outcomes.

History of MRI

What are the origins of MRI and how did it develop into the sophisticated imaging technology of today?

The story of MRI takes place over several decades and involves a multidisciplinary group of chemists, engineers, physicians, technicians, and scientists. MRI is an outgrowth of work done on nuclear magnetic resonance (NMR) and it is there that the story begins.

In 1937, Columbia University Professor Isidor Rabi observed the quantum phenomenon dubbed nuclear magnetic resonance (NMR). NMR occurs when atomic nuclei absorb or emit radio waves when exposed to a strong magnetic field.

In 1946, Felix Bloch at Stanford and Edward Purcell at Harvard independently elaborated on Rabi's work and discovered that when certain chemical nuclei were placed in a magnetic field, they absorbed energy in the radiofrequency range of the electromagnetic spectrum, and re-emitted this energy when the nuclei returned to their original state. When this absorption occurs, the nuclei are said to be in resonance.

Bloch and Purcell showed that different atomic nuclei within a molecule resonate at different frequencies, allowing the phenomenon of NMR to be used to identify essential chemical and structural information about a molecule. NMR was (and remains) a widely used analytical tool in scientific laboratories and is the basic scientific principle behind MRI. Both Purcell and Bloch were honored with the Nobel Prize for Physics in 1952 for this discovery.

In the 1950s, Hermann Carr (a former PhD student of Purcell's at Harvard) reported on the creation of a one-dimensional MRI image. Paul Lauterbur at the State University of New York at Stony Brook expanded on Carr's technique and developed a way to generate the first 2D and 3D MRI images. Lauterbur's technique used *gradients* (precise variations) in the magnetic field, which allowed him to determine the origin of the radio waves emitted from the nuclei of the object of study. This spatial information allows two-dimensional pictures to be produced.

In the 1970s, as the first generation of scientists began to use NMR routinely in their work, developments in MRI came rapidly. Peter Mansfield at the University of Nottingham further developed the use of gradients in the applied magnetic field by providing a new mathematical framework for analyzing MRI signals. His method reduced the time to acquire an image from hours to a fraction of a second. It took about a decade to implement his "echo-planar" technique due to insufficiently advanced computer hardware, but it is now the standard for functional MRI (fMRI).

How it works

The basic idea behind MRI is to scan the body's tissues and structures for the protons of the hydrogen atoms that make up the body's water. (The human body is about 63 percent hydrogen atoms, mostly in the form of water, so MRI can be used to scan nearly any area of the body.) These atoms are momentarily "tickled" by the scanner and, when they relax again, emit a tiny electronic "signature" reflecting the hydrogen content of the imaged area. These small differences in signatures are detected by highly sensitive electronic circuits, then filtered, amplified, and turned into a digital signal for processing by a computer. The MRI machine takes multiple scans of the area of interest at different depths, which are then turned into 2D or 3D images.

The control of the MRI scanner's sensitive parameters is also done by computer. Variables such as how long the scanner should apply a signal and how long it should wait to hear a response, for example, are controlled by *pulse sequences*. Pulse sequences are entirely under software control and define how the MRI scanner will work. New pulse sequences are constantly being developed by researchers to enable the scanner to highlight specific features of anatomy. For example, some sequences highlight water or fat, while others focus on bone or cartilage. Software also controls the movement of the table on which the patient is lying and also combines the millions of tiny electrical signals detected by the scanner into a human-readable image.

Today's MRI scanners use enormous magnets super-cooled to 450 degrees below zero with liquid Helium, generating magnetic fields 20,000 times stronger than the earth's natural magnetic field. MRI today is a life-saving technology that would not exist without sophisticated software controlling all aspects of the image acquisition process. Seeing inside the human body in such detail was not even a dream of medicine until the last few decades. The magic that controls it all is software. ○

MICHAEL DALDER/REUTERS

MRI researchers Peter Mansfield (left) and Paul Lauterbur (right).

Scientists prepare a Peruvian mummy for an MRI scan.

PHOTOSHOP 4

ALTERING PERCEPTION

BY DAG SPICER

We live in a highly visual culture. Images surround us from the moment we stare at our cereal box in the morning to the late-night TV commercials we watch before we go to bed. The creation of images—in print, online, in movies, advertising, politics, and marketing is central to our society's functioning as a democratic, mass production, consumer-oriented culture.

Since the invention of photography, photos have always been subject to manipulation. Before computers, photographs were manipulated using a variety of hand techniques, including double exposure, retouching with ink, airbrushing, and other closely guarded tricks of the trade.

Modern photo manipulation uses computers to change an image. This has made altering an image much easier, more realistic, and harder to detect. It also allows for a whole new set of possibilities that were beyond the reach of traditional image manipulation—like giving people flawless skin or pictures of strawberries that can't exist in nature, or green skies, or four moons, or dogs driving speedboats … How did this happen and what computer magic is used?

The *magic* is software.

In 1990, Adobe released version 1.0 of its Photoshop image manipulation program for the Apple Macintosh computer. It has since become the leading program for working with photographs and images in the world today.

Inventors of Photoshop Thomas (left) and John Knoll (right). The two brothers started what would become Photoshop as a hobby project.

The Roots of Photoshop

Where did Photoshop come from?

