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Conference on the History of Telecommunications

Organized by
the IEEE History Center and the IEEE History Committee.
Held at
Memorial University, St. John's, Newfoundland,
25 – 27 July 2001.

Wednesday 25 July 2001

Breakfast 8:00 – 9:00

Hatcher Dining Hall

Welcome and Introduction to the Conference 9:00 – 9:15

Room EN-2006, Engineering and Applied Sciences Building
Martha Sloan, Chair IEEE History Committee, and Michael Geselowitz, Director IEEE History Center

Session 1: Technology and Business Strategy, Part 1 9:15 – 10:30

Room EN-2006, Engineering and Applied Sciences Building
Chair: William Aspray

From the Cutting Edge to the Conservative Trough: The Telegraphy Business from the 1850s to the 1920s
Bernard Finn

Those who promoted underseas telegraph cables in the 1850s and 60s were making a gigantic step into the unknown, risking substantial amounts of money as well as personal reputations. Initial failures only increased their resolution, and they were paid back with success that was not only impressive technologically but also dramatic in its social effects. For the succeeding three-quarters of a century, however, the industry became ultra-conservative, and when modest change did come about it was stimulated by work in other sectors. I propose to describe these circumstances and to suggest some reasons why they occurred. Although I have been working in the general area of submarine telegraphy for many years, this particular approach is a work in progress, rising from work on a recent exhibition "The Underwater Web" which can be found at <www.sil.si.edu>.

Partners in Crime: The Telegraph Industry, Finance Capitalism, and Organized Gambling, 1870-1920
David Hochfelder

One day in the summer of 1887, President Wright of the Chicago Board of Trade threw the telegraph instruments of the Western Union and Postal Telegraph Companies out of an exchange-hall window. A few months later, he ordered a Board employee to take an axe to some telegraph and telephone cables leading out of the exchange building. Wright was neither deranged nor a Luddite. Instead, his forceful actions were dramatic examples of the troublesome technological, cultural, and economic relationship between the telegraph industry, finance capitalism, and organized gambling in the United States between 1870 and 1920.

This paper examines how the telegraph ticker blurred the economic, institutional, and moral distinctions between speculation and gambling, and helped to usher in organized crime alongside modern finance capitalism. On the one hand, the ticker helped to legitimate stock and commodities speculation as a respectable and useful economic activity. Most Gilded Age Americans regarded speculation as parasitic and immoral. In response, exchange officials waged a protracted battle lasting from the late 1870s until about World War I to deny their quotations to gamblers and market manipulators. On the other hand, the ticker democratized speculation, and by doing so it firmly linked the rise of finance capitalism with the emergence of organized gambling. The telegraph companies provided ticker service to hundreds of bucket shops, gambling dens in which patrons placed bets on the fluctuations of stock and commodity quotations. Despite unremitting pressure from the major exchanges, the telegraph companies were reluctant to cease this lucrative service.

By the turn of the century, most Americans readily recognized the ticker as a tool of financiers and as a symbol of the triumphant capitalist order. However, the ticker had also become an important fixture of the criminal underworld. While the ticker helped to concentrate economic power on the floors of the exchanges, it also encouraged the formation of national, centrally-controlled gambling syndicates. During the Gilded Age and Progressive Era, modern finance capitalism and organized crime emerged together, linked by the telegraph ticker.

Several Paths Leading to the Use of Small Earth Stations for Satellite Communications Systems
Robert M. Walp

The chain of events resulting from the author's obsession with satellite communications for less developed regions, plus several chance occurrences make an interesting account leading to the first use of small earth stations at C-band frequencies and the first Ku-band commercial systems. Initial efforts to place a high-power S-band transponder on NASA's ATS-G satellite for demonstrations in Brazil were deflected, becoming, instead, the Health and Educational Telecommunications experiment on ATS-6, serving several regions in the United States. Alaska was one of these, leading to participation in a group advising the state during the change from military to private ownership of its telecommunication system. Despite strong objection by the new, private owners, the state ultimately persuaded them to employ 4.5-meter earth stations to supply telephone and television service throughout rural Alaska.

Another path, less convoluted, began with concern over the difficulty in placing C-band earth stations where terrestrial microwave links of at the same frequency were in service. Ku-band satellite bands are not shared with terrestrial services, but exhibit higher rain attenuation. The author collected and analyzed all the rain date he could obtain during the late 1960s, but could not generate support for use of these frequencies by his employer, Hughes Aircraft Co. A chance meeting led to an introduction to the founder of MCI, and several abortive attempts to put supplier and user together. Eventually MCI and Lockheed made the first application to construct and operate a Ku-band system, was quickly followed by several more. After several ownership changes, MCI-Lockheed became Satellite Business Systems (SBS), probably the first major satellite system to become a business failure.

