interface and functionality can be invaluable. Understanding details of the evolution of systems (and the reactions of the marketplace and big business) to those changes can be useful in evaluating how new technologies may affect people and industry. There are many parallels, for example, in how the film industry competed with the developing television industry, with each using technology to deliver enhanced consumer experience, and current changes in those now-mature industries facing the Internet.

Movies evolved from nickelodeons (individual silent movie viewers with images a few inches in size, not unlike a *RealMedia* viewer in 1999) to room-size projections over the course of decades. While movie sound was first introduced in 1927, it still took the decade of the 1930s to see it grow in popularity. Television was demonstrated in 1935, and made its big public debut at the 1939 World's Fair. The film industry, not standing still, saw the arrival of television and responded with color. 1939 was *The Wizard of Oz* and *Gone With The Wind*. More color worked its way into films over the 1940s, but not industry-wide until the new color processes of the 1950s. By 1955 the black-and-white NTSC television broadcast standard was revised to include a chrominance signal. But the adoption of color television sets for the public still took more than a decade. This back-and-forth of invention to capture the public imagination continued, through failures like Sensaround, and 3D, to the 1970s and 1980s with widescreen film projection formats followed by higher-resolutions and frame-rate (*e.g.*, IMAX, Showscan) films to this day. HDTV is the latest in the push of television as a film-competitor.

Not only are there parallels between the film *vs* television competitions (circa 1930–1950) and television *vs* Internet (circa 2000–2020). Even in relatively recent years, criticisms of new digital nonlinear systems (1989–1993) sound remarkably familiar to debates about usability and opportunity, as pundits evaluate and predict the future of broadband video on the Web.

The history and experiences in the development of nonlinear editing are not only quaint reminders of the speed of technological change, but may also provide one of the most appropriate benchmarks for understanding the Internet in the present era.

A BRIEF HISTORY

Of Electronic Editing

Film editing has hardly changed since the upright Moviola was introduced in the '20s. Even after the flatbed was developed, although film editors often chose one "system" or the other, both involved many mechanical similarities and identical media.

Through the '40s and '50s, television was born and grew. TV was a strange and arguably inferior medium than the theatrical presentation of film, but it was a growing trend and unmistakably pervasive. In its early years, programming was LIVE, broadcast directly from studios in New York to viewers across the country. It was not edited, and thus didn't involve the editing community—it was just this other "thing."

But since Los Angeles time is three hours earlier than New York time, and LIVE television is seen simultaneously all over the country, there was no way for the early networks to provide ideal scheduling of shows for everyone. They wanted a way to delay West Coast broadcasts. But how do you delay a LIVE broadcast?

1956

The delay problem is solved. A company in California—Ampex—invents an electronic recorder for broadcast television; the first videotape recorder (VTR) utilizes a 2" wide roll of magnetic tape and is called the VR-1000.

To properly set the stage, we must first recognize that of the three networks, CBS was clearly the leader. Not only did they have the top-rated shows, but also had a powerful research division called CBS Labs. Although a branch of NBC was actively doing research in mechanisms for using the new videotape, CBS was in the unique position of having both

photo courtesy of Ampex Corporation

November 30, 1956:

The historic first videotaped broadcast, "Douglas Edwards and the News," played back three hours after the fact for CBS's west coast audience. Within six months, both NBC and ABC were broadcasting from videotape as well.

was testing missiles, they had devices monitoring from various locations around the test site: some at the launch point, some thousands of miles away. Launch and missile data were recorded on magnetic tape, and along with that information was a time-of-day clock, which allowed them to track and relate events occurring at different data recording locations.

Dick Hill felt this technology might solve the pulse tone problems in editing and began sending reports to CBS headquarters in New York. Adrian Ettlinger, a CBS engineer, was sent to investigate Hill's reports. Ettlinger reported back to CBS that this was a good thing, and that they should encourage the development of what was to become known as TIMECODE.

1967

➢ EECO (The Electronic Engineering Company), in Orange County, California, begins manufacturing the first timecode equipment. ➢ IBM creates the first floppy disk.

With timecode available, CBS Labs began developing an editing system to utilize these numbers. Ettlinger, with other engineers, first experimented with a system of Sony recorders that could perform a continuous play of an edited sequence by accessing a number of duplicated source tapes—the origin of "look-ahead" previews. But the 2" tape machines were unwieldy and too many would have been required to achieve any useful kind of nonlinearity. Later they began using computers to control various kinds of newly-developed 1/2" videotape machines, with mixed degrees of success.

1968 – 69

➢ NBC's "Laugh In" pioneers the use of videotape editing as something more than an extension of live switching. The show has 400–450 physical edits where most other shows have between 40–100. ➢ The first version of UNIX is invented for the PDP-11 computer at Bell Labs. ➢ ARPAnet is launched.

By 1969, none of CBS Labs' tape format experiments had proven particularly appealing, so they abandoned tape and began experimenting with magnetic disk platters for storing the analog video information. They ran into some mechanical problems involving the disk platters and turned to the Memorex Corporation for assistance. Memorex was intrigued with exploring the technical feasibility of recording video on disk media for random access.

The CMX 600, as shown in the original CMX product brochure (1971).

