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The History of Computing in the History of Technology

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Abstract

In the standard story, the computer's growth has been rapid and short. It starts with the giant machines warehoused in World War II–era laboratories. Microchips shrink them onto desktops, Moore's Law predicts how powerful they will become, and Microsoft capitalizes on the software. finally small, cheap devices come out that can trade stocks and beam video around the world. That is one way to approach the history of computing—the history of solid-state electronics in the past 60 years. But computing existed long before the transistor. Ancient astronomers developed ways to predict the motion of the heavenly bodies. The Greeks deduced the shape and size of Earth. Taxes were summed; distances mapped. Always, though, computing was a human pursuit. It was arithmetic, a skill like reading or writing that helped a person make sense of the world. The age of computing sprang from the abandonment of this limitation. Cash registers came first to organize mathematical computations using what we now call "programs." The idea of a program first arose in the 1830s, a century before what we traditionally think of as the birth of the computer. Later on, the modern electronic computers came out. These electronic computers were capable of doing any kind of information processing and also the manipulation of its own programs. These are the computers that power our world today. This paper discusses some of the major issues addressed by recent work in the history of technology. It suggests the different aspects of the development of computing. These are relevant to those issues for which that recent work could provide models of historical analysis.

Keywords:- Steps Toward Modern Computing, Computing Present History, The Tripartite Nature of Computing , History of Computing as History of Technology.

Introduction

Since World War II 'information' has emerged as a fundamental scientific and technological concept applied to phenomena ranging from black holes to DNA, from the organization of cells to the processes of human thought, and from the management of corporations to the allocation of global resources. In addition to reshaping established disciplines, it has stimulated the formation of a panoply of new subjects and areas of inquiry concerned with its structure and its role in nature and society . Theories based on the concept of 'information' have so permeated modern culture that it now is widely taken to characterize our times. We live in an 'information society', an 'age of information'. Indeed, we look to models of information processing to explain our own patterns of thought. The computer has played the central role in that transformation, both accommodating and encouraging ever broader views of 'information' and of how it can be transformed and communicated over time and space. Since the 1950s the computer has replaced traditional methods of accounting and record-keeping by a new industry of data processing. As a primary vehicle of communication over both space and time, it has come to form the core of modern information technology. What the English-speaking world refers to as "computer science" is known to the rest of western Europe as informatique. Much of the concern over information as a commodity and as a natural resource derives from the computer and from computer-based communications technology. For this reason we can say that the history of the computer and also of computing is central to that of information science and technology, is providing a thread by which to maintain bearing while exploring the ever-growing maze of disciplines and subdisciplines that claim information as their subject. In spite of the persistent occurrence of computing in modern science and technology, not to mention modern society itself, the history of computing has yet to establish a significant presence in the history of science to characterize the unprecedented capabilities of computers linked to telecommunications, Nora and Minc coined the term télématique. and technology. Meetings of the History of Science Society and the Society for the History of Technology in recent years have included very few sessions devoted specifically to history of computing, and very small sessions have included contributions from the perspective of computing. There is clearly a balance to be redressed here.

