# From Computer Operators to Operating Systems:
# The Hidden Costs of Business Computing

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The commercial computer industry came of age in the 1960s. At the beginning of the decade the electronic computer was still a scientific curiosity, its use largely confined to government agencies and a few adventurous and technically sophisticated corporations; by decade's end the computer had been successfully reinvented as a mainstream business technology, and electronic computers and their associated peripherals formed the basis of a $20 billion industry. During the 1960s this industry grew at an average rate of 27% annually, making it one of the largest — and certainly the fastest growing — sectors of the American economy.[1]

It was during this period that the IBM Corporation rose to world-wide dominance, establishing in the process a series of institutional structures and technological standards that shaped developments in the industry for the next several decades. Under IBM's substantial umbrella a broad and diverse set of subsidiary industries flourished, including not just manufacturers of complementary (or even competing) hardware products, but also programming services companies, time-sharing "computer utilities", and independent data processing service providers. When we consider such subsidiary industries, our estimate of the total size of the computer industry almost doubles..[2]

Accompanying this rapid and remarkable growth in the size and scope of the industry were equally spectacular developments in the technology itself. The adoption of transistorized components, solid-state core memories, and fixed disk drives meant that computers in this period became progressively faster, more reliable, and less expensive. It was in the 1960s that the electronic computer began its long and steady march towards Moore's Law: as computers became inexorably cheaper, smaller, and faster, the computerization of society — or at the very least of the modern corporate organization — appeared to have become inevitable.

[1] J.W. Cortada. "Commercial applications of the digital computer in American corporations, 1945-1995". In: *Annals of the History of Computing, IEEE* 18.2 (Summer 1996), pp. 18–29.

[2] McKinsey & Company. "Unlocking the Computer's Profit Potential". In: *Computers & Automation* 16.7 (1969), pp. 24–33.

It is tempting, in light of the extraordinary success of the computer industry in the immediate post-war period in the United States, to assume that the adoption of the electronic computer by American corporations was an inevitable and uncomplicated process driven largely by growing informational demands of the modern Chandlerian firm. Indeed this is the traditional interpretation of this period among business and economic historians and historians of computing: just as in earlier periods firms had readily adopted (or developed) new technologies for internal control and communication, so too did they embrace the electronic computer.[3] In this interpretation, the computer is in many respects an evolutionary, rather than a revolutionary, technology. The firms that succeeded in computing did so by domesticating the computer, by reinventing it as a business data processing machine. These early commercial computers were essentially little more than "chromium-plated tabulators"; faster, more reliable than their earlier mechanical counterparts, but otherwise functionally and organizationally equivalent.[4]

A close reading of the business and industry literature of the late 1960s, however, reveals a startlingly different picture of this supposed "Golden Age" of corporate computerization efforts. What is most immediately striking is the growing and widespread sense of crisis among contemporary industry observers. Some growing pains might be expected in any nascent industry perhaps, but the emerging crisis of the late 1960s appeared to challenge the very foundations of the industry. In an influential 1969 report entitled "Unlocking the Computer's Profit Potential," for example, the venerable consulting firm McKinsey and Company issued a devastating critique of contemporary corporate computerization efforts: in all but a few exceptional companies, such efforts were not only unprofitable, but in "real, if often unacknowledged, trouble." Despite years of investment in "sophisticated hardware," "larger and increasingly costly computer staffs," and "complex and ingenious applications," most of these companies were nowhere near realizing their anticipated returns on the investment in electronic computing. Instead, they were increasingly plagued by rising costs, lost opportunities, and diminishing returns.[5]

[3] JoAnne Yates. *Control Through Communication: The Rise of System in American Management*. Johns Hopkins University Press Baltimore, 1989; James R. Beniger. *The Control Revolution: Technological and Economic Origins of the Information Society*. Harvard University Press Cambridge, 1986.

[4] Haigh Thomas. "The Chromium-Plated Tabulator: Institutionalizing an Electronic Revolution, 1954-1958". In: *IEEE Annals of the History of Computing* 4.23 (2001), pp. 75–104.

