UTAH COMPUTER HISTORY PROJECT

Promontory Summit, Utah, was the location of the famous chips using VLSI. He developed the Cosmic Cube (1981), an "golden spike" representing the completion of the early message-passing system with a hypercube interconnect transcontinental railroad in 1869. A century later, University topology commercialized as the Intel iPSC. Seitz then of Utah's role as the fourth node on the original ARPANET founded Myricom, capitalizing on custom VLSI designs to was referred to as the second golden spike, connecting Utah to provide high-speed local area networks to clusters of three other sites in California in December 1969, followed by workstations (1994). By 2004, Myrinet was used in about 40 east coast sites a year later. ARPANET research at Utah led to percent of the Top500 HPC systems. interconnect and network emulation design, which continues today. Storage innovations at Utah focused on representing **DIGITAL RECORDING** 1g1tal sound.

ARPANET

were spurred by David Evans' role in establishing a new sound recording and editing, which led to the large-scale computer science department in 1965 (see High-Performance production of compact discs and CD players. For these Computing display). Bolstered by a large contract from technical achievements, Stockham won an Emmy, Grammy ARPA, each of the four original nodes interfaced with and Oscar award (informally called EGO). In 1974, Stockham different computers to explore interoperability issues: a was one of six experts to analyze the infamous "gap" in PDP-10 (Utah), an SDS Sigma 7 (University of California, Richard Nixon's tape recordings, providing evidence of the Los Angeles), an SDS 940 (Stanford Research Institute) and Watergate cover-up that led to Nixon's resignation. an IBM 360 (University of California, Santa Barbara).

Evans and graduate student Steve Carr came from Berkeley to between computers and digital music. Alan Ashton's lead early efforts in ARPANET research at University of Utah. dissertation work described an architecture that connected an Carr participated in the first Network Working Group meeting organ to a computer to control the music it played (1970). in 1968, chaired by Elmer Shapiro from SRI, and also Ashton founded WordPerfect (1978), a widely used attended by Steve Crocker, Jeff Rulifson, and Ron Stoughton. word-processing system that introduced innovations such as With UCLA researchers, Carr designed the initial continuous documents, function key shortcuts, modeless Host-to-Host Communication Protocol for the Arpanet(1970). editing and primitive WYSIWYG formatting.

Bob Taylor was credited with initiating the ARPANET project WORLD WIDE WEB AND NETSCAPE as director of ARPA's Information Processing Techniques Although ARPANET made significant advances in Office (1966-1969). The architecture of the ARPANET and government research, it had yet to impact home computer the use of a separate Internet message processor (IMP) was users in the early 1990s. In 1991, CERN introduced the World hatched in 1967 by Wes Clark of Washington University while Wide Web, developed by Tim Berners-Lee and Robert in a rental car with Taylor and Evans. Taylor worked with Caillau. This technology combined hypertext with personal Evans at University of Utah in 1970, before heading to computers and networking technology to provide the critical California to launch legendary computer science laboratory link between home computing and applications. National Xerox Palo Alto Research Center, which later employed Center for Supercomputing Applications staff member and several Utah graduates, including Alan Kay, John Warnock University of Illinois undergraduate Marc Andreesen created (Adobe), Martin Newell, Patrick Baudelaire, and Frank Crow. Mosaic in 1993, the first successful web browser. In 1994, In 1983, Bob Taylor left PARC to co-found DEC's Western Utah alumnus Jim Clark and Andreessen created Netscape, Research Laboratory, and convinced DEC to establish the which first commercialized web technology and was the DEC Paris Research Laboratory with Utah graduates Patrick leading web browser in the 1990s. Baudelaire and Henri Gouraud.

Taylor and Roberts prepared and signed the "networking" Networking research at Utah continues today. Created in April program plan for ARPA funding in 1968. An RFP for 2000 by Utah research faculty member Jay Lepreau, public procurement of 4 IMPs was released after the program plan testbed Emulab made it possible to configure sizable networks was approved by the Director of ARPA. Roberts and Barry of real machines in just a handful of minutes, thereby Wessler (and other contractors) reviewed the proposals and changing experimental standards in the systems research selected BBN's as the winner. In 1969 Taylor left ARPA to join community. As of June 2012, the Utah Emulab site had more Evans in Utah for one year. Wessler remained at ARPA than 4,070 users from more than 560 institutions worldwide, UCLA, SRI, UCSB and Utah. In 1970 Wessler left ARPA and nodes in 2011. In addition, the open-source Emulab software became a Utah graduate student under David Evans until he operates more than three dozen other testbed sites at public received his Ph.D. in 1973.

SWITCHING, MESSAGE PASSING AND LOCAL AREA NETWORKS

While initiating the first wide area networking technology, distributed federation of testbed sites for networking research. Utah researchers were also developing interconnects inside these newly-designed computing systems. Utah faculty David Evans and Ivan Sutherland founded the company Evans and **INNOVATION FOR THE FUTURE** Sutherland (1968) and began designing interactive computing Utah's role in the second "golden spike" connecting the West systems. Chuck Seitz joined the faculty from MIT (1970) to to East, has ensured current and future high-speed networks work on switching circuits that would be integrated into these must pass through Salt Lake City, including today's Internet2 systems. Seitz's MIT thesis work was on the design of optical network. asynchronous circuits called mutual exclusion elements, which he continued to develop while on the Utah faculty. During this time, Seitz co-designed Evans and Sutherland's first computer, the Line Drawing System (LDS-1). Seitz and former faculty member Robert Barton continued to develop asynchronous switches called self-timed systems at Burroughs (1973). Later at Caltech, Seitz designed message-passing multicomputers and self-timed routing and communication

Concurrent with the ARPANET advances, University of Utal researchers made significant advances in digital sound. Recruited to Utah by Evans, Tom Stockham (faculty member Efforts in networking and storage at the University of Utah 1969-1981) founded Soundstream Inc. and pioneered digital

Other research at Utah at this time explored the connection

NETWORK EMULATION

aging the IMP implementation and first installations at with more than 15,750 experiments run on 110,000 physica and private institutions worldwide. Today, the Flux Research Group at the University of Utah is using Emulab as a basis for virtualization research related to clouds, hypervisors, mobile networking and as a basis for ProtoGENI, a geographically

This is the second in a series of three displays on the role of Utah students and faculty in computing history. The others describe high-performance computing and high-performance analysis.



