2014

CORE

A Publication of
the Computer
History Museum

The Web at 25
The Creation of the IBM System/360
How Apple Conjured Up the iPod

Cover: "Hampster Dance," 1997. This GeoCities webpage became an iconic web "meme." This page: Ask Jeeves costume, late 1990s. Used for promotional events this costume portrays the mascot of search engine AskJeeves.com, the ultra-competent butler Jeeves from P.G. Wodehouse's novels Opposite page: Pets.com sock puppet toy, ca. 2000. This short-lived online pet supply company built huge brand recognition around its adorable sock puppet mascot.

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THE WEB AT 25

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Jennifer manages the day-to-day activities of the oral history program. Jenny holds bachelor degrees in art history and English from the University of California, Santa Barbara, and a master's degree in art history from San José State University.

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IBM 1401 PROJECT MANAGER

Robert's career in Silicon Valley spans 36 years of management and engineering beginning at Xerox, then Sun Microsystems, Brocade Communications, and IBM Research. In 2003, he volunteered at the Museum to lead the restoration of the IBM 1401. He recruited and organized a team of retired volunteers, who after five years restored two IBM 1401 systems and vintage punched-card equipment to full functionality.

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PRESIDENT & CEO

John directs the Museum's strategic planning and operations. He is the frequent host of *Revolutionaries*, the Museum's acclaimed speaker series, on public television and radio.

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DIRECTOR OF COLLECTIONS

Karen advocates for the health and well-being of the Museum's artifacts, attends to the legal aspects of acquisitions and loans, and collaborates with a wide range of people on a daily basis. A self-proclaimed museum geek, she holds several degrees including a master's in museum studies and has published in the journal *Museums and Social Issues*.

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SEMICONDUCTOR CURATOR

David is a founding member of the Semiconductor Special Interest Group. He contributed to the Digital Logic and Memory & Storage galleries of *Revolution*. Laws has worked in Silicon Valley semiconductor companies, including Fairchild Semiconductor and Advanced Micro Devices (AMD), in roles from engineer to CEO for more than 40 years.

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FORMER ASSOCIATE DIRECTOR OF INDIVIDUAL GIVING

Meghan managed the Museum's Core donor program and contributed to the newly launched planned giving program.

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VP OF EDUCATION

Lauren founded the Education department at the Museum. She oversees the development of all education programs and resources, including school programs, docents, and artifact demonstrations. Her background includes a PhD in developmental psychology, plus over 20 years of experience teaching in schools, universities, and museums.

DAG SPICER

SENIOR CURATOR

Dag joined the Museum in 1996, and leads the Museum's collecting strategy. His interests include early electronic computing, computers in medicine, IBM, supercomputers, semiconductors, and computer architecture.

KIRSTEN TASHEV

VP OF COLLECTIONS & EXHIBITIONS

Kirsten is responsible for the Museum's preservation and interpretation mission and oversees the collections management, curatorial, and media teams. She has played a key role in developing the strategic direction of the Museum, including the development of the Museum's permanent exhibition *Revolution*.

RICHARD S. TEDLOW

MBA CLASS OF 1949 PROFESSOR OF BUSINESS ADMINISTRATION, EMERITUS

Richard is a specialist in the history of business and served for many years as a Trustee of the Museum. He received his BA from Yale in 1969 and his MA and PhD in history from Columbia in 1971 and 1976 respectively. He came to the Harvard Business School on a fellowship in 1978 and joined the faculty in 1979.

MARC WEBER

FOUNDER AND CURATOR OF THE MUSEUM'S INTERNET HISTORY PROGRAM

Marc pioneered web history as a topic starting in 1995, and co-founded two of the first organizations in the field. The Internet History Program is the first of its kind at a major historical institution. Weber presents and consults on the history of the online world to conferences, companies, journalists, filmmakers, courses, patent firms, and other museums.

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CEO'S LETTER

RELIVING HISTORY

The world's fascination with the history of computing is increasing. Even a superficial review of recent best-selling books, popular films, television documentaries, and YouTube programming confirms it. Last year alone, the Computer History Museum had more than 50 different media teams from around the world working in our exhibition space and performing research in our collection. They ranged from a team of Chinese filmmakers shooting a multi-part series on the Internet to a creative team looking for a 1980s-style "luggable" computer to appear on *Flip It to Win It* on the Home & Garden Television cable channel.

At the Museum, we find that both noted and emerging historians want to work with us to explore the questions that have occupied us here for decades: How has the world moved, in the blink of an eye, from a time of no computing devices to a time when computing is ubiquitous? Who are the men and women who made that happen? How did they do it? Why does computing have such profound impact on us today? And what are the implications for the future?

In this issue of *Core*, we feature a provocative look at many of those issues from a historical perspective.

First, an important anniversary that many of you will find hard to believe: 25 years ago this year marked the first proposal for the World Wide Web, heralding a new era of digital publishing, human networking, pioneering company-building, and unparalleled risk-taking. In four separate articles, Marc Weber takes a detailed look at several overlapping anniversaries in the evolution of our online world including the birth, explosion, financial crash, and rebirth of the web. Marc is a pioneer of web history as a field and is Founder and Curator of the Museum's Internet History Program (computerhistory.org/nethistory). Our program is the first of its kind at a major historical institution, and collects materials on the origins of our online world including the web, networking, and mobile data.

We also observe the 50th anniversary of the announcement of the IBM System/360, one of the twentieth century's most daring business decisions. Class of 1949 Professor Emeritus Richard Tedlow of the Harvard Business School, who served for many years as a Trustee of the Museum, has done much to document IBM's history. In an original essay written exclusively for the Museum, Richard takes a fresh look at the fateful decision by Thomas J. Watson Jr. to launch the 360 project, a "bet the company" decision that cost $5 billion 50 years ago. He shares, for the first time, a new view of the risks it involved, the personal relationships it strained, and the historic outcomes it produced. I believe you'll enjoy the expert and seasoned perspective that Richard offers.

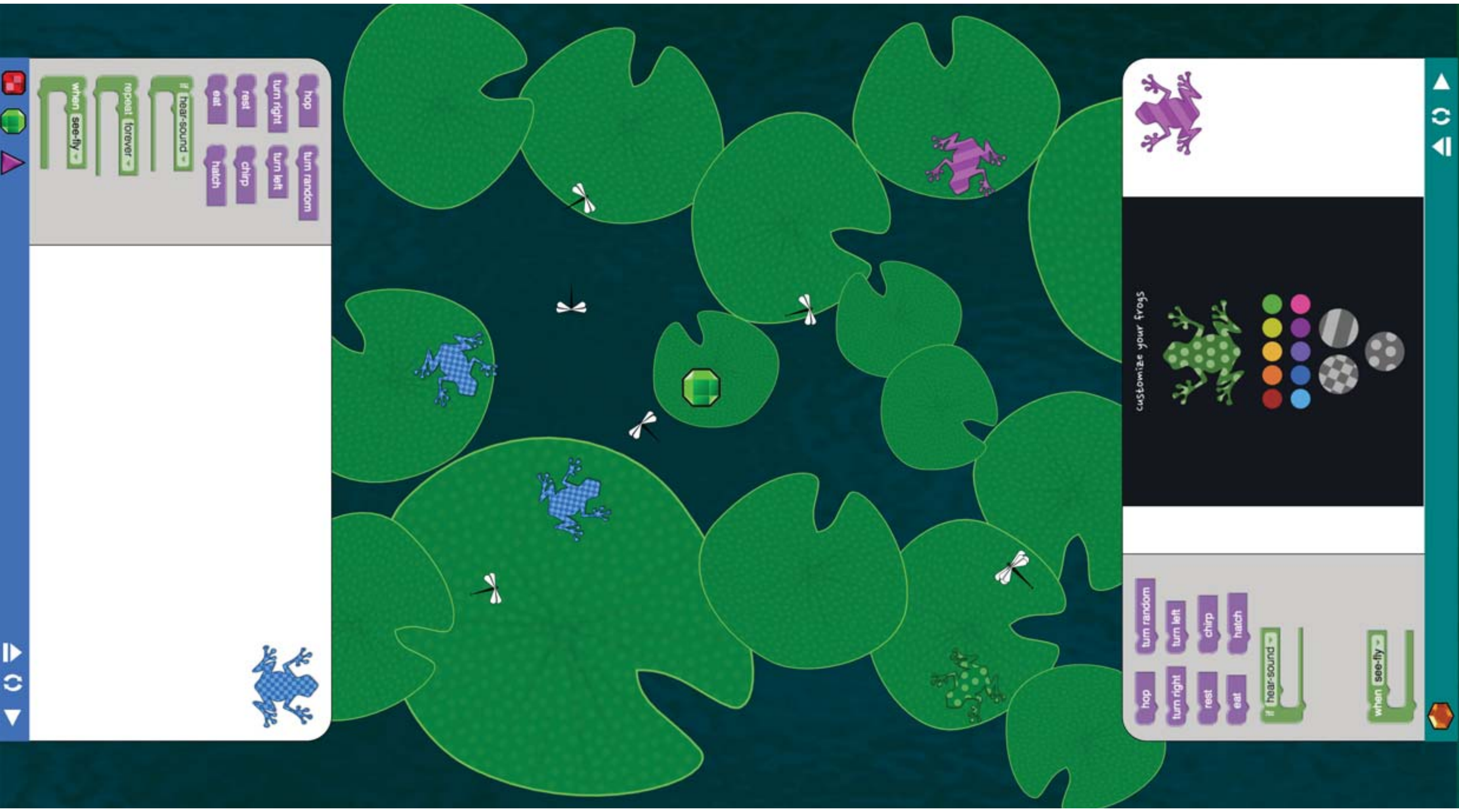
Other members of our team also feature significantly in the magazine. Vice President of Education Lauren Silver examines the rollout of the new national K–12 Common Core curriculum standards and its connection to the Museum's education programming. The ongoing introduction of our long-term software history initiative is in the spotlight with *Make Software: Change the World!* exhibition updates from Vice President of Collections and Exhibitions Kirsten Tashev and from Jennifer De La Cruz, who directs our worldwide oral history program.

All of this work, of course, is made possible through the generosity of our dedicated and growing base of individual, corporate, and foundation donors. To all of you, we say thank you! I hope you enjoy this issue of *Core*.

Yours sincerely,

JOHN C. HOLLAR
PRESIDENT & CHIEF EXECUTIVE OFFICER

Screen shot of the prototype for *Jump into Programming*, under development for the software lab. Visitors create a program to control a frog on a large multi-user horizontal touch screen.



MAKE SOFTWARE

EXHIBIT UPDATE

BY KIRSTEN TASHEV

Make Software: Change the World! will inspire and educate Computer History Museum visitors about software's impact on society by showing the interplay between software applications and systems with daily life around the world. By interacting with touch screens, media, and hands-on "exhibitry," visitors will learn that software, software developers, and the businesses they have created have changed the world forever. The central objective is to show non-technical visitors that software makers have extended our reach, amplified our minds, and given us immense powers in a constantly changing world, alive with information and interaction. A secondary goal is to explore how software is made and the rich interaction that occurs between makers and users of software and applications. Finally, the exhibition enhances the Museum's interpretive offerings about the online world by featuring key web stories.

Make Software: Change the World! has three major themes, featuring specific software applications or systems within the themes:

Life & Death: MRI technology/ digital diagnostics and car crash simulation/making the real world safer

Perception & Reality: MP3/ digital music and Photoshop/ photo editing

Knowledge & Belonging: Short Message Service (SMS) texting/ The Other Internet, *Wikipedia*/online collaboration, and *World of Warcraft* (WoW)/ global multiplayer gaming

Each of the software stories demonstrates a major impact on the world and tells a different kind of historical and/or technical story. Taken together, they create a fascinating and varied journey for the visitor.

A centerpiece of the exhibition is the *Make Software* lab, where visitors will be able to explore what software is and how it's made. The lab is the first area visitors will see when they enter the exhibition. The lab will introduce the concept of software to all general visitors and will be a special focus of the Museum's education program. In this gallery there are a series of hands-on interactive activities where visitors can develop an understanding of the basic concepts of software and apply them to a programming task or simulated programming task. Our primary goal is to create an environment where visitors can be successful in completing a simple programming task with a fun visual or physical output.

In order to achieve this goal, the Museum has been working closely with Google and Northwestern University using a visual programming approach to teach kids about programming. For example, *Blockly*, a new web-based visual programming editor developed by Google, helps people build an application by dragging blocks of "code" together. Basically, Blockly allows users to hack code together with no keyboard. While it's designed to inspire and interest kids, Blockly is also fun for adults because it allows users to program at increasingly sophisticated levels as they achieve mastery.

The lab will also feature documentary-style films that take visitors behind the scenes of software companies. Through the films, visitors will follow multidisciplinary teams of software professionals as they develop products and services. Visitors will learn about the wide range of people involved in creating software, the software development life cycle, the creative and technical process, and the interactions and emotions of the people involved. We hope that the "day in the life" documentary will surprise and challenge visitors' current understanding of how software is made.

Another exciting dimension of the development process of this exhibition is the expanded interpretive approach that includes both makers and users of the technology and the interplay between them as mediated via the software they create and use. Understanding this historically situated choreography between user and code is central to the exhibition.

Expanding our interpretive approach to include the user perspective felt like a natural

Top: High-resolution MRI scan of the human brain. Bottom Left: Image created by Photoshop artist Erik Johansson. Bottom Right: A dwarven gryphon rider soars high above Azeroth, from *World of Warcraft*.

extension of work the Museum has been undertaking for years. The Museum has been collecting personal narratives in the form of oral histories for decades. In addition, the Museum's Media Director Jon Plutte has been a documentary filmmaker for many years and is a master storyteller.

For *Make Software*, the curatorial and media team set out to collect interviews of software makers and users both locally and internationally, including the UK, Germany, and Kenya. Highlights of these oral histories include: Karlheinz Brandenburg, the inventor of MP3; Sir Peter Mansfield, one of the Nobel Prize winners for MRI; Friedhelm Hillebrand, "father" of text messaging; Thomas and John Knoll, the creators of Photoshop; Blizzard founders, Mike Morhaime and Rob Pardo; M-Pesa founder, Nick Hughes; and *Wikipedia* founding publisher, Jimmy Wales. The team also conducted interviews with many fascinating users, such as digital artist Bert Monroy, many Wikipedians, *WoW* players, musicians, and users of text messaging in the developing world, including fishermen and Maasai tribesmen.

The Museum is also excited about the online companion to *Make Software*, which is being developed concurrently. The Museum's philosophy has always been to make all exhibition-content available online and *Make Software* is no exception. That said, we are also exploring how the online exhibition can transform the Museum's digital interpretive experiences. In addition to developing an experience that is mobile friendly, we are looking at web-only experiences, such as content visualizations based on visitor's interests, a participatory social media experiences, access to rich video assets, as well as teacher and classroom resources.

The Museum's Education team is contributing to the development of *Make Software* from the outset and they are developing a series of education programs suitable for 4th and 5th grades, middle school students, and high school students. The content will be designed to apply the principles of the *Make Software* exhibition to science, technology, engineering, and math (STEM) topics in the new Common Core curriculum standards for California, which will be introduced throughout the state in 2014–15. The Museum's education program, *Get Invested*, was named in 2012 as the best engineering program in the country by the Silicon Valley Education Foundation and was the winner of the 2013 California Association of Museums education award given by the State School Superintendent of California. In addition, Vice President of Education Lauren Silver is excited about the potential of this exhibition to extend the Museum's current *Get Invested* program that inspires high school students to use historical inquiry to identify contemporary issues or problems related to technology and to propose innovative solutions.

The $5 million campaign for the exhibition is in its final stage. The Museum plans to open *Make Software: Change the World!* in 2015. ○

Conceptual rendering of the *Make Software: Change the World!* exhibition.

AROUND THE WORLD FOR MAKE SOFTWARE!

BY JENNIFER DE LA CRUZ

From life-saving advances in medicine and car crash testing to digital music to the accessibility of mobile banking in underdeveloped countries, it is easy to acknowledge that such technologies have impacted our lives and forever changed the world we live in. That's the *what*. But how do they function—how did they come about and just how exactly do they know what to do, what they do, so as to have such a profound affect on our lives? That's a bit more challenging. The answer is: software. We're surrounded by software-driven applications and systems that have seamlessly entered and become integral parts of our everyday lives. Software is familiar to us both as users and beneficiaries, yet we find ourselves in the dark about its history and further separated by the complexity of the technology that defines it.

The Computer History Museum's new exhibition *Make Software: Change the World!* will explore the origins and impact of seven software applications—car crash simulation, MP3 and digital music, magnetic resonance imaging (MRI), Photoshop, texting, *Wikipedia*, and *World of Warcraft* (*WoW*)—in an attempt to educate visitors about the role software plays in their lives and that of others around the world. This is no easy feat, but we're up for the challenge!

In addition to the *Make Software* lab, which will give visitors a hands-on introduction to what software is and how it works, one-of-a-kind physical artifacts, and an abundance of multimedia and interactive features, the Museum embarked on a journey around the globe to collect firsthand stories from software inventors, experts, and users alike. What follows is a list of interviewees to date, the location where they were interviewed, and a brief description about their unique contributions and relations to software. These stories will help the Museum tell a more comprehensive tale about how software has changed (and can change) the world.

Car Crash Simulation

Dilip M. Bhalsod
Livermore, California
Engineer and software developer, Livermore Software Technology Corporation (LSTC)

John O. Hallquist
Livermore, California
Founder, Livermore Software Technology Corporation (LSTC)

Philip Ho
Livermore, California
Engineer and software developer, Livermore Software Technology Corporation (LSTC)

Brian Wainscott
Livermore, California
Engineer and software developer, Livermore Software Technology Corporation (LSTC)

Richard Jeryan
Detroit, Michigan
Engineer (retired), Ford Motor Company

Priya Prasad
Detroit, Michigan
Technical Fellow for Safety and engineer (retired), Ford Motor Company

MP3 and Digital Music

Karlheinz Brandenburg
Ilmenau, Germany
MP3 Pioneer and Director of the Fraunhofer Institute for Digital Media Technology (IDMT)

David Hughes
Washington D.C.
Senior Vice President of Technology, Recording Industry Association of America

Jon Rubinstein
Mountain View, California
Computer scientist and electrical engineer, Apple, Palm, Hewlett-Packard, Qualcomm

Marc Weinstein
San Francisco, California
Co-founder and musician, Amoeba Music

Tom Oberheim
San Francisco, California
Audio engineer; Founder, Oberheim Electronics

David Smith
San Francisco, California
Audio engineer and musician, "Father of MIDI," 2013 Technical Grammy recipient, shared with Ikutaro Kakehashi

Magnetic Resonance Imaging (MRI)

Sir Peter Mansfield
Nottingham, England
2003 Nobel Prize laureate in Physiology or Medicine for discoveries in MRI, shared with Paul Lauterbur

Photoshop
Russell Preston Brown
Mountain View, California
Senior Creative Director,
Adobe Systems, Inc.

Thomas Knoll
Mountain View, California
Co-Creator of Adobe Photoshop and software engineer,
Adobe Systems, Inc.

John Knoll
San Francisco, California
Co-Creator of Adobe Photoshop, Adobe Systems, Inc.;
Chief Executive Officer, Industrial Light & Magic (ILM)

Bert Monroy
Berkeley, California
Hyper-realist artist, expert user of Adobe Photoshop and Adobe Illustrator, 2004 Photoshop Hall of Fame inductee

Stephen Johnson
Pacifica, California
Landscape and nature photographer, expert user of Adobe Photoshop

Jeff Huang
New York, New York
Freelance Art Director and Illustrator, The Fifth Order

Photoshop World attendee and staff interviews,
Las Vegas, Nevada

Texting
Ken Banks
London, England
Creator, FrontlineSMS

Caroline Tagg
London, England
Texting linguistics editor

Nick Hughes
London, England
Creator, M-PESA

Finn Trosby
Oslo, Norway
Advisor, Telenor;
contributor to the development of Short Message Service (SMS)

Friedhelm Hillebrand
Bonn, Germany
Mobile Standards Pioneer;
sometimes called "Father of The Text Message"

Jeremy Gordon
Nairobi, Kenya
Engineer and entrepreneur;
Founder, mSwali.org; Founder and Chief Executive Officer,
FlashCast Ventures

Betty Mwangi Thuo
Nairobi, Kenya
General Manager, Financial Services, including M-PESA,
Safaricom

Pauline Vaughan Nairobi,
Former General Manager of Financial Services including
M-PESA, Safaricom

Les Baillie
Nairobi, Kenya
Former Chief Financial Officer,
Safaricom

Stephen Mwaura Nduati
Nairobi, Kenya
Head of National Payments System, Central Bank of Kenya

Marteenie Maenah
Naivasha, Kenya
M-PESA agent

M-PESA users
Masai Mara and
Lake Naivasha, Kenya
Fisherman, tourist guides, students, and Maasai tribesman

Wikipedia
Jimmy Wales
London, England
Entrepreneur and co-founder,
Wikipedia and Wikia

Ward Cunningham
Mountain View, California
Inventor of the wiki, pioneer in design patterns and Extreme Programming (XP)

Alexander M. Wafula
Nairobi, Kenya
Co-founder and project manager, Wikimedia Kenya;
Coordinator of Offline Wikipedia Project of Kenyan Schools

GLAM-Wiki Boot Camp attendee interviews
London, England

World of Warcraft
Nick Yee
Mountain View, California
Senior Research Scientist,
Ubisoft Entertainment

Michael Morhaime
Irvine, California
Video game developer and co-founder of Blizzard Entertainment

Rob Pardo
Irvine, California
Chief Creative Officer and former Lead Designer of *World of Warcraft*, Blizzard Entertainment

BlizzCon attendee interviews
Anaheim, California

CURATING THE FOUNDING DOCUMENTS OF SILICON VALLEY

MUSEUM UPDATES

BY DAVID LAWS

The rise of Silicon Valley to worldwide renown is often perceived as a relatively recent phenomenon. Younger generations attribute its success to Steve Jobs, Sergey Brin and Larry Page, and even Mark Zuckerberg. The dual entrepreneurial and technology underpinnings of its growth were in fact laid more than a century ago, and the entrepreneurs and companies most responsible for its name are largely forgotten.

