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Finding a Story for the History of Computing

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Finding a Story for the History of Computing

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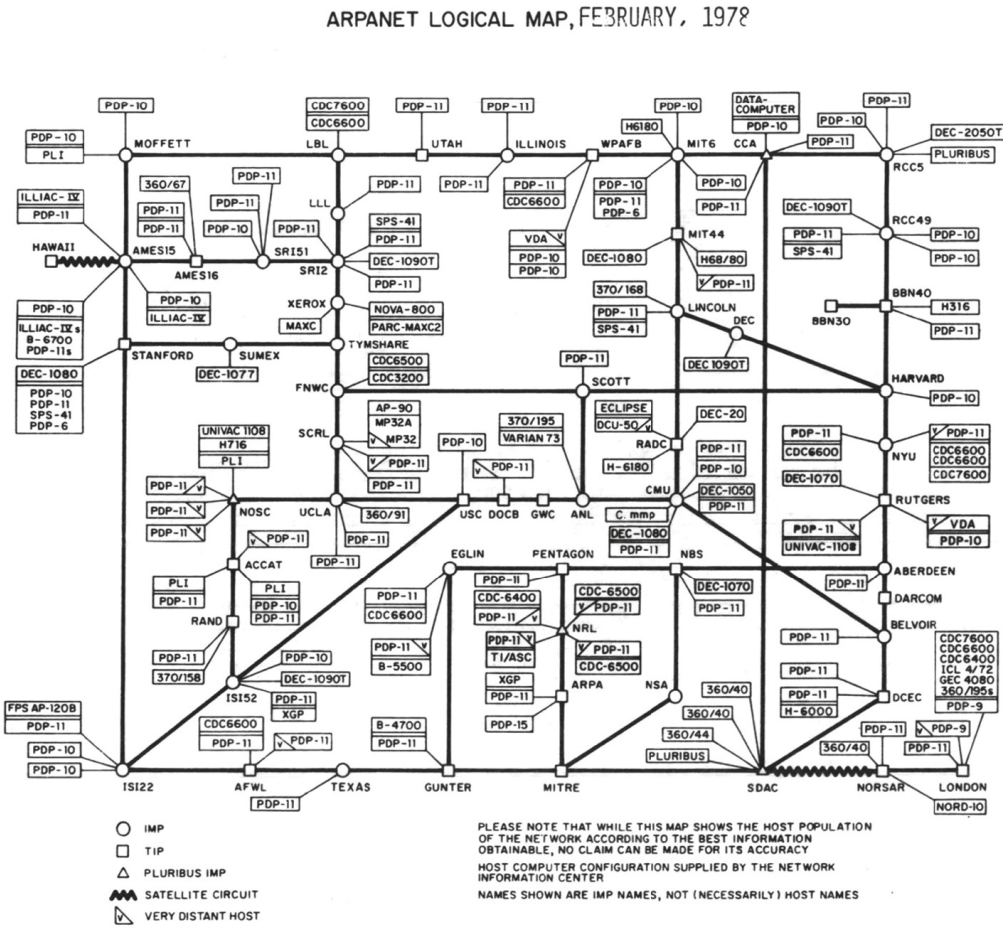

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As I write this I am almost half way through the process of collaborating with Paul Ceruzzi to produce a new and extensively revised manuscript for his book *A History of Modern Computing,* an authoritative and widely relied on historical overview of a vital topic. This will be published by MIT Press, probably as a third edition although we have discussed the possibility of tweaking the title to something like *A New History of Modern Computing.* We started at the beginning of 2017 and our contract states that we will deliver an initial draft for review by the end of 2018 and a final version ready for copyediting in the summer of 2019. The midpoint of the project is a good place from which to explain what we are trying to achieve and to talk about the challenges and opportunities of trying to tell the history of computing as a new kind of story.

Finding a Story for the History of Computing

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Abstract Thomas Haigh is working with Paul Ceruzzi of the National Air and Space Museum in Washington, D.C., on an expanded and completely reorganized version of Ceruzzi's classic monograph *A History of Modern Computing.* Haigh discusses the challenges involved in producing a one volume history of a uniquely flexible technology. Since the first edition of the book was published twenty years ago our sense of what the computer is for has shifted utterly, to encompass media consumption, personal communication, and shopping as well as the traditional activities of business administration and scientific number crunching. To reflect this, Ceruzzi and Haigh are adopting a new structure, in which each chapter of the book tells the story of how "the computer" becomes something different through its interaction with a particular set of users and applications. Haigh connects this structure to the work of historian Michael S. Mahoney, and his discussion of the "Histories of Computing(s)." He ponders the particular difficulty of avoiding a simplistic narrative of historical progress, often called a "whig history," in summarizing the evolution of a technology whose spectacular technical improvement has come to define our idea of modernity. Haigh also discusses Ceruzzi's text in relation to other comprehensive histories of computing, the production process of the new edition, and some of the editorial choices involved in a project of this kind.

Keywords History of Computing, Paul Ceruzzi, Michael S. Mahoney, Media History, Moore's Law, Internet History

Master Narratives for the History of Computing[1]

What is the history of computing the history of? This question, above all others, must be answered by anyone attempting to write a comprehensive history of computing. The accepted answer to that question has changed over time.

Historian Michael S. Mahoney, who posed the above question in one form or another in many of his papers, observed in this context that "nothing is really unprecedented. Faced with a new situation, people liken it to familiar ones and shape their responses on the basis of the perceived similarities."[2] The search for precedent is also a search for a narrative. Humans make sense of the world by telling

1 Portions of this section are adapted from Thomas Haigh, "The History of Information Technology", *Annual Review of Information Science and Technology* 45 (2011): 431–487.

2 Michael S. Mahoney, "The Roots of Software Engineering", *CWI Quarterly* 3, no. 4 (1990): 325–334, here 326.

stories to themselves and each other, and so to understand and explain the first electronic computers it was necessary to package them inside a story.[3] The computer's history has been told for as long as there have been computers. As historical work necessarily takes place sometime after the events concerned, we can trace the spread of computer technology in the changing narratives of the history of computing. The lag appears to be two or three decades.