Coffee break 10:30 – 11:00

Junior Common Room, R. Gushue Hall

Session 2: Technology and Business Strategy, Part 2 11:00 – 12:15

Room EN-2006, Engineering and Applied Sciences Building
Chair: W. Bernard Carlson

Turning up the Clock Speed: Corning and the Fiber Optics Revolution
Margaret Graham

In 1970 when Corning Glass Works surprised the telecommunications research world with an announcement that it had achieved a breakthrough in transmission capabilities for glass fiber, AT&T was predicting that communications networks based on a replacement for copper cable could be expected to appear around the year 2000. As AT&T had recently secured a cross-licensing agreement with Corning for all of its communications related technologies, and as AT&T would be the major customer for fiber in the United States, there seemed little reason to doubt that AT&T's prophecy would be self-fulfilling. In fact Corning filled its first large optical fiber order for MCA in 1985. Although this timing was closely related to the AT&T break-up, Corning's ability to advance the speed of the fiber optics revolution depended on many other factors. Corning was a technical pioneer with no market position at all in the old industry. To be prepared to fill MCA's order in the mid-1980s, and to go on to secure for itself a major share of a very large market, Corning not only pursued a tenacious research and development program, but combined it with an audacious intellectual property litigation campaign at a time when it had no telecommunications business at all, and only the slimmest prospects for getting one. The technical story, which has been told in part before, bears repeating; the intellectual property story is new and provides a vital missing piece.

History of Developments of Vapor-Phase Axial Deposition for Optical-Fiber Fabrication and Pioneering Work of Silica-Based Planar Lightwave Circuits
Tatsuo Izawa

[1] Initiation of early research on high silica fiber fabrication methods and minimum loss estimation at a wavelength of 1.55 ?m.

[2] Invention of the vapor-phase axial deposition (VAD) method which has an advantage in terms of producibility.

[3] Development of the VAD method by solving many technical problems.

[4] Achievement of the ultimate low loss silica fiber and the realization of mass-producibility by the VAD method.

[5] Leading the introduction of VAD fibers into telecommunication systems.

[6] Pioneer work of silica-based planar lightwave circuits.

One World, One Telephone, One Love: Iridium, A Post-Cold War, Postmodern, Global-A-Go-Go Tale
Martin Collins

Inaugurated in November 1998, Iridium used a constellation of 66 satellites in low-earth orbit, ground stations, and cellular-sized handsets, to provide wireless, digital telephone coverage over the entire earth--a first in the history of telephony.

Conceived by Motorola, a leader in the cellular phone business, in 1987, Iridium ranks as the largest private technology venture ever -- $7-8 billion of investment. To implement its ambitious, globe-straddling services, the project pioneered innovations in the design, manufacture, and launch of satellites and in business practice and organization. Yet within ten months of its debut in 1998, the company filed for bankruptcy and collapsed as a business concern in August 2000.

Iridium's rise and fall provides a unique window on a period of extraordinary transformations as the world moved from the Cold War to a global economy and politics shaped by market forces and U.S.-style democratic values--and by a revolution in communications.

Lunch 12:15 – 1:15

Junior Common Room, R. Gushue Hall

Session 3: Submarine Telephony 1:15 – 2:30

Room EN-2006, Engineering and Applied Sciences Building
Chair: Frederik Nebeker

The First Transatlantic Telephone Cables
Lenore Symons

Telegraph cables had spanned the Atlantic since 1866 and by the 1920s voice communication by radio across the Atlantic had been achieved, but circuits were vulnerable to atmospheric interference. Moreover, they were extremely expensive and the telegraph remained the primary means of quick transatlantic communication.

All that changed in 1956 when the first telephone cable was laid between Scotland and Sydney Mines, Nova Scotia. A joint US, British, and Canadian project, it was completed ahead of schedule and was built “to the most exacting submarine cable specifications ever prepared”. The deep ocean cable consisted of two cables each including 52 flexible single-way repeaters, while the single shallow cable between Newfoundland and Nova Scotia incorporated novel rigid repeaters developed by the British Post Office. In 1960 the CANTAT cable adapted the shallow water system to deep water by using a new light-weight type of cable.

This paper will analyse the route, the development of the technology, and the actual laying of the cables and will show how they influenced subsequent development of transatlantic cable communication.

