History of Computing

William Aspray *Editor*

Historical Studies in Computing, Information, and Society

Insights from the Flatiron Lectures

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Preface

This book includes revised papers from seven distinguished lectures presented during the Spring 2018 and Fall 2018 semesters in the Information Science Department at the University of Colorado Boulder as part of the Flatirons Distinguished Lecture Series in the History of Computing, Information, and Society.[1] When I invited these distinguished scholars to campus, I gave them wide latitude in the selection of their topic. The general domain in which their paper was to fall was defined by the areas of interest of the highly successful special interest group on computers, information, and society of the Society for the History of Technology, known as SIGCIS. The papers cover a wide range of topics and methods.

One of the reasons for arranging this lecture series was to help promote research and build ties at the University of Colorado Boulder. In 2015, the university opened the College of Media, Communication, and Information (CMCI). It was the first new college at the university in 53 years. One of the seven departments in this new college – opened at the same time – was the Department of Information Science. Much of the early attention in the new college was on creating curriculum and attracting students to CMCI classes and majors. Less attention was being given to building a strong, interdisciplinary research environment for faculty and graduate students across the college. This lecture series was intended to contribute to the building of that interdisciplinary research environment.

It is also an appropriate time in the history of computing and information community for such a work to appear. This book is a recognition that this field has matured to a point that it has developed a number of senior, distinguished scholars who hold their own with the best scholars of older and more mature fields such as History of Science, History of Technology, or American History. (Biographical sketches of these distinguished lecturers appear at the end of this book.) The first dissertations were written on the history of computing in the late 1970s, but as late as the 1990s when SIGCIS convened, the entire group could meet around a few luncheon tables. Today, the story is very different. There are more than 500 members

[1] One lecturer, Gerard Alberts of the University of Amsterdam, was unable to contribute a paper to the volume.

of SIGCIS, and there is so much demand for its annual conference that they have to run parallel sessions of talks.

The distinguished lecture series is named after the Flatirons, a prominent geological formation in Boulder, which represents the western edge of Boulder and a part of the eastern edge of the Rocky Mountains. The Flatirons are estimated to be approximately 290 million years old – in any event, older than computing!

The lecture series was made possible financially because of my start-up funds from the University of Colorado Boulder and a grant arranged by CMCI Dean Lori Bergen from the Josephine Jones Fund. Todd Amodeo and Sarah Mandos from the Information Science Department provided excellent staff support. I appreciate the assistance from my faculty colleague Michael Paul, who in his position as colloquium chair worked all of my lectures in to the active colloquium schedule. And, of course, I thank the lecturers – all of whom have busy schedules – who took time to travel to Boulder from across the United States or Europe to spend several days meeting with graduate students and faculty on campus as well as presenting their lectures. I also appreciate the interest in this project from the History of Computing Series editors, Gerard Alberts and Jeff Yost, and the Springer senior editor, Wayne Wheeler. Prasad Gurunadham has ably managed the production effort for this book at Springer. Thanks to all!

The Papers

These papers cover such a wide range of topics that I found it impossible to clump them together or identify a meaningful ordering based on their content; and in fact, the readers can profitably skip around in the book, reading what is most of interest to them. In the end, I have decided to present the papers in rough chronological order, based upon the time periods (decades) that are the major emphasis of the papers. An author might mention an earlier or later event, but their period of coverage is determined by their most significant focus of analysis. Based upon this ordering scheme, the papers appear as follows: Geoffrey Bowker (1830s), Jennifer Light (1890s–1910s), Ronald Kline (1920s–1990s), JoAnne Yates (1920s–2010s), Gregory Downey et al. (1930s–1970s), Thomas Misa (1950s–1980s), and Shane Greenstein (1980s–2000s). Below, you will find descriptions of each of these papers.

In his paper entitled "The Time of Computers: From Babbage and the 1830s to the Present," Geoffrey Bowker examines the relationship between developments in information technologies (and other contemporaneous scientific developments in Geology) and the concept of time. This study examines the work of Charles Babbage and shows how his machinic view of human and natural time is conceptualized in terms of his difference engine. Bowker then shows how this conceptualization shapes modern thinking and how the ever faster time of the computer has a paradoxical effect of creating a drive to stasis.

In her paper entitled "Expanding the Usable Past," Jennifer Light aims to broaden the notion of what the history of computing is about in order to make it more usable in understanding the present and future of computing and information technologies. In particular, she is concerned about the narrowness of the device-centered focus that is common in many historical treatments of computing. She points to a growing interest in a much broader set of objects of analysis among professional historians. The history of the junior republic movement – a program that began in upstate New York in the 1890s that enabled thousands of children from New York City tenements to build model cities and role-play – is used to illustrate the broader opportunities for thinking with history that recent developments in computing and information history represent.

In his paper entitled "The Modem that Still Connects Us," Ronald Kline discusses the history of the modem as an example of an interim technology that has had great staying power – from the 1960s into the present century. This story, Kline argues, "contradicts the logic of modern digitalization, in which digital always drives out analog media." The paper shows how the modem had an important use – not at all foreseen by the creators and manufacturers of early modems – in interactive computing, notably for airline reservations and computer time-sharing in the 1960s and 1970s and for connecting personal computers to the Internet in the 1980s and after. This paper is a part of a larger project to understand the history of digitalization in the United States, whereby digitalization is a hybrid process involving digital systems layered on top of an installed analog base. The story that Kline tells tracks the role of technology, telecommunication regulation, and user experience in the history of the modem.

In her paper entitled "Values, Media, and Genres for Standardization," JoAnne Yates returns to the notion of genre, which drives much of the analysis in her award-winning book, *Control Through Communication*, and her years of collaborative research with Wanda Orlikowski on new electronic media, and applies this concept to the history of voluntary standardization. She explains how genres shape and are shaped by values and processes for arriving at product and performance standards. In particular, she examines how standards for the Internet prepared by the Internet Engineering Task Force (IETF) and for the World Wide Web by the World Wide Web Consortium (W3C) both grew out of but differed from earlier standard-setting activities for electrical technologies.

In their paper entitled "Talking About Metadata Labor: Social Science Data Archives, Professional Data Librarians, and the Founding of IASSIST," Greg Downey and his coauthors Kristin Eschenfelder and Kalpana Shankar describe the professionalization of social science data curators and reveal some of the hidden work that these data curators do with distributed large-scale information infrastructures that underlie much of modern social science research. The paper focuses on the creation in the 1970s of a new professional organization called the International Association for Social Science Information Services and Technology (IASSIST). The paper describes issues of building professional identity, building peer networks of data curators, developing and circulating best practices, and providing exemplars showing the value of social science data archives.

In his paper entitled "Gender Bias in Computing," Thomas Misa addresses the issue of underrepresentation of women in computing. He reviews the various professional organizations that have addressed this inequity and describes the explanations put forth by historians. Misa scrutinizes the linear historical claims that "computer programming was born female and then made masculine, and that this history has passed straight down to the present day." Many of these accounts have pointed to the 1960s as an inflection point, where gender bias led to the computing field becoming increasingly masculine. Misa undertakes a new, careful analysis of data. He compares 1970 census data to other data he collected from the archives of the IBM user group SHARE and the Mark IV software user group. He finds these data sets all show that previous accounts have overstated the number of women in computing prior to the 1960s, that women's participation in computing in the 1960s is actually increasing rather than decreasing, and that the declines in women's participation only occur in the 1980s. This leads him to call into question existing historical accounts and to call for examination of the 1980s, which he plans to address in a forthcoming book.

In his paper entitled "An Archetype for Outsiders in Technology Commercialization," Shane Greenstein addresses an important question in the business history of information technology. We all know of certain "insider" firms, such as Google, Amazon, and Microsoft, that have numerous and powerful advantages in dominating their markets. Yet, we also know that the markets in computing and the Internet are dynamic, characterized by numerous start-ups – the majority failing but some succeeding spectacularly. This paper addresses the competition between these insiders and outsiders, looking at their strategies and interactions. Because the number of firms involved as outsiders in these competitions is large, with many individual eccentricities, Greenstein simplifies by creating "an archetype of confrontations that highlights the distinctive perspective of an outsider" at both the entry and confrontation stages of this competition. The paper uses a number of specific examples to illustrate his points. The paper is enriched by being deeply embedded in the general theories and literatures of business history.

I believe these papers not only are enjoyable to read but also provide valuable insights into new directions for the history of computing, information, and society.

Respectfully submitted,
Boulder, CO, USA William Aspray

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About the Editor

William Aspray, the editor of this volume, is professor of Information Science at the University of Colorado Boulder. He has previously taught at Williams, Harvard, Indiana, and Texas and held senior administrative positions at the Charles Babbage Institute, the IEEE Center for the History of Electrical Engineering, and the Computing Research Association. He was the editor of *Information & Culture* and has written or edited more than 25 books, including *John von Neumann and the Origins of Modern Computing*; *Computer: A History of the Information Machine* (with Martin Campbell-Kelly, Nathan Ensmenger, and Jeffrey Yost); *Women and Underrepresented Minorities in Computing: A Historical and Social Study*; *Participation in Computing: The National Science Foundation's Expansionary Programs*; *The Internet and American Business* (edited with Paul Ceruzzi); *Computing Before Computers*; and *John von Neumann's Papers on Computing and Computer Theory* (edited with Arthur Burks). He holds a PhD in History of Science from the University of Wisconsin-Madison.

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Chapter 1
The Time of Computers: From Babbage and the 1830s to the Present

Geoffrey C. Bowker

Abstract This chapter argues first that Babbage and Lyell developed a similar, machinic view of human and natural time, with the difference engine for Babbage being at the center of this conceptualization. This view involved the smoothing of time socially and naturally to create a form of stasis. Second, it maintains that the ever-faster time of the computer, prefigured by Babbage, has led to the historical creation of a new ontological level at which events occur well below the threshold of human perception – and that this new level is associated with a drive to stasis.

Keywords Temporality · Difference engine · Analytical engine · Ontology · Industrial Revolution

1.1 Introduction

In a recent design competition, Valeria Mercuri and Marco Merletti[1] envisioned the data center of the future – a set of geothermally powered, air-cooled towering structures serviced by drones towering over a plain in Iceland. Data are such an essential part of our society that we can't think without them; in many ways data have become more important than books. So, in the old days, we used to have the Library of Alexandria, and we used to have the great collections in huge buildings such as the Library of Congress. Today, the designers say, we should have the data tower, 65

[1] https://www.inverse.com/article/13413-a-hive-of-drones-and-an-icelandic-data-center-would-make-awesome-futuristic-skyscrapers accessed 3/30/2019

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stories high. This phallic symbol would recognize the centrality of data to our society right now.

Today data is highly synchronized. Its law is tied to the incessant rhythm of the computer clock – the clock in my computer clocks a rate of 8 GHz, which is eight billion ticks per second. I can find really only two groups of people who need more than a billion ticks per second: one is stock brokers, because you want to get closer and closer to Wall Street so you can do high-frequency trading,[2] and the other is high-energy physicists (who now examine events happening at the zeptosecond – 10^{-21} s).[3] Between this extremely fast time and the irruption of geological time into our lives through debates about the Anthropocene, time is being very differently conceived in the media, science, and business than it was a hundred years ago. Many temporalities are imploding into our present through the medium of computing.

I will make two fundamental arguments in this chapter. The first argument is that accompanying the ever-faster ticking of the computer clock is a somewhat paradoxical vision of timeless time – time without any change at all – and that the origins of this vision can be found in the 1830s, the epoch of Babbage's difference engine and Lyell's geology. Even though we think of the nineteenth century and the twentieth century as the era of progress, it has also been an epoch of stasis. Accompanying this has been a vision of timeless time, a time without change. The second is that new ontological layers have been built across society through temporal engineering over the past 200 years. This leads up to a theme of new ontologies of life at the femtosecond. The argument here is akin to Latour's pasteurization of France work where he showed that when bacilli – those minute creatures – were discovered in the nineteenth century, you suddenly had a new kind of society made up of new configurations of humans (including microbiologists) and nonhumans (bacilli; microscopes).[4] Society before and after was different – you may have had the entity tuberculosis before, but it fit into new configurations of institutions, machines, and people. As we develop new temporal levels, we people societies with new kinds of entities and events.

While making reference to later developments, my argument will be rooted in the 1830s. This is the epoch of the apogee of the Industrial Revolution in England, the period within which Charles Babbage conceived of his difference then analytical engines and the decade when Babbage's friend Charles Lyell wrote his classic *Principles of Geology*.[5] Babbage and Lyell were good friends, with complementary views on temporality; both put forward machinic visions in which time was effectively annihilated.

[2] See Lewis (2014). He describes premium prices being paid for the positioning of a server within a room of servers.

[3] https://www.smithsonianmag.com/smart-news/physicists-record-smallest-slice-time-yet-180961085/ accessed 4 April, 2019.

[4] Latour (1988).

[5] Lyell (1830–1833).

1.2 Babbage and His Machines

It is a well-trodden historical path to take Charles Babbage, through his physical design and arguably Ada Lovelace's programming skills[6] for an Analytical Engine, as the progenitor of the modern digital computer. This hindsight can make it harder to see an origin of computing in the production of *machinery* – the Engine was to be a vast machine, deploying techniques learned in his tour of machinery and manufactures in England in the 1820s (weaving and watch production) in the heat of the Industrial Revolution and expressed not in binary code but in a symbolic language describing the functioning of machines.[7] He conceived it not only in terms of the time compression we associate with computing but also its opposite: "It is impossible to construct machinery occupying unlimited space but it is possible to construct finite machinery, and to use it through unlimited time. It is this substitution of the *infinity of time* for the *infinity of space* which I have made use of, to limit the size of the engine and yet to retain its unlimited power."[8] This infinite logical time was also – as this new language and as his analysis of time taken for operations in watch production in the 1820s – complemented by time compression: the ineluctable drive to make things happen faster and faster: "whenever the Analytical Engine should exist, all the developments of formula would be directed by this condition – that the machine should be able to compute their numerical value in the shortest possible time."[9]

Charles Babbage's difference engine was never completed in his time – it was finally built in the 1980s at the Science Museum in London.[10] Babbage got his idea of building the computer through the principle of division of labor at work in the manufactures of England in the 1820s. He was particularly taken by the Coventry mode of watch production, where you took what used to be a suite of tasks carried out by expensive, skilled watchmakers and turned them into a set of 32 operations – each of which could be performed by cheap, semiskilled laborers. James Keene, in a passage Babbage cited approvingly, wrote of watch production that "movement maker, is divided into frame mounter, brass flatter, pillar maker, screw maker, cock and pottance maker, wheel maker, wheel finisher, barrel maker, barrel arbor maker, pinion maker, balance maker, verge maker, ratch and click maker and other small steel work; dial maker, copper maker, enameller, painter, hand-maker, glass maker, pendant maker; case maker divided into silver flatter, box maker, case maker, joint finisher; motion maker divided into bolt maker, slide maker, motion wheel maker, motion maker, spring maker; chain maker divided into riveter, finisher and preparer; engraver, which is divided into cock and slide engraver, name engraver, cap maker, jeweller, scapement maker, finisher, wheel and fusee cutter, case spring maker,

[6] For some discussion see Husbands et al. (2008): 5.

[7] Babbage (1826).

[8] Babbage (1994[1864]).

[9] Ibid., 90.

[10] Swade (2000).

spring and liner and polisher; y maker and several other branches, to the number of 102 in all."[11] Babbage saw this as occurring through a form of temporal engineering producing saving in time and in money – a set of sequential tasks could be turned into a set of synchronized tasks along a production line (so that at any one time, any part of the watch was in production). He saw this as a possible breakthrough in intellectual life. He drew on Gaspard de Prony's construction in the multiplication which took many years to produce into semiskilled, lower paid work of subtraction and multiplication.[12] Babbage wrote that "the advantages which are derived from machinery and manufactures seem to arise principally from three sources: the addition which they make to human power. – The economy they produce of human time. – The conversion of substance apparently common and worthless into valuable products. The economy of human time is … [so] extensive and important … that we might, if we were inclined to generalize, embrace almost all the arguments under this single head."[13] He wrote of the machines as "a *regulariser* of time" in contrast to the "inattention, the idleness, or the knavery of human agents" and "the irregular and fluctuating effort of animal or natural force."[14] The principle of the division of labor and the economy of time – both so central to the difference engine – were picked out by an admirer of this work. Thomas Turner wrote to Babbage that "workmen <u>as a class</u> do not invent – The best workmen are probably the mere copyists; as in the case of the logarithmic tables, the most accurate computators know nothing of the scientific part – and the improvement of machines must be referred to the repetition of a thing producing skill because division of labour tends to set apart an <u>inventive class."</u> He then gave a table of the division of labor in the economy and developed the point: "By way of illustration, suppose a gigantic scientific institution formed and divided into classes and sub-classes. A large class might consist of original observers. The active might be dispatched to all parts of the world, the more quiet or patient remain at home, the blind might be referred to on points of delicacy of sound, and the deaf might watch change of form and colour, the logicians and mathematicians would form a central body, would receive the various reports and by classifying ascertain every law that could be deduced and point out to the observer the points on which further information was desired etc. etc."[15] This vision persisted into the twentieth century – for example, in H.G. Wells' vision for a world brain, where the unwashed and semi-educated would gather information for the intelligent elite.[16]

Babbage was not alone in seeing industrial machinery in terms of a general-purpose machine which worked by abolishing time, moving irregular human time into the clockwork universe of absolute time – Neil Arnott wrote of the steam

[11] *British Sessional Papers,* 1817, vol. 6, p361.

[12] Babbage (1832).

[13] Ibid., 3–6.

[14] Ibid. 39; 43.

[15] Thomas Turner to Charles Babbage, 28.11.32, <u>*Correspondence, vol. 6, 1832*</u>, British Museum Add.Mss. 37185–37191, ff.247-9.

[16] Wells (1938).

engine: "which never tires and wants to sleep; and only refuses to work when worn out with age; it is equally active in all climates and will work at anything."[17] Mary Somerville wrote that "Armed by the expansion and condensation of fluids with a power equal to that of lightning itself, conquering time and space, he flies over plains, travels on paths cut by human industry even through mountains, with a velocity and smoothness more like planetary than terrestrial motion…."[18] The general-purpose machine, then, prefigured the computer as envisaged by Babbage and would annihilate time, be indifferent to weather, and work ceaselessly and endlessly. As would the work – for Bergery – the division of labor was central to our state and led to "simple periodic tasks" for the workers. He noted that "each person is capable of executing at least 5 movements a second, that there are 36,000 s in a ten-hour day and that consequently 180,000 movements are possible" and continued that "your interests are better served by an ordinary but regular manufacturing process than by perfect, but unmethodical work."[19]

From this beginning, then, time and timekeeping was central to the development of the computer. This comes out particularly clearly in Babbage's maverick text: "The Ninth Bridgewater Treatise – a Fragment."[20] In this work, his aim was to use the metaphor of the difference engine to prove that Christian theology and natural science can be reconciled. The Bridgewater treatises were commissioned texts by the great scientists of the day to prove the existence of God through design; Babbage was particularly unhappy with William Whewell's treatise on astronomy and physics[21] and wrote his own treatise, separate from the series. He wanted to prove that miracles are possible, and the way he did so is by describing how his difference engine works, the idea being that the engine could do the same thing for countless eons, for a hundred million billion operations, but then you can type in, from the start, that it will do something weird, after a hundred billion and one or a hundred billion and two operations. Thus Babbage as creator (he does put himself in this position) could set the machine up so that it would: "true to the prediction of its director, after the lapse of myriads of ages, fulfil its task, and give that one, the *first* and *only* exception to that time-sanctioned law."[22] So this is the way we can have a natural, clockwork universe but can also have miracles, so the two can actually sit side by side with each other.

Following Kittler, who argued that the computer is a medium as much as a machine for calculating,[23] we can see a further development of his regular temporality in his theorizing of media. Time was essential to media. He argued that until the invention of the printing press, "the mass of mankind were in many respects almost

[17] Arnott (1827).

[18] Somerville (1834): 249.

[19] Bergery (1829).

[20] Babbage (1837).

[21] Whewell (1833).

[22] Babbage, op. cit. note 20: 140.

[23] Kittler (2017).

the creatures of instinct."[24] Now, the great were encouraged to write, knowing that "they may accelerate the approaching dawn of that day which shall pour a flood of light over the darkened intellects of their thankless countrymen," seeking "that higher homage, alike independent of space and time, which their memory shall for ever receive from the good and the gifted of all countries and all ages."[25] For him, this marked the true commencement of our species – stopping being creatures of instinct, through gaining this empire of time, which is an intellectual empire of time. The Bridgewater treatise has a chapter devoted to time, based on the premise that "Time and change are great only in reference to the faculties and beings who note them." He has a lovely passage about the mayfly whose life only lasts 1 day. And then he comes to the strangest part of the book: "If we imagine the soul in an after-stage of our existence is connected with a bodily organ so sensitive that it vibrates with motion in the air, a being of infinitesimal force … would be able to hear all the accumulated words pronounced from the creation of man. So we could hear the Sermon on the Mount. The criminal could be punished by hearing the vibrations on his ear of the very words uttered perhaps thousands of years before, which at once caused and registered his own condemnation." The subtheme in Babbage is that he associates memory with punishment, which is a psychological side. He wrote this despite his friend Herschel telling him his listening device would never work – the vibrations would have been absorbed over time.[26] The first medium (the book) gives us timeless time; the second (the listening device) gives the implosion of all historical time onto the present. The computer (in the form of the difference and analytical engines), the steam engine, and the media each separately and combined gave us a regular timeless time in an ever more packed present (packed in terms of calculations, operations, and vibrations in turn). Ever-greater speed was completely consonant with every more regular, constant temporality.

This implosion can be seen in a review of Comte's *Course of Positive Philosophy* in the *Edinburgh Review*: "Is man to be for ever a shepherd pilgrim in this lovely Oasis, treading on its green pastures and listening to the music of its quiet waters? Or is he, in the perfection of mechanism, to be for ever flying over its surface with the speed of Camilla,[27] visiting every clime, greeting every individual of his race, and compressing into the diminished span of his being all the events of an antediluvian existence?."[28] Or again, Auguste Perdonnet argued that railways were superior to canals because of their speed: "Time is the stuff of life, Franklin has said. Railways lengthen life by economizing on time."[29] He continued that as Montesquieu said, the spirit of commerce brings "order and rule" and that "Communication net-

[24] Op. cit. note 20: 39

[25] Ibid.: 54.

[26] Lyell to Babbage, 17/2/37. Add. Mss. 37190. f.37.

[27] Who was thrown by her father Metabus across the Amisenus river attached to a javelin.

[28] *Edinburgh Review*, 1838: 285–286.

[29] Perdonnet (1832): 28.

works in general, and above all the railways, are the most effective means of inducing this spirit of commerce …. Men, like metals, are polished by friction."[30]

Babbage's Bridgewater treatise was controversial – the *Mechanics Magazine* lambasted it for its comparison of the operations of the Deity to the workings of Babbage's own calculating engine and concluded: "The sooner it is consigned to oblivion, the better for the author's reputation in every respect; it is, in all points of view, to be deeply regretted that the author's judgement or that of his friends (if any were consulted) had not kept it from being hurried through the press and before the public."[31] Mary Somerville did like it though, as did the evangelical Thomas Chalmers, who wrote another of the Bridgewater treatises.[32]

It demonstrates clearly that for Babbage, at the origin of the computer, vision of the world is thinking about temporality in its many forms. In a parallel development, new information processing technologies were about sorting through data on new scales in ever-faster times. The late eighteenth century to the early nineteenth century sees the development of the great national censuses: data collections, which allow new kinds of governance to occur. The same thing happens in natural science; there were new kinds of classification of animals and plants – which allowed for catalogues of life to be built up – each of them associated with a new kind of information technology. Thus, for example, the French encyclopedists created new kinds of information technologies that would process the vast amount of data that they were dealing with.

1.3 Smoothing Human Time: Babbage, Lyell, and Company

We now move onto the flip side of this constant acceleration through calculation and data storage and analysis. In Charles Lyell's work, in the 1830s, we get the principle non-time, things not changing over time. Just as Babbage made up out of whole cloth his hearing instrument, Lyell created out of whole cloth a new temporality for geology. He argued that the earth does double-entry bookkeeping, just as humans do. Both (ideally) reduce everything to a zero-sum ledger: "In order to confine ourselves within the strict limit of analogy, we shall assume, 1st, That the proportion of dry land to sea continues always the same. 2ndly, That the volume of land rising above the level of the sea, is a constant quantity; and not only that its mean, but that its extreme height, are only liable to trifling variations. 3dly, That both the mean and extreme depth of the sea are equal at every epoch; and 4thly, It will be consistent, with due caution, to assume, that the grouping of the land in great continents is a necessary part of the economy of nature."[33] There is always the same

[30] Ibid.: 29.

[31] *Mechanic's Magazine.* 9/9/37: 381–2.

[32] Somerville to Babbage, 6/6/37. Add. Mss. 37190. ff.204-5; Chalmers to Babbage, 10/10/37. Add. Mss. 37190. f.295.

[33] Lyell, op. cit. note 5: vol.1: 112.

amount of earth, there's always the same amount of sea, destructive processes and constructive processes are in complete balance. He asserted this, however, without any evidence whatsoever. For him, the earth keeps an archive just as humans do; both keep a record of the past in book keeping form. The logic of this pushed him to say that temporally humans are natural agents: anything that we do is not affecting the earth, even though it seems to be. If humans were wiped from the face of the earth, in a couple of centuries, the earth would be exactly what it always was (this enabled him to ignore, e.g., the new pigeon types created by humans beloved of Darwin). Babbage and Lyell shared a machinic view of time – be this of the earth or of the computer – in which apparently secular change could be always reduced to smooth time.

In *the Ninth Bridgewater Treatise*, Babbage notes that the gnat sees flowers as of unchanging duration; he then builds up longer-term analogies to this perception and concludes: "These periods again merge into other and still longer cycles, during which the latest of a thousand forests sinks beneath the waves … ."[34] He then cites, slightly misquoting, Hutton's maxim that "human observation, aided by human reason, has as yet discovered few signs of a beginning – no symptom of an end."[35] Lyell responded to this passage in a letter to Babbage: "I once wrote a flight of fancy of this kind for my first vol. and if I find it I will send it. It began with a caterpillar thinking the foliage of the oak an evergreen universe and after banqueting on some of the leaves for his turn he curls up one leaf by aid of his thread or silk and having formed a green sepulchre turns into a chrysalis admiring the everlasting foliage and contrasting it with his transitory state – Then the leaves turned yellow and admired their long-lived, unchangeable, everlasting parent the trunk etc."[36] Secular change always dissolves into cyclical change against an unchanging backdrop.

For writers such as G. Poulett Scrope, the new temporality of uniformitarianism would apply to human time – it was an outcome of the process of civilization that become more uniformitarian – so human time will become more of the same, more linked, and more synced, over time.[37] This theme of the syncing, human time and geological time, was developed from Charles Dunoyer, one of the great theorists of the Industrial Revolution in France in the 1830s:

> under the industries influence, people will start grouping themselves more naturally, mass according to their real analogies and their real interests. Given this the same arts will be cultivated in equal success among all people, the same ideas will circulate in all countries, even languages will become closer. Universal costumes will be established in all climates no matter what the conditions of nature, the same needs of similar civilizations will develop everywhere, and finally the largest countries will end up representing a single people without confusion or violence, relations both as complex and easy as peaceful and as profitable as may be.[38]

[34] Op. cit., note 12: 88–89.

[35] Ibid.: 90.

[36] Lyell to Babbage. May 1837, Add.Mss. 37190, f.187.

[37] Poulett Scrope (1833).

[38] Dunoyer (1837).

This is an eldritch remark for someone infused with the "spirit of industry," which it is easy to associate with untrammeled progress. Another annihilation of time through the fusing of human, natural, and astronomical times can be found in the work of geologist Marcel de Serres. He wrote that "The only difference that the phenomena of the old world and those of the current world present comes down to the fact that the former have been determined by the actual temperature of the globe, or of the central heat."[39] He continues that there is, however, another point of view by which we could look at the question: "that of the final causes which have always presided over the harmony of created things"; with current causes being "essentially causes of order and harmony."[40] If we look to the solar system, as on the earth, we find current fixity and stability.[41] His general conclusion is that it is therefore: "extremely probable that if nothing is changed in the progress and the action of the current elements, all which exists, on earth, as in the rest of the Universe, will not submit any further important or large-scale modifications."[42] This leads us to the current "happy" epoch which has "not only separated old and new times, but has led the totality of created things towards that harmony and that stability which is the most imperious and necessary law of the current epoch!".[43] We have achieved stasis: "How many millions of years will flow by yet before existing phenomena may undergo some slight modification!".[44]

This theme of no time occurs later in the history of computing, in cybernetics. There is a direct link from the nineteenth century either through Claude Bernard's principle of homeostasis or that great symbol of the Industrial Revolution, the governor, which could ensure the constant running of a steam engine through a feedback mechanism alternately providing more air when it needed to run faster and crimping the supply when it needed to go slower ("cybernetes" means "governor"). These threads are beautifully drawn out in Beniger's *The Control Revolution*, which brings feedback to the fore in the "Second Industrial Revolution" of the mid-to-late nineteenth century.[45] Cybernetics, then, grew from roots in the nineteenth century and was hugely influential in the development of computing in the 1960s and 1970s. It is in part based on the principle of the governor, which is a way of ensuring constancy and uniformity in machines over time. Thus Ross Asby's Homeostat could take any input and turn it into a constant output – a machine that is reminiscent of the self-closing box mechanism – a cybernetic flight of fancy from the 1950s.[46]

Jumping to the twenty-first century, we can find exactly the same kind of statement being made. This is the massive hubris of the Human Memome[47] Project,

[39] De Serres (1837): ij.

[40] Ibid.: ij; iij.

[41] Ibid.: iij.

[42] Ibid.: iij.

[43] Ibid.: 5.

[44] Ibid.: 33.

[45] Beniger (1986).

[46] Pickering (2010).

[47] http://www.humanemergence.org/humanMemome.html accessed 29/3/2019.

which takes the Human Genome Project as a model and argues that we need to fine the memes which lead to healthy living and we need to propagate those memes, so that people will eat more alike, will exercise more alike (Fitbits 10,000 paces a day), and will act more alike. And this memetic function was deployed by Cambridge Analytica, who deployed memes to try and control political thinking during the last election in the United States. Gabriel Tarde's dark side … though it's not clear he ever had a light one![48]

1.4 New Ontological Layers

Babbage's new technology, then, ushered in its own infinite time – at the time of the invention of the new infinity of time in the 1830s in geology – a consonance of which Babbage was deeply aware: variations in time scale from the fleeting life of the mayfly to the æons of geology were central to his imaginary.[49]

One of the tricks of the trade for digital computers is to collapse potentially infinite serial time through synchronization (many times at the present moment): running many operations at the same time and synchronizing the results.[50] Commands to go parallel, spawn processes, and sync results sit on top of the underlying serial structure.[51] A *nec plus ultra* of the substitution of space for time here is David Deutsch's description of quantum computing as a way of allowing tasks to be performed collaboratively across multiple universes[52] – he reckoned that to factor a 250 digit number, we would need to deploy 10^{500} different universes (the operation would run parallel in each, and the result would be given by interference) in almost no time – where Donald Knuth had estimated that it would take over a million years using a million computers.[53] Time for Deutsch was a budgeting issue: "Evolution would never have got off the ground if the task of rendering certain properties of the earliest, simplest habitats had not been *tractable* (that is, computable in a reasonable time) using readily available molecules as computers … What computations, in other words, are practical under a given time and under a given budget."[54]

Parallelism of computing today – whether based in the cloud or under the hood of a pc in the form of multicore processors – trades between two temporalities, the speed of messaging (spatial) and the remorseless ticking of the computer clock (temporal; not highly scalable above current limits).

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48 Candea (2010).

49 Charles Babbage, The Ninth Bridgewater Treatise: A Fragment, op. cit. note 12.

50 This temporal collapse is perhaps pointed to by Kittler's use of "a screaming comes across the sky" (16) – the opening and closing lines of Gravity's Rainbow, encapsulating the extensive time of the novel into the moment of the dropping of a rocket.

51 Cormen et al. (2009): 774.

52 Deutsch (1997): 155.

53 Ibid.: 200.

54 Ibid.: 196–7.

The fastest computers now can do about 16 petaflops (floating point operations) per second – that is, 16 by 10^{15} operations. That is a whole lotta flops, even for an industry which romances the decimal point.[55] It means that in fewer than one hundred seconds, they can do the equivalent of one calculation per second since the putative Big Bang roughly. On the other hand, in a deeply meaningless calculation, it has been asserted that the human brain performs at about between 10 and 30 times as many.[56] The reason why this comparison is even a question is that the holy grail of artificial intelligence needed to replicate the work of many complex professions (scientist, psychiatrist) – known as AI-complete programs – that we need to completely emulate the human brain in the interests of efficiency.[57] If we succeed: "then it will become feasible for machines to carry out such jobs, and to do so more cheaply and more effectively than humans … ."[58] Indeed, "if and when human-level AI is achieved, superintelligence will soon follow. … Even if human-level AI is achieved by the most conservative means – by slavishly copying nature – the resulting liberation from the speed restrictions inherent in biology is enough."[59] The romance does not stop there – Murray Shanahan fantasizes that: "A theoretically perfect computer with a mass of 1 kg and occupying a volume of 1 liter would perform 5.4×10^{50} logical operations per second on 10^{31} bits."[60] This is 39 orders of magnitude greater than today's computers. In the future, we might see a portion of space: "rapidly transformed into a cyberspace, [wherein beings] establish, extend, and defend identities as patterns of information flow … becoming finally a bubble of Mind expanding at near lightspeed."[61]

We do not generally think of these kinds of speeds – our lives seem to flow at the rate of less than one thought per second, and connectivity for many is so fast that it's basically just instantaneous and so invisible. (The days of watching an email message unfurl painstakingly over a modem attached to a telephone line are long over.) And yet they affect us in our daily lives. They can irrupt – in the form, say, of the flash crash of 2010, where trading algorithms were making and changing bets at an astonishing rate, leading to a trillion dollar dive on Wall Street that lasted all of 36 min. (More insidiously, very fast computing times are needed for the forms of machine learning being used by casinos, states, and advertising companies such as Facebook and Google to create the nudge technologies, which cosset you along the path of life mostly without you being aware[62]). Thus, Armin Beverungen and Ann-

[55] I borrow this felicitous phrase from Service (2004).

[56] https://aiimpacts.org/brain-performance-in-flops/, accessed 11/21/18. Kurzweil gives 10^{16}.

[57] "Messy emulation" is just doing neuron for neuron mapping; other forms would develop new kinds of intelligence. (It is surprising that such a limited view of the workings of the brain – neuron firing – persists in computer science, as well as the willful ignorance of the distributed, embodied nature of cognition).

[58] Shanahan (2015): 152–3.

[59] Ibid.: 157.

[60] Ibid.: 35.

[61] Ibid.: 157 – citing Hans Moravic.

[62] Schüll and Zaloom (2011): 1–24.

Christine Lange cite Katherine Hayles on the missing half second between perception (registering an event) and consciousness (processing it): "This cost [the delay],… assumes new importance when cognitive nonconscious technical devices can operate at temporal regimes inaccessible to humans and exploit the missing half-second to their advantage."[63]

This new ontological level – things brought into existence well below the threshold of human perception and yet which form powerful actors in our world – is a direct outcome of the machinic vision of time developed in the 1830s by Babbage, Lyell, and others. They telescoped temporal scales – moving freely between the very small (the imperative of computing devices and steam engines to go ever faster) and the very large (the discovery of stasis in the face of apparent change through the trick of the (relative) increase in temporal scale). It reaches its apogee when the techniques of working at the smallest time scale work to create stasis at the largest.

1.5 Conclusion

Bringing our threads together, what is this new kind of world we are creating, and how is it operating? A central concept today is the Internet of Things. The article that led to the concept of the Internet of Things was written by pragmatist sociologist Neil Gross in an article for a popular business press in 1999.[64] He argued that "the Earth will don an electronic skin. The skin is some uncanny piece of engineering, it processes an immense amount of data on temperature, pressure, humidity and texture, it registers mood, it does more that register superficial events, it's a controller. It sends signals to regulate body flow, activate sweat glands, immune cells, and so forth." So we are getting a new skin, and that new skin is interposed through data. One could argue, drawing here on a lovely passage in *Computable Bodies* by Josh Berson, which argues that our bodies were always already computers with their own ways of processing environmental inputs, but we are moving them from one regime of computing to a another.[65] Gross went on to say "the skin is already being stitched together… it consists of millions of embodies electronic devises, thermostats, pressure gauges, EKGs, EEGs, they will private monitor cities and endangered species, ships, highways, conversations, bodies and dreams." This skin, then, is interposing itself in every aspect of human existence – from the fantasy through to the industrial – interposing this movement of calculation and analysis in fractions of a second into the most intimate moments of human existence.

This is a common picture of what the Internet of Things is going to look like: a new skin for ourselves and for our planet. It brings together the two themes developed above – the development of new regimes of temporality (personal and social control by introducing new temporalities faster than "natural" physiological or

[63] Beverungen and Lange (2018): 80.

[64] I am grateful to John Seberger for pointing this out to me. Gross (2019).

[65] Berson (2015).

social processes) and turning this into a machine for creating no time – a vast homeostatic society where we will be in permanent balance with each other and with nature. A common illustration has vehicles, assets, people, and pets monitored and controlled using exactly the same devices and exactly the same technology.[66] We are not talking about the specificity of being human. We are talking about creating humans and creating a humanity which is controllable within a cybernetic system, in the same way as pets and assets and trees and nature can be controlled. Crucially, I have argued, this is not a shiny new reality or brave new world: it has roots in the steam engine, the difference engine physically, and the implosion of time and creation of harmony/uniformitarian time at the apogee of the Industrial Revolution.

This long dominant conception of the world has immediate political and social consequences. It is central that we stop thinking about climate change and biodiversity in terms of trying to preserve things exactly the way they were – the machinic vision we have enshrined from the origin of computing. This is both a losing game and a strange vision. We seem to think that the climate we have now is the ideal kind of climate: that we could keep on with the same kind of climate for all eternity, that we could have the same species (humans) dominant, and that we could preserve geodiversity just as we are preserving biodiversity, so it's all about preservation – of species, climate, or indeed cultures. Along with the colonialist vision of keeping people in reservations so they can preserve languages and traditions comes the vision that we will put nature in reservations so it can go on without being bothered by us too much.

We need to face the reality of what Michel Serres has called "the natural contract." whereby since the early nineteenth century, we have increasingly come to know as a species that we are in the process of managing the whole planet – essentially since Malthus, the world has moved from being infinite in extent and resources to being finite and therefore needing to be managed.[67] That management is happening centrally, through practices of synchronization. If we want to look where politics is happening now, we don't go to the agora, to the Althing, or to parliament house, we go to the computer. It is through looking at the code and understanding the code and understanding computer practices that we get to the core of the changes that are occurring in the world today. William Heath's March of the Intellect series from 1828 reminds us of the constancy of our solutions. He prefigured a flying postman, just as Amazon today is talking about flying warehouses with drones bringing packages for customers. He prefigured a vacuum tube taking us from Paris to London where Elon Musk is talking about one linking Los Angeles and San Francisco. And, crucially, he put information technology (in his case the printing press) at the center of the equation. Timothy Mitchell's wonderful *Carbon Democracy* makes a related empire of time argument. He says that by plundering the stored energy from the sun, in carbonic inorganic form, we are basically spend-

[66] http://www.engineersgallery.com/wp-content/uploads/2015/11/things.jpg accessed 4 April, 2019.

[67] Serres (1995).

ing down a huge time budget, in a very short period of time – we burn 400 years of the combined animal and vegetable output of the planet every year (a somewhat meaningless, but arresting statistic – I would guess that it's within an order of magnitude).[68] He argues quite correctly that we couldn't have had social theories like Marx and economic theories like Keynes, without the background of this temporal waste and expenditure. We need new theories and new ways of relating to the world that get us away from the coordinative timelessness I have described in this chapter.

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[68] Mitchell (2011).

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Chapter 2
Expanding the Usable Past

Jennifer S. Light

Abstract Across diverse industries and professions, speculations about the future of computers and information technologies have been joined by frequent invocations of the past. These efforts to look backwards and forwards find many uses for history. Yet the turn to a usable past has been unnecessarily limited in its device-centered focus, particularly in light of the growing interest in a much broader set of objects of analysis among professional historians. This essay uses the history of the junior republic movement to illustrate the broader opportunities for thinking with history that recent developments in computing and information history represent.

Keywords Uses of history · Learning science and technology · Gamification · Virtual words · Simulation

Across diverse arenas from education and journalism to law and medicine to architecture and city planning, speculations about the future implications of computing and information technologies have been joined by frequent invocations of the past. These efforts to simultaneously look backwards and forwards find many uses for history – among them to speculate on changes to professions, to abstract "recipes" for nurturing innovation, to offer cautionary tales of the unanticipated consequences of new technologies, and to legitimate proposals for ideas that might otherwise be poorly received.

As a historian of computing and information technologies, it has been thrilling to witness the expanding audience for research in our field. And yet the turn to a "usable past" and search for "lessons from history" would benefit from casting its net more widely than the largely device-centered focus to date. Educators, for example, encountering a new generation of educational tools from online learning and MOOCs to virtual worlds and video games note prior efforts to introduce new technologies into the curriculum as they think through ways to maximize learning

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opportunities for "digital natives" while forestalling potential instructor rejection of new learning machines. City planners thinking about smart cities turn to earlier uses of computer models and GIS in urban management. Each of these reflections is useful and yet, taken together, merely scratch the surface of how history might help to engage contemporary concerns. A key development in the field over the past quarter century is the move beyond stories about devices to treat a much broader set of objects of analysis – redrawing the boundaries of the category of "computers and information technology" in ways that remain unnoticed by broader audiences (Light 2016, 2017).

This essay highlights the opportunities for thinking with history that such recent historiographic developments represent. Its focus is the first two decades of America's junior republic movement, which ran from the 1890s to World War II. Junior republics, immersive environments designed as pedagogical and socialization tools for American youth, were initially constructed as freestanding institutions and later integrated into classrooms and communities. The early history of these sociable simulations offers an entry point into the broader national conversations about and experiments with simulation in education and recreation that greeted another period of economic and cultural transformation: the Industrial Revolution. Of course, the virtual worlds and augmented reality games of junior republics, based in physical and imaginative space, differ substantially from their contemporary electronic counterparts. Yet the rich resonances between these century-old immersive environments and a range of contemporary technologies now being applied to educational purposes with the blessing of learning science and technology invite wider appreciation of a fundamental tenet in historical research: Past actors' ways of thinking and talking about their world often differ from present-day classification systems and lexicons. This basic tenet seems too often forgotten even as it has implications for where we seek a "usable past" – revealing how many close cousins of present-day innovations lie far "computing and information technology" as currently understood.

2.1 Introducing Junior Republics

The "junior republic" was the brainchild of William R. George, who first hosted children from New York City tenements on his upstate Freeville property in the 1890s. The miniature republic modelled on the government of the United States they organized would be the first of thousands of similar role-playing simulations – all miniature cities, states, and nations run by kids. With supervising adults in the background, the young officials made laws, took civil service exams, and paid taxes. They ran restaurants and stores, printed newspapers and currency, and built dorms and sewer systems (Light 2012).

Behind the initial push to introduce junior republics across the nation was a community of Progressive Era reformers who called themselves Goo Goos (an abbreviated reference to their membership in the "good government" movement).

Concerned about corruption, inefficiency, and boss rule in public administration, they, like many at the turn of the century, were confident that scientific methods and technological tools would be the route to a better future for the United States (Schiesl 1977; Stivers 2000). One Goo Goo strategy focused on making government more rational and efficient – gathering more and better data, creating policies free from politics, and streamlining government operations. With cities concentrating many of the nation's economic and social problems at the top of their agenda, they established Municipal Research Bureaus to gather facts around the nation. They also introduced civil service exams to certify a new expert class of government workers.

Another strategy focused on civic education (Welling 1942). Goo Goos were frustrated that immigrants who flooded cities in search of work in the industrial era seemed to like quasi-monarchical political machines, and native-born middle classes appeared too apathetic to prevent boss rule. But they were confident that citizens equipped with the right information would see the wisdom of their proposals to rationalize government. This was the root of their interest in the republic idea.

The nation's youth proved highly receptive to the Goo Goos' message when the medium for delivering it was a junior republic where they could vicariously experience life as a senator or mayor, a business owner, or a newspaper reporter, by immersing themselves in the alternative reality the republic supplied. When one of the junior citizens, "a lad just out of knickerbockers," presented his republic experience to a New York City audience, the *New York Times* reported how he "talked so intelligently of tariffs, currency rations, and legislative problems that his hearers were subdued with astonishment" ("Junior's President Talks," 1897, p. 10; "'Jakey' and the Junior Republic," 1897).

2.2 A Movement Gathers Momentum

Although government reformers led the junior republic movement, educators and youth workers swiftly followed on their heels. The Progressive Era was a period of shifting expectations around young peoples' behavior. As an industrial wage economy replaced the prior family economy in which parents trained their offspring for productive work at home, and experts and the public began to question whether children should be working at all, schools and youth-serving institutions assumed greater economic and social importance as *parens patriae* – replacement parents – with responsibilities for both training and protecting the nation's youngest generation (Zelizer 1994; MacLeod 1998; Kett 1977). Before there were widespread laws *for* compulsory schooling, *against* child labor, and age-based local restrictions like curfews, however, kids had to be persuaded to change their behavior. The activities found in junior republics – like those of adults but not those things in themselves – turned out to be very persuasive tools. Not only were kids persuaded to spend more time in adult-supervised settings; they were motivated to study civics textbooks and police their friends. As one boy who failed to meet the standard to join the republic's police force put it, "Ain't but one thing riles me, that's me mudder didn't lick me and make me go ter school so's I could pass the civil service examination fer the police force" (Sangree 1895, p. 24).

As a result, some educators and youth workers emulated William George and designed stand-alone institutions and even more integrated republics into the educational and recreational programming at schools, playgrounds, boys' clubs, settlements, housing projects, and other youth-serving institutions (Light, *States of Childhood* forthcoming). Later, republics could also be found beyond campuses, classrooms, and clubhouses in America's city streets. For the more than 4000 participants in Milwaukee's Newsboy Republic in the 1910s, for example, a joint project of the city's schools and its street trades department, some activities were held in schools and social centers. But most republic life took place in the streets of Milwaukee, reconceived as a miniature United States (Light 2012).

Thousands of these participatory simulations were established across the United States over a half century. Widespread media coverage hailed the educational and socialization potentials of the "miniature" and "model" versions of American life and the opportunities for a "second life" they offered to the nation's youngest generation (Light 2012; "A Republic in Miniature," 1897; "Boys Found a Model City," 1904; Todd 1898). They were featured in travel guides such as *Baedeker's*, which noted how "a visit to Freeville rivals in sociological interest that to Ellis Island" (Muirhead 1909, p. 146). William George became a popular speaker on the lecture circuit, compared to the pantheon of American inventors including Samuel Morse, Thomas Edison, and Alexander Graham Bell (Winship 1912).

