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Why is "Ether" in Ethernet?

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An interpretive analysis of discourse by physicists in the mid- to late 19th century and electrical engineers in the mid- to late 20th century identifies cognitive and normative dimensions of the "ether" metaphor in relation to Ethernet, a standard for local area networks and a founding infrastructure for the Internet. This analysis reveals contradictions between idealized representations of information networks and the methods used to capitalize on these networks. In so doing, the research demonstrates how the use of metaphor ascribes meaning to emerging technologies in ways that function differently during the development and commercialization phases. This article concludes by asserting the utility of a comparative framework for the analysis of discourse before and after a technology enters the marketplace.

Keywords: *networks, historiography, Internet, metaphor, Ethernet, ether, information*

Introduction

Ethernet is a local area network (LAN) system, which means it connects computers and digital devices within a small geographical area, such as within an office building. Electrical engineers developed Ethernet in the 1970s at the Xerox Palo Alto Research Center (a.k.a. Xerox PARC) in Silicon Valley. By the mid-1980s, it was the most popular networking technology for private industry worldwide. Throughout the 1980s and early 1990s, these intracorporate networks proliferated, were linked together, and became one of the foundations for Internet infrastructure (Abbate, 1999, pp. 187–188; Burg, 2001, pp. 74–77; Crovitz, 2012). At the development and commercialization phases, Ethernet was framed in ways that appealed to various constituencies: Xerox patent attorneys and the Xerox PARC community during development and the Institute of Electrical and Electronics Engineers (IEEE) and prospective Ethernet hardware vendors during its commercialization phase. The engineers at the Xerox PARC employed the "ether" metaphor in ways that helped make sense of their ideas and also in ways that structured the future of digital information networks. An analysis of these "cognitive" and "normative" functions of metaphor (Wyatt, 2004) sheds light on the assumptions and aspirations that helped shape Ethernet in particular, and the Internet in general.

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The ether metaphor was used to communicate features of Ethernet such as the network's capacity to make information equally accessible throughout the research center. In addition, the metaphor signaled an institutional commitment to shared knowledge across different scientific disciplines within a research community. As Ethernet left the Xerox PARC and entered the marketplace, it carried with it discourses of equal access to ubiquitous information as a means to build community. However, the tactic used to commercialize the networking technology depended on privileged insiders within the Ethernet community in a position to benefit from the strategic control of information. This example attests to the usefulness of comparing the different functions of metaphor during the development and commercialization phases of a technology. In the case of "ether" and Ethernet, imperatives of the technology's development culture instilled meanings that were strategically deployed during the commercialization phase.

Why is “ether” in Ethernet? Not only is "ether" part of the name for the LAN system, the ether metaphor was used extensively in documents that circulated within the Xerox PARC. Other metaphors were considered, but “ether” became the primary communicative tool for the new technology. The ether concept has a long and storied history dating back to antiquity.[1] For example, in Book III of the *Physics*, Aristotle (trans. 1983) refers to ether as an unchanging cosmic element from which the stars were made (p. 30). As Milutis (2006) explains, the modern uptake of ether contains traces of the transcendental properties found in classical definitions of the term (p. 4). In the *Principia*, Newton (1687/1846) refers to an ether that "freely pervades the pores of all bodies" (p. 321). Milutis (2006) describes this ether as "the irrational element of Newton's rational universe" (p. 8) because the concept is used to explain immaterial functions within a mechanical universe. By the 19th century, the ether metaphor was widely used in both scientific and spiritualist circles to denote ubiquitous, immaterial forces such as the transfer of energy.

Among spiritualists, the universal accessibility of ether stood for nonhierarchical modes of social organization, as the notion of "ubiquitous electric energies resonated more with the new position of a growing commercial class" (Milutis, 2006, p. 5). Thibault and Bardini (2008) connect ancient, early modern, and contemporary ideas of ether via an interpretation of a longstanding ether mythology that offers infinite possibilities for human connection with a paradoxical loss of intimacy (p. 372). This ether myth, which is bound up with the myth of Theseus, was articulated first to wireless telegraphy and early radio, then later to wi-fi networks and cell phones. The modern use of "ether" failed to account for the paradoxical implications of the myth, such that wireless media was promised to bring about greater human understanding without recognition of the costs involved (p. 368). Concomitant with the use of "ether" to refer to early wireless modes of communication, physicists in the 19th century also used ether as a signifier for the substance through which energy traveled. In the early 20th century, the concept largely fell out of favor as the paradigm shifted from a Newtonian model based on physical forces to a

[1] For the classical definition of ether (sometimes "Aether"), see the introduction of Milutis (2006). On the modern revival of “ether” previous to the Victorian era, see Cantor and Hodge (1981) and Chapter 1 of Whittaker (1910).

model shaped by Einstein's theory of relativity.[2] In the 19th century, however, the ether metaphor was used to describe a mysterious, universal medium that connected everything on earth and beyond.