Reminiscences of TAT-1

Jeremiah F. Hayes

Newfoundland has been a crossroad for transatlantic communication for a long time. The first, short-lived, telegraph cable landed at Heart's Content in 1858. In 1865, a permanent connecting was established between Valencia, Ireland and Trinity Bay. Previously, there had been schemes involving fast packet steamers plying between St. John's and Galway on the west of Ireland with telegraph connections at either end. The centennial of the most celebrated transatlantic link will be celebrated later this year. On December 12, 1901, Guglielmo Marconi received a radio signal from Poldhu in Cornwall on a simple apparatus located on Signal Hill, which is a nice walk from downtown St. John's. (It is reported that the time was 12 noon, so we have the twelfth hour of the twelfth day of the twelfth month.)

Commercial telegraph service began in 1908. The art of radio transmission had advanced to the point that long wave service was established in 1927 and short wave in 1928. Interestingly, Oliver Heavyside contributed significantly to both developments. He found that cable attenuation could be reduced by means of inductive loading. He was also the first to suggest a conducting atmospheric layer. The Heavyside layer is the channel for short wave transmission.

While radio circuits provided a voice service, they are subject to the vagaries of sunspot and seasonal and daily variations. In 1919 a study of deep-water submarine telephone cable began. In 1928 this work culminated in a proposal for a repeater less cable bearing a single voice channel. Two considerations killed the project: radio circuits were continuously improving and the cost estimate was $15 M in the midst of the Great Depression.

By the early 1930's electronic technology had advanced to the point where a submarine cable system with repeaters became feasible. Work on the key component, the vacuum tube for the repeaters, was begun in 1933. Since the repeaters were to lie at the bottom of the sea for twenty years, the reliability requirements were unprecedented. Tubes of this design were continually tested for a period of eighteen years. They were manufactured under conditions that presaged those of modern semiconductor fabrication.

In the thirty third Kelvin lecture given in 1942, Oliver Buckley, president of Bell Labs, said, "Submarine cables, like all things that go the sea, can never be disassociated from chance of disaster." Safety considerations preclude stopping to drop off repeaters. A unique flexible repeater, which could be paid out from a standard drum was designed. The repeater was eight feet long and had a diameter of 2.875 inches tapering down to the cable width of 1.21 inches over twenty feet. There were fifty repeaters in a cable stretching over 1940 nautical miles. Each repeater provided 65 dB of gain and 144 kHz bandwidth around 164 kHz.

The system design called for two cables, one in each direction. H.M.T.S. Monarch laid the two cables in the summers of 1955 and 1956, respectively, which was then the world's largest cable ship. The links were from Clarenville, Newfoundland to Oban, Scotland. A different submarine system connected Newfoundland to the mainland through Sydney Mines, Nova Scotia. Initial service provided 29 telephone circuits between London and New York, six circuits between London and Montreal and a single circuit split among the three destinations for telegraph and other narrow band applications. The system, designated TAT-1 operated, without repeater failure for over twenty years when it was taken out of service.

I graduated from university in 1956 and joined Bell Labs where I was assigned to work on TAT-1. As part of the work, I visited both Sydney Mines and Clarenville where I assisted in a cable repair. I found that the unique aspect of the project was the marriage of high-level telecommunications engineering with the ancient lore of the sea.

Milestones in Submarine Telecommunications
Robert Chapuis

The completion in 1956 of the first transatlantic telephone cable has justly received attention as a marking a new era in communications. But work on submarine telephony had a long history before this event, and in the decades that followed many other momentous advances occurred.

Coffee break 2:30 – 3:00

Junior Common Room, R. Gushue Hall

Session 4: Politics and Communications Technology 3:00 – 4:15

Room EN-2006, Engineering and Applied Sciences Building
Chair: David Hochfelder

Communications in Troubled Times: the Case of Ireland and Newfoundland
Donard de Cogan

Newfoundland and Ireland have been intimately linked in the global communications network since 1858. There is much written about the brighter sides of wireless and cable links, but not so much has been mentioned of the darker side - communications during conflict. This paper will seek to address some of the relevant issues.

Newfoundland played an important part in the nationalist activities in Ireland and the attempts to maintain communications during the civil war of 1922 which followed Irish independence are perhaps some of the first examples of internet connections. Although the almost total breakdown of cable communications following the submarine earthquake of 1929 placed enormous demands on cable engineers, the situation was less critical from a global perspective due to the fact that much traffic could be diverted to wireless. This event demonstrated that wireless and cable could complement each other.