2.3 What Explains the Popularity of These Role-Playing Simulations

Recent scholarship on the histories of computing, information, and related media technologies has been characterized by an ever-diversified list of participants and subjects of inquiry (Light 2016, 2017). As historians in a range of subfields (e.g., history of science and technology, labor history, business history) and subsequently scholars in media studies, design, library science, and other disciplines joined the technical specialists who pioneered the field, they redrew its boundaries, pushing to consider more mundane "technologies" as well as to investigate other topics like the histories of concepts such as information and the histories of perceptual practices around screens (Kline 2015; Friedberg 1993). A notable finding in this work is that, much as the first electronic computers occupied entire rooms, so too, a century ago, a diverse range of "virtual" environments including large-scale panoramas, motion rides, wax museums, biblical theme parks, sham battles, and living villages were considered marvels of their day – entertaining and educating the public by offering them vicarious access to different times and places (Griffiths 1996; Tennerielo 2013; Rabinovitz 2004; Rydell 1984; Mitchell 1989; Schwartz 1998; Gunning 1994; Kirschenblatt-Gimblett 1991).

Such context helps to make sense of why junior republics proved so popular with kids; these participatory simulations went a step further than other attractions, immersing them in an alternative reality that offered opportunities for identity play and to game out the consequences of different actions in the world. As journalist Albert Shaw described: “The scheme has in it all that is fascinating for children in a play, with the further point in its favor that it is not, after all, a mere playing at government but is so far as it goes a real and serious thing” (Shaw 1899, p. 679). In other words, while the kids were not real government officials, inside these simulated societies, they really governed other kids.

If the role-playing central to the republic experience proved popular with kids on account of its resonances with popular entertainment technologies and the vicarious access it offered to the labor force and public life from which they were increasingly being removed, it proved popular with adults on account of its fit with the era’s cutting-edge scientific research. Eminent psychologists from G. Stanley Hall to Josiah Royce wrote widely on imitation and impersonation as natural features of child development. Their observations of kids at play attested to how young people constantly impersonated adults – dressing up as cops and robbers, establishing businesses, and printing newspapers among other activities in the process of identity formation (James 1890; Royce 1894; Hall 1904; Frear 1897; Sheldon 1898; Crosswell 1899). By implication, then, role-playing was the most “natural” point of departure for a modern curriculum – making junior republics a cutting-edge learning approach. When Goo Goo Wilson Gill campaigned to introduce junior republics into public schools across the United States, he compared the new method of civic education with lab science (Gill 1903, 1911). Recognizing how many participants viewed the learning activity generating “more intense interest than the most exciting ball game,” Philadelphia’s Franklin Institute awarded Gill its Cresson Medal for achievements in science and engineering in 1904 (Shaw 1899, p. 679). John Dewey – who used similar language to promote learning-by-doing and whose work has been remembered while Gill’s has not – joined the board of Gill’s organization.

2.4 From Developmental to Economic Productivity

With the spread of junior republics, George oversaw the creation of freestanding institutions in several states, and adaptations including “school cities,” “playground republics,” “boy cities,” and “junior towns,” – evidence mounted as to the educational benefits of immersion in simulated societies, campuses, classrooms, and communities. Young people playing roles in these virtual worlds learned about government by governing. They honed their skills for the new economy by running businesses and practicing trades. Protected from public life and child labor, children from the tenements made good in the longer term – becoming students at Ivy League universities, enlisting in the military, and following other productive career paths (Light forthcoming).

These sociable simulations also reduced institutional costs. Activities adopted because they were developmentally productive proved economically productive as well. So, for example, when an "architectural firm" at the Freeville republic won the contract to construct a building, it meant that no outsiders were hired to improve the institution's facilities. "Truant officers" and "health inspectors" in school-based republics tracked down absentee pupils and sent sick ones home before schools had resources to hire adults for these positions; "public works departments" built playground equipment at almost no cost. The trial board at Milwaukee's Newsboy Republic heard 7500 cases over a decade; with Milwaukee officials assigning real world status to deliberations in the virtual court, these young officials diverted all but the most serious from the actual juvenile court (George 1902; Cronson 1907; Light 2012; Gill 1913).

Goo Goos seeking efficiency in government operations were thrilled by these findings; so, too, were the educators and youth workers struggling to get their institutions off the ground. Yet most were sympathetic with the era's anti-child labor campaigns. For these reformers and the broader public, the associations with educational entertainment and developmental psychology that popularized republics equally shaped interpretations of their cost-saving effects by explaining away young peoples' economic contributions as being not real but instead simulations. Describing the Freeville republic's "system of labor and currency" in which the young carpenters "built nearly all the buildings in the republic grounds, besides making the furniture…there is the bakery and laundry, there are three hundred acres of land given over to farming and there is work in the improvement of the streets." For example, journalist Nina Marbourg emphasized the developmental rather than the economic benefits of this work-like play:

> Breathes there a man with soul so dead that he cannot remember those joyous days when he played at 'grown up'? There is a period of air-castle building in almost every boy's life...a season of wonderful colored paper trades and purchases, a time for the accumulation of tops and marbles. The art of bargain and exchange is all so seriously regarded, even at this age, that the boy is really working at his play and carrying out in his childish way just the transactions his father is perfecting with dollars and cents. (Marbourg 1904, p. 2)

According to this view, constructing a republic building or policing peers for the purposes of civic education and character development were merely "miniature" or "model" versions of adult occupations – not the same as doing these tasks for pay in the "real world." It did not occur to Marbourg – nor to other observers and reformers – that, in profiting from young peoples' vicarious experience of adult roles inside such virtual worlds, republics had relocated rather than eliminated children's labor.

2.5 Occupational Role-Playing Beyond Republics

The junior republic movement offers a fascinating example of the widespread use of simulations in an earlier generation of educational and social reform – tools linked to young peoples' preferred leisure activities and rooted in the era's learning science. Significant in their own right, these virtual environments make visible the industrial era's vastly broader embrace of educational simulations in schools and youth-serving institutions and later in a range of community-based youth programs – as well as the widespread effects of a popular discourse of playful virtuality that transformed economically productive activities from work into "work" and hid young peoples' contributions to getting new institutions off the ground. For even more widespread than republics were their component activities – from the vocational education that aimed to "reproduce practical processes" such that "shop standards, not school standards," prevailed; to the home economics instruction that transformed housekeeping into a "game, not a duty"; to the student governments that mirrored local governments in order that "pupils shall get a good idea of the actual work and purpose of the real city department" whose staff they impersonated; to the junior police programs in which "the boyish love of adventure" was "directed to the imitation of the deeds of the real heroes of American cities—the brave, honest, and unassuming members of the police force, in uniform and out" (Snedden 1910, p. 38; Kittredge 1913, p. 189; "Mimic Cities in Schools," 1897, p. 594; Mason 1915, p. 31). In short, at the moment of their mass popularization, a variety of educational and recreational activities came to be understood as role-playing simulations that could offer young people vicarious access to adulthood while simultaneously protecting them from premature exposure to the hazards of the labor force and public life.

Programming at Gary, Indiana's Emerson School illustrates these broader trends (Dorr 1911; Hendrick 1913). Home to two "boy cities" (despite the coed school, these cities were single sex), the ethos of the republic movement pervaded the curriculum there. Vocational education classes manufactured school desks, lockers, bookcases, and playground equipment and repaired the plumbing and heating systems. Home economics classes planned lunchroom meals for students and staff – keeping budgets, ordering supplies, and preparing meals. Chemistry classes assisted the municipal chemist, testing milk and water supplies. This approach "saved enough for the school system to pay the entire cost of conducting the school departments, including the salaries of the instructors," but it was the educational benefits that attracted greater attention (Hendrick 1913, p. 69). Such role-plays of adult occupations represented the cutting edge of instruction by "laboratory methods," keeping more kids engaged and regularly attending school. Superintendent William Wirt, who had studied with John Dewey, explained how, "It is not child labor," but a "preventive agency," because as one interpreter summarized his view, "there is a wholesome environment and the children are being instructed" (Wirt 1912; "Studying Gary to Help New York," 1914, p. 37). Prominent anti-child labor advocates supported this interpretation. Gary was one of the best examples of efforts to create places where children "obtain educational values not only through books but through genuine life activities," wrote Ruth McIntire of the National Child Labor Committee. "Here at last education has been made vital and absorbing to the child," giving students "a richer, more educative life in school than any plan as yet put into execution" (McIntire 1917, pp. 289, 291). Emerson became a model for more than 200 other communities in short order and over 1000 by 1929.

Such institutionally sited activities inspired still more programs linked to the republic idea. Following the template of community-based republics such as the Milwaukee Newsboy Republics, Goo Goos and public officials soon organized a broader suite of role-playing programs in communities across the nation. George followed his stand-alone republics with a program of this kind called Junior Municipalities in which junior understudies were assigned to each senior government official in a city or town ("Boys Hold Elections Like their Elders," 1913; Stowe 1914). Other programs focused on duplicating a single agency. For example, kids who served as volunteer probation officers and juries on "junior juvenile courts" in Cleveland and St. Louis rounded up suspects and adjudicated misdemeanors, keeping their peers out of the actual juvenile court system ("A Boyville Court Handling Cleveland's Juvenile Crooks," 1914; Street 1915; Oyez, Oyez, Junior Juvenile Court Is Now in Session 1914). Junior sanitary inspectors in Philadelphia and San Diego compiled reports on street conditions such that, in Philadelphia, it became "possible for the municipal authorities, without leaving the city hall, to comb the town every 24 hours, and in a few moments tell as to the clean and unclean street conditions in any one as well as every section" ("Junior League Has Helped Make a Clean City," 1915, p. 6; Seymour 1916). Junior police in New York City and Council Bluffs patrolled their neighborhoods, enforcing laws, for example, against street bonfires, gambling, and firework use. In these and other community-based programs, kids made essential contributions to efficient government operations – keeping order, gathering data, and reducing strains on the public purse ("Boy Police Installed in Park" 1913; Mason, "The Boy Police of New York," 1915; "The sturdy boy police force of Echo Park," 1915; "Boy police make an orderly fourth," 1907). These programs were in many cases a direct response to municipal manpower shortages: "New York City has long needed five or six thousand more men on its police force, but the cost of providing them has always remained prohibitory to the governing authorities," Gregory Mason explained in *Labor Digest*, noting that "The creation of a body of an equal number of boy police" was "much cheaper" (Mason 1915, p. 31). Yet because they enlisted children to play roles (oftentimes in costume), they were held up as examples of child protection rather than expansions of the child labor pool, education for future citizenship rather than present-day financial aids.

2.6 Conclusion

As a contribution to histories of computing and information, this brief account of the junior republic movement's efforts to design simulations like the real world and turn the real world into a simulation calls our attention to an earlier generation's robust body of theory and practice around the educational and socialization potentials of role-playing simulations. Its story of century-old activities that resonate with contemporary efforts to use young peoples' leisure activities as inspiration for a new generation of pedagogical tools including virtual worlds and live action role-playing games, as well as the widespread erasure of their labor in a discourse of virtuality and play, does not seek to trace a direct line from past to present.[1] Rather, its ambition is to recover the forgotten history of now extinct junior republics and remind us that a vast range of their still extant component activities – for example, vocational education, home economics, student governments – were once regarded as cutting-edge instruments of simulation. In a pattern that historians and other scholars have documented with a multiplicity of media from effigies to photography, it was the mass popularization of these activities that ultimately shifted public perceptions (Orvell 1989; Taussig 1993). Activities once regarded as impersonations of adult life came to be understood as children's realities (Light forthcoming).[2] Recovering this set of older understandings reveals how a multiplicity of concepts associated with twenty-first century computing and information technology, including virtuality, gamification, role-playing, and play labor, have deep roots in American life as well as consequences that seem to have been overlooked.

Excavating prior generations' distinctly different ways of knowing and talking about the world not only supplies a richer understanding of the diverse conceptual as well as technological roots of the modern age. For the educators undertaking reforms to meet the educational and socialization challenges of a digital age, the stories of junior republics and component activities presented here offer new bodies of empirical evidence for understanding how similar efforts played out as their predecessors confronted the challenges of an industrial age. These materials are equally rich as resources for generating new kinds of questions for present-day reflection, for example, about the hidden assumptions as to the real-world status of virtual activities, the models of society and citizenship embedded in social and political simulations, the implications of the discourses that accompany new technologies, and the shifting border between the meanings of reality and virtuality as "virtual" activities become increasingly routine.

In showcasing how some antecedents of present-day technological tools and practices may lie in places we might not expect to find them, this account speaks to broader audiences about the more general practice of thinking with history as well. Computing and information historians – like historians more broadly – have long recognized that aspects of what seem novel about the present have as much to do with the stories we have previously told ourselves about the past as with actual differences between past and present (Gitelman et al. 2004; Light 2006). The explosion of work in our field in recent years has already diversified the stories of the past. A clear task ahead is to bring this knowledge, and the larger questions about historiography, to broader audiences.

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[1] On the use of leisure inspiring pedagogy, see McGonigal (2011) and Bogost (2010). On the erasure of labor, see Terranova (2000) and Yee (2006).

[2] Light (forthcoming), which treats junior republics over a longer period, documents the shift from discourse of simulation to education and recreation. The subsequent evolution of these activities – for example, the shift of student government away from mirroring federal, state, and local agencies – is also part of this story.

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Chapter 3
The Modem that Still Connects Us

Ronald R. Kline

Abstract The history of the modem demonstrates that digitization is a hybrid process, in which analog-digital techniques were (and still are) essential. As an indispensable "gateway technology," the modem has integrated heterogeneous information infrastructures since the 1960s, by layering a digital system on top of an installed analog base. Its transparency (especially its visibility and audibility) has changed with changes in technology, the regulation of telecommunications, and user experiences. The surprising resiliency of the modem—its long life as an interim technology—challenges the digital technological progress narrative. Ironically, the most sustained progress narrative in this story celebrates rapid advances in the speed and functions of the supposedly outdated modem.

Keywords Modem · Digitization · AT&T · Analog-digital · Computer time-sharing · Information infrastructure

At the start of the dot-com boom in the early 1990s, the first sign of getting online was not visual but aural. Users monitored the familiar beeps and squeals from a dial-up modem, which was negotiating with a distant modem at the Internet service provider, hoping to hear the sound of a zip followed by silence, telling them they had made it online and that they had entered the modern era, what Nicholas Negroponte at MIT's Media Lab famously called "Being Digital".[1] Technically savvy users may have appreciated the irony that the modem soundscape was produced by a hybrid technology, not a purely digital one.[2] The modem utilizes the analog world of the telephone network to interconnect the digital world of computers. It sends digital (discrete) signals, representing 1's and 0's, from one

[1] Negroponte (1995).

[2] On the concept of soundscape in the history of technology, see Thompson (2002).

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computer to another by modulating analog (continuous) signals, which represent sound waves.

Today, the modem start-up sound is the object of nostalgia, as fans download its ring tone for their smartphones.[3] Yet the modem has not disappeared; it has just become mute. It quietly connects us to the Internet and to each other, by visible cable and DSL modem boxes at home and the invisible modems hidden in Wi-Fi routers and cell phones. Whenever 1's and 0's need to be transmitted through analog channels (by telephone wires, TV cables, or the radio waves that make us wireless), modems have done that work for the past half century. Currently, even some fiber-optic systems use analog modems to send digital TV signals via cable to the home.[4]

This chapter is part of a larger project to examine the history of digitization in the United States, from World War II to the present, with an analog lens.[5] I argue that the case of the modem demonstrates that digitization is a hybrid process, in which analog-digital techniques were (and still are) essential. As an indispensable "gateway technology," the modem has integrated heterogeneous information infrastructures since the 1960s, by layering a digital system on top of an installed analog base. Its transparency (especially its visibility and audibility) has changed with changes in technology, the regulation of telecommunications, and user experiences.[6] The surprising resiliency of the modem—its long life as an interim technology—challenges the digital technological progress narrative.[7] Ironically, the most sustained progress narrative in this story celebrates rapid advances in the speed and functions of the supposedly outdated modem.

3.1 Invention

The invention of the modem (short for modulator/demodulator) occurred in the context of AT&T's extensive telecommunications network in the United States. Although most accounts date the modem to the Cold War, the technique can be traced to the early 1920s, when AT&T developed a system to send telegraph messages over telephone lines.[8] The system transmitted on-off signals from telegraph

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[3] Madrigal (2012).

[4] Although fiber-optic systems have typically used digital modulation (shutting on and off the laser beam) to represent 1's and 0's, some recent fiber-optic systems employ analog modulation to enable a hybrid fiber/coax technology, which has become a popular technology for cable television in the United States. See Hecht (2015), pp. 8–9, 50, 231, 686–690.

[5] On this methodology, see Kline (2019): pp. 19–39.

[6] On gateway technologies, layering, and transparency in infrastructure studies, see Starr (1999); and Jackson et al. (2007).

[7] On technological narratives, see Nye (2003).

[8] Compare Pahlavan and Holsinger (1988), with Edwards (1996), 140; and Russell (2014), 140. I use the term "modem" anachronistically in this section. AT&T engineers coined the term in the late 1930s to designate analog rather than digital transmission, for a modulation-demodulation technique in telephony, in which analog signals modulated an analog carrier to increase channel capacity. See Chestnut et al. (1938), on 107.

equipment (the earliest form of digital telecommunications) on (analog) telephone lines, typically at 75 bits per second.[9] Engineers divided the voiceband carrier, having a frequency of about 4 kilohertz, into a dozen or more channels, in order to send more telegraph messages over a single telephone line. They accomplished this feat by using the telegraph signal—representing dots, dashes, and spaces—to modulate (vary) the amplitude of the voiceband carrier. At the destination, electronic circuits demodulated the carrier to retrieve the sender's signal. By the end of World War II, AT&T had replaced a Morse code telegraph service with an extensive teletype service, which utilized the modem technique to transmit at 100 bits per second.[10]

The teletype modem was transformed into the basis for today's data modem with the emergence of the electronic digital computer in World War II and the desire to transmit computer data faster than teletype speeds. The initial site for this transformation was a gigantic Cold War engineering project, the ground air defense system known as SAGE (Semi-Automatic Ground Environment). Developed for the Air Force by MIT, IBM, Bell Laboratories, and other military contractors in the 1950s, SAGE was built to help protect the United States from attack by Soviet bombers carrying nuclear weapons. The massive control and communications system utilized computer-controlled Direction Centers in two dozen sectors across the country to automate the existing air defense system, in which technicians telephoned radar data to human computers who used it to calculate enemy flight paths. In order for SAGE to keep track of all air traffic, identify threats, and dispatch jets to intercept enemy planes—all in real time—the Direction Centers had to receive timely data from the radar sets in their sectors. Each four-story Center contained two Whirlwind II electronic digital computers (AN/FSQ-7), cathode-ray tube (CRT) displays, and voice and data communication equipment. Early in the project, George Valley, the MIT Physics Professor who headed the Air Force's Air Defense Systems Engineering Committee (ADSEC), which did the initial design for the project, realized that the ability to send analog radar data to digital computers quickly and reliably was key to the success of SAGE.[11]

Valley thought that was feasible after seeing a demonstration at the Air Force's Cambridge Research Center in December 1949. In the demo, a prototype system transmitted data from a Microwave Early Warning radar at nearby Hanscom Field in Bedford, Massachusetts, to the Cambridge lab. John Harrington, head of the group who developed the Digital Radar Relay system, recognized that it would be impractical to transmit the high-bandwidth (megahertz) video signal from the radar by low-bandwidth (about 4 kilohertz) telephone lines, which they wanted to use in

[9] The term "bits per second" is anachronistic here because the term "bit," short for "binary digit," was not coined until 1948. See Shannon (1948), 623–656.

[10] Hamilton et al. (1925); Duncan et al. (1944); O'Neill (1985), 702, 728–729; and Pahlavan and Holsinger," Voice-Band Data Communication Modems," 17.

[11] Everett et al. (1957), 148–155; rpt. in *IEEE Annals of the History of Computing*, 5, no. 4 (Oct. 1983): 330–339; Valley (1985); Edwards (1996), Chap. 3; Hughes (1998); chap. 2; Redmond and Smith (2000).

place of expensive microwave links. They solved this problem by converting the relevant information in the analog signal at the radar site into a digital signal, which represented such essential information as the range and bearing of a target. Drawing on AT&T's work on teletype modems, they transmitted the digitized radar signals along telephone lines by using the pulses to modulate the voiceband carrier and then retrieving the signals by demodulation at the receiver. The technique achieved a compression ratio of 1000 to 1. At a second demonstration to ADSEC, in April 1950, they transmitted a radar signal to the Whirlwind I computer at MIT at 1300 bits per second and displayed the data on a CRT. They achieved this high speed with vestigial-sideband amplitude-modulation. They also took into account noise and usable bandwidth, which they determined by testing the telephone lines leased from AT&T. When MIT established Lincoln Laboratory to do the systems engineering for SAGE in 1951, Harrington's group moved to the new lab, where they developed a Digital Data Transmitter (DDT) and a Digital Data Receiver (DDR), a combination that would later be called a modem. In April 1951, a DDT sent radar data to the Whirlwind I computer at a reliable and fast enough rate for it to calculate flight paths, display the results on a CRT screen, and direct an interceptor plane to "attack" a target plane during a mock exercise. Harrington's group then developed the Coordinate Data Processing Set, the AN/FST-2, consisting of over 6000 vacuum tubes. Manufactured by the Burroughs Business Machine Company, the computer-controlled AN/FST-2 was more accurate than the original Digital Radar Relay System. SAGE installed an AN/FST-2 and a DDT at each of its hundreds of remote radar sites to rapidly transmit radar information to the Direction Centers.[12]

In the mid-1950s, AT&T engineers worked with Lincoln Laboratories to redesign the DDT/DDR as the A1 Signaling Data System, made by Western Electric, the manufacturing arm of AT&T. After extensive field trials in the spring of 1956, the A1 system went into operation in 1958. The standard modem for SAGE met Harrington's group strict transmission requirements: a data rate of 1300 or 1600 bits per second (the speed necessary to track planes) and an error rate of less than 1 bit per 100,000 bits transmitted (about one error per minute). Engineers at Bell Labs adapted the A1 system to AT&T's national telephone network as much as possible, without extensively conditioning the lines. Upon detecting too much noise or other errors, the DDR's Trouble Detector circuit switched to a redundant telephone line to ensure the reliable transmission of radar data.[13]

The A1 system transmitted many other types of digital data for SAGE. In duplex mode, with a DDT/DDR pair (a modem) at each end of the line, the computer in one Direction Center could communicate with the computer in an adjacent Center. Typically, the computers automatically transferred the radar tracking data of a plane flying from one sector to another. The DDT also enabled Direction Centers to send data via telephone and radio links to command headquarters, weapons bases,

[12] Harrington (1983); and Ogletree et al. (1957), 156–160.

[13] Ruppel (1957); Irland (1958); Enticknap and Schuster (1959); James (1959); Soffel and Spack (1959).

and ground air systems.[14] In the fall of 1957, as the technical and popular press began reporting on SAGE, Bell labs Engineer A. E. Ruppel noted that the system "will probably be the largest data transmission network in the world for many years to come."[15]

3.2 Commercial Data Communications

When SAGE was nearing completion, AT&T decided to adapt the A-1 system for the civilian market, to meet the demand of sending data rapidly between the growing number of digital computers in government and business.[16] Bell Laboratories took up the task in the traditional manner of a regulated telecommunications monopoly and developed a system-wide service, called Dataphone.[17] The goal was to convert a technology designed for a special-purpose military application into a product for a general-purpose commercial market.

AT&T rolled out the Dataphone service with much fanfare in February 1958, with a demonstration to journalists at the Savoy Plaza Hotel in New York City. Adopting the common trope of the computer as an "electronic brain," *The New York Times* proclaimed, "Now Robots Chat Long Distance, Feed Each Other Data by Phone." *The Times* noted that the service could send information recorded on paper tape, magnetic tape, or punched cards from office to office over switchboard telephone lines, for a rental fee of between $40 and $120 a month. A publicity photograph of the event shows a woman operating a Recorded Carrier Subset, which transmitted data stored on magnetic tape. Next to it stood the Digital Subset, which transmitted data in real time. Each unit was the size of a small filing cabinet and could send data at 800 words per minute (600 bits per second). AT&T inaugurated the Dataphone service on a trial basis in the Illinois Bell, Michigan Bell, and New York Bell areas.[18]

Yet the trial proved disappointing. In November 1958, Bell Labs announced that, in conjunction with AT&T and Bell Operating Company engineers, it was conducting the "first large-scale evaluation of the data-transmission capabilities of the Bell System telephone network. Information gathered from these comprehensive, long-term tests will be used as a basis for the design of future Dataphone equipment… At the present time, the service is being offered on only a limited scale." Problems of intersymbol interference, caused by envelope delay and impulse noise, were severe. The first of two specially outfitted test trucks was in the New York City area, measuring noise, delay, and attenuation. The next stops for the truck were Chicago and the West Coast. The second truck would cover the South and the Southwest.

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[14] Everett et al. (1957), 150; and Anonymous (1957), on 64.

[15] Ruppel (1957), 402.

[16] Norberg (2005).

[17] Russell (2014), 140–141.

[18] Anonymous (1958a); and *New York Times*, Feb. 2, 1958. On the trope of an "electronic brain," see Martin (1993).

Engineers back at Bell Labs employed a computer to analyze the data and determine the feasible bit rate to transmit digital data on switchboard circuits, the probability of errors, how much the errors could be reduced, and so forth.[19] The report on these tests, published in 1960, concluded that the Digital Subset could attain speeds as high as 1200 bits per second, provided that AT&T "design around many of the data limiting characteristics of the network—the compandors [speech compressor-expanders] and echo suppressors, for example." For reliable transmission, AT&T could utilize equalizers, error detection, and retransmission.[20] The official history of the Bell system explains matter-of-factly that "Field tests with these modems [the Digital Subset and the Recorded Carrier Subset] in the late 1950s proved disappointing, however, and a general service offering was deferred pending further studies."[21]

What happened? Why did AT&T's first commercial data modems not work satisfactorily when run at the same speed as the company's A1 Signaling Data System, which met SAGE's stringent technical requirements? The main difference is that SAGE leased lines from AT&T, which it could condition to reduce delay and noise. Also, the leased lines did not have the "impulse" noise caused by dial-up switchboards in the AT&T system. Bell Labs engineers had taken these considerations into account while developing the Dataphone service. They designed the first experimental Data Subset to have the technical parameters of the A1 system: amplitude modulation (AM) and a speed of up to 1700 bits per second (bps).[22] But they soon switched to frequency modulation (FM) because FM was much less susceptible to noise than AM. They also ran the Digital Subset at a lower speed than the A1 system: 600 bps for switched lines, 750 bps for leased lines, and 1000 bps for specially treated leased lines. They may have rushed the development process, though. The Recorded Carrier Subset, for example, did not have its own modem but used an existing FM terminal modem from AT&T's teletype service.[23]

Yet Bell Laboratories recovered remarkably well from the disappointing Dataphone rollout. In the brief span of 3 years, its engineers developed a full line of Data Sets, their preferred term for "modem" at this time,[24] which set the de facto modem standards for years to come. AT&T announced the impressive modems in Fall 1961, not by calling a press conference at a posh hotel as they had done with the Dataphone service but by sending Bell Labs engineers to give papers at a meet-

[19] Anonymous (1958b).

[20] Alexander et al. (1960), on 474.

[21] O'Neill (1985), 703.

[22] Malthaner (1957).

[23] Gryb (1957); and Weber (1959).

[24] At this time, the Bell system preferred to use the term "data subset," or more commonly "data set," rather than "modem," which it reserved for analog-to-analog modulation-demodulation schemes. See, e.g., Peterson (1957), on 188; Student (1965), on 177; and Lundry and Willey (1965) on 762. For an exception, see Alexander et al. (1960), 433, 474. That usage prevailed until the early 1970s; see, e.g., Davey (1972).

ing of the American Institute of Electrical Engineers.[25] A color sales booklet, "Data Communications," issued in October 1962 (Fig. 3.1), pitched the new series of modems to a wide range of imagined users in government and industry.[26]

The most obvious physical feature of the new modems was their small size. Engineers took advantage of the transistor technology invented at Bell Labs after the war to make their modems small enough to fit on a desktop. Each unit advertised in the booklet (the 100, 200, 400, and 600 series) was much smaller than the Digital Subset and the Recorded Carrier Subset introduced in 1958. While the handshaking procedure was basically the same on the 100 and 400 series as on the 1958 sets—dialing a telephone to call and initiate connections between the sender and receiver—the 200 series had a data-send button and status light to start the transmission, once a call was made.

The new line of modems had a wide range of characteristics and prices (see Table 3.1).[27] The transmission speed varied greatly, from the slow teletype speed (up to 150 bps) of the 100 series to the fast speed of the SAGE system (1200–1600 bps) on the 202 modem and the breakthrough speed (2400 bps) of the 201 modem, made possible by phase modulation. Customers wanting to transmit at the highest speeds, approaching that of private microwave links,[28] could lease the wideband 300 series (not shown in Fig. 3.1). It transmitted at the remarkable speed of 40,800 bps by modulating and demodulating the high-frequency (48 kilohertz) N-carrier telephone lines in the AT&T network. The new line of modems also accommodated different forms of input and outputs. The low-speed 400 series transmitted data between magnetic tape units in a parallel tape-code format rather than the serial format common in most data transmission. The 600 series enabled customers to send analog data, such as that from a tele-writing machine or a facsimile (Fax) machine.[29] The cost of leasing these modems depended on their speed. In 1965, prices ranged from $5–10 per month for the slow 401 modem to $70 for the high-speed 201 modem. In the middle range, the new 103 modem cost $25 per month and the 202 modem $45 per month.[30]

Figure 3.2 shows how AT&T (and the FCC) viewed the interface between the customer's responsibility and the Bell System's responsibility for data transmission in the early 1960s. For digital data, AT&T provided interface equipment in the form

[25] Anonymous (1961). These papers were later published. See Saltzberg and Sokoler (1962); and Baker (1962).

[26] On the concept of imagined users, see Oudshoorn and Pinch (2003), 1–28.

[27] Anonymous (1962a), on 75–77; Saltzberg and Sokoler (1962); Baker (1962); AT&T, "Data Communications," sales booklet, Oct. 1962, https://ia800102.us.archive.org/1/items/TNM_Data-phone_Service_data_over_telephone_-_Bell_20171205_0142/TNM_Data-phone_Service_data_over_telephone_-_Bell_20171205_0142.pdf, accessed Jan. 7, 2019; Anonymous (1962b), on 81; Sokoler (1962); Meyers (1963); and Student (1965)".

[28] Strong and Lockwood (1962).

[29] Although the 600 series works with analog inputs and outputs, it is a modem. It uses analog signals to modulate a voiceband carrier, which is demodulated at the receiver to transmit the analog signals.

[30] Anonymous (1965) on 37. For the rollout prices, see Anonymous (1962a), 75–76.

of a Bell Data Set, whether for teletype services operated by AT&T (note the feminine hand, indicating a gendered division of labor) or for services in which the customer provided what AT&T called "terminal equipment." This included the digital teletypewriter and card reader, as well as the analog telewriter and facsimile. The customer paid a regular fee for the AT&T Dataphone service, which relied on a Data Set designed, manufactured, owned, and maintained by AT&T as a regulated monopoly. This state of affairs lasted until 1968 when the FCC issued its Carterfone decision (see below).

The main use Bell imagined for its Data Sets was transmitting computer data rapidly by phone rather than mailing it through the slow Post Office. That technological progress narrative was a common theme in advertisements directed at data processing managers in industry and government. A 1962 ad in *Computers and Automation* showed an old-fashioned roll of brown wrapping paper and twine waiting to wrap a stack of IBM punch cards for mailing, alongside a modern 200 series Data Set waiting to have the stack of cards read into it, to send the data over phone lines. The ad proclaimed, "In the Time You Take to Wrap It, You Could Telephone the Data."[31] Another ad in *Datamation* showed a close-up of a (man's) finger ready to press a data button, with the caption "PUSH THIS BUTTON … and you can send mountains of business data from coast to coast in less time than it takes to read your morning newspaper!"[32] A graphical illustration in a sales brochure for the 202A Data Set in 1963 depicted a modem sending and receiving data from magnetic tapes, punch cards, and paper tapes between factories and offices in the field and the company's Data Processing Center. The caption stated that the 202A "Transmits and receives business machine codes over regular telephone lines or private lines—across town or across the nation."[33]

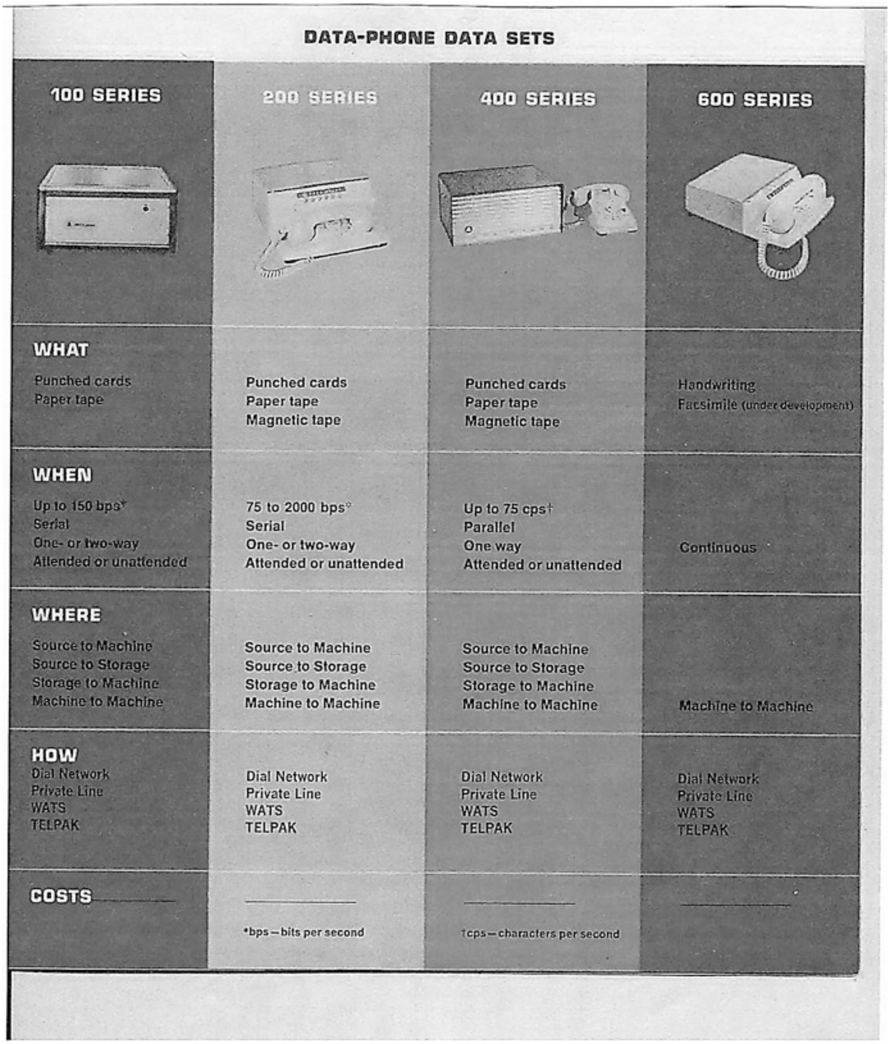
The early Data Sets were used in the manner the Bell System had promoted for the Dataphone service. In early 1961, AT&T ran a full-page ad in data processing magazines with the headline "Biggest DATA-PHONE system in the United States today!". The ad featured a photograph of James P. Jacobs, President of the Hardware Mutuals-Sentry Life insurance group, standing in front of a 100 series data set with a dial telephone on top. The modem sent "business records from 32 branches to the company's centralized computer center at Stevens Point, Wisconsin," at 200 words per minute. Jacobs praised the system for cutting down the time needed to make management decisions "from 3 days to 3 min," supposedly saving the company 1 million dollars a year.[34] A year later, in spring 1962, *Datamation* ran a story about a large government data processing setup, with the title "Social Security Network

[31] *Computers & Automation*, 11, no. 6 (June 1962), 2.

[32] *Datamation*, 8, no. 4 (April 1962): 70.

[33] AT&T, "Data Set 202-A," sales brochure, March 1963, 2, https://ia600101.us.archive.org/19/items/TNM_202A_DATA_phone_data_communication_over_telep_20171204_0210/TNM_202A_DATA_phone_data_communication_over_telep_20171204_0210.pdf, accessed Jan. 7, 2019.

[34] *Computers & Automation*, 10, no. 3 (March 1961), 2; and *Datamation*, 7, no. 4 (April 1961), 10. AT&T began installing the system in late 1960; see Anonymous (1960).



DATA-PHONE DATA SETS

	100 SERIES	200 SERIES	400 SERIES	600 SERIES
WHAT	Punched cards Paper tape	Punched cards Paper tape Magnetic tape	Punched cards Paper tape Magnetic tape	Handwriting Facsimile (under development)
WHEN	Up to 150 bps* Serial One- or two-way Attended or unattended	75 to 2000 bps* Serial One- or two-way Attended or unattended	Up to 75 cps† Parallel One way Attended or unattended	Continuous
WHERE	Source to Machine Source to Storage Storage to Machine Machine to Machine	Source to Machine Source to Storage Storage to Machine Machine to Machine	Source to Machine Source to Storage Storage to Machine Machine to Machine	Machine to Machine
HOW	Dial Network Private Line WATS TELPAK	Dial Network Private Line WATS TELPAK	Dial Network Private Line WATS TELPAK	Dial Network Private Line WATS TELPAK
COSTS				

*bps—bits per second

†cps—characters per second

Fig. 3.1 Bell Data Sets, 1962. (Source: AT&T, "Data Communications," sales booklet, Oct. 1962, 4. Courtesy of AT&T Archives and History Center.)

Links 600 Offices." The elaborate system consisted of teletype terminals, the Dial-o-verter tape processing unit made by the Digitronics Corporation, and the 200 series Bell Data Sets. At each district office, teletype operators sent social security claims data to 1 of 48 relay points. From there, the data was assembled and sent by teletype to one of six communications control centers, where it was received as punched tape. At the communications centers, Digitronics sorting devices assembled messages on reels of paper tape, whose data the Dial-o-verter transmitted to the central computer center at Baltimore via regular telephone lines using the Bell Data

Table 3.1 Bell Data Sets introduced in 1962

Model	Speed	Modulation
101A	150 bps	FSK
102A	75 bps	FSK
103A	200 bps	FSK
201A/B	2000/2400 bps	4-Phase
202A/B	1200/1600 bps	FSK
301A/B	40,800 bps	4-Phase
401A/B	20 characters/sec	FSK
402A/B	75 characters/sec	FSK
601A/B	N/A	Analog I/O
602A	6 pages/min	Analog I/O

Sources: See note 27. *FSK* Frequency-Shift Keying. The 601A was designed for the telewriter, the 602A for Fax

Sets.[35] AT&T allowed the Social Security Administration to use the Dial-o-verter in conjunction with its Data Sets because only the Data Sets were connected to the telephone network.

3.3 Interactive Computing

In its sales brochure for the 202A Data Set, AT&T listed six general capabilities of the modem under the heading, "Meets Your Needs for Flexible Data Communications." Five of the items referred to the type of data communication between business machines and central computers discussed in the previous section. The sixth item noted that the 202A "Accepts electrical signals directly from computers—makes possible direct computer-to-computer operation."[36] Some companies and universities utilized that capability to access central computers from a remote terminal, what came to be called interactive computing. A 1966 survey noted that "Tele-data-processing systems (in which many remotely located users are connected via communication links to a central computing facility) have long been familiar in such specialized areas as airline reservations, air defense, mail-order tallying, inventory control, and department-store point-of-sale recording. More recently, the tele-data-processing concept has been extended to more general-purpose fields with the objective of sharing the costs of a digital computer among a number of users" in a time-sharing computer facility, often called a "computer utility" at the time.[37] Here, I focus on interactive computing in two areas: airline

[35] Anonymous (1962c). See, also, "US Agency to Open New Data Network," *New York Times*, Jan. 30, 1962. Dial-o-verter advertised that it had installed more than 100 systems in 30 cities in the U.S.; see *Datamation*, 8, no. 9 (Sep. 1962), 15.

[36] AT&T, "Data Set 202-A," 2.

[37] Parkhill (1966), 2–3.

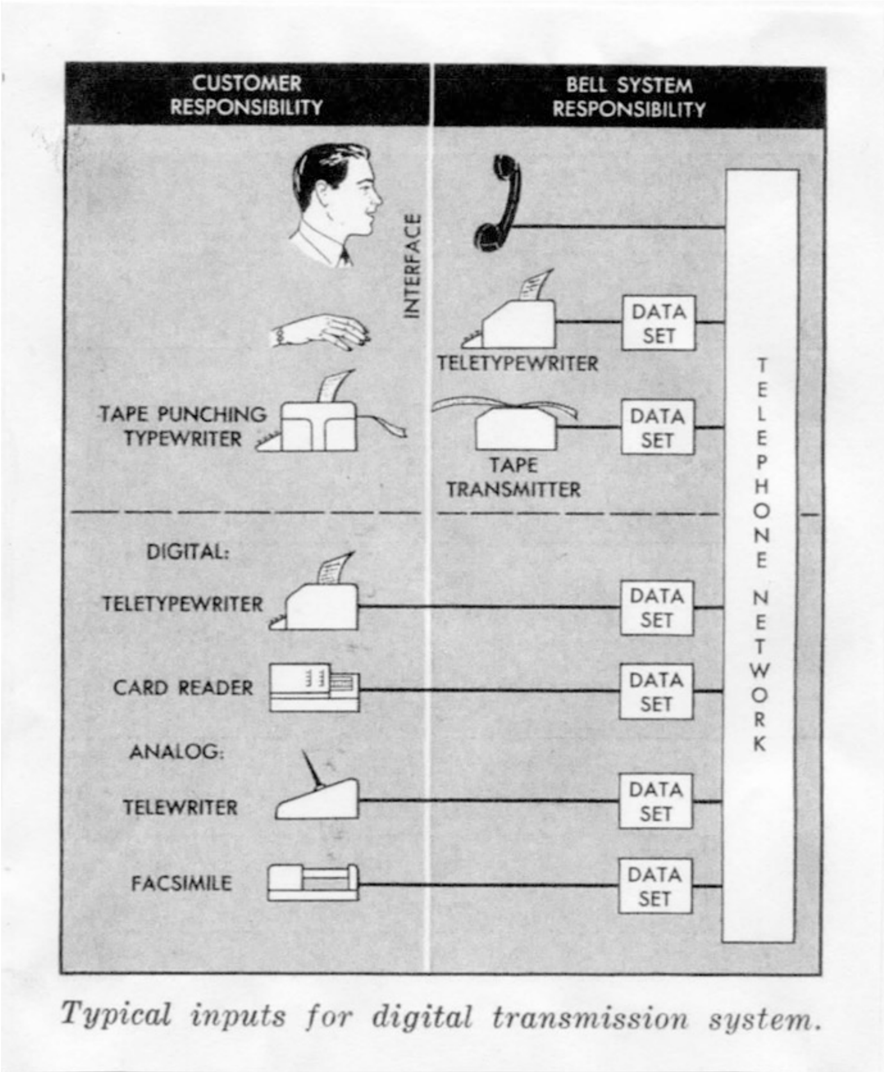


Fig. 3.2 AT&T's view of data sets on telephone lines. (Source: Bell Laboratories Record, 41, no. 2 (Feb. 1963): 65. Courtesy of AT&T Archives and History Center.)

reservations and computer time-sharing. Unforeseen by AT&T when it introduced the Dataphone service, these applications created a high demand for telephone line modems in the 1960s and 1970s, before modems became a household appliance to hook up personal computers to computer networks in the 1980s.

The computerization of airline reservation systems relied on massive telecommunication networks. A 1962 survey found that eleven national airlines in the

United States had contracted with electronics companies to install reservation systems, half of which were already online. Two major computer companies, IBM and UNIVAC, built systems for five of the airlines, including American and Eastern.[38]

IBM's SABRE system was the most complex and well-known endeavor. IBM drew on its experience designing and building the massive, real-time computers for the SAGE air defense system in the 1950s to work with American Airlines and AT&T to develop SABRE over the course of a decade. It went into operation on a nationwide basis at Delta Airlines in the Spring of 1963 and at American Airlines at the end of 1964. Consisting of three main elements—an Electronic Reservations Processing Center, Agent Sets, and a Communications Network—SABRE received reservation and sales requests for air flights from ticketing desks across the country, confirmed reservations, made sales, and kept records and statistics on all of this for customers and managers alike.

A distinctive feature of SABRE, as compared to most commercial installations of Bell modems, was its computerized control of communications over a national network. Rather than sending data through the AT&T switchboard network, SABRE sent data back and forth between Agent Sets and the central computer center over telephone lines leased from AT&T. In 1964 that amounted to 31,000 miles of lines that connected 1018 ticket and sales desks.[39] On the American Airlines system, the Mulcom (Multiplexor Communications) switching units and a buffer to store incoming messages handled the data communications. Both units were controlled by the central computer, an IBM 7090.[40] For the Delta SABRE system and the PANAMAC system, designed for Pan American, IBM introduced the 7750 computer to better control the flow of information in this complex network.[41] It is not clear from published sources which modems the IBM 7750 employed on airline reservations systems at this time. Most likely they were Bell Data Sets.[42]

While airline reservation clerks could now remotely access central computers, the ability to communicate with a computer over a telephone line was not new. In 1940, Bell Labs Mathematician and Computer Pioneer, George Stibitz, designed a digital, relay-controlled Complex Number Computer, which could be operated via teletype lines. Stibitz publicly demonstrated this capability with a special teletype link set up by AT&T during a meeting of the American Mathematical Society held at Dartmouth College in the summer of 1940. One of the attendees, MIT mathematician Norbert Wiener, who later founded the science of cybernetics, was fascinated that he could key in a problem in New Hampshire and get an answer from the com-

[38] Anonymous (1962d).

[39] Parker (1965); and Copeland et al. (1995).

[40] Plugge and Perry (1961).

[41] Anonymous (1962d), 52; Anonymous (1962e); and Emerson et al. (1991), 577.

[42] Block diagrams in the IBM 7750 manual (*IBM 7750 Programmed Transmission Control Programming Logic and Organization*, Reference Manual C22-6695, IBM, 1962, http://bitsavers.trailing-edge.com/pdf/ibm/datacomm/7750/C22-6695_7750_ProgrammingLogic.pdf, accessed Jan. 7, 2019) do not show a modem, but the manual says that one of the functions of the Channel Adapter is to "control digital subsets" (9), the language of the Bell system.

puter in New York. He tried, without success, to trick it into giving a wrong answer.[43] The SAGE system also relied on computer-to-computer communications, but that was mostly for data transmission, not the remote operation of a computer.