Precursors to Silicon Valley

The first wave of tech start-ups began with the Federal Telegraph Company in Palo Alto, California, in 1909. Federal supported Lee de Forest’s development of the first vacuum tube amplifier and trained engineers and technicians for the boom in broadcasting and radio communications that followed. Over the next 50 years a succession of technology-fueled business bubbles swept through and began to pave over the former agricultural Santa Clara Valley at the southern end of San Francisco Bay. High-power transmitting tubes in the 1930s were followed by microwave components in the ’40s and Cold War defense electronic systems in the ’50s.

Co-inventor of the transistor William Shockley recognized the existing human and technology resources together with their proximity to Stanford University as ideal for nurturing his start-up company. He planned to exploit an emerging opportunity for semiconductors based on silicon rather than the earlier germanium material. In 1955, he setup shop in a Quonset-style, former apricot packing shed in nearby Mountain View and hired a contingent of bright young engineering and scientific minds to staff his Shockley Semiconductor Laboratory. In October 1957, frustrated with Shockley’s paranoid management style, eight of his most talented employees quit to found their own company—Fairchild Semiconductor Corporation. Their timing was impeccable. Four days later the Soviet Union launched its Sputnik satellite and the space race was on.

US aerospace companies clamored for new silicon transistors to replace bulky, power-hungry, and unreliable vacuum tubes in their airborne electronic systems. The Fairchild founders delivered a unique solution, a double-diffused silicon transistor that out-performed every other device on the market. Their company was an overnight success. They capped this with the development of an innovative new manufacturing technique called the planar process that enabled the production of integrated circuits (ICs), commonly known as computer chips or microchips.

Aware of the typical short life cycles associated with technology products, management invested heavily in research and development to ensure a

Entrance to the Fairchild Semiconductor Research and Development Laboratories building, Miranda Drive, Palo Alto, 1962.

Top: Robert Noyce, General Manager, Fairchild Semiconductor Division. Bottom: Four members of the Fairchild founding team. From left to right: Julius Blank, Robert Noyce, Gordon Moore, and Victor Grinich.

flow of ever more sophisticated semiconductor devices for consumer, computer, and industrial markets. In 1962, Fairchild opened a 100,000-square-foot R&D laboratory on Miranda Drive in Palo Alto. The extraordinary outpouring of processes and products from this facility ensured that by the mid-1960s, Fairchild controlled more than 30 percent of the world market for ICs and employed some 30,000 people.

This investment proved a double-edged sword for the company, but it resulted in a bonanza for the region. Researchers explored so many promising new directions that the company could not pursue them all. Investors eagerly funded new companies to exploit their neglected ideas. Over the decade of the 1960s, 38 new semiconductor companies opened their doors in Santa Clara County. In January 1971, journalist Don Hoefler wrote an article in the industry newspaper *Electronic News*, tracing their lineage back to Fairchild. He headlined the story with the first published use of a nickname that had been used informally by business visitors for some time: Silicon Valley, USA. It stuck.

This silicon-driven boom proved more durable than earlier technology business cycles. Although individual products were relatively short-lived, advances in manufacturing techniques generated a seemingly endless increase in the complexity of each new generation of chips. This phenomenon, the eponymous Moore's Law, was first described by Fairchild's Director of R&D Gordon Moore in 1965 and continues today. Those first planar ICs held just four transistors. Microprocessor chips currently built by Moore's successor company, Intel, routinely contain in excess of one billion transistors. Coupled with a risk-taking entrepreneurial business culture, this constant increase in the capability of silicon chips is the foundation of the ongoing growth of Silicon Valley. And it was kick-started by those eight renegades from the Quonset hut in Mountain View.

Patent Notebooks Recorded Ideas

During its first weeks in business, Fairchild issued patent engineering notebooks to all professional employees. These were intended to record new and patentable ideas relating to products and processes of possible future importance to the company. Those ideas deemed most significant were witnessed and signed as "read and understood" by the authors' peers. On leaving Fairchild an employee's notebook was retained in the R&D library for reference by others.

After its fall from industry leadership in the 1970s, Fairchild was acquired by one of its own spinout progeny, National Semiconductor. National diligently guarded the notebooks for their proprietary information. After National was in turn acquired by Fairchild's arch competitor Texas Instruments (TI), the new owner deemed the contents of no further commercial value. In 2012, TI donated the books to the Computer History Museum.

Handwritten and illustrated, the books are filled with calculations, plots, graphs, tables, photographs, samples of silicon wafers, and other mementos as well as day-to-day accounts of meetings and experiments. Each book offers a unique insight into the work and life of the author during Silicon Valley's formative years. By itself every book tells a story. Collectively, they tell the history of a generation that changed the world. They have been called "the founding documents of Silicon Valley" by the *San Jose Mercury News*.

From Lunch at Kirk's to the Mysteries of QSS

Fairchild issued over 3,000 notebooks between 1957 and 1987. The TI donation comprised 1,334 volumes. Thus, as many as 1,800 books have been lost, stolen, or have otherwise gone astray. I reviewed the collection in late 2012 and prepared biographical data on the authors and generated an abstract of the key contents for 200 of the volumes. These notes are accessible on the Museum's website at: computerhistory.org/collections/fairchild/.

The majority of the books are identified with the author's name and a serial number. Some are further differentiated by titles related to topics that range from mechanical engineering and optics to physical chemistry and quantum physics. The lowest number in the collection is #3, assigned to co-founder Jean Hoerni in 1957. The highest, #3191, was assigned to Director of R&D James Early in 1986. Both authors are legends in the industry: Hoerni for his invention of the planar process and Early for his discovery at Bell Telephone Laboratories of the "Early Effect" relating to the operation of transistors.

The following examples are organized by serial number and were selected to give a sense of the breadth and depth of the collection.

Jean Hoerni (Notebook 3)

Physicist and co-founder. Hoerni describes experiments together with process and design ideas that were used as the basis for his important patent filings. It includes the disclosure of a "Method of protecting exposed p-n junctions at the surface of silicon transistors by oxide masking techniques." This was his first expression of the planar process patent that revolutionized semiconductor manufacturing and enabled the production of ICs. It continues to be relevant today.

Jay Last (Notebook 5)

Physicist and co-founder. Last was charged by General Manager Robert Noyce with the task of implementing the ideas disclosed in his IC patent. Several entries in this volume address the physical isolation technique that Last developed to demonstrate the first proof of concept Micrologic IC devices in May 1960.

Gordon Moore (Notebook 6)

Physical chemist and co-founder. Moore's notebook contains an almost day-by-day account of the challenges and issues

The original Kirk's Steakburgers (1948–68) on El Camino Real at Arastradero, Palo Alto, was a popular lunchtime spot for employees of the Fairchild R&D Labs.

KIRK'S PHOTO: COURTESY OF KIRK'S STEAKBURGERS

Sam Fok taped an experimental wafer of the first planar integrated circuit together with its epoxy isolation backing material onto this page of his notebook.

associated with developing the company's first transistor for IBM. He includes many pages on "tap testing" performed to identify "crud" in transistor packages that threatened the early survival of the company. The collection includes four later volumes by Moore. Moore went on to co-found Intel with Noyce.

Sheldon Roberts (Notebook 7)
Metallurgist and co-founder. Roberts opens with a description of his plan to establish a silicon crystal growing capability, including the features of an ingot puller he designed. Succeeding pages offer detailed day-by-day accounts of typical progress and problems encountered in a start-up company in the late 1950s.

Robert Noyce (Notebook 8)
Physicist and co-founder. With disclosures from parametric amplifiers to adaptive machines, this volume illustrates the breadth of Noyce's creative contributions during his service as Director of Research and later as General Manager. An entry in July 1958, where he proposed interconnecting multiple punch-through diodes on a single wafer to form a function table, shows that he was pondering approaches to microcircuit integration six months before his first conception of the groundbreaking planar IC. The latter is described in detail in January 1959 under the heading "Methods of isolating multiple devices." Noyce went on to co-found Intel with Moore.

C. T. Sah (Notebook 17)
Electrical engineer and physicist. This book is largely devoted to experimental work on tunnel diodes, a major focus of the company's research effort in 1959–60. It also includes his invention of the Surface Potential Controlled Transistor, Fairchild's first foray into metal-oxide semiconductor (MOS) technology. He describes a meeting at popular local lunch spot Kirk's Steakburgers in Palo Alto with his superiors Moore and Noyce to disclose his ideas for a superconductor transistor.

Sam Fok (Notebook 126)
Chemical engineer. Fok filled nine patent and four laboratory notebooks that detail the development of masking and photolithographic technology over the decade of the 1960s. He taped one of the first Micrologic IC wafers into this volume. It retains the epoxy backing material used to implement Last's physical isolation technique.

David James (Notebook 135)
Physicist. James describes building the equipment and growing Fairchild's first epitaxial silicon films. This yielded a significant improvement in the IC manufacturing process. He went on to become founding president of Signetics Corporation, one of the first independent producers of ICs. According to his obituary, one of his proudest achievements was a role in the movie *Howard the Duck*.

R. Beeson (Notebook 146)
Electrical engineer. Beeson presented an IEEE paper on new forms of integrated logic, including transistor-transistor logic (TTL) for which his supervisor, David Allison, coined the popular name "T-squared L." After hearing his presentation, Tom Longo at Sylvania adopted the idea and pioneered the first commercial TTL family. Texas Instruments copied Sylvania's approach with the series 54/7400 TTL family and usurped Fairchild's market leadership position in logic ICs by the end of the 1960s. In no small irony TI acquired National Semiconductor and the remaining assets of Fairchild in 2011.

David Hilbiber (Notebook 164)
Electrical engineer. Hilbiber investigated a wide range of analog device applications, including photochoppers, temperature sensors, and operational amplifiers. He describes his most lasting contribution, the concept of the band gap reference, a key element in the design of the IC voltage regulators that are essential components in every electronic device today.

Frank Wanlass (Notebook 239)
Physicist. Wanlass worked for Sah on MOS research. His disclosure of a "Micropower Switching Element" resulted in the seminal patent for complementary metal-oxide semiconductor (CMOS) technology. It remains the most widely used IC form today. He also described an "interesting phenomena [sic]," the tunneling effect later exploited in erasable programmable read-only memories (EPROM) that led to modern FLASH thumb-drive storage chips. Wanlass went on to become the Johnny Appleseed of MOS by spreading his knowledge across the industry, including at TI, General Instrument, and several start-ups.

Andy Grove (Notebook 413)
Chemical engineer. Grove was a member of a team hired by Moore that included Bruce Deal and Ed Snow to solve the significant challenges associated with commercializing MOS technology. In this volume he describes ideas that led to patents as well as work that generated important understanding of surface-state charge (QSS) and other characteristics of the silicon-to-silicon oxide interface. Grove went on to lead Intel Corporation where he became one of the most admired CEOs in American business.

Maija Sklar (Notebook 425)
The first female professional engineer hired by Fairchild R&D. Sklar authored five notebooks in which she documents her work on MOS experiments that led to her being named as co-author with Deal, Grove, and Snow of "Characteristics of the Surface-State Charge (QSS) of Thermally Oxidized Silicon," the fifth most frequently cited paper in the history of the influential Electrochemical Society and a critical contribution to the commercialization of MOS technology.

Herbert Kroemer (Notebook 490)
Physicist. Kroemer was one of the first researchers to include a copy of a computer printout in his notebook where he highlights an error in his program listing with the comment "What a blooper!" In 2000, he was awarded the Nobel Prize in Physics for "developing semiconductor heterostructures used in high-speed and opto-electronics."

Other volumes include books authored by individuals who went on to senior positions at Intel, such as Sunlin Chou, Dov Frohman-Bentchkowsky, Ted Jenkins, Willard Kauffman, Gerry Parker, Ron Whittier, and Albert Yu. James Angell, Paul Gray, John Moll, and C.T. Sah are among important contributors who also served with distinction in academia.

The Museum's Fairchild collection of patent notebooks offers a unique from-the-trenches view of three decades of semiconductor technology innovation within the company responsible for the naming of Silicon Valley and the modern integrated circuit. It also represents, probably, the last generation of significant scientific research that will be recorded by the inventor's hand in this manner.

The Museum is continuing to benefit from ongoing financial support for the long-term curation and preservation of its collection of Fairchild patent notebooks. For more information on how you can help email Vice President of Development Eileen Gill, egill@computerhistory.org.

EXHIBITING A COMPUTER NAMED WATSON

BY DAG SPICER

On June 10, 2013, at the Computer History Museum, IBM Senior Vice President and Director of IBM Research Dr. John Kelly formally presented part of the IBM Watson *Jeopardy!* stage set to Museum President and CEO John Hollar.

The custom-designed television stage set is part of an informative and entertaining temporary exhibit—named *A Computer Called Watson*—on the Watson system, its remarkable recent performance on the television series *Jeopardy!*, and IBM's plans for using Watson technology in future computing systems.

The exhibit has the actual podiums used by *Jeopardy!* champions Ken Jennings and Brad Rutter, at which you can stand, write your name on its screen, and even "buzz in." Pulsing gently in the background is the mysterious and enigmatic Watson avatar. There's also a wall-size timeline of Watson-development, four short movies about Watson and what it can do, and an interactive kiosk where you can try your hand at playing *Jeopardy!* against a simulated Watson.

The Match

The man-machine showdown took place between February 14–16, 2011, when *Jeopardy!* champions Jennings and Rutter battled wits against each other and Watson.

Competing against the humans—who have a three-

Vice President of Collections and Exhbitions Kirsten Tashev and Museum Semiconductor Staff Director Doug Fairbairn at the *Jeopardy!* podiums before the exhibit opening.

IBM WATSON EXHIBIT WILL CLOSE SPRING OF 2014.

pound, 10-watt processing unit—was Watson's 80,000-watt hardware, made up of ten seven-foot computer racks filled with 90 IBM Power 750 servers, and 16 terabytes (TB) of dynamic random-access memory (DRAM). The system is massively parallel and stores nearly all of the *Jeopardy!* game database in memory (not on hard disk) for very fast access—like human contestants, Watson has only three seconds to devise an answer. Watson's servers can analyze documents, websites, and books at a rate of 66 million pages a second.

Watson's parallel architecture suits the DeepQA (Deep Question and Answer) software technology it uses as the foundation for playing *Jeopardy!* DeepQA is optimized for searching through extremely large amounts of unstructured data, a pretty good definition of the sources Watson draws upon to build up its *Jeopardy!* database. Sources for the contest included encyclopedias (including the full text of *Wikipedia*), thesauri, news articles, dictionaries, and literary works.

The Future

Now that the hubbub about the *Jeopardy!* match has died down a bit, what's next? Watson is a philosophy as much as a computer system, an approach and model of the world as well as a physical computing platform. Watson is part of the IBM Smarter Planet initiative, in which computing systems adapt from being machines that are programmed to machines that can learn themselves, and which can act upon and respond to a world full of sensor information, databases, novel information sources, and gigantic amounts of unstructured data.

Not only is the amount of data produced in our world staggering (2.5 quintillion bytes/day—that's 1 with 18 zeroes after it), there are not enough computer programmers in the world to write the software to deal with it. IBM's view is that some type of machine intelligence, always guided by humans, must be applied to find the small fraction of usable data from a torrent of information.

While Watson is most impressive in the *Jeopardy!* context, its development potential is really in the very early stages. Currently, Watson is being used in test-bed scenarios in a small number of important industries, including healthcare and finance. It will be a while yet before the process of mutual alignment between user and machine in these industries is completed and Watson's true value is realized.

In the meantime, we invite you to celebrate the singular achievement of Watson's *Jeopardy!* triumph and visit this iconic exhibit. ○

This article is based in part on Dag Spicer's blog post, "IBM's Watson *Jeopardy!* Comes to CHM," available at computerhistory.org/atchm/.

Demonstrator and Museum docent Bill Worthington holds up a magnetic tape reel during a demonstration in the *IBM 1401 Demo Lab* exhibit.

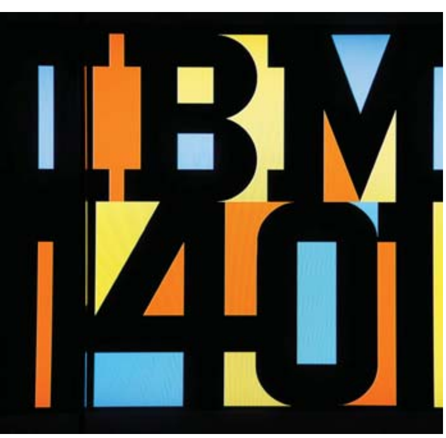
OUR NEWEST EXHIBIT: THE IBM 1401 DEMO LAB

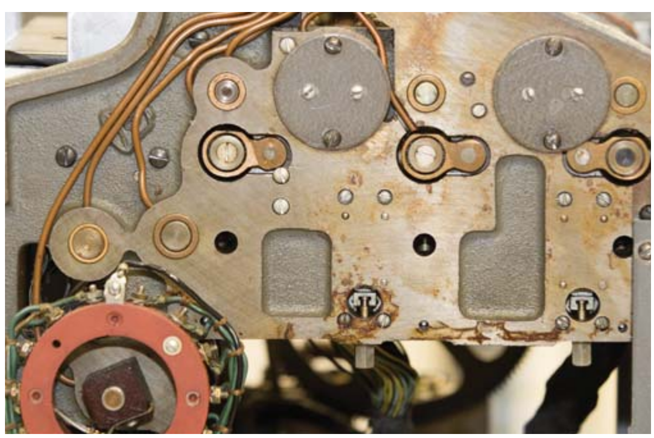
BY ROBERT GARNER

"Is anyone willing to lead a proj-ect to restore an IBM 1401?" Mike Cheponis enthusiastically asked with a glint in his eye. I knew Mike after attending several of his Digital Equipment Corporation (DEC) PDP-1 restoration sessions at the Computer History Museum. While most of my late night college hours were spent on DEC, UNIVAC, and Scientific Data Systems (SDS) computers, I had little exposure to IBM in the day. After designing central processors and leading-edge workstations at Xerox (1979) and Sun Microsystems (1984), with a new position at IBM Research and a curiosity about the history of early computers, I naively accepted the challenge. A few moments later, I asked: What exactly is an IBM 1401?

I was also intrigued about whether it would even be practical to restore a transistorized computer from the early 1960s, especially after 30 years of uncontrolled storage in a questionable climate. After posting "An IBM 1401 Needs Help" ad in the *San Jose IBM Retirement Club Newsletter*, I was grateful when about a dozen retired IBMers stepped forward to

Crowds gather on opening night for a live demonstration of the IBM 1401. Demonstrations were conducted by docents Bill Worthington and Jim Strickland.





Left: IBM 1401 Graphics used on opening night, from original IBM marketing brochure. Right: Close-up of the IBM Type 077 Collator, designed initially for the Social Security Administration in 1937. It could process 240 cards per minute.

bring the 1401 back to life. As they were mostly customer and manufacturing engineers who had serviced IBM 1401s in its day, I couldn't have wished for a better team of experienced, enthusiastic, and witty story-telling volunteers. After securing donations, IBM and Maersk Logistics crated and shipped a 1401 from Germany, plus its crucial documentation, to the Computer History Museum in the spring of 2004.