Computing's Present History

In the history of computing the present literature is self-consciously historical, it focuses in large part on hardware and on the pre-history and early development of the computer. A major portion of the literature stems from the people involved either through regular surveys of the state and development of various fields or compilations of influential papers or through recollections and retrospectives, either written directly or transcribed from their contributions to conferences and symposia. Biographies of men or machines –some heroic, some polemical, some both-- are a prominent genre, and one reads a lot about "pioneers". The minority corporate histories have appeared, most notably *IBM's Early Computers* , but they too are in-house productions. This literature represents for the most part "insider" history, full of facts and firsts. While it is first-hand and expert, it is also guided by the current state of knowledge and bound by the professional culture. That is, its authors take as givens what a more critical, outside viewer might see as choices. In the long run, most of this literature will become primary sources, if not of the development of computing per se, then of its emerging culture. The computer has attracted the attention of journalists, who by the late '50s were beginning to recount its history. The result is a sizable inventory of accounts having the virtues and vices of the journalist's craft. They are vivid, they capture the spirit of the people and of the institutions they portray, and they have an eye for the telling anecdote. But their immediacy comes at the price of perspective. That is Written by people more or less knowledgeable about the subject and about the history of technology, these accounts tend to focus on the unusual and the spectacular, be it people or lines of research, and they often cede to the self-evaluation of their subjects. Thus the microcomputer and artificial intelligence have had the lion's share of attention, as their advocates have roared a succession of millenia. It is difficult to distinguish from futurist musing on the computer, the discussions of the effects of the computer on society and its various activities tend on the whole to view computing apart from the history of technology rather than from its perspective. Much of it comes from popular accounts taken uncritically and episodically to support non-historical, often polemical, theses. A few of this literature rests on a frankly political agenda; whether its models and modes of analysis provide insight depends on whether one agrees with that agenda. Finally, there is a small body of professionally historical work, dealing for the most part with the origins of the computer, its invention and early development. It is meant as no denigration of that work to note that it stops at the point where computing becomes a significant presence in science, technology, and society. There historians stand before the daunting complexity of a subject that has grown exponentially in size and variety, looking not so much like an uncharted ocean as like a trackless jungle. We pace on the edge, pondering where to cut in.

The Tripartite Nature of Computing

Some of the above questions and models into forms specific to the history of computing, it may help to reflect a bit on the complexity of the object of our study. The computer is not one thing, but many different things, and the same holds true of computing. There is about both terms a deceptive singularity to which we fall victim when, as is now common, we prematurely unite its multiple historical sources into a single stream, treating Charles Babbage's analytical engine and George Boole's algebra of thought as if they were conceptually related by something other than 20th-century hindsight. Whatever John von Neumann's precise role in designing the "von Neumann architecture" that defines the computer for the period with which historians are properly concerned, it is really only in von Neumann's collaboration with the ENIAC team that two quite separate historical strands came together: the effort to achie ve high-speed, high-precision, automatic calculation and the effort to design a logic machine capable of significant reasoning.9 The dual nature of the computer is reflected in its dual origins: hardware in the sequence of devices that stretches from the Pascaline to the ENIAC, software in the series of investigations that reaches from Leibniz's combinatorics to Turing's abstract machines. The two strings until come together in the computer, they belong to different histories, the electronic calculator to the history of technology, the logic machine to the history of mathematics,10 and they can be unfolded separately without significant loss of fullness or texture. Though they come together in the computer, they do not unite. The computer remains an amalgam of technological device and mathematical concept, which retain separate identities despite their influence on one another.Thus the computer in itself embodiesone of the central problems of the history of technology, namely the relation of science and technology. Computing as an enterprise deepens the problem. For not only are finite automata or denot ational semantics independent of integrated circuits, they are also linked in only the most tenuous and uncertain way to programs and programming, that is, to software and its production. Since the mid-1960s experience in this realm has revealed a third strand in the nature of the computer. Between the mathematics that makes the device theoretically possible and the electronics that makes it practically feasible lies the programming that makes it intellectually, economically, and socially useful. Unlike the extremes, the middle remains a craft, technical rather than technological, mathematical only in appearance. It causes the question of the relation of science and technology in a very special form. That tripartite structure shows up in the three distinct disciplines that are concerned with the computer: electrical engineering, computer science, and software engineering. The first is the most well established, since it predates the computer, even though its current focus on microelectronics reflects its basic orientation toward the device. Computer science began to take shape during the 1960s, as it brought together common concerns from mathematical logic (automata, proof theory, recursive function theory), mathematical linguistics, and numerical analysis (algorithms, computational complexity), adding to them questions of the organization of information (data structures) and the relation of computer architecture to patterns of computation. Software engineering, conceived as a deliberately provocative term in 1967, has developed more as a set of techniques than as a body of learning. Except for a few university centers, such as Carnegie-Mellon University, University of North Carolina, Berkeley, and Oxford, it remains primarily a concern of military and industrial R&D aimed at the design and mplementation of large, complex systems, and the driving forces are cost and reliability.