What is new with the time-sharing systems is the ability to access a central computer to perform a range of general functions rather than a specific function such as making airline reservations. Time-sharing allowed users to retrieve information such as news and weather reports, run existing computer programs, and even program the computer to do new tasks. These were the hallmarks of the computer utility and university time-sharing systems.[44] The development of a prominent experimental system at MIT, Project MAC (which stood for "Machine-Aided Cognition" or "Multiple-Access Computer"), indicates the role of modems in time-sharing. Inspired by the Compatible Time-Sharing System (CTSS), which Fernando Corbató's group developed at the MIT Computation Center, and funded by the Pentagon's Advanced Research Projects Agency, MAC went into operation in 1963. Its data communications technology resembled that of the advanced SABRE system. An IBM 7750 computer enabled 24 users (soon updated to 30) on the MIT campus and in the Cambridge area to simultaneously access the central computer, an IBM 7094, as though it was their private computer. Standard teletype units or IBM Selectric teletypewriters made up the majority of terminals; MAC also had a couple of expensive CRT graphical displays. As with SABRE, the 7750 computer automatically controlled the modems at the computing center, most of which operated at 100 bits per second. By grouping some of these lines together, the system could handle three 1200 bps modems, one of which interfaced with a PDP-1 minicomputer to operate a graphical display terminal. The head of Project MAC, Robert Fano, noted in 1965 that "All of these terminals are compatible with Bell System Dataphone data sets," i.e., the 100 series and 202 Bell modems.[45]

Corbató made the decision to use Bell modems during the development of the CTSS. He recalled that after convincing IBM to provide them with a 7750 computer, "We then began to work on obtaining modems. The earliest modems were 110 baud modems, which are incredibly slow by today's standards, but they were upgraded pretty fast. The modem itself was a box as big as a couple of shoeboxes, incredibly cumbersome."[46] Corbató chose the same type of modems for the ill-fated Multics system (Multiplexed Information and Computing Service), which was designed in 1965 in conjunction with Bell Labs and General Electric. GE had replaced IBM as the supplier of time-sharing computers to Project MAC. The

[43] Ceruzi (1983), 92–93; Millman (1984), 359; and Stibitz (1993), 112.

[44] Norberg and O'Neill (1996), Chap. 2.

[45] Fano (1965), on 58; and Fano and Corbató (1966), which is illustrated by a photo montage of the 30 users at work at their terminals.

[46] Spicer (2015), on 9. Baud is not equivalent to bits per second, because it refers to the symbol rate of transmission, which is not necessarily equal to the bit rate. See Fist (1996), 70.

Generalized Input/Output Controllers in Multics used "standard telephone data sets," that is, Bell modems.[47]

Martin Campbell-Kelly and Daniel Garcia-Schwartz have recently shed light on the impact of modems on the data processing services industry in the era of time-sharing. They found that, between 1963 and 1978, online services gradually replaced the traditional method of transmitting data by mailing IBM cards and paper or magnetic tapes to a computer center. Because the center would process them in the batch mode of computing, this data processing service was called "mail batch." The online services consisted of "remote batch," the usage AT&T advertised for its Dataphone service in the 1960s, and "interactive," i.e., the time-sharing systems. Made possible by modems, these online services grew steadily, despite the business recession in the computer industry in 1970–1971. Yet it took 15 years for online services (remote batch and interactive combined) to earn more revenue than mail batch ($2.8 billion versus $2.1 billion in 1978), because mail batch also grew substantially at this time. This phenomenon illustrates what historian David Edgerton has called the "shock of the old," the persistence of old technologies alongside new ones.[48]

3.4 Computer-Mediated Communication

Yet the time-sharing industry soon fell on hard times. Campbell-Kelly and Schwartz argue that it "was killed by the rise of the PC" in the early 1980s.[49] Favorable FCC rulings and the invention of email; home computer networks, such as Compuserve and Prodigy; and faster and cheaper modems also played a role in the fall of time-sharing and the rise of what became known as computer-mediated communication. As a result, the modem became a much more resilient technology than the Bell system had ever imagined it would be. By the 1990s, the supposedly outdated modem became an essential part of the hybrid analog-digital information infrastructure that supported the explosive growth of digital media during the dot-com boom.

The race among Bell and private companies to increase the speed of modems and lower their prices was spurred by the FCC Carterfone decision of 1968. It allowed non-Bell companies to attach modems to the dial-up telephone network through a protective device supplied by AT&T, a requirement which the FCC lifted in 1976. The headline in Datamation read "FCC Carterfone Decision Unsettles Carriers, Encourages Modem Makers."[50] Inventors greatly increased the speed of voiceband modems by using multiple-bit modulation techniques, conditioning leased lines,

[47] Ossanna et al. (1965), 231–241, on 240. On GE time-sharing and IBM's response to GE, see Lee (1995); and O'Neill (1995).

[48] Campbell-Kelly and Garcia-Swartz (2008); and Edgerton (2007).

[49] Campbell-Kelly and Garcia-Swartz (2008), 31.

[50] *Datamation*, 14, no. 8 (August 1968), 86; and Mathison and Walker (1972), on 1261–1263. When the FCC removed the requirement for a protective coupler device in 1976, it reduced the cost of the modem-dependent Fax machine. See Coopersmith (2015), 107.

and providing error correction. In 1967, the Milgo Company broke the 2400-bps speed barrier with its 4800-bps modem. The Bell 203 Data Set bested that with a speed of 7200 bps in 1969. Two years later, the Codex company introduced the first successful 9600-bps modem. G. David Forney designed it by applying information theory techniques he had researched as a PhD student at MIT. All of these firms tested their modems on lines leased from AT&T, which they could fine-tune for the greatest speed. By employing the automatic equalizer technique patented in 1965 by Robert Lucky at Bell Labs, the Bell 203 Data Set transmitted at 4800 bps on dial-up lines. By 1981, the Paradyne company and Codex had surpassed the 9600 limit with modems that ran at 14,000 bps on leased lines. At the time, information theorists had calculated the Shannon channel capacity for telephone lines to be 19,200 bps.[51] The NEC corporation in Japan reached that speed in 1985; it was surpassed in 1994 by modems meeting the International Telecommunication Union (ITU) standard, v.34, which achieved 28,800 bps on dial-up lines.[52]

These state-of-the-art modems were pricey. In 1968, the first version of the Codex 9600 sold for $20,000![53] Only large computer centers in business and the military who leased special lines from AT&T could afford them. As was the case in other areas of semiconductor electronics, prices dropped dramatically when inventors incorporated integrated circuits into modems. The price of a Codex 9600C, for example, dropped in half, to $8900 in 1979. After more start-up companies entered the business and employed very-large-scale integrated circuit chips, the price for a 9600-bps modem fell even more dramatically to $1299 for a Hayes V-series Smartmodem in 1988.[54] For those who wanted to send email via PC computer networks, rather than transmit volumes of data at high speed, there were plenty of low-speed modems available. The Pennywhistle 103, an acoustic-coupled 300-bps modem, is sold as a kit for $100 in 1976. A 1979 survey of over 400 modems listed a dozen 300-bps modems that cost under $300, including the popular Novation Cat. By 1984, the price of 300-bps modems ranged from $60 to $350.[55]

A modem's speed set the conditions for how users could participate in the computer-mediated communications movement of the 1980s: whether they were able to send and receive email, post notices to bulletin boards, or retrieve news, weather reports, and other timely information from videotex and other information services.[56] In late 1984, Byte magazine noted that 300-bps modems (Bell 103 compatibles) and 1200-bps modems (Bell 212 compatibles) dominated personal computer networks, because they could handle these applications nicely. The reviewer

[51] Holtzman and Lawless (1970); Forney (1984), on 632–633; and Pelkey (2007)

[52] Pahlavan and Holsinger (1988), 22; and Fist (1996), 697. The United States used the de facto Bell standards until the break-up of AT&T in 1984, when it aligned with the ITU standards. See Held (1991), Chap. 4.

[53] Anderson (2016), on 47.

[54] Anonymous (1979), on 193; and Humphrey and Smock (1988), 104–110, 112–113, on 104.

[55] "The Pennywhistle 103," *Byte*, 1, no. 15 (Nov. 1976), 60 (ad); Anonymous (1979), 169–170, 174, 177; Maxwell (1984), 182, on 180. On the Novation Cat, see, e.g., an ad in *Byte*, 5, no. 4 (April 1980), 265; and Garetz (1983), 82–83.

[56] On videotex, see Boczkowski (2004), Chap. 2.

explained that "Faster modems for the switched network—at 2400, 4800, and even 9600 bps—have been produced, but they are not in general use because they require unusual protocols or simply cost too much." To download large files and fill a screen quickly required speeds greater than 1200 bps. It took 17 s to fill an IBM PC screen at 1200 bps, "which is intolerable and virtually precludes home programming." Yet most computer networks, including Tymnet and Telenet, only supported data transmission speeds of 300 and 1200 bps at the time. The reviewer concluded that "No major network offers dial-in service at 2400 bps on a widespread basis."[57]

All of that changed, of course, with the invention of the World Wide Web and the privatization of the Internet in the 1990s.[58] The affordable 300-bps and 1200-bps modems of the 1980s were too slow to display the colorful Web pages. Inventors of voiceband modems then engaged in another speed race and price war, which ended in the late 1990s with the development of the v.90 modem. By combining digital and analog transmission techniques, the v.90 downloaded files at the incredible speed of 56 kilobits per second (kbps) on switchboard telephone lines and cost only $100.[59]

Users attributed wider cultural meanings to modems employed in computer-mediated communication than they had to those in data communications and time-sharing. Pundits of the digital age praised the personal computer and the modem for bringing about an information revolution, a digital utopia. Stewart Brand, the founder of the *Whole Earth Catalog* and the Whole Earth 'Lectronic Link (WELL), an early Bay-area bulletin-board system, noted in 1987 that "A personal computer without a telephone line attached to it is a poor lonely thing."[60] In 1993, journalist Howard Rheingold, a denizen of the WELL, explained how to create a "virtual community" by joining the digital grassroots movement: "A BBS [Bulletin Board System] is the simplest, cheapest infrastructure for CMC [computer-mediated communication]: you run special software, often available inexpensively, on a personal computer, and use a device known as a modem to plug the computer into your regular telephone line. The modem converts computer-readable information into audible beeps and boops that can travel over the same telephone lines that carry your voice; another modem at the other end decodes the beeps and boops into computer-readable bits and bytes. The BBS turns the bits and bytes into human-readable text."[61] Nicholas Negroponte, founder of the Media Lab at MIT, further explained the modem sound in Being Digital (1995), a collection of columns he wrote for *Wired* magazine, the apostle of digital utopianism. "Just listen to your fax or data modem next time you use it. All that staticky-sounding noise and the beeps are literally the

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57 Maxwell (1984), 179, 180, 182. The Bell 212 modem was dual speed, running at either 300 bps or 1200 bps; see Fist (1996), 72.

58 Abbate (2010).

59 English (1999), 120, 122. The V.90 was a modem pair. The "digital modem" at the server transmitted downstream at 56 kbps on a digital line, whose PCM signal was decoded and received by the client's "analog modem." The analog modem transmitted upstream to the server at 33.6 kbps using the v.34 standard. See Gao (1998).

60 Brand (1987), 23. On Brand, see Turner (2006).

61 Rheingold (1993), 8–9, his emphasis.

handshaking process. These mating calls are negotiations to find the highest terrain from which they can trade bits, with the greatest common denominator of all variables."[62]

The sound of handshaking in the PC era, lasting about 30 s, signified much more than it had previously. Microprocessors now enabled modems to communicate with each other through a protocol of audible tones to find the fastest and most reliable mode to transmit data. After setting up the call, modems at each end of the telephone line negotiated the highest common speed between them and cancelled echo suppressors on the line by sending out a specific tone. In the v.32 (9600 bps) ITU standard of 1984, the modems probed the characteristics of the line and used those results to "train" the echo canceller in the sending modem and the adaptive equalizer in the receiving modem to compensate for the electrical characteristics of the dialed-up connection. Later modems also agreed on data compression and error-correction schemes. When the handshaking ended, the transfer of information began, by tones signifying the transmission of bits. Because the modems cut out their built-in speakers during this period, the data tones were inaudible to the user, unless she happened to pick up the telephone handset and listen in. It was this feat of digital signal processing performed by the computerized "smart modems," combined with the mundane electronic ability to switch off the speaker after handshaking ended, that created the distinctive, now nostalgic, screeching modem sound—the soundscape of going online during the dot-com boom.[63]

3.5 Conclusion

In the logic of modern digitization, in which digital media always drive out analog media, the modem should not exist in the twenty-first century. A device that transmits digital data over an existing analog network in a hybrid manner should have been replaced long ago by an all-digital communications network.[64]

In fact for many decades the Bell system—which began digitizing its network in 1962, the same year it commercialized the data modem—viewed the modem as a necessary but interim technology.[65] In T1-carrier, AT&T's first digital network, pulse-code modulation (PCM) converted analog telephone signals into digital signals, which were transmitted at 56 kbps on reconditioned medium-haul lines equipped with repeaters. By 1983, more than one-half of AT&T's exchange trunks

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[62] Negroponte (1995), 207. On the development and extensive use of the Fax machine, see Coopersmith (2015).

[63] Fist (1996), 312, 432, 695–698. On the history of digital-signal processing, see Nebeker (1998).

[64] The hybridity of the modem, itself, changed over time. It worked mostly by analog electronics, with some digital circuits, up to the 1980s, when the microprocessor turned it into a small digital computer, with some analog circuitry.

[65] See, e.g., Pierce (1966); and O'Neill (1985), 708.

were digital.[66] To digitize the so-called last mile (the local loop) between the already digitized parts of the telephone network and the home, AT&T adopted the Integrated Services Digital Network (ISDN) system, a worldwide standard established in 1981.[67] The telecommunications industry had high hopes for ISDN. In the authoritative textbook *Computer Communications and Networks* (1996), John Freer observed that "Telecommunication authorities are now introducing all-digital networks to which the subscriber enters data in digital form through a standard interface, thus making modems unnecessary."[68] Like most digital enthusiasts, Freer underestimated the resiliency of the modem. While ISDN sent data at the faster rate of 64 kbps, the inexpensive 56-kbps v.90 modem competed effectively against the expensive ISDN service in the United States. Both technologies were replaced in the early twenty-first century by megabit-per-second broadband systems. Ironically, they relied on modems, a new breed of modems initially developed for video-on-demand over wired channels: cable modems (on coaxial TV cable) and DSL modems (on twisted-pair, copper telephone lines).[69]

In 1999, Robert Lucky, the inventor of automatic equalization, expressed his amazement at the resiliency of modems: At "Bell Labs in 1961, we didn't realize modems would still be around 40 years later… Nevertheless they work, and work everywhere, so they're still around. I never would have dreamed that 40 years later everyone would have these in their houses and carry them on trips. Modems were something then that would be used for big computer centers. They weren't personal things. I never thought I would actually own a modem of my own. And modems were what I worked on at that time."[70] Although the personal piece of infrastructure described by Lucky—the PC external modem—has virtually disappeared, he captures the salient features of the digital process narrative.[71]

In contrast, I have emphasized the analog progress narrative of increasing modem speeds and the presence of the analog in digitization, in the past and the present. The infrastructural meanings of the modem, a gateway device that allowed a digital system to be layered on top of an installed base of analog lines, depended on time, place, and usage. In regard to transparency, some form of soundscape has been produced by voiceband modems from SAGE to the present, because the device works by sending audible signals (tones) over a telephone line. The tones heard only by technicians and operators at computer centers, before the invention of the personal computer, were heard by millions of PC users in the 1980s and 1990s, now as the screeching sound of handshaking. But there is no shock of the old with today's modems. Most modems are now silent because the high-frequency carrier signal of broadband is far above the range of human hearing. Modems are invisible in smart-

[66] Aaron (1979); and O'Neill (1985), chap. 18. On the history of PCM, see Millman (1984), 399–417.

[67] Wienski (1984).

[68] Freer (1996), 57.

[69] Anonymous (1999); Chen (1999); Ciciora (2001); and Anonymous (n.d.).

[70] Hochfelder (1999).

[71] See Kline (2019).

phones and largely unnoticed in Wi-Fi routers, cable modems, and DSL modems at home. Whether noticed or not, they still connect us through the analog channels of wire, coaxial cable, radio waves, and light beams, thus challenging the digital progress narrative of our time.

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Chapter 4
Values, Media, and Genres for Standardization

JoAnne Yates

Abstract This chapter applies genre theory to the history of voluntary standardization. Drawing from research on electrical, Internet, and Web standardization reported in Yates and Murphy (Engineering rules: global standard setting since 1880. Johns Hopkins University Press, Baltimore, 2019), I show how genres shape and reflect the values and processes for arriving at product and performance standards across firms in voluntary standard setting, and how they change when new values and media are adopted. The traditional genres of standardization used through most of the twentieth century (demonstrated in genres used in radio frequency interference standardization in the 1960s through 1980s) reflected values of technical orientation, consensus, balance of stakeholders, respect for all stakeholder views, willingness to spend time on due process through repeated balloting, and (at the international level) internationalism. In the late 1980s, new standards organizations emerged to set standards for the Internet and the World Wide Web. In them, new or altered genres arose, reflecting and revealing shifts in values toward transparency, timeliness, and free availability of standards, and less emphasis on balance, respect, due process, and international representation. The move to electronic communication occurred from the beginning in the new standards organizations, also shaping the new genres. In contrast, the old organizations simply reproduced existing genres in new media, reinforcing my earlier work identifying values more than media as the key driver in genre change. More broadly, this study argues that genres are useful tools for historical and contemporary social analysis in many realms.

Keywords Genre theory · Genre repertoire · Standard setting · Voluntary standards · Internet standards · Web standards · Consensus

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4.1 Introduction

Genres of communication within communities and organizations played a major role in most of my scholarly work from the 1980s into the early 2000s. In *Control through Communication: The Rise of System in American Management* (Yates 1989), I studied the emergence of twentieth-century genres of business communication (e.g., memos, reports, graphs, tables, forms) around the turn of that century. In it, I argued that systematic management, an engineering and management movement with a belief in system and efficiency, drove the emergence of new genres. Its ideology focused on documenting practices and communicating them in writing rather than by word of mouth, as well as on collecting data and analyzing and comparing it to improve practices. Technologies of written communication—such as the typewriter, carbon paper, and vertical files—while not the driving force behind their emergence, facilitated and shaped the new genres as they produced, reproduced, stored, and retrieved documents enacting each genre. This work demonstrated that genres are shaped by ideologies, values, practices, and norms, as well as by the media in which they are instantiated. It also suggests that studying a community's genres, in conditions of both stability and change, may illuminate the community's values and practices, as well as its media use.

Shortly after that book was completed, I began almost two decades of collaboration with my colleague Wanda Orlikowski in the MIT Sloan School of Management's Information Technology group. We defined the notion of genre in social science terms and used it to study communication in the new electronic media that were just emerging at that time (Yates and Orlikowski 1992; Orlikowski and Yates 1994). In this research, we studied what happened when paper-based genres such as the memo and proposal migrated into electronic media. In general, we argued (theoretically and empirically) that genres shape and are shaped by purposes and norms as well as communication media.

My historical projects undertaken during and since that period (Yates 2005; Yates and Murphy 2019), however, have not focused on genre. In this chapter, I return to the notion of genre and apply it to the history of voluntary standardization, the subject of *Engineering Rules: Global Standard Setting Since 1880* (Yates and Murphy 2019), written with my co-author and husband Craig N. Murphy. I demonstrate how focusing on genres can illuminate that history and argue that a genre lens may be broadly useful to many historical and contemporary studies. In particular, I show how genres shape and are shaped by—and consequently reflect—the values and processes for arriving at product and performance standards across firms in voluntary standard setting, and how they change when new values and media are adopted. I draw from our research on electrical, Internet, and Web standardization to examine genres of communication (initially paper-based and later electronic) used to develop standards. I found that the values and norms of standardization were embedded in the genres that structured the standardization process, as the values of systematic management were in the genres I studied in *Control through Communication*. In addition, new media also shaped the genres. Studying the genres of standardization gives us insight into stable and changing values and norms over the twentieth century and into the twenty-first. I conclude by arguing that genre analysis can be an important tool for historical and contemporary social analysis of communities and organizations.

4.2 Genre Framework

A *genre* may be defined as a typified communicative action with a socially agreed-upon purpose and recognizable form features (Orlikowski and Yates 1994). A genre is a structure (Giddens 1984) that individuals draw on and enact in typical situations. For example, the resume genre is used to present a person's educational and job history and achievements for use in seeking jobs. Members of a community recognize the purpose, as well as common format characteristics of genres, such as structural and linguistic features (e.g., a resume's list of jobs by date, with most recent listed first). Such patterns of communication typically emerge gradually over time, in interactions among individuals' communicative actions, their social and organizational context, and the media they use. Over the last three decades, the concept of genre has been used as an analytic device to study use of new media (e.g., Orlikowski and Yates 1994; Kwaśnik and Crowston 2005) but also to examine language use in organizations (e.g., Bhatia 1993) and the structure of online communities (e.g., Emigh and Herring 2005).

Genres do not always operate individually. A genre system, which is a sequence of interrelated genres in which "each participant makes a recognizable act or move in some recognizable genre, which then may be followed by a certain range of appropriate generic responses by others" (Bazerman 1994), structures activities and processes (Orlikowski and Yates 1994). For example, the genre system of journal peer reviewing[1] starts with an author's submission of a manuscript to a journal editor. The editor acknowledges its receipt and sends it to potential reviewers, with a letter requesting that they review it (now often a standard message sent through an electronic system). The reviewers may accept or reject the request, these days typically electronically. Once reviewers have accepted, they read the manuscript and write reviews of it; then they send or electronically submit the reviews—along with a private recommendation to the editor on whether to reject, accept, or request a revise and resubmit—back to the editor. When the editor receives enough reviews, he or she reads them and writes a decision letter or electronic message to the author. If the decision is to reject the manuscript, the genre system enacted in this case is complete. If the decision is revise and resubmit, a slight variant of the process starts over again when the author resubmits a revised manuscript. An acceptance triggers a new genre system for final editing and proofing of an article for publication. A

[1] To save space, I have simplified the process here, omitting, for example, desk rejects and additional layers of editors used by many major journals.

genre system may be shorter and simpler than this one, as in the case of a query followed by a reply.

Another aggregation of genres that is useful as an analytical tool is the genre repertoire—the set of genres a given community draws on and enacts regularly (Baktin 1986; Devitt 1991; Orlikowski and Yates 1994). Studying a community's genre repertoire illuminates its values and norms at a particular time, indicating a community's established practices and its socially agreed on purposes. Examining the repertoire over time can provide insight into how the communicative practices emerged or changed in interaction with its values and norms, where and when new genres were first introduced, and how and why they were drawn on frequently enough to make them part of the established repertoire. Various academic disciplines, for example, use particular genre repertoires that reflect their norms, values, and assumptions about the nature of knowledge and knowledge production. The genre repertoires of lab sciences (including lab reports, grant proposals, technical reports, journal or conference publications, etc.), for example, differ considerably from the genre repertoires of humanistic disciplines (including books and articles, and possibly grant proposals that take a very different form than those of the sciences), reflecting different epistemologies and purposes.

In this chapter, I will show what the genre repertoires of several communities of standardizers tell us about the values of these communities and the standardization process. In particular, I will show how the genre repertoire changed beginning in the late 1980s, when computer networking ushered in new standards organizations, processes, and media. That change will be the focus of this chapter's genre analysis.

4.3 Voluntary Standardization: Nature, Origins, and Values[2]

Standards provide an invisible infrastructure in our world. Metrological or measurement standards (e.g., inches, feet, miles; centimeters, meters, and kilometers; watts and ohms), often mandated on a national level, may come first to mind, but standards for hundreds of thousands of industrial and post-industrial products and processes play key roles in our lives, as well. On a macro level, shipping container standards support and enable global supply chains and markets. On a more micro level, screw thread standards enable a person to buy a garden hose at a hardware store, with the assurance that the hose will screw onto the appropriate outside faucet at home. Smart phones may incorporate hundreds or thousands of standards.

Although standards may be mandated by governments or intergovernmental bodies, or may emerge within markets (often through standards wars), the vast majority are established by standards committees within private, nongovernmental organizations. Many of these organizations are dedicated solely to standard setting, either national standards organizations such as the American National Standards Institute (ANSI) or international organizations such as the International Organization

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[2] This section is based on Yates and Murphy, *Engineering Rules*, 2019, especially Chapters 1–3.

for Standardization (ISO). Others are the standards wings of professional or trade associations such as the Institute of Electrical and Electronic Engineers (IEEE) or the Society of Automotive Engineers (SAE). The members of such committees, primarily engineers, arrive at consensus on and publish standards for products and processes for industry. They are not compensated by the standard setting bodies; typically they are either supported in these activities by their employers (who often have a stake in the standards) or they volunteer their time. Importantly, producers and users of the products or processes being standardized adopt the standards voluntarily.[3]

Engineers developed the organizations and processes for establishing private, voluntary standards in the late nineteenth and early twentieth centuries (see Yates and Murphy 2019, Chapters 1–2, for a detailed treatment). As engineers professionalized in industrialized countries in the late nineteenth century, they formed professional societies and sought a mode of public service to support their claims to professional status, adopting industrial standard setting as such a contribution to the common good. The standards committees formed within engineering societies were followed by organizations developed expressly for setting standards in a broad industrial realm and including members from multiple engineering disciplines. At the national level, this began with a British national committee founded in 1901 (the predecessor of today's British Standards Institute or BSI) and followed by many others, including an American national body (a predecessor of today's ANSI), just before, during, and after the First World War. In 1904, only 3 years after the initial British body was formed, an international group of electrical engineers agreed they should establish an international body to set standards in that restricted technical domain. In 1906 they established the International Electrotechnical Commission (IEC), the first surviving international voluntary standard-setting body, which still sets international standards today.

Between the First and Second World Wars, many national standard-setting bodies were established, and their leaders made a first (only mildly successful) attempt at establishing a broad-based (rather than domain-restricted) international body. Immediately after the Second World War, standardizers established the first really successful ongoing, broad-based international standard setting body, the International Organization for Standardization or ISO. Between its 1946 founding and the 1980s, ISO, with IEC serving as its electrotechnical division, became the apex of a fairly stable, hierarchical international standards system with multiple organizations that shared a set of values and a process for setting standards.

Around 1900 the engineers leading the standardization movement developed a set of values and processes that were honed over the decades and that would guide voluntary standard setting throughout most of the twentieth century (see Yates and Murphy 2019, Chapters 3 and 4). Standardization leaders believed that standards

[3] Of course, once a standard is widely adopted, small producers and users may feel they have no choice but to adopt it. In addition, governments (or intergovernmental bodies such as the European Union) may later incorporate private, voluntary standards into regulation, ultimately making them mandatory.

improved efficiency, bolstered national economies, reduced class warfare between workers and management by increasing the size of the economic pie, and, when extended to the international level, forwarded world peace. Consequently, serving on a standard-setting committee—which involved a multi-year commitment to travel to meetings, painstaking technical work, and endless discussion and argument over standards—was a contribution to the common good. They created norms of formality and professionalism in dress and language; in the first half of the century, they wore top hats and tails to formal receptions opening and closing meetings, to reflect the professional status that this public service was intended to bolster, and after the Second World War, such dress was replaced by suits and ties, signaling professionalism in a changed world. They also believed that standards should reflect scientific and technical values, not economic ones. That is, standardizers should use technical criteria to arrive at standards that served the public interest, rather than use economic criteria to choose the best standard for their private economic interests.

Recognizing that private self-interest (typically in the form of a firm's interests) could not be entirely eliminated, they developed a consensus process that both encouraged supporting the common interest and created checks and balances to prevent private interests from dominating it. For example, they created norms and rules that a technical committee should be composed of a balanced group of engineers representing producing firms, consuming firms, and the general interest (unaffiliated engineers such as consultants and academics), to prevent any one of those interests from dominating. By requiring that no group of stakeholders hold a majority, they prevented producing firms, for example, from railroading through a standard that favored their interests over user firms' interests. In addition, they believed that all points of view must be listened and responded to, as long as they invoked technical evidence and reasoning. Consequently, they created a form of due process to resolve disagreement; this process required repeated voting to gauge consensus on a draft standard, each time responding to opposing positions of all who voted against it. Although consensus did not, finally, require 100% agreement in most standard-setting organizations, committees and organizations did not declare a standard based on a majority, as long as reasoned opposition remained. They were committed to taking as long as necessary to get to as complete a consensus as possible. Finally, standards leaders believed that standards should be regularly revisited and updated so they would not impede progress. Each updating required the same balanced committee and due process.

From the beginning of the century to the late 1980s, the communication media used in standardization did not vary much. Technical committees met face to face as frequently as multiple times a year or as infrequently as once every 4 years, depending on whether the sponsoring organization was national or international and other factors. Because many of the international standardization leaders were from European countries and most international standards bodies were headquartered there, international standard-setting meetings were most often in Europe, requiring lengthy trips for those from the United States or Japan, for example, to attend. Air travel did not replace ship travel until the second half of the twentieth century. In between the meetings, many technical and process-oriented documents were typed or stenciled on paper and transported by mail over land and sea (airmail, even when available, was too expensive for these organizations, given the large quantities of documents and large number of people involved). Although pairs of individuals could talk by long distance and overseas telephone, if necessary, the phone could not be used as a regular method of communication within committees, for cost as well as logistical reasons. Thus communication occurred primarily at in-person meetings and via paper-based correspondence and documentation.

These values, practices, and communication media, which I will refer to as traditional, undergirded the standard-setting process through most of the twentieth century, until the late 1980s. Genres of communication and documentation emerged to structure this process. The next section will illustrate these traditional genres.

4.4 Traditional Genres for Standardization in RFI

In this section, I examine the genres of communication used in standard setting around radio frequency interference (RFI) at the national level (in the United States) and at the international level from the 1960s through 1980s.[4] In this obscure but critical technical domain during that period, standards were set to prevent radio frequency emissions from electrical and electronic devices (e.g., microwave ovens, automobile starters, and computers) from interfering with radio or television reception, or with other devices susceptible to radio waves. On the national level, the primary US standards body dealing with RFI was the American National Standards Institute (ANSI) committee C63. The major international standard-setting body in this arena was a special committee of the IEC known as CISPR (Comité International Spécial des Perturbations Radio, or the International Special Committee on Radio Interference).

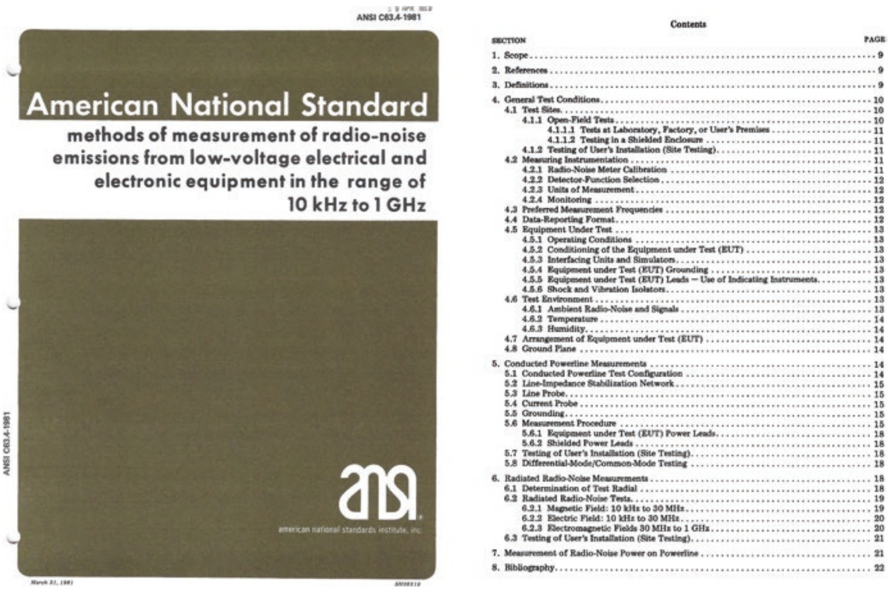
4.4.1 Traditional Genres in US National RFI Standardization

The C63 Sectional Committee on Radio-Electrical Coordination was established in 1936 (under a predecessor of ANSI), but only began producing standards after the Second World War was over. Between 1946 and 1964 it issued its first four standards (C63.1–C63.4). During this period its members were primarily professional and trade organizations or government departments, rather than firms or individuals

[4] This discussion of RFI standardization is based on Chapter 6 of Yates and Murphy 2019. The chapter is based in great part on 200 boxes of personal files of Ralph M. Showers, at different times chair of both the C63 Committee and of CISPR (discussed below), made available after his death by the Showers family. These papers have now been deposited at Hagley Museum and Library. Hereafter these papers are referred to in the text as the Showers Papers, with dates and identifiers of specific documents.

(Yates and Murphy 2019, Chapter 6). One genre and one genre system in the C63 repertoire were key elements of C63's genre repertoire: the *standard genre* and the *balloting genre system*. I will examine both in the context of standard C63.4 (entitled "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 10 kHz to 1 GHz"), a standard establishing the method for measuring radio noise, an essential step before setting limits on it.

Like all voluntary standards, C63.4 was a document (an instantiation of a genre) rather than a physical artifact, meant to guide producers and users in specifying technical objects or processes to be voluntarily followed. Although the body of standards varied in form and length depending on the technical area (including, for example, figures, technical specifications, or code depending on what was appropriate to the area), standards issued by a given standardization organization during the twentieth century had a recognizable stiff, colored cover with the name of the organization, to which was added the name, number, and date of the specific standard. The original, multipage C63.4 standard published in 1964 had such a cover, as did revised versions of the standard published in 1975 and 1981. Figure 4.1 shows the cover and table of contents of the 1981 version of C63.4. The numbering of sections and subsections and the inclusion of references and bibliography were common format characteristics of standards in this area, resembling the formatting of technical reports. The 1981 version was already 22 pages long. Subsequent versions were published in 1988 (when it was renamed "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of



Contents

Fig. 4.1 Cover and table of contents for ANSI C63.4-1981

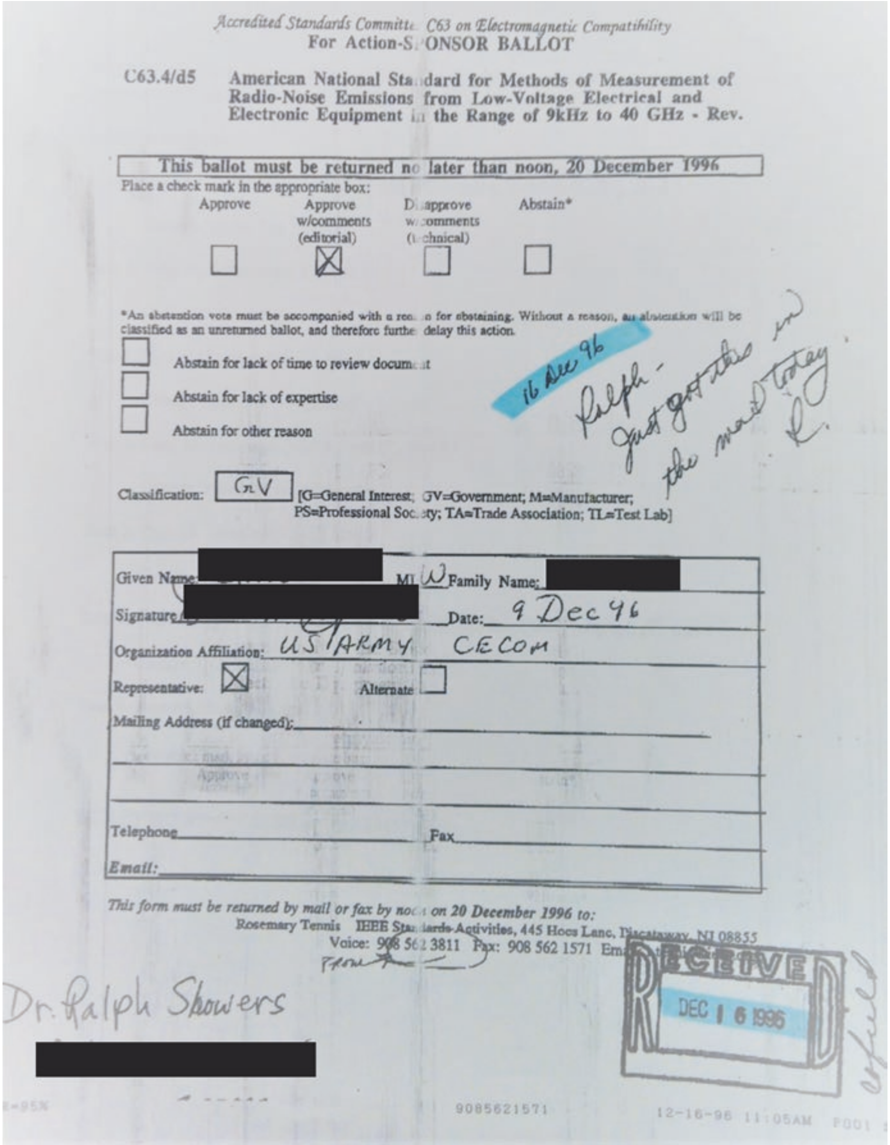
9 kHz to 40 GHz”), 1991, 1996, and so on going forward (Showers Papers, C63.4 binders).

The standard genre reflected the values of ANSI C63 and other standardization bodies of the twentieth century. It was clearly the central genre of standard setting and the source of efficiency and order that engineers valued so highly. Moreover, ANSI and C63 sold these standards (i.e., copies of the documents in the stiff covers) to support further standardization, thus continuing to serve the common good. Its technical numbering system and bibliography reflected the value standardizers placed on its scientific and technical (rather than economic) orientation, while its repeated updating reflected their belief that standards should not impede progress.

The *balloting genre system* was another key element in the standardizers’ repertoire. Important in shaping what, if anything, would be published as a standard, this genre system consisted of the *draft standard* being voted on, the *ballot* sent out to members of the technical committee with the draft standard, the set of *completed ballots* returned by members, and the *ballot response* report from the ad hoc committee created by the chair. Figure 4.2 shows a completed 1996 ballot for a subsequent revision of the C63.4 standard. The ballot asked members of the technical committee to approve, approve with comments (editorial), disapprove with comments (technical), or abstain (indicating below why they abstained) by a specified date (typically about 3 months from when it was sent out). It also asked them to indicate what their classification was (e.g., government, manufacturer, etc.), what organization they were affiliated with (since organizations, rather than individuals, were members of C63 and other such standard-setting bodies), and whether they were a representative or alternate for that organization. The individual who filled out this ballot approved the draft with editorial comments, which were typically written on the draft itself.

With a set of completed ballots in hand, the C63 chair assembled an ad hoc editing committee composed of himself and two other members to compile and respond to comments made on the negative votes and suggestions made on affirmative votes. The ballot results report, circulated to the committee members, was composed of an overview (which included a description of the balloting pool, based on the classification data provided on the ballot) plus a table of every comment (by section or page), its source, and the ad hoc committee’s suggestions of what could be done to respond to each comment, or why they thought no change was needed.[5] After the suggested changes were made to the draft, the chair circulated a new draft for comments, then invoked the balloting genre system again. For example, the C63 chair conducted ballots on eleven drafts of C63.4 in revising the 1988 version to create the 1991 standard. Even that number does not fully capture the effort, as he conducted ballots on four different versions of the eleventh draft. Thus the process of achieving consensus was extensive, requiring a great deal of the C63 committee chair and ad hoc committee, as well as of the members.

[5] For example, such a table created in 1975 for the introductory section to the updated versions of C63.2, C63.3, and C63.4 may be found in ANSI C63 Correspondence, in Leonard Thomas Papers, obtained from Dan Hoolihan (a former chair of C63) and deposited in Hagley Museum and Library.



Accredited Standards Committe C63 on Electromagnetic Compatibility
For Action-S ONSOR BALLOT

C63.4/d5 American National Sta dard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment i the Range of 9kHz to 40 GHz - Rev.

This ballot must be returned nc later than noon, 20 December 1996

Place a check mark in the appropriate box:

Approve ☐ | Approve w/comments (editorial) ☒ | D approve w comments (t chnical) ☐ | Abstain* ☐

*An abstention vote must be accompanied with a rea n for abstaining. Without a reason, an abstention will be classified as an unreturned ballot, and therefore furthe delay this action.

☐ Abstain for lack of time to review docum t

☐ Abstain for lack of expertise

☐ Abstain for other reason

16 Dec 96

Ralph - Just got this in the mail today. R.

Classification: GV [G=General Interest; GV=Government; M=Manufacturer; PS=Professional Soc ty; TA=Trade Association; TL=Test Lab]

Given Name: [redacted] MI W Family Name: [redacted]

Signature: [redacted] Date: 9 Dec 96

Organization Affiliation: US ARMY CECOM

Representative: ☒ Alternate ☐

Mailing Address (if changed):

Telephone Fax

Email:

This form must be returned by mail or fax by noo on 20 December 1996 to:
Rosemary Tennis IEEE Sta lards Activities, 445 Hoes Lane, Piscataway, NJ 08855
Voice: 908 56 3811 Fax: 908 562 1571 Em

From

RECEIVED DEC 16 1996

Dr. Ralph Showers

[redacted]

9085621571 12-16-96 11:05AM P001

Fig. 4.2 Ballot for C63.4 Draft 5, filled in by C63 member (Showers papers)

This balloting genre system, like the standard genre, embodied the values of voluntary standard setting. The ballot itself reflected the requirement for a balance of stakeholders by asking for the classification of each voter. This classification was used in determining whether balance existed within the voting group (that is, whether no single constituency had a majority of those voting), a fact recorded in the ballot results report; without balance, the vote was not valid. The ballot results genre, with its tabulation and response to every single comment, followed by a new draft, reflected due process and respect for all views in reaching consensus. This iterative balloting process typically went on until a draft received no negative ballots within the committee, when the C63 chair submitted the standard to ANSI. ANSI itself then circulated it for a public comment period, when it might receive more negative comments—which also required responses, if not necessarily changes (Showers Papers, C63.4 binders). This painstakingly and time-consuming process assured that every party's views were heard and responded to. Finally, the insistence on frequently updating standards reflected the value standardizers put on not impeding technical advance.

The standard genre and the balloting genre system shaped the C63 standardization process. They were accompanied by genres and genre systems less available for analysis, such as the technical dialogue among members exchanged by mail and in face-to-face meetings of the balanced technical committee, through which they discussed the issues and tried to reach agreement on potential changes before the chair circulated a *new draft standard* to members of the committee. The balloting genre system incorporated the values and norms of voluntary standardization: balance, full consideration of all opinions based on technical arguments (including due process for every negative argument), and eventual, painstaking convergence on a consensus for a standard that would be voluntarily adopted by stakeholders. This process also took considerable time, a factor that would eventually become increasingly problematic.

4.4.2 Traditional Genres in International RFI Standardization

When standardization occurs on the international level, additional factors come into play (Yates and Murphy 2019, Chapters 2, 4). The international standards organizations such as IEC and ISO incorporated the belief that standardization forwarded world peace and that their mission should transcend politics. After the Second World War, international standardization leaders of ISO and IEC worked hard to bring into the new ISO (and back into the older IEC) enemy countries such as Germany and Japan, as well as to retain communist countries despite growing Cold War tensions. In addition, although founders of both organizations believed in the necessity of including a balance of producers and consumers, they thought that stakeholder balance between these constituencies should be left to the national delegations, which were chosen by the national technical societies or standard-setting bodies (e.g., ANSI in the United States), which already took into account the balance between producers and consumers. They focused more attention on national balance. Each country got one vote, no matter its size, a norm started in the intergovernmental treaty organizations of the nineteenth century (e.g., in the International

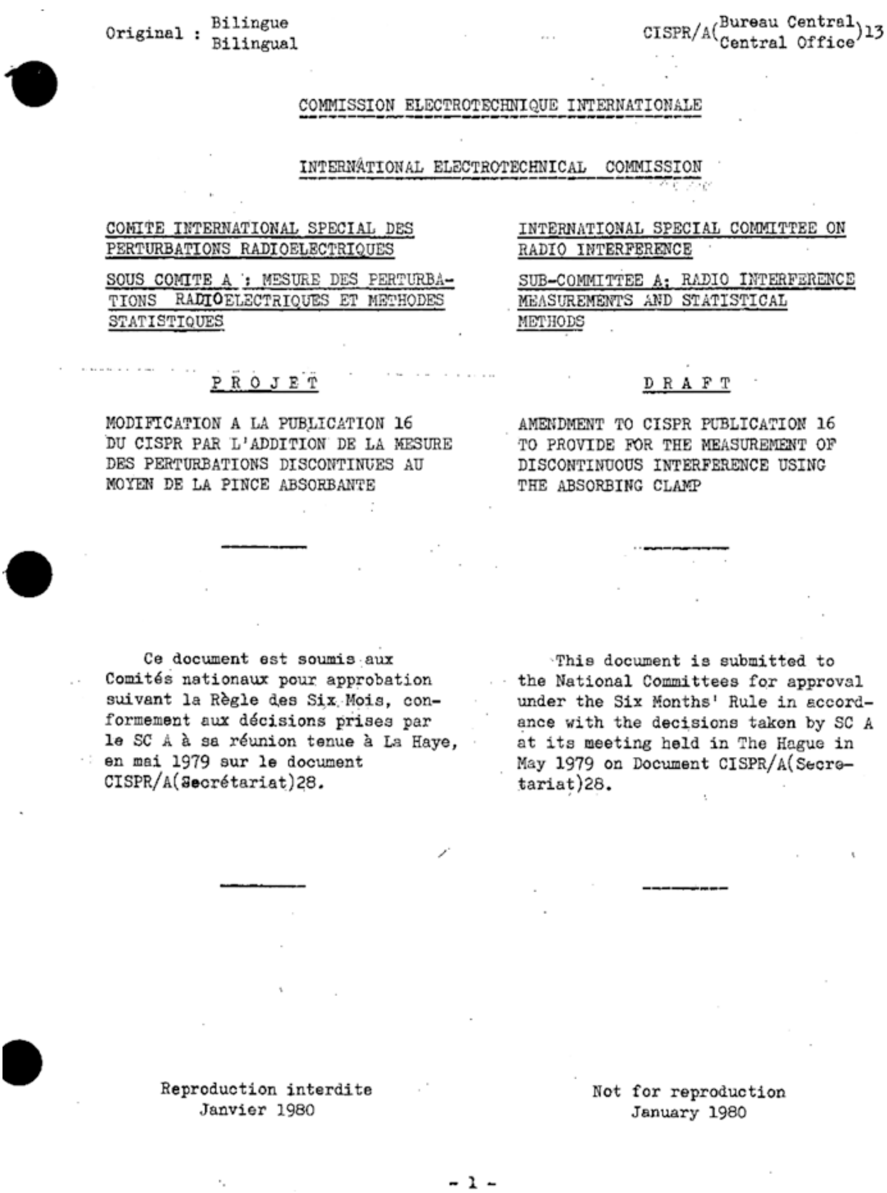
Telegraph Union or ITU).[6] Finally, international standards bodies had to deal with multiple languages, typically embracing two or more official languages, of which English and French were the most common.

In the technical arena of RFI, the major international standard-setting body was the special committee of IEC known as CISPR. It was established in 1933 to deal with increasing problems of radiofrequency interference, initially in Europe, and its status as a special committee reflected its inclusion of a few representatives of international trade associations of broadcasters, in addition to the normal IEC national delegations. After the Second World War, it extended its work beyond Europe. From the 1960s onward, CISPR was the international body that the ANSI C63 committee interacted with most frequently. It elected its first American chair (a former chair of C63) in 1968. In CISPR, as in C63, the *standard genre* and the *balloting genre system* were key to the standard-setting process, although here I will focus on the *draft international standard* (DIS) rather than the final international standard.