When the German 1401 arrived, the full extent of the challenge hit us: a central processing unit with 3,000 printed circuit cards, mechanically driven card reader/punch, hydraulically controlled chain line printer, and six reel-to-reel vacuum-column tape drives. The acquisition also came with some even older punched card equipment: 077 Collator, 082 Sorter, 513 Reproducing Punch, and 026 Keypunches, about which I knew nothing! The project was daunting. Not only would it involve restoring mainframes comparable to the PDP-1s, but restoring the other equipment would be like fixing about a dozen old automobiles! It would also consume about 12,000 watts of 50-Hz power. I needed project leads for each of the different subsystems and a large enough team that would stick it out for an unknown number of years going forward.

As the team began work on the German 1401, the extent of the corrosion became worrisome, especially on exposed surfaces, mechanical moving parts, and transistors. Transistors! Low and behold, the metal cases and leads of the early alloy-junction germanium transistors and crystal diodes contained iron! Many had rusted, resulting in bizarre failure modes when their hermetic seals, as a matter of course, were compromised.

By meticulously debugging 1401 diagnostic instruction sequences, step-by-step, several faulty Standard Modular System (SMS) circuit cards were found and repaired each passing month. In all, 130 failed SMS cards were located and fixed. Working in parallel, the 729 tape restoration group elected to entirely re-fabricate the drive mechanicals and to build a custom tape drive analog/PC-controlled hardware emulator to debug the 1401's tape controller unit. The 1403 printer didn't require as much work, but relays and corroded card handling paths in the 1402 card reader/punch required constant attention.

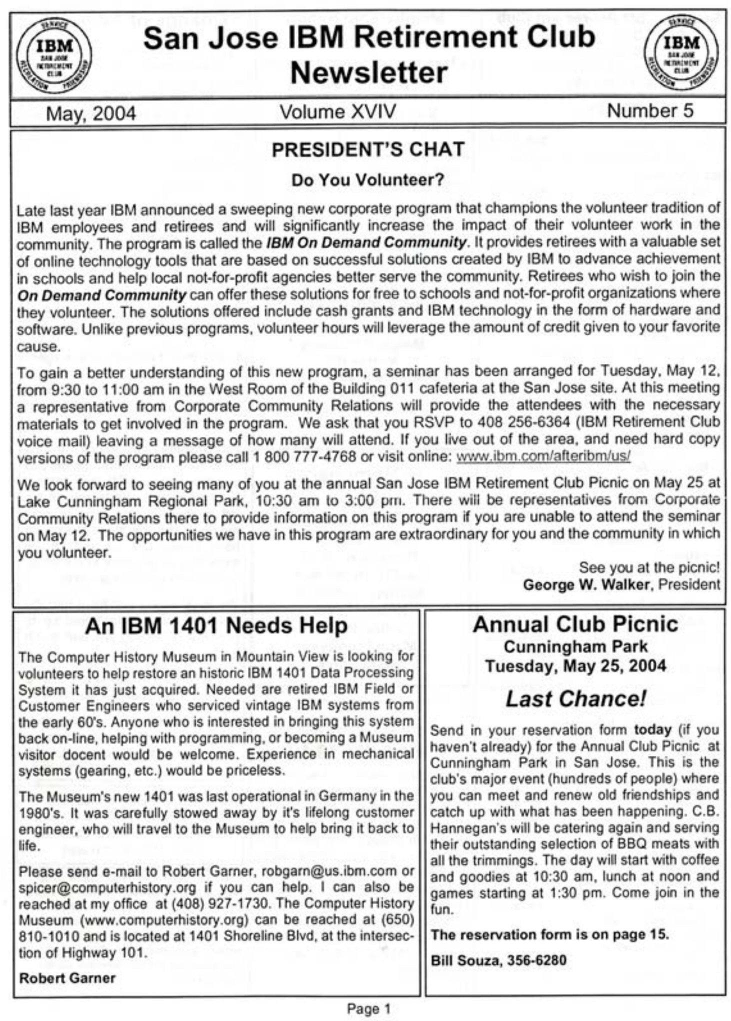
In 2007, as I fretted that we may have procured an impracticable number of rusted-out transistors, I got a surprise call offering another 1401! This similar system had been operated by a mom-and-pop business up until 1995 in the dehumidified basement of their family home in Darien, Connecticut. Local riggers extracted it from the basement, and IBM and McCollister's Transportation Group shipped it to the Museum. Upon the Connecticut 1401's arrival, the German 1401 seemed to recognize a sibling rival. Offering up its last faulty transistor, the German 1401 started to behave correctly! As I expected, only about 30 faulty SMS cards were found in the Connecticut 1401, and it was up and operational within six months. Even though a single 1401 system comprises over half a million discrete components(!), our two 1401s do operate reliably for many months before a failure. Back in its era, it's reported that 1401s ran for over six months before needing service.

The biggest joy for the volunteer team, who has put in over 20,000 hours, is not repairing the old equipment, but demonstrating the "compusaurs" to families and younger visitors. Kids' and adults' eyes light up as they punch cards on a keypunch, witness a clattering chain printer, stand before the human-sized spinning tape drives, gawk at its big size, and are taken aback by its "low cost" ($3 million in today's dollars). Visitors experiencing our running 1401s feel as if they've stepped into a technological time machine! ○

This article is based in part on a previous blog post by Robert Garner, entitled "Restoring the IBM 1401," available at computerhistory.org/atchm/.

The Museum salutes and thanks Robert Garner for his long service to the IBM 1401 project.

Top: Museum's IBM 1401 Restoration Team in June 2013. **Bottom:** *San Jose IBM Retirement Club Newsletter* including the Museum ad for IBM 1401 help.



San Jose IBM Retirement Club Newsletter

May, 2004 | Volume XVIV | Number 5

PRESIDENT'S CHAT

Do You Volunteer?

Late last year IBM announced a sweeping new corporate program that champions the volunteer tradition of IBM employees and retirees and will significantly increase the impact of their volunteer work in the community. The program is called the ***IBM On Demand Community***. It provides retirees with a valuable set of online technology tools that are based on successful solutions created by IBM to advance achievement in schools and help local not-for-profit agencies better serve the community. Retirees who wish to join the ***On Demand Community*** can offer these solutions for free to schools and not-for-profit organizations where they volunteer. The solutions offered include cash grants and IBM technology in the form of hardware and software. Unlike previous programs, volunteer hours will leverage the amount of credit given to your favorite cause.

To gain a better understanding of this new program, a seminar has been arranged for Tuesday, May 12, from 9:30 to 11:00 am in the West Room of the Building 011 cafeteria at the San Jose site. At this meeting a representative from Corporate Community Relations will provide the attendees with the necessary materials to get involved in the program. We ask that you RSVP to 408 256-6364 (IBM Retirement Club voice mail) leaving a message of how many will attend. If you live out of the area, and need hard copy versions of the program please call 1 800 777-4768 or visit online: www.ibm.com/afteribm/us/

We look forward to seeing many of you at the annual San Jose IBM Retirement Club Picnic on May 25 at Lake Cunningham Regional Park, 10:30 am to 3:00 pm. There will be representatives from Corporate Community Relations there to provide information on this program if you are unable to attend the seminar on May 12. The opportunities we have in this program are extraordinary for you and the community in which you volunteer.

See you at the picnic!
George W. Walker, President

An IBM 1401 Needs Help

The Computer History Museum in Mountain View is looking for volunteers to help restore an historic IBM 1401 Data Processing System it has just acquired. Needed are retired IBM Field or Customer Engineers who serviced vintage IBM systems from the early 60's. Anyone who is interested in bringing this system back on-line, helping with programming, or becoming a Museum visitor docent would be welcome. Experience in mechanical systems (gearing, etc.) would be priceless.

The Museum's new 1401 was last operational in Germany in the 1980's. It was carefully stowed away by it's lifelong customer engineer, who will travel to the Museum to help bring it back to life.

Please send e-mail to Robert Garner, robgarn@us.ibm.com or spicer@computerhistory.org if you can help. I can also be reached at my office at (408) 927-1730. The Computer History Museum (www.computerhistory.org) can be reached at (650) 810-1010 and is located at 1401 Shoreline Blvd, at the intersection of Highway 101.

Robert Garner

Annual Club Picnic
Cunningham Park
Tuesday, May 25, 2004

Last Chance!

Send in your reservation form **today** (if you haven't already) for the Annual Club Picnic at Cunningham Park in San Jose. This is the club's major event (hundreds of people) where you can meet and renew old friendships and catch up with what has been happening. C.B. Hannegan's will be catering again and serving their outstanding selection of BBQ meats with all the trimmings. The day will start with coffee and goodies at 10:30 am, lunch at noon and games starting at 1:30 pm. Come join in the fun.

The reservation form is on page 15.

Bill Souza, 356-6280

Page 1

Manager of School and Teacher Programs Aimee Gardner leads a group of high school students through ***Revolution*** **as part of our program *Get Invested: Case Studies in Innovation.***

MUSEUM EDUCATION: SETTING UP STUDENTS & TEACHERS FOR SUCCESS

BY LAUREN SILVER

The past two and a half years have been eye-opening for the Education department at the Museum. Since the launch of *Revolution: The First 2000 Years of Computing*, we have hosted more than 10,000 students from elementary school through college, nearly doubling our student attendance between 2012 and 2013. Educators from around the world have told us that our exhibitions, programs, and online resources are interesting and relevant for students of all ages, and that the Museum is a valuable resource for helping their students meet critical learning goals. Additionally, our education programs have been recognized locally and statewide with two major awards for excellence and innovation.

One of the reasons for our success is that we offer programs that align with state standards and inform what must be taught in all grade levels from elementary through high school. Our content is relevant to a wide range of college-level courses, as well. In the world of kindergarten through 12th grade (K–12) education, however, radical shifts are on the horizon with the impending adoption of new, national teaching standards that will transform not only what is taught in classrooms around the US, but also how that teaching takes place. Rather than focusing on isolated subject-specific facts, the new Common Core standards in Math and English Language Arts, and the Next Generation science standards in STEM (Science, Technology, Engineering, and Math) fields emphasize critical thinking, problem solving, and analytical skills that cut across multiple disciplines. For example, instead of placing the names and dates of historical computers on a timeline, students might be asked to analyze technical manuals in order to explain the practical implications of computer innovations for scientists trying to solve important problems throughout different historical eras. The focus is on bringing greater depth to students' understanding of core subjects and asking them to apply their knowledge appropriately and effectively; the goal is to set them up for success not only in kindergarten through 12th grade, but in college, careers, and all aspects of their lives beyond school.

The adoption of the new standards presents exciting opportunities for the Museum, since much of our content and the teaching strategies we use align perfectly with the Common Core. Schools and districts are seeking collaborators with the expertise to provide much-needed professional development for their teachers, along with content-rich, skills-based teaching resources that can be used in the classroom. To ensure that we truly address educators' needs, we will be spending much of the next one to three years conducting focus groups, interviews, observations, and surveys; assessing our current offerings and piloting new ones; and engaging in conversations with other museums and education providers to explore partnerships and determine how best to focus our strengths and align our efforts for maximum impact. Ultimately, we will create a rich array of programs and resources that will build on the foundation we have established in the past two and a half years and make certain the Museum's role as a vital resource for K–12 education in the Bay Area and beyond. ○

LAUNCHING THE ADOPT AN ARTIFACT PROGRAM

BY KAREN KROSLOWITZ

For any collecting museum, particularly those with collecting programs as active as the Computer History Museum's, the preserving part of its mission is straightforward: provide a stable storage or display environment in order to minimize the further damage or deterioration of artifacts. Usually this includes cataloging, packing items or preparing artifacts using archival supplies and methods, and providing secure storage.

It's when artifacts require conserving that things become complicated and rather expensive. Artifact conservation is the science of mitigating damage, performed by a professional conservator using archival methods, in ways that will not cause harm at the time of treatment and will prevent deterioration in the future. Though they may be rare and compelling, some artifacts simply aren't useful without appropriate conservation.

The Museum accepts an average of 400 donation offers each year, which calculates to several thousand individual items. With volume like that, our staff must be highly selective and accept only "museum quality" artifacts. But sometimes, it becomes the Museum's ethical obligation to accept damaged items when they are exceptionally rare. Such was the case with a National Cash Register (NCR) 304 salesman's model donated by Albert Schott (Lot X6712.2013), which arrived with a few broken pieces. Commonly used by salesmen in the 1950s and 1960s, these miniature replicas enable the Museum to demonstrate the hefty space and complex requirements for operating large mainframe systems, like the NCR 304. So when it came time to accession Schott's model into the Permanent Collection, the Museum was delighted to do so. But how to fund its repair for eventual display remained in question.

The NCR 304 was included in a new endeavor the Museum launched this past year: *Adopt an Artifact*. This program helps raise awareness and funds for conservation of rare items, each with a unique story to tell. Along with the NCR 304 model, the Honeywell fox from the company's famed animal sculpture series, and a silk portrait of J.M. Jacquard, inventor of the programmable loom,

PHOTO COURTESY OF ELMER HOEKSEMA

Left: Donor Elmer Hoeksema adopted the National Cash Register (NCR) 304 model. Right: National Cash Register (NCR) 304 model donated by Albert Schott.

were also selected. It was the one-of-a-kind story of the NCR 304 that caught the attention of Computer History Museum fan, Elmer Hoeksema.

A resident of the Netherlands, Mr. Hoeksema engages with the Museum's website, computerhistory.org, between in-person visits and was intrigued by the Museum's new adoption program. Although he'd never heard of the NCR 304, his research into the system inspired his full sponsorship of the model. In particular, he was excited to learn that the 304 was the first fully-transistorized NCR computer. He explains, "This was a huge step in computing. Transistors made computers so much more reliable. The invention of the transistor was also a very important step towards the current technology we use today. The most modern chips are still based on the basic transistor design." It is stories like that of the NCR 304 that the Museum is working to preserve for generations to come.

Despite not living in the same country as the Museum, sponsoring an artifact enables Mr. Hoeksema to participate in the mission of the organization. He says, "I think it's very important to preserve computer history for future generations." We at the Museum are extremely grateful to Mr. Hoeksema for his generosity, which enabled the damaged pieces to be repaired and the full NCR 304 model to be displayed in our lobby.

Conservation is an ongoing challenge for every museum, and the Computer History Museum invites you to help us meet those challenges by adopting an artifact today. The Honeywell fox and silk portrait of J.M. Jacquard are still available for consideration and, as these are adopted, the Museum will offer other artifacts in the future. ○

You can learn more about the *Adopt an Artifact* program at computerhistory.org/contribute/adoptartifact. For more information, contact Darren Ponce at dponce@computerhistory.org or call 650.810.2730.

The Honeywell fox is one of several originally designed and constructed for Honeywell Information Systems as a part of their legendary computer marketing campaign. It currently has three broken legs.

This framed portrait of Joseph Marie (J.M.) Jacquard, dated 1839, shows deterioration. Jacquard was the inventor of the programmable loom, which automated the process of weaving fabrics.

Facebook Chief Operating Officer and author Sheryl Sandberg on *Revolutionaires* stage with Google's Executive Chairman Eric Schmidt in May 2013.

SANDBERG AND SCHMIDT EXPLORE LEANING IN

LECTURE

BY JOHN C. HOLLAR

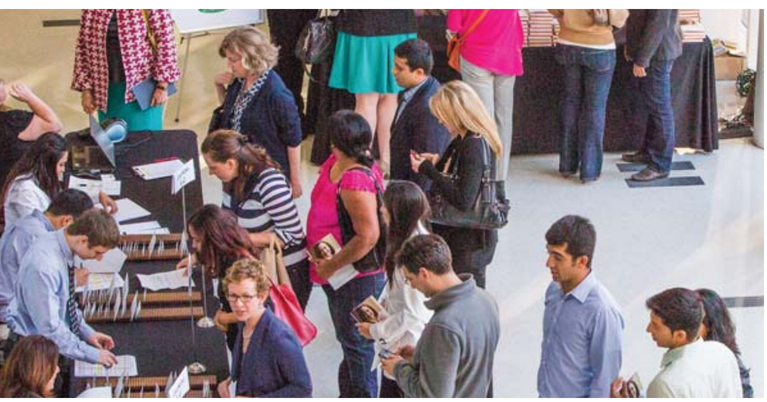
The Museum's Revolutionaries lecture series annually features some of computing's leading figures from both the past and the present day. In May 2013, Facebook Chief Operating Officer Sheryl Sandberg and Google Executive Chairman Eric Schmidt—long-time friends and colleagues—appeared together to discuss Sandberg's worldwide bestselling book, *Lean In: Women, Work, and the Will to Lead*. In their wide-ranging conversation, Sandberg discussed her career, business experience, and perspective on the challenges and opportunities facing women in the twenty-first century workplace. Here's an excerpt:

Eric Schmidt: I met Sheryl in the late '90s when she was running what appeared to be about a third of the Treasury Department. Impossibly young and impossibly smart, she impressed all of us with what she did in the Clinton Administration in the first and second terms. After joining Google, in the subsequent six years, she reworked sales and built a business that today is worth somewhere around $20 billion and established the recruiting practices that led the company to its current excellence. Then, shockingly, shockingly, she shows up and says, "I'm going to go work for Mark [Zuckerberg]," and I said, "How could this be? I mean, is there something wrong?" She said, "No, no, no, no, no. No, I'm interested in this new area." And, at Facebook, in fact, she repeated the success a second time, which has really not occurred, I think, very often in our industry, maybe once or twice, and I thought, "Wow, that's pretty impressive." So, then she decides to write a book, which immediately becomes a number-one bestseller. I have no idea what she's going to be doing as her next encore, but we're talking about one of the great leaders of our industry.

Sheryl Sandberg: I want to thank Eric, who gave me, as I say in my book, the best advice of my career. We all say this, but we all get to do the things we do because of great mentors and great advisers, and Eric has been that through Google, through Facebook, which he was lovely about, and throughout everything I've done, and I'm super grateful.

Schmidt: Let's start with one or two important ideas from the book. You write, "In addition to the external barriers erected by society, women are hindered by barriers that exist within ourselves. We hold ourselves back in ways both big and small, by lacking self-confidence, by not raising our hands, and by pulling back when we should be leaning in." Can you finish that thought?

Sandberg: Women have held 14 percent of the top jobs in corporate America for 10 years. You taught me that trends that go up for a long time and then are flat for a long time don't go up again. They often go down. Women are held



Top: Sheryl Sandberg greeted fans at the book signing following the program.
Bottom: Guests check-in at registration before the event.

back by all kinds of external barriers: bad public policy, institutional barriers, sexism, discrimination. All of that is really important to recognize. But we're also held back by our own internalization of stereotypes. For example, do this: go to a meeting tomorrow at work and watch where people sit. Relative to the same level of position, more men than women sit in the front and at the center, and more women sit at the back and on the side. Both metaphorically and in reality, we hold ourselves back. And if we're going to fix the problem for women in leadership, we have to solve both the external barriers and the internal barriers.

Schmidt: In the book, you point out that, in broad generalizations, female performance in math and science is roughly equal to that of men. It is higher in verbal skills for women. Furthermore, around 59 percent of women are now completing college, and less for men. There's this huge cohort of women who have come into the workplace and are changing it, and yet they've not gotten to the top.

Sandberg: Women graduate at higher levels from college. They get more graduate degrees. They get more entry-level jobs, and then it just winnows out. And so, every year, fewer women get promoted, and then by the time you get to the top, you're at 14 percent in the United States. It's not just us. There's not a single country in the world that doesn't have 95 percent of its top companies run by men. Some women leave the workforce if they can afford to do so. Some of them stay in the workforce, but don't go for promotion.

Schmidt: In the book, you talk about a fact that's generally known in psychology, which is called the "stereotype threat," where people actually underperform if they're told they're a member of a stereotype. Do you think that that's one of the things driving these behaviors?

Sandberg: Yes, one of them, and it explains both the dearth of women and leadership skills and the dearth of women in computer science. As we're at the Computer History Museum, it's so important to say: it's the same thing. Stereotype threat means that if you become aware of a stereotype, you will act in accordance with it. Studies show that if you ask

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

boys and girls to first identify themselves on a math test by checking M or F for their gender, girls will do worse. If you tell those same girls right before [the test], "Girls do really well on this math test," they will do better. Our stereotypes of boys are that they're better at math and science, and girls facing that stereotype will underperform.

Schmidt: You also take people through "imposter syndrome"—the feeling that, if you're doing really well at work, you may think, "I'm a fraud." What you say, for example, is that both men and women are susceptible to imposter syndrome, but women tend to experience it more intensely and be more limited by it. How does that play out?

Sandberg: Imposter syndrome means that you don't believe you own your success. The data tells us that, given the same level of performance, men remember their success as slightly higher and women remember theirs as slightly lower.