[5] McKinsey & Company, op. cit.

## The operational costs of computing

This paper began as a fairly modest project aimed at understanding the crisis of confidence that occurred in commercial computing the late 1960s. This crisis is often explained in terms of the rising cost of software development in this period: as more firms began to use more computing power for more complex purposes, the cost of developing the software that enabled such computerization efforts increasingly outpaced the costs of the actual computers themselves. The so-called "software crisis" of the late 1960s, which shaped many of the key technological, managerial, and organizational developments of the next several decades, is generally — and rightfully — identified as the central culprit behind the rapid rise in the cost of computing that occurred in this period.[6]

But when you actually look at what companies are spending their money on, when you follow the money into the heart of the computing crisis of the mid-to-late 1960s, you make some surprising discoveries.

The first is that companies were spending between 1/3 and 1/2 of all of their software dollars — software itself being the largest and most rapidly growing cost associated with computing — doing "software maintenance." This is surprising because in theory software should never need maintenance. Software does not break down or wear out, at least in the conventional sense. Once a software-based system is working, it will work forever. Generally speaking, software can never be broken. I gave a paper on this the problem of software maintenance at the SHOT conference in Lisbon, and so will only note here that "maintenance" itself was not so much about fixing things that were broken, but about the operational costs associated with adapting software applications to a constantly changing business environment.[7]

After software development, the second largest expense associated with computerization (other than the capital costs of the equipment itself), was a broad collection of activities that we might lump together as "operations." In fact, one contemporary study suggested that operating expenses comprised between 30-61% of all computing costs.[8] Again, this is a somewhat surprising discovery: we

[6] James Taylor and Neal Dean. "Managing to manage the computer". In: *Harvard Business Review* 44.5 (1966), pp. 98–110; Richard F. Clippinger. "ECONOMICS of the Digital Computer." In: *Harvard Business Review* 33.1 (1955), pp. 77–88.

[7] Nathan Ensmenger. "Software as History Embodied". In: *Annals of the History of Computing, IEEE* 31.1 (2009), pp. 88–91.

[8] Taylor and Dean, op. cit.

generally do not think of the electronic digital computer as a machine that must be operated. Certainly, there might be inevitable overhead costs associated with *using* a computer: electricity, air conditioning, office space, etc., but what is there to actually *operate* in terms of a computer?

## The Hidden Labor of Electronic Computing

For most corporate data processing centers in this period, labor costs were the single largest component of operating expenses.[9] Although individual firms often developed their own idiosyncratic taxonomies of job titles associated with computing activities, for the most part these can be generalized into six major categories: data processing supervisor, systems analyst, computer programmer, computer technician/repairman, computer operator, and keypunch operator.[10] Table 1 shows the breakdown of these categories according to the 1970 Census:

| Occupation | Total Employment (1000s) | Male | Female | Percent Female |
|---:|---:|---:|---:|---:|
| Supervisor | 13.3 | 11,445 | 1,806 | 13.6 |
| Systems Analysts | 79.3 | 68,213 | 11,736 | 14.7 |
| Programmer | 161.3 | 124,956 | 36,381 | 22.6 |
| Technician/Repair | 31.7 | 30, 844 | 864 | 2.7 |
| Computer Operator | 117.2 | 83,023 | 34,199 | 29.2 |
| Keypunch Operator | 272.6 | 27,896 | 244,674 | 89.7 |

Table 1: 1970 Census Summary for Computer Related Occupations

Of the two types of computer workers that are best categorized as operators, keypunch operators are simultaneously the largest and least understood by historians. In fact, despite being by far the single largest group of computer workers in this period, keypunch operators have generally overlooked by computer historians, even those focused on labor and work process issues.[11] This is in part because

[9] John P. Carroll. "Determining Computer Service Operating Costs." In: *Banking* 57.1 (July 1964), p. 42; James A. O'Brien. "The Costs of Computerized Banking." In: *Banking* 60.11 (May 1968), p. 69.