The most obvious understanding of the early computer was a calculating machine, literally as something performing computations. It was seen as a natural evolution of earlier calculating devices such as the hand cranked calculators widely used in business.[4] The most important early edited volume on the history of computing, *A History of Computing in the Twentieth Century,* was prepared by members of the Los Alamos scientific computing staff.[5] The first textbook for computer history, *The Computer from Pascal to von Neumann*, was a mixture of historical research and memoir from a close collaborator of von Neumann.[6]

Another answer is that the computer is an "information machine". This narrative was first adopted by Edmund Callis Berkeley's classic 1949 book *Giant Brains, or Machines that Think*. This was the first popular treatment of the new technology, providing an introduction to the hitherto obscure world of computing to a generation of impressionable youngsters. He described computers of the 1940s such as the ENIAC, MIT's differential analyzer, and the series of machines built by Harvard and Bell Labs in some detail. Berkeley called the computer a giant brain not because it could think but because it "can handle information with great skill and great speed." (p. vii) This sense-making narrative was much more novel at the time, though it has since become a cliché. In this context the digital computer was precedented by earlier machines and systems for handling information, such as nerve cells, cave paintings, beads on strings, and human language (p. 10–13). But in "a deep break from the past," it could transfer "information from one part of the machine to another [with] flexible control over the sequence of its operation." (p. 5) In other words, it could execute a program.[7]

That framing of the computer was endorsed, rhetorically at least, in the subtitle of *Computer: A History of the Information Machine* by Martin Campbell-Kelly and William Aspray. First published in 1996, this remains one of the two standard histories relied on today by readers and instructors looking for a well-balanced, comprehensive, and reliable overview. By the 1990s scholars began to explore its administrative use and situate it in the context of earlier technologies like punched card machines and typewriters. *Computer* echoes this perspective. On its publication the book's most novel feature was its insistence on the computer as primarily a tool for administrative coordination rather than scientific calculation. (In other words, its framing had caught up with the world of the 1960s rather than remaining in the 1940s). Although accessible, it is not simplistic, and nicely summarizes and connects key insights and stories from the secondary literature as it had developed to the early 1990s.

Computer exemplifies the tendency of overview histories of computing to produce coherent narratives by exploring only one kind of computer platform in each time period: typically mainframes up to 1965, minicomputers from about 1965 to 1975, personal computers from 1975 to the mid-1990s, and the Internet since then. That is misleading, as existing computing platforms never go away and never stop being important. IBM still earns a significant share of its profits from its mainframe business, and minicomputers were much more important in the early 1980s, after personal computers were invented, than in the late 1960s. As we move closer to the present, this approach becomes even less satisfactory. Smartphones did not make other platforms go away, and the Internet can be traced further back in time than the IBM PC. In fact, the rise of cloud computing has been underpinned by the evolution of personal computer technology into the new building block for giant server farms and supercomputers.

The other major overview history of computing is the book that I am currently working with Paul Ceruzzi to revise. *A History of Modern Computing* was written in parallel with *Computer* and published shortly afterwards.[8] It might be hard for me to give an unbiased description of a text that I am now so intimately intertwined with. Some years ago, when comparing the two books, I wrote that "Ceruzzi's book has less to say about applications, and skips the digital computer's forebears completely to launch

3 Karl E. Weick, *Sensemaking in Organizations* (Thousand Oaks, CA: Sage, 1995).

4 Most notably in Michael R. Williams, *A History of Computing Technology* (Englewood Cliffs, NJ: Prentice-Hall, 1985).

5 Nicholas Metropolis, Jack Howlett, and Gian-Carlo Rota, eds., *A History of Computing in the Twentieth Century: A Collection of Papers* (New York: Academic Press, 1980).

6 Herman H. Goldstine, *The Computer from Pascal to von Neumann* (Princeton, NJ: Princeton University Press, 1972).

7 Edmund C. Berkeley, *Giant Brains or Machines That Think* (New York: John Wiley & Sons, 1949)

8 Paul E. Ceruzzi, *A History of Modern Computing* (Cambridge, MA: MIT Press, 1998).

the story in the mid-1940s. Ceruzzi provides more detail on the architectural development of computers and better coverage of the minicomputer, which he argues for persuasively as the source of today's personal computing technologies. His book focuses more on technical history and has a somewhat more episodic structure."[9] *A History of Modern Computing* offers some well-researched case studies of computer use, but at its heart is the story of the development of the computer itself into an interactive partner of mankind.

Both books have been updated—*A History of Modern Computing* in 2003 and *Computer* in 2004 and 2014 (with the addition of Nathan Ensmenger and Jeffrey Yost as coauthors). These updates focused, as one would expect, on adding new material to better cover the Internet and the web. Neither book has as yet fully assimilated newer conceptions of the computer—which today is experienced more often as a media player, communication device, or control system than as a business tool or scientific calculator. Neither has much to say on the evolution of the personal computer after the mid-1980s, on video games, or on mobile computing. They have less to say about software than a modern reader might expect, with both books cloistering the topic in a chapter of its own (Chapter 3 of *A History of Modern Computing* and Chapter 8 of *Computer*) rather than integrating software into the main narrative.

Although those books were written more than twenty years ago and a great deal has changed in the meantime, there have been no serious attempts to challenge them. Walter Isaacson's startlingly old-fashioned but inarguably popular story of brilliant inventors, *The Innovators* (2014), must be outselling both by several orders of magnitude, but it is a different kind of book.[10] Strong overview business histories have appeared of specific sectors, most notably Martin Campbell-Kelly's history of the software industry and Jeffrey Yost's books on the computer industry and the computer services industry.[11] There have been a couple of highly-compressed histories, most notably Ceruzzi's own *Computing: A Concise History* and others written to be accessible to high school students.[12] Books continue to appear about the very early history of electronic computing, including George Dyson's engagingly and frustratingly eccentric *Turing's Cathedral*, and a shelf full of recent books that are (unlike Dyson's) actually about Turing.[13] But in the realm of full-length synthetic history, the duopoly of *Computer* and *A History of Modern Computing* has endured.