Schmidt: About that data, you write, "Ask a man to explain his success, and he will typically credit his own innate qualities and skills. Ask a woman the same question, and she will attribute her success to external factors, insisting that she did well because she worked really hard or got lucky or had help from others."

Sandberg: And if she doesn't say that, other people will say it about her. And so what happens with imposter syndrome is that relative to levels of performance, men feel more self-confident.

Schmidt: You talk about experiments in likeability. You cite data showing that success and likeability are positively correlated for men and negatively correlated for women. You may remember that [at Google] we studied correlations of male questioners versus female questioners, and when men would hire people, they would correctly predict the person they hired's success if it was a man. But when they scored the likelihood of female success, it was anti-correlated. In fact, the prediction was exactly wrong.

Sandberg: We all may feel gender bias, myself included. One thing that happens with gender bias is this: as women get more successful, more powerful, they tend to be less liked. As men get more successful and powerful, they tend to be better liked. The data shows it's true of both women and men. Part of what I want to do is have us admit that we are there. Making it safe to admit that is a really important part of the answer.

Schmidt: Now, when you talk about childcare and you talk about the decision to have children, which is obviously a complicated decision for professional women, one of the problems that you describe is that for women—unless they're in high-tech and have stock options and so forth—the math doesn't work. How do we solve this core problem women feel?

Sandberg: Childcare issues exist on both ends of the income spectrum. At the lower end of the income spectrum, it's very clear that we need public-policy reform and institutional reform. We're the only developed country in the world that doesn't offer one day of federally mandated paid maternity leave. Something like 40 to 50 percent of women in this country—and men—don't get a single sick day paid to take care of a child or deal with paternity or maternity issues. We must provide affordable childcare and solve some of these basic issues, and nothing else is as important.

On the upper end of the spectrum, I think women sometimes do the math wrong. They look at the cost of childcare today, and their salaries today, and they see only difficulty. Ten years later, the salary of a woman with a college degree is likely to cover plenty of childcare and all kinds of other things, because their incomes rise. I believe women need to look ahead at what's coming, not what they have right now.

Schmidt: There has been so much said and written about your book around the world, and it's started an important conversation and an important movement. If you look objectively at what's been said, what do you think is the most accurate criticism?

Sandberg: The best criticism, which I struggle with a lot, is that in trying to change stereotypes, I am embracing those stereotypes. I don't want to embrace a stereotype to change it. I just decided that I'm pretty much a pragmatist. The world is what it is. If more women smile, say "we," and negotiate in a way that justifies their raises, for example, they'll get raises, they'll become CEOs, then people will ascribe leadership to women for being the leaders they are. ○


IBM
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CB
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CR
CD
CF
CG
CV
CC
COUNT REGISTER
CHANNEL NUMBER ONE
DATA REGISTER
KEY
COMMAND

THE IBM SYSTEM/360

BY RICHARD S. TEDLOW

A LOOK BACK AT THE CREATION OF A COMPUTING HISTORY GIANT

The IBM System/360 is rightly viewed as one of the great new product introductions in the history of business. The 360 transformed both the company that introduced it and the industry of which that company was a part. Not incidentally, the struggle to create the new world dominated by the 360 transformed the lives of many of the key people involved in what was to become a great drama.

Thomas J. Watson Jr., CEO and chairman of the board, announced the System/360 on April 7, 1964, a half century ago. There was no hiding of lights under bushels on the occasion of the announcement. The company hired a special train to take about 200 reporters from Grand Central Station to its facilities in Poughkeepsie, New York, where Watson spoke; and press conferences were held in 165 cities across the United States and in 14 other countries.[1]

"We are not at all humble," began Watson, "about asking you to come here today . . . to share with us the most important product announcement that this corporation has ever made in its history."[2] This was not an overstatement. Many years later, Andy Grove remarked that the 360 casted a shadow that lasted decades.[3]

Realizing a Computer of the Future

What was it about the 360 that made it an artifact of such supreme importance? Central to the 360 were two related ideas. One was that the "computer of the future" should be able to serve the needs of business, government, and science. During the 1950s, computers were often special-purpose machines. IBM, for example, built the SAGE (Semi-Automatic Ground Environment) computer system for the United States Air Force in order to detect hostile aircraft. The RAYDAC (Raytheon Digital Automatic Computer), to choose another example, was built by Raytheon for the Naval Air Missile Test Center in California.

To be sure, not all computers were one-offs. IBM marketed both a scientific line and a business line of processors in the late 1950s. However, as their names suggest, one line was targeted at business and the other at scientific markets. Businesses tended to want computers for simple calculations involving text and decimal numbers, performed at a reasonable speed. Computers targeting the scientific market, in contrast, typically had to be able to perform very sophisticated calculations on immense data sets.

Perhaps the single most important characteristic of *all* computers prior to the 360 was that they could not communicate with each other. Born in the midst of World War II, during which the need to deal with huge amounts of data was paramount, analysis rather than communication was what computers were developed to deliver.

With the remarkable progress in computers from vacuum tubes to transistors after World War II, it became progressively more obvious that computer users wanted computers that were compatible—that could use the same software and peripherals as their businesses grew. Compatibility became the "Holy Grail" of the industry in the late 1950s and 1960s.

Compatibility was important for any number of reasons. Without it, every time customers made a change from one central processing unit (the hardware, which was the heart of the computing system) to another, they had to change everything else. All the peripherals—printers, input/output devices, magnetic storage devices, and so on—had to be changed as well. This was no small matter. Some 44 peripheral devices were announced that fateful day in the early spring of 1964 along with the System/360 CPU itself.[4]

Hardware was only half the problem that had to be solved for compatibility to become a reality. The other half, perhaps even more difficult to manage, was software. One of the earliest theoretical works about software was published by the brilliant Alan Turing in an essay written in 1935.[5] Software was just coming into its own as a discrete field in the 1950s. *Wikipedia* defines software as a set of instruc-

Preceding page: Close-up detail of IBM System/360 Model 30.

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[1] Chuck Boyer, *The 360 Revolution* (Armonk, NY: IBM Corporation, 2004).

[2] Quotation courtesy of the IBM Archives.

[3] In conversation with the author, 2005.

[4] Emerson W. Pugh, Lyle R. Johnson, and John H. Palmer, *IBM's 360 and Early 370 Systems* (Cambridge: MIT Press, 1991), 167.

[5] "History of Software," *Wikipedia, The Free Encyclopedia*

[6] Wikipedia contributors, "Software," *Wikipedia, The Free Encyclopedia*, http://en.wikipedia.org/wiki/Software.

[7] See http://www-03.ibm.com/ibm/history/ibm100/us/en/

tions that tells computer hardware what to do, a deceptively simple description for what can be a phenomenon of great complexity.[6]

In the 1950s, software for one computer was not portable to another. Thus, every time a customer wanted to change computers, they would have to write a whole new set of program instructions for the new machine. This was time-consuming, intricate work in which mistakes were not uncommon.

As a result, each decision to change a computer required the expenditure of time, effort, energy, and money. If you wanted a more powerful machine because you were growing or you wanted an additional machine because you were expanding geographically, new software and peripherals were required.

For the vendor, this situation was highly problematic. It led to product proliferation, which made it impossible to capture scale economies. It meant you could not achieve customer "lock-in." That is to say, each time a customer wanted to change computers, he owed it to himself to survey the whole competitive landscape rather than to stick with you because of the necessity of rewriting software and buying new peripherals. Incompatibility was the enemy of brand loyalty.

A Threat to Service

For IBM, incompatibility was a problem of special urgency. Founded in 1911, IBM was a company built on service. Through the electromechanical era into the electronic era, IBM's service was always beyond compare. Yet by 1960, IBM's capability to provide superior service was being severely tested. The technological accomplishments of the 360 are so striking that marketing, sales, and service can be easily overlooked. Yet they were critically important, especially for IBM.

IBM has always been focused first and foremost on sales and service. The man who imprinted his approach to business indelibly on the firm was Thomas J. Watson Sr., CEO from 1914 to 1956. He was pre-eminently a salesman who used to tell his engineers that IBM did not sell punched card ma-

IBM President and CEO Thomas J. Watson Jr. (left) and IBM Senior Vice President Vin Learson with IBM System/360 Model 20, ca. 1966.

Typical IBM System/360 Model 65 installation, 1965.

chines but rather "a service that satisfies."[7] The eight CEOs who succeeded Watson all came up through sales and marketing. None was a technologist.

In the words of his son and heir, Tom Jr., "The main aim of our business is service, to help the customer solve his problems no matter how many problems this may create for us." Young Tom also said that IBM hopefully delivered "cutting edge equipment, hopefully all sorts of pioneering efforts, hopefully Nobel Prizes . . . but the service is something most companies forget."[8]

Incompatibility was threatening IBM's distinctive competitive advantage in service. By the early 1960s, according to Watson, "our product line had become wildly disorganized." For each processor, such as the 1401, 1620, 7070, 7080, and 7090, IBM was committed to providing its customers with programming, training, and field service.[9] IBM had to train its own people to perform these tasks before they could educate others . The company could not move a field service person from a 1401 to a 7090 if demand required because the codes and the peripherals were different. That service person would have to be retrained.

It is in the marketing function that we can find the answer to one of the great puzzles of the 360. That puzzle is: Why did IBM, the industry leader by a wide margin, take this giant leap into the unknown? It is rare enough for any company to make a bet of this magnitude. It is close to unheard of for such a bet to be made by a company that was winning the game as it was being played.

Despite the real problems caused by product proliferation that incompatibility generated, IBM was by far the dominant force in the industry. In 1960, its market share was about 75 percent. The competitors, some of which were big companies loaded with engineering expertise, included General Electric (GE), Radio Corporation of America (RCA), and American Telephone and Telegraph Company (AT&T), who were dwarfs by comparison to IBM in computing. Nearly half of all computers in the world by the early 1960s were 1401-type systems. But in order to maintain its dominance, the company would have to bring out a new line of computers that was not compatible with any of the machines it was marketing in 1960. It risked sacrificing its leadership and letting everybody start all over again on an equal footing.

The Series That Wasn't: Brooks vs. Evans

In 1960 and 1961, IBM's 7000 series was due for a refresh. The 8000 series was being created to fill this role. The 8000 represented an incremental improvement over its predecessor. Fred Brooks, a 29-year-old Harvard PhD and a computer genius, was the product champion.

The specs and the pricing had all been worked out. There was even a prototype. Everyone was happy with the presentation Brooks made about the device in January of 1961 . . . with one exception. The exception was to matter a great deal.

T. Vincent Learson was a senior vice president of IBM in 1961. He had majored in mathematics at Harvard, from which he graduated in 1935, and went to work at IBM in sales and marketing. He spent his entire career with the company.

The 8000 proposal represented a clear advance over the 7000. In the short- and medium-term future, it would enable IBM to maintain its leadership in computers. But over the long-term, it would intensify the product proliferation problem with which IBM already had to contend.

Don Spaulding, Learson's chief of staff and another major player in what would become the 360 decision, prepared a lengthy memorandum on product policy. He believed that IBM already had too many different computers requiring too much support and too many peripherals.[10] Spaulding felt the task at hand was to focus and simplify.

Spaulding's memorandum reinforced Learson's own concerns. Another important influence on Learson's thinking was a course on industrial dynamics, which he attended at MIT along with a group of computer users. This experience contributed to his conviction that computer applications would rapidly expand.[11] A bold move away from mere record keeping and toward more sophisticated uses was called for. The 8000 may have been an improvement on its predecessor, but it was, nevertheless, a move in the wrong direction.

In 1961, Learson transferred Bob Evans, the manager of processing systems at the General Products Division, from Endicott, New York, to Poughkeepsie to serve as head of planning and development for the Data Systems Division and to help think strategically about charting a new course for overall product policy. Thirty-four years old, Evans had ascended quickly at IBM after joining the firm in 1951. Sleeping four hours a day and working the remaining 20, Evans piloted the 1400 series at the General Products Division in Endicott from the projected 5,000 units to four times that many.

On one December day in 1960, Evans found himself in Milwaukee calling on happy 1401 customers to learn more about what they wanted him to be doing with new products in that family. He received a phone call at about 1:30 in the afternoon informing him that he should be in Learson's office in New York City that evening at eight o'clock. So,

Learson said to him, "Bob, they have this 8000 series up in Poughkeepsie. Go up and look at it. If it's right, do it. If it's not right, do what's right."

[8] See www.03.ibm.com/ibm/history/multimedia/wav/ibmservicewav.wav

[9] Carliss Y. Baldwin and Kim B. Clark, *Design Rules: The Power of Modularity*, Volume 1, (Cambridge: MIT Press, 2000) p. 171.

[10] T.A. Wise, "IBM's $5,000,000,000 Gamble," *Fortune*, September 1966, 118–21.

[11] Ibid.

[12] See The IBM System/360 40th Anniversary, Computer History Museum, http://www.youtube.com/watch?v=8c0_Lzb1CJw.

What was the new product that IBM wanted to bring to market going to be? No one knew. But many in the company knew what had to be avoided. Product proliferation had to be conquered.

he canceled his plans and made the trip. Learson said to him, "Bob, they have this 8000 series up in Poughkeepsie. Go up and look at it. If it's right, do it. If it's not right, do what's right."[12]

This is why Evans was relocated from Endicott to Poughkeepsie. Late in March 1961, he submitted a report to the president of the division concluding that the 8000 series should die. The technology was wrong, and the incompatibility problem was not being addressed.

Forty years later, Fred Brooks remembered vividly the intense emotion of the product fight that went on in 1960 and 1961. He and his team had been optimistic following the presentation in Poughkeepsie in January of 1961. The 8000 was designed to meet an immediate sales need "because the competition was eating us, and we were becoming obsolete."[13] The fight over its future continued from January until May.

Twice, the battle was escalated to IBM's top management. In March 1961, it looked like Brooks had won and the 8000 would proceed. In May, however, the corporate management committee again considered the product roadmap, and this time Evans won.

After he had prevailed in May, Evans well understood that there was no plan in place for the Data Systems Division in Poughkeepsie to do anything. He invited 25 of the top people at the division to attend an off-site meeting at the Gideon Putnam Hotel in the old resort town of Saratoga Springs, New York. Fred Brooks was among the people present. As he put it, he "just tagged along" to make sure that all his people landed on their feet. He expected to return to research after the meeting.[14]

On May 15 at Saratoga Springs, Evans announced to the 8000 team that the product was cancelled. It was his responsibility to reassign those who had championed it to other tasks. Gloom and doom reigned. As one participant said, "There was blood all over the floor."[15]

A New Leader

The first step that Evans took was to develop "temporizers." If IBM did not make at least incremental improvements to its product line, it would lose share to the competition which, as he put it, "would kick the heck out of IBM's current products." Thus, the 7095 was planned to breathe some life into the 7090, and some improvements to the 7080 gave it some life as well. Other temporary improvements were planned and one model was developed in order to satisfy the desire of the sales force for mid-range scientific processing power.[16]

"We went back to work hammerin' and sawin', and we needed a leader," said Evans. Evans made what he called the second best decision of his life (the best having been to ask his wife to marry him). That second best decision was to ask Fred Brooks to be the head of the new product launch. He said Brooks "was the best guy around by any measure."[17]

No one was more surprised at this request than Brooks himself. "You could have knocked me over with a feather when he asked me to take the crown jewels of the new plan. That is a big man, and I was absolutely stunned. I talked to one or two senior executives and asked if this was real. Was this something I should do? One of them replied, 'No one who has ever worked for Bob Evans has regretted it.'"[18] So Brooks accepted the assignment.

What was the new product that IBM wanted to bring to market going to be? No one knew. But many in the company knew what had to be avoided. Product proliferation had to be conquered. IBM was

[13] Ibid.

[14] Brooks, Fred (Frederick P., Jr.) oral history, September 16, 2007, Oral Histories Online, Lot X4146.2008, Catalog Number 102658255, Computer History Museum.

[15] Wise, "Gamble."

[16] Bob O. Evans, "System/360: A Retrospective View," *Annals of the History of Computing*, Vol. 8, No. 2 (April 1986): 163. See http://www.youtube.com/watch?v=8c0_Lzb1CJw.

[17] Ibid.

[18] Ibid.

[19] William O. Ingle and Joseph L. Bower, "The IBM 360: Giant as Entrepreneur," HBS Case #9-389-003, Rev. April 1, 1998, 7–8.

saying yes to too many good ideas. The result was an overwhelming strain on the company's ability to service customers. The only solution was compatibility.

Indeed, top management wanted a compatible product line well before the technical people—the engineers and designers—knew whether or not this goal could be achieved. In 1959 and 1960, customers were complaining loudly to IBM's sales force about the costs of complexity and incompatibility in IBM's product line.

Unfortunately, IBM's top managers could not command its engineers to do what many thought was technically impossible. How much compatibility could be achieved? Should the instruction set legacies of the 1400 and 7000 machines be perpetuated? Or was it time to start with a clean sheet of paper? These are the questions for which Brooks and his colleagues had to provide answers.

The SPREAD Task Group

During the late summer and early fall of 1961, Watson and Learson initiated discussions with their division heads aimed at defining a new strategy for a new era. The results of these discussions were less than satisfactory. Learson, therefore, formed a special committee with representatives from all major parts of the company to provide policy guidance.

Learson wanted not only to make the right decision. He wanted to make the decision right. As his vehicle for making the right decision the right way, he impaneled a special task force. Thirteen people were members of what was known as the SPREAD (Systems Programming, Research, Engineering, and Development) task group.

Not a patient man on a good day, Learson, by November, found the progress of this group "hellishly slow." In December, he sequestered these 13 men in the Sheraton New Englander motel in Cos Cob, Connecticut, near Stamford, and told them not to come out until they had reached some conclusions.[19]

What emerged on December 28 was their final report. They recommended the introduction of a new product line, which would satisfy the heretofore separate commercial and scientific markets. The new product should be compatible all the way from the basic 1400 machine to the top-of-the-line most sophisticated machine in the 7000 series.

Left: Robert Evans, Vice President, Development, Data Systems Division
Right: Vin Learson, the man who led the System/360 project at the executive level.

Remarkably—incredibly—the task force concluded that since the new product line "must have capabilities not now present in any IBM processor product, the new family of products will not be compatible with our existing processors."[20] Therefore, not only did the task force advocate leapfrogging the industry, their recommendations actually advocated rendering IBM's present market-dominating products obsolete. It was as if Henry Ford decided in 1921, when the Model T had 55 percent of the automobile market in the United States, to abandon it not only for an enhanced Model T, but for an automobile powered by electricity instead of the internal combustion engine.

The conclusions of the SPREAD report were presented to IBM's 50 top executives on January 4, 1962. The mellifluous Fred Brooks managed the presentation. The reception was mixed.

The engineers were in favor of it, but other people were shocked. The proposals were met by almost violent opposition from marketing. Their smorgasbord of machines would be done away with. Variety was their ally. That is how they sold. "We have the machine just for you." With the newly proposed product, customers would have to reprogram, not something salesmen were anxious to tell them. In finance, people were very concerned. Learson saw them slam their books shut. They thought the proposal was too grandiose. The report said, for example, that IBM would spend $125 million on programming the system at a time when the company spent only about $10 million a year for programming. As Learson recalled, "The job just looked too big. . . . Everyone recognized it was a gigantic task that would mean all our resources were tied up in one project—and we knew that for a long time we would not be getting anything out of it."[21]

Nevertheless, Learson concluded, "All right, we'll do it." In May 1962, IBM's corporate management committee formally approved the new product launch.

Gambling on the Unknown

A lot of the drama and a great deal of the uncertainty that surrounded the 360 took place after the decision to more forward with it had been made. IBM did not have a firm understanding of what it was getting itself into. The whole project was almost sunk by the unknown unknowns.

Nothing of the magnitude of the 360 had ever been attempted before—certainly not in this industry. Therefore, IBM had no models to guide it. The company's estimates of the cost of hardware and software were so incorrect that the project was in jeopardy on more than one occasion.

The software was a tremendous hurdle. Hundreds of programmers had to write millions of lines of computer code. Nobody had ever tackled that complex of a programming job, and the engineers were under great pressure to get it done.

As late as 1966, a year and a half after the announcement of the 360, Watson, speaking to a group of IBM customers, said, "We are investing nearly as much in System/360 programming as we are in the entire development of System/360 hardware. A few months ago, I was informed that the bill for 1966 was going to be $40 million. I asked Vin Learson before I left [for this meeting] what he thought the cost would be for 1966, and he said $50 million. Twenty-four hours later I asked Watts Humphrey, who is in charge of programming production, in the hall here and said, 'Is this figure about right? Can I use it?' He said, 'It's going to be $60 million.' You can see that if I keep asking questions we won't pay a dividend this year."[22]

Making one big bet on the 360 led to other big bets, which had not been anticipated. Up until the 360, IBM was essentially a company that assembled, marketed, and serviced computers. But for technical reasons, the 360 meant that IBM had to enter component manufacturing, a basic change in the character of the company. In the day of vacuum tubes and transistors, IBM designed the components for circuits, ordered them from other companies (such as Texas Instruments), and then assembled them to its specifications. But with the circuitry required by the 360, those specifications would have to be built into the components from the outset.