Photoshop's splash screen, the image you see when you launch the application today, credits more than 40 people for its development. But the two key developers are brothers John and Thomas Knoll.

In 1987, when personal computers were becoming powerful and affordable, Thomas was a PhD student at the University of Michigan doing work in image processing. John was at the groundbreaking special effects firm Industrial Light and Magic (ILM), the company that created special effects for *Star Wars*.

Thanks to declining hardware costs, Thomas was able to buy an Apple Macintosh II personal computer to work on his thesis. Almost right away he began improving on the Mac's ability to display more realistic images, developing a program called *Display*. This allowed him to view the more photorealistic greyscale images he was interested in—a better technique, in his view, than the Mac's built-in software supported. John saw this work and the two began collaborating on a color version that also added features to make it more useful. By 1988, their software, now named *Image-Pro*, was made up of dozens of useful graphics processing tools that the two had developed, with John suggesting changes and features for his work at ILM and Thomas writing the code. Within a year, the program had developed enough that John thought it might become a commercial product. Thomas had not yet finished his PhD, but decided to take a risk and put his studies on hold.

The Knolls eventually took their breakthrough to Adobe art director Russell Preston Brown, who persuaded his company to work on developing the program further. Brown got the Knolls' software accepted internally at Adobe and became one of its key contributors. After further refinement, the first official release of the product, now called Photoshop, was in February 1990.

Photoshop plays a key role in our image-driven culture, bridging the gap between computer-like perfection and human nature. The imagery Photoshop can create has changed our concept of beauty and art, if not reality itself. ○

Photoshop artist Erik Johansson creates impossible images like this one by playing with our sense of reality.

THE OTHER INTERNET

Texting from the fields. Two billion people have access to mobile phones but not the Internet.

BY MARC WEBER

Texting—short text and multimedia messages on mobile phones—has grown far beyond a way for teenagers to communicate in a way their parents can't control. It is becoming the dominant form of messaging on earth, with nearly four billion users—three out of four humans on the planet. As an industry, texting is worth over $150 billion a year, 25 times more than email.

But texting isn't just about personal messages, from "cu@8" to the infamous sexting. It's also being used for nearly every kind of transaction: money transfers, advertising, gambling, voting, security verification, spam, emergency services, and more.

A Parallel World

In developed countries texting is still mostly a supporting act to the "real" online world of the Web and the Internet. In developing countries the situation is reversed. From Africa to India texting and mobile phones effectively are the online world for billions, with full Internet access a luxury. Here, the humble feature phone (a.k.a. "dumb phone") is the ubiquitous portal to the things you can do on networked computers, from messaging to games.

In fact, the feature phone is the most common computer on earth.

About two billion people are connected to the public Web and Internet, some with mobile phones. But two billion more use mobile phones that have no regular Internet connection; they communicate over private networks operated by phone companies.

ANTONY NJUGUNA/REUTERS

In this other online world, texting is more than just a way to chat. It also carries some of the important or formal messages that email, fax, or written correspondence would in developed countries, from death announcements to official summonses. And like the telegram long before it, texting is a medium for transactions from money transfers to shopping to voting.

The SMS (Short Message Service) standard behind texting can support simple interactive menus, not just static text. Short codes—like "text 'prices' to 7204 for current list"—can function a bit like Web addresses. So tasks that would be handled on a secure Web page in the United States may be done by text in the Philippines or Afghanistan, from registering an official complaint to paying salaries.

Personal Texts: Let Your Fingers do the Talking

All the world seems to love personal texts. Some studies claim they're as addictive as cigarettes. True or not, these minimalist messages grab users of all ages for many of the same reasons that first made them a hit with teenagers.

First is access. Most people's phones are always with them, even at the bedside. They can text during idle moments from dawn to dusk, anywhere, and without knowing in advance that they have a chunk of time free as with a voice call.

Discretion is another big reason. Experts can even "blind" text—send a message with the phone concealed under a table, in a pocket, and even in a *tween's* Ugg boot.

Texting started out free, and in many circumstances is still far cheaper than voice.

But perhaps the biggest reason people send personal texts is that they work. Other people respond, and fast. This is partly cultural convention—we wait far longer to answer emails or calls, if we do at all—and partly because it's so easy to respond to texts for the reasons above.

It also doesn't hurt that texts are really short. This makes them quick to read and send, and precludes unwanted conversation or explanation.

ERIC THAYER/REUTERS

Triumph of an Underdog

Simple text messaging was included in the GSM (formerly *Groupe Spécial Mobile*, now known as Global System for Mobile Communications) standard for mobile phones in the mid-1980s. But it was by no means the star attraction—that was voice calls, with high-speed mobile computer connections ("tethering," in modern terms) a runner-up.

In fact, texting was such an under-loved feature that many carriers didn't bother charging for it when GSM networks rolled out to customers in the early and mid-1990s. This helped get it off the ground (free is attractive!), and texting took off exponentially from there—first among European youth, then in the Philippines, Africa, and soon everywhere.

In technical terms, text messages, tweets on Twitter, instant messages, and telegrams are the closest of cousins. But the world seems perpetually surprised when apparently simple communication media take off. At Twitter's start, for example, journalists were nearly as giddy with a sense of novelty as when the first public telegraph message was sent 170 years before.