Robert Metcalfe, an engineer at the Xerox PARC and one of the principle architects of Ethernet, often tells an origin story in which he borrowed the ether metaphor from Victorian era physicists (Metcalfe, 1985, p. xi; Metcalfe, 1994, p. 83; Metcalfe & Boggs, 1976, p. 396). In "ether," electrical engineers found a vocabulary for making sense of information exchange within local area networks. This article focuses on the ether metaphor in the discursive contexts through which Ethernet was developed and commercialized in addition to physicists' discourse from the mid- to late 19th century referenced by Ethernet architects. The analysis is of primary historical documents consisting of technical reports, patent applications, journal articles, and Xerox PARC memoranda. In these texts, "ether" plays an important role, but technology is not determined solely by language. Rather, words work in conjunction with the social practices of individuals and the material effects that the technology creates (Bazerman, 1999; Wyatt, 2004). Metaphors for technology in history help us understand the politics of technology in the present (Lyman, 2004), and an historical examination of metaphor runs parallel to scholarship that looks to contested contemporary terms to show the rhetorical work through which technology is understood and evaluated (for example, "platform" in Gillespie, 2010).

An examination of the discourse through which Ethernet circulated during its development and commercialization phases reveals how language played a key role in smoothing over contradicting values held by members of what Turner (2006) refers to as the New Communalist wing of the postwar counterculture in the United States. Distancing themselves from the overt political agenda of the New Left, New Communalists embraced an idealized notion of universal information access as a means to level bureaucratic hierarchies of the industrial era. Nevertheless, ideals regarding information equality did not translate to a broader egalitarian social agenda as New Communalists, such as the Ethernet architects, led the charge toward a networked mode of production in the closing decades of the 20th century. Furthermore, the use of the ether metaphor during Ethernet's development phase sheds light on a way that natural science discourse shapes the meanings we make for new technologies, and in this regard, the research follows in a direction suggested by Peters (2003) to look to fields other than the humanities and social sciences as an influence on contemporary communication practices. The analysis demonstrates how the normative functions of natural science metaphors can serve contrasting purposes for when technology is incubated within a research institution versus for when the technology is marketed as a commodity.

This article examines the cognitive and normative dimensions of the ether metaphor in the three sections that follow.[3] In the first of two sections dedicated to exploring the development phase of

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[2] As Dalrymple (2002) argues, ether gained traction as an explanatory concept among many physicists for a couple of decades beyond the 1905 publication by Einstein of the theory of special relativity, and although the concept went out of fashion in natural science, the idea of ether held tremendous cultural relevance in spiritualist circles as well as in modernist painting and sculpture throughout the early 20th century.

[3] The sections intertwine analysis of the cognitive and normative dimensions since the ether metaphor often served both descriptive and ideological purposes at the same time. See Edwards (1996) as another

Ethernet, the ether metaphor conveys a particular wiring structure (a.k.a. topology), a decentralized control protocol relative to previous LAN design, and a logic of "packet switching" positioned as a new form of information transmission that differs from a logic of "circuit switching" common to telephony. The next section explains how the ether metaphor communicated cultural values of the Xerox PARC, with its ideals of universal information access and interdisciplinary collaboration across the sciences. The penultimate section of the article investigates the commercialization phase of Ethernet in which the metaphor is used to help naturalize the ethos of universal and equitable information access, while simultaneously using a strategy that depended on withholding information to benefit particular privileged individuals. The conclusion argues for the utility of comparing the different functions of metaphor within the development and commercialization phases of a technology.

Packets, Topology, and Protocol

"Ether" served cognitive and normative functions during its development phase as it helped convey ideas concerning the logic of distributed computing, the particular wiring structure of Ethernet, and the way information traveled through the Xerox PARC network. The Ethernet architects established notions that the LAN was ubiquitous and readily accessible throughout the research center by referencing the use of "ether" in the 19th century. In so doing, the "ether" in Ethernet shared characteristics of Victorian-era experiments that treated ether as having ambiguous properties that resisted representation and were not directly observable. It is important to note that the use of the ether metaphor did not materialize out of nowhere; rather, it was shaped by institutional mandates. Administrators at the research center stated explicit networking needs (Pake, 1985, p. 58) that laid the groundwork for the formation of Ethernet and the language used to describe it. One of the hallmark innovations at the Xerox PARC was the Alto, one of the earliest desktop computers on which the IBM PC and Macintosh computers were modeled. Instead of relying on a central mainframe computer, PARC researchers had an Alto computer on each desk. Members of the computer science division were given the task of finding a way to create a conduit for data transfer between Altos as well as to the newly created laser printer (Hiltzik, 1999, p. 184).