[10] Neal J. Dean. "The computer comes of age." In: *Harvard Business Review* 46.1 (1968), pp. 83–91.

[11] Aad Blok and Greg Downey, eds. *Uncovering Labour in Information Revolutions, 1750-2000*. Cambridge University Press, 2004.

the work that keypunch operators did was, and is, considered to be more clerical than technical, a necessary but essentially uninteresting stage in the transition from paper-based to electronic data processing. Keypunch operations predated computerization, and were therefore an evolution of pre-existing work practices that dated back to the 19th century. Keypunch operations were the also first and most successfully mechanized aspect of computer operators, and the occupational category gradually disappears over the course of the late 1970s and 1980s (although in many ways it is simply transformed into data entry, which remains a significant cost associated with computing). The fact that by the job was also almost completely feminized by this period is probably also not insignificant in explaining the lack of attention paid to it in the contemporary or historical literature.

The second class of worker associating with "operating" a computer were the computer operators. This was a large category of worker, trailing only slightly the total number of computer programmers.[12] And unlike keypunch operators, computer operators were seen to be directly associated with the electronic computer (although many of their work practices as well could be traced back to an early era of mechanized tabulating machine-based data processing).

What is it exactly that these computer operators operated?

At its most basic level, the labor of computer operators was focused on the management of work processes. These processes, called jobs, were a combination of programs, data, and procedures. For example, a job might require an operator to load the magnetic tapes or punch cards on which the program code was stored, switch tapes or card decks to load data, to initiate the execution of the program, monitor its progress, possibly switching cards or tapes mid-operation as new subroutines or data was required, and to determine when the program was completed running, and prepare whatever output (printouts, additional tapes or cards) was required by the end user. Some of this work was obviously routine: (i. e. mounting/dismounting magnetic tapes, replacing printer paper, removing cards from full cardpunch hoppers, etc.), but much of it involved a substantial degree of knowledge and skill — for example, monitoring execution of input/output so that one job did not interfere with another in use of I/O devices, recovering from hardware errors (when possible), queuing printer outputs on a system output device (SYSOUT), causing SYSOUT to be printed when appropriate, providing

[12] Charles Lawson. "A Survey of Computer Facility Management". In: *Datamation* 8.7 (1962), pp. 29–32; Enid Mumford and T.B. Ward. *Computers: Planning for People*. B.T. Batsford London, 1968.