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History of Computing as History of Technology

Consider, then, the history of computing in light of current history of technology. Several lines of inquiry seem particularly promising. Studies such as those cited above offer a panoply of models for tracing the patterns of growth and progress in computing as a technology. Technological improvement not only enters the structure of the economy through the main entrance, as when it takes the highly visible form of major patentable technological breakthroughs, but that it also employs huge and less visible side and rear entrances where its arrival is unassuming, unannounced, unobserved, and uncelebrated" ? To determine whether what is the case that will require to makes changes in the history of computing as it is currently practiced. It will mean looking beyond "firsts" to the revisions and modifications that made products work and that account for their real impact. Given the corporate, collaborative structure of modern R&D, historians of computing must follow the admonition once made to historians of technology to stop "substituting biography for careful analysis of social processes". Without denigrating the role of heroes and pioneers, we need more knowledge of computing's equivalent of "shop practices, the activities of lower-level technicians in factories" . The question is how to pursue that inquiry across the variegated range of the emerging industry. Viewing computing both as a system in itself and as a component of a variety of larger systems may provide important discernment into the dynamics of its development and may help to differentiate between its internal and its external history. For example, it suggests an approach to the question of the relation between hardware and software, often couched in the antagonistic form of one driving the other, a form which seems to assume that the two are relatively independent of one another. By contrast, linking them in a system emphasizes their mutual dependence. One expects of a system that the relationship among its internal components and their relationships to external components will vary over time and place but that they will do so in a way that maintains a certain equipoise or stability, even as the system itself evolves. Seen in that light, the relation between hardware and software is a question not so much of driving forces, or of stimulus and response, as of constraints and degrees of freedom. While in principle all computers have the same capacities as universal Turing machines, in practice different architectures are conducive to different forms of computing. Certain architectures have technical thresholds (e.g. VSLI is a prerequisite to massively parallel computing), others reflect conscious choices among equally feasible alternatives; some have been influenced by the needs and concerns of software production, others by the special purposes of customers. Early on, programming had to conform to the narrow limits of speed and memory set by factors in the electronics industry made it possible to expand those limits, and at the same time drastically lowered the cost of hardware, programming could take practical advantage of research into programming languages and compilers. Researchers' ideas of multiuser systems, interactive programming, or virtual memory required advances in hardware at the same time that they drew out the full power of a new generation of machines. Just as new architectures have challenged established forms of programming, so too theoretical advances in computation and artificial intelligence have suggested new ways of organizing processors.At present, the evolution of computing as a system and of its interfaces with other systems of thought and action has yet to be uncover.Indeed, it is not clear how many recognized systems constitute computing itself, given the manifold contexts in which it has developed. We speak of the computer industry as if it were a monolith rather than a network of interdependent industries with separate interests and concerns. In addition to historically more analytical studies of individual firms, both large and small, we need analyses of their interaction and interdependence. The same holds for government and academia, neither of which has spoken with one voice on matters of computing. Of particular interest here may be the system-building role of the computer in constructing new links of interdependence among universities, government, and industry after World War II. Arguing in "The Big Questions" that creators of the machinery underpinning the American System worked from a knowledge

of the entire sequence of operations in production,12 Daniels in 1970 pointed to Peter Drucker's suggestion that "the organization of work be used as a unifying concept in the history of technology." The recent volume by on *IBM's Early Computers* illustrates the potential fruitfulness of that suggestion for the history of computing. In tracing IBM's adaptation to the computer, they bring out the corporate tensions and adjustments introduced into IBM by the need to keep abreast of fast-breaking developments in science and technology and in turn to share its research with others.The computer reshaped R&D at IBM, defining new relations between marketing and research, introducing a new breed of scientific personnel with new ways of doing things, and creating new roles, in particular that of the programmer. Whether the same holds true of, say, Bell Laboratories or G.E. Research Laboratories, remains to be studied, as does the structure of the R&D institutions established by the many new firms that constituted the growing computer industry of the '50s, '60s, and '70s. Tracy Kidder's in 1981,the frankly journalistic account of development at Data General has given us a glimpse of the patterns we may find. Equally important will be studies of the emergence of the data-processing shop, whether as an independent computer service or as a new element in established institutions.14 More than one company found that the computer reorganized *de facto* the lines of effective managerial power. The computer seems an obvious place to look for insight into the question of whether new technologies respond to need or create it. Indeed, the numerical analysts clearly considered the computer to be their baby and resented its adoption by "computerologists" in the late '50s and early '60s . But it seems equally clear that the computer became the core of an emergent data-processing industry more by creating demand than by responding to it. Much as Henry Ford taught the nation how to use an automobile, IBM and its competitors taught the nation's businesses (and its government) how to use the computer. How much of the technical development of the computer originated in the marketing division remains an untold story central to an understanding of modern technology.15 Kidder's Soul of a New Machine again offers a quick look of what that story may reveal. One major factor in the creation of demand seems to have been the alliance.We undoubtedly produce software by backward techniques. We undoubtedly get the short end of the stick in contest with hardware people because they are the industrialists and we are the crofters. Today, in this world software production is visible in the scale of industrialization somewhere below the more backward construction industries. According to me its proper place is considerably higher, and would like to investigate the prospects for mass-production techniques in software.