Xerox recruited people who had worked on established digital information networks such as Robert Metcalfe, an engineer and Harvard PhD candidate. He previously had held a job at the Advanced Research Projects Agency (ARPA), and while a master's student at MIT, he had connected the mainframe computer at Project Mac to the ARPA network (a.k.a. ARPANET). Metcalfe, along with Stanford graduate student David Boggs, worked closely with the development of Ethernet. Charles Thacker and Butler Lampson provided essential advice along the way. In a series of three memos, written in April through May of 1973, Metcalfe first described the proposed LAN. The first two memos call it the "Alto ALOHA Network," with "ALOHA" referring to the ALOHAnet, a radio-based computer network designed for use among the campuses of the University of Hawaii scattered throughout the Hawaiian archipelago (Abramson, 1970). In the third memo, dated May 22, 1973, Metcalfe acknowledges the influence of the

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example of how metaphor can perform both functions simultaneously. In the "closed world discourse" through which the United States waged the Cold War, metaphors such as war "games" made sense of, as well as legitimated, military practices and the wielding of state power (Edwards, 1996, pp. 14–15).

ALOHAnet, but he suggests that the network be referred to as "the ETHER Network" (Metcalfe, 1973a). Most generally, the ether in Metcalfe's memo refers to the means of network connection. He wrote, "The essential feature of our medium—the ether—is that it carries transmissions, propagates bits to all stations" (p. 1). Ether, therefore, fulfilled the primary function of the LAN as a means to link all Altos within the PARC. At the same time, the metaphor reflects 19th century usage in regard to the ubiquity of ether.

In the 13-page memo from May 22, 1973, Metcalfe referenced "ether" 53 times. In the first journal publication describing Ethernet, the authors employed "ether" 90 times in the 10-page article (Metcalfe & Boggs, 1976). The prevalence of the word in these influential texts speaks to the significance and varied purpose of the ether metaphor as a way to make sense of and promote qualities of the networking technology. A common reference point for Ethernet architects (see, for example, Metcalfe & Boggs, 1976, p. 396) was the Michelson-Morley (1987) experiment in which two American researchers failed to detect the influence of the ether on the Earth's movement. Metcalfe and Boggs affectionately dubbed the two altos on which they worked "Michelson" and "Morley," thereby further acknowledging the ether influence (Metcalfe, 1994, p. 86). The Ethernet engineers used terms from Michelson and Morley, such as the "passive" qualities of the ether, and the type of ether relevant to Ethernet design (i.e., the "luminiferous ether," or light-bearing ether). Metcalfe (1994) wrote, "The new ether, in Ethernet, is also a ubiquitous passive medium for the propagation of electromagnetic waves, in our case, data packets" (p. 83). In other words, early Ethernet discourse equated data transmission to the movement of light as it was understood near the end of the Victorian era.

During the time of the Michelson-Morley experiment, numerous ether theories were propounded as physicists attempted to explain modern notions of energy as a physical force that made sense within a Newtonian paradigm (Clarke, 2002, p. 21). For models of the luminiferous ether, light between the earth and the sun moved not through a vacuum but through the invisible, yet material substance. The exact properties of ether were unknown and highly contested. This ambiguity of the luminiferous ether was reflected in the deployment of "ether" by Metcalfe and Boggs. In early documents, "ether" worked as a sliding signifier for different media used in data transmission. In the May 22nd memo, for example, Metcalfe (1973a) wrote that "it seems wise to talk in terms of an ether, rather than 'the cable,' for as long as possible" (p. 1). In its earliest schema, the "ether network" could transmit data via a mix of media that included coaxial cable, radio waves, telephone circuits, and microwaves. In fact, the memo contained a diagram in which lines connecting terminals were labeled "cable ether," "telephone ether," or "radio ether" (p. 1). The same flexibility in the referent for "ether" remained in the original Ethernet journal publication (Metcalfe & Boggs, 1976, p. 399). In this 1976 publication, Metcalfe and Boggs outline the central features of the technology, with a particular focus on the Ethernet protocol. The article is notable for exemplifying the research ambitions of Metcalfe and Boggs, and by extension, the Xerox PARC. In addition, the publication offers the first appearance of the network abbreviated from "ether network" to the brand name of "Ethernet."

