Program, Vol. 31, No. 1, January 1997

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Librarians and innovation: an American viewpoint

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ABSTRACT

This paper presents a historical overview of technological developments and their use in libraries and argues that librarians have always been amongst the first to adapt to, and use, the latest information handling and communications technologies. Points made are supported by many citations to the relevant literature of the time.

1. From Sumerian clay tablets to Library of Congress printed cards

Librarians have, in recent years, by introducing OPACs, CD-ROM databases and Internet access into their libraries, convincingly demonstrated their ability to master, manage and use advanced technologies. Thus, it has become fashionable to speak of *a new librarianship and of a new image of librarians*. The perception may be new, and the recognition gratifying, however, in reality librarians have long been pioneering users of new technologies. Contrary to popular notions, librarians have always been among the first to adapt and use the latest information handling and communication technologies.

Sumerian librarians made catalogues in 2000 BC using clay tablets, the most advanced medium of the time for record keeping.[1] In the third century BC, the most famous catalogue of antiquity, the catalogue of the library of Alexandria, or the *Pínakes* of Callimachus, was prepared using the most advanced *communication medium* of the time, papyrus.[2] (The *Pínakes* was intended to be copied, and the copies transported, as it is thought to be a comprehensive bibliography based on the holdings of the Alexandrian library, rather than simply a catalogue of its collection).[3]

The advent of the industrial age, in the mid-18th century, focused attention on repetitive processes and replaceable parts. The invention by librarians of the card catalogue, composed of standard, replaceable, cards, was clearly in harmony with the ambiance of the time. Paolo Paciaudi created the first known public card catalogue at the public library of Parma in the early 1760s.[4] However, this profound innovation was not met with general approval. Detractors characterized it as a dangerous and useless novelty: dangerous, because – since guide rods had not yet been developed – the order and integrity of the catalogue was at risk; and useless, because the public was thought to be incapable of comprehending its value. This innovation lay dormant for nearly 30 years until it was rediscovered on the eve of the apotheosis of the standard,

Program, vol. 31, no. 1, January 1997, pp. 47–58

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replaceable part. The French cataloguing code of 1791 contains specific instructions for constructing a catalogue by making entries on the backs of playing cards for each title.[5, 6] Seven years later, in 1798, Eli Whitney demonstrated the value of standardised, replaceable parts in industrial production.[7]

The first typewriter appeared in 1868. Librarians were quick to appreciate its applicability to their own activities. Four years later, in 1872, Melvil Dewey proposed at a conference in New York that libraries should consider using typewriters to prepare their records.[8] In 1886 Mergenthaler perfected the linotype machine, which led to the modern era of print. Five years later, in 1891, the public library of New London, Connecticut, used a linotype machine to print its catalogue. And, in 1901 the Library of Congress revolutionised bibliographic control by distributing copies of its printed catalogue cards, composed on a linotype, to other libraries.

The Library of Congress and The New York Public Library were among the first to acquire, and use, photocopy machines in 1912. The highly successful use of microfilm by the United States in World War II demonstrated the value and utility of this medium. Consequently many organisations and enterprises found applications for it after the war. Libraries were on the cutting edge of the application of this technology too (in fact they were ahead of most other organisations). In 1937 Harvard University purchased a microphotography camera and three reading machines.[9] Beginning in the early 1960s, and continuing for nearly two decades, librarians used microfilm to reproduce the contents of card catalogues. This permitted them to distribute copies of individual and union catalogues, and thus, to facilitate resource sharing – an obvious forerunner of modern, remote access catalogues.