The west to east trans-Atlantic flight of Alcock and Brown is well known. However, the first east to west flight took place in 1929 and nearly came to grief due to the lack of reliable weather information. Much was learnt as a result of this and subsequent flights. The infrastructures essential for durable aviation links between Ireland and Newfoundland were firmly established in August 1939, less than a month before the outbreak of the second world war, where the well known role of one country and the less well known role of the other were to play critical parts in the ultimate outcome of that conflict.

The paper will draw on this broad spectrum of topics to identify some key issues in Ireland/Newfoundland links.

Switching in a National Relation: Public-Private Cooperation in the Development of Telephony Technology in Postwar Sweden
Mats Fridlund

Since the turn of the 20th century public-private cooperation has been an essential factor in the development of Swedish telecommunications technology. In the beginning this was in the form of rather informal joint cooperation between the Swedish telecommunications administration and the Ericsson telephone manufacturing company that during the interwar years developed into a more formalized relationship – a Development Pair. The paper describes this relation with a special emphasis on its institutionalization in the postwar period around the development of various electronic telecommunications technologies such as the AXE switching system.

Contention Control in Multi-Access Resource Systems
Gertrude Levine

All wireless communications, including radio, satellite and mobile systems as well as wired broadcast networks, have had to determine mechanisms for resolving conflict. Strategies for allocation of sometimes scarce bandwidth among competing users have evolved from no policy (e.g., C/B radio, where strength of signal determines access), to random access with minimal conflict resolution (e. g., Aloha), to complex control and encoding schemes, where access is provided based on varying scheduling goals such as throughput, priorities, bounded waits, and fairness (e.g. DQDB). As wireless media become more heavily used, mechanisms that prevent contention between assigned stations (e.g. CDMA) at a significant cost of bandwidth will have to be balanced against mechanisms that allow collisions to occur, but, at their own cost, recover from it (e.g. IEEE 802.11). We review the various types of policies for conflict control in multi-access resource systems to aid the understanding of why they have evolved and under which conditions they have been successful.

Thursday 26 July 2001

Breakfast 8:00 – 9:00

Hatcher Dining Hall

Session 5: Assessing Stature in the History of Telecommunications, Part 1 9:00 – 10:15

Room EN-2006, Engineering and Applied Sciences Building
Chair: Martha Sloan

Cooke and Wheatstone, and Morse: A Comparative View
Brian Bowers

In 1838, Samuel F. B. Morse was in London seeking an English Patent for his telegraph. The application was opposed by the English inventors William Cooke and Charles Wheatstone, and rejected. In England, Cooke and Wheatstone are seen as the orginators of the practical electric telegraph, while Morse is viewed in a similar light in the United States. This paper will compare and contrast how the two parties became interested in the telegraph and initially set about promoting it,and in particular will look at their dealings with each other both while Morse's patent application was pending, and subsequently; for example, a proposal in 1840 that they should collaborate came to nothing. In this way, the collaborative aspects of the the early development of the telegraph will be illuminated with a global perspective.

The First Transatlantic Wireless Telegraphy in 1901: Collaboration or Competition between Guglielmo Marconi and John Ambrose Fleming?
Sungook Hong

My paper will reconstruct the history of Marconi's first transatlantic wireless telegraphy in 1901. This enormously important achievement was made possible by the fusion of Marconi's wireless telegraphy with the power engineering of John Ambrose Fleming, Marconi's scientific advisor. In their experiments in 1900 and 1901, however, their different styles clashed. Fleming, whose educational background included Cambridge Maxwellian physics, based his approach upon scientific engineering theories and practices such as laboratory experiments, precise measurement, and mathematical considerations. Marconi derived his work from an old style of doing technology such as field experiments, handicraft work, and an intuitive understanding of technological effects. The tension between them reached its peak when the experiment proved to be successful and credit for its success was being assigned.