Mid- to late- 20th century digital information networks such as the ARPANET and ALOHAnet consolidated data into discrete units called "packets," and the way that packets moved through space was discursively positioned as a unique form of information transfer. Postwar information networks that used packets were referred to as decentralized, such that the routing of messages is based on an intelligence built into the hardware and software, whereas the previous mode of circuit switching was modeled as concentrated and hierarchical (Abbate, 1999, p. 11). The Ethernet designers employed a packet-based design, and the movement of information was explained via the ether metaphor as something not directly observable that couldn't be understood by tracing a precise pathway from one particular point in space to another. Instead, the ether "propagates bits to all stations" (Metcalfe, 1973a, p. 1). A packet could travel to any node in the network on its way to its destination, meaning that data could be moving anywhere within the research center at any given time without anyone knowing it.

In addition to the requirement that the PARC network link altos and laser printers, the LAN had to be able to accommodate unplanned growth without disrupting the flow of information (Burg, 2001, pp. 64–65; Hiltzik, 1999, p. 191; Pake, 1985, p. 58). As a result, the topology of Ethernet differed from the designs of many existing networks (Metcalfe & Boggs, 1976, p. 397). The wiring structure of the ether network was referred to as a "branching bus," meaning that it had no dedicated beginning, ending, or centralized site for transmission. The topologies of LANs were usually described using words that point to objects that exist in the real world (e.g., "star," "mesh," "ring"); however, Ethernet topology didn't easily allow for such description. As Metcalfe (1994) wrote, "The ether was not a star, not a mesh, not a ring, but an ether, a branching bus, an unrooted tree, passive, without central control—in the simplest case, a coaxial cable terminated at both ends" (p. 87). Here, Metcalfe first defined “ether” in relation to other local network topology signifiers, but he failed in his effort to find a proper visual metaphor. An "unrooted tree" conveys the ubiquity and flexible growth possibilities of the LAN, but the signifier has no stable referent in the material world. Instead, Metcalfe settled for describing technical properties of the network, namely the "passive" quality of its carrier medium, which conveyed the lack of central control and also reflected the similarities between the ether in Ethernet and the luminiferous ether of Michelson and Morley.

The difficulty in representing Ethernet topology echoed similar problems with the ether of old. Victorian-era physicists were unable to find proper analogies to describe the alleged super medium through which light was said to travel. Was ether a fluid, a solid, a field, or something analogous to air? James Clerk Maxwell developed a series of equations that provided a mathematical basis for electromagnetism, and rather than try to understand the underlying physical reality of the ether, Maxwell's equations eventually took the place of ether models as the prevailing means of describing the movement of light (Hunt, 1991, pp. 77–107). Ethernet engineers were not inclined to favor theoretical explanations nor could they just write algorithms for the LAN because they were charged with the task of building a functional network. The ambiguity of "ether" worked well to describe that the network could be expanded to serve any location within the research center, but when the engineers tried to describe its underlying physical reality, they ran into the same problems as had the 19th century physicists.

"Ether" was also used to describe the nondeterminism of the Ethernet protocol. Because nodes on the network shared the same communication medium, packets were likely to collide from time to time. From the design of the ALOHAnet, Metcalfe borrowed the idea of having a random method for retransmission of packets to solve this problem (Metcalfe, 1994, p. 82). The assumption was that if packets from two terminals collided, and if there were a random interval of time before a packet was resent, the two packets would not be likely to collide again (Abbate, 1999, p. 116). However, this random retransmission method meant that there was no absolute guarantee that a packet would reach its destination (Burg, 2001, p. 63). This so-called "nondeterministic" aspect of the Ethernet protocol was a focus of much criticism during the early years of Ethernet's commercialization phase (Metcalfe, 1985, p. xvii). The randomized retransmission was described as a "best efforts" system (Metcalfe, 1973b, p. vi), meaning that data arrived with a high probability of success, but that its arrival was not guaranteed. In "ether," the designers of Ethernet found a way to make sense of the indirect means through which one might observe the transmission method of packets.

In the late 19th century, the inability to find experimental proof of the existence of the ether helped gain traction for Maxwell's equations as a stand-in for understanding the essence of the ether itself. As Bruce Hunt (1986) explains, the ether was "gradually stripped of most of its physically detectable properties" (p. 111) throughout the 1890s, appearing more and more mysterious until it was mostly discounted. This measurement difficulty is evident in the design of the Michelson-Morley experiment of 1887 in which the detection instrument was built to measure not the actual ether but to measure instead the effect of an ether "wind" on the movement of the earth. The indirect means of observing the ether by Victorian-era physicists mirrored the design of the Ethernet protocol, which enabled it to keep track of collisions for the sake of retransmission, but the engineers left it to higher level protocols to measure the success of the arrival of information. The elusive qualities of the ether within the discourse of late 19th century physics worked well as a means to promote the similar ambiguities of the ether network. The lack of point-to-point transmission in packet switching, the flexible but nonrepresentational dimension to the LAN's topology, and the indirect means by which message transmission could be verified all share qualities similar to the Victorian notion of "ether" referenced by the Ethernet architects. These functions helped reinforce the idea that Ethernet, like the "ether" of the 19th century, was omnipresent. However, Ethernet discourse at the PARC didn't just position the technology as ubiquitous; rather, the ether metaphor helped establish notions that the network had the capacity to be universally accessible and to be a force for community building.