2. Computing

Modern computers were not developed until 1946, and the first commercial use of electronic computers was not until 1951. However, throughout the first half of this century, businesses and government agencies used electromechanical tabulating machines, the precursors of modern electronic computers, to mechanise their information handling and record keeping activities. In 1930 Ralph Parker, at the University of Texas in Austin, designed a system using tabulating equipment to automate the handling of library circulation records, and in 1940 the librarian of the Montclair, New Jersey, Public Library, developed a special machine, known as the *Punching Judy* to mechanise the processing of circulation cards.[10]

There are numerous other instances in which libraries used tabulating equipment in the years before modern computing equipment became generally available: the King County Library (Seattle, Washington), the Library of Congress's New Serial Titles Program, and the Los Angeles County Public Library, each produced book form catalogues using tabulating equipment beginning respectively in 1951, 1951 and 1952.[11]

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Interestingly, it is a librarian who shares credit for the invention of tabulating equipment. John Shaw Billings, Director of the National Library of Medicine, suggested to Hermann Hollerith the use of punched cards to tabulate the 1890 census. In 1919 Hollerith wrote in a letter:

> "... and so it happened that one sunday [sic] evening at Dr. B [sic] tea table he said to me there ought to be a machine for doing the purely mechanical work of tabulating population and similar statistics. We talked the matter over and I remember his idea was something like a type distributing machine. He thout [sic] of using cards with the description of the individual shown by notches punched in the edge of the card ... After studying the problem I went back to Dr. Billings and said I thought I could work out a solution for the problem and asked him would he go in with me. The Dr said no he was not interested any further then [sic] to see some solution of the problem worked out."[12]

Hollerith went on to form a company that built and marketed the machines that Billings had suggested. That company after several mergers and name changes became the International Business Machines Corporation (IBM).

In the first half of the 20th-century there were numerous advances in science, technology and engineering. World War II further spurred developments in the physical sciences and dramatically focused attention on the benefits of scientific research. By the mid-1940s the rate of accretion of new scientific knowledge was such that scientists became concerned with the sheer volume of new information being created and the futility of keeping up with it – the beginning of the information explosion. Vannevar Bush, Director of the US Office of Scientific Research commented in a now classic essay, "As we may think," published in 1945,

> "There is a growing mountain of research. But there is increased evidence that we are bogged down today as specialization extends. The investigator is staggered by the findings and conclusions of thousands of other workers – conclusions which he cannot find time to grasp, much less to remember as they appear."[13]

Bush proposed a mechanical device, the *memex*, as a means to address this problem. The hypothetical memex employed mechanical and photographic technologies rather than the inchoate digital technologies that were under development in the US and Britain. In conception the memex closely resembles a modern personal computer equipped with CD-ROM drives.

One of Bush's most profound observation in "As we may think" was that prior to 1945 "... complexity and unreliability were synonymous."[14] He went on to say, "The world has arrived at an age of cheap complex devices of great reliability; and something is bound to come of it."[15] And something did indeed come of it: the modern digital computer, which as Bush correctly foresaw would be an instrument for managing information rather than simply performing

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calculation. The first electronic computer intended for commercial application was delivered on 14 June 1951. Just weeks later, Frederick Kilgour, the librarian of the Yale Medical Library wrote in his annual report, dated 30 June 1951, "... it is very likely that libraries will in some way in the next half century begin to make use of magnetic, electronic, or other types of memory units for handling and producing information."[16]

Although the transistor had only been invented four years earlier, and the first computer to use transistors was not to be developed for yet another four years, Kilgour, in that same annual report, made the observation:

> "If technicians can perfect the currently invented transistors, which are small, reliable, and use minute quantities of electric power, to replace the vacuum tube, the major difficulties of electronic devices will be eliminated."[17]

Kilgour was by no means a dilettante awed by the wonders of science and technology. He went on to say:

> "Nevertheless, it seems unlikely electronic machines will be useful in a library to perform repetitive tasks or handle information until functional automatic units such as memory units, see'ers, collators, etc., are produced which can be connected with each other to perform various tasks. However, the next fifty years will certainly witness developments in this direction."[18]

The developments came more quickly than Kilgour envisioned, nonetheless. When they did emerge, he readily exploited them to create OCLC, the single most successful venture in librarianship.