Promotion versus Manufacturing as a Strategy for Earning Money from Inventions: Lessons from the Career of Nikola Tesla, 1885-1915
W. Bernard Carlson

This paper will investigate the business strategy used by Nikola Tesla to introduce his new inventions. Previously, historians and economists have assumed that most inventors earned a return on their inventions by establishing new companies to manufacture and market their creations. In contrast to this manufacturing-oriented strategy, Tesla and his backers pursued a promotion-oriented strategy. Rather than set up new companies, Tesla promoted his inventions to investors and the public and then licensed the patents to manufacturers. While this promotion-oriented strategy is still widely employed in the computer and software industries today, we know little about this strategy in a formal and analytical sense. I wish to explore promotion as a strategy by investigating how Tesla evolved this strategy while working with several different backers from 1885 to 1915. I will look at how these entrepreneurs helped Tesla secure patents and how they assisted Tesla in promoting his inventions through public demonstrations, newspaper stories, and scientific articles. This paper will speak to contemporary concerns by providing new insights into the problems facing engineeers and entrepreneurs introducing new technologies (such as telecommunications, the Internet, and the World Wide Web) and I will strive to suggest ways in which policy makers can help individuals undertake the risks of introducing new technologies.

Coffee break 10:15 – 10:45

Junior Common Room, R. Gushue Hall

Session 6: Assessing Stature in the History of Telecommunications, Part 2 10:45 – 12:00

Room EN-2006, Engineering and Applied Sciences Building
Chair: David Morton

Judge Harold H. Greene: A Pivotal Judicial Figure in Telecommunications Policy and His Legacy
Bill Yurcik

On August 5, 1983, Judge Harold H. Greene gave final approval to a consent decree breaking up the largest corporation in the world AT&T. The settlement, which concluded a 1974 antitrust suit filed by the U.S. Department of

Justice (DOJ) to end the regulated monopoly that AT&T had exercised for decades over the U.S. telephone network, was attributed in large part to Greene's skills as a trial judge. The AT&T case was considered by many to be too complex and unwieldy for any court to handle.

The legacy of Judge Greene and the AT&T antitrust case is extremely relevant now with two major technology policy issues pending. The current Microsoft antitrust trial may never have been attempted if not for Judge Greene's example and many economists and lawyers are advocating a Microsoft breakup into "Baby Bills" analogous to AT&T's "Baby Bells". The main issue of an operating system "essential facility" providing opportunity for anti-competitive behavior is a direct analogy to the local loop bottleneck. The other issue is "open access" to broadband cable television systems rules that, in effect, would introduce consent decree style regulation when cable networks are used for Internet access. The dynamics of the AT&T antitrust case set the stage for a 70% drop in long distance rates, further telecommunications deregulation, remarkable business opportunities for tens of thousands of entrepreneurs, and the Internet fueling the greatest economic boom in recent history.

Harold H. Greene died in January 2000 after a distinguished judicial career that spanned 30 years after playing a major role in many of the most important legal questions of our age (desegregation, civil rights, voting rights, due process, separation of powers, executive privilege). I also outline these contributions beyond telecommunications policy and include a rare and exclusive interview recorded with the Judge Greene in 1993.

Pushing Technology: David Sarnoff and Wireless Communications, 1911-1921
Alexander B. Magoun

The academic debate over the sources of innovation—whether by "invention-push," "market-pull," or some mixture of the two—frequently overlooks the roles of individuals in the successful development and diffusion of a technology. During his twenties, David Sarnoff committed himself to a career of managing the expanding business at the Marconi Wireless Telegraph Company of America and the Radio Corporation of America. He also embarked on a lifelong promotion of the forms of wireless communication made possible by electronic technologies. Some writers have cast doubt on the pioneering nature of his vision and the extent of his contributions. This paper will draw on archival evidence to demonstrate the origins of Sarnoff's commitment, and the nature of his contributions in pushing the development of marine, rail, and broadcast radio communications.

Peter C. Goldmark: Technological Visionary
Karen J. Freeze

Peter C. Goldmark (1906-1977), inventor of the LP, holder of many patents in color television, father of Electronic Video Recording (EVR), winner of the National Medal of Science, amateur cellist and indefatigable futurist, was a Hungarian-American who was synonymous with the Columbia Broadcasting System's research activities from 1936 until his retirement at the end of 1971. After retiring from CBS at the end of 1971, he established his own company, Goldmark Communications Corporation, to pursue far-reaching new visions uninhibited by corporate interests.

During his career Goldmark was responsible for over 160 inventions that represent every corner of sound recording, telecommunications, and other technologies related to physics and electrical engineering. Beginning in the late 1950s, he promoted closed-circuit television, then video recording and playback as educational tools for the classroom; by the mid-1960s he was beginning to advocate far-reaching technological solutions to core social problems like overcrowded cities and rural poverty. These solutions would become practical only long after his death, in the "information society" or "digital age" of the 1990s: telecommuting, distance education, videoconferencing, mobile phones, and much else made possible by the Internet.

This paper will focus on his plans for the communications technologies he thought would make the world a better place, plans that were cut short by his untimely death in 1977.