Community and Universality at the Xerox PARC

The ostensible goal for the Xerox PARC was to create a new "architecture of information," a phrase championed by Xerox CEO C. Peter McColough (Perry & Wallich, 1985, p. 62; Smith & Alexander, 1988, p. 50). However, founding director George Pake had additional goals to create a culture that blended the traditional and computer sciences as well as to model the PARC on academic and state-funded research centers (Burg, 2001, p. 76; Hitzik, 1999, p. 60; Pake, 1985, p. 57). The use of "ether" in Xerox PARC materials during the development phase of Ethernet can be seen in relation to the interdisciplinary culture of the PARC. The "ether" in Ethernet helped build a bridge between the natural and computer sciences, and this helped reinforce a sense of community at the research center. The ether metaphor communicated the necessity of equal access to information within the community. In this regard, the Ethernet discourse fit with and helped shape the culture of the institution, which was inspired by the ethos of the New Communalists who valued information sharing, community building, and the use of technology as a means of individual and collective transformation (Turner, 2006, pp. 111–118). In the ether metaphor, engineers found a way to explain what the LAN meant for the culture of the Xerox PARC and a way to make sense of the New Communalist values central to the institution.

Xerox executives wanted the PARC to be built near a major research university, and Pake (1985) chose Stanford, where he had been a professor of physics (p. 54). In addition, Pake had also taken a turn through academic administration where he pushed for interdisciplinary cooperation, and he put a particular emphasis at the PARC on fostering interaction between physics and computer science. His design for the research center included three units: computer science, systems science, and general science (Hiltzik, 1999, p. 55). The general science unit was modeled on the academic research tradition, and the PARC community fostered interaction across units. For example, the physicists in the general science unit collaborated with the computer scientists by helping the latter understand the electrical behavior of certain materials (p. 152). Physics, in particular, offered a model for research, as Pake (1985) wrote,

> Because I found computer science in 1970 to have a very limited academic research tradition, I made a persistent effort to fund and equip real experimental laboratory investigations at PARC, much after the tradition of my own established research field, physics. (p. 57)

The ether metaphor, taken from the history of physics, helped bridge the divide between natural and computer science, thereby fitting into a discursive system that valued cooperation and communication across previously separate fields. In a clear reference to the cybernetic tradition, Pake created a "Systems Science Laboratory" at the PARC, and he talked in terms of cybernetics when he asserted the value of the interaction of elements within the "system," a word he used to describe the research center as a functioning interconnected entity (p. 55). As Bowker (1993) explains, the rhetoric of cybernetics involved a push for a "universal language" (p. 114) through which boundaries were blurred between different areas of study. "Ether" spoke in universal terms, as it crossed disciplinary divides and could be used to explain the unification of mind and matter via a network that promised a new form of information transmission linking together members of the PARC community.

In Metcalfe's (1994) terms, one of the mandates for the PARC LAN was that it had to be "everywhere" (p. 83), and he claimed that he used "ether" to explain the network's universal spatial presence. Metcalfe (1973a) refers to an "ether axiom" dictating that "the ether carries transmissions to all stations" (p. 3). This founding principle for the network led him to assert that, "The ether axiom frees us from considering network routing" (p. 3). Hence, the choice of using packet switching over circuit switching resulted from the dictates of universal information accessibility, and this access was provided via the "ether." Metcalfe (1994) connected the ubiquity of ether in a local area network to the conception of ether held by 19th century physicists who believed in its omnipresence (p. 83). For example, William Thomson, also known as Lord Kelvin (1905), claimed in a series of often-cited lectures delivered in 1884 that "there must be a medium forming a continuous material of communication throughout space to the remotest visible body," a fact to which he referred as a "fundamental assumption" (p. 260). Similarly, Heaviside (1894) treated the ether as if it were "continuously filling all space" (p. 524). For these scientists working within the paradigm of classical mechanics, the ether made complete sense. In a universe in which forces act on objects at a distance, a physical substance might be believed to lie in between.