As a result, IBM became the world's largest manufacturer of computer components, an outcome that was neither planned nor welcomed. It also became by far the world's largest producer of semiconductors. Watson said, "I will never forget how expensive it was to build our first integrated circuit factory. Ordinary plants in those days cost about $40 per square foot. In the integrated circuit plant, which had to be kept dust free and looked more like a surgical ward than a factory floor, the cost was over $150. I could hardly believe the bills that were coming through, and I wasn't the only one who was shocked. The board gave me a terrible time about the costs. 'Are you really sure you need all this?' they would say."[23]

IBM's accounting system was inadequate for the manufacturing tasks undertaken. When time came time to close the books for 1965, no one could figure out how much work-in-process inventory the company had. Al Williams, IBM's president, tried to complete his accounting and financial responsibilities in 1965 and couldn't do it. The best estimate he could get for work-in-process inventory was $150 million, but the data upon which that was based were so vague as to be useless.

Williams tasked John Opel, a future CEO of the company, to find out exactly what work-in-process inventory amounted to. Opel would give Williams an estimate only to find out within a day that he had not only missed, but missed by $50 million. Opel finally got so frustrated that he insisted that each factory manager take a physical inventory, something IBM had never had to do before. He finally discovered that the accounting system had gone completely out of whack. IBM had almost $600 million of work-in-process inventory that none of the factory managers wanted to claim. This made top management frantic.[24]

Here is another example of how badly the forecasting was going. In 1963, IBM decided to pre-pay a major loan from the Prudential Insurance Company bearing an average interest rate of 3.5 percent. But when these unaccounted-for costs started popping up in such large amounts, it actually looked like IBM—the bastion of financial security—might run out of cash. In 1966, the company had to establish bank lines of credit for the same millions it had pre-paid earlier and had to pay about two percentage points more for any of the funds used. Truly startling was that, due to the cash shortage, IBM unexpectedly sold $371 million of stock to the public in the spring of 1965.

The Price of Success

Tom Watson observed that in the autumn of 1965, "everything looked black, black, black. I was 51 years old, I had nine years of fantastic success behind me, and I didn't want my career to be wrecked by an announcement that the whole new product line was never going to fly at all. I panicked."[25] Watson demoted his brother Dick and, because he believed that business needed a dictator to move forward, put the whole 360 program in the hands of Vin Learson. This decision, not surprisingly, alienated the brothers. Watson later reflected, "We remade the computer industry with the System/360, and objectively it was the greatest triumph of my business career. But whenever I think of it, I think about the brother I injured."[26]

We remade the computer industry with the System/360, and objectively it was the greatest triumph of my business career. But whenever I think of it, I think about the brother I injured.

THOMAS WATSON JR.

Here is Learson's assessment, "We made two miscalculations. We were off on our assessment of 360's potential reception, and we were off on our assessment of IBM's production capability to meet the demand. We did what Charles Kettering, an engineering genius and president of the General Motors Research Division, always advised against: we put a delivery date on something yet to be invented."[27]

IBM gambled $5.25 billion on the 360, or 1.9 times the revenue for 1962. (When the 360 was approved, it was budgeted to cost $675 million.)[28] The gamble turned out to be a fantastic success. But the price was high in terms not only of money, but of human relationships.

Perhaps too high. The company never succeeded at anything of this magnitude again. ○

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[20] "Processor products : Final report of SPREAD task group," IBM, December 28, 1961, Jerome Svigals papers, Lot X3951.2007, Box 5, Catalog Number 102713231, Computer History Museum.

[21] Ingle and Bower, "Giant," 7.

[22] Thomas J. Watson Jr. and Peter Petre, Father, *Son & Co: My Life at IBM and Beyond* (New York: Bantam, 1990), 353.

[23] Ibid., 350.

[24] Ibid., 358.

[25] Ibid., 357.

[26] Ibid., 360.

[27] Rowena Olegario, "IBM and the Two Thomas J. Watsons" in Thomas K. McCraw, ed., *Creating Modern Capitalism* (Cambridge: Harvard University Press, 1997), 392.

[28] Boyer, *The 360 Revolution*, 31.

THE WEB @25

The year 2014 marks a series of overlapping anniversaries. First is the 25th anniversary of Tim Berners-Lee's first proposal for the World Wide Web. It's also been 20 years since the web's popular explosion, including the launch of Netscape, Amazon, eBay, and many others. Fifteen years ago Japan rolled out the mobile web the rest of us wouldn't discover until the iPhone era, while here we remember 1999 as the teetering height of the dot-com boom. That's an anniversary rarely celebrated given the immediate aftermath. Lastly 2014 marks 10 years since the web's popular rehabilitation following the crash, including Google's IPO and the rise of "Web 2.0" businesses like Yelp, Facebook, Flickr, and more.

NOTABLE MILESTONES IN THE BUILDING OF THE INFORMATION AGE

BY MARC WEBER

1989

THE BIRTH OF THE WEB

At the start of the 1980s it was hard to imagine that the Advanced Research Projects Agency's (ARPA) Internet protocols would become the "one ring to rule them all," with dominion over the earth's wires and switches from national payment systems to smart refrigerators. They were just one of several experiments in how to tie different networks together at the lower plumbing levels, a process known as *internetting*.

In fact, as that decade's bitter standards wars unfolded around which internetting standard should prevail, the Internet we use today was a scrappy but obscure David facing several Goliaths; Open Systems Interconnect (OSI), the lumbering official favorite of governments and standards bodies, and two proprietary systems from computing giants DEC and IBM.

But then David began taking steroids—in the form of US government cash. With infusions from the military, the National Science Foundation, and other agencies, and building on its loyal base of open-source hackers, the Internet started bulking up.

It didn't hurt that the Internet had working hardware and software when its most serious rival, the European OSI, was still mostly vaporware tied down in endless committee meetings . . . or that the Internet was backed by tech-obsessed senator Al Gore. Internet protocols began to spread like wildfire. Looking back, it's clear that by the decade's end the Internet had already won, even if most insiders didn't realize it at the time.

But because the Internet was a non-commercial net used by geeks, nobody had bothered to write slick, easy-to-use online systems to run over it, such as Minitel, or CompuServe, or Prestel, or AOL, or LexisNexis. Those systems were proprietary, and mostly ran over their own networks. The geeks who traditionally used research networks like the

Internet got by with an assembly of fussy tools only a power user could love. To grow beyond those core users, something had to change.

Who would put an online system on the Internet? Back in the 1960s ARPA itself had kick-started some of the world's very first such systems, from timesharing to Doug Engelbart's eponymous NLS (oNLine System). But the agency's champions of these upper "user" layers—including J.C.R. Licklider, Engelbart, and Bob Taylor—had long since moved on.

So the vacuum above the Internet began to get slowly filled by a rag-tag collection of online systems written by lone wolf volunteers and open-source collaborations, some from within the freewheeling Internet community itself. There was Gopher, a barebones document navigation system from the University of Minnesota, and WAIS, a mildly commercial navigation system similar to a search engine. Usenet, whose sprawling discussion boards had long hosted lively discussions on everything from sadomasochism to particle physics, was the only existing system to get adapted to the Internet. Another set of online systems featured hypertext, the clickable links so familiar today. These included Viola, from brilliant but bored Berkeley student Pei Wei; Hyper-G, a slickly packaged and very complete system by Austrian researcher Hermann Maurer, Lynx; and several others.

Conception

One of the more obscure of the late 1980s attempts to create an online system for the Internet came out of CERN, the huge particle physics laboratory in Geneva, Switzerland.

The tiny project had a comically ambitious name: "WorldWideWeb." Its main inventor, English physicist turned programmer Tim Berners-Lee created the web as a nearly underground project with help from colleague Robert Cailliau and their students and assistants, and without any official support from CERN.

Many of the people strongly attracted to hypertext share personality traits that could be labeled Attention Deficit Disorder: distractible, absentminded, and creative. To these folks, traditional hierarchical categories are numbingly predictable, the cyber equivalent of chloroform. But a clickable hyperlink can lead anywhere. It offers an intoxicating glimpse of what it might be like to make tangible your

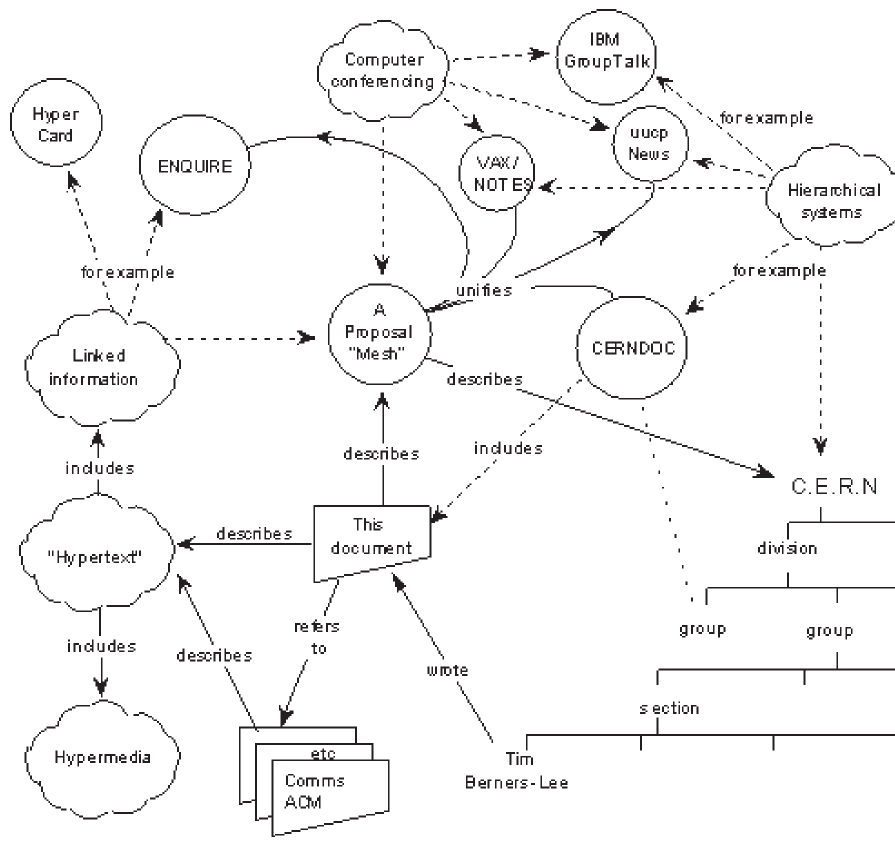


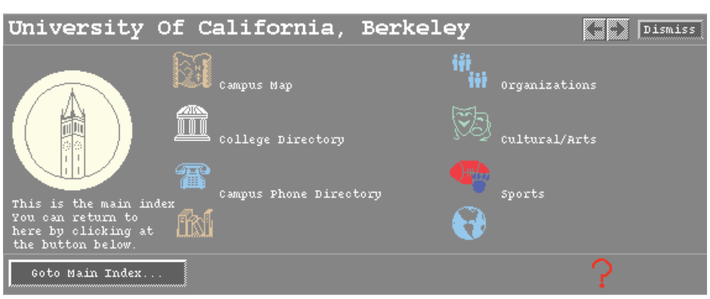
Diagram from "Information Management: A Proposal," by Tim Berners-Lee, CERN, March 1989.

own fleeting thoughts and associations; to pin the butterfly of insight. In fact, the man who originally coined the word “hypertext,” Ted Nelson, may have co-invented the medium partly to compensate for his own troubles focusing.

Passionate, fast-talking Berners-Lee has been described as a living hyperlink. The son of early computer professionals, he had come up with his own hypertext system nearly a decade before the web. The idea stayed with him through a series of contracts and a start-up venture, and by the late 1980s had turned into an obsession. He mercilessly pestered his managers to send him to an emerging series of hypertext conferences in the late 1980s.

Most creators of online systems had started with a blank slate, without worrying too much about compatibility. From Engelbart’s NLS in the ’60s to Hyper-G in the 1980s, they had assumed their adopters would put in some effort just to get the system going; converting existing information to the new format, perhaps even buying custom equipment.

Marie Claire magazine, Minitel edition, ca. 1984. France’s Minitel system was the first truly mass-market “web,” with six million users by 1984.



Viola hypertext system, 1989. Viola was a powerful hypertext system by student Pei Wei. He later turned it into an important early web browser.

Berners-Lee and his colleagues could assume no such thing. The 1980s were a babel of conflicting standards for both online systems and the networks that underpin them. But if there was one place that lived that chaos fully, it was CERN. Because it is funded by over a dozen countries, the institution not only had all the many competing standards of the era but also obscure national ones thrown into the mix, plus a bevy of home-grown contenders developed just for physics.

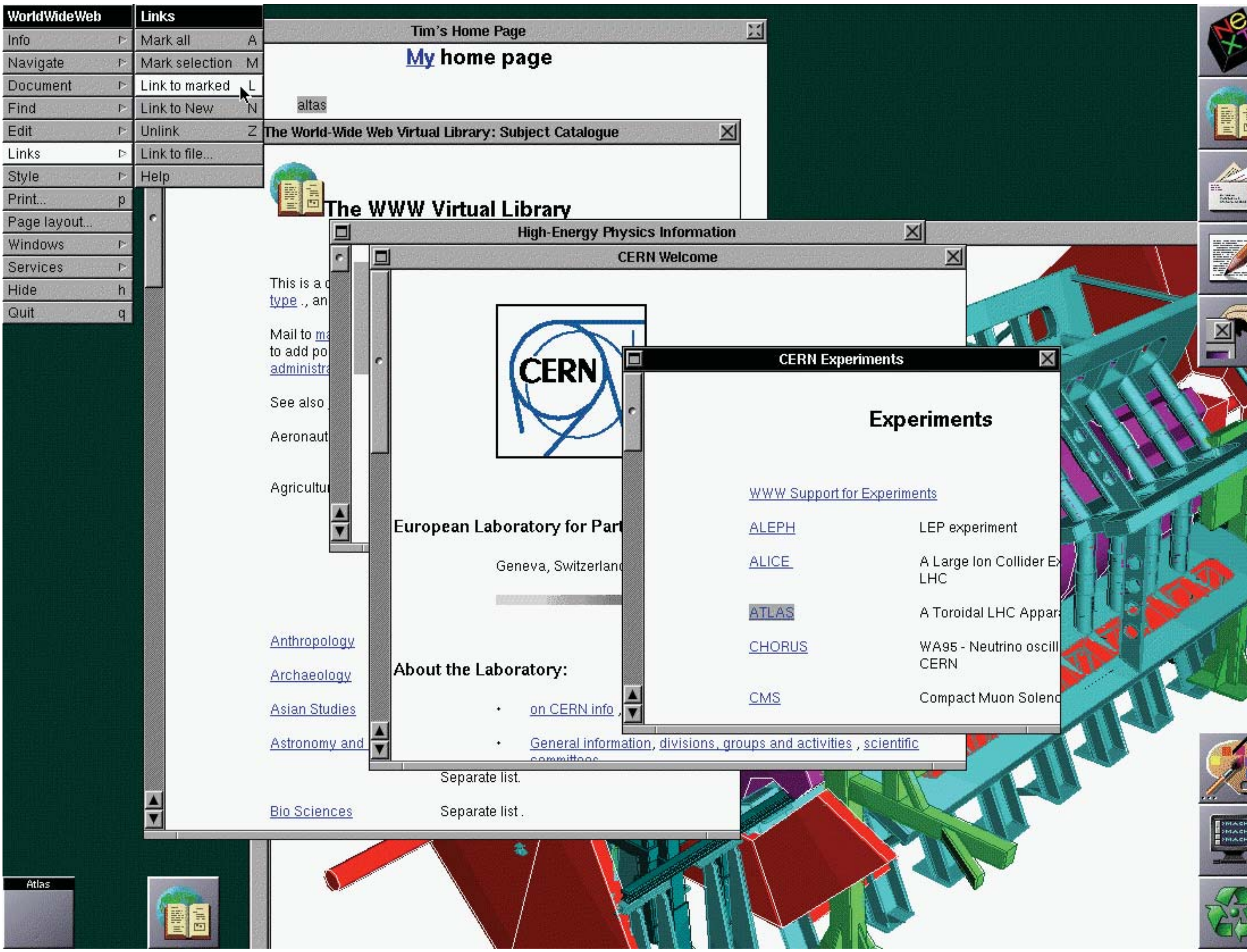
The result? The hypertext-based WorldWideWeb had to work within the mix of existing systems, document formats, and databases—instantly. It was the first time realpolitik and the daily needs of users had been coupled with the hypertext vision to “make sense of the madness” in his words, rather than try to replace it.

Berners-Lee’s idea of how information would appear to web users was a rudimentary version of the elegant visions of earlier pioneers. But his “viral” idea of how the system could spread—user by user, system by system, from the bottom up rather than from the top down—was based on Internet culture and was rare among online systems. The only competing system that developed similar viral hooks was Gopher, which could well have beat the web if not for some bad luck.

Over a couple of months in the fall of 1990, Berners-Lee’s boss Mike Sendall pushed him to finally create prototypes for the main elements of the web we know today. By Christmas, Berners-Lee had URLs for addresses, HTML for pages, HTTP for links, and a web browser. Most remarkably, his prototype browser was also an editor; you could author web pages as easily as in a word processor.

This editing feature was a pivotal part of his vision for the web; not only to be able to read information anywhere in the world, but to be able to contribute to it, and make references to anything, anywhere, in your own personal notes and to-do lists as well as shared documents. His hope was that a web of

WorldWideWeb browser-editor, ca. 1992. Developed in late 1990, the first Web browser was also an editor for creating a personal "web" of linked documents.

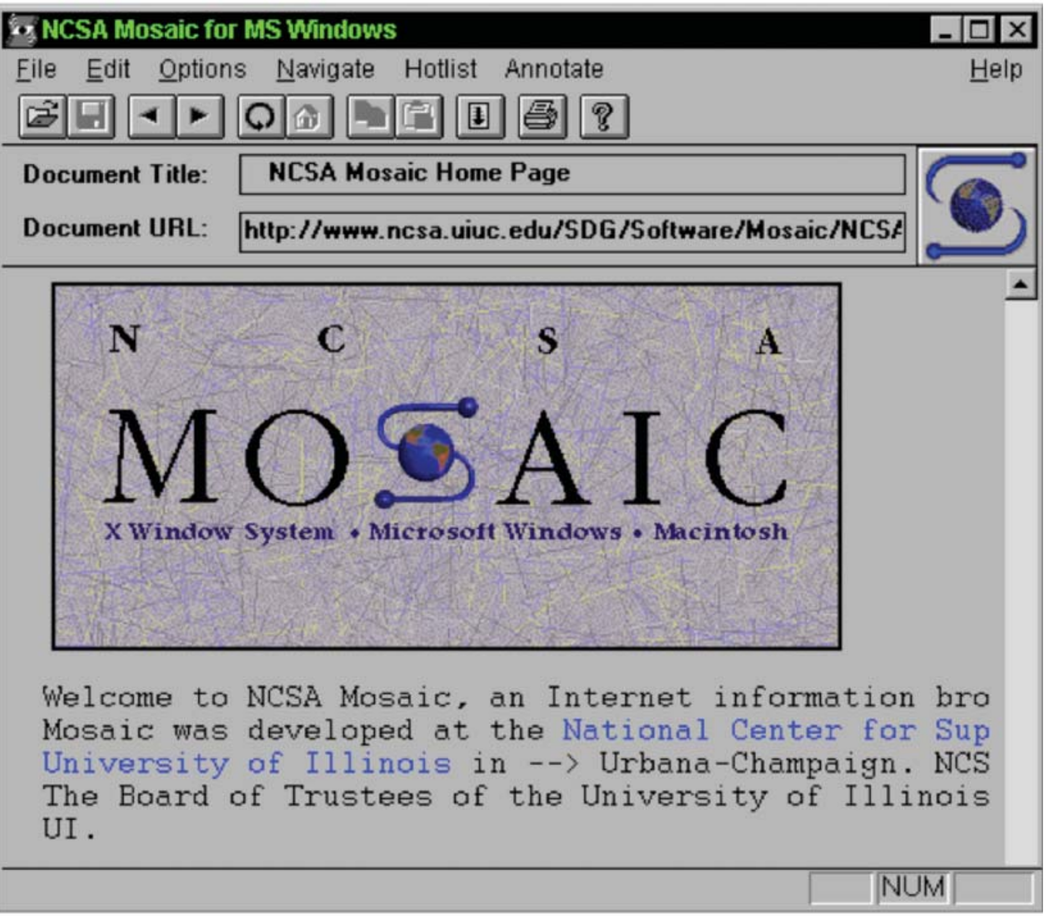


knowledge—perhaps even a "world brain"—would gradually assemble itself from the millions of links made by users in the course of their everyday lives.