The *DIS genre* was a draft standard that a CISPR subcommittee had approved and that IEC headquarters circulated to all CISPR member delegations for balloting. The DIS was more formal than the drafts circulated by C63 but less formal than C63 final standards, and it bore evidence of its international nature. Figure 4.3 shows the IEC cover sheet for a CISPR Subcommittee A draft of an amendment to CISPR Publication 16, circulated in 1980 (Showers Papers, 1980). The IEC coversheet is standard for IEC circulation of all drafts for voting, with identification in the upper right corner using IEC's labeling system ("CISPR/A (Bureau Central/Central Office) 13"). Its two-column format after the heading (as well as the upper left corner designation as "Original: Bilingue/Bilingual") immediately signals that it is bilingual, with French on the left and English on the right. The draft attached to the cover sheet would be solely in French or in English, depending on the national delegation to which it was sent. The cover sheet refers to voting "under the 6-month rule," an IEC rule that required that national delegations return their completed ballots with votes and comments within 6 months from when the ballots were issued by the IEC central office. This rule was shaped in part by the communication technologies of the early twentieth century, which included train and surface transportation within continents and ship transportation between continents. Six months was considered a reasonable amount of time to allow both consensus-building within national delegations and travel time for correspondence.

The DIS genre reflected the value CISPR placed on internationalism and a consensus of national delegations in its bilingualism and in its adherence to the IEC

[6] Beginning in the 1920s, intergovernmental bodies such as the ITU set up their own standard-setting technical committees that were a hybrid of private and public standard setting. They followed many of the norms of private voluntary standard setting, and their standards were recommendations, not regulations. If they were adopted by the ITU itself, however, they often were subsequently written into national and international regulations. Moreover, their national delegations, though typically composed of technical members, were chosen by national governments and could be filled with diplomatic rather than technical members if desired. Their genres reflected the intergovernmental nature of ITU in being more bureaucratic than those of private voluntary organizations such as IEC and ISO. See Yates and Murphy 2019, Chapters 5 and 6.



Original : Bilingue
Bilingual

CISPR/A(Bureau Central / Central Office)13

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMITE INTERNATIONAL SPECIAL DES PERTURBATIONS RADIOELECTRIQUES

SOUS COMITE A : MESURE DES PERTURBATIONS RADIOELECTRIQUES ET METHODES STATISTIQUES

INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

SUB-COMMITTEE A: RADIO INTERFERENCE MEASUREMENTS AND STATISTICAL METHODS

PROJET

MODIFICATION A LA PUBLICATION 16 DU CISPR PAR L'ADDITION DE LA MESURE DES PERTURBATIONS DISCONTINUES AU MOYEN DE LA PINCE ABSORBANTE

DRAFT

AMENDMENT TO CISPR PUBLICATION 16 TO PROVIDE FOR THE MEASUREMENT OF DISCONTINUOUS INTERFERENCE USING THE ABSORBING CLAMP

Ce document est soumis aux Comités nationaux pour approbation suivant la Règle des Six Mois, conformement aux décisions prises par le SC A à sa réunion tenue à La Haye, en mai 1979 sur le document CISPR/A(Secrétariat)28.

This document is submitted to the National Committees for approval under the Six Months' Rule in accordance with the decisions taken by SC A at its meeting held in The Hague in May 1979 on Document CISPR/A(Secretariat)28.

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Janvier 1980

Not for reproduction
January 1980

- 1 -

Fig. 4.3 Coversheet for CISPR draft international standard, CISPR/A (Central office) 12 (Showers papers)

format and 6-month rule. These values were layered onto the values for efficiency and order, for serving the common good, for technical rather than economic orientation, and for frequent updating to avoid impeding progress.

CISPR also adopted IEC's *balloting genre system*, which resembled that of ANSI C63, but adapted to IEC's international scope. After considerable discussion and comment in subcommittee meetings and correspondence, the subcommittee would vote in person to achieve its internal consensus on the DIS. Then the IEC/CISPR balloting genre system would shape the consensus process. That process had extra steps compared to C63's balloting genre system. First, the IEC/CISPR secretariat mailed a *ballot* and a small number of copies of the *DIS* to each CISPR national office, requiring overseas mail by ship for those on different continents. Each national office then further circulated copies (by surface mail) to all delegation members for consideration. Members had to agree on a single vote and set of comments, through correspondence or meeting. Then national offices *completed* the single *ballot* and returned it to the IEC/CISPR secretariat office, which tabulated votes and comments, proposed responses to each comment, and issued a *ballot results report*. As in C63, the process often went through multiple iterations of the genre system until consensus was achieved.

Figure 4.4a shows the 1980 ballot results report (English language version) for the voting on Document CISPR/A (Central Office) 9, and Fig. 4.4b shows the beginning of its 9-page appendix.[7] The report followed IEC labeling conventions, coverage, and format. First, it listed by country delegation all positive and negative votes received, as well as which delegations included comments, all of which needed to be answered. The appendix tabulated each comment, by section or page number of the document and then by country, and provided a suggested response to each. The report summarized the results and salient points of the comments that needed to be addressed and ended by stating the secretariat's view that the document could be amended to address the objections well enough to get the negative votes changed to positive ones. A final section contained the views of the chair of CISPR Subcommittee A, who felt that the document "could benefit by further discussion in SC A," and recommended sending it back to that body rather than following the secretariat's suggested course of action. After more discussion in SC A, the subcommittee would agree on a new draft, which would go through the voting process again.

Like the balloting genre system used by the national level C63 committee, this CISPR genre system reflected the value of achieving consensus on standards, modified to reflect the international level. As in C63, the table listing and responding to all comments revealed respect and due process accorded to all parties, which were key values of standardization. In this case, the parties were national delegations, rather than representatives of different stakeholders within a single country. Moreover, each round of balloting took longer than within C63 (6 months rather than 3 months), given the extra steps required to send it to each national delegation office, then circulate it to members of each delegation to achieve agreement within national delegations. Only then could it be returned to IEC headquarters to consider consensus among the national delegations. International standardizers such as those

[7] This document is in a set of papers digitized by Don Heirman, former chair of CISPR, and shared with me during research on Yates and Murphy 2019, Chapter 6.

Not for reproduction
Original: English

CISPR/A(Central Office)14
March 1980

INTERNATIONAL ELECTROTECHNICAL COMMISSION

INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE (CISPR)

SUB-COMMITTEE A: RADIO INTERFERENCE MEASUREMENTS AND STATISTICAL METHODS

Report on the Voting under the Six Months' Rule for the approval of Document CISPR/A(Central Office)9: Methods of measurement of the suppression characteristics of passive radio interference suppression devices and radio interference filters, together with a statement by the Chairman of Sub-Committee A of CISPR on the action to be taken as a result of the voting

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I. Report on the voting

Document CISPR/A(Central Office)9 was circulated to all National Committees on 2nd August 1978, with a request that the Central Office be informed, within six months, whether or not they were in favour of this document being published as a CISPR specification.

The following replies have been received:

For approval: 13 countries

Australia	letter of	19	March	1979	
Belgium	"	2	January	1979	
Canada	"	26	January	1979	
Egypt	"	17	April	1979	
France	"	15	February	1979	comments
Poland	"	19	January	1979	
Romania	"	22	February	1979	comments
South Africa	"	26	January	1979	comments
Spain	"	12	February	1979	
Switzerland	"	23	December	1978	
Turkey	"	9	February	1979	
U.S.A.	"	9	February	1979	
U.S.S.R.	"	13	February	1979	

Against approval: 3 countries

Germany	"	18	January	1979	comments
Sweden	"	31	January	1979	comments
United Kingdom	"	13	February	1979	comments

II. Comments received

Comments submitted are given in the following attached documents:

CISPR/A(France)2
CISPR/A(Germany)7
CISPR/A(Romania)4
CISPR/A(South Africa)1
CISPR/A(Sweden)14
CISPR/A(United Kingdom)6

III. Comments of the Secretariat

Since there are three negative ballots out of 13, the document CISPR/A(Central Office)9 has not met the requirement for approval as a CISPR publication.

Germany indicates that its ballot would be changed to affirmative if its comments are taken into account. Of the more substantive comments, some of their suggested changes in dimensions are not likely to be valid at the upper frequency range of the document, and the comment on the effects of saturation on the inductors in the buffer networks, although correct, does not automatically disqualify the technique, as was discussed in a Netherlands document presented at The Hague meeting of SC A in May.

Sweden requests a change in title to include the word specification, but then the United Kingdom contends the document needs considerable re-editing to be suitable as a specification. In this connection, the Secretariat notes that most IEC Six-Months' Rule documents do not contain the word specification in the title; consequently, although the document is being treated as a specification in CISPR, it sees no need to explicitly stress this in the title. Furthermore, several (alternate) methods of test are included for different, but specific, purposes. It is left to the user of the document to select which test procedure should be used for meeting his requirements. The document is considered satisfactorily clear in indicating which test is to be used for which purpose.

In so far as the United Kingdom detailed comments are concerned, practically all may be accounted for by amendments to the text. Sweden proposes rather extensive changes in clauses 5.2.1.1 and 5.2.1.2. However, corrections in the text of these clauses may obviate the need for these changes.

In summary, it appears possible to amend document CISPR/A(Central Office)9 to consider almost all of the comments in the negative ballot documents which very likely would result in a change in voting making the amended document acceptable for publication. The appendix contains the changes recommended by the Secretary based on comments received.

IV. Statement of the Chairman of SC A

I have reviewed the comments contained in the voting documents on CISPR/A(Central Office)9, and the comments of the Secretary. It does appear that these changes should result in a document suitable for publication. However, it is considered that the document could benefit by further discussion in SC A. Therefore, I am recommending that it be referred back to SC A for further consideration of the changes recommended by the Secretary.

- 2 - CISPR/A(Central Office)14

Fig. 4.4a Ballot results report for voting on document CISPR/A (Central office) 9, pp. 1–2 (Showers papers)

APPENDIX

CHANGES IN CISPR/A(CENTRAL OFFICE)9 SUGGESTED AS A RESULT OF THE VOTING UNDER THE SIX MONTHS RULE

Clause	Country	Comments	Secretariat Proposals
General Comments	France	Suggest use of the word "affaiblisseur" instead of "attenuateur." (Editorial)	Accept
	Romania	Considers document should contain references to toroidal ferrite core type current compensated coil filters.	Refer to SC A for future consideration
		Figure captions should indicate relation to subclauses (editorial)	Accept
	Sweden United Kingdom	Publication should be kept in abeyance until modification in CISPR/A(Secretariat)27, and other documents, has been decided.	Do not accept. Document CISPR/A(Sec)27 includes new material, not changes in present document which should not be delayed for this reason.
Title	Germany	Replace the term "devices and radio interference filters" by components.	Accept. Modify English text: "Methods of measurement of the suppression characteristics of passive radio interference filters and suppression components." Modify French text:
	United Kingdom	Amend title.	Accept. See reply to German comment
	Sweden	Amend title to read "Specification on methods of...."	Do not accept. No need to identify document as a "specification." "Method of measurement" is sufficient and commonly used in other IEC Six Months Rule documents.

- 3 - CISPR/A(Central Office)14

Fig. 4.4b Ballot results report for voting on document CISPR/A (Central office) 9, p. 3, first page of 9-page appendix (Heirman papers)

in CISPR and IEC more broadly believed it was worth the time required to get a widely supported international standard that would be adopted voluntarily.

The standard (and draft standard) genre and the balloting genre system at both the national and international levels of standardizing around radio frequency interference clearly reflect the values of traditional voluntary standardization, including the technical orientation, consensus, balanced committees (though the nature of the balance differed between the national and international process), respect for all parties and willingness to take the time needed for balloting, with painstaking due process, again and again, and (at the international level) internationalism. The same values were reflected in standardization genres earlier in the twentieth century and in a wide variety of other technical domains affecting industrial products.

In the late 1980s, as the next section demonstrates, new standards organizations and new or altered genres would arise, reflecting and revealing shifts in values and media.

4.5 New Genres for Standardization in Late Twentieth Century

At the end of the 1980s, a new wave of standards organizations emerged around computers and computer networking. Older standardization organizations set some computer-related standards, but first the Internet and then the World Wide Web led to the emergence of completely new types of voluntary consensus standard-setting organizations and new communication media for standard setting. New genres of standardization arose within them. This section looks at new organizations and genres first for Internet standardization in the Internet Engineering Task Force (IETF) and then for Web standardization in the World Wide Web Consortium (W3C). In both organizations, new genres reflected modified values as well as new communication media.

4.5.1 Genres for Internet Standardization

The seeds of late 1980s developments in the voluntary standard-setting world were sown two decades earlier. In 1969 the Advanced Research Projects Agency (ARPA; when "Defense" was added to the name in 1972 it became DARPA) within the US Department of Defense launched the ARPANET project to network the mainframe computers it had funded in several universities and defense contractors (Yates and Murphy 2019, Chapter 7; Russell 2014; Abbate 1999). A group of computer scientists and engineers in universities (faculty and doctoral students) and in defense contractors formed the very informal Network Working Group (NWG) to coordinate protocols (i.e., to develop standards) for the new network. NWG, the predecessor that shaped the IETF and its genres, was not perceived as or modeled on voluntary standard-setting bodies, since it functioned solely within the Defense Department project.[8] The doctoral students who were in charge of developing the software protocols for internetworking, wary of overstepping their authority in the presence of their advisors and potential employers, created the modestly titled Request for Comments (RFC) document series; many of the RFCs were proposed protocols for ARPANET, as close as they came to issuing standards. This document series started out on paper, but by the early 1970s, when the ARPANET was up and running, the RFCs were created and circulated in electronic form.

During the 1970s and 1980s, a standards war played out (Russell 2014; Yates and Murphy 2019, Chapter 7). Two existing standard-setting bodies, the intergovernmental ITU and the private voluntary ISO, both sought to standardize internetworking

[8] Some of the senior members of NWG would become involved later in the 1980s internetworking standards war, but when they did so, they worked through other bodies that were involved in the standard-setting world, not through NWG. See Yates and Murphy 2019 Chapter 7 for a discussion of their unsuccessful attempt to work within the traditional standard-setting organizations.

protocols. Some of the more senior computer experts involved with ARPANET tried to influence these attempts, but without success. The ITU declared a telephone-switching-based standard, X.25, disliked by all computer stakeholders because it placed all the intelligence and control in the network rather than in the computers being connected. In 1978 the ISO launched a subcommittee of its technical committee on computers and information processing to develop a standard for Open Systems Interconnection (OSI). The seven-layer proposed OSI structure became a standard by 1983, but it was only a conceptual framework; during the 1980s and 1990s, ISO got bogged down in determining specific standards for each of the seven layers. Meanwhile, in the mid-1970s, DARPA had decided to use a newly developed transmission control protocol (TCP, soon to be split into two parts as TCP/IP, with IP standing for internet protocol) to link the ARPANET to other networks. By 1983, the entire ARPANET had switched over to TCP/IP, and that year DARPA spun off the civilian Internet. The result was that by the end of the 1980s and the early 1990s, TCP/IP was the only internetworking protocol in wide use, thus becoming the de facto standard for internetworking.

When DARPA spun off the Internet in 1983, its leaders established a new oversight system for it, outside the Defense Department. The Internet Architecture Board (IAB), composed of senior computer scientists and engineers from universities and a few firms, was charged with directing the evolution of the Internet, and the Internet Engineering Task Force (IETF), composed of more junior members, was assigned to develop and maintain standards (including TCP/IP) for the new, civilian and commercial Internet. When TCP/IP became the de facto standard for internetworking, the IETF became the de facto standard-setting body for the Internet.

Because its predecessor NWG, as well as IETF itself, was formed without direct influence of the traditional voluntary standardization bodies, it differed from them in several ways. It described (and still describes) itself as a "loosely self-organized group of people" with no official membership and no voting (Malkin 1993). Participating computer scientists, software engineers, and computer geeks were antiauthoritarian and believed in an open Internet. After what has been called a "constitutional crisis" in 1992 (when IETF participants rebelled against an IAB decision they disagreed with and got it overturned), David Clark, an MIT professor and key member of the IAB, articulated a new manifesto for IETF: "We reject: kings, presidents, and voting. We believe in: rough consensus and running code." That is, it rejected key aspects of the existing standard-setting bodies—a hierarchy of officers and of national and international bodies, voting to achieve consensus and using due process to deal with differences of opinion; instead, it embraced a less complete form of consensus that did not require responding to every opposing view (Russell 2014). Its culture was much less formal than that of the traditional standard-setting bodies, in dress (where IETF preferred t-shirts and sandals to the coats and ties of the RFI standardizers), in processes, and in language (Yates and Murphy 2019, Chapter 7). IETF ushered in a new type of voluntary standard setting, a new electronic communication medium for standard setting, some new or altered values, and new genres of standardization. Two genres (the *RFC genre* and the email *dialogue genre*) and the absence of a genre system (the *balloting genre system*) characterize IETF's genre repertoire.

First is the request for comments or *RFC genre*, developed initially by NWG in 1969. All documents published by IAB or IETF to their community, including standards, were sequentially numbered documents in this series. When IAB and IETF took over from NWG in the 1980s, they maintained the RFC series with no change in number, formatting, or editor (Tom Postel had edited it since its beginning in 1969, when he was a doctoral student). In 1989, Postel (now a member of the IAB as well as editor of the RFC series) laid out an initial set of format rules for all RFCs, whether or not they included standards (Postel 1989). In response to repeated suggestions that standards be handled differently from other RFCs, Postel refused to take them out of the RFC series; in 1992, however, he created a subseries for standards, with an identifier consisting of STD plus a number in the heading, in addition to its sequential RFC number (Postel 1992). Because RFCs were not restricted to standards, the socially agreed-upon purpose of the RFC genre was much more general than that of the standard genre—the purpose was simply for publication to the community; some items shared information, some provided humor, and some presented a standard. The STD subseries (within the RFC series) created a subgenre with the more specific purpose of announcing a standard.

Postel first specified the format of the RFC genre in 1989 (Postel 1989). The official version of an RFC, he declared, must be in ASCII text; ASCII was the lowest common denominator for computer-generated text, and requiring it guaranteed that the electronic document would be readable on any computer of the time. Postel also required that RFCs include a section on status, stating the intention of the RFC (e.g., to propose a standard for discussion, to announce an agreed-upon standard, to share information with the community). In essence, this section stated the more specific purpose of the RFC. It also included a statement about distribution of the RFC, which was almost always "distribution of this memo is unlimited," indicating that they could be shared freely and without charge (unlike traditional paper standards). The header of each RFC, Postel also insisted, must indicate its relationship to previous RFCs, if relevant (e.g., "Updates RFC xxxx," or "Obsoletes RFC xxxx").

Postel specified a standard header, exemplified by his heading for that 1989 RFC on format instructions:

Network Working Group	J. Postel
Request for Comments: 1111	ISI
Obsoletes: 825	August 1989

Request for Comments on Request for Comments

Instructions to RFC Authors

This header differed from the headers in the 1969 RFCs only in indicating its relationship to previous RFCs ("Obsoletes" or "Updates"). With the addition of the STD subseries in 1992 (Postel 1992), lines for category and for STD number were added to the header, as shown in Fig. 4.5 from 1996. Note that even then, long after the demise of NWG, the header still identified the source of RFCs as "Network Working Group," reflecting the origins of the RFC genre in the original NWG. It was well into the 2000s before IAB or IETF replaced NWG in some headers.[9]

The RFC genre reflected values held by the Internet community, including IAB members and IETF participants. First, retaining and continuing the RFC series reflected the Internet community's ties to its origins in the late 1960s as well as the informality that led to its initial designation as Request for Comments, rather than Standard or Recommendation, as was typical of existing voluntary standards organizations. That informality was also reflected in its inclusion of humorous or informational RFCs along with standards in the same series. These values were associated with the Internet and its community, not with standardization in general. The standards within the RFC series suggested a technical orientation in their tables of contents (numbered as in scientific or technical reports) and references, in this respect resembling RFI standards. Aspects of the RFC format, including use of ASCII and the usual designation of distribution as unlimited, reflected the new Internet medium and a growing belief in openness and transparency (Russell 2014), in contrast to the closed committees and the fee-based distribution of traditional voluntary standards. The Internet community wanted its standards available to all so they would be universally adopted. Moreover, electronic distribution was essentially free once the standard had been developed, while paper distribution required paying for copying, binding, and mailing. Without standards sales as a source of revenue, IETF's funding model depended on grants and on companies and nonprofit organizations to sponsor conferences and support their employees' participation in IETF standard setting.

A second key genre in the IETF genre repertoire (and a component of its own genre system) is the email *dialogue genre* (Orlikowski and Yates 1994). From the point at which the ARPANET was connected and functioning, communication between meetings among participants in NWG and later IETF was transmitted and stored electronically, not on paper. Indeed, most RFCs and email lists were open to all with network access, including computer-savvy people outside of the IETF community. An initial message stating a position or argument was followed by one or more responses nested between relevant lines of previous messages. Figure 4.6 shows a recent, simple dialogue message from a current IETF email list. Most email systems place a greater than (">") symbol before each line of the message being replied to, with more > symbols added with each subsequent reply. Figure 4.6 shows an original message and two replies nested within it. The first reply disagrees with the original message, and the second, consisting just of two characters ("+1"), is shorthand in this community for a statement of agreement with the preceding