This is a testimony to their considerable strengths and makes the prospect of reworking one of them a daunting challenge. *A History of Modern Computing* currently has 1,282 citations tallied by Google Scholar. That's more than any other overview history of computing, and more than everything else I've written in my career combined. More people have cited *A History of Modern Computing* than have purchased most academic press books. For many people, such as students assigned it for class, it will be their first and only exposure to scholarly history of computing, particularly if they don't enjoy the experience of trying to read it. We are very much aware of the responsibility we have to those readers: to justify their trust by producing a balanced, engaging, and reliable book.

Covering New History

So what are readers of the current edition looking for? To judge from their comments, they continue to enjoy the book, but are eager above all to see its story continued into the current century. For example, a positive (four star) 2016 Amazon review calling the book "a delightful read" nevertheless notes that the book's "closing date … seems to be a long time ago," so that topics such as the commercial Internet, smartphones, and digital photography are not addressed. The reviewer observes that "'communicating,' 'doing work' and 'having fun' are at the core of today's computer applications, and these central uses do not emerge from Ceruzzi's history of manufacturers and model numbers."[14] The reviewer issued us a number of challenges and the new structure of the book addresses them by bringing the book's coverage of computing fully up to date, and by restructuring the work

9 Thomas Haigh, "The History of Information Technology", *Annual Review of Information Science and Technology* 45 (2011): 431–487, here 339–340.

10 I've discussed some the limitations of Isaacson's view of history in Thomas Haigh and Mark Priestley, "Innovators Assemble: Ada Lovelace, Walter Isaacson, and the Superheroines of Computing", *Communications of the ACM* 58, no. 9 (Sep 2015): 20–27.

11 Jeffrey R. Yost, *The Computer Industry* (Westport, CT: Greenwood Press, 2005). Martin Campbell-Kelly, *From Airline Reservations to Sonic the Hedgehog: A History of the Software Industry* (Cambridge, MA: MIT Press, 2003).

12 Paul E. Ceruzzi, *Computing: A Concise History* (Cambridge, MA: MIT Press, 2012). Eric G. Swedin and David L. Ferro, *Computers: The Life Story of a Technology* (Westport, CT: Greenwood Press, 2005) is an example of an overview history aimed at high school students.

13 If you want to know more on my opinion of Dyson's book, you'll find it at https://sinews.siam.org/Details-Page/an-unconventional-history-of-the-early-ias-computer.

14 Review by Paul F. Ross, May 7, 2016. https://www.amazon.com/History-Modern-Computing/dp/0262532034/ref=mt_paperback?_encoding=UTF8&me=.

around the co-evolution of computing platforms with new applications, from scientific computation to video games and personal media consumption.

The first edition was written during the early- and mid-1990s. Its narrative stopped in 1995 with Netscape's IPO, but other than a few pages on the Internet, it did not have much to say about events after the mid-1980s. Even if we take 1945 as the origin of the first edition (the story nominally starts a little later than that with the first Univac, but much of the first chapter consists of flashbacks) and 1995 as its end point then its text covered fifty years in 400 pages. The new edition runs from 1943 to 2018—a span of seventy-five years. So, by this crudest of measures, we have about 50% more history to cover.

The last four chapters of the new book will consist of almost entirely new material covering events since about 1990:

- Chapter 10: "The Personal Computer Grows Up," looks at the maturing of personal computer hardware and software to replace other computing categories such as graphical workstations, minicomputers, and even supercomputers.
- Chapter 11: "The Computer Becomes a Media Device," looks at the digitization of media consumption, with the addition of multimedia capabilities and 3D graphics to conventional personal computers, the rise of on-demand streaming video, and the integration of embedded computers in digital cameras and digital audio players.
- Chapter 12: "The Network Becomes the Computer," focuses on the commercialization of the Internet and the rise of the World Wide Web as a universal platform for electronic publishing, online commerce, interactive applications, and media delivery.
- Chapter 13: "The Computer Is Everywhere and Nowhere," looks at the growth of new, mobile networked computing platforms such as smartphones and tablets. These have largely subsumed the brief proliferation of specialized gadgets such as GPS receivers and personal digital assistants.

Rebalancing Coverage of Older History

In addition to covering developments since 1990 that were, for obvious reasons, missing from the first edition, we will be rebalancing coverage of events during earlier period. As in any area of history, from the vantage point of a different present we see new things in the past. This is a good moment to attempt a revision as, for the first time, we are starting to get some historical distance on the idea of "the computer" itself.

The second edition left most of the first edition unchanged, but added a bonus chapter consisting of an essay on three crucial tends of the late 1990s: Java, the Microsoft antitrust trial, and the commercialization of the web. Things were changing rapidly back then, and figuring out which developments really mattered was very difficult. Paul acknowledged this when he featured Zeno's Paradox prominently in his introduction to the second edition: "There is a finite time between sending a completed manuscript to the typesetter and the delivery of a book or journal article to the reader. When the subject is computing, Zeno's paradox takes control: enough happens in that brief interval to render what was just written obsolete."[15] Computing was changing so fast that no history could ever get to the present day, however hard its author tried to close the distance. Trying to close that distance carried its own perils. The new chapter he added for the second edition now seems much more dated than anything else in the book, precisely because it dealt with material from which he had no historical distance. Paul was clear that repeating this process by adding another chapter or two onto the end of the book covering social media and smartphones wouldn't be enough to bring it up to date. Something more fundamental was needed.