The web was born.

The next year was perhaps the richest creative period in the web's early development as Berners-Lee, Cailliau, brilliant programmer Jean-François Groff, and a growing circle of students and colleagues fleshed out a vision, which included a number of features yet to be implemented in the web today.

As a hypertext system the web was stripped down, even crude—something the close-knit hypertext community was not shy about pointing out. But the web's design was also fumbling its way toward another goal. From his first Enquire system a decade before, he had been interested in using clickable links as not simply a convenient navigation



NCSA Mosaic browser, 1993. Mosaic brought the web to ordinary users. NCSA's "What's New" page effectively became a home page for the entire early web.

aid for readers, but a way to map the real-world relationships between people, and projects, and ideas, and things.

Once mapped, those relationships could be read—and refined—by computers as well as people. This opened up possibilities for the kind of machine-aided pre-digesting of raw information that could in theory make all the knowledge in the world truly accessible. A decade later, Berners-Lee would flesh out these inchoate ideas into his vision for a "Semantic Web." It was the kind of soft artificial intelligence approach outlined by Licklider 30 years before.

But there was an elephant in the room. Berners-Lee had written his elegant browser-editor on a powerful but rare computer built by Steve Jobs' NeXT Inc., known for its rapid prototyping features.[1] The same work on a more conventional machine might have taken over a year. To demo the web on other platforms he'd had Nicola Pellow create a simple text-only browser. But for the web to grow, proper graphical user interface (GUI) browsers were now needed for PCs, Macs, and the UNIX workstations common in computer science. CERN refused to fund that development, which upper management saw as a stretch for an organization whose real job is smashing the building blocks of the universe to see what makes them tick.The project was stuck.

So Berners-Lee and Cailliau took a leap of faith that was both desperate and hopeful. They had Jean-François Groff create a library of ready-to-use web code, like a roll-your-own browser kit, along with a standardized server. Then they put out an appeal, asking volunteers from the budding web development community to use that library to write the needed browsers.

Explosion

The response to the web team's cry for help was fast, and heartening. Pei Wei converted his Viola hypertext system into the first web browser beyond CERN, followed by a number of others. Viola and Tony Johnson's Midas laid out the familiar features of a browser we still use today. For the web team at CERN, it felt like a barn-raising; brilliant volunteers from all around the globe pitching in and meeting and chatting on the www-talk discussion group. But however beautifully conceived, these were one-man or student efforts; unpolished side projects that frequently crashed and could take even an experienced programmer part of a day to successfully install.

The next volunteer browser changed all that. It was called Mosaic, and it was written in early 1993 by brilliant student Marc Andreessen and UNIX expert Eric Bina at the National Center for Supercomputing Applications (NCSA). At first it sounded like little more than a me-too browser in the model of Viola and Midas. But NCSA had been a major site in the 1980s' expansion of the Internet, and had created and distributed the most popular program to run over the Internet so far, NCSA Telnet.

Recognizing the web's potential, NCSA software manager Joseph Hardin quickly assembled formal teams for UNIX, Mac, and PC browsers as well as a server, and he and NCSA Director Larry Smarr turned the ignition key on the institution's formidable support and PR machines. The result? The first web browser that was properly tested, supported, and easy for non-geeks to install. Like the Viola and Midas browsers it was modeled on, Mosaic left out editing; you could browse web pages but not change them. But Berners-Lee was confident that could soon be added back.

Soon journalists from around the world were virtually camped out at the Oil Chemistry Building where the Mosaic team worked. NCSA's ever-expanding server rooms strained to keep up with the deluge of copies of Mosaic downloaded daily. Andreessen and Bina's "What's New" page became the front page of the infant web.

Suddenly, the whole web community was riding a delicious wave of success together. To pioneers around the world, the late-night dreams of lonely years suddenly seemed not just possible but likely; whether your personal vision of cyber-utopia was an infinitely linked library, or a world brain, or a global marketplace. It was perhaps like the excitement in the early auto or radio industries, but now on a time scale compressed from years to months.

But with success came things to fight over.

There had already been tension between Andreessen and Bina and the core of the web community over the casual way they added simple in-page graphics to Mosaic, ignoring Berners-Lee and Cailliau's long-term multimedia plans. The graphics proved hugely popular.

Mosaic's success also created tensions over credit and control between NCSA and the CERN web team. In fact, much of the world came to know the web not as itself, but under an alias, as Mosaic. NCSA called its generic web server a Mosaic server, and its marketing materials never mentioned the W-word.

But the bitterest break was between the young Mosaic programmers and NCSA management. Each side felt the other was expendable, while their own efforts were the crux of Mosaic's success. The programmers noted that they were paid student wages and given little credit for the product that through their drive and vision was making NCSA world famous. Management was convinced that without institutional support, Mosaic would have remained little more than yet another interesting but obscure amateur browser.

Marc Andreessen quit NCSA at the end of 1993 and took a job at pioneering Internet company Enterprise Integration Technologies (EIT) in Silicon Valley. Jim Clark, wealthy founder of Silicon Graphics, recruited him to help start a web company. Andreessen suggested a "Mosaic Killer" browser and server. They threw down the gauntlet by poaching half the Mosaic team from NCSA, including co-author Eric Bina, and the whole group founded Mosaic Communications (later Netscape) in early '94. Despite a lawsuit from NCSA and commercialization efforts with Spyglass Mosaic, Mosaic was dead within a year—the loser of Browser War I.

Fast, slick, and offering full commercial support, Netscape Navigator was the browser that brought the web—and the online world—to the rest of us.

If it wasn't for Netscape, you'd be calling the web Microsoft Network or AOL by now.

LOU MONTULLI, NETSCAPE FOUNDING PROGRAMMER, CO-AUTHOR OF THE LYNX BROWSER

[1] See entry in the Museum's @CHM blog "MediaView: The nearly forgotten NeXT program that helped save the Open Web."

1994

MAKING THE WEB SAFE FOR BUSINESS

To a savvy business person in the mid '90s, the web looked like a waste of time. There were two big reasons. First, it was an open standard, with open access. That meant no obvious way to charge by the minute, which had been the bread-and-butter of commercial online systems—from 1960s time-sharing to Minitel to CompuServe—and of telephone companies since before living memory. How would you make money?

Second, the web ran over the Internet. Not only was that government-funded network based on another open standard, but until the mid-90s it had actually forbidden commercial use. It didn't help that many of the better known spokespeople for both the web and Internet were hippie hackers, academics, civil liberties advocates, or otherwise seen as less than enthusiastic about e-business. For these folks the Internet was a common good, a public space in which the idea of crass commercialization seemed about as appetizing as blaring TV ads in a public library.

Of course, we all know the web and Internet went commercial in the end. But it took a number of kickstarts to get them there. Their open, non-commercial roots were a big contrast with much of the history of automated information systems. The long history of electrically enhanced business ranges from ninetheenth century telegraphy and Western Union money transfers, to 1930s Telex, and then the flowering of computerized transaction systems from the 1950s onward. In fact, the first dedicated e-commerce device may have been the telegraph-era ticker tape machine for stock quotes.

Many pre-web online systems had also been very friendly to business indeed; for instance France Telecom generated billions in annual sales on Minitel.[1] When the web took off in the mid-1990s, a few pioneers tried to prove that the once-academic

Internet could indeed support trade. By 1993, publisher O'Reilly's pioneering commercial portal GNN (Global Network Navigator) was running online ads, soon joined by *Wired* Magazine's online venture HotWired. Start-ups like CyberCash and DigiCash sought to revolutionize payment much as BitCoin is attempting today. In 1994, Enterprise Integration Technologies (EIT)—the same firm which had hired Marc Andreessen after he left the National Center for Supercomputing Applications (NCSA)—founded the influential CommerceNet consortium to develop web commerce, with members from Wells Fargo Bank to Netscape.

But while mainstream business was still trying to figure out how to monetize clicks, pornography and gambling sites were quietly starting to earn serious profits and pioneering the nuts and bolts of web transactions along the way. The first online lottery started in Liechtenstein in 1995, and soon there was a wildly growing new industry loosely centered around London; a freewheeling world of online casinos, offshore shell companies, wild Caribbean parties, and careful attention to legal loopholes. At the same time, sex and pornography were evolving from earlier models on bulletin board systems (BBS), Minitel, and Usenet to a new and highly profitable kind of web industry.

But it was Netscape's spectacular 1995 IPO that kicked off the dot-com boom, and the success of online firms like Amazon, Yahoo!, and eBay that finally convinced mainstream business to follow the pioneers into web commerce. Netscape's innovative business model—free to individuals, commercial licenses to companies—began to answer the skeptic's question of how an open standard could pay.

Not everybody was happy with the web's emerging flirtation with market forces. But one of the watershed conflicts between the non-commercial, hacker old guard and the forces of Mammon happened over a surprising topic: spam.

Much of the information that had passed over electrified wires since they'd been invented in the nineteenth century had been commercial. But it had also been *controlled* by some central entity—usually the system's owner. This restrained most e-commerce to the slow-moving decorum of a monopoly; more Ma Bell than late-night infomercial. But when the vigorously decentralized web and Internet finally started to get business friendly, there was nobody in charge. The rawer elements of

Universal 3-A stock ticker, ca. 1870–80. Among the first dedicated e-commerce devices, ticker tape machines printed stock prices in real time. They were named for their ticking sound.

[1] See entry in the Museum's @CHM blog "Endangered Online Worlds."

capitalism, previously kept beyond the gates of commercial systems and government-funded nets alike, were now free to roam.

In 1994 two immigration lawyers, Laurence Canter and Martha Siegel, began marketing their dubiously necessary help with the US Green Card lottery through unsolicited emails. The resulting furor—and their provocatively titled book *How to Make a Fortune on the Information Superhighway*—galvanized forces both for and against web commerce.

While spam dates back to nineteenth century telegraph systems, the fact that Internet-based email is *free* turned a once-rare phenomenon into a major industry. The explosive popularity of web-based email with sites like Hotmail meant that even if only one in ten thousand recipients responded, you could make big profits. Spam proved the perfect wedge issue. If the old guard called too vociferously for its suppression they risked sounding like proponents of censorship, something even worse than electronic junk mail.

By the mid-1990s there were working models for some of the main pillars of web commerce: "freemium" software and services with Netscape, ad-supported information portals like GNN and Yahoo!, and direct sales of goods as with 1-800-flowers, Amazon's virtual mega-bookstore, and eBay's unique auction model.

Closing the Frontier

The web fully joined the mainstream in the late summer of '95. The giddy expansion of the last couple of years had finally produced a critical mass of users, developers, journalists, companies, and government support. Equally important, Microsoft got involved.

Netscape had been riding high, particularly when its August IPO made it the first famous "dot-com." Then the sleeping lion in Seattle finally woke up, and the result was the long, cold Browser War II. As in the real Cold War, many other, smaller conflicts slowed down, and what followed were three years of locked combat in which the World Wide Web reached the rest of us.

But the software giant's entry into web development was a reluctant one, since it meant scrapping plans for its own competing Microsoft Network (MSN), a standalone environment with its own networking protocols. The surviving "walled gardens" of the era—CompuServe, AOL, Minitel in France—were already on their way to fading out or becoming web access points. But the tens of millions of copies of Windows 95 that Microsoft expected to sell in the first year came ready to plug right in to MSN, which would have instantly become the biggest walled garden ever. You might be reading this magazine in a quite different world had Microsoft decided to challenge the entire web and Internet.

In a single document, Bill Gates' "Internet Tidal Wave" memo dictated a complete change of direction for the huge firm, akin to turning a battleship around a buoy. It was a recognition that the web—and the business models that Netscape and others had pioneered for making an open standard pay—had gotten too big to simply crush.

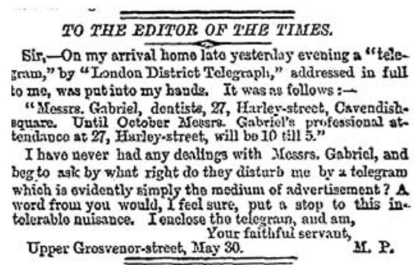
But Microsoft could still crush Netscape. Gates decided to use the firm's near-monopoly over the desktop to take on the browser market by bundling its own licensed version of Mosaic, which it named Internet Explorer, into every copy of Windows 95 and beyond. MSN became a web portal as Microsoft challenged Netscape's Navigator browser head-on.

The world at large was just in the first throes of web mania. But to those most involved in the web's development, the wild ride of the last few years seemed to be palpably slowing down. By the end of 1995, the results of the struggles covered in this and the previous article would produce the first durable balance of power for all the main players in the web's technical development.

The frontier was closing fast. The next story would be one of settlement: not how to make the web, but who would profit from it. ○

Gopher t-shirt in the style of hot-rod artist Big Daddy Roth, ca. 1994. Gopher was the web's most serious competitor. It was developed by Mark McCahill, Paul Lindner, and Farhad Anklesaria at the University of Minnesota.

Telegraph "spam", 1864. This is one of the earliest known unsolicited electronic messages. But telegrams were costly to send, which limited spam.



TO THE EDITOR OF THE TIMES.

Sir,—On my arrival home late yesterday evening a "telegram," by "London District Telegraph," addressed in full to me, was put into my hands. It was as follows :—

"Messrs. Gabriel, dentists, 27, Harley-street, Cavendish-square. Until October Messrs. Gabriel's professional attendance at 27, Harley-street, will be 10 till 5."

I have never had any dealings with Messrs. Gabriel, and beg to ask by what right do they disturb me by a telegram which is evidently simply the medium of advertisement? A word from you would, I feel sure, put a stop to this intolerable nuisance. I enclose the telegram, and am,

Your faithful servant,

Upper Grosvenor-street, May 30. M. P.

Microsoft Network (MSN) logo on Windows 95 box. Windows 95 came ready to connect to this initially proprietary network and online service. MSN later provided internet access.

DOT-COM MADNESS

(AND THE WEB IN YOUR POCKET)

Most people remember the dot-com boom and bust as being about money. In Silicon Valley, where in 1999 the cover of *San Francisco* magazine's "Greed" issue wryly asked "Made Your Million Yet?"—that was a big part of it. But even there the boom and bust also reached deeper, to a very basic cycle about unfettered exploration and the winnowing that follows.

For those caught up in its thrilling start, it was as if you'd changed the vocabulary of everyday life. Gone were all the weary adult words banked in place by a life's experience of limits: "can't," "impractical," "unprofitable," etc. Suddenly a child's lexicon of "want" and "do" was writ large over a stage the size of the world.

Anything was possible. In fact, it was expected. If you didn't think big enough you would lose by default to those who did, perhaps to the kids in the next shared office space with the more outrageous business plan, or a higher concentration of world-changing hubris in their patter.

What better ground zero than the Far West? While a kind of manic-depressive cycle may be common to tech progress in general, California is a special case. We're addicted to booms, in this state founded in the city-building, river-rerouting, land-stealing excitement of the Gold Rush. From the silver boom of the 1870s to the oil boom of the 1890s to the shipbuilding boom of the 1940s, these periodic spasms of wild activity—often but not always followed by contractions—may be as natural a part of our economy as the local cycles of drought and plenty.

In fact, by the mid '90s Silicon Valley had been jonesing for a proper boom for over a decade. The last really big one had been the personal computer revolution of the 1980s, following the earlier silicon chip explosion that changed the Valley's name. (When still filled with the nation's best orchards, it was called "the Valley of Heart's Delight.") The pen-based revolution around 1990 had been a fizzle, and the subsequent "revolution" in multimedia CD-ROMs had been more discreet clap than echoing boom.

The web didn't disappoint. By 1998, people with painted faces puzzled over where to safely stash newly minted business cards under improvised robes at the Burning Man desert art festival, grooving on the sheer disruptive newness of their Mad Max-style surroundings and how that complemented the creative energy of the businesses they would use to reshape the world. The annual event on a vast dry Nevada lakebed was becoming a kind of gonzo Bohemian Club for the dot-com set as it grew from its original 90 participants in 1990 to over 10,000. It was a complement that included the founders of Google among many once and future digerati.

By 2000, investment in publicly traded dot-coms had pushed their collective value to a staggering $1.3 trillion, or nearly 8 percent of the whole US stock market. Few were profitable, but most enjoyed share prices far above conventional valuations. Venture capitalists and angel investors were keeping thousands of equally unprofitable private firms afloat.

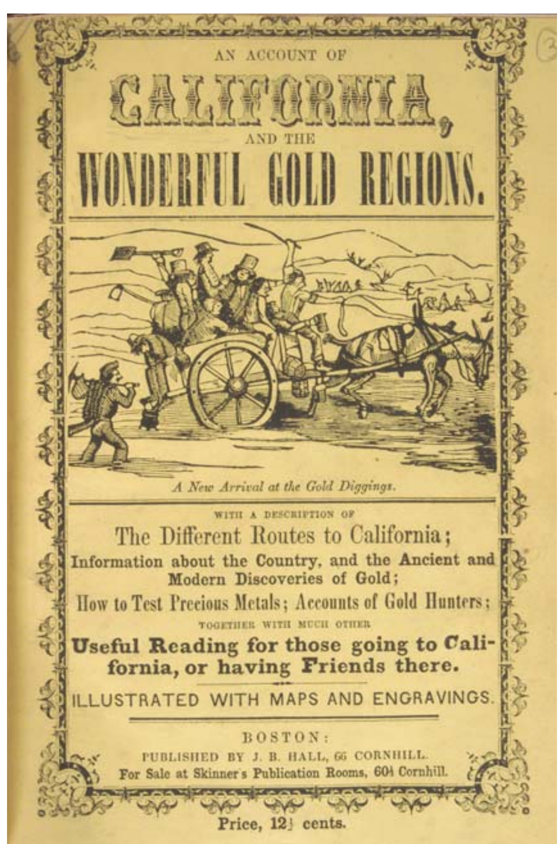
Key parts of the investment community came to believe that the laws of business had been superseded by some kind of next evolutionary phase, and that things could continue to expand forever.

In a sense, the boom and bust was the bipolar mood cycle of the wild-eyed visionary blown-up to societal scale, and with the bankers involved. For a couple of years, a meaningful chunk of society shared in the hopes of idealists like Paul Otlet and Doug Engelbart, that new technology and shared knowledge really could change all society for the better. Millions also came to taste the depressive crash that can follow.

People's dreams followed their natures. Entrepreneurs dreamed of how *webification* could transform each sector, from selling insurance to buying pet food. Finance types dreamed of Dow 40,000; non-governmental organizatons (NGO) of new ways to deliver medicine and micro-loans to remote places; educators of distance learning. Civil liberties advocates imagined new tools for transparency. The average person saw career opportunities he or she might not have envisioned, or the chance to start a home business.

Others were taken into new territory. Hippie hackers long broken to the shoestring grappled with responsibility over suddenly having control over fat budgets. Parents hoped a basement-dwelling son might turn PC gaming skills to use, perhaps as a whimsically named "webmaster."

Sun Microsystems picked up the radical dream of net-based applications making operating systems irrelevant. Java applications attached to your browser would eliminate the need for Microsoft or Apple. Geeks believed the web would erase the old, bad memories of proprietary software and create a new dawn.



Cover: ***An Account of California and the Wonderful Gold Regions.*** **Boston: J.B. Hall. ca.1849.**

This dot-com edition Monopoly set by Hasbro is a time capsule of the important online companies at the peak of the boom.

The result of all this hope and imagination was a kind of virtual land rush, as people furiously tried to convert nearly every networkable computer function to the web, from college campus information systems to medical research networks to airline reservation tools. They were slaking 20 years of pent-up demand, when any kind of networked project had been forced into one tiny silo or another by the feudal incompatibilities of the '70s and '80s standards wars.[1] Suddenly services that would have been restricted to, say, the hundreds of thousands of users of the Network File System (NFS) on UNIX machines could reach a web that was truly becoming world-wide.

The walls of many walled gardens began to tumble. Around the world every industry, every country, and nearly every subculture from religions to hobbyists to gay and lesbian communities went through its own individual history of adopting the web.

But aside from the highly focused—and profitable—gambling and adult industries, many web companies had no clear business model for this new medium beyond securing additional funding. Their marketing reflected that. Much was aimed at building brands, the better to attract "eyeballs" or "mindshare" (a.k.a. users), a currency redeemable at venture capital firms. Some of the excesses became dot-com legend, from the crazy expensive Super Bowl ads to the multi-million dollar campaigns to establish characters like the Pets.com sock puppet, or P.G. Wodehouse's hyper-competent butler Jeeves as the mascot of his own AskJeeves.com search engine.