[9] For example, see RFC 5741, L. Daigle and O. Kolkman, "RFC Streams, Headers, and Boilerplates," which has "Internet Architecture Board (IAB)" at the upper left of the header.

```
Network Working Group                                           J. Myers
Request for Comments: 1939                               Carnegie Mellon
STD: 53                                                          M. Rose
Obsoletes: 1725                             Dover Beach Consulting, Inc.
Category: Standards Track                                       May 1996


                    Post Office Protocol - Version 3

Status of this Memo

   This document specifies an Internet standards track protocol for the
   Internet community, and requests discussion and suggestions for
   improvements.  Please refer to the current edition of the "Internet
   Official Protocol Standards" (STD 1) for the standardization state
   and status of this protocol.  Distribution of this memo is unlimited.

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Myers & Rose                Standards Track                     [Page 1]
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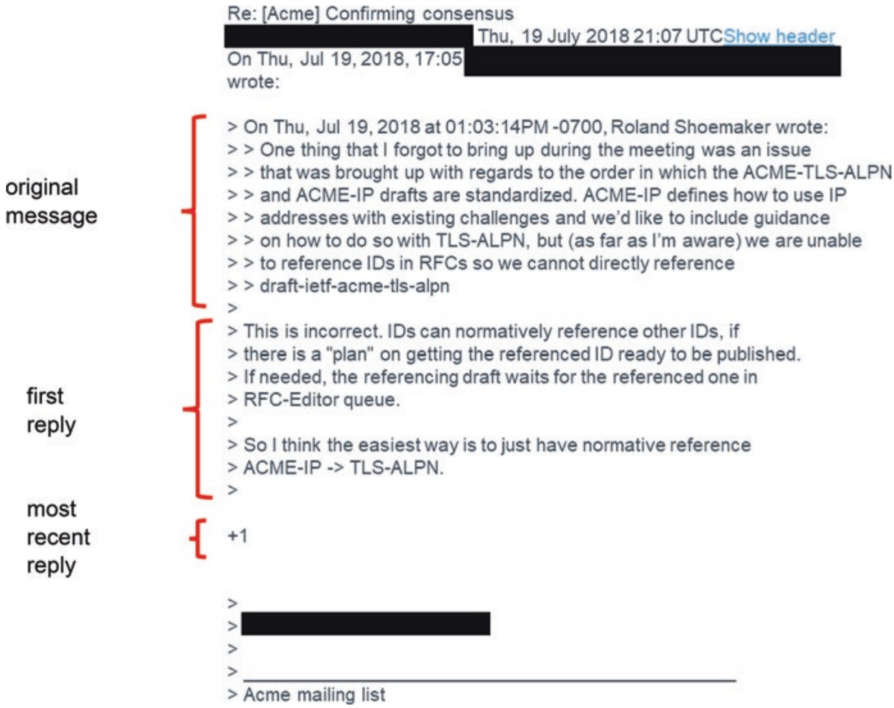
Fig. 4.5 RFC 1939, J. Myers & M. Rose, “Post office protocol – version 3,” 1996, p. 1


Re: [Acme] Confirming consensus
[redacted] Thu, 19 July 2018 21:07 UTC Show header
On Thu, Jul 19, 2018, 17:05 [redacted]
wrote:

> On Thu, Jul 19, 2018 at 01:03:14PM -0700, Roland Shoemaker wrote:
> > One thing that I forgot to bring up during the meeting was an issue
> > that was brought up with regards to the order in which the ACME-TLS-ALPN
> > and ACME-IP drafts are standardized. ACME-IP defines how to use IP
> > addresses with existing challenges and we'd like to include guidance
> > on how to do so with TLS-ALPN, but (as far as I'm aware) we are unable
> > to reference IDs in RFCs so we cannot directly reference
> > draft-ietf-acme-tls-alpn
>
> This is incorrect. IDs can normatively reference other IDs, if
> there is a "plan" on getting the referenced ID ready to be published.
> If needed, the referencing draft waits for the referenced one in
> RFC-Editor queue.
>
> So I think the easiest way is to just have normative reference
> ACME-IP -> TLS-ALPN.
>

+1

>
> [redacted]
>
> ___
> Acme mailing list

Fig. 4.6 Simple example of dialogue genre in recent correspondence on the IETF Acme mailing list

comment. This example is a simple one, but many such dialogue messages became very long and many layered as participants argued specific points, each trying to get agreement on his or her position. The language used in the example is also more blunt and informal than is typical in written correspondence between members of traditional standard setting bodies; for example, the person who made the first reply aggressively stated "That is incorrect," rather than trying to make the argument more tactfully, and the second responder simply used "+1" to indicate agreement with the first reply.

This genre (or genre system when we look at the whole sequence of messages back and forth) reflects both the values of this community and the Internet medium. This method of replying without restating the original point reflects the value this community put on informality and timeliness, facilitated by the capabilities of email in the electronic medium. (Ironically, this format is efficient and timely for the responder, but not necessarily for the reader, since the longer the document and the more layered responses are added, the harder it is for the reader to find the new material or to make sense of the whole.) The informal language and use of shorthand such as +1 also reflect informality and timeliness. The dialogue genre is used to reach rough consensus through ongoing argument. The language and the demands put on the reader to follow the argument are not designed to get every single person on board, since they risk alienating some participants through bluntness and losing some through difficulty of following the embedded, layered document. Nevertheless, participants in this dialogue used technical arguments to reach at least rough consensus, without requiring respect and due process for each dissenting position. Because the lists were open to anyone, dialogue was also transparent to the wider world of people interested in the workings of the Internet.

Finally, the IETF genre repertoire's lack of a balloting genre system also stood out in comparison to that of the more traditional bodies doing RFI standardization. The IETF manifesto, as stated by David Clark in 1992, opposed voting as characteristic of bureaucratic and authoritarian values that participants rejected. Thus it makes sense that IETF did not develop an official balloting genre system for achieving consensus on standards. Indeed, opposition to voting is reiterated in "The Tao of IETF" (Malkin 1993), an RFC spelling out the organization's norms and culture. In keeping with the notion of rough consensus, if committee chairs wanted to gauge the rough strength of consensus on a position, they often asked members favoring it and then those objecting to it to hum and judged the volume and intensity of each group. Responding to every negative opinion was seen as taking too much time. In general, people in this community felt that traditional organizations were much too slow, and eliminating due process was one way to increase timeliness. Also in contrast to traditional standard-setting organizations, IETF made no attempt to establish a balanced technical committee or ballot pool. They viewed themselves as very democratic because they had no membership (and thus no membership restrictions), allowing anyone with online access and/or means to travel to meetings to participate; however, the lack of balance rules made it possible for representatives of one set of stakeholders to turn out in large numbers for an important meeting, thus influencing the outcome (Yates and Murphy 2019).

The ways in which the genres of IETF standard setting differed from those of RFI standard setting reflect the new and modified values of this community compared to traditional standard setters, as well as the new electronic medium they used to communicate. Although the IETF community, like the RFI community, valued technical standards, it valued the Internet technology itself even more highly. Its members believed in the Internet, rather than in standardization per se, as a force for good in society. Participants had fought (e.g., in IETF's constitutional crisis) to free the organization from the authoritarian and bureaucratic values of DARPA and of traditional standard setting (as they saw it) and to make the Internet and its standard-setting process transparent, democratic, and open (Yates and Murphy 2019; Russell 2014). It modified the belief in consensus to a belief in rough consensus and willingly traded off due process and balance for timeliness, a key value of the newly emerging Internet age.

Our next standards body would share some genres and values with IETF, but others with the more traditional organizations.

4.5.2 Genres for WWW Standardization

In the late 1980s and early 1990s, software engineer Tim Berners-Lee developed a hypertext browsing system for scientists working at the European Organization for Nuclear Research, or CERN (the account in these two paragraphs is based on Berners-Lee 1999; Russell 2008). In the process, he invented the key elements of the World Wide Web: universal resource identifiers (URLs), a hypertext markup language (HTML), and a hypertext transfer protocol (HTTP). Because he saw his innovation as important to the world, he convinced CERN to let him release his code free to the public. Worried that what he called the World Wide Web would become balkanized without some centralization, however, and reluctant to give up control of it completely, he founded the World Wide Web Consortium (W3C) as a nonprofit body to set standards for it.

This body combined elements of traditional standard-setting organizations, corporate consortia,[10] and the IETF. Corporate, nonprofit, and government members of W3C provided revenue through dues, on a sliding scale to allow small firms and nonprofits to become members but large firms to provide most of the funding. Unlike IETF, where individuals rather than firms or organizations were participants, W3C allowed no individuals as members. It followed processes modeled in great part on traditional voluntary standards organizations. For example, it sought consensus rather than rough consensus. Nevertheless it valued timeliness and tried to make its standardization process faster than those of the traditional bodies. Because W3C, like IETF, believed that Internet and particularly Web technology was good for the world, and because W3C had access to both from the beginning, its genres reflected the electronic and Internet medium like IETF's did, as well as the even newer capabilities of the Web. Finally, in a new twist, Berners-Lee made himself quasi-permanent director with extensive powers over standard setting, more than those of the heads of traditional bodies or the IETF (Yates and Murphy 2019, Chapter 7).

An in-depth examination[11] of one recent W3C standard-setting committee, the Web Cryptography Working Group (WebCrypto WG) established to create a standard application programming interface (API) for cryptography on the Web, shows four key genres in its W3C repertoire: *standards* (and *standards track specifications*), the email *dialogue genre*, *balloting* (though not the balloting genre system in C63 and CISPR, above), and *Web-supported meetings* (Yates and Murphy 2019, Chapter 8).

[10] As we discuss in Yates and Murphy 2019, Chapter 7, consortia are clearly not voluntary consensus bodies. They do not even attempt to have any balance, but bring together like-minded firms (e.g., all producer or all user firms) that operate on what is often called a "pay-to-play" basis.

[11] Chapter 8 of Yates and Murphy (2019) provides a detailed look at the process of standardizing in this working group, based on following it for almost 5 years. During that period I read all the emails on their list (over 5000), attended two face-to-face meetings, and listened in on biweekly phone meetings. What follows is based on that work and is documented in more detail in Chapter 8.

WebCrypto WG was launched in spring of 2012, and at that time, a *standards track specification* (as early versions of standards were designated) went through five stages (all published on the Web), ending as a W3C Recommendation, or Web standard:

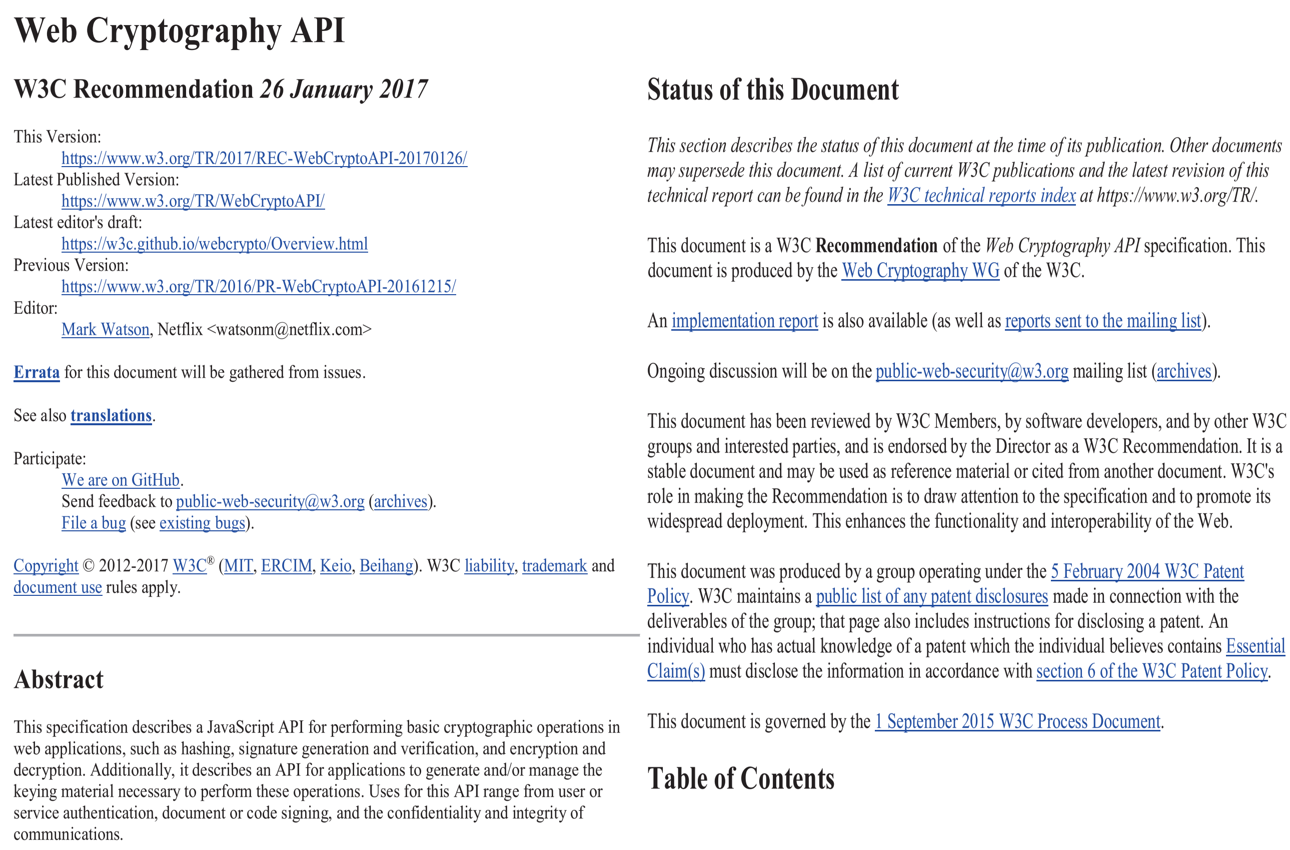
- First Public Working Draft: the first draft that is published outside the working group for comments from the public
- Last Call Working Draft: the last draft that is published for public comments before moving to the next stage (since then W3C has eliminated this as a separate stage to streamline the process)
- Candidate Recommendation: a relatively stable specification that is being implemented in Web browsers
- Proposed Recommendation: a specification implemented on at least two different Web browsers that has been judged by the W3C director to be of high enough quality to be a W3C Recommendation and that is ready to be sent to a W3C advisory committee for final review
- W3C Recommendation: the final standard that has been endorsed by W3C director and advisory committee members

The final W3C Recommendation of Web Crypto API (Fig. 4.7 shows its opening pages) was published in electronic form on the Web. It is freely available to all like IETF standards, but it was produced in HTML to take full advantage of Web capabilities such as hypertext links to other web pages and formatting not available in ASCII (the lowest common denominator form used for IETF RFC standards).

This *standard genre* reflects the value held by both traditional and new standards organizations for creating consensus-based technical standards, and the fact that it is freely available indicates that W3C shares with IETF the values around openness and transparency. The difference between IETF's ASCII format and W3C's Web format shows its commitment to the newer Web technology.

The second key genre in its repertoire is the *dialogue genre* in email. Although WebCrypto WG met face-to-face about once a year and had biweekly phone meetings, most of the actual work and discussion took place over its email list, as in IETF. The group exchanged 5428 emails over its 5-year life, with a large majority of them exchanged in the first 2.5 years of the working group's life. Although WG members received them via email, all of the messages were archived and publicly available on the WG website, where they were easily viewable by date, by author, or by thread for easy search.[12] The emails themselves, like those in IETF, typically enacted the dialogue genre. A WG member would pose an initial question or proposal, to which others would respond, embedding their comments in the original messages. The exchanges were often extended arguments dominated by two or three individuals, creating 10 or more levels of embedded

[12] A few W3C committees (e.g., one that looked at the sensitive issue of patent policy) were closed to nonmembers, but most working group lists were open to be read by anyone, though nonmembers could not post to them. Working groups typically had an additional list on which the public could post comments and get replies from working group members.



Web Cryptography API

W3C Recommendation *26 January 2017*

This Version:
https://www.w3.org/TR/2017/REC-WebCryptoAPI-20170126/
Latest Published Version:
https://www.w3.org/TR/WebCryptoAPI/
Latest editor's draft:
https://w3c.github.io/webcrypto/Overview.html
Previous Version:
https://www.w3.org/TR/2016/PR-WebCryptoAPI-20161215/
Editor:
Mark Watson, Netflix <watsonm@netflix.com>

Errata for this document will be gathered from issues.

See also **translations**.

Participate:
We are on GitHub.
Send feedback to public-web-security@w3.org (archives).
File a bug (see existing bugs).

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Abstract

This specification describes a JavaScript API for performing basic cryptographic operations in web applications, such as hashing, signature generation and verification, and encryption and decryption. Additionally, it describes an API for applications to generate and/or manage the keying material necessary to perform these operations. Uses for this API range from user or service authentication, document or code signing, and the confidentiality and integrity of communications.

Status of this Document

This section describes the status of this document at the time of its publication. Other documents may supersede this document. A list of current W3C publications and the latest revision of this technical report can be found in the W3C technical reports index at https://www.w3.org/TR/.

This document is a W3C **Recommendation** of the *Web Cryptography API* specification. This document is produced by the Web Cryptography WG of the W3C.

An implementation report is also available (as well as reports sent to the mailing list).

Ongoing discussion will be on the public-web-security@w3.org mailing list (archives).

This document has been reviewed by W3C Members, by software developers, and by other W3C groups and interested parties, and is endorsed by the Director as a W3C Recommendation. It is a stable document and may be used as reference material or cited from another document. W3C's role in making the Recommendation is to draw attention to the specification and to promote its widespread deployment. This enhances the functionality and interoperability of the Web.

This document was produced by a group operating under the 5 February 2004 W3C Patent Policy. W3C maintains a public list of any patent disclosures made in connection with the deliverables of the group; that page also includes instructions for disclosing a patent. An individual who has actual knowledge of a patent which the individual believes contains Essential Claim(s) must disclose the information in accordance with section 6 of the W3C Patent Policy.

This document is governed by the 1 September 2015 W3C Process Document.

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Fig. 4.7 Opening pages of W3C recommendation (standard) that emerged from the standard setting of WebCrypto WG responses that made them hard for anyone except a highly motivated reader to follow. The language, as in IETF, tended to be blunt and informal (or, as one member of the working group said to me, some members had "sharp elbows" (Yates and Murphy 2019, pp. 279, 292).

The dialogue genre as used by WebCrypto WG shared the email medium and the emphasis on the values of informality and timeliness seen in IETF. But the Web interface reflected W3C's belief in the Web medium and its use of it to make such discussion available and searchable by the working group and by the public, thus further increasing transparency.

A third genre used in WebCrypto WG was the *balloting genre*; it differed from the balloting genre system of the traditional standards organizations, but also from IETF's rejection of balloting. In W3C, the working group must achieve consensus for each publication (including the ones listed above as stages of the specification as well as W3C-required publications of the specification every 3 months between stages). This consensus required voting by members of the working group, typically in phone or face-to-face meetings rather than by email over the list, today's equivalent of balloting by mail (Yates and Murphy 2019, Chapter 8). Balloting in WebCrypto WG was compressed into a single meeting. Usually the WG, chair or a W3C staff member wrote out the proposal for consensus for all to see on Internet Relay Chat (IRC, discussed further below). Then all WG members present at the meeting (with no quorum or balance required) would vote, more or less synchronously but in text via IRC, using "+1" to indicate yes, "0" to indicate abstention, and "−1" to indicate no. The chair would then state the outcome. In WebCrypto WG, the chair typically treated any no votes as a failure to achieve consensus, although the W3C rules would allow the chair to declare consensus in spite of a no vote. If a member voted no and was overruled, however, that member could file an official objection to the W3C director (Berners-Lee). In one case, a member of WebCrypto WG threatened to block consensus in this way, and the threat was enough to prevent a change he rejected from being pushed through (Yates and Murphy 2019, pp. 280–281).

This balloting genre reflected W3C's belief in achieving consensus (not just rough consensus, as in IETF). But because its balloting took place in face-to-face or especially phone meetings (where attendance was typically quite low and unbalanced), the consensus in WebCrypto WG was not necessarily broad. The desire for timeliness and push to keep the process moving forward trumped getting a more complete and balanced consensus. Also, W3C did not follow the traditional standards bodies' time-consuming due process model of tabulating and responding to every negative comment, instead offering the more limited right of a member organization to file an official objection, which Berners-Lee would review quickly.

Finally, it is worth commenting on the W3C *meeting genres*, another component of the W3C repertoire, based on my observation of their meetings (access I did not have to C63, CISPR, or IETF standard setting). Notably, both phone and face-to-face meetings were augmented by Web tools. Web-based IRC was an integral part of both types of meetings, along with Zakim, a Web-based meeting manager bot. In face-to-face meetings, members all had laptops opened to the meeting Web page to use them. Zakim automatically recorded the attendance on the teleconference (based on phone numbers) and showed the agenda on IRC, and it had automated issue and bug tracker functions to allow easy monitoring of key issues or bugs as required. Zakim also designated a scribe if no one volunteered to serve as scribe. Then the IRC channel allowed the designated scribe for each meeting to record meeting minutes in real time for all to see. IRC also allowed members to make text comments in the background and to indicate that they wanted to enter the queue to speak aloud by typing in “+q.” The use of the text-based IRC with phone meetings required participants to get onto two different electronic systems (the teleconference and the Web-based IRC), frequently causing delays of up to 15 min in starting the 60-min meetings. And in face-to-face meetings, participants followed on their computer screens, reducing eye contact and direct interaction.

This Web augmentation of meetings reflected W3C’s belief in the Web medium as inherently good. They saw it as timely in creating minutes, even when it took extra time to get set up or interfered with human contact. While the traditional standardizers believed that standardization itself was good, both IETF and W3C saw the good as residing in their technology itself and saw standards as necessary to support the technology. Thus the carefully devised processes of traditional standardization were often preempted by new processes that prioritized the technology being standardized, as well as timeliness.

4.6 What Can Genre Analysis Tell Us About Changing Standardization Values

We can see the outlines of a broader set of continuities and changes in the genre repertoires and the values they reveal between the earlier, traditional voluntary standard setting organizations and the new organizations that have dominated standard setting around the Internet and World Wide Web since the late 1980s and early 1990s. In both eras, the standard is still the most important genre, reflecting the fact that standardizers in both eras and types of organizations value the efficiency and order created by standards and believe that technical experts (not governments or markets) should establish them. In the new organizations, however, they value the technology being standardized perhaps even more highly, as shown by their shift to the communication media this technology supports (with standards available not on paper but digitally, through the Internet or on Web sites). Moreover, in line with beliefs held by members of the Internet and Web communities that their technologies should be open to all (Russell 2014; Berners-Lee 1999), IETF and W3C standards are free and freely available to anyone with access to the technology, rather than sold to create a revenue stream for standardization. This shift to free standards was made easier because the new media minimize the cost of making standards widely available, but unlike the traditional bodies, IETF and W3C must depend on other sources of revenue to support the activities of the organizations.

The balloting genre system was critically important to the traditional bodies in the earlier era, reflecting the value placed on consensus and due process—important aspects of the voluntary standardization process beginning in the early twentieth century (Yates and Murphy 2019). The new bodies either eliminated formal balloting in favor of informal methods of judging rough consensus (IETF) or retained formal voting for consensus but temporally compressed it into phone or face-to-face meetings (W3C). Although they still valued consensus (more or less rough), they shifted away from the traditional balloting genre system in part to increase timeliness, which this high tech community valued. Not only did they vote in real time, if at all, but they omitted the laborious due process followed by the traditional bodies, with thoughtful written responses to each negative comment. The requirement for a balanced voting pool reflected in the earlier ballots disappeared, as well. The new genre repertoires valued timeliness over due process and balance. Moreover, as electronic communication augmented and replaced paper-based correspondence, this form of communication between meetings increased enormously in volume and importance. Threads of dialogue messages became the central forum for debate about the technical merits of various aspects of the standards and for pushing toward consensus. The new organizations still valued consensus but achieved it differently, using new and modified genres in new media in place of old ones.

Meanwhile, the traditional standards organizations such as ANSI, ISO, and IEC were aware of the new electronic media, but they shifted toward using it in standard setting much more slowly and incompletely, and even when they used it, their genres shifted much less, as well. The records of one of the ANSI subcommittees working on one element of ISO's open systems integration (OSI) effort (Subcommittee X3T2, Data Interchange) show that its members, even though they were working on standards related to internetworking, strongly resisted using email for anything but scheduling meetings well into the 1990s (Yates and Murphy 2019, p. 249).[13] Only then did the ANSI subcommittee begin to allow balloting by email and facsimile, as well as paper-based mail. In ISO and IEC more broadly, paper processes were retained beside electronic ones into the opening decades of the 2000s, initially to assure that developing countries without digital infrastructures could still take part. Even today, paper processes remain dominant in a few committees, and where committees and organizations shifted to electronic media, they usually simply translated the existing genres (e.g., those making up the balloting genre system) directly into digital form, without significant changes in them.

The fact that the genres shifted only very slowly, if at all, in the traditional organizations reflected their older values. In such bodies the standards themselves are still not universally free, though they are now commonly free for small and medium size companies, especially in poorer countries. Transparency, a key value for IETF and W3C, is not a priority for the traditional organizations; policies about the visibility of email lists and other documents vary by committee. For example, the ISO committee that created ISO 26000, Social Responsibility, had Swedish and Brazilian

[13] The papers of Murray Freeman of Bell Labs, who chaired the X3T2 subcommittee are in Series II, X3T2 materials, Boxes 6–8, Freeman Papers, Haverford College Archives.

co-chairs who cared deeply about inclusion and transparency and made all materials available online (Yates and Murphy 2019, p. 321). In contrast, many other technical committees do not make their communication available to nonmembers. Finally, even when members used email and fax to submit their ballots, the medium changed but the old processes and genres remained, with the due process of responding to every negative comment.

By sticking to the older values and processes, traditional standards bodies risked being made irrelevant by the faster processes of the new bodies (although even IETF and W3C could not set standards as rapidly as they and their stakeholders would have liked) and of corporate consortia (which were even faster because they did not care at all about consensus and actively avoided balance in favor of small groups of like-minded firms). Consequently, ISO and IEC developed new processes to allow standards developed by some of the new bodies to go through an expedited process of validation as publicly available standards (PAS), a new variant on the standard genre that reflected less complete and balanced consensus than the standard genre (Yates and Murphy 2019, pp. 259–260).

What lies ahead for the voluntary consensus standard-setting world is not clear, but a fairly recent development is suggestive. In 2012 five organizations involved with standard setting around electronic communication (IETF along with its senior oversight body the IAB and its organizing and publishing body the Internet Society, W3C, and the traditional IEEE professional society, which also set standards) established OpenStand, an alliance around principles of standardization.[14] The alliance published and endorsed what it identified as the “modern paradigm for standards,” comprising five principles:

- Cooperation among standards organizations
- Adherence to *due process, broad consensus, transparency, balance*, and *openness* in standards development
- Commitment to technical merit, interoperability, competition, innovation, and benefit to humanity [in the 2018 version, this principle is designated as collective empowerment]
- Availability of standards to all
- Voluntary adoption

These principles endorse both traditional and new values. Due process, broad consensus, and balance are values of traditional voluntary standardization reflected in its genres. Transparency, openness, and availability of standards to all are key values added by the new bodies. Both sets of standards bodies embrace the importance of technical merit, benefit to humanity (though seen in different terms), and voluntary adoption of standards. Interestingly, we have seen that IETF and W3C traded off due process for timeliness and that IETF settled for only rough consensus.

[14] See OpenStand web pages https://open-stand.org/infographic-the-5-core-principles-of-open-stand/ and https://open-stand.org/about-us/principles/ (last accessed 12/6/2018) for the five principles as currently stated.

This statement of alliance values seems to reflect new organizations advocating that traditional ones adopt their new values, and traditional ones advocating that new ones adopt their traditional values. In the best case, the OpenStand alliance could signal a convergence of values; in the worst case, it could be an empty gesture reflecting the permanent fracturing of the voluntary standardization community. Only time will tell which, if either, outcome emerges.

4.7 Implications

Looking at voluntary standardization through a genre lens has illuminated the changes in values and media initiated by computer networking and the new organizations that arose to standardize it beginning in the late 1980s. More broadly, however, genre analysis is a powerful tool for studying values and media within any organizational or community setting.

Genres give insight into stable as well as changing values. Genre repertoires can characterize a community, while genre systems can illuminate coordination of processes within the communities. Changes in communication media can trigger simple translations of genres from one medium to another, as they have done in most of the traditional standards bodies. Alternatively, a new medium may introduce new communities with differing values to standard setting, as was the case with IETF and W3C. In these communities, the genres differ considerably from the traditional genres, revealing the influence of their new values, as well as of the new medium.

Genres are useful tools for historical and contemporary social analysis. This lens allows the historian to look beneath the ostensible content of specific documents to the values underlying the socially accepted purpose and form of the genres they enact (see Yates 1989). The lens is equally powerful in analysis of contemporary communities and organizations. As even newer social media become more prevalent and communities (e.g., academics in a particular professional organization, political organizations, etc.) adopt them as communication tools, scholars can study new and transformed genres enacted in these media as one way to illuminate stable and changing values of the communities and organizations they represent. Scholars may benefit from adding this tool to their tool kits, giving them another option for illuminating social relations.

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Chapter 5
Talking About Metadata Labor: Social Science Data Archives, Professional Data Librarians, and the Founding of IASSIST

Greg Downey, Kristin R. Eschenfelder, and Kalpana Shankar

Abstract Contemporary calls for collecting, preserving, and repurposing huge stores of digital social science data within "cyberinfrastructure" are not entirely new. Similar sentiments decades ago motivated the development of what came to be known by the late 1960s as "social science data archives" or SSDAs. These information infrastructures promised a systematized solution to the problem of making social activity visible and intelligible to social science researchers, while relying on the long work hours, creative insights, and collegial collaboration of a hidden network of social data curators. This chapter describes how some of these data curators came together in the late 1970s to form a new professional organization called the International Association for Social Science Information Service and Technology, or IASSIST—not only to make their own collective data curation work more visible but also to make the social science data archives themselves more sustainable. Building this professional identity and peer network was a crucial, voluntary, and undervalued labor challenge, essential to advertising the existence, circulating the products, disseminating the best practices, and realizing the value proposition of the SSDAs themselves.

Keywords Information · Infrastructure · Cyberinfrastructure · History · Curation · Gender · Professionalization

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Archival Sources and Abbreviations

UMIP	IASSIST papers, University of Minnesota Twin Cities Library
IN	IASSIST Newsletter
IQ	IASSIST Quarterly
IAC	IASSIST administrative committee
IAG	IASSIST general assembly
IAR	IASSIST annual report
IOC	IASSIST organizing committee

5.1 Introduction: Social Science Data Archives as Cyberinfrastructure

Now officially 30 years old, today's World Wide Web represents not only a vast informational terrain of e-commerce sites, social media platforms, natural-language search engines, and political action organizations but also an equally vast ecosystem of advertising, surveillance, and activity-tracking systems. For decades now, our aggregate movements over this Web have generated greater amounts and more varied types of quantitative social science data than ever before, resulting in repeated calls for new investment in "cyberinfrastructure" (as a 2005 National Science Foundation report termed it) for enabling the collaborative and interdisciplinary study of the "big data" of social science research (Berman and Brady 2005; Bowker et al. 2010). A 2009 *Science* article even heralded the coming of a new kind of "computational social science," years before "machine learning" became a media buzzword (Lazer et al. 2009). But such calls for collecting, preserving, and repurposing huge stores of digital social science data are not entirely new. Similar sentiments decades ago motivated the development of what came to be known by the late 1960s as "social science data archives" or SSDAs (Shankar et al. 2016). SSDAs may be defined as "distributed large-scale information infrastructure [s] that have been influential in shaping the development of the social sciences, quantitative methods, data standards, and international relationships among data institutions in the latter half of the twentieth century" (Eschenfelder et al. 2018). Just as with the World Wide Web, these information infrastructures both promised a systematized solution to the problem of making social activity visible and intelligible to social science researchers, while at the same time inevitably relying on the long work hours, creative insights, and collegial collaboration of a hidden network of social data curators (Downey 2014). This chapter describes how some of these data curators came together in the late 1970s to form a new professional organization called the International Association for Social Science Information Service and Technology, or IASSIST—playfully pronounced as "I assist!"—not only to make their own collective data curation work more visible but also to make the social science data archives themselves more sustainable. Building this professional identity and peer network was a crucial, voluntary, and undervalued labor challenge, essential to advertising the existence, circulating the products, disseminating the best practices, and realizing the value proposition of the SSDAs themselves.

5.2 Social Science Data Archives and the Metadata Crisis of the 1970s

The roots of SSDAs stretch back to the development of punched card, public opinion sample survey research in the 1930s. By the late 1940s, sociologist Paul Lazarsfeld had developed an empirical social science laboratory at Columbia, social psychologist Rensis Likert had established a survey research center at Michigan, and pioneering pollster Elmo Roper had deposited the original punched cards from his firm's well-known public opinion surveys with Williams College (Hastings 1961; Barton 1979; Featherman 2004). By the late 1950s, data processing in sociology, political science, area studies, and related fields motivated two social scientists, one from the United States and one from Europe, to jointly publish a report through the Columbia University School of Library Science, focused on using library techniques to make the new digital data of social science more widely available. Titled *A Library Center of Survey Research Data* (1957), authored by York Lucci (Bureau of Applied Social Research at Columbia University, New York) and Stein Rokkan (Institute of Social Research, Oslo), the report urged colleagues not only to preserve today's quantitative social science data for the future but also to circulate it across a global geography for greater peer review, comparative study, and interdisciplinary combination (Lucci and Rokkan 1957; Nasatir 1973; Scheuch 2003).

Many of the large social science data archives that remain today, such as the Inter-university Consortium for Political and Social Research (ICPSR) at the University of Michigan and the Zentralarchiv fur Empirische Sozialforschung (ZA) at the University of Cologne, were founded in the 1960s in the wake of the Lucci and Rokkan report. The "quantitative turn" in the social sciences was by then unavoidable, including new methods for conducting sample surveys, new troves of data in machine-readable form, and new tools for digital processing and model building that could enable what sociologist Herbert Hyman dubbed "secondary analysis": the efficient revisiting of old research data by new scholars with new questions (Hyman 1991). Advocates of secondary analysis today list essentially the same potential benefits to archiving social science data as they did in the late 1960s: increasing the accessibility of costly (and often publicly funded) data to a wider community of scholars beyond the original research team; enhancing the standardization of data collection and variable construction methods by making individual research choices visible to other scholars; avoiding needless duplication in data-gathering efforts by providing a way to see if a proposed study was truly unique; providing the means for direct critical replication of scientific findings in order to test the robustness of conclusions; bringing together similar data from different states or nations to do comparative research; and offering tools for the education of new undergraduate and graduate students using real-world examples (Bisco 1970; ICPSR 2018). In this way, social science data archives were promoted as material and organizational expressions of supposedly universal norms of scholarship, collegiality, and progress in the social sciences.

The digital data situation of the early 1970s, then, seemed revolutionary to social scientists of the era. An inventory of the largest SSDA organizations operating at the time would include the ICPSR at Michigan; the ZA at Cologne, Germany; the Roper Center at Williams College; the National Opinion Research Center (NORC) at Chicago; the Political Data Program at Yale; the Survey Research Center and the Institute for International Studies at Berkeley; the UK Data Archive in Essex, England; and about a dozen others. As the Director of the International Data Library and Reference Service at UC Berkeley, David Nasatir, put it in a 1973 UNESCO report, "Unlike the conventional library which loans or gives access to original copies of the information desired […] the data archive produces a new copy of the data (or subset of the data) which the user may then take away to his own analytical facilities" (Nasatir 1973). For example, around this time the Roper Center counted "more than 10 million IBM cards of information: raw data from over six thousand studies from twenty-two American suppliers and seventy-one other organizations located in 43 countries" (Bisco 1967). Similarly, the ICPSR had "grown to ninety-six members and expended over a million dollars" per year from a combination of NSF grants, university funds, and its organizational annual membership fees of $2500 apiece (Johnson 2008). The data infrastructure required investment; while "these new social science organizations were naively viewed in the beginning simply as warehouses of information that should be preserved," according to Ralph Bisco, "data archives necessarily must become complex organizations, with staffs that include specialists in computer operations, programming, and data processing techniques, as well as administrators and professional research personnel" (Bisco 1967).

Such costs seemed a small price to pay for the dream of universal data available on request. Scholarly assessments of SSDAs appeared throughout the 1970s, such as Ralph Bisco's *Data Bases, Computers, and the Social Sciences* (1970), David Nasatir's *Data Archives for the Social Sciences* (1973), and Howard White's *Reader in Machine-Readable Social Data* (1977), telling a celebratory story where new scientific methods and new digital technology had triumphed over the small-scale, idiosyncratic, and isolated interpretive social science investigations of the past. The scientific benefit from the new infrastructure—the value—was attractive: "A new data collection may cost $75,000 or more; a copy of an appropriate computer-processable data collection may cost as little as $5" (Bisco 1970). The only remaining question worth study, as put forth in a 1980 UW-Madison doctoral dissertation, seemed to be why, despite the original suggestions from Lucci and Rokkan back in 1957, academic libraries and archives themselves hadn't been more centrally involved in this revolution in the 1960s and 1970s—an oversight seemingly addressed by 1982, when the same writer edited a special issue of *Library Trends* formally introducing the rest of the library profession to these social science data archives (Heim 1980; Heim ed. 1982).

But asking why libraries hadn't been more involved in the early development of this social science cyberinfrastructure was the wrong question. Even if most *libraries* were slow to take responsibility for the new "machine-readable data files" (MRDF) of the social science data archives, many *librarians* themselves were crucial to the development and daily operation of the SSDAs from the start. After all, "data" does not magically appear from a research study in a form that is preservable, transportable, findable, or even understandable by anyone else other than the original gatherer without first expending significant labor to evaluate, organize, clean, classify, catalog, tag, or otherwise describe and transform the data in way that other people—and other technological systems—can deal with (see for example Plantin 2018). Much of this work results in what information professionals refer to today as "metadata"—information *about* the myriad books and magazines, reports and theses, music and video, and multimedia and hypermedia of all sorts, which libraries collect, organize, store, and circulate. Research on schemas and strategies for producing metadata has been a staple of library and information science for decades, with the concept enjoying a renaissance in the World Wide Web era as the "Dublin Core" emerged as a sort of universal standard for networked digital data projects, while the SSDA community developed its own standard known as DDI through a later cooperative initiative in the 1990s and 2000s. Yet even in today's cyberinfrastructure, "Metadata creation is often an unfunded mandate" (Mayernik 2008).

And quality metadata is only part of that mandate; many forms of "metadata knowledge" which library and archive professionals develop, refine, and impart to both depositors and patrons are necessary—such as practices and norms for choosing what materials are preserved and what materials are circulated in the first place, choices that are inevitably related to speculative value judgments about the cost and benefit of being able to use such materials in the future. This kind of metadata "curation" work is never complete, because the societies within which libraries and archives function, and the expectations of the patrons which they serve, are constantly changing. Old categories must be rethought, renamed, or reassigned based on the most recent discoveries of academic scholarship, the newest need for interdisciplinary translation, or the latest citizen claims concerning social justice. By following the production and reproduction of all of this metadata and the knowledge surrounding it—how metadata is made visible and invisible, valued and devalued, rendered in both physical and virtual forms—scholars of technology and society can analytically connect practices of librarianship across vastly different institutional, functional, social, and technological contexts (Downey 2010).

Metadata production and reproduction is thus a huge labor challenge within social science information infrastructures. Scholars of technological information and communication networks have long pointed to the ways that human work—in what has been called "virtual labor," "digital labor," "immaterial labor," or, in a more general sense, "information labor"—is not only absolutely necessary to realizing the value of moving information through such networks but also often the least visible feature of such networks (Blok and Downey eds. 2004). This is especially true of libraries and archives, where the basic curation and circulation challenge that happens largely behind the scenes is as much temporal as geographical: to take an informational product produced in the past (say, a social science data set) and describe and define it using the tools and terminology of the present, all in a way that will presumably make sense to a potential scholar seeking it in the future (Plantin 2018). All such decisions must be made imperfectly: there is never enough time or money or even storage space to perfectly catalog and safely store every possible item available today for every possible audience of tomorrow (Downey 2014).

Conceptualizing the metadata practices of social science data curators as a special kind of information labor—"metadata labor"—reveals that the question of who performs, and who pays for, such labor is still important in today's "big data" era. Writers in the MIT Press volume *World Wide Research: Reshaping the Sciences and Humanities* (Dutton and Jeffreys 2010) agreed, "In order for data to be reusable by researchers not involved with the original data collection, representations of the data (such as metadata, data dictionaries, or ontologies) need to be created. This process can be expensive in terms of the person power required to clean and annotate the data, even in the research areas where data curation is semiautomated" (Meyer et al. 2010). Back in 1957, York Lucci had hoped that once basic financial support for a single central social science data archive was secured, the main tasks of "selection and screening of studies" and "the development of appropriate archival procedures" for "developing wide and efficient utilization" would only take "several years" (Lucci 1957). Yet such metadata issues vexed the SSDAs for decades—and still do.

For example, even at the height of the SSDA revolution in the 1970s, actually using these archives was a challenge, even for social scientists who knew of their existence. Unlike research library holdings of books and periodicals, or print archival holdings of documents and correspondence, SSDAs shared no cross-institutional finding aid to reveal the availability of research data on a particular topic—there was no "union catalog" for social science data, neither in North America nor in Europe. As a result, the same authors who praised the creation of these resources often lamented that they were underutilized and underfunded. Ralph Bisco noted, "Users are now confronted with a time-consuming, inefficient, and costly means for determining what specific data holdings match their immediate research needs. They must first identify which of the several score archival organizations are likely to maintain the kinds of data they might need, and then they must call, visit, or write each of the likely sources" (Bisco 1970). Thus any data archive which wanted its resources used more widely needed to bear the cost and effort of circulating information about those resources itself—just as the ICPSR and the Roper Center did with their regular lists of new holdings sent out to their own paid members lists. European data archives, which served whole nations and did not have paid members, occasionally advertised holdings descriptions in political science journals or other publications of the scholarly community.

How might these data be more widely and systematically circulated to achieve the transformation in collaborative, secondary, and comparative analysis that social scientists hoped for? It wouldn't be enough to simply list datasets by name, topic, and date. What scholars looking to extend, replicate, or even critique a past study really needed to know were what kinds of questions were asked of research subjects, with what range of answers, collated into what kind of variable categories, for use with what kind of statistical measurements and breakdowns. Scholars needed detailed information from a study's "codebook" in order to know whether it would be worthwhile to have an SSDA ship boxes of punched cards or magnetic tapes across the country or across national borders—and whether it would be worthwhile for a new institution to mobilize its own scarce data processing equipment to redigest and reanalyze the study data. As MIT social scientist Ithiel de sola Pool and his colleagues described it at the time, "A codebook is largely meta-data" (Pool et al. 1969).

Two different approaches to handling this data and metadata discovery problem emerged. The first was to set up a funded organization that would have the power to work with all the SSDAs to produce a centralized catalog. This was one of the reasons for the 1962 founding of the US-based Council on Social Science Data Archives (CSSDA or "Council") (and later the 1976 founding of the similarly named Council of European Social Science Data Archives or CESSDA). From the start, the US-based Council had set an ambitious agenda of rationally organizing the world's academic social science data archives to avoid "duplication or competition" (Alford 1969). But by 1969 the Council had disbanded. One of the projects left unfinished when the Council folded was a promised inventory of secondary studies and data available through all of its member archives internationally. The group ended up with an incomplete listing of some 2000 studies (many of them from a single archive anyway, the Roper Center), which was "eight feet tall" and too unwieldy to actually publish either in paper or on punched card format for distribution to potential users. A professor from SUNY Stony Brook who helped develop the unreleased inventory, Raymond Maurice, described some of the challenges (Maurice 1969): "They got some money and sent out the inventory format forms to all the universities. There, assistants, some who didn't know anything about the studies and some who did, filled out the forms." Maurice said "it's just like pulling blood out of stone to get a clerk to go through the codebook and tell what is in the data." Yet surprisingly, in a conference discussion about the failed project, Maurice revealed that the Council feared disseminating even these results would create too much demand for data reuse! "Let's say I get this inventory out and it goes to five thousand people. All of a sudden we will create a system where people working on Masters' or PhD theses will be doing data analysis. This may start inundating the data archives" (Maurice 1969). Efforts in Europe to develop a means to share information about data holding across national borders, language, and cultural barriers, such as those managed by a subgroup of the International Social Science Council (ISSC) called the Standing Committee on Social Science Data Archives (SCSSDA or "Standing Committee"), were also of limited success.

Within the United States, the second approach to archival data discovery, following the failure of the Council to produce a workable union catalog, was to use a newsletter to provide a regular update of new and interesting holdings at participating data archives—prioritizing timely notice over comprehensive coverage. Dubbed "*s s data*" when it debuted in 1971, this quarterly periodical was edited by social science professor John Kolp at the Laboratory for Political Research of the University of Iowa and funded by a two-year National Science Foundation grant, "to collect and communicate at regular intervals information on data acquired by archives" (Kolp 1971). At first, the foundation funding allowed SSDA metadata to freely circulate (through the mail) to any interested North American users. Two years later, when federal funding expired, Kolp listed "35 archives which contribute regularly to the newsletter and approximately 1200 readers" (Kolp 1973). But even under a subscription model—with individual social scientists, their departments, or, crucially, their college/university libraries paying for this work to continue—the experiment proved financially unsustainable and ended by 1981. Kolp admitted the small staff at Iowa simply could not keep up with all the changes in the data landscape: "it was never possible at any one point in time to know which data archives were in existence and which ones were not" and "the degree of cooperativeness [by the data archives] varied a great deal" (Kolp 1980). But another change was in the readers of *s s data* itself, which Kolp said "serves the data reference community and not primarily the individual researcher, social scientist, or community planner" (Kolp 1980). In other words, the newsletter had become a resource not for social scientists, but for librarians.

5.3 Linking Data Archives to Data Libraries with Metadata Labor

Who were these North American librarians who subscribed to *s s data* in the 1970s, mediating the metadata circulation between the archivists at the big SSDAs and the students, staff, and faculty of their local university social science departments and survey research centers? Many of them were traditional reference librarians working with either campus or disciplinary communities, helping their user communities understand how a particular data set had been put to use as part of a published research study. However, an increasing number worked in new units where they interfaced not only with library staff and social science researchers but with data processing and computer center personnel as well, given their role in helping users to acquire sets of punched cards or magnetic tapes full of research data and statistical analysis programs. Little by little, the many local sites for this kind of work came to be known as "social science data libraries"—in contrast to "social science data archives" which in Europe often served an entire nation (e.g., the ZA in Germany), and within the United States existed as annual fee paying member organizations (e.g., Roper, ICPSR). Thus the persons who staffed these decentralized data libraries became referred to as "social science data librarians" or simply "data librarians."

The University of Wisconsin-Madison offered the first and clearest example of this trend. In September 1966 the UW Data and Program Library Service (DPLS) was founded by sociologists Michael Aiken and David Elesh with six data files—it was later claimed to be the "oldest general [data] archive in the United States." Three years later, in 1969, it counted "about two hundred" data files, had a budget of about $50,000 per year, had affiliated as a member of both the ICPSR and the Roper data archives as members, and employed two full-time staff besides its faculty directors: Margaret (Peggy) O'Neill Adams (Assistant Director) and Alice Robbin (Data Librarian). The DPLS was governed by social science faculty but was "not a part of an academic department"; instead, it was administered by a faculty steering committee "made up of representatives of various social science departments," with funding committed centrally at the college level. Faculty seemed to value this resource, since DPLS staff reported that "we are on the standard tour for all prospective new faculty members in the social sciences." And data librarian Robbin, who received her own Master's in library science from UW, reported that "As a graduate student I had used DPLS myself" (Adams et al. 1969b).

The social science data librarians of the DPLS performed three crucial networking services for students, staff, and faculty who might be interested in what the national SSDAs like ICPSR and Roper had to offer:

1. *Downloading national data to local users.* Data was acquired for users from the big SSDAs (ICPSR, Roper), as well as from state and federal government producers, on punched card or paper tape through the mail. In most cases, a "cached" copy was also made and kept in the data library before passing the original materials on to the patron, so the library would have a safe version available in case of another request. This meant the DPLS kept on hand "several keypunches—some with interpreting mechanisms, verifiers, cardcounters and sorters, a reproducer, and a card reader to one of the university computers" (Adams et al. 1969b).
2. *Uploading local data to national users.* Data libraries became the conduit for any local social science research that might be valuable enough to be submitted to a national archive for permanent storage. And even though data libraries weren't intending to compete with the national SSDAs in terms of data holdings, some locally produced datasets were archived locally as well, especially if they were of such narrow focus or dubious quality as to not be desired by a national repository. Such data would even be provided to other campuses on occasion, "sent out at cost" (Adams et al. 1969b).
3. *Building an interdisciplinary community of practice.* The DPLS promoted the existence of the SSDAs, the availability of government process-produced datasets, and the use of new secondary analysis research techniques, through regular training sessions and individual mentoring interactions. Data librarians also worked with university computer programmers—the librarians were not expected to code solutions themselves, but they needed to be conversant with computing services colleagues in a way that many faculty and graduate students might not have been. And just as a print library or print archive would monitor how their materials are used, the data librarians monitored how their datasets were used—especially noting whenever errors in those datasets were uncovered. Unlike a print library or archive, however, this library made its data users visible to each other so they could learn from each other. "We keep a record of all errors and the

next researcher is warned about them. We also keep a record of all the people who use a file. Each subsequent researcher can go back and talk with another to find out what happened to him when he analyzed the data" (Adams et al. 1969b).

What this pioneering social science data library accomplished in practice, then, was to serve as a meeting place for various university constituencies who each had an interest in the new social science quantitative data movement. Social science faculty used the DPLS resources (and sometimes contributed their hand-rolled data to the DPLS as well). Social science graduate students from all over campus found their way to the DPLS as a training and learning opportunity that they would carry forth to new institutions throughout the 1970s when they themselves were later hired as faculty or researchers. Social science software developers became part of the conversation and actually served on staff at the DPLS with the librarians. And the librarians staffing the DPLS were important conduits back to the local library school for training the next generation of information professionals.

This new forum for technological translation between librarians, scholars, students, and programmers was an important development. After all, only a few years earlier, the well-known library historian Jesse Shera, Dean of the School of Library Science at Case Western Reserve University, had edited "a kind of Intelligent Woman's Guide to Automation in the Library" for the May 1964 *Wilson Library Bulleti*. He characterized librarian resistance to automation as rooted in "fear" and "anxiety," arguing that "being traditionally humanistic, librarians doubt their capacity even to utilize anything that is scientifically derived" (Shera 1964). The apparatus of "library automation" would soon be impossible for the "intelligent woman" of the field to ignore; first with time-sharing mainframe technology and later with desktop microcomputer technology, the 1970s would see a widespread discussion about the proper place of computation in this feminized profession. The MARC project to create a standard format for electronic catalog records enabled the Ohio College Library Center (OCLC) project to connect participating library workers' cataloging computers together over space and time, which in turn inspired and the Online Public Access Catalog (OPAC) projects of the early 1980s, to make those networked electronic catalogs directly available to patrons. Social science data librarians were thus at the forefront of a technological discussion that offered some hope that the gender stereotypes of librarianship could finally be overturned, and the occupational status of librarianship could finally be upgraded, through the widespread adoption of digital library technology (Downey 2010).

The Wisconsin DPLS showed that for a data library to be sustainable during this period, its participants needed to constantly adapt, relearn, and retrain—not only because data processing technologies and social investigation methodologies were always changing but also because new individuals were always entering the campus and experiencing their first exposure to this new infrastructure. Local data libraries trained both their own staff and the social science scholars they served, not necessarily on the detailed statistical methods needed to evaluate the data files (which was handled by research faculty and staff), or even on the detailed computational skills needed to manipulate the data files (which was handled by computer center staff), but on two additional forms of metadata knowledge: the *awareness* of what kind of data of what level of quality was available from what sources in the data archive community, and the *norms* of eventually resharing one's own data with this community in the same way that one has benefited from the data of others. In this period however, data librarians were largely self-taught as few formal resources existed for professional development. For example, in the United States, ICPSR provided training through its annual meeting of organizational representatives and its summer training program as part of its mission to foster the quantitative social sciences. But during the late 1960s and early 1970s, ICPSR aimed to recruit (mostly male) senior social science faculty members as representatives. At that point, ICPSR saw quantitative social scientists, or their students, as their target audience to develop the ICPSR community; a scan of the 1970 representative list shows only two people not using the title of professor or doctor, and the vast majority of the names are clearly gendered male.

These issues were a constant topic of concern among the academic advocates of SSDAs, given the structures they created to build data awareness and enforce norms of sharing—first the Council and then the Standing Committee—but the social science data librarians were often more effective at addressing these issues. For example, in 1969 the DPLS noted that while many faculty "do not seem particularly prone to disseminating their data or to expending the effort needed so that their data can be deposited in a data library," they found "the users of the data library, particularly the graduate students, do develop this type of commitment" (Adams et al. 1969a, b). Promoting such awareness and normative behavior was, according to these librarians, "the primary means for keeping these data alive—to put them continually, without delay, and at minimal cost into the hands of potential users beyond their originators" (Adams and Dennis 1970).

5.4 Linking Data Librarians to Each Other Through IASSIST

The Wisconsin DPLS may have been an early case, but the notion grew through the 1970s that enterprising librarians might retool and reskill to help "keep data alive" (and thus realize its value) in the computer age. For example, Judith Rowe, a leading data librarian herself as Associate Director for Social Science User Services at Princeton University Computer Center, argued that the new availability of the US Census on data tapes was the "thin end of the wedge" which would motivate traditional libraries to take machine-readable social science data seriously: "Every ALA national conference since 1972 has had at least one well-attended program on data resources" (Rowe 1974). It was in this environment that the idea for IASSIST first took hold.

While the history of computing and information literature includes some recollections of the origins and impact of IASSIST as written by the participants themselves—from a first anniversary conference paper (Geda 1977) to a 25th anniversary essay written (Adams 2007)—there has been no systematic study of this organization or the role it played in the larger history of social science data archives. The following account uses correspondence from the IASSIST papers (UMIP), deposited at the University of Minnesota Twin Cities Libraries, to demonstrate that the survival of SSDAs in this period involved not only changes in the technological infrastructure of social science data—moving from mainframe-oriented magnetic tapes to personal computers and online access—but also profound changes in the spatial, social, technological, and gender division of labor necessary to preserve the value and utility of social science data itself. Whereas the centralized social science data archives of the 1960s had been instituted by prominent social science researchers and built by data processing professionals—both of whom were largely male—the subsequent decentralized social science data libraries of the 1970s and 1980s were developed and sustained largely college and university librarians—most of whom were female. IASSIST was an organization modeled after the societies, conferences, and journals of the academic social science and technology professions but intended less as a vehicle for disciplinary knowledge production and more as a vehicle for occupational solidarity and professional advancement.

The idea for IASSIST emerged at an international social science research conference in 1974, where, somewhat unusually, both scholars whose data filled the SSDAs and librarians whose metadata "kept the data alive" were invited to attend. With funding provided by International Social Science Council president and Norwegian social scientist Stein Rokkan—the longtime data archives evangelist and coauthor of the original 1957 manifesto calling for data archives to be created in conjunction with academic libraries—the "Conference on Data Archives and Program Library Services" was held in August 1974 in Toronto, in conjunction with the World Congress of Sociology. The conference was largely organized by a leading social scientist in the international SSDA movement: Erwin Scheuch, Director of the Zentralarchiv SSDA at the University of Cologne and chair of the ISSC's Standing Committee on Social Science Data Archives (the only remaining organizing group for social scientists who worked with data archives, after the folding of the US-based Council in 1969). Normally this might have been another in a long line of conferences where quantitative social scientists gathered to informally network and trade insights on new research methods, new data sets, and new data analysis programs. But as one of the attendees later described, what resulted instead was "a 'floor-level-uproar' […] claiming that no activity was going on with the Standing Committee" (Adams 2007; UMIP 1975-03-19 Rowe to Challener; UMIP 1976-06-15 Nielsen).