In a way, our position is easier now. Technology has not stopped changing, but the innovations are coming mostly in new applications of the Internet. Today's big technology news stories still have a lot of drama: Will Uber ever become profitable? Can Tesla build all the cars that people have ordered quickly enough to keep investors under its spell? Will Facebook find an algorithm to stop Russia from spreading fake news? Yet none of those stories need to be resolved in our book for us to sketch the technology and platforms that underlie mobile apps, self-driving cars, and cloud-cased social media platforms. The story of "the computer" now seems like something with a recognizable end as well as a clear beginning. Computers were big boxes with lights and switches, into which people plugged peripherals like disk drives, monitors, and keyboards. Over time the boxes got smaller and their capabilities changed, but "computer" was a fairly robust category from the 1940s all the way to the early 2000s. Even when laptops came along, people recognized them as miniaturized and portable versions of the computer that used to sit on or under their desks.

From the viewpoint of the computer scientist, there are more computers around than ever. Smartphones are computers, and so are televisions, tablets, thermostats, GPS systems and dozens of other things in cars, Fitbits, smart watches, cameras, and

15 Paul E. Ceruzzi, *A History of Modern Computing* (second edition, Cambridge, MA: MIT Press, 2003): ix.

Bluetooth speakers. But nobody ever pulled out their cellphone to send a text and said "I need to do some computing" or invited a prospective sexual partner over to "compute and chill" with a streaming movie. The amount of time people spend using devices they conceptualize as computers is dropping. That's why our working title for the final chapter is "The Computer is Everywhere and Nowhere."

The ARPANET was only briefly mentioned in the original text. In the new edition it will be the centerpiece of a chapter called "The Computer Becomes a Communications Medium." However, we are also alert to the dangers of Whig history—the same chapter will include online services, bulletin boards, BITNET, USENET, Minitel, and the other forms of online communication that were more representative of computing practice in the 1970s and 1980s. One of the benefits of a collaboration is that we can counterbalance each other's idiosyncrasies. Looking closely at the text together, we realized that some things that fitted implicitly in Paul's narrative should appear more explicitly. For example, Seymour Cray popped up at several points, but the book never described his iconic Cray 1 or its influential use of vector processing. The Whirlwind computer was frequently alluded to, but its novel features and the SAGE project it gave rise to were not fully explored.

Any one volume history of computing is still going to be eclectic to some extent. When Paul wrote the first edition in the mid-1990s, he faced the challenge of writing a synthetic history of a gigantic and amorphous topic with an underdeveloped literature. So did Martin Campbell-Kelly and Bill Aspray when they wrote the first edition of *Computer*. They dealt with the problem differently. *Computer* came out during my time in graduate school. I read it after I had done most of my coursework but before I really delved into my dissertation research. The specific assortment of topics seemed idiosyncratic in places, but a little later when I spent a few days methodically flipping through the entire run of *Annals of the History of Computing* (and several months with the rest of the secondary literature), I realized that the contours of that book closely followed that of the literature from which it had been synthesized. Things like SAGE, SABRE, and the IBM System/360 were there not just because they were historically important, but also because they had been written about.

Paul relied less on the secondary literature, though there are parts of his book that stick closely with stories told; for example, in the monumental IBM histories produced by participants.[16] There are many places in the book where he draws on original research carried out for the book, or oral history interviews. That meant that his story included some things, like the history of minicomputers, UNIX workstations, or SDS timesharing computers, which had not been adequately treated in the existing literature. In the 20 years since he finished the first edition, a lot of gaps in the literature have been filled, which is going to let us put coverage of topics like Plato, Multics, SAGE, and ENIAC on a stronger basis by engaging with and summarizing the conclusions of the people who have researched them. The book should provide pointers to the excellent scholarship being produced in the history of computing community, mentioning authors in the text as well as the footnotes where appropriate.

There are also some historical perspectives that have become more prominent in the history of computing since the mid-1990s. One of these is the study of gender (including masculinity). We are engaging with this in parts of the book, such as the coverage of ENIAC and the famous "hacker ethic" of MIT in the 1960s. Another is the study of labor, which we'll be looking at particularly in the chapter on the history of business data processing and in later discussion of the use of word processors.

Is A One Volume History of Computer Use Even Possible?

The new book will have thirteen narrative chapters. As we looked through the existing text, reading it closely for the first time in more than a decade, we realized that the existing chapter structure was not holding up as well as Paul's original selection of topics and analysis had. Pulling apart the selection of topics within each chapter, we weren't always sure why they were grouped together or why one topic followed another. In some places the chronology was confusing, and some things were dealt with in two separate places. As Paul was already committed to doing more than just adding new chapters, we decided to impose an entirely new chapter structure on the existing material as well as on the five chapters dealing primarily with new topics.

A strict chronological organization with five years covered in each chapter would have been the easiest way to do this. Looking up the date on which something occurred would tell us which chapter it was part of. But we don't think it would have been an interesting or informative book to read—to update the reader on what happened within each area between, say, 1975 and 1980, we would have had to constantly cycle between areas such as minicomputing, scientific supercomputing, business data processing, and personal computing.

That structure would also have made it very hard to engage with computer users and use practices,

16 Charles J. Bashe et al., *IBM's Early Computers* (Cambridge, MA: MIT Press, 1986) and Emerson W. Pugh, Lyle R. Johnson, and John H. Palmer, *IBM's 360 and Early 370 Systems* (Cambridge, MA: MIT Press, 1991).

which have become increasingly central to scholarly work on the history of computing during the twenty years since the first edition appeared. Back in 2001 I was a graduate student getting my first articles ready for publication. At that time, I was grappling with the tension between the hardware-centric, produced-oriented overview histories of computing and the belief among historians of technology that good history would focus on users and follow the mainstream of US history by putting analysis of class, race, and gender at the center of its analysis. Another central commitment of practice-based history of technology is to look at practices and users before and after the introduction of new technologies, which tends to show significant continuities. As I wrote in my article "The Chromium-Plated Tabulator" on the early transition from punched card technology to computers in administrative data processing:

> "The next stage in our exploration of the history of computing must take us beyond the suppliers of computer technology and into the firms and occupations using it. By examining the crucial initial shift from punched card to computer, in the context of historian Ruth Schwartz Cowan's "consumption junction" (the place where technology meets user), we find new dimensions of continuity and discontinuity in usage to complement those in technology, distribution, and production already explored by historians."[17]