The fact is, we're social beings and communication is a large part of what we do, whether through computers or pounding on trees in a "jungle telephone." Maybe that's the secret of why changing methods always feel fresh: communication matters so very much to us that, as in a romance, every nuance counts. Even if the basic story is the same.

Winner Kate Moore, 15, of Des Moines, IA, is congratulated during the National Texting Championship in New York, June 16, 2009.

6 WIKIPEDIA

CROWD-SURFING THE WORLD'S KNOWLEDGE

BY MARC WEBER

From ancient times, visionaries have tried to gather and organize the world's knowledge. The Library of Alexandria (ca. 4th century BC), had as many as 600,000 books. But hand-copying put tight limits on its practical impact. Before the printing press one might gather all the knowledge in the world, but only a few scholars could ever read it.

English-language Wikipedia is now the world's largest single encyclopedia ever and is available in the pockets or purses of billions thanks to mobile phones. Smaller Wikipedias exist in over 200 languages, adding up to a mind-boggling 21 million articles overall.

Yet Wikipedia is just as unique for the bizarre way in which it is made.

Hundreds of thousands of people, in all countries and all walks of life, edit and add to Wikipedia articles. All of this constant editing is volunteer work, with some giving as many hours to volunteer editing as to a full time job. Their tireless efforts keep www.wikipedia.org the sixth most popular website in the world—above Twitter and eBay, but at a fraction of the cost. How did this unique system start?

Nupedia

In the late 1990s Web entrepreneur Jimmy Wales, who had loved the World Book Encyclopedia as a child, thought an open-source model might extend to an ad-supported online encyclopedia. The resulting Nupedia launched in early 2000. But the pace was glacial; the experts he and editor-in-chief Larry Sanger used to create articles produced just two in eight months!

Desperate for more content, they experimented with a new kind of online collaborative software called a "wiki." Invented by master programmer Ward Cunningham, wikis were a Web version of an earlier "idea catcher" he'd created using Apple's HyperCard. HyperCard's simple interface had introduced millions to the idea of the clickable link, now so familiar on the Web but then a research-lab obscurity.

Wikis were named after the Hawaiian word for "quick," since they let groups of people quickly build on and edit each other's work. A core feature was that users could create new, linked pages with a single command, making it simple to add new, related content. This had also been a core feature of the original World Wide Web, but was lost with later browsers that only allowed users to read documents, not edit them.

A New Model

At first Wales and Sanger assumed their new "Wikipedia" wiki would be just a cheap and easy feeder site for Nupedia. The wiki would generate rough content before refining by subject matter experts.

But with strong participation from various hacker communities, as well as original wiki users from Cunningham's projects, Wikipedia produced a jaw-dropping 20,000 finished articles in just 11 months.

So a radical question emerged. Could the crowd itself ever be the final trusted arbiter of an article's quality? It was one thing to outsource content-gathering, but quite another to let anonymous editors create the crown jewels: the final articles on which any reader could rely. Crowd surfing is the risky practice of riding the crowd at a rock concert like a wave, often after diving off the stage. Obviously this requires a lot of trust—not trust of any one person, but trust in group dynamics, in the spirit of the crowd. Wikipedia caught the wave.

The rules

One early rule was the most defining of all, especially in a community of knowledgeable and opinionated volunteers: Wikipedia editors were to simply present what had been established elsewhere by trusted sources, often subject matter experts. The editors were not to serve as sources themselves.

Growing

As Wikipedia scaled up, it experienced a series of sometimes wrenching stages. Formal policies and impersonal committees replaced the tiny, intimate community of the early days. Vandalism became a major problem and required constant policing, like weeding a garden. As the site grew into one of the most visited Web sites in the world, scandals about accuracy became staple fare for journalists and comedians alike. But Wikipedia just kept growing.

Next?

Ted Nelson, co-inventor of computer hypertext, is fond of reminding us that the whole point of electronic literature is not to reproduce the capabilities of print but to do something new. So far, Wikipedia has mostly pioneered a way to use crowds to produce a bigger, better, continuously updated encyclopedia.

But as an editorial method, Wikipedia represents a massive, groundbreaking achievement. Visionaries have sought for a century to harness the power of machines—and later computers—to help people collaborate, often with lofty goals of bettering society and unifying all knowledge. Yet most real-world online collaboration remains stuck at the level of the email mailing list. Wikipedia's success is the first glimmer of new ways of harnessing the power of the group—ways that may eventually help society realize ancient dreams of collecting and organizing the entire world's knowledge. ○

TERRY FOOTE

Top: This Wikipedia page on Jesus Christ restricts editing, as do a subset of pages on controversial topics. Bottom: Wikipedia founder Jimmy Wales.

Concept art for a Fire Giant, a powerful monster in *World of Warcraft*, by Welsh artist Mark Gibbons.

A WHOLE NEW GAME

BY CHRIS GARCIA

***World of Warcraft* (*WoW*) is the world's largest net-**worked massively multi-player online role playing game (MMORPG, or often just MMO). It has proven so popular in the West that it has expanded beyond the world of computer gaming into popular culture with the release of related board games, novels, art books, and even user-generated films. *WoW* also allows for a level of interpersonal interaction that helped define a unique gaming subculture. Despite existing in a fantasy realm, *Warcraft* also features a complex economic system.