Beyond Silicon Valley's charmed bubble, there wasn't much direct money involved unless you were a tech investor. But the money at the boom's center was an important talisman. It was the stamp of credibility that showed the online revolution was real, that gave industrial parks in Ireland the confidence to build on spec, or European telcos the justification for the bidding wars that drove radio bandwidth to unprecedented prices—and a concomitant crash.

[1] See *Revolution* online, http://computerhistory.org/revolution/the-web/20/400

San Francisco magazine, "Greed" issue, 1999. This issue poked fun at dot-com mania with its "Made Your Million Yet?" cover.

New technologies also inspire new crimes. One hundred and fifty years before, the speed of telegraphy had been quickly exploited for fraud around stock prices, money transfers, and race results. While much early computer network "crime" was amateur or exploratory, the web's unprecedented scale—and its decentralized structure—created illicit opportunities worth professional attention.

From phishing (fake official emails that encourage people to reveal bank details) to outright theft, the late '90s marked the start of an illegal industry now worth billions, and affecting as many as one in 20 consumers. The general air of disruptive newness and the suspension of normal business laws also gave cover to more conventional fraud, as Enron's managers aptly demonstrated.

Web in Your Pocket

While American dot-com CEOs were famously dancing on tables in leather pants, Tomihisu Kamada and several other Japanese pioneers were inventing the mobile web—eight long years before the iPhone brought it to the rest of us. They worked with Japanese mobile phone operator NTT DoCoMo to launch the i-mode standard for mobile data in 1999, and competitors soon followed. i-mode used a compact version of the usual HTML web language.

By 2002, over 34 million Japanese subscribers were using i-mode phones for web access, email, banking, live maps, streaming video, news, and pretty much everything else we do with smartphones today. Early devices looked like conventional "dumb" phones, but pushing the "i" (information) mode button opened the browser and a whole new set of options. They could even be used as mobile electronic wallets for buying everything from a soda to a train ticket.

Bust

Back in the West, many dot-com boom participants had a gut feeling that the laws of business had not in fact been repealed, and that the whole house of cards would come crashing down. As in other booms, there was just one practical problem. They didn't know when, though some would claim that superpower in hindsight.

So they stayed in just another day, another purchase, another round of funding—thus further fueling the boom. The big bust came in early 2001, and by 2002 had evaporated over $5 trillion of market value. Technology stocks on the NASDAQ lost 78 percent of their value. But the impact was vastly uneven. Some companies imploded spectacularly like WebVan and Pets.com. Others hung on, battered; a very few, like Amazon, even grew. For a fortuitously just-financed start-up called Google, the bust provided a once in a lifetime shopping opportunity—for engineers, bandwidth, and soon entire datacenters.

The Bay Area's chronically clogged freeways were as fast and smooth as after an angioplasty. Rents, which had reached Park Avenue levels even in slummy areas of San Francisco, dropped to merely unaffordable.

Meanwhile, the web itself kept growing. Steadily.

Do booms and busts serve a purpose? Perhaps they are useful, if painful, ways for societies to explore the limits of new opportunities. Whether you're talking about the industrial revolution or the radio, electricity, and transport booms that preceded the Stock Market Crash of 1929, the manic openness and enthusiasm of a boom can get us collectively loose enough to dare and try all the possibilities of something truly new. Perhaps booms are the cultural equivalent of a baby putting everything in its mouth. Afterwards there is a winnowing, and sometimes a reckoning. When it all happens fast, we call it a crash.

From a whimsical frame of mind, you can see the boom and bust as a kind of tech riff on the story of Icarus, whose homemade wax wings melted when he flew too high and got close to the sun. But with a happier ending. Instead of Icarus just lying there crushed and dead, like in the original anti-technology myth, dot-com Icarus staggers to his feet, shakes himself off, and moves on to found Friendster. The next article sketches out the story of this second, soberer wave of web mania, built from the ashes of the first. ○

i-mode screenshots, Japan. i-mode sites and services for mobile phones offered online banking, messaging, mobile wallets, and much more. Top: bookstore site. Bottom: a mobile map.

2004

WEB 2.0

If you were one of the many millions who went online before the web, from 1960s timesharing systems to CompuServe, a lot of what you saw was created by other users. You might have found discussion groups about Ford Mustangs or owning poodles, or macramé, tax advice, or self-help. Content was mostly organized around discussion groups on particular topics, with users posting and responding. There were manifestos, messages, announcements, user-posted images, classified ads, etc., and it wasn't difficult to add your own.

There was a range, of course; much of the content on the French national Minitel system was professional, while everything on Usenet came from participants. But the bread-and-butter of the online world before the web was what we would now call by those buzziest of early twenty-first century trend words: user-generated content and social networking.

The web's first decade of popular use was quite different. Most content went one way—from publisher to reader. There were exceptions, of course, from GeoCities to early Craigslist. But to the average user the web was effectively a broadcast medium. This was in part because common browsers didn't support direct authoring of web pages, as in Tim Berners-Lee's original web browser-editor. You had to be somewhat of a techie to create and post HTML pages from scratch—a task Berners-Lee and his colleagues never intended people to tackle at all.

Then, in the very depths of the dot-com crash in the early 2000s, things began to change. A growing number of sites began offering various workarounds to let users contribute material even with their read-only browsers. So-called "Web 2.0" brought back in crude form some of the two-way features of the original web and hypertext visions, as well as of other pre-web online systems. You could post your thoughts in a form field in a blog, or edit

CompuServe Pajama Party advertisement, 1983. CompuServe's content was mostly generated by its millions of users, like "Web 2.0" sites decades later.

a wiki, or upload pictures of yourself to a social networking site, or add to other kinds of sites that counted on users actively generating and shaping content.

The great irony, of course, is that this move back to basics was seen as something so new that it needed its own name. The reason was simple. Yes, millions of people had gone online in the three decades before the web. But now *billions* were putting their toes in the virtual surf, and nearly all web users were "newbies," i.e. online virgins. It was not unlike those fast-growing countries where the average age is under 18, and collective memory frays and tears under the weight of sheer numbers. The group that remembered the web's own browser-editor origins was smaller still, perhaps a couple of thousand pioneering geeks.

But the gap was also an opportunity, and web pioneer and impresario Tim O'Reilly was happy enough to give it a moniker with his post-crash Web 2.0 conference series. In an atmosphere that had flipped from the manically irrational exuberance of the boom straight to an equally irrational depression, 2.0 was one of the first notes of shaky cheer for the web investment community, like a mimosa in the flat gloom of a bad hangover.

Of course, once two-way features were back, and now on a shared space for over a billion people, they didn't stand still. Multimedia sharing got practical in ways that would have been impossible in the dial-up world before broadband was common; soon there were music, photo, and even video sharing sites.

Sharing

Then there was the elegantly cynical shift of focus that led to modern social networking. Older online systems like CompuServe organized people's online activities around impersonal discussion topics, like the aforementioned Ford Mustangs or poodle ownership. But why not organize those activities around the topic that interests people most, and on which everybody's an expert—themselves? It was cynical, but also liberating. Many people are shy about tooting their own horn (although not always the right people), and the new social spaces offered an environment where talking about yourself was not only safe, but required; where listing your achievements wasn't boasting but basic participation.

theGlobe.com in 1994 and SixDegrees.com in the late 1990s were early pioneers. Following the

Web 2.0 is really Web 0.0—
a return to the original vision.

JEAN-FRANÇOIS GROFF, ORIGINAL WEB PROGRAMMER, SPEAKING AT REBOOT 2006

O'Reilly Media "Web 2.0" conference program and bag, 2004. The name of this conference by publisher and web pioneer Tim O'Reilly became a rallying cry for the web's popular resurgence.

dot-com crash Friendster, LinkedIn, MySpace, and other sites took the social plunge, and spawned the industry that Facebook later conquered. It was not a pure leap of invention—after all, geeks who could write HTML had been posting personal "home pages" on the web for years, and some earlier online systems had offered simple user profiles for those who wanted to bother. But putting the emphasis on users, and ganging a bunch of them together on the same site, created a critical mass that enabled new features. Many of these were about suddenly-easy interactions between users; links, re-postings, newsfeeds, and more. Ironically, supporting this new connectivity favored closed systems; walled gardens like Friendster or Facebook within the open web.

The rise of social networks was not all about teenagers in massive numbers. Besides professional sites like LinkedIn, the first wave included communities organized by lifestyle rather than age, like San Francisco's blond-dreadlock oriented Tribe.net. There was even the rarefied "socialite network" Asmallworld.com. Conceived during a boar hunt in Germany by the son of a Swedish ambassador and dubbed "Snobster" by wags, it was frequented by Hiltons and Cartiers and featured a viciously exclusive bar for entry to keep membership down. Sometimes such specialized worlds collided. As a former VC and member of Asmallworld.com told an interviewer, "If I'm trying to find someone to look after my purebred Samoyeds while I'm in St. Tropez, I'm not going to ask some naked Burning Man hula-hooper on Tribe.net."

Blogs ("web logs") were one crucial way that people using read-only web browsers could gradually regain some ability to write content online. Blogger, launched in 1999, helped spread the trend. The particular format of the blog also dovetailed perfectly with the new emphasis on the user. Like a public diary, a blog let the user post updates on his or her daily thoughts and experiences. Twitter, with its short posts modeled on text messages (SMS), would later make the same sharing impulse even faster and easier to gratify.

Wikis were born in 1994—brainchild of the visionary hacker's hacker Ward Cunningham. But they didn't get big until the early Web 2.0 era, when *Wikipedia* exploded on the scene. Wikis were another way to write with read-only web browsers. Like blogs, they let the user enter text in a form field, and the server took care of integrating the new words into the finished HTML page seen by others. But wikis also allowed collaborative editing of the same text and easy creation of new, linked pages. The result was a working approximation of certain collaborative features envisioned by early hypertext pioneers like Doug Engelbart and Ted Nelson, and partly incorporated into Berners-Lee's original browser-editor. But the real importance of wikis was that they allowed not just a few, but hundreds or even thousands of people to refine and expand a base of knowledge together; one of the most cherished yet elusive goals of earlier pioneers.

The steady spread of high-speed connections in offices and homes supported the rise of media archiving and playback sites, first music and photo sharing and then the explosive success of YouTube for sharing videos. Such repositories are often used as convenient online archives to link from, say, blog pages or tweets, rather than being destination sites in themselves. But in one area—pornography—the simple "tube" site serving up short and often user-generated video clips proved to be a stable final medium, transforming the adult industry and threatening traditional players. Napster was the first, dramatic shot in the tidal copyright struggles that come with giving users the power to upload content, and which are still in their early stages.

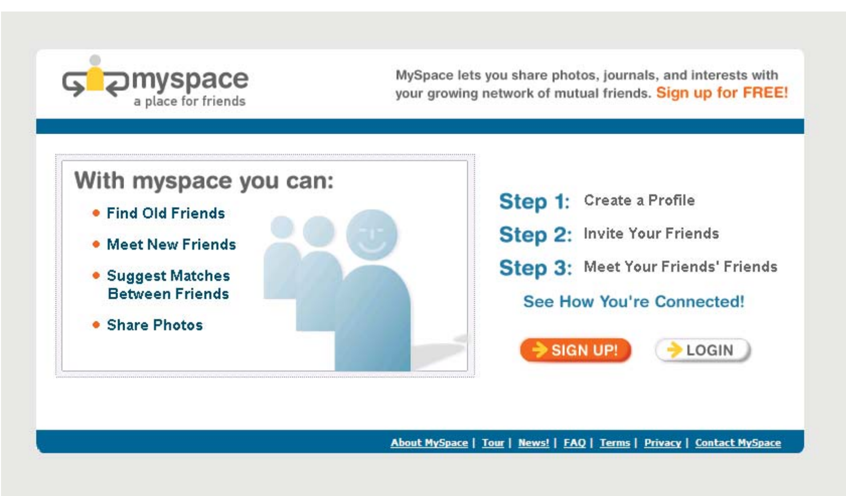
Socialized

Beyond dedicated sites, social and Web 2.0 features began changing the face of all sorts of established models. Contribution, sharing, and rating features "socialized" traditionally broadcast-only sites, from newspapers to restaurant reviews to companies. When you read something stupid or wrong, do you reflexively scroll down to the comments section? Millions do—a gesture which simply didn't exist on the web much beyond a decade ago. Perhaps you read social ratings sites like Yelp as well as traditional restaurant reviews, and even feel moved to offer your own opinions when the experience is sufficiently awful or sublime.

This ubiquitous, casual interactivity may be the most novel ingredient in a far larger process: convergence. From personal letters to newspapers to radio to music to TV, every kind of medium and form of telecommunication is now sharing a single infrastructure, the computer network. There, they can be easily and endlessly mixed and matched; a kind of artist's palette for mass media. What future forms will this amalgam take? That is as unknowable as the format of today's daytime TV shows was a century ago when the Lumière brothers first put together a working movie camera; or the business model of the nineteenth century newspaper in the days when Gutenberg pressed his first pages.

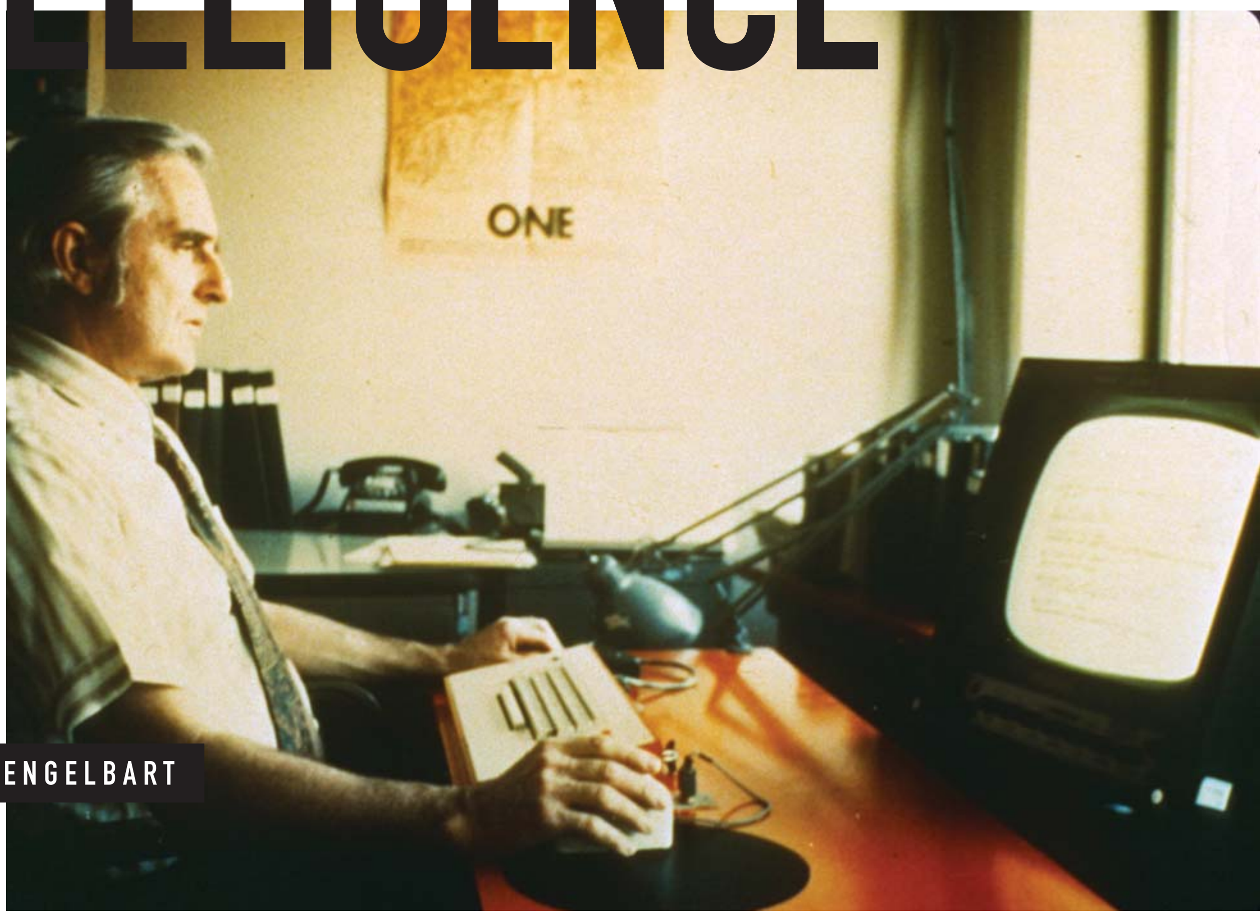
But we do know that the extent to which user contribution makes up those future media will deeply shape their look, feel, and uses. In the five decades since the online world began, we've seen the pendulum swing both ways, from the fully user-generated Web 2.0 worlds of CompuServe and Usenet to the broadcast-oriented worlds of Minitel and the early mass web. It will doubtless swing again. ○

Left: MySpace screenshot, early 2000s. Introduced in 2003, MySpace let users organize content around their own profile and interests. Right: Blogger, ca. 2000. Blogs (web logs) like Blogger let people using read-only web browsers regain some ability to write content online.



AUGMENTING INTELLIGENCE

REMARKABLE PEOPLE



DOUGLAS ENGELBART

Douglas Engelbart at an NLS (oNLine System) workstation, 1960s. NLS pioneered many aspects of modern computing including hyperlinks, browsing, online collaboration, word processing, the mouse, videoconferencing, and much more.

BY MARC WEBER

In 1945, a young naval radar operator was waiting to be shipped home in the slack days after victory in WWII. He read a magazine article in his Philippine jungle base that proposed a new kind of information system based on a fabulous desk called a Memex. Its two side-by-side microfilm readers and a host of hidden machinery would let you browse and create links between spools on any subject. The idea was to use the power of machines to make the whole of human knowledge accessible to all, and to let people add to and refine that knowledge in a virtuous circle.

Some years later that sailor, Douglas Engelbart, now a thoughtful and restless engineer at the NASA (then NACA) Ames research center in Mountain View, California, had an epiphany. Perhaps the new digital computer—not microfilm—could form the heart of a system like the one he'd read about. He imagined moving through information space the way a radar screen let you navigate through physical space.

The article he'd read was "As We May Think," by leading US scientist Vannevar Bush, a polymath who had built analog computers as well as played a major role in the development of the atomic bomb. Bush's article mirrored some of the ideas of early twentieth century pioneers including Paul Otlet and writer H.G. Wells about using the power of machines to assemble all knowledge in a kind of "world brain." To Engelbart, the flexibility of the computer opened up a whole new set of possibilities. He decided that building such a system would be his life's work.

Navigating Knowledge

But as I wrote in my blog piece on 2013 Museum Fellow Bob Taylor, the man who funded Douglas Engelbart through many of his most productive years, the idea of using digital computers to share information wasn't exactly an easy sell in the 1950s and early '60s. Why would you waste these fabulously expensive data crunchers on something as quotidian as communication, in a world that already had telephones, printing, telegraphs, photography, TV, and radio? Just as wild was Engelbart's idea that each person would sit in front of their own keyboard and fabulously expensive radar-style video screen, interacting in real time with the computer and through it, with each other.

Engelbart was not completely alone; a few others had begun to see the computer as the ultimate information machine. A brilliantly precocious college student named Ted Nelson came up with an independent concept of using associative links to navigate and organize all the world's knowledge into a new kind of multimedia literature, and he coined the term *hypertext*.

Two other fellow travelers were in a position to offer Engelbart extraordinarily concrete help. At the military's Advanced Research Projects Administration (ARPA), J.C.R. Licklider and his protégé Bob Taylor would later co-author a paper called "The Computer as a Communications Device." With funding from Taylor, first at NASA and then at ARPA, as well as from several others, Engelbart began to turn his vision into reality.

His goal was nothing less than to augment human intellect—to harness people's ability to collaboratively solve the world's important problems. He believed that properly trained and with the right computer tools, we could raise our "collective IQ." By putting knowledge at the fingertips of those who needed it, and letting them share their refinements and insights with others, he hoped to start a feed-forward process he called "bootstrapping." Each improvement would help accelerate further advances in method, and so on. The concept of bootstrapping also went far beyond computers. Much of his work, and that of his group, was aimed at improving the organizational processes that can help lead to innovation.

This vision was in stark contrast to his artificial intelligence contemporaries, who wanted to create an alternate intelligence on computers rather than help turbo-charge human intelligence. This early fork in the road still leaves its mark on computing today.

Engelbart started a laboratory at SRI (International Stanford Research Institute at the time). He grandly named it the Augmented Human Intellect Research Center (AHIRC), later shortened to Augmentation Research Center (ARC). At the peak he would have 50 people working for him.