The point of quoting myself here is not to glory in my own foresight, but rather to illustrate that I have painted myself into a corner when it comes to a project of this kind. I have always believed that these stories of use and practice are central to understanding the history of computing, and that these stories are specific to different communities and social settings, and so are hard to accommodate within any overview history of computing. I warned that:

> "The use of computer technology in a particular social space (such as the laboratory, office, or factory) cannot be addressed without also studying the earlier history of this setting, the people in it, and the objectives to which the machine is put. So, while coherent one-volume histories of the computer hardware industry and its technologies can be written, it seems unlikely that we can produce a single coherent narrative about the use of computers or of associated tasks such as analysis, programming, or operation."[18]

For example, the story of computer use is often told as one in which women were initially dominant as the programmers of ENIAC but were somehow pushed out from programming work by the 1960s. In "The Chromium-Plated Tabulator," I argued that the ENIAC experience, which built on the established practices of applied mathematics, was not directly relevant to the construction of programming in data processing work where it "evolved at the fuzzy interface between punched card machine operation (a predominantly masculine activity) and systems and procedures analysis (an almost exclusively masculine one)."[19] In contrast, one might expect to see a direct legacy of ENIAC's use of female labor in scientific computing centers, such as Bell Labs, and in the software groups of computer manufacturers.

Returning to the question I posed at the opening of this essay, the problem with a one volume history of computing is that no single answer to the question "what is the history of computing the history of" can any longer seem satisfactory. To fill in the arc of history needed to frame the computer in one way, for example, as a business machine, is to forgo the opportunity to frame it in another way, for example, as a media device. It seems arbitrary to talk about filing cabinets but not televisions, or about calculators but not about pinball machines. As I wrote in 2011 in a review essay titled "The History of Information Technology":

> "Understanding the history of information technology does indeed involve looking at the replacement of one technology by another and its use within particular applications. But the most satisfactory way to do this would be to focus on a single social sphere (school, office, hospital, library) and examine changes in the type, use, cultural understanding of, and management of the information technologies found there over a particular period. A one volume history of computer technology or the computer hardware industry would be hefty but conceptually unproblematic, but a one volume synthetic history that takes the use, work, and social dimensions of information technology seriously is probably impossible given the proliferation of computer technology in recent decades. Think of the precursor technologies one would have to integrate. Computers (whether free standing or embedded in consumer electronics) have replaced record players, walkmen, analog television receiv-

17 Thomas Haigh, "The Chromium-Plated Tabulator: Institutionalizing an Electronic Revolution, 1954–1958", *IEEE Annals of the History of Computing* 23, no. 4 (Oct–Dec 2001): 75–104, here 75.

18 Ibid., 95.

19 Ibid., 96. Having since learned a great deal more about ENIAC, I still believe that gendered practice in applied mathematics has little direct influence on gendered practice in data processing, and the social worlds of data processing and scientific computing were almost entirely separate in the 1950s. However, I no longer accept that "programmer" fully captures the work of the six women hired in mid-1945 to operate ENIAC. See Haigh, Thomas, Mark Priestley, and Crispin Rope. 2016. ENIAC In Action: Making and Remaking the Modern Computer. Cambridge, MA: MIT Press.

> ers, and video cassette recorders. Books, newspapers, and conventional telephones now appear endangered. In the office they have replaced typewriters, adding machines, bookkeeping and billing machines, duplicating machines, letters, memos and carbon paper. File cabinets are vanishing, and in recent years the amount of paper used in American offices has finally begun to diminish. Computer networks are central to every kind of business operation, and play an increasingly vital role in our social lives and personal communication. Databases, automatic data capture, modeling, and statistical analysis capabilities have transformed practice in almost every area of science. Even the game of solitaire has been remade as a shuffling of mice rather than of playing cards."[20]

I am again quoting myself at length to emphasize my current problem rather than my previous brilliance. I now find myself working with Paul to produce a one volume history that takes users and the many different kinds of computing practice seriously, something I predicted in 2001 that "we are unlikely to produce" and reiterated in 2011 was "probably impossible."

Multiple Computings

When pondering how to tackle this impossible mission, I had at the back of my mind a passage in another paper by Mahoney called "The Histories of Computing(s)."[21] He proposed a new model for the history of computing, which he called the "communities of computing" approach.

The argument behind Mahoney's diagram (fig. 1) was that the parallel stories of the communities of computing should be told separately, looking in each case at their practices before and after the introduction of computer technology. Indeed, we cannot hope in one book to do justice to the stories of all these domains of use, as *Computer* does with business administration. To follow the path of each community before and after the horizonal bar that Mahoney labelled simply as "computers" would take 12 books, not 12 chapters.

In that paper, Mahoney was in dialog with my critique of the viability of a single narrative of computer use, which he quoted. He followed that quote with a provocative suggestion:

> "As [James W.] Cortada, Haigh, and [Jon] Agar suggest, the histories and continuing experience of the various communities show that they wanted and expected different things from the computer. They encountered different problems and levels of difficulty in fitting their practice to it. As a result, they created different computers or (if we may make the singular plural) computings."[22]

This insistence that in the course of tackling their problems, different communities "created different computers" and "computings" was a crucial inspiration for the structure of the new edition. Mahoney's declared interest was in the programming work needed to transform what he called the "protean machine" of the modern computer into a useful tool within each community. He continued, "To do so, they had to determine which aspects of their practice were suitable for automation, they had to build computational models of those aspects, and they had to write the programs that implemented those models."[23]

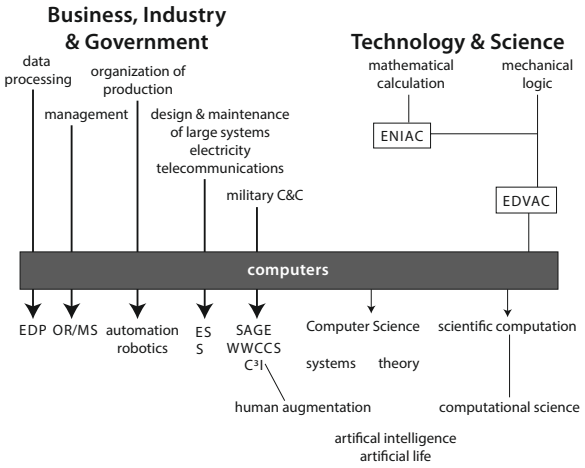

Fig. 1: Diagram from Michael S. Mahoney, "The Histories of Computing(s)", *Interdisciplinary Science Review* 30, no. 2 (2005): 119–135, redrawn by Thomas Haigh.