The Evolution of Gaming

Gaming as a segment of the software industry has grown in significance, and new releases of games for consoles and PCs are major events. The U.S. gaming industry alone earned more than $16 billion in 2010. While this is only a small segment of the $300 billion global software industry, it is a rapidly growing segment. *WoW* itself brings in roughly $2 billion a year in subscription fees. It is also one of the leading examples of games moving beyond the traditional gamer space (i.e. young males) and attracting players of differing gender, ethnicity, and nationality. As of 2011, 42 percent of all gamers—across all games—were female, and the median age was 37.

Multi-user gaming can be traced to some of the earliest days of computing. Early computer games like TREK were often played across early networks, including the ARPANET. Typically, these games were designed independently and often shared between users. The 1980s saw the rise of Multi-User Domains (MUDs), which allowed games to be played across networks and enabled social interaction within the game. These MUDs were text-based and often had a limit to the number of players that could access them at any given time.

The Coming of Warcraft

World of Warcraft was developed and published by Blizzard Entertainment and evolved out of Blizzard's real-time strategy game *Warcraft: Orcs & Humans*, first released for the PC platform in 1994. The game was principally developed by Rob Pardo, Jeff Caplan, and Tom Chilton.

The success of the *Warcraft* line of real-time simulation war games led to the announcement of an online version in September 2001. The online game, however, was not released until 2004 after extensive testing. The release was timed to coincide with the tenth anniversary of the first game in the *Warcraft* franchise. *WoW* was an early success and quickly attracted a strong subscriber base. As of November 2011, there were more than 10 million *WoW* subscribers.

Not Just a Game

Players adventure through the fictional world of Azeroth, collecting materials, weapons, and gold while battling monsters and other players. Players can also form adventuring groups, or Guilds, that allow them to act as a team on quests. Individual Guilds, and even those who simply inhabit the same server, often hold gatherings outside of the game. Groups also create and wear costumes based on the avatars and creatures in *WoW*. Some of these creations have won major awards at conventions, including BlizzCon, the official Blizzard convention.

The success of *WoW* as a game has made it a significant part of popular culture. A series of best-selling novels has been released using *WoW* as the setting. The highly popular web series *The Guild*, created by actress Felicia Day, is the story of a group of gamers in a *WoW*-like game. Television series like *South Park* have used *WoW*—and the legendary depth of player commitment—as fodder for storylines as well.

Making Money

The economic system of *WoW* is complex and exists both in and out of the game. In the game, players can earn gold by completing quests and besting creatures and characters, but they may also buy gold from other players to spend within the game using real currency. Acquiring gold is often referred to as "farming." Some players use automated systems to increase the amount of gold they acquire within the game and then sell that gold for cash to other players.

WoW is not without controversy. While individuals make a living from the game economy, many see it as another means of attracting addictive personality types to the game to keep them playing.

In addition, there have been questions about the game's terms of service and privacy policies, as well as questions about players' rights within the game and how much control Blizzard has over its players and their creations.

The advances that *WoW* has made in attracting new types of players and bringing online gaming into mainstream popular culture have earned *WoW* a place of honor in the history of gaming software.

Group playing *World of Warcraft: Mists of Pandaria* at BlizzCon, Blizzard's fan convention, on October 21, 2011.

BEHIND THE SCENES

SOFTWARE ARCHAELOGY: A CURATOR'S PERSPECTIVE

BY AL KOSSOW

The Museum is one of the few institutions in the world to have someone whose job it is to be the subject specialist for computer software. The field of software is so large that to be an expert in all aspects is impossible. What I'll describe are those parts of the subject that I do claim some knowledge of and, within those areas, how my day-to-day activities expand the resources available to historians and visitors of the Museum, both online and in person.

The working definition of "curator" that I have been using during my six years at the Museum is to be as knowledgeable as I can be about our existing collection, especially our software holdings, and to know what we should be looking for to fill in areas where we have incomplete or no artifacts at all. The collecting scope for software has expanded during the time that I've been here. Originally, we tried to focus on supporting documentation and software artifacts for the computers that we had in the collection. During the curation of the software galleries contained in our permanent exhibit, *Revolution: The First 2000 Years of Computing*, we realized that we had to expand our collecting scope to cover areas important for the full presentation of the history of computing beyond that of just software as support for physical computing artifacts.

In the past 30 years the commoditization of computing hardware has reduced the variety of general purpose computers, while the variety of different kinds of software being created has expanded rapidly. Therefore, the number of ephemeral artifacts greatly exceeds the physical ones. By "ephemeral" I mean things that exist on a medium, such as magnetic disk or tape, that require someone to recover the content before physical degradation of the recording medium or the devices to read the content makes recovery impractical.

Ephemeral can also be used in the context of the computer systems themselves. The devices are developed, used, and eventually replaced and discarded as better/faster/cheaper devices come along. The surviving artifacts from their use are a snapshot of the culture in which they existed. They never can in themselves reveal the complete story of their creation nor how they were used or what effect having these devices had on society. It is also a fact that rarely does an old computer survive with its original documentation or software intact. Part of the job of a curator at an institution like the Museum is to recognize that the artifacts we are entrusted with are never self-documenting and that we have to watch for other pieces of the puzzle. Sometimes they are offered as donations, other times they appear on auction sites like eBay, or as part of the holdings of another institution or private collector.