The "ether" in Ethernet not only explained how the network moved information to any place in the facility, but it also helped reinforce norms of the institution. The culture of the Xerox PARC was shaped by notions of total, accessible information management as imagined and put in practice via inventions by people like Vannevar Bush and Douglas Engelbart (Hiltzik, 1999, pp. 63–64). The free exchange of ideas was of central importance to Pake (1985), who wrote, "We work hard at PARC to make the environment pluralistic, open to all new ideas. . . . in a freely inquiring research atmosphere" (p. 54). This belief in freely accessible information exchange had two key components: that the information be universally accessible and that the ideas be shared on an equal basis. These values attest to the prevalence of a New Communalist ethos at the PARC. New Communalists saw information technology as a means for social change (Turner, 2006, p. 6), and in particular, networked information transfer through peer-to-peer file sharing was a way to build new forms of community free from top-down flows of power indicative of earlier forms of social organization (p. 38). These values were built into the Ethernet and expressed in terms of the "ether."

The "ether" in Ethernet was a way to explain the democratic possibilities of the ubiquitous network. Each node in the PARC network had equal access to the "ether" (Burg, 2001, p. 71). As expressed by Metcalfe and Boggs (1976), "A degree of cooperation among the stations is required to share the Ether equitably" (p. 397). And this degree of cooperation was assured by the Ethernet protocol, which made it impossible that one station might "usurp the Ether" (ibid.). In other words, universal information access was equal information access, and it was through the ether and its attendant protocol that egalitarian possibilities for information exchange could be realized. Equitable information access was not the case for all LANs, however. Whereas the Ethernet protocol assured that no one "usurp" the ether, the protocol for networks, such as the token ring system championed by IBM, allowed for message prioritization by particular stations (Burg, 2001, pp. 113–114). The culture of the PARC was one of information accessibility, and the values held by community members were built into its network. No one station was more important than any other station just like each member of the community was believed to have equal ability to exchange ideas with everyone else.

The values held by PARC community members didn't always reinforce one another, meaning that the free exchange of information did not always lead to cross-disciplinary collaboration. Despite the focus on universal languages and interdisciplinarity, the uptake of cybernetics as an international metadiscipline can be read as fostering cross-cultural division (Peters, 2008). Insofar as Pake's aspirations for interdisciplinary collaboration were informed by cybernetics, the misunderstanding between members of the various PARC divisions can be seen as symptomatic of a broader failure to realize cybernetics' inclusive potential. Regardless of these interdivisional conflicts, Ethernet became a relied upon tool for researchers throughout the institution. The material effects of the network, particularly its ability to send data quickly to laser printers, helped make Ethernet an instrumental part of the PARC's information infrastructure (Hiltzik, 1999, p. 191). While Metcalfe and Boggs were building the network with advice from Thacker and Lampson, they were simultaneously working with Xerox's legal department to write a patent application for the LAN. Xerox guarded its patents carefully and utilized the services of a full-time patent attorney. Part of the reason for the company's success in the copier market was due to its owning key foundational patents (Hiltzik, 1999, p. 290). As a result, the Ethernet architects had to make precise claims as to what was new and therefore patentable in the invention. Ethernet borrowed many elements from previous networks such as a transceiver that was quite similar to a component of the ARPANET (Burg, 2001, p. 73). However, the ALOHAnet, in particular, shared a likeness with the PARC LAN.

By March 31, 1975, the engineers who developed the LAN submitted a patent application (Hiltzik, 1999, p. 192) that was approved on December 13, 1977 (Metcalfe, Boggs, Thacker, & Lampson, 1977). The patent explains the Ethernet protocol and details the chipsets used in its design, but there was no direct mention of "ether." Certainly the precise legal language necessary for the patent application genre leaves little room for metaphors, but the lack of references to "ether" can also be explained in relation to the material properties of the PARC network as it was taking shape in the mid-1970s. By 1975 the PARC Ethernet relied exclusively on coaxial cable. The need to distinguish the network from the ALOHAnet was less pressing now that the "ether" no longer referred to radio waves and also because the two networks used fundamentally different topologies. In the 1976 journal publication, Metcalfe and Boggs acknowledge that their functioning model—what they now term an "experimental Ethernet"—uses coax, but the two authors left open the possibility of other means for information transmission (p. 399). This 1976 publication drew from research dating back several years, which helped explain the heavy reliance on the ether metaphor, despite its having been published after the patent was submitted. The discourse of the journal article more closely resembled the 1973 memos than it did the 1975 patent, because Xerox's legal department would not let the engineers publish anything related to the network until the patent application was submitted (Metcalfe, 1994, p. 87). Notwithstanding the 1976 journal article, direct references to "ether" became less and less frequent after the patent application in 1975.