Lunch 12:00 – 1:00

Junior Common Room, R. Gushue Hall

Session 7: Poster Session with Presentations 1:00 – 2:15

Chair: Wallace S. Read

Engineering Lobby, Engineering and Applied Sciences Building

IEEE Student History Paper Competition winners:

Rodrigo Carvallo-Fernandini, Catholic University of Valparaiso, Valparaiso, Chile (Region 9)
"The History of CTC and Entel: Precursors of Telecommunications in Chile"

Cornelia Connolly, University of Limerick, Limerick, Ireland (Region 8)
"The History of Telecommunications in Ireland"

Rahul Malik, Nanyang Technological University, Singapore (Region 10)
"Spread Spectrum – Secret Military Technology to 3G"

Jakob Nebeker, University of Illinois, Champaign-Urbana, Illinois, USA (Region 4)
"Science and Technology: Lord Kelvin's Atlantic Cable"

Keiko Tanaka, University of Washington, Seattle, Washington, USA (Region 6)
"The Mobile Communications Environment in the European Union: Systems, Regulations, and Consequences in the Past, Present, and Future"

Coffee break 2:15 – 2:45

Junior Common Room, R. Gushue Hall

Session 8: Microelectronics and Telecommunications 2:45 – 4:00

Room EN-2006, Engineering and Applied Sciences Building
Chair: Earl E. Swartzlander, Jr.

The Telephone Answering Machine as a Reflection of Modern Society, 1877-2001
David Morton

The concept of an automatic telephone answering machine originated in the late 19th century, but relatively few people knew of these devices until the 1980s. The history of this device can be divided into four stages, which, taken as a whole, reflect some key aspects of the development not only of the answering machine itself, but also the corporation, telecommunication technology, and society.

The stages include 1) invention, the time when individuals created frames of meaning that defined basic functionality 2) co-option by monopoly capitalism, when corporate policy and government regulation determined access and use 3) a rebirth of the product in the age of microelectronics and 4) diffusion and re-definition of functionality in a postmodern, de-regulated world.

Alan Kay: Transforming the Computer Into a Communication Medium
Susan Barnes

Alan Kay has been referred to as the "father of the personal computer" and he popularized the term "software agent" in his 1984 article published in *Scientific American*. Kay's doctoral thesis called dynabook, his work at Xerox PARC, and his articles have had a major influence on the development of modern computing. From the notebook design of the dynabook to the creation of graphical interfaces, Kay has been a major figure in transforming the computer from a calculating machine to a communication medium. This paper will focus on Kay's work at Xerox PARC and his vision for computing that continues to influence present technology development.

Towards a History of Computer Communications: the 1950's to the 1970's
Mischa Schwartz

We present a rather personalized view of the history of computer communications, in the hope that this will create some interest in delving into this area in much more depth than has hitherto been the case. In describing the genesis of computer communications, which we consider to be synonymous with packet-switched networking, it is convenient to consider two eras. The first covers the period from the early 1950's to the late 1960's. The second covers the period from the mid-1960's to the late 1970's. These two eras overlap to some extent and this division into two eras is somewhat arbitrary.

Three simultaneous developments contributed to the early development of computer communications in the computer communications in the 1950's and into the 1960's. (Note that the term "packet switching" was not coined until the mid-1960's.) The first set of developments, including such systems as the SAGE network and the NIKE Zeus network, and studies at Rand Corp., came from the U.S. defense activity. The second development came from the needs of the airline and banking industries, among other commercial ventures. A prime example was the passenger airline reservations system, beginning in 1952 and continuing into the 1960's. Banking networks in the UK and elsewhere provided another example. IBM played a key role in the development of these systems. Time-sharing computer systems provided the impetus for the third development during this period. The need to timeshare computer systems remotely led to such data networks as TYMNET and the GE Information Services Network, among other such commercial networks.

The second era, that beginning in the mid-1960's and going to the late 1970's, covers two parallel developments: efforts by computer manufacturers such as IBM to provide their customers with the ability to interconnect their computer systems at remote locations, and the by-now well-known story of the genesis of the ARPAnet, designed to interconnect large computer systems. IBM began to develop its proprietary communications architecture, SNA, in the late 1960's, followed by other computer manufacturers. The ARPAnet had its genesis in the early1960's, leading to the first four-node network implementation in 1969. Both developments, the computer manufacturer's proprietary architectures and the ARPAnet, utilized the concept of layered communication architectures, and introduced the term *protocol* into communication network design. International standardization efforts by the then-CCITT and ISO followed soon afterwards.