This "uproar" came about because the 65 attendees at this conference, from 16 different countries, "differed from participants in previous ISSC activities, wherein social science researchers prevailed" (Adams 2007; UMIP 1975-03-19 Rowe to Challener). With the conference title specifically inviting "Program Library Services" attendees, one of the American co-organizers, Wisconsin sociology professor (and DPLS director) Michael Aiken, "sent more than 300 invitations to the conference" that went to "staff members of census agencies, research institutes, and social science data archives (data banks, data libraries)" (Adams 2007; Robbin 1975). As a result, the August 1974 conference included library and computing professionals who made both central data archives and decentralized data libraries work behind the scenes to acquire, clean, transfer, store, search, and deliver that data. It was this shift in the division of labor that made all the difference: "The group identified professionalization and training of data archivists, the people on whose work social science research depended, as the first means of accomplishing their goals" (Adams 2007). Researcher David Nasatir (Berkeley) described the idea as "a grassroots effort among professionals engaged in the daily operations of social science data archives" (UMIP 1975-05-21 Nasatir to Adams). But just who were these professionals? Social scientist Hesung Koh (Yale) termed them "information intermediaries": "experts who can understand and work well with both information specialists and scholar-users of information […] their specialization involves understanding the interface between these areas, and serving as mediators, helping both information specialists and scholarly users to arrive at more effective reciprocal accommodations, and developing workable structures to accommodate their mutual interests and contributions" (UMIP 1975-05-22 Koh to Adams). In other words, these were social science data librarians. And, hoped sociologist Michael Aiken, these librarians would get things done: "an association of professionals in the data archive field who will define projects of mutual concern [and] set up task forces to carry out these objectives" (UMIP 1974-10-08 Aiken to Geda).

However, this new organization would not simply differ from previous social scientist groups like the Council and the Standing Committee in its focus on the professional division of labor. From the founding ad hoc committee, it was clear that it would also differ in terms of a gendered division of labor; key leadership positions were, for the first time, occupied by women. In addition to the organization efforts of Peggy Adams and Alice Robbin of Wisconsin's DPLS, two more women in particular became central to the story: Carolyn Geda, of Michigan's ICPSR, was chosen as chair; and Judith Rowe, of Princeton University, was selected as the "US Secretariat" (there was one representative from each major global region). These four would form a leadership team which remained largely in place, with slightly shifting roles, throughout the first decade of the organization's history (UMIP 1974-12 Geda).

Importantly, Europe at the time had no alternative professional organization for data librarians. The data archiving conversation in Europe was also driven by largely male social scientists through meetings of political researchers who had become interested in data. For example in a 1973 meeting of European Consortium for Political Research data exchange group (which in 1977 morphed into an early formulation of CESSDA), political science attendees led by Rokkan, discussed familiar problems like how best to facilitate exchanges of political data within Europe, how to build social networks for data dissemination, and how to effectively advertise data holdings to promote reuse (ECPH DEG 1973).

This dual technical and gendered shift in leadership—from the male social scientists to the female library professionals—was crucial to IASSIST's mission. Geda and the ad-hoc committee imagined that IASSIST would serve the field of social science by actually accomplishing the kinds of metadata tasks that the social scientists themselves had lamented about for years (and which the Council had failed to deliver upon in the 1960s): classification, cataloging, indexing, and all of the standardization required to make that happen. As Danish sociologist Per Nielsen would note later, "The whole IASSIST matter was, in my perception, started in part as a reaction against an authoritarian structure and low-level activity within existing professional settings" (UMIP 1975-11-07 Nielsen). Or as one prospective member put it upon being informed of the new organization, "I hope this organization can be more than the idealistic talk and lousy permanence which seems to characterize most such efforts in this field" (UMIP 1975 anonymous).

5.5 Negotiating the Purpose and Power of IASSIST

However, the question of how to actually organize and fund IASSIST—and which side should hold real power in the organization, the social scientists or the librarians—proved problematic from the beginning. The library-based IASSIST organizers desired real autonomy of action from the faculty-led Standing Committee; however, they also wanted to have a voice in the decision-making of the Standing Committee (and, if possible, benefit from the funding opportunities that the Standing Committee had access to, such as its ties to UNESCO). Aiken wrote to Geda that "many of the people on the Standing Committee were internationally known social scientists, which gave a certain visibility to the committee," which he clearly thought would be important to building IASSIST's legitimacy. Thus Aiken proposed that "the task force chairmen of [IASSIST]" should also "occupy the position of task force chairmen in the Standing Committee. From a technical point of view, this would mean that each task force chairman would wear two hats." Aiken even listed several existing Standing Committee groups headed by prominent social scientists—dealing with computing issues, content analysis, historical data, and archival development in the "Third World"—which he imagined would simply become IASSIST task forces themselves. Aiken believed this was crucial for IASSIST "to have legitimacy in the international social science community" (UMIP 1974-10-08 Aiken to Geda).

But Aiken's proposal would have ensured that the academic "chairmen" of those Standing Committee task forces, if mirrored in the IASSIST task force structure as well, had a clear place of power and control within the supposedly professional IASSIST from the start. Fellow social scientist David Nasatir from the Berkeley data archive (who had published a UNESCO report on SSDAs in 1973), was clear about this in a hand-written letter to Geda sent shortly after the Toronto meeting. Nasatir admitted to Geda "I'm sorry to say that somewhere […] some developments took place that might be misinterpreted as an exploitative ripoff"—meaning that if the IASSIST action groups were chaired by Standing Committee men and, as Nasatir noted, "no women?!" that would clearly be problematic. Nasatir apologized for this and offered his own advice to Geda: that IASSIST should be organized "first as an independent organization, then an alliance (from strength) with the Standing

Committee." In other words, whether it ever interfaced with the social scientists or not, "IASSIST should grow and thrive on its own (considerable) merits" (UMIP 1974-09-11 Nasatir to Geda).

Carolyn Geda responded tactfully in her mailing to the ad-hoc organizing committee in December 1974, making her case for the structure and purpose of the new organization (UMIP 1975-03-05 Geda to Nielsen). Looming behind this pitch was the recent memory of the failed US Council on Social Science Data Archives. Geda did not want IASSIST to follow the Council's path—winning great funding and attention upon its founding, but unable to produce any changes or systems of lasting impact—but at the same time she knew that the success of IASSIST would be measured against its ability to achieve some of the goals originally imagined (and abandoned) by the Council. Geda's pitch was, as a consequence, carefully crafted. It started with a summary history of where the field had been—"a list of some of the major archival meetings occurring between 1962–1969"—a time period exactly spanning the previous Council's existence. The implication was clear: Much has been said but little has been done. Next it provided some examples of organization constitutions and bylaws, again using the Council as an example. Third came Geda's summary of the Toronto meeting, including a tentative list of task forces and a questionnaire she proposed sending to any prospective members. Finally were suggested journals, newsletters, and individuals to contact in drumming up membership and publicity for the new organization. A questionnaire for prospective members rounded out the packet. Importantly, both the questionnaire and the wide-ranging mailing list indicated that this was to be a "bottom up" organization of working professionals across a wide range of social science data production, storage, and use sites—and not simply a "top down" organization of prominent social science faculty (UMIP 1974-12 Geda).

This grassroots emphasis was clear from Geda's list of tentative IASSIST task forces, which differed substantially from the list of Standing Committee task forces that Aiken had proposed a month before. Geda's task forces were designed to "improve the quality of research data, improve data archive and data library management and services, increase the amount of use and enhance the quality of the use of data for secondary analysis and aid communications among data archives people"—with "data archives people" broadly defined to include not just researchers, but students, policymakers, and especially, library professionals (UMIP 1974-10 Geda). In the end she proposed eight task forces, each charged with a particular technical deliverable (some more easily attainable than others) (1974-12 Geda C):

1. *Data Archive Registry*: "produce a directory containing the names, addresses, phone numbers, types of holding, dissemination policies, etc., of existing data archives and data libraries throughout the world"
2. *Data Archive Development:* prepare "a bibliography of all existing materials, including fugitive papers, on the establishment and administration of data archives and data libraries"
3. *Data Archive Policies:* "establish guidelines in such areas as acquisition, ownership, diffusion, dearchiving, and confidentiality"

4. *Data Documentation*: generate "minimum standards or guidelines of documentation, e.g., directories of holding, library catalog cards, data abstracts, and codebooks"
5. *Classification and Inventory*: "deal with major information schemes such as library cataloging and bibliographic information systems" to incorporate data sets into these tools
6. *Process Produced Data*: consider the "special problems inherent in the acquisition, documentation and use of data not initially collected for research purposes," such as US government census or budget data
7. *Professionalization of Data Archivists*: recommend best practices for "job descriptions, job titles, training programs, aptitude tests, etc., which relate to the functions people now perform or could perform in data archives or data libraries"
8. *Extension of Traditional Library Reference Services*: push to alter normal library practice "to include information available in machine-readable form"

Only one of these eight task forces, "Data Archive Development," matched Aiken's original list of topics more appropriate to social science researchers.

Besides sending this summary to everyone on the organizing committee (including her librarian colleagues Rowe and Robbin, as well as professors Aiken and Nasatir), Geda copied this initial sketch for IASSIST directly to European faculty Stein Rokkan and Erwin Scheuch at the Standing Committee. Rather than accepting Aiken's suggestion that IASSIST be woven into the existing task force structure of the Standing Committee, Geda left the question of affiliation open to discussion (even suggesting that "an appropriate library association" might be a better partner than the social scientists' group). She concluded by suggesting that the name IASSIST might be too closely tied to the social sciences—"too exclusive"—and invited input on alternatives (UMIP 1974-12 Geda).

Replies to Geda's outline for IASSIST rolled in during the early months of 1975. Nasatir responded that Geda had done "a splendid job of putting things together" (UMIP 1975-01-14 Nasatir to Geda). John McCarthy, the new head of the Berkeley International Data Library and Reference Service (from where David Nasatir had just stepped down), answered that "the idea […] is an excellent one," addressing "the need for greater communication between Data Archives and the people who run them." McCarthy even offered that "The problem is that at this point some archives are run by librarians, while others are run by professional social scientists" (UMIP 1975-01-02 McCarthy to Geda). The new director of the SSRC Survey Archive at the University of Essex, Ivor Crewe, replied "I am all in favour. […] International agreement on cataloguing conventions, the exchange of administrative and technical knowhow, the compilation of a register, minimum standards of data documentation etc all need to be done urgently" (UMIP 1975-02-26 Crewe to Geda). And Hesung Koh (Yale) agreed that: "unless there are efficient information intermediaries who can effectively explore and utilize these highly developed information systems and aid the users, it may become impossible for some researchers and practitioners to benefit from these complicated tools" (UMIP 1975-05-22 Koh to Adams).

Finances were the greatest limitation that the prospective organization faced. Geda lamented that even holding a meeting of the organizing committee would "require nearly $5000 in travel alone" given the international scope of the group. And as for a journal, "I think this is almost impossible. I'm told that a publisher expects a circulation of 1200 individuals at a minimum and an additional $5000" (UMIP 1975-01-08 Geda to Rowe). Questions like these forced Geda, Rowe, and Robbin to better clarify what IASSIST was designed to accomplish—as Robbin put it, "any organization exists to be more than a social agency for its membership," so "a principal reason for establishing this international organization is to solve problems" (UMIP 1975-01-08 Robbin). Robbin was unflinching in her assessment of how well the academic social scientists had done on solving those problems over the previous decade, through organizations like the Council: "Scholars of the international social science community have done an admirable job of delineating the problems. But, it is obvious that problems described by scholars of the research community more than 10 years ago are the same problems which archive/library personnel continue to face on a daily basis" (UMIP 1975-01-08 Robbin). Thus, funding for communication, whether through meetings or newsletters, was imperative if (in these pre-email days) such action was to be organized and carried out: "While scholars have had multiple mechanisms for expressing quite clearly their needs because their communication networks are well established, personnel of the repositories have had limited access to each other, largely because communication networks in the form of journals and organizations do not exist. In my opinion, the strongest raison d'etre for the establishment of an international organization composed of individuals and institutions engaged in data repository activities (taken in their broadest sense) is to organize a more rational and efficient means for dissemination of information" (UMIP 1975-01-08 Robbin). Thus a funding structure was created to maximize participation from information professionals, with individual dues set at only $15 (UMIP 1976-01 Rowe).

During this time Geda, Rowe, and Robbin faced considerable communication challenges themselves. They worked together at a distance to pull IASSIST together, from Michigan, Princeton, and Wisconsin. In turn, Geda relied more and more on advice from Nasatir as a friendly member of the academic social science community (UMIP 1975-01-10 Geda to Nasatir). Together, these four spent considerable effort discussing Scheuch's response to Geda's IASSIST outline, since he represented the official voice of the social scientists on the Standing Committee (UMIP 1975-01-08 Geda to Rowe). Scheuch did agree on the basic idea of IASSIST as "an independent organization based on individual membership," where people might "participate regardless of their place in official hierarchies." However, Scheuch saw IASSIST not as a network of professional experts coming together to solve long-standing data archive problems that social scientists had ignored but as a network of technical service providers coming together to better support the newest cooperative and comparative research schemes of the social scientists. Scheuch was blunt in this assessment; he felt that "Inter-archive cooperation as far as organizations are concerned appears to function satisfactorily," but that IASSIST task forces could be mobilized by the Standing Committee "for an integrated program of research"

(UMIP 1975-01-02 Scheuch to Geda). Scheuch's view was clear: IASSIST might be nice for its members, but it would never replace the agenda of the social scientists themselves.

Reaction from the IASSIST organizers was swift; Geda called it "our first confrontation," and Robbin urged a quick reply to Scheuch "so that he understands that we are not as naive as he thinks we are." Robbin's view was "it is clear that he wants to maintain the power in his group's hands" (UMIP 1975-01-10 Geda to Nasatir; UMIP 1975-01-13 Robbin to Geda and Rowe). Geda read Scheuch's response as a turf battle over funding: "Somehow, I feel that he has concluded that we are or will attempt to fund ourselves at his expense" (UMIP 1975-03-05 Geda to Nielsen). David Nasatir feared that this burgeoning split between the Standing Committee and IASSIST would be fatal; he wrote at the time, "Coordinating the needs of the international research community for machine readable social science data with the sources of such data and the repositories of it is a task that currently is not being accomplished, in part, due to potential conflicts between the partisans of IASSIST and those of the [Standing Committee]" (UMIP 1975-05-21 Nasatir to Adams). He agreed with Geda, though, that while Scheuch "acknowledges the basic reason for IASSIST […] to provide a basis for direct communication among practicing data archivists," Scheuch "fails, however, to pick up on the other major purpose—i.e. to provide a basis for professional identity, growth and recognition." He also agreed that "It simply isn't true that [the Standing Committee] can do what IASSIST proposes to do at the level it proposes." Thus Nasatir offered encouragement to the IASSIST organizers: "Shuech is afraid, and I think rightly so, that if IASSIST working groups get going, [the Standing Committee] will be shown up as the relatively do-nothing group that it has been." Nasatir advised Geda, "don't be put off by Erwin's letter. Rather, let's keep rolling with the effort to get IASSIST going as a stand alone organization—open to those who want it" (UMIP 1975-01-20 Nasatir to Geda).

After so much back-and-forth over the mail, an in-person meeting was necessary to finalize many of the ideas. Piggybacking on the annual gathering of the European Consortium for Political Research in London, Geda and Rowe pulled together as many of the IASSIST organizers as they could in April 1975. Many of the European archive leaders like Per Nielsen (Denmark), Cees Middendorp (Amsterdam), Philippe Laurent (Belgium), and Ivor Crewe (England) attended; however, rather than the contentious Erwin Scheuch of the ISSC Standing Committee, Stein Rokkan, at the time head of the ISSC himself, was there to give his blessing to the project, confirming that "informal relationships were quite satisfactory at this point and that [IASSIST] would work closely with the ISSC and [the Standing Committee]"—without having to harmonize each other's task forces under a single leadership (UMIP 1975-03-19 Rowe to Challener; UMIP 1975-08-01 Geda).

5.6 Setting a Metadata Labor Agenda

By September 1975, about a year after the idea had been hatched, the official IASSIST announcement was ready to go out to a mailing list of about 1000 prospects (over half of whom were in the United States) (UMIP 1975-08-01 Geda; UMIP 1975-10-02 Rowe). The pitch, for "an international association for individuals managing, operating, or utilizing machine-readable data archives, data libraries, and program libraries," included a several-page-long historical background, written by Robbin. Her summary located the start of the data archive movement with the 1957 manifesto from Stein Rokkan and York Lucci; called out the unique contribution of the Roper Center, Zentralarchiv, and ICPSR data archives; and even cited the value of the short-lived Council in the United States and the continuing Standing Committee in Europe. But most importantly, Robbin described the main challenge for SSDA success as the split between the academic world and the practitioner world, with academics interested in "analytic problems of the data base" and practitioners interested in "facilitated access to […] the data base." IASSIST was intended to address the latter problem, because "Although social science scholars had developed multiple mechanisms for expressing their needs through historically established communications networks, personnel of the data base repositories had limited access to each other" (UMIP 1975-07-08 Robbin to Rowe; UMIP 1975-09-01 Rowe). One of the main reasons for such a comprehensive announcement was to convince prospective members that IASSIST would not duplicate the mistakes (or inaction) of the now-defunct Council: "there is a group of people who will continue to invest their time to increase the membership, fulfill the objectives and see that it is sustained," wrote Geda (UMIP 1975-03-05 Geda to Nielsen). Another reason was to make clear that this new organization was open widely—as Rowe put it earlier that year, "First of all, our interests are not limited to survey data and second of all, we would hope to attract data library as well as data archive members" (UMIP 1975-03-18 Rowe to Geda).

One important aspect of the IASSIST proposal had changed over the 6 months of planning: the "task force" structure. The agenda for action moved away from the Standing Committee's academic priorities (like producing computational tools and harmonizing historical data across different countries) and toward the IASSIST professionals' more pragmatic, service-oriented priorities (like harmonizing classification, cataloging, indexing, and other metadata standards across data archives). Even the language changed: In March, Geda wrote that the term "Committees of Correspondence" should replace the term "task force," because "the [IASSIST] Committees will solve problems, not formulate policy" (UMIP 1975-03-05 Geda to Nielsen). Although this "Committees of Correspondence" language was used in the draft IASSIST constitution, it was finally replaced at the April 1975 meeting in London with the simpler and more direct term, "action group" (UMIP 1975-03-28 draft IASSIST constitution). And each "action group" was chartered with a specific published, deliverable product, since, as Geda put it, "If we could not readily conceptualize a relevant product, given restricted resources, we deleted the area from consideration" (UMIP 1975-08-01 Geda).

Not all of the original proposed topics for action groups made it into the final list. For example, the training function for information intermediaries had been the subject of not one but two of the initial IASSIST "task force" ideas—the "Professionalization of Data Archivists" group, which was to recommend best practices for "job descriptions, job titles, training programs, aptitude tests, etc., which relate to the functions people now perform or could perform in data archives or data libraries," and the "Extension of Traditional Library Reference Services" group, intended to push to alter normal library practice "to include information available in machine-readable form" (UMIP 1974-12 Geda). However, those two goals—the ones most important to the professional development of data librarians themselves—were dropped from the final list of six "action groups" that the IASSIST organizing committee (made up of both social scientists and academic researchers) eventually agreed upon. The final six action groups (and their chairs) were:

1. *Data Archive Registry* (David Nasatir, American University): create "A [machine-readable] directory containing names, addresses, types of holdings, and dissemination policies of existing data archives and libraries throughout the world will be compiled." This group argued that "the lack of a controlled vocabulary for descriptions of categories or holdings of data, was a major factor in the lack of good subject access to data archives" (IN 1:3 1977).
2. *Data Acquisition* (Donald Harrison, National Archives): "Recommended procedures for the acquisition of data would be developed with the intent of assisting researchers at critical points during the data collection process to ensure and promote the transfer of high quality data to the public domain for further academic investigation" (IN 1:1 1977).
3. *Data Documentation* (John Grasso, West Virginia University): "Standards will be developed for 'simple background variables' used in surveys, i.e., educational level, age, head of household, as well as constructs such as job satisfaction, anomia, political interest (i.e., to be measured by a scale or index). Thus, the work of this group will be closely linked to that which is going on regarding the development of social indicators. The codes will be incorporated into source books to provide researchers with a resource tool for coding and organizing their data consistently" (IN 1:1 1977).
4. *Classification* (Sue Dodd, University of North Carolina Chapel Hill): "the library cataloguing of machine-readable data files in public multi-media catalogues" (IN 1:1 1977). This was necessary because "there are no rules or a standard format for citing data in the published literature," making it impossible "to identify a data file, or its source, or data elements on which the published analysis has relied" (IN 1:2 1977).
5. *Process-Produced Data* (Michael Leavitt, Brookings Institution): This group would study government-produced data and "the merging of such data with data from sample surveys" (IN 1:1 1977). This group noted that "We developed a list-

ing of minimally required elements of information, which we hope each entry in a Catalogue of Data Files would provide" (IN 1:3 1977).

6. *Data Archive Development* (Alice Robbin, UW-Madison). Promised "A procedures manual consolidating current archival organizational, administrative, and personnel structures, procedures, and policies," as well as workshops "to provide professional training in the skills necessary for effective operation of a data library, data archive or social science information center" (IN 1:1 1977). This final action group was, in fact, meant to cover the area of the abandoned "Professionalization of Data Archivists" group. They would soon announce development of "A Guide to Providing Social Science Data Services" (IN 1:2 1977).

So out of the six action groups, half were chaired by academic social science researchers, and half were chaired by data archivists and data librarians (Robbin, Dodd, and Harrison). But one thing was clear: Each of the action groups was meant to address a clear metadata challenge that could only be achieved by drawing on the expertise of the archival and library professions.

5.7 "Off We Go!": From Action Groups to Mutual Assistance

With the action group agenda set, the new organization was finally launched—"OFF WE GO!" enthused Per Nielsen in November 1975 (UMIP 1975-11-07 Nielsen). "A series of lASSIST meetings were held on August 16-20, 1976, in conjunction with the International Political Science Association World Congress in Edinburgh, Scotland"; this is where IASSIST was formally established (IASSIST 1:1 1977 3). But the group still faced the daunting challenge of building, and sustaining, their new vision. The initial mailing only had a 20% response rate, which worked out to about 130 US members (UMIP 1975-11-26 Rowe; UMIP 1976-01 Rowe). As Per Neilsen wrote, "The main problem of the IASSIST will be that of finding people with an enthusiasm and energy which is far above normal standards!" (UMIP 1975-11-07 Nielsen). And from an international perspective, the group also faced challenges related to language, long distance communications (pre-email!), and travel costs.

The first IASSIST newsletter—twenty pages, hand typed with a do-it-yourself "zine" aesthetic—went out to members in 1977, almost 3 years after the original idea had been raised in Toronto. It proudly declared that IASSIST represented "an international cooperative effort on the part of individuals managing, operating or utilizing machine-readable data archives, data libraries and data services." In February, the group held its first North American meeting (in Cocoa Beach, Florida). By the time the second issue of the newsletter went out, the organizers could tout their first successes: "The United States response to the first IASSIST Newsletter has been very gratifying. Fifty people are already on the list of paid members and

22 attended the February conference." Individuals could become members for $15/year, sending payment directly to Judith Rowe at the Princeton University Computer Center (IN 1:1 1977; IN 1:1 1977).

But the origin story for IASSIST doesn't end with the first mailing and the first gathering. Through the end of the 1970s—a period of economic "stagflation," taxpayer revolts that cut funding to public agencies like libraries, and rapid technological development in both microcomputers and dial-up networking—IASSIST leaders and members worked to figure out how to bring their carefully designed plan into practice. The landscape for SSDAs by this time was still troubled in the United States and Europe. The newsletter *s s data* was in its last years of publication, starved for subscribers and frustrated with the lack of collaboration from even some of the largest SSDAs. (Subscriptions from IASSIST members would help it last until 1981.) And similar issues affected IASSIST's own membership; Per Nielsen, IASSIST co-chair, mentioned his own fundraising problems at his home institution, the Danish Data Archive: "In DDA, we are still fighting for our lives, and that fight takes a lot of time and energy; if we fail (i.e. get no funds or get conditions we can't accept) we shall be out of business as of April, 1977," he admitted (UMIP 1976-07-06 Nielsen to Robbin). In this fraught environment, IASSIST hoped it could help—but it also demanded significant time and effort among its leaders and members to do so.

The first order of business is following through on the promises of the "action groups." Through 1976 and 1977, progress on the US action group agenda varied—and several of the most crucial action groups effectively folded as their original leaders bailed out. In January 1977, David Nasatir, newly employed at California State College where he was now "without support for the activities germane to IASSIST," pled "Mea culpa!" revealing that "I have not kept up my end of the IASSIST activities, and, as a matter of fact, have done nothing in this regard since last August" (UMIP 1977-01-13 Nasatir to Rowe). Nasatir soon turned over leadership of the Data Archive Registry action group to Iowa's John Kolp, editor of the *s s data* journal (UMIP 1977-03-16 Nasatir to Rowe). But Kolp himself bailed out of the role less than a year later, noting that his own data laboratory at Iowa was under threat of budget elimination: "We are currently on a temporary budget from the University until the Dean makes a decision," and "the University will no longer support any conference trips for individuals in my type of position" (UMIP 1977-11-15 Kolp to Rowe).

The lack of follow-through on the action groups persisted as a problem for years—precisely because IASSIST was composed of both academics and professionals working to keep their own institutions (and careers) afloat in tough budget times; these same people unsurprisingly were forced to let the ambitious collaborative projects of IASSIST fall to the side in favor of local crises. In 1980, William Gammell of the Roper Center resigned as coordinator of the Data Organization and Management action group saying "the demands of my position—from helping develop proposals to making sure a user's dataset was copied correctly—are such that I can not do a good job as DOMAG Coordinator" (UMIP 1980-02-11 Gammell to Rowe). In the summer of 1983, the administrative committee reported that the Inventory of Data Archives and Libraries project "had been started several years ago, however it had not progressed very far" (UMIP 1983-05-18 IAC). Even IASSIST stalwart Alice Robbin fell short of her action group promises. By January 1977, Robbin's Data Archive Development group had produced a draft outline for "A Guide to Data Archive Organization, Management and Servicing" (UMIP 1977-01-05 Robbin to Rowe). But less than a year later in October 1977, she wrote to one of her action group colleagues that "I find it impossible to work 200%; thus, IASSIST has gone by the wayside, in terms of tangible output," and she decided to resign as coordinator of the Data Archive Development action group (UMIP 1977-10-06 Robbin to Ruus).

Writing decades later, Peggy Adams reflected that "Perhaps the best known and most influential product to emerge from the early IASSIST years was the Working Manual for Cataloging Machine-Readable Data Files, prepared by Sue A. Dodd, the U.S. chair of the Classification Action Group" (Adams 2007). However, this was a project that Dodd herself had already been engaged in for years—in a sense it was merely rebranded under the IASSIST banner. Her success, though, illustrates that none of the IASSIST action groups ever attempted to reproduce the failed "union catalog" effort of the Council from a decade before—nor was there a separate "data archive updates" group to try to take over from the now-defunct *s s data*. Arguably via the IASSIST social infrastructure, the community was able to achieve a standard for cataloging of data holdings in library catalogs. The process of discovering resources at the data archives would be handled through library catalogs: by bringing standardization to the metadata describing those archives' holdings (the Data Documentation and Classification groups) and then cataloging these, along with the data archives themselves (the Data Archive Registry group) in traditional library cataloging systems (which were themselves moving at that time to new online, networked infrastructures). And ensuring this all worked smoothly would be the responsibility of the two training groups—one for social science researchers themselves (the Data Acquisitions group) and one for the new data librarians who would be tasked to work with them (the Data Archive Development group). This was a classic library science response: create metadata standards, teach those metadata standards, and enforce those metadata standards in order to keep information circulating.

Yet no matter what the plan of the action groups may have been at the start, many founding IASSIST members—especially those with careers in librarianship—continued to push for professional development as a key focus of the new organization (the one focus that had been deleted from the initial list of six action groups). For example, in 1976, as one of the first official IASSIST-sponsored activities, Robbin, Rowe, and Geda organized a 2-week summer workshop on "Data Management, Data Library Activities, and Data User Services" at the ICPSR, which was a big departure from this SSDA's normal summer program offerings directed at social science faculty and graduate students. With 32 attendees, including "many individuals from 'traditional' libraries," Robbin reported that "the excellent response of the participants has led to the instituting of the Workshop as a permanent part of the ICPSR Summer Program" (UMIP 1976-09-20 Robbin). Sue Dodd wrote to Geda that such an ongoing workshop was a great idea: "I have spoken with three librarians recently […] who have inherited data from Political Science Departments or from one active faculty member, and which have now grown too large to be maintained by one person. […] I personally feel that librarians could be trained to handle data files and thus the workshop would be of tremendous value. I also feel that a background in the Social Science, plus some exposure to quantitative research methods is more important than a background in computer science" (UMIP 1976-05-07 Dodd to Geda). Soon such activities were officially folded back into the "Data Archive Development" action group, even splitting out a new action group specifically on "Data Organization and Management" which would focus on "better teaching tools, workshops, etc., to teach people appropriate techniques for data cleaning organization and management" (UMIP 1976-09-20 Rowe).

By the end of 1976, Alice Robbin was urging her IASSIST action group colleagues that their success on individual IASSIST projects would translate directly into greater status and visibility for their new profession as a whole. "I realize that for many years we have viewed this type of job as a temporary/ transient one, in which we spend a few years before we move on to another job. It is probably difficult for a number of us to think in terms of the professionalization of this area—but it has arrived. IASSIST was created as a communications mechanism for data services people, just as the American Sociological Association and American Political Science Association were created for the sociologists and political scientists. I hope you will consider yourself a member of this profession" (UMIP 1976-11-23 Robbin). So IASSIST seemed to be succeeding in its role of bringing together a correspondence network of data librarians and data archivists, especially in the United States—uniting the "information intermediaries" into a community of practice with a growing professional identity. But this success also drew IASSIST farther away from the social science researchers who initially supported it.

The heavy (and evidently unrealistic) workload that IASSIST had set for itself in its action groups motivated subtle changes in IASSIST's focus as it entered the 1980s. The founding documents had specified a 3-year term for group's president, so given a rough start date of 1976 for IASSIST when Geda began her time in the role, an election was held for a new president for the 1979–1982 period. Upon Alice Robbin's election as the new president of IASSIST, her administrative committee meeting of May 1979 detailed new ideas to address the "loss of direction in the action groups." The first change was to formally prioritize and improve the communication function—after all, the newsletter was the largest expense of the organization, and "the only visible manifestation of the association." The second change was to charter a subcommittee for "the maintenance of the present membership and the expansion of membership" (UMIP 1979-05-06 IAC). Action groups were still part of the IASSIST mission, but more as a way to attract members who were already engaged in productive activities that could be shared to a wider audience—especially with affordable but vibrant conferences. (This was the model of their one clearly successful action group, which had brought Sue Dodd's work under the IASSIST umbrella and given it wider exposure.) Wrote Robbin in July 1979, "We must think of some ways to improve the activities and participation of the IASSIST membership or this organization is going to go down the tubes. One conference a year is not enough to sustain an organization" (UMIP 1979-07-30 Robbin). So while action groups would nominally remain, IASSIST was going to concentrate more on reaching and representing its front-line data archive and library members, relying on its newsletter and conference to showcase and, hopefully, inspire real-world progress in data services.

This vision for IASSIST was lauded by Robbin in her October 1979 letter to the administrative committee, where she described the way IASSIST was seen by participants in a UNESCO-sponsored roundtable on social science information held at the University of Minnesota: "it appeared to all participants […] that IASSIST was one of the two organizations represented there who was actually doing something about social science information problems. We are unaffiliated with any government; we are composed of individuals; and we are working in the 'trenches' (to use a phrase that cropped up for two solid days) on a daily basis and are thus aware of the real problems. Finally, we are not hung up with beautiful policy recommendations, but concerned with implementation" (UMIP 1979-10-28 Robbin).

This pattern persisted into the 1980s, rounding out IASSIST's first decade as a professional association. The organization ran conferences every year—with the larger ones dutifully cycling between US, Canadian, and European locations, and smaller ones organized by local and regional data libraries as appropriate—always featuring a slate of hands-on training workshops (UMIP 1980-06-16 Robbin). In fact, the only substantive new venture to emerge once the original "action groups" fell away was a new "Standing Committee on Education" chartered "to develop, establish, and maintain educational programs and professional standards appropriate to those managing machine-readable data files" (UMIP 1980-11-10 IAC). Professional development of data archive staff remained a top priority in the 1989 IASSIST 5-year plan which included proposing a curriculum and running short courses (UMIP 1989-11-02 Future Directions report). These conferences and workshops ended up being both successful recruiting events for new members, and gentle moneymakers for the IASSIST treasury. Although proceedings of presentation articles and abstracts were assembled and published out of the 1980 and 1981 conferences, these products were eventually folded into the IASSIST newsletter—renamed as the more official-sounding "IASSIST Quarterly" in 1982 (UMIP 1982-10-13 IAC).

IASSIST was also making a conscious choice not to become a research-based society. Starting in 1980, they engaged in several years of negotiations with North Holland Press to create an "IASSIST journal" that would be called *Computers and the Social Sciences*—a companion to an already-existing journal called *Computers and the Humanities*. Judith Rowe had been in favor of this venture: "North Holland has done a marketing study and they think—in spite of our reservations about computing journals—there is a market for a single journal catering to the needs of producers, distributors, and users of data, software, systems, and hardware of interest to social scientists." She admitted, however, that it would take "some arm-twisting" to find enough authors among the IASSIST membership to fill such a journal, especially the debut issue: "We really need stars for those. After that we deal with our relatively small constituency, few of whom are motivated to publish" (UMIP 1980-06-11 Rowe). The journal idea was debated for a year but ultimately abandoned in favor of simply continuing the newly renamed "IASSIST Quarterly" (UMIP 1981-04-03 White). In this way, IASSIST was providing a professional outlet for reports on practitioner projects, but not a commitment to generalizable quantitative social science research. As their own membership committee put it in 1981, "IASSIST needs to have a working membership, working toward assisting one another" (UMIP 1981 IAR).

5.8 Conclusion: Success Through "Assisting One Another" in Metadata Labor

"Assisting one another" turned out to be the IASSIST goal that sustained the organization. Its 1989 5-year plan described the organization as "in a position to advance the interests of […] data professionals, promote professional development of this new career" (UMIP 1989-11-02 Future Directions report). In another example of its professional social infrastructure building function, IASSIST established awards that helped formalize the profession. The IASSIST Achievement Award which recognizes "contributions of an individual to the organization and to the profession" was first given out in 1990. In the proposal for the creation of the award explained, "the profession has matured during the past twenty-five years even to the point that people who have contributed much to [the] field or to IASSIST are beginning to retire" (UMIP 1990-05-29 IAC). Establishment of the award was a declaration that the field existed and that its most valued activities were not social science research projects, but the work involved in managing data, data libraries, and data archives.

IASSIST still survives today—with a Web presence at http://iassistdata.org—describing itself as "an international organization of professionals working in and with information technology and data services to support research and teaching in the social sciences" counting some 300 members "from a variety of workplaces, including data archives, statistical agencies, research centers, libraries, academic departments, government departments, and non-profit organizations" (http://iassistdata.org 2018-11-25). And founders Adams, Geda, Robbin, and Rowe continued to influence the field for years to come. (In a way, Alice Robbin even crossed over into the camp of the academic social science researchers, after earning her doctorate at UW-Madison in political science in 1984 and pursuing a second career as a professor.)

The founders' goal of building a far-flung and professional organization of information intermediaries, able to adapt to changes in computer and archival technology over the long term, was realized. IASSIST has persisted in its focus on social science data services, through the rise of the World Wide Web and the current excitement over "big data." For observers writing at the turn of the twenty-first century, the role of the "data librarian" in the knowledge ecosystem of data archives no longer needed to be explained and justified. It has a professional society with a standing conference, a standing journal and a career award. For example, University of Connecticut sociologist (and former data archivist) Richard C. Rockwell wrote "When ICPSR was formed over 30 years ago, it usually dealt with departments of political science and young professors in those departments. Since its formation, a new profession—that of data librarian—has arisen, and increasingly these professionals find their homes in libraries rather than in departments or research institutes" (Rockwell 1997).

Why did these information professionals spend so much time and effort, over so many years, building this professional organization, especially in the face of so much resistance from the very academic constituency which they were hoping to serve? The professional network building represented by IASSIST was certainly timely in the trajectory of library professionals transitioning into information experts along with the deployment of new technological infrastructures. This was a practice visible in other facets of library work where those with expertise in online communications and cataloging, or "machine-readable data," or even basic microcomputer application literacy, hoped for a path to upgrade their skills and status—as well as the status of their profession. And all of these efforts took place within a profoundly gendered division of labor, with service work gendered female and technological expertise gendered male (as it often still is today) (Downey 2010).

But something else was at work as well—something more fundamental to the demands of data reuse in the social sciences, where constant negotiation between different disciplines, different survey methodologies, and different policy agendas lurked behind every supposedly independent set of data cards and tapes, every variable and coverage entry in a data codebook. For these librarians to succeed as *social science data librarians*, they needed to constantly negotiate for access and information, constantly trade and produce and correct and cross-reference a myriad of metadata structures, constantly explain and train and justify their very position in the nexus between competing social science faculty, professionalizing social science graduate students, and changing technical services and computing colleagues. Coalition building, peer learning, and negotiated information exchange were built into the job of a social science data librarian in order to make the entire technological infrastructure work—even in the absence of an organization like IASSIST. Or, another way to put it, the social science data archive was itself a socio-technical knowledge infrastructure, depending as much on interpersonal trust and coordination as it did on computational hardware and record formats. Both the work that IASSIST members talked about and the work of keeping IASSIST running itself as a forum for those conversations were crucial forms of metadata labor within this socio-technical knowledge infrastructure.

Thus IASSIST's most important contribution in these early years may have been fostering an information infrastructure of expertise and learning that allowed data archivists and data librarians to better "assist" each other across a global geography fraught with disciplinary and institutional debates among the academic and national sponsors of the large-scale data archives. IASSIST, through its routines of regular meetings, interest groups and a publication, incubated and supported the human connections of information infrastructure by providing means of socialization and means of professional recognition and achievement in the field through leadership positions and organizational achievement awards. Through the 1980s, IASSIST only ever counted around 250 active, dues-paying members at a time (although more tended to attend their regular conferences and workshops, and the IASSIST Quarterly went out to about 400 different addresses) (UMIP 1988-05-25 IAC; UMIP 1990-06-02 IAG). Yet the impact of IASSIST stretched through the professional and social networks of all those working across the data archive and library landscape as it evolved through a key period of transition, from a still largely experimental practice of only the largest and most elite research universities and social science departments in the mid-1970s to an accepted facet of social science research and education at schools and colleges small and large at the end of the 1980s. As Robbin herself had written in 1975, "the data library/archive cannot, nor should not exist independent of other information centers. Rather, the data library should be viewed as one node in a data information network and the focus of members of the data library should be on the formalization of contacts with other nodes in the network" (Robbin 1975). Collectively, IASSIST was unable to realize much of its original hopes—it did not, for example, become a standards-setting body for all social science metadata, although many of the individuals involved with the development of IASSIST were also involved in early social science metadata work, and the IASSIST working group on codebook documentation and data cataloging helped foster the later DDI metadata standard. Yet IASSIST was a crucial sociotechnical knowledge infrastructure—in a pre-Web, pre-email world—for a new category of interdisciplinary "information intermediaries" who needed to negotiate a landscape of high-status academics who often knew much less about technology and metadata than they did. In this way, the IASSIST community produced and reproduced great value for its members. As one of them put it, "IASSIST has helped me develop a professional identity—it's nice to know that others are just as crazy" (UMIP 1980-02-11 Gammell to Rowe).

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For more on this project, see https://kreschen.wordpress.com/social-science-data-archives-history-and-sustainability/.

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Chapter 6
Gender Bias in Computing

Thomas J. Misa

Abstract This chapter examines the historical dimension of gender bias in the US computing workforce. It offers new quantitative data on the computing workforce prior to the availability of US Census data in the 1970s. Computer user groups (including SHARE, Inc., and the Mark IV software user group) are taken as a cross-section of the computing workforce. A novel method of gender analysis is developed to estimate women's and men's participation in computing beginning in the 1950s. The data presented here are consistent with well-known NSF statistics that show computer science undergraduate programs enrolling increasing numbers of women students during 1965–1985. These findings challenge the "making programming masculine" thesis and serve to correct the unrealistically high figures often cited for women's participation in early computer programming. Gender bias in computing today is traced not to 1960s professionalization but to cultural changes in the 1980s and beyond.

Keywords Gender issues · Computer user groups · SHARE, Inc. · Mark IV software package · Computer science · Computer programming · Grace Murray Hopper · Gender analysis · Computing profession · Computing workforce · Women in computing · IT workforce

Gender bias in computing is fundamentally a historical problem, and it persists into the present. Computing is distinctive among all the so-called STEM fields in that computing was actually more gender-balanced three decades ago in the 1980s than it is today. By many measures, women since the 1960s have slowly but surely gained proportional representation across the biological, physical, and social sciences and the diverse engineering fields. In most of these fields, women today hold a greater proportion of bachelor's, master's, and doctoral degrees, they form a greater

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proportion of faculty and researchers, and a greater share of the highly skilled technical workforce in the United States (as well as many of the technology-intensive economies of the wealthy countries of the world) than they did three or four decades ago. For this reason, advocates of women in the sciences such as historian Margaret Rossiter can point to significant progress for women in these fields, even if obstacles remain to women's full participation in the STEM fields.[1] Computing, however, does not fit this pattern.

Around 1960 computing resembled the other technical fields with low representation of women in the early white-collar computing workforce and low participation in the earliest computing undergraduate degree programs. But then something unusual happened. From 1965 to 1985, women gained an increasing proportion of undergraduate computer science degrees, one readily accessible if obviously incomplete measure of the emerging field, fully tripling across these years from around 12% to 37%. These 20 years witnessed great intellectual and institutional changes in the field of computer science and great expansion, but all the same, no other technical field in the post-1945 era of higher education experienced such swift growth in women's participation. Similarly, although the national statistics are incomplete, women experienced significant growth in participation and absolute numbers in the white-collar computing workforce. US Department of Labor Statistics compiled for the Standard Industrial Classification (SIC) indicate that women's participation in the computer *manufacturing* workforce increased from 27 to 31% during 1967–1974 and by the mid-1980s, women's participation in the white-collar computing workforce had risen all the way to 38%.[2] These impressive numbers were a powerful positive corrective to those in later decades who floated ill-advised suggestions that somehow women did not like computing or even, as Harvard's Larry Summers infamously put it, that "issues of intrinsic aptitude" made women ill-suited to careers in technical fields.[3] Obviously, since computing was at a certain moment nearly half women, these half-baked suggestions mostly fell flat.

Then in the mid-1980s came the second historically distinctive development in computing. Women's proportion of computer science undergraduate degrees in the United States peaked—and then started falling dramatically—with the numbers going down to around 15 or 20% by the early 2000s, depending on which statistics are consulted, and with women's absolute numbers falling steeply. Computer science degrees awarded to women during 1985–1995 fell by more than half from 14,431 to 7063, while those awarded to men dropped around a quarter from 24,690 to 17,706. Generally, women's share of master's degrees in computer science

[1] Rossiter (2012); see perceptive reviews by Toon (2012) and Tuchman (2013).

[2] Weber and Gilchrist (1975). For historical statistics, see Hayes (2010), 25–49. A valuable analysis of the IT workforce since 1970—including assessment of the evolving Census categories used to analyze it—is Beckhusen (2016). One mistake in this report, a consequence of its following the *decade-by-decade* Census data is that it does not pick up the *1985* peak, instead asserting (using data from 1970, 1980, 1990 et seq) that "The percentage of women working in IT occupations peaked in *1990* [emphasis added] at 31.0 percent."

[3] Jaschik (2005).

peaked in the mid-1980s at 30% and then held steady for 15 years, while women's share of doctoral degrees experienced slow if unsteady growth throughout the 1960s–2000s. In Rossiter's words, for undergraduate women there was a "collapse … in computer science … after 1985."[4] Computer science became something of a boy's club. Generally, during these years, the most prestigious computer science departments experienced precipitous drops in their enrollment of women,[5] but the trend existed across virtually all US computer science programs; and it has persisted so that today the proportion of women gaining undergraduate computer science degrees, apart from a few notable success stories, is near where it was in the 1960s.[6] Many of the OECD countries followed these US trends.[7]

This collapse in women's undergraduate enrollments in computing—computer science, information science, and similar computing-centered degree programs—has attracted a great deal of attention by the computing profession, the educational world, and policy actors.[8] And the problem is not at all confined to the United States. For 21 countries based on OECD data from 2001, researchers found substantial "male overrepresentation" across the board in undergraduate computing-degree programs ranging from a low of 1.79 in Turkey to a high of 6.42 in the Czech Republic; the United States was a middling 2.10, with these figures corrected for the underlying male/female enrollments in each country's higher education system.[9] It is modestly good news that women have not been further left behind with the current boom in computer science, as total undergraduate computer science majors are recently up by 300% (2006–2015). Still, as a recent analysis reminds us, "as previous enrollment surges [in the mid-1980s and early 2000s] waned, interest in com-

[4] Rossiter (2012), quote p. 41 (collapse). Compare Rossiter's graphs for computer science (figure 3.11) with other fields (figures 3.5 to 3.10). For computer science degrees, see Hill (1997).

[5] According to the well-respected CRA Taulbee survey of doctoral-granting departments, the low point in women's share of undergraduate computer science degrees was 11.2% in 2009. See data available at www.cra.org/resources/crn/, www.cra.org/resources/taulbee, and ncsesdata.nsf.gov/webcaspar/

[6] Carnegie Mellon, Harvey Mudd, and University of California–Berkeley are widely discussed recent success stories for women in undergraduate computer science. See McBride (2018).

[7] "An analysis of computer science shows a steady decrease in female graduates since 2000 that is particularly marked in high-income countries," reports UNESCO in "Women still a minority in engineering and computer science" (2015) at http://www.unesco.org/new/en/media-services/single-view/news/women_still_a_minority_in_engineering_and_computer_science/. See also Galpin (2002); Lie (1995); UNESCO (2015).

[8] It is essential to acknowledge that academic computer science is only one route, among many, to the computing workforce. Indeed, "most IT workers receive their formal education in fields other than computer science," according to Freeman and Aspray (1999), quote p. 17 at archive.cra.org/reports/wits/it_worker_shortage_book.pdf. The authors list no fewer than 20 "IT-related Academic Disciplines Offered in the United States" (table 2–1 on p. 28). Diverse computing disciplines—such as software engineering, computer engineering, computational science, information systems, information science, and others, in addition to computer science—contribute to the computing profession, in the view of Denning (1998).

[9] Charles and Bradley (2006), 183–203 on 190.

puting by females dropped more significantly than for males and has never recovered to previous levels."[10]

Even worse for the wider economy, the proportion of women in the skilled computing workforce in the United States also began *dropping* in the late 1980s, clearly indicating that the problem was not merely one in academic computer science. In the 2011 American Community Survey from the US Census, women constituted just 27% of the computing workforce, down more than 10% points from the mid-1980s peak—a decline by more than one fourth.[11] And despite composing 48% of the entire US workforce, women represent around half that share in the computing workforce; and since the computing workforce now accounts for fully 50% of the STEM workforce, women's underrepresentation in computing has wide ramifications.[12] In recent years, an avalanche of journalism has lamented the low participation of women in the tech workforce and documented the persistence of harrowing and offensive sexism.[13] Women are on the margins of technical jobs at top Silicon Valley companies, ranging, according to 2015 figures, from Apple (20% women), through Google and LinkedIn (both 17) and Facebook and Yahoo (both 15), down to Twitter (10%).[14] Men outnumber women 10:1 in Silicon Valley's executive positions and 40:1 in volume of venture-capital funding.[15] Uber's CEO Travis Kalanick became a demented poster child for endemic tech sexism, leading to his ouster in June 2017.[16] And even at image-conscious Google, there was the attention-grabbing internal memo asserting "the distribution of preferences and abilities of men and women differ in part due to biological causes" which (it was claimed) leads to women's low participation in tech jobs and tech leadership.[17]

As can readily be imagined, the magnitude of gender bias in computing has generated an immense and dauntingly diverse literature. There is alas no easy answer to the question "what caused" the dramatic fall in women's participation in computing, and a great many have offered suggestions about "what is to be done?" Policy actors, such as the National Science Foundation, the National Center for Women in

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[10] Roberts et al. (2018).

[11] One can acknowledge increases in the absolute numbers of women, since expansion in the IT workforce offsets declines in female participation. The US IT workforce was 781,000 in 1980, 1.5 million in 1990, 3.4 million in 2000, and 4.0 million in 2010, according to Beckhusen (2016) p. 2.

[12] Landivar (2013) on pp. 4, 6. With greater detail, the ACS table 3 reports women at 26.6% of the computing workforce, ranging across 12 subcategories from a high of 40.1% of database administrators to a low of 11.4% of computer network architects. The largest subcategory is software developers, comprising a full 11.8% of the entire STEM workforce, with 22.1% women. The AAUW's analysis of Census data reported women computer professionals in 11 sub-categories ranging from a high of 39% for web developers to a low of 7% for network architects (with database administrators at 32% women); see Corbett and Hill (2015).

[13] Evans (2014); Jason (2015); Mundy (2017); Benner (2017); Kolhatkar (2017); and Chang (2018).

[14] Smith (2014); for recent figures see Evans and Rangarajan (2017).

[15] Kosoff (2015); Zarya (2017).

[16] Fowler (2017); Isaac (2017).

[17] Conger (2017); Barnett and Rivers (2017).

Information Technology, the Anita Borg Institute for Women and Technology and its now-annual Grace Hopper Celebration of Women in Computing, the Alfred P. Sloan Foundation, as well as professional groups, such as the Computing Research Association's Committee on the Status of Women in Computing Research (CRA–W), and the Association for Computing Machinery's Committee on Women in Computing (ACM–W), have debated, proposed, and enacted numerous initiatives to correct women's underrepresentation.[18] These include attention to systemic issues in the computing curriculum, classroom culture, recruitment, and retention as well as more focused interventions such as peer programming. For their 2006 edited volume, *Women and Information Technology: Research on Underrepresentation*, Joanne McGrath Cohoon and William Aspray surveyed the voluminous social science literature and came to the sobering conclusion that "twenty-five years of interventions have not worked."[19] Recently Aspray published two Sloan-supported volumes narrating NSF's efforts at broadening participation in computing and describing the experiences of women, African-Americans, Hispanics, and Native Americans in the field.[20] While much of the literature focuses on the United States, there are suggestive case studies from around the world and three book-length treatments that pay sustained attention to Europe.[21]

Naturally, academic historians of computing have engaged the problem of gender bias. Historians Jennifer Light, Nathan Ensmenger, Janet Abbate, and Marie Hicks have each contributed to raising the visibility of women in early computing. The suggestion is even that early computer programming was dominated by women. In her well-cited *Technology and Culture* article, "When Computers Were Women," Light points to an idiom of sex typing that was pervasive during and after the Second World War—"designing [computer] hardware was a man's job; programming was a woman's job"—and goes on to describe "how the job of programmer, perceived in recent years as masculine work, originated as feminized clerical labor."[22] Women such as Grace Hopper, Jean Jennings, Frances Elizabeth Holberton, and dozens of others certainly were prominent in early computer programming. "The exact percentage of female programmers is difficult to pin down with any accuracy," writes Ensmenger in *Gender Codes*, "but … reliable contemporary observers suggest that it was [close] to 30 percent." Elsewhere he suggests women were as much as *50%* of computer programmers in the years before male-dominated professionalization and garden-variety sexism resulted in pushing them aside and "making programming masculine."[23] In a follow-on article, Ensmenger points to "the masculinization of computer programming" during the 1960s and early 1970s (note the years) that resulted in the distinctive, pervasive, and permanent masculine

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[18] Bix (2016).

[19] Cohoon and William (2006), quote p. ix.

[20] Aspray (2016a, b)

[21] Lie (2003); Misa (2010) and Schafer and Thierry (2015). Influential international studies include Vivian Anette Lagesen (2008); Mellström (2009) and Varma and Kapur (2015).

[22] Light (1999). An earlier article documenting this history was Barkley Fritz (1996).

[23] Ensmenger (2010b), quote p. 116. For the claim of 50%, see the unedited Ensmenger chapter at homes.soic.indiana.edu/nensmeng/files/ensmenger-gender.pdf (accessed January 2018) on p. 2.