In June 1976, there were obvious changes to Ethernet discourse in relation to the ether metaphor. At a presentation by Metcalfe at the National Computer Conference, gone were the different ethers of the radio and telephone. In fact, he used as a visual aid a diagram with many similarities to the one found in the May 22, 1973 memo, except that the term "ether" refers only to coaxial cable linking network nodes (Shotwell, 1985). As Bazerman (1999) argues, often technologies reach a "representational resting point" (p. 345) where the language that accompanies technology becomes stabile. As an invention is used and understood through different discursive systems, terms drop out as meanings change, and words and ideas that helped shape technology are not evident in later discourse. Often a patent "fixes a description of the innovation" (ibid.) after which formative concepts are taken for granted. The "ether" in Ethernet exemplified this scenario, as the post-patent discourse of the technology relied less on direct references to "ether" through the standardization phase. The networking technology had a long period of development, but in 1979 a new head of the Xerox Office Products Division prioritized the commercialization of inventions at the PARC (Hiltzik, 1999, p. 363). As a result, Metcalfe and others led a charge to have the networking technology become a LAN standard, thereby increasing the potential profitability of Ethernet-related hardware. In the next section, we will see how, in the commercialization phase, the values of universality and community were used in ways that helped obscure market-driven strategies that relied on restricting information flow to privilege particular members of the Ethernet community.

Limits to an Open Standard

During the early years of commercial integrated information systems, a business looking to install a local network would need to purchase many different products that ranged from adapter cards to microchips. By 1980, before Ethernet was on the market, there were as many as 40 companies selling LAN components, most of which were not interoperable ("Wang's game," 1980). The lack of compatibility resulted in a great deal of confusion. Metcalfe used his connections in Silicon Valley to form a consortium of companies in a position to benefit from making Ethernet a LAN standard. This group, known as the DIX alliance, consisted of Digital Equipment Corporation (DEC), Intel, and Xerox, along with Metcalfe's new startup 3Com, and with key assistance from Ralph Ungermann and Charles Bass (Burg, 2001, pp. 5–7). The DIX alliance chose an usual licensing strategy for the Ethernet patents. Rather than build a proprietary system, the alliance decided to license the intellectual property (IP) for a nominal fee of $1,000 (Hiltzik, 1999, p. 364). Xerox had the most to lose, given their control of the Ethernet patents, but CEO David Liddle believed that a popular LAN system would increase sales of their laser printer and Alto-based workstation (Burg, 2001, pp. 102–107). The decision to relinquish control of the Ethernet IP, thereby allowing other companies to manufacture Ethernet-related components, is often termed an "open standard" strategy (ibid.). The belief that the value of Ethernet would increase dramatically as the system gained users guided the formation of the DIX alliance. In 1982 the DIX alliance succeeded in its task of getting Ethernet accepted by the IEEE, the central governing body for technological standards.

Throughout the standardization process, direct references to "ether" were few and far between. The DIX alliance presented the specifications for Ethernet to the IEEE in the "blue book," a mostly technical manual whose name derives from its blue cover (Digital Equipment Corporation, Intel, Xerox Corporation, 1980). There was no direct mention of "ether" in the blue book, but traces of the metaphor can be found throughout. The manual offers a detailed explanation of the network's topology, its ostensibly decentralized control structure, and its nonhierarchical protocol (Digital Equipment Corporation et al., 1980, p. 4), all of which were ideas communicated via the ether metaphor during development. In addition, the blue book explains the function of the LAN, with its goal of fairly reaching everywhere within the network (p. 6). A diagram in the manual looks quite similar to the one Metcalfe presented in 1976 at the National Computer Conference, but the communication medium between stations previously termed "ether" is now clearly labeled as "coaxial cable" (p. 7). Aside from the blue book, there were direct references to "ether" in related publications during this time. A booklet published by Xerox and intended as contextual information for the blue book included a few mentions of the term (Shoch, Dalal, Crane, & Redell, 1981). In other words, the ether metaphor helped carry meanings from the development phase to the commercialization phase. In documents such as the blue book, the DIX alliance carefully presented these ascribed meanings to the IEEE to garner support for making Ethernet a de jure LAN standard. In addition, these texts facilitated the coming together of a large community of vendors selling Ethernet hardware, which would make the networking technology the de facto standard as well.