In the early 1960s transistors replaced vacuum tubes, creating the second generation of computing equipment (vacuum tubes characterised the first generation). Transistors decreased the cost of computing equipment, diminished the amount of power it required, acutely reduced the heat it needed to dissipate, and markedly increased its reliability. As a result it became practical for many organisations to acquire and use computers. In 1958 IBM announced the first computer that relied entirely on transistors, the 7074. This, in effect, was the beginning of the computer age in America. The number of computers installed in the US increased from 2,550 in 1958 to 18,200 in 1964 (more than a sevenfold increase in six years.[19] Libraries were quick to exploit this latest technology. In 1961 the Library of Congress sought, and received, a $100,000 grant from the Council on Library Resources for a "... survey of the possibilities of automating the organization, storage and retrieval of information in a large research library ...".[20] The National Library of Medicine,[21] the Washington University School of Medicine,[22, 23] the Columbia, Harvard, and Yale Medical Libraries,[24] among others, undertook inhouse development efforts that resulted in noteworthy systems.

In 1964 IBM introduced a new type of computer, the System 360. It was the first of a new, third generation of computers. It utilised integrated circuit

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electronic components. The new computer system was the first general purpose computer (prior to it, computers were either designed for scientific applications, e.g., the IBM 7094, or commercial applications, e.g., the IBM 1401). The use of integrated circuits led to further, substantial decreases in the cost and size of computers and marked improvements in their capabilities and reliability. As a consequence, the number of computers installed in the US increased 40 per cent in one year, from 1964 to 1965.[25]

Because of the enhanced capabilities of third generation computers, all sorts of organisations were able to initiate ambitious projects that had previously been impractical. Third generation computers made possible the bibliographic systems that we know today. In 1966, two years after IBM announced the System 360, the Library of Congress initiated the MARC (*Ma*chine *R*eadable *C*ataloguing) pilot project, which in 1968 resulted in the MARC distribution services that continue today and are an essential source of bibliographic data for all library applications.[26]

Throughout the 1960s computer processing was generally done by gathering a quantity, *or batch*, of transactions over a period of time and submitting them to be processed together. This made the most efficient use of the costly computers then available. It was not until the 1970s that transaction processing became common.[27] Libraries, led by OCLC and Frederick Kilgour, began planning to utilize these capabilities as early as 1965,[28] and inaugurated the first, successful online, real-time bibliographic system in June 1971.[29] In the early 1970s, with the exception of airline reservation systems and defence-related systems, very few systems employed as extensive a communication network, maintained direct access files as large or handled as many transactions in unit time, as OCLC did.

In 1971 the state-of-the-art of video display terminals (VDTs) were inadequate to the demands of online bibliographic systems. In order efficiently to create and edit bibliographic records using video display terminals (VDT), it is necessary that the terminals have large buffers and extensive editing capabilities. These features existed, but were not commonly found on generally available computer terminals. In addition, VDT terminals must be capable of displaying a very large number of characters. In the late 1960s and early 1970s most VDT terminals had upper case-only displays. Upper and lower case displays existed, but were also not generally available. Terminals that could display a character set as large as the complete MARC character set were simply *not* commercially available. Since adequate terminals were not available, Philip Long, OCLC's Head of Research and Development, designed a terminal that had all of the foregoing capabilities, plus some other unique features that allowed OCLC to make very efficient use of its telecommunication network and to minimize response time – matters critical to OCLC's economic and technical viability at the time. This terminal and the online bibliographic service it helped spawn are of such historical significance that the Smithsonian Institution has added one of the original OCLC VDT terminals to its permanent collection.

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In 1971 Intel invented the microprocessor.[30] Within less than two years Philip Long designed for OCLC a new bibliographic terminal that used a microprocessor. This substantially lowered the cost of these terminals, enhanced their performance and increased their reliability.

3. Standards and telecommunications

Librarians addressed the problems of developing standards, or protocols, far ahead of many other computer users. In 1975, the Telecommunications Committee of the American Library Association began work on a computer-to-computer communication protocol. In 1976, at the urging of Henriette Avram (the person who led the Library of Congress's MARC development efforts), the National Commission on Libraries and Information Science (NCLIS), in co-operation with the National Bureau of Standards (NBS), established a task force to continue and accelerate this work on a computer-computer communication protocol. Members of the NCLIS/NBS task force seem to have been acutely aware of the international data processing community's latest thinking regarding the development of standards for computer-to-computer communication. The results of their work were remarkably similar to what the International Standards Organization proposed several years later.