culture in computing.[24] In a recent prize-winning book *Programming Inequality*, Hicks widens these observations to suggest that Britain lost its early lead in computing (its proto-computers for breaking the German wartime Enigma and Lorenz ciphers, although shrouded in secrecy, were foundational for the first stored-program digital computers at Manchester and Cambridge universities) because the country shunted its largely female computing workforce into dead-end jobs. Hicks specifically includes both highly skilled programmers and analysts as well as lower-skilled operators and technicians, reminding us that women up and down the status hierarchy made contributions to getting early computers to do useful work. Focusing more on "the upper echelon of the computing field," Janet Abbate's recent *Recoding Gender* is based on 52 interviews with eminent professional women in the United States and United Kingdom with the aim "to make visible some notable contributions by women."[25]

It is fascinating to watch the transformation of a historian's conjecture into the certainty of a widely circulated "meme" broadcast to the public by the Smithsonian, National Public Radio, and the *Wall Street Journal*.[26] It seems the conventional wisdom now is that while men dominated the hardware side, "computer programming was a women's field" and that "computer programming was a feminized occupation from its origins."[27] Historians' nuanced discussion of women in early computing was popularized by Walter Isaacson in his best-selling *The Innovators* (2014) and

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[24] Ensmenger (2015).

[25] Hicks (2017); Abbate (2012), quote p. 7. Corinna Schlombs explores the wider sense of "gender" not limited to women's history *per se* in Schlombs (2017). Like Hicks, Thomas Haigh includes both higher-and lower-skilled women in his analysis of the data processing workforce; see Haigh (2010). By comparison, my concerns are the higher-skilled or white-collar computing (or information technology) workforce. In 1970, the Census used 3 subcategories (computer programmers, computer systems analysts, and "all other" computer specialists), and by 2010 it used 12 subcategories; see Beckhusen (2016, 3–6.

[26] The claim of computer programming being, at any time, 50% women is thinly sourced. Ensmenger's source for the "reliable contemporary observers" claiming 30–50% women is Canning (1974). It is also the source—besides an incompletely cited article in the trade journal *Datamation* (1964) that is mis-attributed to sociologist Sherry Turkle—supporting his later claim (2015: quote p. 59) "in most corporations women represented at least 25–30% of all computer personnel" specifically not including the highly feminized computer and keypunch operators which, if they were included, "the representation of women would be even higher." Women are mentioned on two pages of the 1974 Canning article: a manager with IBM Federal Systems Division stated that, for one IBM programming group, "about one-half the programmers are women, and … the number of women managers is rising rapidly" (p. 2); and in a different context "a woman team member might in fact play the moderating role of 'mother'." (p. 5). Canning's quote that "the number of women managers is rising rapidly" is consistent with women entering the computing workforce in the 1970s and is obviously inconsistent with the counterfactual assertion that women were leaving computing in the 1970s.

[27] Quotes, respectively, from Rose Eveleth (2013), and Ensmenger (2015), p. 44. "Decades ago, it was women who pioneered computer programming," according to Laura Sydell (2014).

subsequently amplified by journalists, bloggers, and filmmakers.[28] Along the way, the numbers of women grew ever more impressive. "Between 30 and 50 percent of programmers were women in the 1950s," according to one oft-repeated meme.[29] It seemed (in another repeated meme) that "men's takeover of the field in the late 1960s [led to] an immense climb in pay and prestige."[30] "The decline in female programmers coincided with the professionalization of coding in the 1960s," writes the *Wall Street Journal*.[31]

I think the process that connects an academic conjecture to the certainty of Internet memes goes something like this. We ache for some comprehensible understanding to the origin of gender bias in computing. The notion that computer programming was born female and then made masculine, and that this history has passed straight down to the present day, seems plausible. It has the great attraction of a linear storyline or plot: the world was once some way (women dominated computer programming), then it changed (programming was made masculine), and that led directly to the present moment, where quite obviously men dominate computing. Ensmenger's claim of 30 or even 50% women in computer programming, launched in academic publications and available on the world wide web, gained a wide audience through his interview for a popular film "Code: Debugging the Gender Gap" (2015) done by Robin Hauser Reynolds.[32] This film then became the source for numerous confident assertions that "women made up 30 percent to 50 percent of all programmers."[33]

Only *one* of the three above widely publicized "memes" about women in early computing is plausibly true. Computer programming was a booming and lucrative field in the 1960s. The other claims are not well grounded. The commonly held view of computing women during these early decades leaves a lot to desire. Let's consider each of these assertions—before presenting this chapter's new data that corrects our understanding. Getting the history correct—when did women leave computing?—is essential to correctly perceiving the current problem of gender bias in computing.

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[28] For a critical review, see Haigh and Priestley (2015).

[29] O'Connor (2017). See additional citations in note 33.

[30] "What Programming's Past Reveals About Today's Gender-Pay Gap," *Atlantic Monthly* (September 2016) at www.theatlantic.com/business/archive/2016/09/what-programmings-past-reveals-about-todays-gender-pay-gap/498797/. "In the 1950s and '60s, employers began relying on aptitude tests and personality profiles that weeded out women by prioritizing stereotypically masculine traits and, increasingly, antisocialness," according to Little (2017).

[31] Mims (2017). In three paragraphs the logical inconsistency is revealed: "The decline in female programmers coincided with the professionalization of coding in the 1960s, writes computer historian Ensmenger (2010a). The proportion of women earning degrees in computer science peaked in 1984 at 37%" (emphasis added).

[32] See "Code: Debugging the Gender Gap," (2015) at https://www.codedoc.co/ and Cass (2015).

[33] "By the 1960s, women made up 30% to 50% of all programmers, according to Ensmenger" (specifically citing the film), states Porter (2014). "50 years ago, half of computer programmers were women," affording to Chang (2014). "Between 30 and 50% of programmers were women in the 1950s" according to Kapadia (2017). "Between 30 and 50% of programmers were women in the 1950s," repeats Rebel Girls on Facebook (8 June 2017) at www.facebook.com/rebelgirls/posts/1580025575364635. "In the 1950's, 30–50% of computer programmers were women," reiterates Shapiro (2017).

First, while women were clearly prominent in early computing and played critical roles in developing computer programming, it is inaccurate to claim that women composed half the professional or highly skilled members of the early field. Ground zero for our understanding of women in computing has been the "women of ENIAC," Grace Hopper, and their many women colleagues' remarkable achievements and unusual prominence. In 1949 at an international computing conference at Harvard University, there were 33 notable women who formed a who's who for women in computing, with high-level representation from Harvard, MIT, Raytheon, the US National Bureau of Standards, Census Bureau, and three military agencies, among other computing hotspots at the time. Mina Rees from the Office of Naval Research chaired a 3-hour session on "Recent Developments in Computing Machinery" with heavyweight contributions from Bell Telephone Laboratories, General Electric, Raytheon, Eckert-Mauchly Computer Company, Harvard, and MIT; but she was the *only woman* on the 4-day program. In addition to the 33 female attendees, there were 540 male attendees who can be identified, and so women comprised around 6% of the Harvard conference. This chapter analyzes new data from the 1950s through 1980s and estimates that women were roughly 15% of the computing field as it developed into a highly skilled and highly paid profession (see photograph Fig. 6.1).

Fig. 6.1 Harvard Mark 1 team in 1945. An image of computing as *16%* women (2 women in 13) with Lieutenant Grace Hopper in second row and computer operator Ruth Knowlton behind Commander Howard Aiken

Second, the oft-repeated suggestion that men staged a take over of computing sometime in the 1960s and pushed women aside is simply wrong. Women *did not leave* the computing field to men in the 1950s or 1960s or 1970s; quite the opposite. As noted above, women gained an *increasing* proportion of computer science bachelor's degrees between 1965 and 1985, and women formed an increasing proportion of the white-collar computing workforce through the 1980s. During the very years when the entrenched popular meme has it (incorrectly) that men were chasing women out of computing, women were actually flooding into computing.

Third, I believe that getting the history correct is necessary to properly understand gender bias in computing and the tech industry. In the 1950s and 1960s, women, notwithstanding their achievements in computing, were soundly outnumbered by men, as data in this chapter will demonstrate. Through the 1960s and 1970s, women's participation in computing was steadily *increasing*. Only in the 1980s did women's participation in computing began shrinking and, from then, lead to today's situation. We cannot understand present-day gender bias in computing as a product of 1960s sexism but rather need to understand the later developments of the 1980s.[34]

This chapter supports these three observations with newly collected data from the 1950s through 1980s. It first introduces a method developed at CBI to extract meaningful and systematic data on women in computing before 1970. It then discusses two prominent computer user groups whose records permit coverage of the years 1955–1989. This chapter is drawn from a larger book-length study on women in the computing industry.

6.1 New Data on Computing Women Before 1970

All data on large populations depend on statistical methods and proper sampling. For the 1970 US Census, a 20% sample of US households were asked about their occupations, and from this sample comes the figure of 22.5% women in the US computing workforce, widely cited as the first reliable figure.[35] Earlier censuses did not separately tabulate women in the computing workforce. I do not claim that my three data samples reported below, individually, are perfect. Nevertheless, as we shall shortly see, these varied samples do have the virtue of consistency: they

[34] In Ensmenger (2010b), Ensmenger cites instances of egregious sexism sourced from the trade journal *Datamation* (13 citations) from the 1960s. But he overlooks the changes in the 1970s and 1980s in computing's gender composition and the changed cultural climate in the computing industry and profession.

[35] Gilchrist and Weber (1974). In turn, the Census figure of 22.5% women is consistent with a 600,000-person salary survey done in 1971 by *Business Automation* which found "women made up 14% of systems analysts and 21% of computer programmers," according to Haigh (2010), quote p. 64.

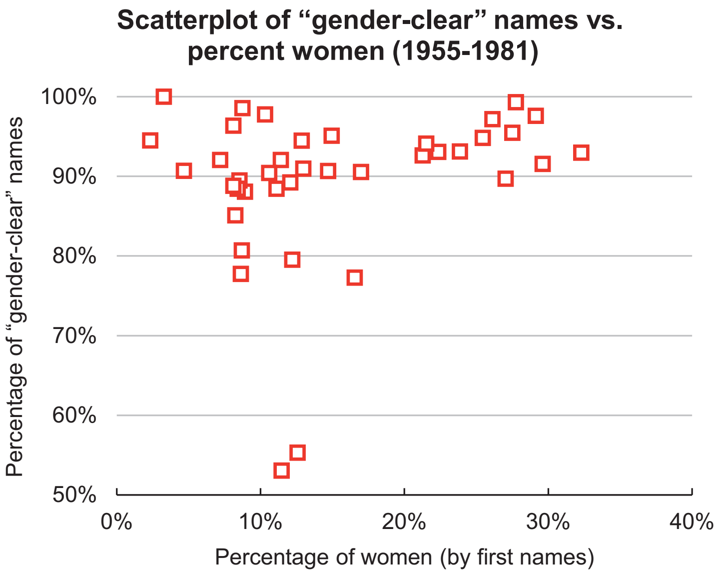
indicate a reliable pattern that suggests computing women were around 5% of the field in the 1950s and then increased to roughly 15% by the 1960s and continued rising into the 1980s. I next discuss the research method used to create this new data series.

Computing conferences, professional societies, and user groups prepared attendee and member lists that are now available in their organizational archives. Many of these lists included both first (given) and last (family) names. On a suggestion by CBI's Jeffrey Yost, and after refinement by William Vogel, I examined CBI's set of user group archival records with a sizable sample reported here.[36] It's a simple matter to count the number of Margaret, Betty, Mary, and Dorothy's in these lists and tally against the number of William, George, Robert, and Edward's. To resolve cases of initials-only attendees, one can look for the gender-revealing first names often given in accompanying documentation; explicit references to "Mr" or "Mrs" or "Miss" can resolve gender-ambiguous first names and initials. What is more, the Social Security Administration published thousands of the most-common first names—ranked by frequency of their use and identified by gender—year-by-year beginning in 1880.[37] Names change. Whereas "Robin" was a gender-ambiguous name for people born in 1930 (7:5 male) and becomes a woman's name by 1960 (10:1 female), "Leslie" actually changes gender between 1930 (9:1 male) and 1960 (3:1 female). The short name "Pat" remains gender-ambiguous throughout. In this way, instances of most US names can be resolved with historical accuracy.[38] Persons with initials-only or gender-ambiguous names were sometimes resolved by "linking" the specific person to gender-clear identifications in other meetings or publications or oral histories. Overall, as the scatterplot indicates, typically 80–100% of individuals in this data set can be clearly identified by gender, even as the percentage of women varied from around 3 to just over 30%. The two low-ball figures (just over 50% gender-clear names) are discussed below.

[36] Vogel (2017). I have done preliminary analysis also of data from early computer conferences and membership lists (1948–1955) and two other user groups.

[37] See data at www.ssa.gov/OACT/babynames/limits.html. The dataset is elsewhere described as "a 100% sample of Social Security card applications after 1879" (trimmed to suppress first names with fewer than 5 instances); see https://catalog.data.gov/dataset/baby-names-from-social-security-card-applications-national-level-data

[38] I verified this method with a list of 228 women who gained PhD's in math before 1940, scoring 223 correctly as female, 0 incorrectly as male, and 5 or 6 gender-ambiguous names (Wealthy, Shu Ting, Abba, Andrewa, Echo, Bird). SSA's 1900 year-of-birth data does not list these 5 names nor "Bird"; its 1880 data identifies "Bird" as female. See Green and LaDuke (2009).



For each computer user group list, I computed the percentage of women in the (gender-identified) total of men and women and have plotted as time series these percentages along with the total size of the user group meeting in the graphs below. For the percentages, both the numerators and denominators set aside the gender-ambiguous “Pat’s” and initials-only attendees, if they could not be resolved, while the total size includes all attendees for each meeting. This data on women in early professional computing gives insight into computing’s gender balance in the decades before the government statistics are available.

6.2 Data from IBM User Group SHARE

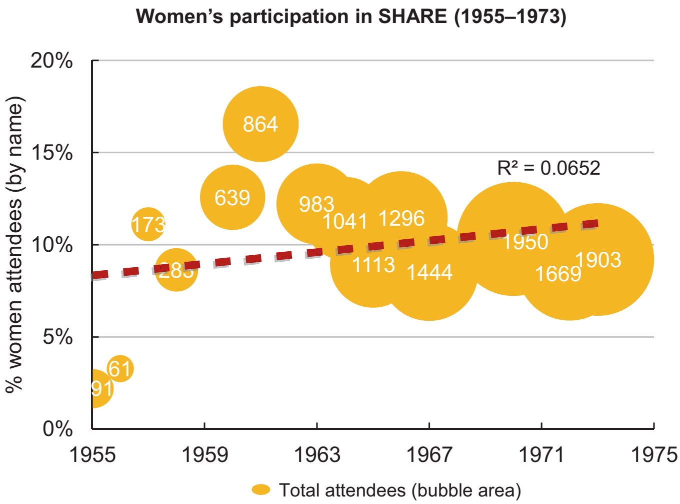
The computer industry’s prominent user groups began in 1955 with the organizational users of IBM and UNIVAC computers, initially centered in southern California’s aerospace industry, with major computing efforts at Ramo-Woodridge, Douglas Aircraft, Hughes Aircraft, Lockheed Aircraft, North American Aviation, and RAND. The founding meetings of SHARE and USE, both in 1955, were held at RAND and Ramo-Woodridge, respectively; and both user groups quickly attracted nationwide participation. These included government facilities at Los Alamos, Livermore, the National Security Agency, and the Census Bureau; Boeing Airplane in Seattle; corporations such as General Electric and General Motors; east coast aviation companies Curtiss-Wright and United Aircraft (a spin-off from Boeing); and other users of these large-scale machines. Since SHARE meetings included representatives of computer users and the computer manufacturer IBM, the user group data sheds light on both computer users' and manufacturers' employment of women. By the early 1970s, nearly two thousand people attended SHARE's twice-yearly meetings. The IBM user group SHARE has been profiled in articles by Atsushi Akera and by Jeffrey Yost.[39]

Attendance lists from SHARE show that it was dominated by men, especially in its first few years. Within 2 years of its founding, SHARE began a durable practice of organizing two large meetings a year. In its first months, however, there were organizational meetings in different parts of the country. I made a composite from the first three meetings in 1955; the very first such meeting had no women at all but then one woman attended each of the next two. The 1956 data point represents one regular meeting so its attendance appears anomalously lower. Participating organizations sent to SHARE their managers as well as their rank-and-file with attendees from such positions as manager, group supervisor, analyst, systems programmer, applications programmer, and catch-all "other." For 1 year (where this data was available), systems programmers were the largest single category followed by managers, "other," analysts, and group supervisors.[40]

One measure of IBM's success in the computer marketplace was SHARE's large and increasing size. In the late 1960s when the Univac user group had around 300 members at its meetings, SHARE was 4 or 5 times larger, and it grew to nearly 2000 attendees by 1970. IBM soundly dominated mainframe computing during these decades, and there is every reason to think that SHARE's membership was a representative sample of computer users across the country and (in time) around the industrial world. It seems unlikely that SHARE attendance data would be at odds with the wider field of computer programming (hypothetically) being fully 30–50% women in the 1950s and falling in the 1960s with (supposedly) "men's takeover of the field." Instead, the SHARE data supports quite the opposite. After the first few years, women consistently made up 8–16% of SHARE attendees with a rough "trend line" increasing from 9 to 12%. (With such a low R^2 value, it's unlikely there is any statistical significance.) The highest SHARE attendee level at 16.5% women is roughly half the hypothesized 30%.

[39] Akera (2001); Yost (2015). For background, see Watt (1975).

[40] SHARE *Proceedings* 41 (13–17 August 1973): 1:37 (tabulation of position). Of the total registration of 1714, the positions were tabulated as manager (429), group supervisor (193), analyst (205), systems programmer (518), applications programmer (73), operations (19), and "other" (277).



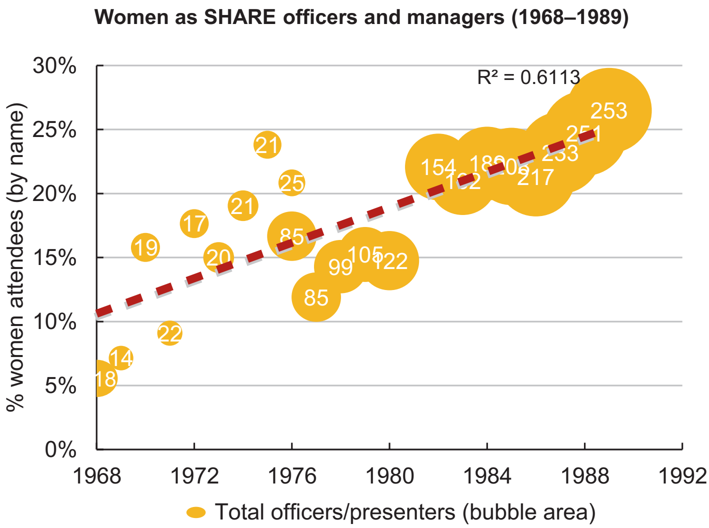
SHARE's continual growth provoked logistical challenges. Its meetings became immensely complicated to organize, and its semiannual *Proceedings* volumes became larger and fatter. The professional staff in SHARE's Chicago headquarters expanded to keep pace. With its publication costs "skyrocketing," SHARE shifted in the mid-1970s from printing and mailing three thick paperback volumes after each (semiannual) meeting to instead publishing just two volumes per meeting, with a physical "volume 1" profiling the talks and presentations deemed of general interest to SHARE members, while "volume 2" became a catch-all repository for the rest, eventually totaling a whopping 15,000 two-column pages on microfiche.[41] The attendance records became unmanageable, too; March 1973 was the last meeting where first names are available for all attendees. The printed attendance records then permanently switched to initials-only, symbolizing a shift from a first-name-basis community to a larger and more impersonal society.

To extend a statistical view beyond 1973, we can examine the first-name listings of SHARE's officers. SHARE was run by around 20 volunteer officers until 1976, when in the middle of that year, its officer corps more than tripled to 85. The organization had originally been organized around "projects" such as compilers and time-sharing and a few years earlier had already adopted a "divisional structure" with a small phalanx of "managers" responsible for various technical areas and managerial concerns. In 1976 the organization added legions of sub-managers for these evolving areas so that by the late 1980s, there were 250 officer-managers responsible for the organization's six divisions: SHARE-wide activities, Applications Architecture and Data Systems, Communications, Graphics and Integrated Systems, Management, and Operating Systems Support. Possibly with an eye to making its officers and man-

[41] For explicit discussion of publication costs, see SHARE *Proceedings* 42 (4–8 March 1974), 3:1671 (skyrocketing).

agers readily identifiable by rank-and-file members, SHARE published their complete first and last names and featured them prominently in the physical volume 1.

Women's participation in SHARE leadership was substantial and growing throughout these years. Shirley F. Prutch from Martin-Marietta Data Systems became SHARE president in 1974, which led to some good-natured ribbing about her "coronation as the first Queen of SHARE" and, owing to her energetic leadership, the retitling of SHARE as "Shirley Has Aided in Rejuvenation of Everyone."[42] Prutch was rising through the executive ranks in Martin-Marietta and in the mid-1980s became divisional vice president for systems integration and also chair of a National Bureau of Standards panel on computer sciences and technology.[43] SHARE provided a valuable space for discussion about women flooding into computing.[44] Even before the 1976 expansion, women comprised generally 10–20% of SHARE's officers and managers and then rose to 26% by 1989.



The long-term growth of women in SHARE leadership—the trend line for officer-managers during 1968–1989 goes from roughly 10% to just over 25% with an R^2 value of 0.61 (moderate correlation)—is entirely consistent with the nationwide statistics on women's increasing proportion of computer science bachelor's degrees and women's increasing participation in the white-collar computing workforce. It is, of course, inconsistent with the notion of programming being fully 50% women or, especially, men staging some takeover of the field in the 1960s or 1970s.

[42] SHARE *Proceedings* 43 (26–30 August 1974), volume 3:1622–26 on 1624 (queen) and 1625 (rejuvenation).

[43] "Manufacturing," *Washington Post* (11 February 1985) at https://www.washingtonpost.com/archive/business/1985/02/11/manufacturing/41c52850-91d1-4e84-9d4c-f79aa8d27308/; "Executive Corner" *Computerworld* (9 January 1984): 81; White (1992).

[44] See SHARE *Proceedings* 43 (26–30 August 1974), 3:162.

6.3 Data from Mark IV Software User Group

What became the "Mark IV" software package had its origins in aerospace computing and the go-go years of the software products industry in the 1960s. To tell a long story short, a 1962 spin-off from aerospace giant TRW (Thompson Ramo Wooldridge) called Informatics bought the software package's corporate owner and signed up its original designer who aimed a major new product, so-called Mark IV, at the brand-new IBM System/360. Informatics was led by Walter Bauer and Frank Wagner, and both had been aerospace company executives and user group leaders, respectively, in USE and SHARE. Mark IV enhanced the popular line of IBM 360s by offering to users structured forms that permitted "file creation, file maintenance, selection, extraction, processing, creating output files, sorting, and reporting," what we understand today as database management. Its sales really took off after IBM announced in 1969 that it would no longer "bundle" its software and hardware, neatly creating an open market that Mark IV stepped into squarely. In short order it smashed sales records right and left, eventually racking up an astounding $100 million in cumulative sales.[45]

Also in 1969 was the inaugural meeting for the Mark IV user group, sometimes labeled as the "Ivy League." Its female attendees included one "C. Ching" from Standard Oil of California. Later explicitly identified as Carol Ching, she was featured in an 1969 advertisement in the trade journal *Datamation* notable for positively valuing women as computer programmers. Ampex was selling its magnetic tape, and the ad was formed around a personal image of her with the tag line "when programmer Carol Ching ignores our tape, we know we're doing our job." In an era when advertisements were sometimes soaked in "Mad Men" style sexism, this matter-of-fact invoking of a female programmer was a sign that the culture of computing was changing.[46] And it was changing *not* to drive women out of the field, but rather recognizing that women were entering the field in increasing numbers. On the Mark IV data from 1969 to 1981, women increased from somewhat under 10% to just over 30% of the user group attendees; and the R^2 value of 0.94 suggests reasonable significance for the trend line showing this increase. The 1981 figure of 32% is the first (and only) time in this dataset that women's participation topped 30%.

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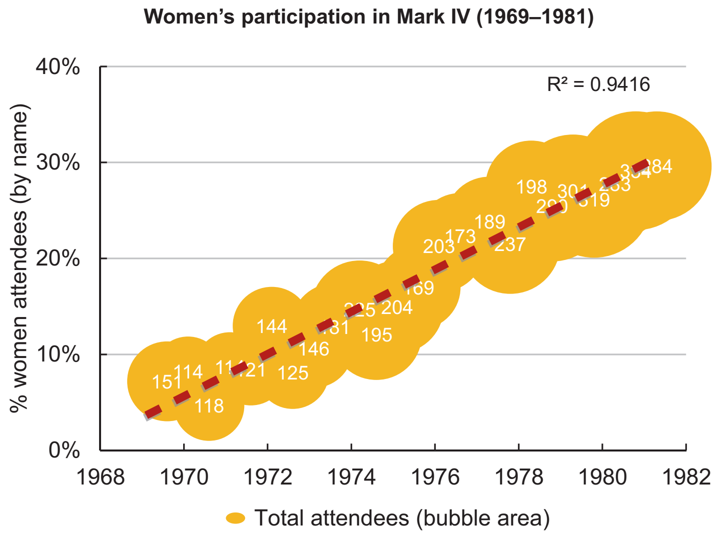
[45] Canning (1968), quote p. 2 (Mark IV description); Campbell-Kelly (2003).

[46] Vogel (2017) on 52. An image of Carol Ching from 1970 appears in Spicer (2016) on 38. "Not until around 1970 does any explicit discussion of sexism or the need to examine and redefine gender assumptions appear in the data processing literature," notes Haigh (2010), quote p. 63.



6.4 Were Women Hidden Somewhere?

Given this new data on women in the computing workforce, one of two things must be true: either there are thousands of women somehow "missing" from this data set or we must revise the common (but incorrect) image of women's numerical dominance in early computing as well as the (also mistaken) "takeover by men" of the field in the 1960s or 1970s. I believe it's the commonplace "memes," discussed in this chapter's introduction, that need revising. All the same, let's examine some possible weaknesses in the dataset.

I approached this data originally thinking that women *might* prefer to be known by their initials rather than by their gender-identifying first name. Several prominent computing women were widely known by traditional men's names, such as Stephanie "Steve" Shirley and Elizabeth "Jake" Feinler, who, respectively, founded an early woman-dominated software company (in 1962) and directed the Arpanet–Internet's Network Information Systems Center that created the top-level domain names such as .edu, .gov, .org, and .com.[47] Perhaps women preferred to be known by their gender-ambiguous initials and family names? With more than 15,000 names from SHARE alone, we have some data to consider.

There is little evidence that women in this dataset preferentially used initials or otherwise disguised their given first names. After "resolving" hundreds of initial-only names, it dawned on me that the balance of (resolved) women's and men's names were in proportion to the underlying balance of women and men. Where

[47] Feinler (2011).

women were (say) 10%, it was roughly one in 10 initials-only names that could be identified as a woman; and where women were larger or smaller in the sample population, the pattern was roughly the same. Indeed, in successive years, the same person might be listed as C. Ching or E.A.S. Clark in 1 year and as Carol Ching and Anne Clark in the next. I can detect in this data no overarching "preference" expressed by women to use, or not use, initials for whatever reason. In name lists from the 1950s, typescript was common, and by the 1960s, computer printouts and then laser-printed sheets were the chosen means. At a certain moment when the registration lists became truly immense, as with SHARE's nearly 2000 attendees, the easily formatted "initials-only" names might have looked cleaner or neater to the conference organizers. Either way, the use of initials does not seem a mechanism to hide women.

Another line of evidence suggesting that women were neither disproportionately hidden nor for that matter revealed by use of "initials only" comes from closer examination of the SHARE rosters. In his analysis, Will Vogel observed that the proportion of women in SHARE meetings stayed consistent even when successive meetings varied widely in the use of initials-only attendance lists. For instance, for 3 years during 1958–1961, the prevalence of initials-only in the registration lists nearly doubled from 24 to 47 and then fell back to 22%, while the proportion of women in the gender-identified sample grew steadily from 9 to 15% (with an intermediate value of 13% when nearly half the meeting roster was initials-only). Even more dramatically, in four sample years during 1966–1972, the prevalence of initials-only was as high as 48% and as low as 0.6% (in 1970), while the proportion of women in the gender-identified sample was steady around 8%—with actual year-by-year numbers of 8.5, 7.5, 8.6, and 8.4%.[48] (See the two low-ball data points in the scatterplot above.) Surely if, hypothetically, hundreds of women were hidden behind initials-only names, they would have been revealed in 1970.

6.5 Concluding Thoughts

Two conclusions seem reasonable based on the data presented in this chapter. First, the dataset on user groups is consistent with the 1970 census tabulation of women as 22.5% of the computing workforce. It's not surprising that SHARE, the largest such user group, is reasonably close to the Census's estimate (which recall is itself a *sample*). Women in the Mark IV user group passed 22.5% in the mid-1970s and reached just over 30% by the early 1980s, near the peak of women's share of

[48] Vogel (2015). Vogel's numbers are slightly different from the ones I report in this chapter; he and I found the same amount of women, but I tended to "resolve" more initials-only and gender-ambiguous names (using the SSA data). I also used standard statistical sampling (confidence level 95%, p 0.5, error 0.05) when the meetings grew larger than 800 (from 1961), while he tallied *all* SHARE attendees (up to 1950 names).

employment in the computing industry. Still, it must be allowed that the user group data samples might undercount women in the wider computing workforce since it's possible that more men than women from the membership organizations actually attended the user group meetings (see tabulation of "positions" discussed above). This is one possible source of systemic bias that is not easily resolved, in the absence before 1970 of comprehensive firm-level or nationwide data on computing women. Second, across the graphs in this chapter, women were an *increasing* portion of the computing workforce beginning in the 1960s and continuing through the late 1980s. There is no evidence from this data that men were staging a takeover of computer programming in the 1950s, 1960s, or 1970s.

This chapter provides new data on the computing workforce suggesting that women were a prominent but relatively small proportion of the skilled computing workforce in the 1950s and 1960s. In these years, I think it is more likely that women were around 15% of the skilled computing workforce than the 30–50% that is now widely accepted. A figure of roughly 15% women is consistent with trade literature and professional publications, images in technical and popular media, dozens of archival photographs, and periodic salary surveys of the computing workforce.[49] The data in this chapter strongly supports that women were an *increasing* proportion of the skilled computing workforce beginning in the mid-1950s through to the peak in the mid-1980s. The data is entirely inconsistent with any suggestion of a male "takeover" of computing sometime in these decades. To repeat the obvious, women were flooding into computing during these years—not being chased out. I have also suggested why the inaccurate but possibly comforting image of the male takeover, and its connection to a "linear storyline," has taken hold of our imagination.

The chapter has one longer-term implication for understanding gender bias in computing today. If, hypothetically, men staged a takeover in the 1950s or 1960s with the aim of raising the status of the computing profession by ridding it of lower-status women—such "feminization" is discussed in the sociological literature[50]—the clear implication is that gender bias and sexism were "baked into" the computing profession during the years that it was forming. Ridding a profession of such core values might be difficult indeed. But this data supports a different viewpoint entirely: it suggests that gender bias is not a foundational or core value of computing professionals, since computing as a profession took form during the years when women were flooding into computer science and the skilled computing workforce. The problem of gender bias in computing today is not to be located in the 1960s sexism but the more recent cultural and social dynamics of the mid-1980s. Further research is needed on why women entered the computing profession and skilled workforce, what their experiences were during those years of expanding educational and workforce opportunities, and how the more complex subsequent history bears on the current problem of gender bias in computing.

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[49] In its 1960 salary survey the trade journal *Business Automation* found "Less than 15% of the [computer] programmers reported were women," quoted in Haigh (2010), p. 54.

[50] See Strom (1987); Wright and Jacobs (1994); and Hicks (2010).

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Chapter 7
An Archetype for Outsiders in Technology Commercialization

Shane Greenstein

Abstract This chapter presents an archetype of confrontations that highlights the distinctive perspective of an outsider. In this archetype *insider* refers to an established leading firm in a specific market, while *outsiders* are startups or historical nonparticipants in the insider's market. The chapter interprets events as a conflict between the outsider's novel point of view and the insider's established point of view. To support this interpretation, the chapter examines numerous illustrations involving prominent firms, such as Microsoft, IBM, Britannica, Intel, Apple, Dell, and others, and events related to the determination of technological leadership in a market. The chapter stresses the factors that ease entry, such as perceptions of sclerotic behavior from an insider, and the origins of the outsider that lead to surprises. The chapter also examines the factors that lead insiders to imitate outsiders by quickly changing their plans (or not) and by quickly altering their investment priorities (or not). The discussion stresses the mechanisms that slow down response and potentially reduce the seeming advantages of incumbency.

Keywords Creative destruction · Value creation · Cognitive frames · Disruption · Technological competition · Commercialization · Insiders · Outsiders

7.1 Introduction

Many confrontations between insiders and outsiders have garnered attention in technology markets over several decades. What can we learn from these prominent confrontations? Is there anything common to them? This chapter presents an archetype of confrontations that highlights the distinctive perspective of an outsider. In this archetype *insider* refers to an established leading firm in a specific market, while *outsiders* are startups or historical nonparticipants in the insider's market. The chapter interprets events as a conflict between the outsider's novel point of view and

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the insider's established point of view. To support this interpretation, the chapter examines numerous illustrations. In each, the outsider takes actions to gain customers, which leads to a reaction from the established firm.

The archetype directs attention toward commercialization, the act of translating technical knowledge into valuable products and services, hereafter referred to as *product(s)*. In this context *valuable* or *value* refers to market value, such as the price of a product and the profits of a firm, while *commercialization* is the less glamorous sibling to invention that translates inventions into value. Here the spotlight of inquiry focuses on the range of activities affiliated with designing the product's attributes, as well as producing and distributing it—that is, offering it for sale, competing with others for buyer attention, and doing this at scale. Though outsiders and insiders differ in their points of view, they both must perform similar activities, namely, bringing their product to market. In both firms, management and employees must plan operations and distribution, execute those plans, and improve their execution by learning from experience.

The archetype contains two broad stages—specifically, *entry* for the first stage and *confrontation* for the second. The first stage focuses on an entrant aspiring to confront the insider's leading position. The entrant is an outsider, by definition, because it has adopted a distinctive point of view about how to create value around a certain product. In this chapter, we examine the differing points of view between insiders and outsiders regarding how their operations can support the marketing of the product to achieve success. During the entry phase, the outsider goes through a period of "experimenting," namely, developing a commercial approach along its point of view, resolving open questions about how to tailor its approach to technical limits, operational requirements, and features users find desirable. Its view may remain hidden or unrevealed to the insider for a time. Meanwhile, the insider has its own marketing strategy and point of view—sometimes not even foreseeing the potential for the product the insider is developing.

The second stage, confrontation, focuses on the reaction of the insider. During this second stage, the established firm and the outsider *both* "experiment" in the marketplace (Rosenberg 1992)—in the same sense as just described, plus a bit more. Each firm attempts to learn about open-ended questions regarding the value of features of demand, operations, and ways of organizing commercial actions. They also may imitate each other's experiments and learn from each other's lessons. The archetype focuses attention on this competitive interplay between two rivals with distinct points of view and emphasizes the links between that confrontation and the ways in which the confrontation emerges.

Confrontations between insider and outsider are uninteresting when an entrants' viewpoint leads to products that lack appeal with customers. Accordingly, the archetype spends its time analyzing situations where the outsider's ideas do have some merit and leads the outsider to confront the insider in the second stage. For similar reasons, in comparison to the outsider's novel view, the archetype focuses on insiders who either (a) misestimate demand for major products that use the new technology or (b) misunderstand how to employ new technology while supplying goods. In all cases, errors in estimating and understanding will go unappreciated by the insider until after the outsider enters the market with a distributed good. In this sense outsiders "surprise" insiders, and their novel point of view generates competitive pressures, thereby motivating the insiders to act in ways they otherwise would not have. To overstate it somewhat, in the archetype outsiders are an agent of change, either by "unexpectedly" creating value for customers or relatedly, by motivating insiders to respond in ways that end up creating value.

What factors contribute to generating healthy competitive interplay between outsider and insider? The first part of the chapter stresses the factors that ease entry, such as the lower costs of specialization, the prevalence of open governance, and the gains and challenges of outsiders partnering with insiders. Perceptions of sclerotic behavior from an insider—due to organizational inertia or strategic paralysis or merely persistent misperception of opportunity—also make the competitive situation more attractive for outsiders. The origins of the outsider also play a role in fostering surprise—whether the outsider comes to the setting with experience from another market or a university or whether it arrives as part of a wave of entrants. The next parts of the chapter offer an inductive approach to supporting the archetype. The discussion draws heavily on many known events. It features prominent firms, such as Microsoft, IBM, Britannica, Intel, Apple, Dell, and others, drawing from events that often receive some notice in the business news before disappearing into conversations inside organizational boundaries. This part of the discussion develops several themes around organizational inertia, examining the factors that lead insiders to imitate outsiders by quickly changing their plans (or not) and by quickly altering their investment priorities (or not). The discussion stresses the mechanisms that slow down response and potentially misdirect in ways that reduce the seeming advantages of incumbency.

The archetype is suited to recent events in technology markets in which dispersed technical leadership shapes supply conditions (see, e.g., Ozcan and Greenstein 2018, Bresnahan and Greenstein 1999). Many firms, both startups and established firms, have access to scientific knowledge, frontier technical tools, and essential engineering talent. Both rely on the same providers of servers, standardized software, and cloud contractors. Both employ commodity suppliers and contract manufacturers, and both get key inputs from contract labor for frontier programming. That reduces differences between outsiders and insiders and facilitates entry by outsiders. The argument here is that different points of view about how to create value lead firms to approach the same opportunity with different operations and distinct competitive positions, leading to differentiated technological competition between entrants and established firms. The broad goal of the chapter is to establish the plausibility of that argument.

The archetype has space for only so many comparisons. Why select these events for illustrating the archetype? First, the chapter focuses on important and recent events related to the determination of technological leadership in a market—i.e., determining which organization possesses the largest market share and the frontier product designs. In addition, it is rare to have sufficient information to describe one firm's point of view in any depth, even with the benefit of hindsight, and rarer still to make direct comparisons between two points of view at two different firms. The events in this chapter contain the depth necessary to support the analysis. These confrontations described in this chapter happen to have left publicly available records, and these provide insights about both points of view. That selection criterion raises the risk that some of these confrontations appear to be sui generis and raises questions about their generality. That heightens the importance of demonstrating the match between the archetype and actual events, a point the chapter stresses. Said another way, because the chapter makes a "proof of concept," it needs to address questions about the generalizability of the archetype. It necessarily cannot answer all such questions, and so, some attention in the conclusion will go to specifying the limits of the archetype.

7.1.1 Contributions

The point of departure for this chapter is a well-known theme in the history of computing. Many studies celebrate the primacy of "spin-offs" that arise from disagreements among managers at established firms. These disagreements lead experienced employees to leave and start their own firms. Among the most documented examples are the actions of the "Traitorous Eight" employees of Shockley Instruments, who left to begin Fairchild. These employees left both to escape Shockley's managerial practices and—often less emphasized in popular retellings—because the employees had come to a different point of view (than Shockley) about the best technical direction to pursue in manufacturing transistors (Thackray et al. 2015).

More broadly, spin-offs receive attention because they play a prime role as an agent of change in the evolution of economic activity. A widely accepted model of spin-offs is due to Klepper (2007) and Klepper and Thompson (2010), who modeled the formation of new firms as a product of disagreements and argued for the generality of the phenomenon. Note the contrast with this chapter's archetype, which would characterize disagreements, such as those at Shockley Instruments, as a "confrontation between insiders with distinct points of view." Unlike the existing theory of disagreements and spin-offs, a theory of outsiders does not start from shared experience by the managers of the insider and outsider organization prior to the entry of the outsider. Hence, a theory of outsiders directs one toward different questions, such as the factors that nurture entry and confrontation with insiders. For example, how do outsiders overcome lack of commercial experience and bring their new perspectives into market events?

The focus on the confrontation between outsiders and insiders draws motivation from the vast literature motivated by Schumpeter's (1942) essay on "creative destruction."[1] Schumpeter argues that competition to gain leadership can motivate

[1] Perhaps the most quoted summary of the Schumpeterian argument about creative destruction is this: "Capitalism, then, is by nature a form or method of economic change and not only never is but never can be stationary... The fundamental impulse that sets and keeps the capitalist engine in motion comes from the new consumers' goods, the new methods of production or transportation,

competition among firms, both striking fear in established firms and providing strong incentives to new entrants to displace them. This chapter's archetype draws closest to one strand of the literature inspired by Schumpeter, which asks whether Schumpeter's vision carries over to settings in which competitors possess different "cognitive frames" about how to create value. These different "frames" lead firms to pursue distinct strategic approaches to new opportunities in technology markets (e.g., see Kaplan and Tripsas 2008, Eggers and Kaplan 2013, Martins et al. 2015, Rindova et al. 2012).[2] Within this strand, this chapter's archetype most closely resembles studies that compare the approach of two or more distinct firms in an otherwise similar technology market.[3] For example, Tripsas and Zuzal 2018 compare different strategic approaches to developing businesses for air taxis at different firms; Gavetti and Rivkin 2007 compare different evolving strategies for developing the business of portals during the 1990s; and Eggers 2012, 2014 develops different strategic approaches to choices for developing flat panel displays. Similar to this prior research, the analysis herein also directs attention at the planning processes and priorities of established firms. It also stresses how cognitive differences or beliefs support or limit distinct choices. Unlike the prior literature, this chapter focuses less on managerial lessons and more on the factors relevant to the determination of market structure and leadership, such as the role of institutions that enable or discourage entry of outsiders, and the factors that limit effective responses from leading firms. It also focuses more on the features of situations that lead endogenously to differentiated market positions, each supported by distinct points of view during a confrontation.

A related literature focuses on the causes of failure at established firms and analyzes the processes that shape choices at an established organization. Failure of established firms is an essential part of understanding market leadership and so receives attention in this archetype as well. This chapter resembles a blend of two approaches. The first is due to Gans (2016) and Tripsas (1997), which tends to deemphasize the cognitive foundations of differentiation and uses economic analysis to examine different types of "disruptions" (for a broad overview, see Christensen et al. 2018). As in Gans' approach, this chapter's archetype distinguishes between

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the new markets, the new forms of industrial organization that capitalist enterprise creates... This process of Creative Destruction is the essential fact about capitalism."

[2] This language uses Kaplan's (2008) characterization of arguments among executives inside a firm as "framing contests," where executives debate ways to perceive uncertain events. Kaplan (2008) does not focus on the implications for industry evolution or competitive interaction. Rather, she goes on to show how such framing contests not only shape decisions ahead of uncertain outcomes but also shape understanding of them after the fact. This links the framing contest to organizational status and power and strategic priorities. Note that, similar to the above remark about spin-offs, Kaplan's characterization is a model of "disagreements among insiders," where sometimes a spin-off arises and often times it does not.

[3] In this sense, the archetype also offers additional examples to the related literature about "technological competition"—i.e., society's contest and choice between two distinct technical approaches to providing a seemingly similar functional need. This theme arises in the history of computing, such as studies of competition between different computing platforms—such as mainframes and client/server (Bresnahan and Greenstein 1999).

evolution of a leading firm's understanding of uncertain features of demand and supply and asks how experienced managers plausibly misforecast in market areas in which they have considerable experience. This approach typically finds seeds for a misforecast in mismatches between historical experience and the requirements for a new product or service. The second approach examines manager's forecast about "radical" technical change and examines the cognitive processes that lead to misforecasts. Here, again, the emphasis tends to stress the mismatch of experience with new requirements. For example, Gavetti and Tripsas (2000) study the confusion at Polaroid, as its managers repeatedly (mis)perceived events and, relatedly, invested in capabilities (un)suited to the new competitive challenges. This approach heightens the relevance of prior industry experience in building capabilities. It also stresses how managers can act by imitating other firms perceived to be similar. It also stresses the importance of perceiving the learning from experiments inside an organization, which takes time (Benner and Tripsas 2012).[4] A blend of these two approaches, along with an additional emphasis on how distinct points of view arise, provides part of the framework for this chapter's analysis for why many insiders respond so slowly to new challenges and why anticipation of such slowness inspires entrepreneurial entry. In comparison, this chapter stresses why more than just market experience nurtures different cognitive approaches of outsiders, and it stresses how competitive processes endogenously encourage different points of view.

Note also the differences of this archetype with models of technical change during the industry life cycle. A large literature examines early moments of markets—i.e., before technologies "mature" into widely accepted products affiliated with modes of large-scale production and design or modes labeled as a "dominant design" (see, e.g., Kaplan and Tripsas 2008). In contrast, this chapter's archetype makes no presumption about the life cycle and its stages. In the approach of this archetype, entry can occur at any point in a technology's life because institutional factors, such as dispersed technical leadership, encourage entry at many moments. In addition, this archetype allows for incremental changes during competitive confrontations to accumulate into something that later observers regard as "radical," and it describes the process during confrontations. "Radical technical change," therefore, is endogenous to the features of the confrontation and the conditions that nurtured entry, and there is no necessary presumption that the entry of outsiders always leads to radical technical change.

Another important overlap and contrast with prior work arise by comparing this archetype and neoclassical economic models of Schumpeterian confrontation. As in neoclassical models, in this chapter's archetype, the creative destruction takes the form of differentiated competition. However, the neoclassical tradition in economics does not contain room for lack of managerial omniscience, mistakes in

[4]A specific area in this literature focuses on the role of firm identity in shaping innovation (Callen and Tripsas 2016). In this approach, an "identity" becomes associated with it a set of norms that represent shared beliefs about legitimate behavior for an organization with that identity. Investments that contradict this identity do not receive as much attention initially, and then, once they receive attention, organizations find it more difficult to adjust their processes (Tripsas 2009).

logic, or misperception of business models.[5] While the neoclassical view yields exact answers about incentives, an important contrast arises in the insights about asymmetric incentives to innovative. While neoclassical approaches allow for differences in incentives linked to factors shaping cost and demand, this chapter's archetype links those asymmetric incentives to the distinct points of view held by insider and outsider and argues that asymmetry always arises when outsider and insider hold different points of view. Hence, asymmetric incentives are inevitable in such confrontations and should be a central feature of any analysis.

Finally, this chapter's archetype borrows a key insight from the literature that derives lessons for managers, where, as part of their competitive efforts, firms attempt to convince analysts and observers of the merits of their particular outlook (McDonald and Eisenhardt 2016). Like this approach, the archetype in this chapter does not presume any single definition for "industry" has or has not gained wide acceptance when an outsider first enters nor when insiders confront outsiders in the market for users. That is, the definition of "industry" is an open-ended social construction determined by market events. The confrontation between insider and outsider may lead to new definitions for the market and for the group of firms in an "industry," and the success of the outsider in gaining market leadership may determine whether that new definition receives acceptance.

7.2 Nurturing Factors

Although many startups fail before ever making it to market, several nurturing factors play a role in the archetype examined here, which will focus most attention on outsiders who achieve enough success to motivate a response from insiders. We consider features that arise in our settings, such as organizational inertia, financial partnerships, specialization strategies, and open governance.

7.2.1 Organizational Inertia

A long-standing puzzle lies at the core of any analysis of different points of view. An established and leading firm would seem to have enormous advantages over its competitors in a new market. Established and leading firms bring refined processes, existing distribution and production, and favorable branding. Why would a successful firm come to have any difficulties organizing for a new market? Why would a new point of view about how to commercialize a technology give rise to any challenge? The archetype below stresses the role of planning and investment delays in the face of uncertainty.

[5] Such models have a long history in economic theory. See, e.g., Arrow (1962) and Gilbert and Newbery (1982). For recent advances in this approach, see Cabral (2017).

Uncertainty plays a specific role. Firms must identify the salient features of demand, operationalize production, and distribution and achieve scale in their organization; and the valuable approach for doing so remains unknown in advance of commercialization. This observation is an assumption in this archetype: there exists no inexpensive way to resolve the uncertainty with a laboratory test or by building a prototype. Even the best experts must guess until they observe operations, distributions, and sales at scale. That uncertainty permits multiple guesses to survive.

It is tempting to say the following: insiders or outsiders both face risks, and those risks overwhelm all else. After all, insiders fail from time to time, and the vast majority of outsiders fail to realize their grandest aspirations.[6] If nothing more than randomness determines outcomes, then any simple theory reduces to two probabilistic distributions—one determining the probability of success by an entrant and the other determining the probability of success of a leading firm. While logically valid, this chapter will not explore such a theory. It is inherently unsatisfying because outcomes depend entirely on randomness. It lacks a causal explanation tying outcomes to grounded facts and provides no insight into *why* sometimes an established firm had a poor outcome at the same time as an entrant experienced success.

The archetype in this chapter stresses the role of planning at established firms and the time it takes to invest around these plans. Both are essential features of any commercialization process at established firms.

The role of planning is essential to the operations of any large organization. Planning cycles determine which factors an organization attends to and which factors receive low priority. Every large organization has budgeting cycles that take time and effort. Established firms rarely plan to cannibalize their own products without prompting and rarely seek to reduce the return on investments in unique bodies of knowledge, experience, and training. Relatedly, leading firms rarely invest in developing prototypes that do not serve their own interests—at best, they underinvest in prototypes that appear distant from their own interests. Simply, even the best plans are rarely omniscient.

Even when established firms do change their priorities, new investments take time to execute. To change their priorities, established firms need time to communicate to their management and workforce about such priorities. They may need to change incentives systems to support the new business. They may need to build momentum into investing with priorities consistent with an existing business. As discussed below, such priorities manifest as several tendencies, namely, (1) to extend existing products for existing customer base; (2) to use existing talented work force in known ways; and (3) to build in ways consistent with existing

[6] There is some question whether the era of the commercial Internet—from which many of these examples are drawn—was any different in the experience of failure. One group of researchers has argued that it displayed a higher rate of private success and well-known big failures (Chap. 12, Greenstein 2015), and the emphasis of venture capital on massive profitability, which few also achieve, distorts the historical picture of the broad trends. See Goldfarb et al. (2007) and Kirsch and Goldfarb (2008).

firm-wide assets, where the challenges "integrating" new and old lines of business will draw particular attention. These priorities limit the actions of established firms in the short run, particularly on the scope of products and services offered. The last factor especially limits the riskiness of a firm's actions in new technology markets by limiting, for example, its ability to quickly merge with another firm and rebrand it as its own.

These two broad elements—planning and investment delays—will play a role in leading insiders astray. As shown below, entrants make different plans than established firms; those differences reflect distinct points of view, and the speed in implementing those plans plays a key role in any success. Outsiders will seek to take advantage of the insider's delay adjusting to the new point of view and the challenges insiders face in learning to imitate.

7.2.2 Outsiders Working with Selective Insiders[7]

In many settings an outsider cannot execute its plan without the cooperation of at least some insiders. Do outsiders have a difficult time finding an insider partner? In one place, venture finance, this question has been studied extensively. Do outsiders obtain finance from insiders? The answer is yes. It is one of those things frequently observed among outsiders who reach prominent success. However, examining only these successes selects observations on outcomes and does not fully characterize the situation before any cooperation emerges. In fact, some outsiders do find funding from or cooperation with insiders, because insiders do not let social station get in the way of a business investment if it appears profitable. It is a feature of modern VC practice, and a notable one, that financing can overcome social status.

One illustration of financing from insiders can be seen in the founding of HoTMaiL, which was funded by Draper, Fisher, and Jurvetson (DFJ). Tim Draper is the archetypical insider in commercial high tech; he has a Harvard MBA, and his father and grandfather were VCs on the West Coast. Following in the family's footsteps, in 1985 Draper formed a VC firm in Menlo Park, California, eventually partnering with John Fisher and Steve Jurvetson to form DFJ.

By 1995, DFJ specialized in funding entrepreneurs aspiring to start new firms. The entrepreneur's social station, age, and ethnic background did not matter to the financing. Very little about the entrepreneurs' identity mattered except what business they could build and their chances for success. Although this practice is especially risky, DFJ believed financing firms with high potential and hoping to nurture a small number of extraordinary successes would make up for the losses of the majority of the other financed firms.

It did. One day in 1995, two unknown, first-time entrepreneurs, Sabeer Bhatia and Jack Smith, pitched a product to DFJ. Even with backgrounds as far apart as possible, the parties made their deal less than 48 hours after they first met and began

[7] See Chap. 8, Greenstein (2015).

to create the technology that would become HoTMaiL, a new web-based email service.

HoTMaiL grew quickly, because user communication became the instrument in spreading the adoption of the services. This behavior, eventually known as *viral marketing*, utilizes users to help the supplier sell the product. DFJ became a major proponent of the practice, and it advertised its expertise as a way to attract more startups. Eventually HoTMaiL grew to 12 million users in less than 2 years and with almost no marketing. It sold to Microsoft for 400 million dollars in 1997. Even today it remains the second most popular email service.

Partnership between insiders and outsiders may or may not place constraints on that discretion on the outsider. It depends on whether the interests of the insiders and outsiders are aligned (or not). The interests of a financier and entrepreneur tend to be aligned when the young firm grows rapidly, particularly when the costs go up more slowly for both participants than the potential revenue. Yet, as examples below describe, if the costs of the partnership increase for the insider without greater increases in revenue, those interests become less aligned and produce tension.

7.2.3 Specialization

A specialist performs one function and takes for granted that the other functions will be performed because those other functions are part of a designed network. Many startups fail, and for a variety of reasons, but outsiders have an easier time if the market supports specialists, which increases the likelihood of success and increases the potential for experimentation, as the following examples depict.

For example, from its founding and continuing into the present, Google is a search specialist. To deliver its service to your home today, Google must partner with every data carrier around the world—both wireline broadband firms and wireless smart phone supporters. In addition, it must partner with other firms using web technology, smartphone markers, ad exchange operators, content delivery network providers, browser and web server makers, and dozens of others.

At its founding, however, Google needed only to search and to do it well. At that point, it needed to operate its own servers and the software that ran on it. The software for spiders and algorithms resided on the server. In addition, the Internet and the World Wide Web were open technologies and, by definition, were available to all. Related, web pages built by users defaulted to being open as well—a web master had to opt out deliberately—which made most of the web available to a spider without frictions.

Other successes were also specialists: HoTMaiL performed one activity, provided only one service, namely, browser-based electronic mail. Similarly, as discussed below, at the outset Netscape performed one activity. It designed, produced, and distributed a browser. As another example, Microsoft's encyclopedia department was close to being a specialist. In 1991, its development team involved only four employees and separated itself from all other activities at the firm. The team focused on Encarta and expected that other functions later would receive attention from the rest of Microsoft. In fact, Microsoft actions to support Encarta did not begin to grow until after Encarta's initial success in 1993; and, during its first few years, the Encarta team was a separate organization that reported directly to the CEO (chief executive officer) and COO (chief operating officer).

7.2.4 Open Governance[8]

Although outsiders face many challenges when entering a market, open governance provides another nurturing factor that can ease their entry. Without established firms and other actors (e.g., government regulators) slowing down the entry of outsiders into markets, entrants have the discretion to act as they prefer.

For example, note the governance of both the Internet and the World Wide Web: there were more than 20 years of operations and refinement prior to the Internet's widespread commercialization, during which time the IETF (Internet Engineering Task Force) developed a large number of protocols for providing networking services. The idealism of the founders of the Internet played a key role in establishing open governance. The IETF was founded within academic norms, and the major participants chose to keep the institution open. Likewise, some of the same principles carried over to the World Wide Web Consortium when Tim Berners-Lee chose not to privatize the World Wide Web; instead, he operated a consortium with limited rights over information. While membership in the consortium permitted privileged access to information to some sooner than others, and Berners-Lee retained the ultimate right to settle disputes, his consortium adopted practices that did not preclude other participants from gaining information at later moments. The open governance of the Web further altered the architecture and governance of the Internet technology, which then shaped outsider entry.

Consequently, because the Internet is decentralized, anyone with a computer can access the Internet in a variety of ways. Meanwhile, the openness of the Web allows users to share information across the Internet with transparent and clear interfaces between different parts of the Web. Any specialist working with the Internet and the Web can gather information about how to work with the rest of the network. There are no limits on who can view information about the operations of the network; and there are no limits on how the information could be deployed nor to whom and to where.

This kind of setup provides an absence of a key legal feature that a lawyer would characterize as "reach-through" rights. In other words, specialists working with the network have full discretion to invest in their business without fear of a partner in the network interfering with their activities or making a property claim against their action.

[8] The origins and operations of open governance have a long history. See Greenstein (2015), Chapters 2, 3, and 7.