Friday 27 July 2001

Breakfast 8:00 – 9:00

Hatcher Dining Hall

Session 9: Science, Mathematics, and Telecommunications 9:00 – 10:15

Room EN-2006, Engineering and Applied Sciences Building

Chair: Bernard Finn

The "American Method": The 19th-Century Telegraphic Revolution in Finding Longitude
Trudy E. Bell

The invention of the telegraph revolutionized surveying. Its biggest contribution was simplifying and exacting the determination of longitude on the earth, by allowing the nearly instantaneous comparison of the time a star transited the meridian of a site of unknown longitude compared to that of a reference site (such as Boston or Washington, D.C.). Less than five years after the United States' first telegraph line was completed between Washington, D.C. and Baltimore, the telegraphic "American method" of determining longitude had become so accepted worldwide that, in the words of U.S. Coast Survey chief Alexander Dallas Bache, it "may be considered to have passed into one of the regular methods of geodesy." Indeed, virtually the first use of the first *transatlantic* telegraph cable laid in 1866 was to send star-transit timings between astronomers in Newfoundland and Great Britain, to nail down the exact longitude differences between points in Europe and North America. Telegraphic longitude determination was supplanted only in 1922 by radio navigation techniques. This paper will outline some of the key inventions and telegraphic techniques used by 19th-century American astronomer-surveyors.

Inventing the 'Black Box': Mathematics as a Neglected Enabling Technology in the History of Communications Engineering
Chris Bissell

Historians of telecommunications have tended to concentrate on enabling technologies such as the vacuum tube, the transistor, the microprocessor, and so on – or on the socio-political aspects of developing, regulating, and managing large-scale communication systems. Yet just as significant historically – but largely neglected by historians of technology – is an approach to modelling, analysis and design based on a quintessentially 'communications engineering' use of mathematics. This approach, ultimately characterised by terms such as 'linear systems theory' and 'black box analysis' is still a key factor in the development of communications devices and systems.

By the 1920s, engineers at Bell Labs and elsewhere were becoming familiar with operator methods and Fourier techniques to explain the transient and steady-state response of electrical networks, and to design the wave filters necessary to exploit the potential of carrier telegraphy. Communications engineers soon learned to move effortlessly between time and frequency domains – for example, when developing novel modulation techniques such as single side-band, suppressed carrier. The 1920s and 1930s also saw an increasing use of highly stylised modelling techniques for filter design. Complex circuits were modelled and designed as distinct system subunits, even when they did not exist physically in this form (Black's famous diagram of the feedback amplifier, for example). Communications engineers ultimately invented a new and distinct 'language' in which the distinction between mathematical models, 'prototype' circuits, and engineering models such as pole-zero plots became ever more blurred – a language that effectively rendered the mathematics transparent to the designer. Even non-causal models proved to be valuable for the design of real circuits and systems; the early work of Karl Küpfmüller in Germany before and after WW2 was particularly novel in this respect, although his name is barely known today outside the German-speaking countries.

The role of communications engineers in interdisciplinary WW2 military R&D, which ultimately led to such seminal work as Shannon's information theory and Wiener's cybernetics, has been comparatively well documented. Such approaches were rooted in the earlier achievements outlined above, especially in the way engineers used highly theoretical approaches to identify limits to the performance of real systems – that is, to model ideal (often non-causal or otherwise unrealisable) behaviour that could then be approximated ever more closely in practice as technological developments allowed. The corpus of modelling techniques that emerged, further encouraged by the 'engineering science' movement of the Cold War era, included linear systems theory, which was applied with increasing success to such areas as signal processing and automatic control as well as to communication systems. Indeed, essentially the same approach lies at the heart of more recent developments such as modem and mobile telephony technology. Particularly fruitful has been the increasingly sophisticated engineering application, over the whole of the twentieth century, of the mathematical concept of orthogonality – from the early Fourier analysis of telegraphic waveforms to the COFDM technique used in contemporary digital broadcasting.

This paper will outline the history of the use of mathematical modelling in communications engineering, and attempt to set it in the wider context of telecommunications technology, including instrumentation and simulation aspects. It reports work in progress, and aims to stimulate discussion of this neglected area of the history of telecommunications

The Recent History of Secure Voice Communications
Earl E. Swartzlander, Jr.