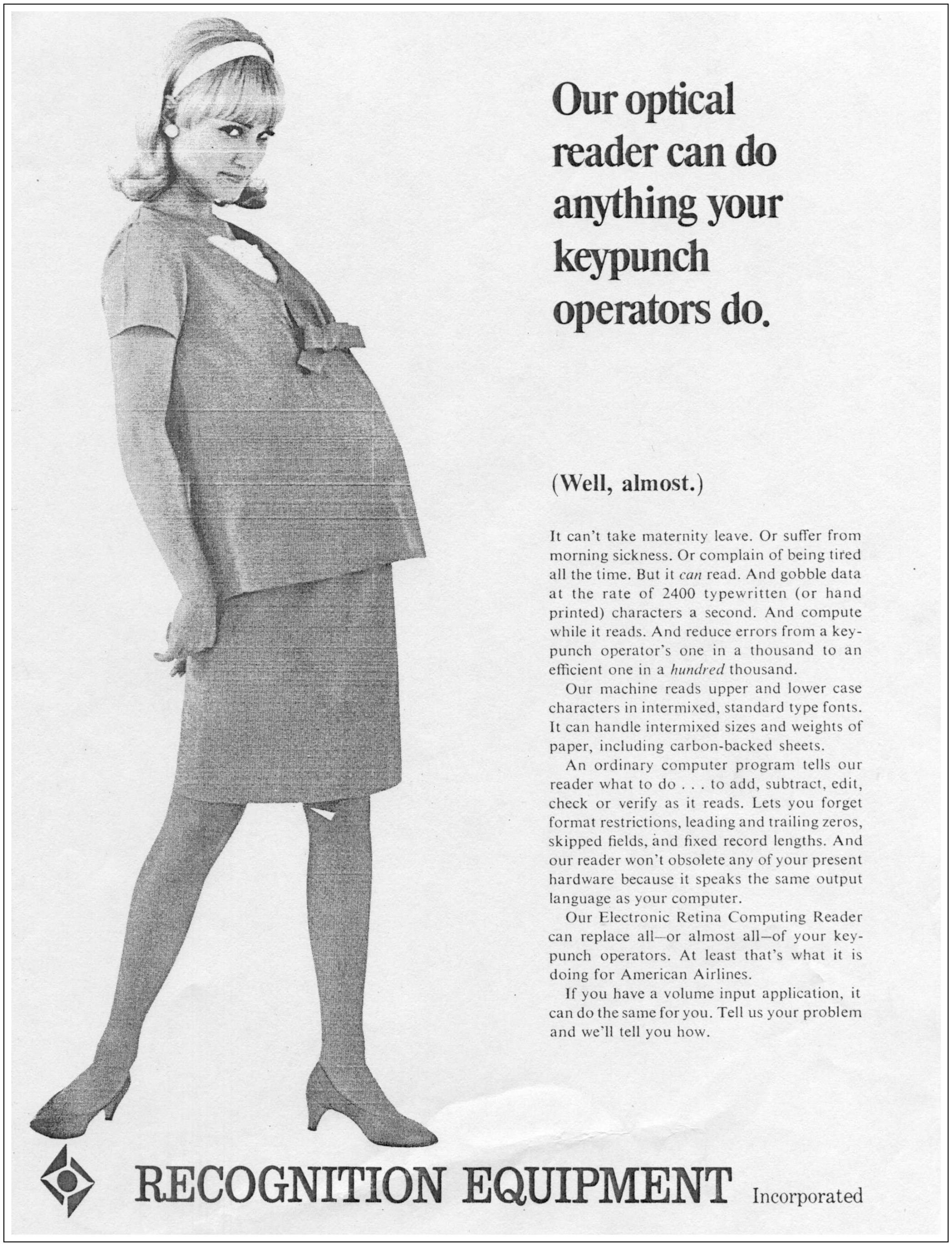

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Figure 1: Datamation Magazine Advertisement, 1967: The occupation of keypunch operator was aggressively mechanized during the late 1960s and early 1970s.

blocking and buffering support for applications and keeping careful measurements of the resource utilization of each job for billing and analysis purposes. There was also the even-higher level work of managing the job queue: making sure that the machine was being run efficiently and at full capacity; prioritizing jobs according to a range of criteria (including the organizational/political), and interacting with users.

The question of whether or not computer operators were skilled laborers is an important one. It is easy in retrospect, because so much of the work of these operators has been automated or mechanized, that, like keypunch operators, computer operators were at best semi-skilled workers, a transitional phase in the evolution of entirely electronic computer oriented data processing. But it was clear that these operators were considered skilled users. Consider, for example, the following list of criteria identified as the essential performance characteristics of an IBM 7094 operator:

1. Ability to program.
2. Ability to distinguish between machine malfunction, program error, and operator error and pinpoint the source of the problem.
3. Ability to handle nonroutine jobs with facility.
4. Ability to use the most efficient sequence in processing a job.
5. Demonstration of concern for each individual job — and the ability to pursue problems to the utmost.
6. Will seek out work upon completion of a job.
7. Ability to explain operations to others.
8. Follows computer center procedures to the letter but is not content with maintaining status quo — uses ingenuity in suggesting and implementing new procedures or modes of operation.
9. Ability to get along with others.
10. Ability to work quickly and accurately under pressure.
11. Retentive memory and ability to recall that which has been learned and apply or implement.
12. Ability to handle large volumes of tape, paper, and cards carefully.[13]