What McIlroy had in mind was not imprint in large numbers, which is trivial for the computer, but rather programmed modules that might serve as standardized, interchangeable parts to be drawn from the library shelf and inserted in larger production programs. A quotation from McIlroy's paper served as leitmotiv to the first part of Peter Wegner's series on "Capital Intensive Software Technology" in the July 1984 number of IEEE Software, which was richly illustrated by photographs of capital industry in the 1930s and included insets on the history of technology.18 By then McIlroy's equivalent to interchangeable parts had become "reusable software" and software engineers had developed more sophisticated tools for producing it. Whether they were any closer to the goal is less significant to the historian than the continuing strength of the model. It reveals historical self-consciousness. We should appreciate that self-consciousness at the same time that we view it critically, inclination temptation to accept the comparisons

Conclusion: The Real Computer Revolution

We can take this example a step farther. From various perspectives, people have been drawn to compare the computer to the automobile. One has to wonder about an article on software engineering that envisions progress on an industrial model and uses photographs taken from the Great Depression. Apple, Atari, and others have boasted of creating the Model T of microcomputers, clearly intending to convey the image of a car in every garage, an automobile that everyone could drive, a machine that reshaped American life. The software engineers who solicit the image of mass production have it inseparably linked in their minds to the automobile and its interchangeable variations on a standard theme. The two analogies serve different aims within the computer industry, the first looking to the microcomputer as an object of mass consumption, the second to software systems as objects of mass production. But they share the vision of a society absolutely altered by a new technology. Beneath the comparison lies the conviction that the computer is bringing about a revolution as profound as that triggered by the automobile. The comparison between the machines is fascinating in itself. Just how does one weigh the PC against the PT. Question is deeper than that. What would it mean for a microcomputer to play the role of the Model T in determining new social, economic, and political patterns? The historical term in that comparison is not the Model T, but Middletown (Lynd and Lynd 1929), where in less than forty years "high-speed steel and Ford cars" had radically changed the nature of work and the lives of the workers. Where is the Middletown of today, similarly transformed by the presence of the microcomputer? Where would one look? How would one identify the changes? What patterns of social and intellectual behavior mark such transformation? In short, how does one compare technological societies? That is one of the "big questions" for historians of technology, and it is only in the context of the history of technology that it will be answered for the computer. From the very beginning, the computer has borne the label "revolutionary". Even as the first commercial machines were being delivered, commentators were extolling or fretting over the radical changes the widespread use of computers would entail, and few doubted their use would be widespread. The computer directed people's eyes toward the future, and a few thousand bytes of memory seemed space enough for the solution of almost any problem. On that both enthusiasts and critics could agree. Computing meant unprecedented power for science, industry, and business, and with the power came difficulties and dangers that seemed equally unprecedented. By its nature as well as by its youth, the computer appeared to have no history. Yet, "revolution" is an essentially historical concept . Even when turning things on their head, one can only define what is new by what is old, and innovation, however imaginative, can only proceed from what exists. The computer had a history out of which it transpire as a new device, and computing took shape from other, continuing activities, each with its own historical momentum. As the world of the computer acquired its own form, it remained submerged in the worlds of science, technology, industry, and business which structured computing even as they changed in response to it. In doing so they linked the history of computing to their own histories, which in turn demonstrate the presence of a fundamentally new resource.

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