The Museum has many thousands of artifacts containing software. One of the decisions that I've made over the years working with our archivists is, which of the containers of these software artifacts are most at risk of not being able to have the information contained on them be recoverable. In some cases, for example paper tape and punched cards, the medium is stable enough that the carriers, the paper tapes and punched cards themselves, should survive for the immediate future. What is less obvious with them is that the devices that are capable of reading them have a much shorter lifespan because of the parts that they were built from. The things that I have seen fail most often in the past have been parts made of rubber which de-vulcanize over time, especially if they are exposed to ozone. Unfortunately, most card readers, tape drives, and disk drives have some critical part made of rubber in them. Magnetic tape has also proved to be a problem to recover data from, especially tapes made in the late 1970s to the mid 1980s when there were problems with the plastic used to suspend the magnetic particles, developing "sticky shed syndrome" where the tape will stick together, sometimes pulling the oxide off of the layer below it.

Because of the physical space required to store the thousands of reels of tape in the Museum's collection, and the "inherent vice" of the container, projects have been ongoing to recover the contents of the tapes and preserve them using best practices for *born digital* archival data. Rather than restoring and trying to maintain computers of the era, the Museum uses the most modern tape and disk drives capable of reading the media. In the case of magnetic tape, custom devices such as a humidity-controlled convection oven have been built to attempt to mitigate the problems with old tapes that have "sticky shed" problems. A specially modified tape transport with multi-track magnetorestrictive heads will soon be operational which will make recovery of 7-track half inch tape possible. Currently, data from several thousand half inch magnetic tapes have been archived.

Punched cards are read using a modified card reader with a USB (Universal Serial Bus) interface. A similar approach will be used for paper tape and for Digital Equipment Corporation's DECtape. A prototype of a simple DECtape reader was built in 2006 and the lessons learned from that will be used for an improved version soon.

Floppy disk recovery is an ongoing project, with several different solutions having been developed depending on the type of disk. Most often, the disk can be read on a conventional IBM PC with special software. A working stock of the most common 8-inch, 5.25-inch and 3.5-inch floppy drives are kept near the machine used for recovery, and are swapped in and out as needed.

As network connectivity has improved, computer manufacturers and creators of software have moved away from the physical distribution of software on tapes, floppy disks, and CD-ROMs, and instead just make software available through the Internet. This presents a challenge for preservation. How do we preserve software and documentation when the distribution channels are virtual or are locked to a particular bit of hardware?

There is also the problem of the preservation of firmware—code that exists in electrically programmable memories inside computers. The technology used to store the information in these devices is, by its nature, volatile. The charge stored on gates inside the programmable memory ICs will leak off over time, losing the information stored there. Even with the best museum preservation techniques for the physical artifacts, the device will cease to function due to the loss of information stored inside the parts.

Where practical, it is necessary to recover as much internal firmware from computers in the collection while it is still possible to do so. In some cases, this will not by physically possible and over time the device will not function. If the firmware has been archived, it should be possible to restore the code by replacing or reprogramming the memory chip in the artifact, or to use the data to create a functioning copy through simulation.

After the contents of digital media and firmware have been recovered, the Museum has to keep that recovered information in a stable, invariant state. Fortunately we have been able to obtain grant funding from Google.org to establish a digital repository for the Museum. Working with the Museum's former digital archivist, Heather Yager, we have begun the process of migrating the software, firmware, and scanned documentation that are now in machine-readable formats to the prototype digital repository. Much more work will be occurring in the next few years as the project gains momentum.

Beyond just archiving our digital artifact collection, we are actively working on being able to make this information available to visiting and online researchers, hobbyists, restoration teams from other organizations, and others who are attempting to develop simulators for old computers, for example.

We have had some success in getting the cooperation of companies to make available portions of the archival software collections for non-commercial use. Apple, Inc. has granted the Museum the right to distribute the sources for MacPaint and Quickdraw. Hewlett-Packard has done the same for the software for the HP 1000 minicomputer, Apollo workstations, and early HP 9000 computers. Xerox PARC has made available all of the sources for the pioneering Alto personal computer, and Unisys granted us the right to distribute the source code for BTOS, a follow-on product to CTOS created by Convergent Technology.