Said simply, open governance nurtured outsiders by preventing self-interested insiders from taking actions to slow them down or blockade outsiders. It permitted outsiders to experiment without giving any veto rights to established firms. Consequently, outsiders could then learn from their experiments and further refine their products, service designs, and operations.

Summarizing, the opportunity for outsiders rises in markets with dispersed technical leadership when the market opportunities enable entry by specialists. Specialists find it less difficult to introduce their ideas when they have access to support from financial intermediaries, such as VCs, and when partnerships with insiders do not place restrictions on their actions. Open technologies also help, because that provides discretion to develop their businesses, and reduce interference from other firms.

7.3 Entry

The entry stage begins when an outsider has a point of view about how to create value, distinct from the leading insider. The outsider goes through a period of experimenting with prototypes and developing a commercial approach to this point of view with limited interaction in the market. Its view may remain hidden or unrevealed to the consensus for a time. In fact, many of these firms fail before their point of view becomes widely known.

The examples examined here disproportionately come from prominent successful outsiders in order to economize the presentation of the archetype and show how these firms have had an impact on insiders' point of view about demand and operations.

Below we examine the entry experiences of three outsiders with unique points of view. In one case, the outsider's point of view built on its experiments and prior experience in another market. In the second example, the outsider's perspective built on its experience and experiments at a university, outside of a competitive environment. In the third case, the outsider's view and experimentation depended on a rush involving many firms. In the first two instances, the outsider's point of view remained hidden from the insider for a time, while in the latter case, the outsider's point of view only became clear to the insider suddenly. Table 7.1 provides a summary of the confrontations in the first three rows.[9]

[9] The descriptions below are necessarily cursory summaries. See the references for further details.

Table 7.1 Taxonomy of examples to illustrate archetype

Technology, insider, and outsider	Plans of leading firm	Key difference in points of view and open question	Experience of outsider before entry	Causes of delays at insider	Pathway that puts new point of view into practice
CD-ROM encyclopedias, Britannica, Encarta (Microsoft)	Plans for digital future with its own proprietary content	Does a valuable product need text and the authoritative voice of existing text? How does it need to use pictures, sound, video, and links?	Comes from PC market experience	Faced internal conflicts distributing new products	Outsider displaces insider in new product market
Search, Portals (Yahoo!), Google	Treats search as complement to their portal and indexing service	Is search of peripheral importance, or can search serve as the primary starting point for users?	Built prototype at university, used by many students	Lack of plans or investments Late to recognize	Outsider displaces insider in new market
Browsers, Microsoft, Netscape	No plans then plans with proprietary approach to new opportunities	Will the Web become the primary organizer of applications? Or will the PC OS maintain that role?	Build prototype at a university, used among students	Planned for proprietary technology No plans for browser investment	Insider imitates outsider and improves product Insider displaces outsider
The Web, IBM, Dot-com entrants in electronic commerce	Plans in its own lab for a proprietary approach to opportunities	Will electronic commerce build sites from proprietary software or from software such as the Web?	Prototype used at a university and at many early dot-coms	Planned for proprietary technology No plans for open technology	Insider adopts technologies of outsiders and uses it to sell new product
Wireless local area networks, Intel, IEEE 802.11 committee	Plans for wireless access as option over which OEMs have discretion	Will wireless access become a default feature of the laptop or should it remain as an option?	Prototypes at IEEE, designed into an Apple product	No plans or investment Late to recognize	Outsider's technology became widely adopted, compelling insiders to act
Video streaming, Comcast, Netflix	Large investment in existing processes for delivering services	Can video streaming become a viable subscription business to homes?	Comes from mail-order, video-rental experience	Internal conflict related to protection of investment in existing revenue	Insiders and outsider sign contracts, and it enables outsider to continue its experiment

7.3.1 Experimentation Built on Experience[10]

Consider the canonical and well-documented example of an outsider upending the digital age: the young Bill Gates and the introduction of Microsoft Encarta. As a young executive, Gates had many well-known obsessions, and that included entering the encyclopedia market, despite lacking any experience with it. Although the firm had only a small revenue stream, starting in 1985, he made entering the encyclopedia market a pet project and assigned one person to pursue it.

Experience in other markets did not confer any particular advantage to Microsoft, and the early experience did not go well. No existing player agreed to enter into a joint venture with Microsoft. By 1989, a division of Britannica, Compton's, issued its first CD-ROM encyclopedia, which was met with critical acclaim but not high sales. At the same time, Microsoft had to settle for a deal for text from Funk & Wagnalls. The consensus of insiders regarded this text as low quality. It used simple language that aimed at school-age children. The articles were short and uncomplicated. Unlike Britannica, the articles lacked the authority of recognized experts.

Many features of "a new point of view" arise in this example: (1) Microsoft saw value in the low-quality text despite others' disparagement of it; (2) persisted in pursuing the encyclopedia market, despite the refusal of other firms to collaborate; and (3) foresaw the potential for the product to help its sales, in contrast to Apple's PCs, which aimed at the home market and took market share from Microsoft's operating system. Gates continued to believe that some development work might reveal insight into how to approach the situation. Success appeared unlikely to all others.

By 1990, the firm was bigger and more experienced. Microsoft's board considered killing the project and temporarily did eliminate funding for it, but after an employee suggested a new approach, the CEO championed the project, and it was reinstated. It assigned skilled employees to the product's small four-person team. Unlike existing book encyclopedias, Microsoft anticipated it would sell the CD-ROM through third-party retailers at a low price. That approach to distribution and sales leveraged Microsoft's existing channel experience and gave it a distinct outlook for designing a digital encyclopedia.

That distinct point of view shaped design choices. For example, like any other firm, Microsoft faced severe space constraints on the CD-ROM. Its team of designers considered numerous ways to store songs, pictures, and movies and encountered the same space constraints that others had encountered before. There were only so many ways to address that constraint before it became binding. Microsoft's reaction built on its unique point of view. Cognizant that it had only a few minutes to persuade buyers to purchase the product, it chose to design a product that grabbed the attention of a shopper in a third-party outlet.

Two features turned out to matter. Having failed its first launch in the winter of 1993, Microsoft brought the price down to $99 from $299 for a relaunch in fall of 1993. In addition, the design team carefully selected videos, which appealed to

[10] This is a summary of a much longer and more detailed study. See Greenstein (2016).

parents. One such clip was Neil Armstrong's first step on the moon and his words, "One small step for man, one giant leap for mankind." Another notable clip was from current events—in this case, the signing ceremony between Rabin and Arafat on the White House lawn, which had taken place only a few months earlier. The latter clip highlighted the difference between a CD-ROM-based encyclopedia and a set of books, namely, once printed, books cannot easily add pages with new information, but computers updated periodically, so they can use additional new information.[11]

In short, the company's point of view—lowering the price, appealing to parents, and using attention-capturing video to show how current digital encyclopedic information can be—emerged from Microsoft's experience distributing software in third-party markets and thus shaped its design. It made an enormous difference to their commercialization. The established firm, Britannica, took a very different approach (technically novel, yet consistent with its history) and will be investigated in the section on confrontation.

7.3.2 Experimentation Inside a University[12]

The previous example features a firm that had business experience prior to entering a new market. What about outsiders who found their first firm? Do different origins provide different paths into the market?

Consider another well-documented, canonical example: Larry Page and Sergey Brin, graduate students at Stanford, developed a project that ultimately became Google's search engine. In the late 1990s, theirs was one of several search engines and, arguably, not even among the most celebrated at the time (such as Inktomi or AltaVista). Ultimately, Google became ubiquitous.

As graduate students in a laboratory, Brin and Page did not work within the commercial consensus and were outsiders to the market. In their research, they pursued a spider-enabled ranking algorithm, named *BackRub*, for making recommendations in a search engine. While deploying the search engine at Stanford and allowing the university to patent the algorithm and pursue licensees, Brin and Page made no effort to commercialize it. As the algorithm took traffic from many users at Stanford, Brin and Page experimented and refined their approach over several years. This project fulfilled the basic requirements for a laboratory project in computer science, at the outset, but commercial success appeared remote. Meanwhile, the project continued to improve the engine's accuracy and relevance through leveraging users' experiences; and the online traffic helped BackRub learn how to conduct search, though this experience taught Brin and Page little about how to generate revenue from ads.

[11] This was mostly a marketing ploy to make Encarta look current. Britannica sold a yearly "update" to its encyclopedia to address the demand for current events, and most buyers never looked at it.

[12] This example is described in more detail in Chap. 13 of Greenstein (2015).

Brin and Page did not begin their commercialization efforts immediately. Instead, they wrote two papers, one between the two of them and one with their laboratory supervisors and thesis advisors. By 1998, both had finished taking classes, and these papers served as stalking horses for dissertation chapters. While their efforts did not remain "hidden" to anyone who bothered to read the papers or use BackRub, the technical capabilities were primitive and unrefined.

Meanwhile, Stanford patented the algorithm and tried to license the patents affiliated with the PageRank algorithm. Most user traffic went through portals, such as Yahoo! and AOL, and these firms seemed like natural targets for the license. Several of them used search engines as a means for users to find pages and categories that otherwise had not been indexed. Inktomi, another search engine that grew out of an experiment at UC Berkeley, provided the search services for Yahoo! and others. Stanford's effort to gain further licensees from portals, including Yahoo! and Excite, did not yield much, because the asking price was too steep for the portals. In other words, none of the leading firms perceived the invention as particularly valuable.

There was nothing particularly wrong with this assessment based on the current capabilities of the software. In 1998 BackRub lacked the speed and scope that would mark its later versions—versions that had considerably larger investments in hardware behind the performance, as well as multiple programmers refining and improving the server software. Making an accurate forecast required a distinct point of view about how the capability would evolve with improvements.

Thus, Brin and Page's unique point of view to improve their technology within the university setting before beginning to commercialize not only nurtured their experimentation but also gave them a vision about how to make their product successful. They began commercialization only *after* several years of experience improving their technology in the university. The cofounder of Sun Microsystems, Andy Bechtolsheim, himself a former graduate student of Stanford's computer science department, decided to act as an angel investor, providing money, advice, and connections, which not only gave Brin and Page access to other investors and VCs but also helped them with the first difficult steps of starting a business. Ultimately, after Brin and Page received funding, and only after they had been operating their firm for a while, did the VCs insist on experienced management, which led to hiring CEO Eric Schmidt and CMO Jonathan Rosenberg.

Brin and Page's unique point of view also included their neutrality to several commercial opportunities, which ultimately shaped the business. Initially, Sergey Brin and Larry Page continued on the path they had pursued at the university, namely, combining PageRank and spiders to create a search engine. The search engine was oriented toward giving users the most satisfying experience and was "commercially neutral" with respect to advertisers. This deliberate approach was regarded by some VCs as naïve and unlikely to lead to much revenue, because it differed from other experiments to build search engines that yielded revenue by listing the firms that bid the most.

Experimentation took a very neutral form as well. For the first few years of its existence, Google displayed a search bar at its primary website. Next to the search bar, Google occasionally displayed banner ads, which were sold in advance and without regard to the search, but they were not regarded as the primary source of revenue. Regarding neutrality as an essential feature for licensing to multiple parties, early on, Google aspired to license its services to other portals. Similarly, the organization established a practice it would maintain for good, namely, the division that sold the ads was kept separate from the division that designed the search engine. One could not influence the other.

Many of the portals did not perceive any competitive threats and eventually cut deals with Google for its search engine, which was still a small fraction of traffic on most portals. Following a much earlier deal with Netscape, in mid-2000 and continuing throughout 2001, Google displaced Inktomi (and eventually all other portals, as well) as the predominant search engine on Yahoo! Though these contracts accounted for only a small fraction of traffic at the portals, they gave Google a nearly ubiquitous view into the search behavior of the entire Web. The contracts also had important symbolic importance. Specifically, they provided attention and legitimacy. Why did so many firms agree to such contracts? Because the consensus view did not perceive Google as a competitive threat.

The environment was nurturing in another way—it fostered imitation. Imitating a practice invented by others, principally Goto.com, Google began experimenting in the fall of 2001 with marrying their service with an auction for ads, where the ads matched to the keywords entered by the user in a search. Google's employees reengineered many improvements to match their own unique outlook—that is, that the ad should help the user find what they wanted and should not influence the result in the search. The experiments, once again, reflected the unique point of view of the founders. The search engine remained neutral in the sense that its results remained uninfluenced by the ads. They imitated other auctions, improved them, and applied it to advertising with the search engine. The auction eventually took a unique set of features, becoming a quality-weighted second-price position auction. This design abandoned the preference for first-price auctions used elsewhere in favor of a process that showed more positive properties.

The realization of what was happening crept up on many observers gradually instead of quickly. First, and this is hard to appreciate in retrospect, for a long time, Google was not given much of a chance to earn revenue. The prevailing view among most analysts favored Yahoo!, and Yahoo! treated search engines as a minor component for miscellaneous searches. Second, there were not many analysts with the experience to appreciate the accumulation of Google's many little successful experiments. In particular, Google had begun conducting A/B testing in 2000, a new practice for rapidly improving the design and conduct of their services in myriad dimensions.[13] Few appreciated what that practice would yield.

Third, and for many years, Google purposely muted its voice, trying not to be too brash in shouting about its aspirations. Later observers would give this behavior a label, calling it a "stealth strategy." Nothing was a secret to the innovating firm's employees, but for various competitive reasons, they typically did not share their progress with others. Eventually, the market presence became hard to ignore, and

[13] Quoted from Stephans-Davidowitz (2017).

many observers—competitors and analysts—slowly took notice. In that sense, the commercial success came as a surprise to both rivals and analysts. Competitors began taking actions later, such as Yahoo!'s purchase of Goto.com, but these were too little too late. By this point, Google had accumulated a service with considerable appeal, and, importantly, this service generated revenue. They also had put in place organizational practices for continuing to improve the service.

7.3.3 Experimentation During a Technology Rush[14]

The prior two examples focused on experimentation by single outsiders. Experimentation in a technology market sometimes arrives in a different form. Like the gold rushes in the 1800s, a technology rush (1) occurs when many firms all react to the same new information and hurry to bring a technology to market and (2) is unknowable in advance. Like every historical gold rush, a technology rush is unique because it happens in a particular place at a particular time and not again. There are, however, general economic patterns to technology rushes. Before the rush, market participants are rare. Then, after information about the discovery spreads, many potential participants perceive that they must act quickly or be left out of the profits. That creates the incentive for everyone to move fast. By circular definition, the rush cannot happen until the discovery, which cannot be known in advance. Hence, forecasting the timing of a rush is impossible, even though it is easy to forecast the general tenor of economic activity after discovery.

Follow the logic of the metaphor. A prominent commercial event in a technology market typically acts as a catalyst, thereby triggering the technology rush. Predicting one of these catalytic events is near impossible, just like forecasting a gold rush. Moreover, for every one of these examples, there are scores of product launches that fail to generate the same vigorous response. That makes it even more difficult to predict which of the many young firms will become a catalyst and when.

What were many analysts waiting for? They needed something concrete, a working prototype. The working prototype had to appeal to more than a technically adept chief technology officer (CTO). It had to contain enough functionality to persuade CEOs, boards, and VCs that a mass-market user might find it appealing. Most had to appreciate how the prototype would fit into a recognizable and reliable value chain that could support packaged software. As it would turn out, Netscape fit those qualifications.

The story of Netscape's founding has been told many times. Only a brief outline is required here. Jim Clark, a well-known senior executive, partnered with Marc Andreesen, who was the lead programmer for NCSA (National Center for Supercomputing Applications) Mosaic, and Eric Bina, an otherwise unknown student designer. Andreesen and Clark approached and received support from Kleiner Perkins, a name brand venture firm. Importantly, Andreesen had worked on the

[14] The basis for this anecdote comes from Chap. 6 of Greenstein (2015).

browser for more than 2 years at the University of Illinois, helping to write a browser for both Unix and Windows systems. In other words, the product had incubated in a noncommercial university environment, oriented toward large-scale use by students.

The team that developed Mosaic left the university in the spring of 1994 and founded Netscape. After rapid development, the company released a product. Netscape's launch of its first product was a catalytic event, and it triggered a rush in February of 1995 (and, arguably, was triggered earlier by the release of the Beta version in November, 1994). Why? As has been well documented, commercial analysts lacked experience with the Internet and Web, but Netscape had incubated and improved among technical users in research universities. Many commercial analysts neither appreciated how refined and reliable the technology had become nor perceived the Internet's value to nontechnical users and the myriad and clever ways it could serve them. The insider belief also did not perceive how to build a profitable browser business. Jim Clark remarked later, "I'd say there was a fair amount of skepticism at the time about whether the Internet held any promise. And, of course, I felt that it did."

The technology rush followed quickly after the launch. The product was adopted quickly and generated an astonishing amount of revenue in a short time. Its distribution combined conventional and novel modes. The conventional side worked like any business-to-business software, involving licenses with major business users and third-party distribution of packaged software. The novel mode involved "downloading" the software at no charge, aimed primarily at households with technically sophisticated users. The latter largely displaced Mosaic, which had been available through a license from the University of Illinois, but had not been marketed aggressively. Thus, Clark's unique point of view in the Internet's commercial profitability swayed the technical market only after the product was offered.

By the time of Netscape's IPO (initial public offering) in August of 1995, there were no doubters in any part of technology markets. In May of 1995, Bill Gates had written and circulated a memo inside Microsoft stating his change in priorities for the firm regarding the Internet, and the consensus held Microsoft as already 6 months late, if not more. In June, Microsoft tried to buy a part of Netscape and failed to come to terms. In other words, by August of 1995, every technology analyst believed the commercial Web-enabled Internet would have an astonishing set of capabilities, and Netscape was the catalyst for this new perception and the immediate impetus for startups that followed over the next year or so.

7.3.4 Summarizing Entry

What do these examples tell us? They showed the entry experiences of three outsiders with unique points of view and showed that there was no single way of discussing the origins of their point of view. In one case, the outsider's point of view emerged from a combination of experiments and prior experience. In the second example, the outsider's perspective emerged from experience and experiments at a university. In a third case, the outsider's view emerged during a rush involving many firms.

The outsider's viewpoints also differed in their visibility to insiders. In the first two instances, the outsider's point of view remained hidden from the insider for a time. In the latter case, the insider perceived the outsider's point of view suddenly, along with many other events. Despite that variety all shared an element of "surprise."

Table 7.1 provides a summary of the three cases described so far. The discussion below about confrontation will build on these entrants and identify commonalities with several other entrants, which have not yet received attention and who will be introduced in the text below. This delay is for the sake of brevity.

7.4 Confrontation and Competition

The second stage begins after the outsider enters and the insider decides to react. During this stage, the established firm and outsider both "experiment" by interacting with market actions to learn about open-ended questions regarding features of demand and operations. Either the established firm changes its point of view or not, typically, it does. A competitive confrontation takes place in the market, and then experimentation continues until both insider and outsider settle into differentiated competition niches or one or both exit the market.

The key question is: Does the presence of the outsider prompt the established firm to take action that differs from what would have occurred otherwise? Obviously, a controlled experiment cannot address this question because firms take only one concrete action. It cannot compare what happened against an alternative concrete action in which they face different circumstances. Instead, they compare one concrete action with one hypothesized alternative.

Accordingly, what shapes the likely alternative? Established firms tend to develop options consistent with their present business for two essential reasons. One involves planning, and the other considers the time required to make investments.

Because the market entry of outsiders can be catalytic, insiders may act in ways that they would not have otherwise. Several reasons motivate insiders to develop new products:

- Protection of revenue: Anticipating that success from an outsider could lead to reduced revenue at the established firm in the near term, the insider becomes motivated to develop prototypes and products that reduce the likelihood of revenue declining at the established firm.
- Newly perceived awareness of a market demand: Because the outsider demonstrates a demand that the leading firm had not fully appreciated, the insider can be motivated to develop new prototypes and products.

- Control over intermediate inputs: An established firm may forecast that products, markets, and technology standards will develop outside of their control, which has consequences for their ability to generate revenue and measure demand.
- Cost: The outsider can drive up unanticipated costs for the insider who had acted as a partner. Entering the market aims at moving costs back onto the outsiders.

This understanding of motives links observed actions, confrontation, to causes, distinct points of view. It also informs an approach for analyzing situations. If a new point of view motivates change, then there should be plenty of evidence that such motives played a salient role in an insider's strategy and activity. There also should be plenty of evidence that the insider would not have taken the action, because the new action remains inconsistent with an older (pre-entry) approach to technology commercialization.

Once again, Table 7.1 summarizes the events. Two of the examples continue stories begun above. The three new examples appear in the fourth through sixth rows of the table.

7.4.1 Internal Conflict as a Barrier to Reaction: Britannica[15]

As was discussed earlier, Microsoft was the outsider to the electronic encyclopedia market and Britannica the insider. Britannica developed its new product in a manner consistent with its existing practices in distribution and product design. Microsoft's product did decidedly well after its second launch. Meanwhile, Britannica scrambled to respond and failed to do so effectively. But why?

Britannica's point of view was based on its established business and successful existing practices. One of the clues to ascertaining why Britannica stumbled stems from a closely related market—online encyclopedias. Britannica had a remarkable record in online encyclopedias. It was the first firm to develop one successfully and offer it in an HTML-compatible version. Britannica made it available in a beta format in January 1994 and began a licensing program a year later. It began selling to many libraries and began a program for licensing access to homes.

Nevertheless, while libraries responded, households did not. So, although Britannica had foresight and correctly anticipated library demand for such a product, it mis-anticipated household demand. At its peak, the licensing to libraries amounted to five percent of revenue, which made a modest contribution to the bottom line. Unfortunately, households constituted a much larger market, and so Britannica's actions were not lucrative.

More to the point, the experience in browser-compatible encyclopedias suggests Britannica did not lack the technical capabilities required for new markets, nor did it have myopia in its vision of how to transition its product into the digital era. Britannica had first-rate technical capabilities in its own technical team and success-

[15] This argument is made in more detail in Greenstein (2015).

fully deployed those technical skills in the online encyclopedia market much sooner than anyone else. Indeed, it led the online category for a decade, until Wikipedia came along in 2002. In other words, Britannica had no problems with developing technical skills or deploying them. Thus, its timing and planning were solid. Britannica pursued a distinct design strategy, one that preserved its brand and existing text.

Why, then, did Britannica have a less satisfactory experience in CD-ROM encyclopedias, where it faced direct competition from Microsoft's Encarta? Why did Britannica's existing business provide challenges that slowed down its actions in the new CD-ROM market *in spite* of the possession of capabilities and a forward-looking outlook?

The answer is based in the insider's internal structure and branding. Britannica would have continued to act in certain ways even if Microsoft, the outsider, had not entered. In addition, the outsider's entry highlighted the insider's struggles.

To begin, Britannica possessed a set of assets that served its interests in the existing markets of book-based encyclopedias, and those assets had to be shared with the new CD-ROM market. Sharing the assets posed an internal conflict for Britannica around (1) brand, (2) text, (3) distribution, and (4) working capital.

Brand Britannica had invested in its brand as the leading expert encyclopedia with the most scholarly material and most complete information. While that prestige and reputation served its needs in the market for online licenses for libraries, it interfered with its needs for the home market, which wanted text aimed at school-age children. Encarta oriented itself to that customer demand. Partly as a result, Britannica took cautious experiments with its brand. It first attempted to sell the Compton's branded encyclopedia, which was aimed at a younger audience, but Compton's had less brand appeal than Encarta.

Text Britannica sought to port its text to the CD-ROM and could not. Because of Britannica's brand, which prided itself on its product's intellectual superiority, it also used a lot of "special characters" and thus was difficult to transfer into computer language. Again, this motivated the use of Compton's, which had none of the historic appeal of that associated with Britannica. Moreover, Britannica's designers sought to move existing text and photos over to the CD-ROM and did not extensively redesign the text for the new medium. It also neither used hypertext or search extensively, for example, nor did it reformat for display on screen. It largely sought to use its existing asset in the new setting without reconceiving of its use.

Distribution Britannica had developed the best door-to-door sales force in the world. Employing full-time staff, their sales force was well suited to selling a product that sold for $1500 dollars, where the material cost of production for a set of encyclopedias did not exceed $250. There was plenty of gross margin to support high-powered incentives for the sales force, who invested heavily in each visit to a home. A $100 CD-ROM product did not, and could not, replicate such returns. Pricing became a major source of conflict when the new product was put in the existing channel.

Working Capital Britannica had an unusual governing structure, combining private ownership with the behavior of a nonprofit. It donated all profits each year to the University of Chicago, whose libraries its staff used for research. As a result, it had no cash reserve, and when demand began to drop in the face of competition from Encarta, it had limited options for borrowing funds to finance a new set of efforts.

Essentially, internal conflict at Britannica caused problems for its CD-ROM encyclopedias. Britannica needed a rapid response in 1994 to Encarta's success during the holiday season. Instead, Britannica's response was marked by conflict with its sales force. Management chose to meet the demands of its sales force and protect the profitability of the efforts affiliated with selling the books, which, at the time, accounted for an enormous fraction of the profitability of the firm. That strategic priority manifested in the inappropriate pricing of the CD-ROM offering and an ineffectual product offering. Encarta could not have asked for a more favorable rival for its first year of existence.

Summarizing, Britannica contains a striking set of contrasts. Management anticipated the general demand CD-ROM encyclopedia and even undertook early experiments to develop the product. Yet, management did not take actions that indicated it anticipated the precise and specific features that would eventually appeal to mass buyers, features that an outsider ended up developing. The insider's own internal struggles played a role in those misperceptions, and, arguably, possessing the correct perception might not have made any difference, because these too would have faced these internal challenges. Most important, the existence of these internal challenges played an important role in encouraging the outsider to differentiate from the insider, which it did by developing the features that allowed its product to appeal to mass users.

7.4.2 Late Reaction to a New Demand: Microsoft[16]

Unlike Britannica's far-sighted view for electronic encyclopedias, Microsoft, the insider in operating systems for personal computers, was myopic and did not anticipate demand for the Internet soon enough. It changes their role from outsider to insider.

We can directly observe Microsoft's reaction to Netscape. It appears in the views and actions of Bill Gates. Gates' views received attention due to the federal antitrust case brought against the firm, which made many internal memos public. In addition, long before the antitrust case became central to events, Microsoft had been comparatively unrestrained about the importance of Gates' perspective. Gates, the best software CEO of his generation, missed the Internet. His change in vision illustrates that no CEO is omniscient.

[16] This summarizes the much longer analysis of Bresnahan, Greenstein, and Henderson (2012).

Seen in retrospect, the insider slowly changed its point of view, and that slowly changed the investment priorities and activities of the firm. In the spring of 1994, Gates set in motion a series of investments, product designs, and marketing plans. More precisely, Gates did understand the technology behind the Internet, and he appreciated the timing of its arrival; he included plans, for example, to include TCP/IP compatibility in server software. The plans also included the key design elements for the next upgrade to Windows, which later would be called Windows 95. Importantly, however, the designs did not include any plans for a browser, because Gates classified that as application software. He wrongly concluded in the spring of 1994 that the considerable expense and effort affiliated with making a browser were too high.

If Gates had perceived its commercial potential, as well as its strategic importance, to be sure, he would have authorized a team to develop such an application. Spring of 1994 was well before the launch of Windows 95, so it provided sufficient time for developing a new application. (Indeed, Netscape was founded in the spring of 1994 and had a beta browser built from scratch by that November.) Instead, confident in his assessment, Gates authorized no investment and deliberately declared that the software lay outside of Microsoft's interests. He believed there was no possibility that browsers would either have a strategic purpose or potential to generate revenue or a potential to achieve near ubiquity as a mass-market application. Nonactions followed directly from misperception.

A group inside of Microsoft believed this decision was problematic. A small skunk works were formed, which eventually wrote memos about the commercial potential for the Internet and the Web. Ben Slivka eventually authored four versions of these memos, with the fourth and final one emerging in May of 1995 as a twenty-page memo. It went alongside an eight-page memo from Bill Gates entitled "The Internet Tidal Wave." Slivka had been analyzing the outsiders for many months and had come to understand their point of view before Gates did.

The first major change to Microsoft's point of view came in January of 1995—right after Netscape released the beta version of its browser. Notably, Netscape's team of programmers had previously created Mosaic, a browser to which the University of Illinois retained the property rights and initiated a licensing program. So, at the beginning of 1995, Microsoft arranged for a license of the Mosaic browser. More than 100 firms had already taken out licenses by the time Microsoft did. As it would turn out, Microsoft's license would be the last and most lucrative of them.

The second major change came in April of 1995. The same personnel in the skunk works with whom Slivka worked arranged for Gates to surf the Web. After spending the better part of the night surfing the Web and educating himself on the Web's capabilities, which, until that moment, he had not experienced extensively firsthand, Gates' perspective changed. A month later Gates released his famous memo, The Internet Tidal Wave, announcing his change in perspective about the commercial potential for the Web and its consequences for Microsoft's actions.[17]

[17] The Internet Tidal Wave is exhibit 20 for the federal antitrust case.

The memo reveals several concerns. When he announces the change in strategic direction, Gates effectively concedes that the commercial Internet and Web developed in directions that he had not foreseen, though, remarkably, the memo never admits that error directly. Gates goes on to describe the general situation and expresses concerns that many standards developed on the Web were not Microsoft standards. He also expresses concerns about the Web's potential for developing products with functionality that users find acceptable and that bypass Microsoft's products. Additionally, he foresees the possibility for these products to use APIs (application program interfaces) developed by Netscape, which would support a value chain outside of Microsoft's control.

The first consequence of this change in views came in June 1995, when Microsoft tried to invest in Netscape, buy a board seat, and/or purchase the entire company, an event that later became fodder for immense scrutiny during the federal antitrust trial. The second response occurred in August 1995, when Microsoft included a browser as part of the Windows 95 "plus pack." This used the Mosaic browser that had been licensed from the University of Illinois in January. In other words, it included a set of features it otherwise would not have included. In December 1995 the third consequence became apparent when Microsoft announced that all browsers would be both available without charge and integrated into subsequent versions of the operating system.

It is not an exaggeration, therefore, to say that the "browser wars," that is, the fight for market share between Netscape and Microsoft, which took place primarily between 1996 and 1998, followed from Gates's memo, which followed from Netscape's entry. None of this would have occurred had Gates persisted in his misperceptions about the Internet, which were likely without Netscape's entry.

This "war" eventually took billions of dollars of investment from Microsoft, involved competition between three upgrades of browsers from both firms, employed thousands of people, and grabbed managerial attention, as well as the attention of analysts and application providers. In other words, internal memos uncovered the links between the actions from the outsider and the insider's change in perception about the value of browsing, and these changes link directly to actions in the market place.

7.4.3 Reacting to the Changing Market Conditions: IBM[18]

A rather different story arises at IBM, another insider. It too reacted to the rush created by the Netscape browser. It too changed its actions, but the manner by which IBM took these actions followed a very different path than Microsoft's. For the sake of brevity, these changes can be viewed through the lens of the career of Irving Wladawsky-Berger. Working at IBM the better part of his career after attaining his PhD, he became director of a number of projects and divisions. The newly arrived

[18] Chap. 10, Greenstein (2015)

CEO, Louis Gerstner, tapped Wladawsky-Berger for a tough assignment in 1995, namely, to become the first general manager for the IBM Internet Division. He was to put together an Internet strategy for IBM from scratch.

Two enormous problems stood in the way. First, unlike Microsoft, which strategized, albeit belatedly, to include Internet capabilities in its products, IBM did not have a strategy for the Internet/Web at all at the time. Second, the firm had just been through a near-death experience. Arguably, an Internet/Web strategy looked like a key to further prosperity, and its success could shape the employment of tens of thousands of IBM's people. Hence, solving the first issue held the potential to solve the second one, but how to do that was far from obvious in 1995. Upon taking the position, Wladawsky-Berger toured IBM's labs for electronic commerce. As it turned out, over the next few years, Wladawsky-Berger helped IBM emerge with a healthy strategy and a lucrative line of services, and he did so by adapting IBM's point of view to the Web's unique circumstances.

The company had seen something like the Web coming and had made prototypes of many services in its labs, but most had presumed the Web-like software would be proprietary software. To Wladawsky-Berger, IBM did not lack vision. Rather, all advanced prototyping in IBM had anticipated proprietary software, not the open standards of the Web and the inexpensive software approaches to building services. Supplying services required inexpensive inputs and open software, but for years IBM had developed prototypes on the basis of inappropriate assumptions. Thus, IBM's point of view changed the most during Wladawsky-Berger's first year as he pointed out that the company had identified the demand but not the right way to provide it.

As mentioned, IBM struggled to make the transition from proprietary to open software. Many of IBM's clients—large enterprises—had large investments in proprietary software and needed help integrating the commercial Internet into their businesses processes. Because IBM had not foreseen the change in the cost of inputs, it had not developed any prototypes for transitioning large enterprises to use such inputs. To survive, it had to invent an approach for doing so.

Oversimplifying a complex and ultimately successful solution for the sake of brevity, under Wladawsky-Berger, IBM invented a type of software known as *middleware*. Integrating old IBM installations with new technology turned out to be productive, because IBM reused existing capital for new purposes instead building processes and operations from scratch. Yet, IBM had not developed the right software because its prototypes had been premised on the wrong conception of how the end product would function and where it would get its components.

As in Microsoft's case, IBM's management got its motivation from the fear that buyer revenues would go to other firms. Helped, however, by the underlying suspicion that many electronic commerce entrants did not know how to serve large enterprises or were not developing appropriate products and services for IBM's client base, IBM changed its point of view about what technologies to use. That led their management to change their point of view about how to develop them. In addition, it also added a new layer to its point of view about demand, specifically, what users wanted.

Ultimately, IBM developed pioneering prototypes for middleware for order fulfillment and logistics. Although these applications were unglamorous, functional, and complicated, there were a large number of potential buyers for them, many from among IBM's traditional clients. In this way, IBM became a leader in providing technology to enable the "transparent firm." That is, it helped firms offer services that linked internal logistical information with queries from buyers. It also became a key part of one of the greatest turnarounds in corporate history.

Summarizing, the established insider, IBM, would not have committed resources without prompting from Netscape and those following Netscape. Incorrect assumptions about the supply of inputs were embedded in its own prototypes. Yet, unlike the first example, here the links between outsider and insider's actions differ. While IBM perceived the demand for electronic commerce, it had constructed its prototypes upon a presumption about supply that did not have relevance to the market conditions in 1995. Changing its point of view about the use of components permitted IBM to alter how it addressed the new commercial opportunities.

7.4.4 A Chain of Adoption as a Reaction: Wi-Fi[19]

The development of Wi-Fi illustrates another manner in which outsiders can act as catalysts. Many insiders had loads of experience trying to develop Wi-Fi, but, like IBM with the Internet, they predicated their experimentation on the assumption of Wi-Fi being proprietary. In contrast, Apple—the outsider—included Wi-Fi for free, which triggered a chain of events. While all the other examples of an outsider's entry into the market created some degree of competitive pressure, the history of Wi-Fi differs in the sequence of events. Here, the outsider triggered a chain of adoption—not a competition between two similar products. Additionally, competitive incentives drove the chain of adoption. Most important, those cascading series of actions eventually changed an entire supply chain. The outsider here is Steve Jobs, the newly returned CEO of Apple, and the insiders are all the existing OEMs (original equipment manufacturers) in the supply chain for personal computers.

Jobs sought to take a laptop, an existing product at Apple, and add one additional capability. The additional capability was easy to describe and difficult to implement. Jobs wanted a laptop that could send and receive data without wires. In practice this required a "data-antennae capability" inside a laptop coupled with a "data-antennae" capability in a server.

Jobs concluded that Apple could use a technical standard from the Institute of Electrical and Electronics Engineers (IEEE) committee 802, which had been attempting to design standard protocols for wireless local area networks (LANs) since the early 1990s. A standard had been released in 1997, but flaws had become readily apparent. The leader of the IEEE effort came from Lucent; and the standards were in the midst of improvement when Jobs arranged a meeting with the team at

[19] Chap. 14, Greenstein (2015)

Lucent. Jobs believed Lucent could produce the electronic components required for both making a wireless server and adding the wireless capability to a laptop.

The meeting was a one-sided conversation in which Jobs described his vision and the price he wanted to pay, which Lucent eventually agreed to. The components became part of the product called the Apple AirPort. It was released with great fanfare in July 1999. Dramatically, on stage, Jobs took a hoop and put it around the laptop to prove that no hidden wires supported the transfer of data.

Jobs actions motivated a response by Michael Dell, the CEO of Dell computers and the largest provider of PCs using the Windows operating system. Dell had abandoned efforts to develop a wireless capability for Dell laptops in 1993. He phoned the same Lucent team that had supplied Apple and arranged for a supply of similar components. He also arranged for Microsoft to alter Windows to support wireless capabilities. Dell's products—a wireless laptop with an operating system that supported the device and wireless router—were released in 2001.

Like many of the other examples previously discussed, at this point, the marketing of Wi-Fi illustrates how an outsider, Jobs, had a different point of view about how to create value and a competitor reacted. Yet, the difference is how Jobs' action altered an entire supply chain.

Other OEMs reacted and followed Dell's lead. The reaction had a multifold and cascading effect. First, many laptop makers began procuring cards to enable their laptops to have similar capabilities. Meanwhile, many firms entered the market to make those cards. Additionally, many firms entered the market to supply wireless routers.

Next, the biggest supplier of computer components, Intel, responded with a program that became known as *Centrino*. With Centrino, Intel redesigned the laptop motherboard and gave away the design. The new design included an antenna and a new set of chips to support its work with the other microelectronics on the motherboard. The program also included a large certification program for OEMs, where they "earned" the Centrino brand by successfully implementing the design in their laptops. Intel also began funding support to provide geographically ubiquitous Wi-Fi, such as programs to subsidize certification of airports and hotels that supplied routers.

Similar to Britannica, Intel had to deal with internal struggles in the face of the new product. The Centrino effort involved taking resources away from the desktop division and devoting them to the laptop division, an action that the desktop division fought. The Intel CEO, Craig Barrett, had to settle the conflicts that resulted, and, when delays and snafus interrupted Intel's best laid plans, the CEO had to publicly recommit to the strategy, putting his prestige and job on the line. During this upheaval, Intel's largest customer, Dell computers, resisted using the Centrino program and refused to cooperate during its first year, preferring to market its own branded versions of wireless routers and laptops. Ultimately, though, Centrino was such a success in the marketplace that after a year Dell ended its opposition and cooperated with Intel.

Said simply, the outsider, Steve Jobs, acted as a catalyst. The evidence is most obvious in the behavior of the largest PC supplier, Dell, which would not have devoted resources to wireless LANs as quickly without this prompting from Jobs. A similar observation holds for other OEMs and suppliers. Finally, Intel would not have taken its actions in the absence of the outsider's catalytic actions.

7.4.5 Chain of Reactions in a Partnership: Broadband Carriers[20]

The example of Wi-Fi illustrates a situation in which an outsider partnered with insiders and a supply chain altered the features available to users. As in that situation, outsiders often need insiders to realize their commercial aspirations, and that is especially so at early moments. Not all such situations turn out well for the aspirations of outsiders. Insiders may benefit from the partnership, but if they do not see benefits, they tend to act in ways that hinder the outsider.

The following example illustrates an outsider, Netflix, who, out of necessity, partnered with many insiders, broadband carriers, who, for a variety of business reasons, lacked enthusiasm for the partnership. When the experiments of Netflix took a direction that raised costs for the carriers, Netflix found itself with an unwilling participant. The different points of view exacerbated the conflict. The resolution of the conflict was less essential for this illustration than the fact that it was present; it illustrates how an outsider can generate reluctant actions in an insider, who otherwise would not have taken such action.

Netflix started as a video rental business by mail. It had a strong customer orientation and began its competitive rivalry with Blockbuster by stressing the discontinuance of return fees for late returns. As the business grew, Netflix also began stressing the availability of titles (i.e., not limited by shelf space) and its recommendations for bundling demand.

While music streaming had already shown some potential as a commercial service, video streaming had been confined to short lengths, such as YouTube, due to the bandwidth required. Only pirates had made a practice of streaming full-length movies, and often these efforts used Torrents, which did not require continuous service.

Netflix, though, began experimenting with streaming movies well before others did, and it built this new business on the experience it had supplying titles to households. The service proved to be extraordinarily popular, and the number of customers grew rapidly. As it grew, Netflix began to move large volumes of data to its subscribers. By 2010 it became the largest provider of data streams in the Internet, and by 2012 it far surpassed any others. Its success became a source of tension for Netflix's business partners.

Netflix and broadband carriers were business partners out of necessity. Netflix was a specialist and needed carriers to carry their data to homes. Broadband carriers

[20] See Greenstein and Norris (2017).

needed content on the Internet to justify household purchase of broadband service, and this symbiotic relationship worked well for both parties when Netflix was small. As Netflix's success grew, two consequences arose:

1. The expense of success: Netflix faced a tremendous and novel operational problem, which no firm had ever confronted on such a scale. The firm found expenses for its content delivery network (CDN) on Akamai's systems to be a major cost. It tried to reduce those costs through a variety of approaches, such as moving data across the national backbone and across many other CDNs. Netflix began offering to install a CDN devoted to its shows inside networks and at Netflix's expense, and many small ISPs (Internet service providers) agreed to this. None of the large ISPs came to such an agreement, and it was rumored that they demanded collocation fees, which they had successfully gotten from other large content firms, such as Google/YouTube, Facebook, and others. Netflix refused to pay, and the two sides reached an impasse.

2. The burden of success: Netflix faced an escalating confrontation with its many partners, especially broadband carriers, which had to carry the data to end users. The carriers requested advanced notice of future traffic needs and moved to support their own investment priorities. Netflix experienced outsized growth that did not work well within the established system. Consequently, its very success left Netflix's partners trying to manage data flows at a much faster pace than carriers anticipated.

While the impasse partially arose from the costs and burdens of supplying a growing new service, it also highlighted a conflict of interest. Some of the carriers—particularly those in the cable business—also had a thriving business for video-on-demand in homes. The success of streaming movies threatened some of that revenue.

To be clear, that alone does not suggest that the carriers had incentives to slow down Netflix's success, since streaming service also could motivate new purchases of broadband service. It was an open question whether the additional revenue gained by carriers from new broadband customers exceeded the losses from foregone revenue in video-on-demand business.[21] (That said, it is also far from clear that such finely tuned calculation informed decision-making among the largest broadband carriers.)

As time passed and the impasse continued, Netflix experienced more growth. Lacking CDNs inside the networks of large ISPs, Netflix found itself moving large volumes of data into ISPs "from outside the ISP's network." These streams used national backbone firms in ways that the ISPs had not planned for, and, accordingly, despite increases in traffic, they did not make investments to carry the traffic from those locations. This would have involved investing in "ports" at the handoff from

[21] Little evidence at the time suggested that streaming movies was leading customers to "cut the cord," so this is not relevant to the trade-off. In addition, Hulu, a streaming service, was a marginal effort for the carriers involved.

the national backbone to the ISP and investment in the infrastructure behind the ports to carry the traffic to users.

Eventually the traffic volumes exceeded capacity, and users began to experience repeated delays in viewing streaming. That made the dispute and impasse public for 5 months in late 2013 and early 2014.

At the time it appeared that Comcast led the negotiations and the other three large national carriers at the time—Verizon, Time Warner Cable, and AT&T—followed Comcast's lead. All refused to invest in ports or in any other part of the network related to carrying such volumes of traffic. Not coincidently, all refused to accept Netflix's CDN program without a collocation fee.

While this situation hurt the customer experience with Netflix, it also hurt Netflix's ability to gain more subscriptions. Different opinions made it into public discussion. Some portrayed Netflix as the innovative entrepreneur with a new business, whose operations challenged a system erected for the advantage of the largest firm. Others portrayed Netflix as an obstinate entrepreneur that tried to use networks intensively without paying for the consequence, as other large data providers had.

After the 5-month impasse, they reached a deal, but the terms never became public. Only its general outline became known: in exchange for a fee for a fixed period of time, the carriers agreed to upgrade their networks. Both the fee and investment in an upgrade to accommodate streaming were novel for this partnership. From later filings of income statements, it became clear that the fee was not "material" enough to shape profitability much for either side. This suggests the confrontation was more about setting a precedent over the fee and the upgrade behavior, and not about the level of money that changed hands.

The actions taken to resolve the conflict are less essential than the general point: when the interests of the outsider and insider aligned, then both had reasons to cooperate in their partnership. When their interests did not align, as happened when the outsider drove up costs for the insider and the partners had different expectations about how the growth could be handled, a standoff emerged. In this case, the standoff motivated the outsider to start assuming some of the costs associated with growth.

7.4.6 Summarizing Reaction

What general lessons emerge from these examples of reactions by insiders? Exposure to a different point of view motivates established firms to undertake experiments they might not have done. They examine opportunities for creating new value that they had not perceived, and they alter the prototypes for using technology for their customers. Insiders react to outsiders due to one or more motivations. They may seek to (1) protect revenue through development of new products and approaches to distribution, (2) develop a new prototype and business to meet a demand or type of market they had not anticipated, (3) adopt new inputs into their prototypes and businesses, and (4) renegotiate their relationship with an outsider.

In most instances, the outsider's actions come as a "surprise" to the insider, and an effective response requires changes in planned activities and the priorities for investment. That suggests the importance of the outsider remaining hidden from the insider for a time. No simple reason or observation characterizes why outsiders remain hidden from insiders. Mistakes arise due to analytical error or internal organizational conflict that interferes with accurately perceiving events. Outsiders may also deliberately try to remain hidden, especially if it delays a competitive response from an insider.

Consequently, an environment can be more nurturing for either outsider or insider. In some settings, for example, analysts track all participants, or insiders employ market analysts themselves. Such behavior can remove hidden actions. Quick action or technology rushes heighten the potential for surprising insiders.

The forgoing also identifies the importance of experimentation in the market place by both insider and outsider. Just as outsiders use actual production, distribution, and sales to learn about how to refine important features of demand and supply, so too do insiders use their own market experience for a similar purpose. And both potentially can use each other's experience to learn additional lessons.

7.5 Conclusion

This review of prominent confrontations between outsiders and insiders creates an archetype. That archetype consists of two broad stages. The entry phase occurs during the time that an established firm has a leading position in a market, while the outsider has a distinct point of view about how to create value. The outsider's view may remain hidden or unrevealed to the consensus for a time, either because the outsider invents without commercial motive or expectation of competition or because the entrepreneurial effort becomes part of a "rush" that moves more rapidly than the insider anticipated. This period of time allows the outsider to grow faster, avoid failure by reaching customers before insiders, and, in most cases, surprise the insider.

During the entry phase, the outsider begins with a period of "experimenting," namely, developing a commercial approach to its point of view with limited interaction in the market. At early moments in commercial experience, the outsider experiments with prototypes that appeal to users and/or experiments with lead users. Sometimes this experimentation is situated in universities; most often it is in markets. In all cases, these experiments support inexpensive and extended prototyping with technical and distributional attributes of business, sometimes with the help of insiders, such as VC financing. At some point this experimentation becomes successful enough to generate forecasts about the growth of a large-scale market.

The second broad stage begins when the insider learns enough and decides to react. During this second stage, the established firm and outsider both experiment, by attempting to learn about open-ended questions regarding features of demand, operations, and ways of organizing commercial actions. The established firm either changes its point of view or not, and a competitive confrontation takes place in the market. Experimentation continues until both insider and outsider settle into competition, which is sometimes differentiated. The outsider accumulates assets and/or capabilities affiliated with addressing prior disadvantages of outsider status. Meanwhile the outsider and (maybe) the insider learn about features of demand and operational strategy.

Three features arise in every example. First, learning takes time—for both outsider and insider. Because the value of the product remains unknown or hidden, firms must take time to learn about the product's experience in market. Reorganization of production and distribution for the new opportunity also takes time. Second, and perhaps most difficult, competitive situations cannot play out instantaneously. All participants, both insiders and outsiders, must plan and invest and wait for user choices and operational details to become widely known so they can assess the value of their actions. Third, the very definition of the "market" evolves over this time, as outsiders displace insiders with new products or insiders imitate outsiders with changes to their own products. Indeed, the very definition of participating in the market and "industry" evolves with these changes to production and distribution—and industry actually has no singular unchanging meaning in any of these examples. These observations confirm that the analysis adds up to distinctly Schumpeterian situations.

This archetype suggests that asymmetric innovation incentives shape insider and outsider actions. Those asymmetries arise because insiders and outsiders perceive the same situation from different time scales and with distinct and different information about operational strategy, product design, and/or distribution strategy. Outsiders approach the new commercial opportunity with little experience or limited experience, while insiders invariably approach the opportunity with a cornucopia of experience with operations and distribution, which may or may not generate conflict and biases toward their approach to the new opportunity. It would be a remarkable coincidence if insiders and outsiders perceived the same profit potential and/or shared the same incentives to address the new commercial opportunity.

More broadly, these different incentives undermine predictions about the outcome of competition. That also represents a limitation of the archetype. In many of the examples, market analysts could not forecast winners at the outset of competition. In some cases the features of the winning outcome emerged *during* competitive interaction and as a result of the confrontation, which makes it particularly unpredictable. While users benefit from many trials from its entrepreneurs for every new opportunity, individual successes cannot be forecast in advance. Schumpeterian confrontations, therefore, are not inevitable in this situation. In addition to the usual factors that reduce the likelihood of a startup's success, an outsider requires a nurturing environment for experiments and sufficient time to work out key attributes of its business.

The archetype favors competition policy that enables unrestricted entry, and it favors policies that support institutions that permit a "thousand flowers to bloom." This fosters a policy outlook with great humility about any specific participant's ability to predict the identity of entrants because in settings with dispersed technical leadership, competitive pressures can arise from many corners. The point of policy is to raise the likelihood that it does arise *from at least one entrant* and grow into a form that places competitive pressures on established firms. Hence, policy focuses on nurturing the factors that encourage entry in settings with dispersed technical leadership—e.g., open governance, specialization, and mutually beneficial partnerships with insiders.

These insights come with limitations and potential pathways for additional insight. This archetype focuses on prominent outsiders, and it focuses on those outsiders that confronted insiders and does not analyze the setting where outsiders sell out to established firms through acquisition or merger. Selling out can and does shape innovation incentives—and the likelihood of Schumpeterian creative destruction. It awaits further analysis of how insiders integrate an outsider's view and how outsiders cooperate with insiders when they begin their commercialization activities with distinct points of view. There is also considerable room for subsequent research about the generalization of this framework and the scope of settings over which these insights apply.

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