Doug Engelbart had a thoughtful, gentle manner, and a wonderfully open smile. When he met people he was charming and often funny. At the same time he gave the sense that he was considering things

Replica of first mouse invented by Doug Engelbart and Bill English in 1964, the first mouse was carved from a block of California redwood.

The better we get at getting better, the faster we will get better.

DOUGLAS ENGELBART

really, really deeply; that there was some serious purpose to everything he did. With prematurely gray hair and deep-set eyes framed by his large nose and prominent brows, he had the perfect presence for a visionary, or a guru.

As a manager he was often hands-off when it came to operational details, but concerned with communicating his vision so that others could help build it. He wasn't terribly interested in technical details either. But he was brilliant at inspiring some of the best programmers and engineers of the time to come and work with him.

In a sense, Engelbart and his teams only built one big thing in his long career, the oNLine System (NLS), later repurposed as Augment. The mouse was merely Engelbart's idea for a convenient input device, which hardware wizard Bill English developed as one of several ergonomic accessories to that system; the chord keyset was another.

Yet if you tried to map the features of NLS to the computing world we know today, you would have to include pretty much all the core features of the web as well as word processing, spell checkers, online collaboration in forms like wikis and Google Docs, videoconferencing tools, personal information software for things like grocery lists, a full featured email system, archiving software for saving documents with permanent identifiers, and some features of databases. Other features wouldn't map at all, since they still haven't reached wide use. These include documents that are editable by multiple applications rather than belonging to a single one, and a whole host of specialized hypertext features.

How could one system do so much? When Engelbart and his few peers imagined the future of computer communication in the early 1960s, the power of the machine was already clear to them, as was the fact that this power would get exponentially cheaper and faster (later immortalized as Moore's Law).

The rest was gloriously wide open; a blank frontier in which to build not just castles, but whole cities made of sand and imagination. There were no standards to support, no established players to consider in business strategies, no relevant conventional wisdom from advisors and investors. The result? By the mid-1960s Engelbart and his team had actually prototyped many of the core features of the computing world that would unfold over the next 40 years, plus others that may come.

Similarly, Ted Nelson independently conceived a number of these features plus his own vision of new kinds of electronic literature and multimedia, and built out some of them with help from his former schoolmate Andy van Dam. J.C.R. Licklider and Bob Taylor laid out quite different, but also sweeping visions of the future of computing.

By contrast, an example of an ambitious and lavishly funded computing project today might be launching a new social network within the ecosystem of established precedents.

Partly as a result of their lofty aspirations, Engelbart and his researchers forged close connections with many key figures of the 1960s counterculture. There was Stewart Brand of the *Whole Earth Catalog*, Ken Kesey and his Merry Pranksters, and many others. Like the ARPANET community that would follow, the ARC lab represented an uneasy intersection of two very different flavors of open-ended exploration; that of military-funded research, and the sometimes idealistic, sometimes just for kicks questing of an emerging caste of hippie hackers. This intersection is beautifully explored in John Markoff's book *What the Dormouse Said*.

In 1968, Engelbart and his staff put on the so-called "Mother of all Demos" at a major conference in San Francisco, showing off all the features they had developed over the years. For ninety minutes, the stunned audience of over 1,000 computer professionals witnessed many of the features of modern computing for the first time: live videoconferencing, document sharing, word processing, windows, and a strange pointing device jokingly referred to as "the mouse." Elements on the screen linked to other elements using associative links—or hypertext.

Only Connect

In the late 1960s, NLS was a timesharing program, meaning that it ran on a single computer shared by a community of perhaps a couple of hundred users who logged in from their own terminals. True computer-to-computer networking promised to create far larger communities, but it was still in the process of being invented. Engelbart and his lab played a significant role in that process.

Bob Taylor of ARPA had asked Engelbart to have his ARC lab host one of three centers on the experimental ARPANET; the Network Information Center, or NIC. This would act as a central library and card catalog for all of the information on the growing network, with the archives of the ARC group itself as a foundation. It would also maintain the central directory for all of the computers on the ARPANET, a function that later evolved into the familiar Domain Name System (.com, .org, etc.).

Engelbart enthusiastically agreed; he saw the chance to expand the reach of NLS from hundreds of users on timesharing systems to thousands all over the country and beyond; the start of a true online world. His team even made plans to add multimedia, foreshadowing features on the web a quarter century hence.

At the end of 1969, ARC programmer Bill Duvall became one of the first two users on the ARPANET, the world's first major general-purpose computer network. Over the next two decades the SRI NIC would play a pivotal role in the expansion of the ARPANET and later the Internet.

Fragmentation

But the fortunes of the ARC lab itself began to falter. In 1969 Bob Taylor left ARPA, and ARPA itself also changed its funding policies as part of a general government belt-tightening. Grants began to dry up, and SRI management, always wary of Engelbart's freewheeling group of renegades in colorfully patched jeans, started to make more demands. Engelbart, who was more of a visionary leader than a hands-on manager, felt things slipping away.

The NIC and the ARPANET did indeed bring NLS to a broader spectrum of users, but for those who only used it occasionally it was a lot to learn. It also required every user to login to the NIC server, which soon got overloaded and slow. So the NIC turned to simpler but faster tools for accessing its information.

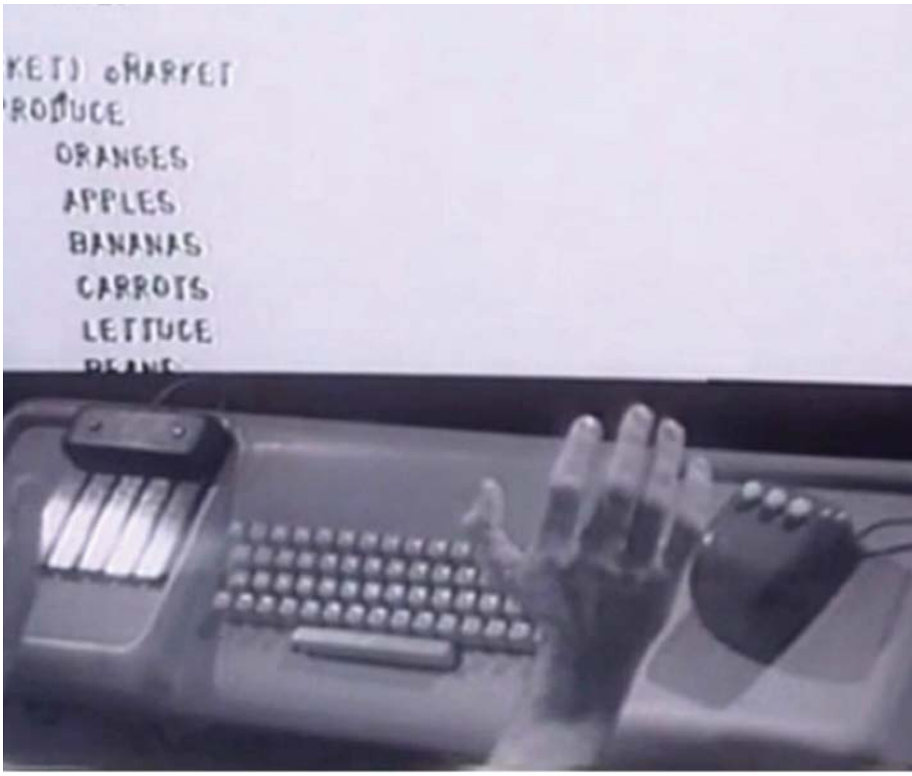
Another blow came when Bob Taylor became the leader of the Computer Systems Laboratory at Xerox's newly created and lavishly funded Palo Alto Research Center, or PARC. The ARC lab's former benefactor began to hire more and more ARC team members to build his own "Office of the Future," eventually including some of Engelbart's closest lieutenants like Bill English, Jeff Rulifson, and Bill Duvall. The bitter joke ran that ARC was a training program for PARC.

The ARC alums brought many of the baseline concepts pioneered in NLS to PARC, and thus into the stream of development that eventually led to much of modern computing. Yet after the internal failure of the PARC On-Line Office System (POLOS) project, which was meant to be a PARC version of NLS, a lot got left out as well—from hypertext links to the overall emphasis on collaboration and augmenting human intellect.

In 1977, SRI sold the ARC project to Tymshare, later a subsidiary of McDonnell-Douglas. There, Engelbart and his remaining team turned NLS into Augment, and adapted it to run under Internet protocols (TCP/IP). However, the momentum was gone, and Tymshare had little interest in pursuing Engelbart's main goals. He retired from Tymshare in 1986, and continued to pursue his vision in offices provided by a grateful mouse-maker, Logitech.

Engelbart continued to speak widely, and in 1988 he founded the Bootstrap Institute with his daughter Christina, one of four children, to perpetuate his work. He won the National Medal of Technology, the Lemelson-MIT Prize, the Turing Award, and was a Fellow of the Computer History Museum. Widowed in 1997, he and his second wife Karen attended public events into the spring of 2013.

Douglas Engelbart died on July 2, 2013 at his home in Atherton, California. He was 88. ○



oNLine System (NLS), with keyset and mouse. NLS was meant to be used for navigating knowledge of all kinds, including everyday needs like grocery lists.

Some of the main records of Engelbart's laboratory at SRI are in the Museum's collection. Contributions in his memory may be made to the Douglas Engelbart Memorial Fund, which helps support preservation for and access to these materials.

ORAL HISTORIES

HOW APPLE CONJURED UP THE iPOD

INTERVIEW BY
ALEX BOCHANNEK
EXCERPTS BY
JENNIFER DE LA CRUZ

The Computer History Museum's Oral Histories Collection comprises more than just oral histories—a biographical format designed to gain complete and detailed information about an interviewee's life, education, and career. It also contains an abundance of subject-specific interviews with inventors and entrepreneurs, as well as everyday users of a unique product.

Such interviews are conducted for the Museum's exhibitions in an effort to bring our visitors a wide range of information about a specific topic or technology from a diverse group of interrelated subjects. You can catch glimpses of these types of interviews in *Revolution: The First 2000 Years of Computing* and the same will be true in our new exhibition *Make Software: Change the World!*, slated to open in 2015.

In preparation for *Make Software*'s gallery dedicated to MP3 and digital music, former Curator and Senior Manager Alex Bochannek sat down with Jonathan "Jon" Rubinstein, a senior vice president at Apple from 1997–2006 and an integral player in the development of the first iPod.

In the excerpt that follows, Rubinstein discusses how and why Apple developed the iPod—the portable music device that would go on to transform the music industry and revolutionize the way the world listens to music.

Alex Bochannek: So, how then did the iPod come to be. There were already MP3 players out there that could be used as a peripheral device to load music onto? Why the iPod for Apple?

Jon Rubinstein: So why do an iPod is the question. It's actually a complicated—it seems like it should be a simple answer but, it's actually a complicated answer. We did the original iMac and it had a tray-load drive and Steve [Jobs] hated that. He had a complete meltdown about it before the launch and insisted I do a slot-load. So we did the slot-load for the iMac—he asked me to do a favor for him and so I did that. And then HP came out with CD-burning and they kind of got the jump on us, which was unusual at the time because we were pretty in tune with what was coming technology wise. This sent a big shock into the system and we said we got to have CD-burning; we need rip/mix/burn which was the ad campaign that came out [for iTunes on Apple's iMac in 2001]. So we bought a company that brought Jeff Robbins, who's the guy who did iTunes, into the company. The first product we could get out was the tower because that used the half-height CD drive which is what CD-burning was coming in. It would take us another . . . probably on the order of six months to deliver the slot-load drive for CD-burning. It put a lot of company focus around CD-burning and delivering the whole rip/mix/burn capability. Obviously at that point in time, not only did we start looking at CD-burning but we started looking at DVD-burning and doing movies and things, as well.

The iTunes team got off and running to develop iTunes. It was a crash program. And as part of that program, we were playing around with all those music devices that were out there. I forget all the companies but Creative Labs, obviously, and Philips had their own, and Philips was licensed to Nike. There were actually quite a few products and they were terrible. They were worse than terrible. They were all based on USB 1 and so either if you had a reasonable amount of storage they took forever to load the data, or if they didn't have a reasonable amount of storage they had no music on them. I think the Nike one had—the Philips one, same thing—I think had 10 songs. I'm a runner, that doesn't last you long enough. So it was either the choice of a big crappy product or a little crappy product. So we were all sitting around and we all love music and decided we ought to do one of these.

We started the investigation process of what it would take to do what became the iPod. And initially I looked at the technology and went, "You know, it's not there." The hard drives were too big, the batteries weren't good enough, the displays weren't good enough. But over about say a six-month time period, the technologies really kind of jelled. And I was over in Japan for—I go over fairly regularly, visit all suppliers, review all the road maps for our current products and at the end of one of those meetings, the Toshiba team brought out a small hard drive and said, "We're not sure what to do with this, but could you guys use this?" As soon as I saw it, I knew how we were going to build the player. It was more than just the hard drive. You needed a fast way to get data on to the device and that was FireWire, we owned that. As a matter of fact, all of our—most if not all of our computers shipped with FireWire so it was compatible with our products out there. You needed a good display and because of the explosion of cell phones at the time, the displays were then available for a reasonable price and the same thing with battery technology. Battery technology had evolved rapidly at that point in time because of the cell phone industry. So we kind of had all the key pieces.

I went back to Steve and went, "Okay, I know how to do this now." I had been holding him off for months saying that the technology wasn't ready, the technology wasn't ready, but now it was and I said, "Oh, I need a $10-million dollar check," and he said, "Okay, you have it," and then I called Fred [Anderson] to make sure I actually had a $10-million dollar check. And we assembled a skunk works team to define the product, but now we kind of really got going. I made one phone call to IBM, to Doug Gross who was running the mass storage group at IBM at the time. They had the microdrive. And I said, "Okay, look, we've got this product we want to do" I didn't tell him what it was but I said, "I need a hard drive—a microdrive with this capacity at this price." And he started laughing. He says, "No, no, no we can't do that, not interested." I said, "Okay." So I gave him a shot. And so we charged forward.

We gave the industrial design [ID] team basically what form factor it needed to be because when you took all the parts and just kind of laid them onto each other, it was about the size of a deck of cards. So we said, "Okay, it's got to be about a deck of cards." And we were brainstorming about how to do user interface and how you do the physical interface to it, and Phil Schiller had been using a product with a scroll wheel and suggested a scroll wheel for it—there's lots of different input from different groups. The ID team came up with, I think, it was three designs and we all sat in a meeting with Steve and we all had one we wanted to do, and so we positioned it well so he would choose the one we all wanted to do, and he picked it and started charging forward on it.

Computer scientist and electrical engineer Jonathan Rubinstein, who played an instrumental role in the development of the iMac and iPod.

COLLECTION

RECENT ARTIFACT DONATIONS

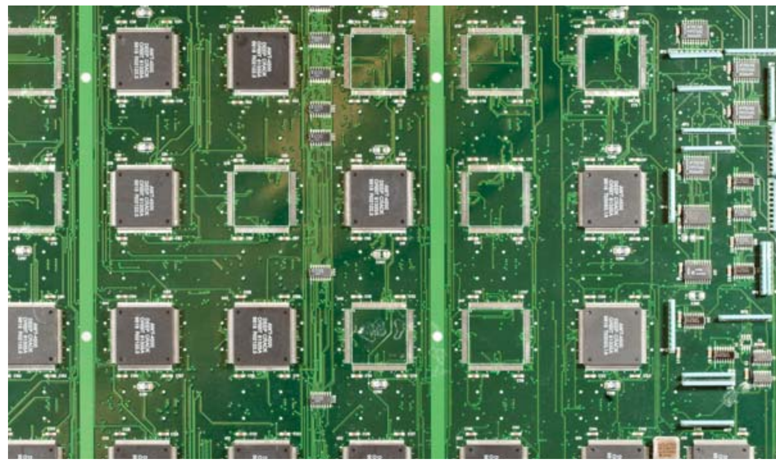
BY ALEX BOCHANNEK

TOSHIBA–APPLE MULTIMEDIA PLAYER PROTOTYPE

CHM#: 102718244
DATE: 1993
DONOR: Allen Baum

The CD-ROM format, an extension of the audio compact disc standard, was the basis for a range of multimedia applications that combined text, images, and sound. By the early 1990s, CD-ROM drives for personal computers became more affordable and multimedia encyclopedias were popular.

This portable multimedia player was part of a larger strategy by Apple that foresaw a convergence of computers and consumer electronics. It was developed in concert with Toshiba with software by Kaleida, an Apple-IBM joint venture; Time Warner was considering producing content on CD-ROMs for the player. This is an internal evaluation unit, the player never shipped as a product. ○



IBM PERSONAL COMPUTER ANNOUNCEMENT

CHM#: X6747.2013
DATE: 1981
DONOR: Robert Locke

George Conrades, head of IBM's Data Processing Division, introduced the IBM PC in this internal presentation to the division's staff. The 10-minute video put the new product in the context of IBM's existing product lines, but also contrasted the technical features with similar computers already available. Several potential markets for the IBM PC are highlighted with special attention given to academic users.

The new sales channels for the IBM PC through ComputerLand and Sears represented a shift in IBM's strategy and explaining those changes to the IBM staff is a key element of this video. Finally, IBMers were encouraged to write new software for the PC, which IBM would then consider distributing. ○

EFF DES CRACKER "DEEP CRACK" BOARD

CHM#: 102718529
DATE: 1998
DONOR: Allen Baum

Developed in the mid-1970s, the Data Encryption Standard (DES) became widely used to protect electronic data. The involvement of the United States National Security Agency (NSA) during the standardization of the algorithm led to suspicions that DES may have been designed in such a way that the NSA could easily break it.

The company RSA Security issued a challenge in 1997 to show that DES was insufficiently secure. The processing speed of computers had advanced to the point where it seemed feasible to decrypt a message by simply trying out all possible decryption keys. The non-profit Electronic Frontier Foundation (EFF) decided to build a relatively inexpensive machine that consisted of over 1,800 custom "Deep Crack" microchips. The machine was able to decrypt a message in 56 hours. DES has since been replaced with stronger algorithms in most applications. ○

DONOR PROFILE

THE MUSEUM'S PLANNED GIVING SOCIETY

BY MEGHAN O'HARE

Gene Amdahl's influence on computer history is indelible. He was the chief architect of the IBM System/360, one of the most successful mainframe computers of all time. In 1970, he left IBM to establish Amdahl Corporation, which, by 1979, had more than 6,000 employees worldwide. Amdahl even has an eponymous law, which is used to find the maximum expected improvement to an overall system when only part of the system is improved.

Amdahl and his wife Marian realize, however, that impacting technology is only part of the equation: as active philanthropists, they want to have an impact on their community as well. The Amdahls recently became the Inaugural Partners of the Legacy Society of the Computer History Museum, our new planned giving initiative.

"There was so much history involved in Gene's career, and we want to preserve his story for those who will follow Gene's entrepreneurial spirit," Marian Amdahl explains. "We want to make sure the legacy of Gene and other pioneers lives on, as well as the Computer History Museum. Gene has given much of himself to the industry, and the industry has in turn been very good to us. It's great to be able to give some of that back by supporting the Computer History Museum."

We hope you will consider joining the Amdahls as Partners in the Legacy Society and investing in the Museum's long-term financial health by considering a planned gift. By including the Museum in your will, you will be preserving both the legacy of computer history and your own legacy as well. Planned gifts provide much-needed support for the Computer History Museum while potentially offering tax advantages to the donor. (Please seek counsel from an estate lawyer or CPA, as the Museum cannot provide tax advice.)

Partners in the Legacy Society of the Computer History Museum will receive a lifetime membership, invitations to exclusive events, and a print copy of our award-winning *Core* magazine. They will also be recognized in our print publications, on our website, and on our donor wall. To become a Partner of the Legacy Society at the Computer History Museum, please contact the Development office at 650.810.2722.

Legacy Society Inaugural Partners Marian and Gene Amdahl.

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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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. The Museum is dedicated to the preservation and celebration of computer history and is home to the largest international collection of computing artifacts in the world, encompassing computer hardware, software, documentation, ephemera, photographs, oral histories, and moving images.

The Museum brings computer history to life through large-scale exhibits, an acclaimed speaker series, a dynamic website, docent-led tours, and an award-winning education program.

INTERNET HISTORY PROGRAM

The Internet History Program, computerhistory.org/nethistory, records the history of computer networking including the web, the Internet, and mobile data. It is the first comprehensive effort in this area by a major historical institution. It covers networking as both a technical invention and a new kind of mass medium. Founder and Curator Marc Weber has researched the history of the web since 1995, and co-founded two of the first organizations in the field. The program works with Museum staff, Trustees, and advisors with special expertise in networking, including a number of key pioneers.

HOURS

Wednesday–Sunday
10 a.m.–5 p.m.

CONTACT

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