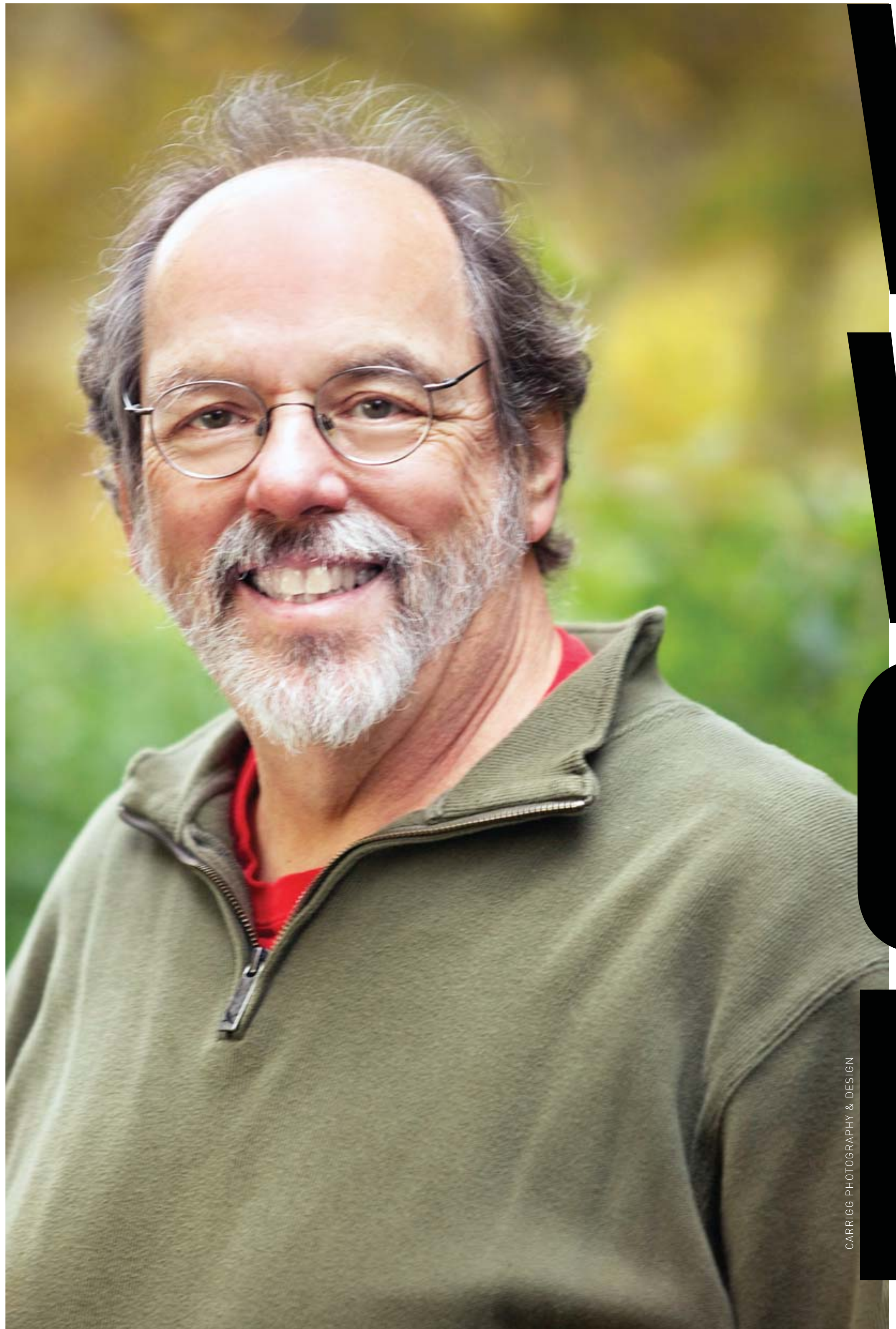
Working with companies to make the Museum's collection available is an ongoing project, and we hope to add much more of our holdings to the list as time goes on. We are also actively working on funding so that we can accelerate the rate that the institution can recover, catalog, and ingest the backlog of media to process into the permanent digital archive. This will expand the Museum's online information knowledge base in the history of computing technology and foster a deeper understanding of how it has influenced and changed the way we live and work. ○

Top: Operating system tapes for Digital Equipment Corporation PDP-15. DECtape was a low-cost tape system for minicomputers.
Bottom: Al Kossow, Robert N. Miner Software Curator at the Computer History Museum.

INTERVIEW
AND EXCERPT BY
MARC WEBER

WHERE WIKIS COME FROM

ORAL HISTORIES



Wiki inventor
Ward Cunningham

The Museum's Oral History Program records first-person accounts of the pioneers responsible for key developments in computing history. The Museum's collection now exceeds 500 oral histories, and curators and expert volunteers collect 75–100 new recordings each year.

Oral histories capture significant stories in the participant's own voice. At times, they also recover little-known anecdotes and folklore that offer a richer flavor of the working environment, places, and people involved. Interviewees reflect on their careers and lessons learned, and offer analyses on the arc of technological development.

In early 2012, I sat down with Wiki inventor Ward Cunningham. The session served two roles—as a full oral history with a pivotal pioneer, and as source material for the Museum's upcoming exhibit, *Make Software: Change the World!*

When he wrote it in 1994, Cunningham's WikiWikiWeb software was a new way for groups of people to quickly build on and edit each other's work. A core feature was that users could create new, linked pages with a single command, making it simple to add related content. Cunningham's first Wiki became the forum for his own project, a long established group where programmers collaboratively build on each other's techniques and patterns. But he also let other people use the software for their own projects, and Wikis spread.

In the excerpts below, Cunningham describes the origin of the name "wiki" and his relationship with Wikipedia. He also explains how his initial dismissal of the encyclopedia project turned to deep respect.

Weber: Where does the name "wiki" come from?