This fairly extensive list of desiderata included both technical knowledge and social, organizational, and managerial skills, and could have applied almost equally

[13] Bruce F. Gordon and Richard A. Dennis. “Characteristics and performance predictors of 7094 computer service operators”. In: *SIGCPR ’66: Proceedings of the fourth SIGCPR conference on Computer personnel research*. Los Angeles, California: ACM Press, 1966, pp. 96–103.

well to what are generally considered the higher-order occupations associated with computing, such as systems analysis and computer programming. In fact, in the technical literature on personnel research from this period, the work of computer programmer and computer operator were often conflated.[14] Although programming was widely regarded to be the more complex and intellectually challenging activity, both occupations were considered skilled technical work with a strong creative and organizational component.[15] The same types of aptitude tests that were developed for computer programmers (and used by the vast majority of companies in this period for personnel selection) were developed for computer operators.[16]

## Automating Operations & Automatic Operators

Because operational costs absorbed such a large part of most organization's computer budget and, like software development, but in stark contrast to hardware, were constantly increasing, both computer manufacturers and users began looking almost immediately for ways to reduce these operational expenses, through the automation or routinization of labor.[17] In the case of computer operator, these efforts were embodied technologically in the development of the operating system. As Atsushi Akera has ably described elsewhere, the organization of IBM users, called SHARE, began working on one of the first significant operating system (or "automatic operators," as it was known at the time) in the late 1950s, in a deliberate attempt to routinize and automate the labor of operators.[18]

[14] *Perspectives on Testing for Programming Aptitude*. Vol. Proceedings of 1971 ACM Annual Conference. Association for Computing Machinery New York, 1971, pp. 268–277; *Development of computing professionals*. Vol. Proceedings of the tenth annual SIGCPR conference. 1972, pp. 104 –122.

[15] *Analysis of careers for Georgia youth in computer occupations, 1971-76*. Vol. Proceedings of the eleventh annual computer personnel research conference. ACM Press, 1973, pp. 62–79; W. J. McNamara. "The selection of computer personnel: past, present, future". In: *SIGCPR '67: Proceedings of the fifth SIGCPR conference on Computer personnel research*. College Park, Maryland: ACM Press, 1967, pp. 52–56.

[16] Lawson, op. cit.; George P. Hollenbeck and Walter J. McNamara. "Cucpat and Programming Aptitude". In: *Personnel Psychology* 18.1 (1965), pp. 101–106.

[17] *Management controls for effective and profitable use of EDP resources*. Vol. Proceedings of the 1966 21st national conference. 1966, pp. 201 –207.

[18] Atsushi Akera. "Voluntarism and the Fruits of Collaboration: The IBM User Group, Share". In: *Technology & Culture* 42 (2001), pp. 710–736; Atsushi Akera. *Calculating a natural world: scientists, engineers, and computers during the rise of U.S. cold war research*. Cambridge, Mass.: MIT Press,

Operating systems took over some, but not all, of the work of computer operators. Certain tasks, such as job scheduling and the loading of subroutines and libraries, could be effectively automated. Other, more physical tasks, such as mounting tapes or loading punch card desks, continued to require human labor (albeit much less skilled human labor). But other aspects of operating a computer, such as communicating with users, determining and organizing priorities, and, above all, making efficient use of computing resources, were more difficult to construct into a software-based operating system. For example, managing computer time, the key concern of all computer operators in a period when expense and constraints of computer hardware demanded that every available moment be used productively (in order to amortize initial capital costs), was to make sure that there was no "dead time" on the computer.[19] Early operating systems made it difficult to computer centers to monitor the operations of the computer. In describing the development of the Weyerhauser Operating System (WECOS), Charles Bachmann described the problems associated with its lack of feedback mechanisms:

> "This used to drive the computer room operators wild. They look at the IDS machine and it just sat there, blinking. These were the days when computers had blinking lights on the front of them. They would blink fast, so you couldn't really tell what's going on. The operators would ask, "What if it's in a loop? How do I know?" You couldn't tell anything, just standing looking at the machine."[20]