The NCLIS/NBS Task Force on Computer Networking published, *A computer network protocol for library and information science applications*, in 1977, the same year that the International Standards Organisation (ISO) established a subcommittee (Technical Committee 97, SC 16) charged with responsibility for developing a framework for standards for linking heterogeneous computer networks. SC 16 published its work for approval by member nations at the end of 1980. The product of this effort is the Open Systems Interconnection (OSI) reference model. An important characteristic of the ISO *reference model* is that it separates the complex processes associated with computer-to-computer communication into seven distinct *layers*.[31] This layered approach permits standards makers to focus their attention on specific, manageable aspects of the process without getting bogged down by its overall complexity. It also permits standards affecting discrete parts of the communication process to be developed and revised without compromising its total structure. The protocol for computer-to-computer exchange of bibliographic data proposed by the NCLIS/NBS Task employed a similar, layered structure. It consisted of five layers.[32]

These standardisation efforts led in 1980 to the establishment of the Linked Systems Project (LSP); a project to interconnect the computer systems of the three major US bibliographic utilities (OCLC, RLIN, WLN) and the Library of Congress. The Linked Systems Project was committed to employing international standards, in particular the emerging OSI communication standards.[33]

In January 1981, Guy Silvestre, the National Librarian of Canada, noting the importance of facilitating resource sharing through the development of a nationwide library and information services network, appointed a task group on computer/communications Protocols for Bibliographic Data Interchange

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and charged the National Library of Canada's Office for Network Development to pursue this goal. Dr. Silvestre noted that this work is "... an essential element in [Canada's] ... effort to promote links amongst the major bibliographic centres in the country in the environment of Open Systems Interconnection."[34]

Here again, librarians were in close alignment with the latest technical developments. Commitment to OSI standards was the wisest course of action to pursue in the early 1980s. The National Bureau of Standards had been working since the late 1970s on specifications, that embodied OSI standards, which US government agencies would be required to use when purchasing new or replacement computing and communication equipment.[35] By 1986 the General Services Administration and the Department of Defense had agreed to require OSI conformance in all of their future computing and communications purchases.[36] In August 1988 the US Department of Commerce issued Federal Information Processing Standard (FIPS) 146, which mandated compliance with OSI standards. The US government spent $3.9 billion on computer equipment in 1986. Thus, it appeared there would be a substantial market for OSI-compliant equipment.[37] Furthermore, OSI standards were internationally accepted, were non-proprietary, promised to build on, and extend, the best networking standards available at the time. In short, the library community had done its homework.

Unfortunately, development of the full suite of standards needed to realise the OSI reference model did not progress as rapidly as had been hoped. Competing standards (most notably TCP/IP, the standards employed by what became known as the Internet) were improving and gaining ever wider acceptance. As a result the major thrust of efforts to network computer systems took a different direction.

As it turns out, the diversity and technical astuteness of the US library community comprehended both OSI and TCP/IP. While the Library of Congress and the major US bibliographic utilities were working to implement communication systems based on OSI, other libraries were successfully employing TCP/IP as a communication standard.

In 1981 the University of California's Division of Library Automation let contracts to Bolt, Beranek and Newman (BBN) for a feasibility study and design of a communication network to support the University's recently implemented, computerised public access catalogue. BBN had successfully developed the communication technologies used by the US Advanced Research Projects Agency Network (ARPANET), a nationwide computer network implemented by the Department of Defense in the 1970s.[38] The University of California's network was deployed in 1982-83. Since the BBN network employed the same communication protocols as the ARPANET, communication between computers and users on the two networks became possible without much additional effort. The ARPANET was the predecessor of the Internet. Thus, the University of California's online catalogue, MELVYL, became a part of the Internet, consequently users of that catalogue gained access to the many resources available on the Internet.