Cunningham: That goes back to before I invited the first people to join. I was just punching in pages like crazy. And I'd been doing it by using a text editor; just going through the Web and… say[ing], "I need something here." Boom. I'm in an editor. Boom. I made the page. It was quick. So I almost called it QuickWeb, the quick way to make the Web. But I didn't really want to be associated with QuickBasic, because although it was a very successful program, people looked down on Basic. So I remembered that "Wiki" meant "quick" in Hawaiian. And in fact, they double words for emphasis, so I called it WikiWikiWeb.

Weber: And when had you learned this?

Cunningham: My first time to Hawaii was on my honeymoon, and the little shuttle bus that goes around the airport terminal is called the Wiki Wiki bus, the very quick bus. And they directed me to the Wiki Wiki bus. And I said, "What?" <laughs> It was an unusual word, but I knew any word you say often enough, it becomes normal. Right? So I wanted to insert something in people's brains that had a unique label and WikiWikiWeb sounded like World Wide Web, www. So I liked that alliteration. Now the tradition in UNIX, of course, is to have very short, lowercase names. So the script that I wrote to be the WikiWikiWeb, I just called it wiki. And most people would see that up in the location bar and they just came to call it wiki. So I lost the alliteration but I still got it into people's brains. And it's a funny enough word that people like learning it.

Weber: When did you first encounter the Wikipedia people?

Cunningham: Cliff Adams was the guy. [Editor's note: Adams' Wiki software was initially used by Wikipedia.] Cliff said, "Oh, they've got this new project. It's going to be an encyclopedia, it's going to be really cool." And I thought, "Encyclopedia. That's kind of boring. That's not inventing a new way to write. That's resuscitating an old way to write. I'm inventing new worlds and people are discovering, programming, new structures into their brains and so forth." So I was very excited about how I had activated a community to do something that I don't think could be done any other way. And they were just going to write an encyclopedia.

But they demonstrated that even with an encyclopedia, having a group of people who are willing to work to make something that they collectively own is a very powerful notion. It's not a notion that comes out of the book economists study. It's a different kind of motivation and people are still trying to figure out why it works. But I knew it worked in small groups and I was pleased to see it work in the thousands that contributed to my Wiki, and Wikipedia's gone orders of magnitude larger than that. It has become a word that describes a relationship among people. Community of practice. Or community of purpose. Wiki is a shorter word than any of that, but it's become that and I think that's fabulous.

I'm very proud to have made that contribution, even though it was the encyclopedia people who got my next door neighbor to know what I did. I never would've been able to explain Extreme Programming or any of that to my neighbors. But they say, "A day doesn't go by that I don't look something up on Wikipedia."

Wiki means "quick" in Hawaiian, as on this airport bus. Cunningham thought it a perfect name for his new program.

MEGAN S. HACK

On Wikipedia expanding the notion of an encyclopedia

Cunningham: A few years, maybe three or four down the road for them… I realized… [Wikipedia] hadn't just made an encyclopedia. It was a categorically different experience. I think the hurricane in New Orleans just totally transformed my understanding. Because news was leaking out of there so slowly, but you could go to Wikipedia every day and there was a coherent and clear and not gossipy <laughs> story about this emerging understanding. And I thought, "Well, this is truly an amazing service to have [news] described in an encyclopedic style…" Having all of history described right up to the moment is really something.

Weber: So you realized Wikipedia was not only reproducing an encyclopedia, but also that it was a new thing in and of itself. Tell me how you got involved with the project.

Cunningham: Jimmy Wales came to an OOPSLA [Object-Oriented Programming, Systems, Languages, and Applications] conference, which is kind of my digs, and we had lunch together, a group of maybe five or six people, and the conversation of course, went to Wiki. It was strange in the sense that I didn't know him at all, but we were kind of completing each other's sentences in the way that Kent Beck [long-time colleague] and I used to do after 15 months of programming side-by-side. And I thought, "This is weird that Jimmy Wales and I share an experience that lets us talk the same way even though I've never met him and only interacted once or twice by email or something." Then I realized "Of course! He grew a community and knew all the issues of growing a community in a Wiki environment, and I grew a community and knew all the issues."… Two people with the same experience, which at that point, was still very unique. And that was interesting.

Soon after that they held their first Wiki conference and invited me to keynote, and so I went out—that was in Frankfurt—and I had a chance to meet a lot of Wikipedians. That's when I realized they all loved the encyclopedia. Just everyone could talk about reading the encyclopedia as a kid, and their devotion to that style of knowledge is very deep. So I've stayed involved because I think it's profoundly important. I think mine is still important because I changed programming, and when you change programming, you change a lot of people's lives indirectly. But they've changed a lot of people's lives very directly, so that's profound. ○

I'm very proud to have made that contribution, even though it was the encyclopedia people who got my next door neighbor to know what I did.

COLLECTION

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BY ALEX BOCHANNEK

US NAVY MK 14 MOD 8 GUN SIGHT, SPERRY GYROSCOPE

CHM#: 102747153
DATE: ca. 1942
DONOR: Gift of Mark Warren

The MK 14 Gun Sight, a type of analog computer, was designed to control the aim of anti-aircraft guns when tracking fast-flying planes. It was developed at MIT and manufactured by Sperry Gyroscope. The Navy ordered 85,000 of them following successful testing in a 1942 battle. Together with the MK 51 Gun Director, it was the most successful weapons control system of its type during World War II.