Our goals are a little different from Mahoney's, and we are taking the idea that "different computers" were created for and by different communities somewhat more literally. We are interested in how hardware and software were both reshaped to meet the needs of particular user communities, and in how those innovations then became part of computing as

20 Thomas Haigh, "The History of Information Technology", *Annual Review of Information Science and Technology* 45 (2011): 431–487, here 441.

21 Michael S. Mahoney, "The Histories of Computing(s)", *Interdisciplinary Science Review* 30, no. 2 (2005): 119–135. The paper gave its name, in slightly modified form, to the collection of Mahoney's papers I edited after his death. Michael S. Mahoney and Thomas Haigh (ed.), *Histories of Computing* (Cambridge, MA: Harvard University Press, 2011).

22 Michael S. Mahoney, "The Histories of Computing(s)", *Interdisciplinary Science Review* 30, no. 2 (2005): 119–135, here 127.

23 Ibid., here 127.

experienced in other communities. That means we are doubling down on a distinctive feature of the existing book: its engagement with computer architecture. Architectural features originally developed to meet the needs of one kind of user, for example, Los Alamos, eventually show up in smartphones. The supercomputers themselves, with their hand-wired circuits and exotic cooling systems, never make the transition into our handbags, but a focus on architecture helps to highlight relevant connections between chapters and from the older material to the systems used by readers today.

To summarize: We haven't managed to square the circle by figuring out how to write a satisfactory one volume history of computer use. I still think that's probably impossible. What we have, I hope, managed to design is a one volume history of computing that takes the interplay of use and innovation seriously by exploring the process in which the computer is successively remade through its encounters with different communities of users. This aligns with, and was informed by, the focus of the Media of Cooperation project on publics and their relationships to the affordances provided by technological infrastructures.

Our New Structure: The Computer Becomes X

In other words, *A History of Modern Computing* does not aspire to comprehensively explain how "The Computer Changed the World."[24] It does aim to explain how particular aspects of the world changed "The Computer." Any good narrative needs a protagonist. Ours is "The Computer." Obviously there is not, and has never been, any such entity. Computers are very different from each other. Considering the range of computers in the world, it might seem to be absurd to talk about computing in this way. As well as the machines themselves differing hugely, from video game consoles to supercomputers to smartphones, their users, producers, and associated social practices and cultural meanings are utterly different. From one chapter to the next we see profound discontinuities in users and applications.

Yet there are very real continuities on the level of technology and architecture between the chapters. In our story, "The Computer" is not just a piece of hardware but a cluster of technologies and techniques—hardware, software, architectural features, programming languages, ideas, and practices. This assemblage moves from one chapter to another, accreting capabilities as it goes.

Below are the names of each chapter in our current outline plan. In each chapter something happens to "The Computer" and in most of them it "becomes" something.

- 1: Inventing the Computer (1943–54)
- 2: The Computer Becomes a Scientific Supertool (1951–1976)
- 3: The Computer Becomes a Data Processing Tool (1951–1975)
- 4: The Computer Becomes a Real Time Control System (1951–1977)
- 5: The Computer Becomes an Interactive Tool (1961–1975)
- 6: The Computer Becomes a Communications Platform (1968–1980)
- 7: The Computer Becomes a Personal Plaything (1971–1985)
- 8: The Computer Becomes an Office Tool (1972–1990)
- 9: The Computer Gets a Graphical User Interface (1973–1987)
- 10: The Personal Computer Grows Up (1984–2001)
- 11: The Computer Becomes a Media Device (1984–2003)
- 12: The Network Becomes The Computer (1980–2005)
- 13: The Computer is Everywhere and Nowhere (2000–2017)

Our protagonist, "The Computer," has a rich career full of adventures. In the first chapter our protagonist is born, or rather invented. Each chapter engages with a different domain of use within which the computer is remade. That means interacting with different users and uses in each chapter. In a sense our structure is like the parallel arrows in Mahoney's diagram: each chapter is a different community, although our communities are different. Fortunately, the book's existing text starts around 1945, so there are no chapters on Babbage, Hollerith, or early scientific computation to tie us to a single domain-specific conception of what our history is the history of.

It enters one realm of human existence after another. In each realm it becomes an essential and transformative part of technical practice, making possible things that would not otherwise be possible. As it transforms practices it is itself transformed. "The Computer" learns new tricks and is given new capabilities to meet the specific demands of its new environment. Some aspects of that transformation remain local. For example, Chapter 4 explains how the specific needs of the SAGE air defense project led to computers so large that they filled the entire floor of a building, and how NASA's hopes that the space shuttle would be a reliable "space truck" led to the installation of five redundant flight computers in

24 That's (almost) the question that Tom Misa challenged the history of computing community to explain, in the title of a review essay he composed after winning the field's only endowed professorship. Misa, Thomas J. "Understanding 'How Computing Changed the World'." *IEEE Annals of the History of Computing* 29, no. 4 (Oct–Dec 2007): 52–63.

each orbiter, any one of which could have landed it. Neither approach would translate directly into other contexts. Yet many of the technologies developed for these real-time aerospace projects did quickly become part of "The Computer." High reliability electronics, silicon chips, prioritized interrupts for real time operations, and computer graphics all made the transition from exotic novelties into core features of "The Computer" as later introduced into homes and offices. Our chapters overlap a great deal in time. For example, the second, third, and fourth chapters cover much the same time period.