1970

➢ In January, CBS Labs and Memorex create a joint venture called CMX to make editing systems. They build the CMX 200 and CMX 600.

The business plan for the CMX (which stood for **C**BS, **M**emorex, e**X**perimental) venture was drawn up by Adrian Ettlinger and Bill Connelly (both from CBS), and Bill Butler and Ken Taylor (both from Memorex). Butler became the company's general manager. Their first product had two parts. The first part, the CMX 600, was a computer with a stack of removable disk platters, each holding about 5 minutes worth of material. The platters looked like a horizontal bread slicer—their cost: $30,000. With six disk drives working in union, the 600 could locate any frame in under a second from about 30 minutes of mediocre (half-resolution) black-and-white dailies. This part was a nonlinear editor, using what would become SMPTE timecode. It did not produce a master videotape, but a punched paper tape encoded with a list of timecodes for re-creating the edits on a broadcast-quality machine. The second part of the system was the CMX 200, a linear tape assembler that would take as input the 600's list and build a master 2" broadcast videotape.

agement tool), and finally "Wizard" (which became "Super Edit"). Eventually, Bargen marketed these products to other CMX clients.

1977–78

The CBS-Sony system is created. Laserdisc players are first sold. A film from young director George Lucas dominates at the box office. "Star Wars" has what will become the largest ticket sales in the history of movies; the trilogy of films will gross over 4 billion dollars in ticket, cassette, and product rights over the next ten years. IBM researchers build the first relational database.

Because Joe Flaherty still believed that television should be done on videotape, CBS Labs continued to develop systems. Late in 1977, CBS began an advanced form of their CMX 600 project, this time using a new type of 1/2" videotape, called "Beta," that was being developed by Sony. This new format unfortunately required expensive tape decks. CBS's new editing system used modern computers, and the interface, like the 600's, was through a lightpen. Adrian Ettlinger was moved from consulting peripherally on the project to being the software product manager. By 1978 the CBS-Sony system, as it was called, was in use at CBS. But both companies decided not to pursue the marketing and manufacturing of the product, and it remained in-house at CBS.

In 1977, the first LaserVision videodisc players were sold in the educational market. MCA teamed up with Pioneer to form a venture, Universal Pioneer Corporation (UPC) to mass-produce videodisc players. Magnovox introduced their competing disc format, "MagnoVision," utilizing completely different technologies to play videodiscs.

At the New York Institute of Technology (NYIT), Alvy Ray Smith and Ed Catmull invented the "integral alpha channel."

1978–79

New video formats deluge the market. ISC is formed. Philips demonstrates the first audio "compact" discs. Bell and Howell acquires Telemation. CMX invests in DBS; begins developing new kinds of editing systems. Lucas and Coppola investigate video applications to filmmaking. Hayes ships the first 300-baud modem.

A host of new video formats began to inundate the consumer market: Sony's **Beta** format on 1/2" videotape; Panasonic also had a 1/2" tape format called **VHS**; Magnovox's MagnoVision videodiscs; MCA and partner IBM's 5-year-old entity DiscoVision Associates (DVA)'s 12" videodisc format, LaserVision.

Dave Bargen, formerly of CMX, worked with a former chief engineer of Vidtronics, Jack Calaway, who had built a somewhat more flexible machine controller interface than the previously best-known CMX I^2. Bargen used a DEC computer, Calaway's hardware, and his own CMX-like software to create a new editing system. He formed the Interactive Systems Company (ISC).

In mid-1979, CMX/Orrox's penetration into the equipment market was beginning to plateau (over 90% of all broadcast editing in 1978 was on CMX equipment). CMX/Orrox saw the Direct Broadcast Satellite (DBS) business as the next boom industry. In a bold move, they began to invest heavily in DBS.

At the same time, development began on the newest CMX products, the 3400 and 3400 Plus. The plan was to move videotape editors smoothly from somewhat difficult and number-intensive editing (in the 340) to a modern editing system; the 3400 Plus would have a database management system (DBMS) and soft-function keys, and would implement a new computer feature—a windowed graphical interface.

Also in 1979, George Lucas began investigating ways of improving the filmmaking process. His friend and mentor Francis Ford Coppola had been active in using video technologies to help in production. Coppola and Lucas, like their friend at CBS, Joe Flaherty, understood the cost savings that could be achieved on location by shooting in video instead of film—by being able to view immediately the material you had shot. But since neither felt video looked as good as film for production, it was generally understood that the video would only be a tool in the film process.

Coppola had pioneered the use of a video camera alongside the film camera on shoots—the video was fed to and recorded in a customized trailer that sat at his locations, called the "Silver Bullet." With his video specialist Clark Higgins, Coppola is considered the first to use video assist in film productions, in particular on 1982's *One From the Heart*.

Lucas was more interested in facilitating post-production by using computers and video technology. He hired an Ed Catmull, an expert from NYIT, an institution known as a leader in academic computer applications, particularly in computer graphics and animation. Catmull moved to Lucasfilm in California where he began investigating the post-production process and planning what type of technologies could be used.

Bell and Howell, a Chicago-based film equipment company established more than a half-century earlier as a manufacturer of 35mm film