A special thanks to the J. Willard Marriott Library Special Collections, Artist Anna Campbell Bliss and the Computer History Museum for contributing materials for this display and associated video.



ARPANET project.

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program. He was one of four university investigators for the original

"What we're beginning to see with new computing systems is greatly improved means of communication between men and machines. Certainly, computer-aided instruction is one of e areas in which we are sorely limited, not only by our understanding of the educational processes, but by our capability of building machines and systems which can communicate well with people. We're beginning to see some fruits of our experimental systems which we call interactive systems, with which people can communicate well."

– David Evans, Presented to the 1967 Conference of Associated University Bureaus of Business and Economic Research, October 11, 1967.



December 1969, which includes the designation of the host machines.



ne of the four original BBN Internet Message History Museum. Specifications for the call for proposals for the IMP were written by ARPA The front panel of the IMP is shown here, and clarifies [from CHM, copyright Mark Richards]



Wessler: where it gets its name. [from CHM, copyright Mark Interce, and chards] IMP, and worked with Crock the first host-to-host protocol.



d Evans, and was the first Ph.D. student that Evans graduated at Utah. Carr was the Utah student responsible for bringing up the ARPANET IMP, and worked with Crocker and Cerf to define





Processing Technology Office (IPTO) Director who initiated the ARPANET he spent a year at Utah collaborating computer science research program. Taylor hired Utah students to join Xerox, including Alan Kay and John Warnock.

"In 1967 ... I had an annual ARPA contractors meeting, this time at the University of Michigan, Ann Arbor. .. at that meeting, I announced that [the ARPANET] was what ARPA was going to do. After the meeting, I was driving back in a rented car to the airport, and in the car was Dave Evans, who was our principal investigator at the University of Utah, Wes Clark, who was principal investigator at Washington University, St. Louis, Al Blue, who was my contracting expert and worked for me in ARPA, and Larry [Roberts] and me. I was driving the car, and Wes Clark, at the meeting, had passed me a note ... saying, "I have an idea about the ARPANET." ... [In] the car [he] said, "Well, you ought to separate control of the ARPANET from the communication throughout the ARPANET." He said, "The way to do that is to put a small computer at every host, and you connect the small computers one to another, and that solves your variability problem, the problem of the differences between machines... And the other ends of each of the small computers are connected to their local host." And I thought that was brilliant, and I said so. I said, "Dave?" He said, "It Xerox PARC to found its legendary sounds right to me." And that's the way the ARPANET architecture got fixed.

- Bob Taylor, "Oral History of Robert (Bob) Taylor", Interviewed by Paul McJones, Computer History Museum, October, 2008.

worked with Evans and Sutherland on the architecture of the LDS-1. After Utah. he n *Burroughs, and subsequently Caltech before*



audio recording. Tom was a fan of Caruso. One of Caruso from an analog master, which was released lesign of the Cosmic Cube and the Myricom by RCA records.







between computers and music. Ashton went on to



Jay Lepreau was a research professor at Utah until his death in 2008. Lepreau created the widely used Emulab network testbed in 2000. Unlike a typical compute cloud, Emulab provides users with "bare metal" access to a variety of devices and fine-grain











Barry Wessler was an ARPA program manager who Roberts, who replaced Taylor. Wessler assisted Roberts in the writing of the ARPANET calls and management of the project. After leaving ARPA, Wessler received a Ph.D. at Utah in 1973 under Evans.



94 issue of WIRED magazine. Bob Taylor is on he far left of the first row, and Barry Wessler is on the far right of the third row.





he founded in 1982, Clark founded Netscape in 1994 in the early years of the world wide web.

-Jim Clark, co-founder of Netscape in 1994, and 1974 Utah Ph.D., Vanity Fair, July 2008.



Internet2 Network by the numbers

10 Juniper T1600 routers **7** Juniper MX960 nodes for TR-CPS

15,500 miles of newly acquired dark fiber

2,400 miles of partnered capacity with NTN

300+ Ciena ActiveFlex 6500 network elements

49 custom colocation facilities

250+ amplification racks

8.8 Tbps of optical capacity

100 Gbps of IP capacity



"At Utah, [Tom Stockham] turned his attention to signal quality and presentation. First, he needed a lab where he could hear the difference between an analog and a digital recording. Working with Ercolino Ferretti, he converted one of the Engineering Department's precious classrooms into a 'quiet room.' This 'room within a room' was aything but quiet. It had dual 16-bit ADA converters and quadraphonic Bose speakers putting out 1 horsepower of acoustic energy from 50-kHz sampled signals. From this test bed came the core technology for compact disks and the digital forensic evidence from the 18-minute gap that helped put Nixon out of office."

- "In Memoriam Tom Stockham: from theory to practice," Steven Boll,

he things that struck me at that early embryonic state was that as going to mutate the newspaper industry, was going to change the classified-a ind change the music business. And so I went around and met with Rolling Stone magazine. I met with the Times Mirror Company, Time Warner."