Working Method & Progress

Our first step towards the new structure was to set up the new outline as a series of headings. We made a first effort on a clean sheet of paper to sketch out the chapter structure of a new history. The very first draft of this deliberately ignored the existing text entirely, as a thought experiment in what an all-new history might look like. In January 2017 I met with Paul in Siegen to go over the outline and we revised it significantly. We also cross-referenced the new outline with the existing text to see which topics were well-covered and which would need significant new material. There was a good fit between the topics that an all new history would deal with and those that Paul had already covered, making it clear that it made more sense to work with what we had than to start from scratch. At the January workshop on the "Early Digital" and at later events, we showed the evolving outline to different experts and continued to revise it in response to their feedback.

Here, as an example, is the outline from our working document for Chapter 3 ("The Computer Becomes a Business Data Processing Tool"):

- Lyons Electronic Office
- *IBM 702/5 (36–37)*
- *IBM 650 (43–44) & 1401 (73–76)*
- Data Processing Labor & Department Structure
- Sorting and Report Generation Programs
- *COBOL (91–3)*
- *RAMAC (69–70) & Disk Drives*
- The Dream of Management Information Systems, leading to IDS (the first DBMS)
- *IBM System 360 (144–153)* including *OS/360 (100–101)* and *PL/I (107)*
- *Data Processing at the Internal Revenue Service*
- Creation of the Commercial Software Industry (focused on commercial DBMS packages and finishing with SAP/R1)

The topics in italics were the ones where we identified existing text to work into the new structure, and the page numbers show where in the second edition that can be found. You can see from the range of page numbers that new structure pulls together thematically related material previously found in three different chapters. In particular, this structure integrates the history of hardware, software, architecture, applications and users within each chapter. In this chapter, for example, we explain the development and adoption of hard disk drives as a response to the specific needs of business data processing users. We explain the development of the COBOL language as part of the trajectory of data processing, rather than exiling it to a separate discussion of software issues. In fact, we explain the existence of a commercial packaged software industry as a phenomenon rooted in the needs of business data processing users for database management systems and, eventually, enterprise application packages too elaborate to develop in-house.

We put a lot of thought into the new chapter structure, paying particular attention to the start and end points of each chapter so that the journey from one to another illustrates changes in the way that a particular kind of task was approached. These paths provide each chapter with a clear and largely self-contained narrative arc in which a particular kind of computing is developed. Applications usually evolve consistently within a chapter. For example, the narrative arc of the second chapter, "The Computer Becomes a Scientific Supertool," runs from IBM's first big scientific computers, the 701 and 704 in the mid-1950s, all the way through to the iconic Cray 1 supercomputer in the late-1970s. Along the way we cover a massive increase in computing power and look at a number of new technologies and architectural features introduced in response to the needs of scientific computing, from high level languages like FORTRAN and Algol to pipelined instructions, batch processing operating systems, and vector instructions. What gives the chapter its narrative coherence and sets it aside from the others is the continuity in users and usage style. The computers we mentioned were all built with the needs of Cold War nuclear labs and aerospace contractors in mind. They were all very expensive machines produced in dozens rather than millions and they all tackled the same kinds of application, such as Monte Carlo simulation.

In July 2017 Paul returned to Siegen to give us a week of undisturbed work on the book. In preparation I had prepared very rough drafts of two chapters to test the new approach—one based largely on reassembling existing material. We were pleased to discover that it seemed to be working, although we still found plenty of specific points to debate. During that week we made what I called "test assemblies" of the existing material into the new structure for most of the chapters, cutting and pasting it into new files to see which already had so much text that significant tightening would be needed and which were largely empty.

I wanted to make sure that we found a place in the new structure for everything that either of us was particularly attached to in the existing text, so we also went through a paper copy of the second edition with highlighters. To guide me as I reassembled the material, Paul used one color to mark material that he thought could be trimmed, and another to highlight passages that should definitely be retained.

Since then we have been collaborating remotely to get more of the chapters into shape. As of March 2018, we have first drafts done for the first four chapters. I've added new material to them based on my previous research on the history of things like database management systems, data processing, and management information systems. Paul has integrated new material based on his knowledge of the space shuttle and the SAGE system. I'm almost done with a draft of Chapter 5 and have most of the material for Chapters 7, 8, and 10, but with some significant gaps to fill. The big challenge will be getting the last three chapters ready in time, as these consist primarily of all-new material.

As we work there is a constant interplay between the "bottom up" development of the text and the "top down" refinement of the new outline. For example, we hadn't originally planned to have a separate chapter focused on the development and early adoption of graphical user interfaces. Some of these topics (the work at Xerox PARC, for example) had originally been slated as the culmination of Chapter 6 ("The Computer Becomes an Interactive Tool") and other topics (graphical workstations, the Macintosh and its competitors) were to have been the start of what is now Chapter 10 ("The Personal Computer Grows Up"). But as the text for those chapters came together, we realized that they were both going to be excessively long and ungainly. We also realized that Chapter 6 would be much more coherent if it focused on timesharing throughout, so that the arc was from MIT's CTSS to Unix (via Multics, the software crisis, and the commercial timesharing industry). Of course, every structural decision that solves one problem creates another. Right now, my big worry is how to squeeze discussion of 1970s mainframe virtual machine technologies and DEC VAX minicomputers into a chapter on graphical user interfaces.

Making Trade Offs

The first edition covered forty years in 400 pages. Will the new book cover sixty years in 600 pages to retain all the existing text and cover new development to a comparable level of detail? No. The existing text was already close to the limits of what readers and publishers will tolerate—approximately 150,000 words. We have promised MIT Press that the new book will be no more than about 10% longer than the second edition, which demands some difficult tradeoffs. That's one of the things that pushed us to an entirely new structure rather than just adding new chapters to the end of the existing text.