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The University of California's telecommunication network was not the first involvement libraries had with BBN. In 1961, even before BBN's work on the ARPANET, Richard Bolt had advised the Council on Library Resources on the characteristics of the library of the future; and in 1964 J.C.R. Licklider, an engineering psychologist with BBN, had completed a study on libraries of the future for the Council on Library Resources.[39] It is particularly interesting to note that work that BBN subsequently did has in fact established the infrastructure for the Library of the 21st Century.

Libraries have clearly demonstrated their ability to utilise advanced information handling technologies. This reality was not lost on the larger research and education community in the US. It actively recruited librarians to support their efforts to enact legislation to establish a high capacity National Research and Education Network (NREN). The library community lent its assistance to the successful efforts that resulted in the *High performance computing act of 1991*.[40] In exchange for their support, librarians were able to ensure that language was incorporated into the legislation that recognises libraries as legitimate users of the NREN.

Librarians have, without doubt, been among the first to show an interest in the Internet and its potential. This can be demonstrated by a review of when the term Internet first appears in the literature of various disciplines. A search of *Library and Information Science Abstracts* reveals that the earliest mention of the Internet is in connection with a 1982 study undertaken by visitors from the Department of Computer Science of London's University College to the National Library of Medicine in order to study online Internet retrieval activities. The earliest mention of the Internet in ABI/Inform, an electronic database of business and management information, citing a non-engineering periodical, is from 1983. Likewise, the earliest mention of the Internet in *Magazine Index*, a general periodical literature database, citing a non-library periodical, is also from 1983. Thus, librarians were aware of the importance of the Internet before members of most other disciplines, with the exception of computer scientists.

CD-ROM and multimedia computing are now very common technologies. However, it is interesting to note that digital audio compact discs (CDs) were first introduced in Japan in late 1983. They were not introduced to the rest of the world until 1984.[41] That same year the first computer application of this technology, CD-ROM, appeared. The first commercially produced CD-ROM, containing the complete file of Library of Congress MARC records for English language books, was produced by the Library Corporation, a company that had been supplying bibliographic data on microfiche.[42] For many years libraries remained the principal market for CD-ROMs. With the advent of multimedia computing, the market has broadened, nonetheless libraries are still important consumers of these products; and librarians have become particularly adept at using and deploying them.

The Internet is only the latest of the important technological advancements that librarians have enthusiastically adopted in their quest to deliver improved information services to library users. An anecdote related by Peggy Sullivan in

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her final Executive Director's report to the American Library Association serves as a final illustration that librarians often lead, rather than follow, members of other professions in the use of new technologies. Ms. Sullivan writes:

> "At a recent program of the Association Executive Council, a Chicago-area group of association executives, the topic was the information highway and the audience was 24 men and 2 women. When asked how many of us used electronic mail regularly, only my hand went up. When asked how many of us had staff members who used it regularly, fewer than a dozen hands were raised. Too often, we stutter when we should be strutting."[43]

4. Conclusion

Librarians are the custodians of information resources that have steadily grown in magnitude, diversity and complexity. Acquiring, organising and providing access to those resources has been an increasingly demanding task. Consequently, librarians have created sophisticated apparatuses for resource sharing, bibliographic control, information access, and information dissemination. They have done this by employing the best-developed information handling technologies of their time. Though rarely possessors of advanced training in technical disciplines, librarians have been quick to grasp the significance of new technologies and have generally been among the most innovative and earliest adapters of information handling technologies.

These characteristics have been in evidence ever since people recognised the importance of preserving and making accessible the record of human thought and deeds. They have been most clearly in evidence during the most recent half century, which has seen the birth and maturation of computing technology. Librarians developed among the first and largest transaction processing systems; they were early, enthusiastic users of the Internet; they recognised before many others the importance of standards for computer-to-computer communication and the complexity of such standards; and they provided the first viable market for CD-ROMs.

Librarians are now actively engaged in developing digital libraries, which will extend and enhance the common notion of a library. In so doing they will help extend the limits of electronic imaging, data transmission, automatic indexing, natural language processing, and numerous other related technologies. If history is any guide, librarians will uncover the problems, help to define the solutions and be among the earliest adopters of those solutions.

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Program, Vol. 31, No. 1, January 1997

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