FORD SYNC MODULE (ACCESSORY PROTOCOL INTERFACE MODULE), FORD MOTOR COMPANY

CHM#: 102743469
DATE: 2007
DONOR: Gift of Ford Motor Company

Introduced in the 2008 car models by Ford and Microsoft, Ford SYNC offered hands-free calling with Bluetooth, voice commands, and a USB connection for music players. Later versions became more tightly integrated with the car's entertainment and information systems, demonstrating how cars are transforming into mobile communications platforms.

ALL IMAGES © STUDIO DIZON

SANDY LERNER'S CUSTOM "IPO DRESS"

CHM#: 102717910
DATE: 1990
DONOR: Gift of Sandy Lerner

Cisco co-founder Sandy Lerner wore this dress to her company's IPO (initial public offering) party on February 16, 1990. Lerner made the dress herself using $100 bills as a pattern. At the event, a string quartet played "We're in the money!" *Forbes Magazine* considered the Cisco offering the top performing IPO of the 1990s.

SUPPORT

DONOR PROFILE

The Museum has had the good fortune to benefit from the ongoing financial support of individuals, foundations, and corporations from Silicon Valley and throughout the United States. Among the most generous supporters during the last decade has been Intuit, the innovative business and financial management software company based in Mountain View, California.

Intuit was founded in 1983 with a single product: Quicken personal finance software. Quicken was built to take advantage of the emerging market for personal computing and to simplify a common household dilemma: balancing the family checkbook. By 2011, Intuit had grown into a family of financial products serving global audiences, inventing new solutions to solve important problems. Its revenues were approaching $4 billion. In parallel, the company developed a strong commitment to community engagement and corporate social responsibility.

In 2004, Intuit contributed $5 million to the Museum to support our comprehensive campaign to build a major, permanent exhibit. This gift, made in honor of Intuit co-founder Scott Cook, served to underwrite the Software gallery of *Revolution: The First 2000 Years of Computing* and its featured film, "The Art of Programming."

In 2011, Intuit pledged $1 million as the lead corporate benefactor of the Museum's forthcoming exhibition on "game changers" in software history. The physical and digital exhibit, *Make Software: Change the World!*, is now in production for completion and opening in early 2014.

"As technology evolves, so do we," said Brad Smith, Intuit President and Chief Executive Officer. "Intuit started as a financial software company nearly 30 years ago with the creation of Quicken for the desktop. Today, our customers can simply manage their business and personal finances from the palm of their hand, no matter where they are.

Software is part of our legacy, and we're delighted to support the Computer History Museum's *Make Software: Change the World!* exhibit as well as its commitment to preserve and present the innovation behind the Information Age." ○

Generous contributions from individuals like you support our work in collections, exhibit development, and educational programming. We strive to foster greater understanding of the computing revolution's worldwide impact on the human experience. Please help us tell the fascinating stories of the Information Age by making a gift today. For more information, go to computerhistory.org/contribute/

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Vision
To explore the computing revolution and its world-wide impact on the human experience.

Mission
To preserve and present for posterity the artifacts and stories of the Information Age.

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ABOUT THE MUSEUM

BACKGROUND

The Computer History Museum is the world's leading institution exploring the history of computing and its ongoing impact on society. It is home to the largest international collection of computing artifacts in the world, including computer hardware, software, documentation, ephemera, photographs, and moving images. The Museum brings computer history to life through an acclaimed speaker series, dynamic website, on-site tours, and exhibitions.

CURRENT EXHIBITS

Revolution: The First 2000 Years of Computing
Revolution chronicles the evolution and impact of modern computing from the abacus to the smartphone. *Revolution* encompasses 25,000 square feet. It features more than 1,000 unique artifacts, hundreds of videos, graphics and photos. *Revolution* is for everyone. It's for people who love cool museums and history. It's for tech professionals who love their work. It's for people who want to understand the technological world we all live in. Join us to experience the mind expanding stories of the people, machines, programs, and companies that continue to write the history of the Information Age.

Babbage Difference Engine No. 2: The Story of the First Computer Pioneer
Charles Babbage (1791–1871) designed the first modern programmable computer—complete with a printer—but he failed to build it. Engineers at the London Science Museum finally built the first working Babbage Engine in 2002. The Babbage Difference Engine No. 2 on display at the Museum, has 8,000 parts, weighs five tons, and measures 11 feet in length. Learn more about this extraordinary object and the people who built it.

Going Places: The History of Google Maps with Street View
Since 2007, Google Maps with Street View has transformed our ideas about going places, from faraway lands to a restaurant across town. Visitors to the exhibit can sit inside a Street View car, ride a Street View trike, hear behind the scenes stories from the Google Street View team, and learn about vintage street views, including the revolutionary Aspen Movie Map project from 1978.

PDP-1: The Mouse that Roared
Digital Equipment Corporation's (DEC) PDP-1 was one of the first commercial computers designed to interact with a single user. The Museum's restoration team brought a PDP-1 back to working condition. They retrieved data from its main memory, restored all the peripherals, and loaded the machine with vintage games, including *SpaceWar!*

HOURS
Wednesday–Sunday
10 am–5 pm

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