Most of the existing text found a home somewhere in the new structure, but it is being heavily reworked. When we reassembled the existing text in the new structure, most of the new chapters had something for most topics, but we quickly noted an imbalance. Some chapters were already too long, without inserting any of the new material, while others (particularly in the last third, but also the earlier chapter "The Computer Becomes a Communications Device") were largely empty. Some of the space savings we need come from line-by-line trimming in the passages and sections being preserved. Words that don't need to be there are being ruthlessly hunted down and eliminated. The new structure flows more naturally, and in some cases allows us to consolidate material that was previously spread over two chapters—this brings space savings by not having to recapitulate background the second time a topic emerges.

Only a few topics dealt with in the first edition are vanishing completely from the new text, but many of them are appearing in new contexts. For example, the first edition had systematically characterized each of the "BUNCH"—IBM's five main competitors in the early 1960s. As the main strength of the book is charting the coevolution of computer architecture and applications, we felt that this business history detail was unnecessary. However, Burroughs is still introduced when describing its pathbreaking B5000 stack based, Algol-oriented architecture as an example of a path not taken in mainstream computer design. This kind of restructuring helps build narrative momentum because each topic is introduced to make a point within the narrative arc of a chapter. In some places we found we could achieve that with significantly less detail than in the first edition—for example, in the discussion of small drum computers in the 1950s, which is significantly tightened in the new edition.

As we got closer to the present, we similarly concluded that the in-depth discussion of the relationship of CP/M to MS-DOS seemed less essential now than it did when MS-DOS was still widely used. Yet this also reminded us that there are many kinds of background knowledge that we can no longer assume our readers will have. This pushes the text in the opposite direction, towards longer explanations. Paul always understood that he would need to explain what an IBM 7094 installation looked like, but in the mid-1990s he could assume that a reader had a sense of what it would be like to use an IBM-PC, for example how big its box was, what kind of environment it would be found in, and that had a primarily textual user interface.

The history of computer science is covered selectively rather than comprehensively in the existing text. Computer science is an academic discipline that evolved during the 1960s from bits and pieces of other disciplines and from campus computer centers and projects. Computer science has many different subfields such as formal methods, graphics, artificial intelligence, operating systems, computer architecture, and databases. These fields are often only loosely coupled with each other and have their own origins and trajectories, so squeezing all of these stories into the book would be hard. Compounding this problem, the history of computer science remains unwritten—we do not yet have any overviews of the history of this discipline or of most of its subfields. The new edition will be likewise cover computer science selectively and highlighting specific contributions rather than the overall development of the discipline. Where computer science research (whether in universities or corporate labs) had a clear impact on computer practice or technology, we will introduce it. I hope that we'll be able to make such connections more often in the new edition. My informal goal is to work in some kind of mention of about half of the Turing Award winners, giving readers a sense of how their contributions helped to develop computer hardware and software as we know it today. For example, we will talk about the influence of theory on the creation of relational database management systems, the work behind the RISC approach to process design, and Dijkstra's contributions on operating system theory.

Confronting Progress

Herbert Butterfield long ago warned against the dangers of the "Whig Interpretation of History," a caution against the construction of teleological narratives that has been taken to heart most strongly by historians of science. To the extent that our mission is to explain how an iPhone came to be, we might pick out historical details and arrange them in a path that runs straight to Cupertino, leaving out all the messiness of actual history. Butterfield warned that the danger was most acute for projects of the kind that was are undertaking: "There is a tendency," he warned, "for all history to veer over into whig history," but history becomes "more whig in proportion as it becomes more abridged."[25]

The challenge of avoiding a triumphalist narrative of progress looms particularly large because we are dealing with a technology that has effectively come to define progress in the modern world. Moore's Law is held up as a challenge to other technologies and as an explanation for all kinds of cultural and economic phenomena. Paul has even argued for Moore's Law as a reason to take seriously the unfashionable idea of "technological determinism."[26] Institutions and industries are compared to an idealized version of Silicon Valley and are criticized for making too little progress or being insufficiently disruptive. The dramatic advance of computer and communication technology is used to justify claims that society is being transformed by technology at an unprecedented rate, even though technological change and productivity growth in recent decades are weaker now than at any time since the Industrial Revolution.

The new structure will help us deal with this challenge. Over time "The Computer" really does become spectacularly cheaper, smaller, and faster even as it develops remarkable new capabilities. We can't deny that computer technology has followed a unique path, and it would strain even the most determined skeptic to deny that this constitutes a kind of technical progress. Within chapters, however, our narrative has space for paths not taken in computer architecture, business models, and applications. Entire classes of machine, like graphics workstations, minicomputers, and single processor supercomputers come and go from the narrative. Technologies introduced for one purpose find unexpected applications, and predictions for the future are usually wrong. Neither, we must finally stress, is it at all clear that the social and economic changes facilitated by these new technologies will ultimately make the world a better place.

Final Thoughts

Overall, I am excited about the progress we are making on the book, although I'm sometimes reminded of the old joke that the first 90% of a project takes the first 90% of the time and then the last 10% takes the other 90% of the time. Paul has an unrivaled depth of knowledge in the history of computer technology, and our areas of expertise fit together well. We are integrating the histories of computer hardware, software, architecture, and use to make apparent the connections between these different areas. In collaboration with Siegen's Media of Cooperation and Locating Media initiatives we are broadening the traditional history of computing, to consider the

25 Quoted in William Cronon, "Two Cheers for the Whig Interpretation of History", *Perspectives on History* (September 2012), https://www.historians.org/publications-and-directories/perspectives-on-history/september-2012/two-cheers-for-the-whig-interpretation-of-history.

26 Paul E. Ceruzzi, "Moore's Law and Technological Determinism: Reflections on the History of Technology", *Technology and Culture* 46, no. 3 (2005): 584–593.

computer as a media and communication infrastructure as well as a tool for calculation and administration. The new structure should rebuild the book on a foundation that will last for several editions to come, and provide readers and instructors with a new way of conceptualizing the history of computing. If we do our job well, *A History of Modern Computing* will remain the most frequently read and cited scholarly overview history for another twenty years.