Eventually Bachman introduced a system that connected an IBM Selectric typewriter to the powerful GE-235 computer that ran the WECOS operating system. Every hour the Selectric would print out a list of the current job queue, and it was assumed that if the job queue was different every hour, then the system must have been operating correctly.[21]

Ultimately, of course, automated operating systems do take over much of the work of computer operators. [Although it should be noted, however, that as late

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[19] Bruse Moncreiff. "An automatic supervisor for the IBM 702". In: *Papers presented at the February 7-9, 1956, joint ACM-AIEE-IRE western computer conference*. San Francisco, California: ACM, 1956, pp. 21–25.

[20] Thomas Haigh. "Charles Bachman interview: 25-26 September, 2004; Tuscon, AZ". In: *ACM Oral History interviews*. New York, NY, USA: ACM Press, 2006, p. 3.

[21] Ibid.

as 2006 there were still more than 100,000 computer operators employed in the United States alone, and that although the job title of computer operator might be disappearing, there are still many tapes that need to be changed, printers that need to be filled with paper, and hardware resources that need to be managed.[22]] But the fact that an occupation has been effectively automated out of existence does not make its history irrelevant or insignificant. The fact is that for much of the first several decades of the 20th century "Computer Revolution" labor issues, work processes, and organizational innovations — and not equipment costs or hardware innovations — served as the focus of some of the most contentious debates about the proper role of electronic computing in the modern American corporation. The history of corporate computerization efforts are often seen as being the story of the automation of white-collar labor, but it is not always clear what labor is being automated, and why, and for what purposes. There were often as many new jobs created as were eliminated by the computer: different jobs, to be sure, and jobs done by different kinds of people, but jobs nevertheless.

## Conclusions

My exploration of the transition from computer operator to operating systems is still at a very early stage, but what I have discovered so far suggests at least three important lessons or challenges:

The first is that there is a great deal more to be uncovered about the labor history of computing: not only do we need more detailed studies of the more familiar categories of labor (programmers, systems analysts, data processing supervisors), but we also need to develop new categories (or rediscover the categories of our historical actors). The fact that 2 of the 3 largest groups of computer workers — keypunch operators and computer operators — have been so infrequently mentioned in the historical literature is surprising, to say the least.

A second and closely related lesson is that computing is a much more human activity that we might otherwise imagine, even in the era of electronic computing. There were hundreds of thousands of computer workers employed in the first two decades following the invention of the electronic computer, and the "human element" in computing was frequently identified by contemporaries as *the* critical challenge facing the future of the commercial computing industry.[23]

[22] Bureau of Labor Statistics, 2006

[23] B. Conway, J. Gibbons, and D.E. Watts. *Business experience with electronic computers: a*

Finally, like all technological systems, an operating system is a social and political artifact. It is quite clear from even this brief history of computer operators that the conception and development of operating systems were framed in explicitly human terms, and to accomplish particularly human agendas. Atsushi Akera, for example, has suggested that operating systems "transformed the social relations between a computing center and other units within the firm."[24] Specific operating systems privileged different types of users, priorities, professional identities, and organizational structures. It has been much to easy to view the evolution of the operating system through the technologically deterministic lens of our historical actors, or using the categories imposed by contemporary computer scientists. Focusing on labor, laborers, and labor practices will allow us to capture the politics of this particular artifact, and provide an important and much needed tool for integrating a history of software systems into the larger history of computing.

*synthesis of what has been learned from electronic data processing installations*. Price Waterhouse New York, 1959; Rolf Rogers. "The Human Element in Systems and Consulting Work". In: *Personnel Journal* 46.8 (1967), pp. 516–519; Nathan Ensmenger. *The "Computer Boys" Take Over: Computers, Programmers, and the Politics of Technical Expertise*. MIT Press, 2010.

[24] Akera, "Voluntarism and the Fruits of Collaboration: The IBM User Group, Share".