In the 1970s secure voice communications systems were developed initially for military applications. In this paper I will review the basic concept of the linear predictive coding (LPC) algorithm. The LPC algorithm enabled voice signals to be digitized at rates comparable to analog voice signals. This algorithm also achieved adequate fidelity so that listeners could confirm the identity of speakers which is extremely important for many applications. The basic concepts could be viewed as a precursor to current cell phone technology.

In this paper I will show three systems which were developed over several years in the 1970s to confirm the viability of the algorithms and to develop a cost effective implementation. These systems serve to demonstrate the effectiveness of developing application specific processors for high volume applications.

Coffee break 10:15 – 10:45

Junior Common Room, R. Gushue Hall

Session 10: The Internet and Earlier Telecommunications Networks 10:45 – 12:00

Room EN-2006, Engineering and Applied Sciences Building
Chair: Michael Geselowitz

Content Versus Connectivity in Telecommunications History
Andrew Odlyzko

The Internet is widely regarded as primarily a content delivery system. Yet historically, connectivity has mattered much more than content. Point-to-point communication, typically first for business applications, then (as a technology developed) for sociability, has usually been dominant. (Radio is an interesting case, in that it started out as point-to-point communication, evolved into a broadcast medium, and now is moving back to connectivity through growth of cellular systems.) Even on the Internet, content is not as important as is often claimed, since it is email that is still the true "killer app."

The preoccupation with content at the expense of connectivity has been a common theme in history, although it appears to never have been as extreme as it is today on the Internet. It applied to the United States postal system in the first half of the 19th century, as well as to the phone system in its first few decades.

The primacy of connectivity over content explains phenomena that have baffled wireless industry observers, such as the enthusiastic embrace of SMS (Short Message System) and the tepid reception of WAP (Wireless Application Protocol).

The Telegraph of Claude Chappe: An Optical Telecommunication Network for the 18th Century
J-M. Dilhac

Claude Chappe (1763-1805) invented a semaphore visual telegraph. The lines between cities were composed by a series of towers (stations), 10-20 km apart, equipped with a pair of telescopes and a semaphore whose beams were permitted discrete angular positions. These positions were assigned to numeric symbols in connection with a code book. Where the transmission of a message had taken days it needed only tens of minutes with Chappe's telegraph (individual symbols may be transmitted at 500 km/hr!).

Begun during the French Revolution, the network grew to 556 stations covering 3000 miles of lines, most of them in France. However, cities like Amsterdam, Brussels, Mainz, Milan, Turin, Venice were also connected. Small networks were also deployed in Algeria and Morocco, while a mobile network was used during the Crimea war. In 1853, it was finally replaced by the electric telegraph.

The purpose of the presentation is to first present the technology of this optical telegraph, and to demonstrate the modernity of its principles. Nevertheless, political and social implications will be described to show their strong similarities with the (supposed) implications of the World Wide Web. More precisely, such issues like source coding, error detection, and signal restoration, control and data signals, routing, regulation and fraud, dissemination of new social behaviors, will be addressed.

Weaving the Once and Future Web: Comparative Telecommunications History in Public Space
Michael Sappol and Hunter Crowther-Heyck

In the light of our own current experience with the Internet and World Wide Web, scholars and journalists have recently begun to reexamine the history of telegraphy. In works like Tom Standage's *Victorian Internet*, the story of the telegraph has been reworked from an older history of technological revolution into one of network proliferation, online culture and cultural transformation. The era of the telegraph, Standage and others tell us, was the first online networked society: what is going on now, first went on then. But how productive is the parallel? What are its limitations? What does the history of telegraphy have to tell us about the Internet and our own experience? What does the history of the Internet have to tell us about the telegraph? And how useful is comparative history in engaging a mass audience, in fostering public awareness of what is now a largely forgotten technological and social history, and in cultivating a critical historical perspective on our own experience? In May 2001, *The Once and Future Web: Worlds Woven by Telegraph and Internet* opens at the National Library of Medicine, Bethesda, Maryland, an exhibition that explores the Internet and the telegraph as the parallel histories of two communications technologies that transformed the world. In a slide presentation and accompanying discussion, Hunter Crowther-Heyck and Michael Sappol, curators of *The Once and Future Web*, explore some of the issues raised by comparative telecommunications history, the problems of public history, and give a guided, inside tour of *The Once and Future Web.*

Awards Luncheon 12:15 – 1:30

Junior Common Room, R. Gushue Hall
Arthur Maxwell House, Lieutenant Governor of Newfoundland and Labrador

Excursion 2:00 – ca. 10:00

Heart's Content Cable Station (departing by bus from Memorial University, returning to Memorial University)