The "ether" in Ethernet reflected universal information access and a shared sense of community during development, and as the networking technology was commercialized, Ethernet's open standard was talked about in ways that shared these values of universality and community. However, a closer examination of the ostensibly open standard reveals limitations to these values as Ethernet entered the marketplace. The open standard strategy of the DIX alliance was described in terms similar to those used to refer to Ethernet at the Xerox PARC. Given the accessibility of Ethernet IP and the technological community that it was said to foster, the strategy was hailed as a business model that mirrored the openness and community-building potential of integrated information systems in general (Burg, 2001; Burg & Kenney, 2003; Markoff, 1998). By extension, Ethernet was couched in terms of openness that facilitated the free exchange of ideas. This perception was aided by Metcalfe's "relentless lobbying efforts" (Burg, 2001, p. 202) to enlist many companies to accept Ethernet as the dominant LAN system and to become vendors of Ethernet products. The strategy used by the DIX alliance with its surrounding vendor community exemplified a larger trend of taking the collaborative social practices of research institutions and utilizing them for entrepreneurial endeavors in the early years of the commercial computer industry. The seeming openness of the Ethernet standardization strategy and the inclusive efforts to build a broad base of suppliers reflected ways the ether metaphor was employed to communicate and legitimate functions of the LAN during its development phase. The sharing of Ethernet IP reflected Xerox PARC values of universal, equitable information sharing, and the Ethernet community, built across different companies, resembled the interdisciplinary focus of the research center. These values of universality and community were then taken for granted as essential features of Ethernet and its standardization strategy.

By the end of the 20th century, the open standard of Ethernet was often contrasted with the monopolistic and proprietary practices of companies like Microsoft (Markoff, 1998). Rather than build a system whose components only the DIX alliance could manufacture, the consortium allowed other companies to make Ethernet products. Microsoft, on the other hand, used a proprietary strategy with its operating system and software brands that pushed for market dominance. The openness of the Ethernet standard was then equated to new modes of information exchange made possible by the Internet. For example, at an event in 1998 honoring the 25th anniversary of Ethernet, then-Vice President Al Gore delivered a personal message to Robert Metcalfe via video address in which he said, "Bob, it really is hard to imagine where we would all be today had you not succeeded with your vision for Ethernet and computers, communication, and compatibility" (Mayfield Fund, 1998). Ethernet was celebrated as a way to realize a utopian dream of the Internet as a transcendent power to unite humanity through "computers, communication, and compatibility." In this regard, Ethernet, like the "ether" of the 19th century, was described as a universal, unifying force. More recently, however, the definition of an open standard has been called into question by scholars looking for a more refined understanding of existing control mechanisms in information technology. Bringing this critical perspective to bear on the Ethernet standardization strategy helps illuminate a contradiction between the residual development discourse of Ethernet and the practices used to turn the technology into a profitable commodity.

Once a standard is approved, it appears natural, which then renders invisible the complicated and often conflicting processes that went into its creation (Busch, 2011, p. 75). The openness of the Ethernet standard was similarly taken for granted. To say that a standard is "open" does not mean the same thing as saying that the standard is free from control (Simcoe, 2006). The discourse concerning open standards often reflects an ideal of openness, but in reality, "standards are rarely fully open or fully closed” (West, 2007, p. 88). Ghosh (2011) claims that the openness of open standards needs to be measured not just in terms of the openness of the process but also in terms of the economic effects resulting from the standardization process. Seen in this light, a standard is open only if "access to the technology is available to all (potential) economic actors on equal terms providing no advantages for the rights holders" (p. 79). The DIX alliance members used the community method of sharing information to create value for Ethernet, but they were in a position to capture much of that value once it had been created by the approval of a universal LAN standard (Simcoe, 2006, p. 173). As Burg (2001) puts it, the core companies and affiliated start-ups had "insider knowledge," and such "insider knowledge positioned them well to take advantage of the Ethernet standard, initially kept secret by the DIX group" (p. 126). The technical features of Ethernet were made widely available only after certain privileged people positioned themselves accordingly.

Poststandardization, there was not equal participation in the community created around the DIX alliance. Whereas early Ethernet publications decried anyone usurping the ether, the practices of the DIX alliance did not reflect these communal values. Despite notions of democratic accessibility of the ether network at the Xerox PARC, the group responsible for pushing the technology into the market did not practice universal information sharing. The commercial strategy for Ethernet therefore attests to contradictions that Turner (2006) identifies in the New Communalist ethic. The information technology pioneers used openness of information to build communities that countered industrial monopolies mired in Old World bureaucracies. The egalitarian agenda, however, was undermined by a sense of elitism, with a New Communalist belief that they had privileged knowledge and understanding of what information technologies could do (Turner, 2006, p. 259). The Ethernet standard was positioned as universal and open in contrast to systems owned by more vertically-integrated companies like IBM (Burg, 2001, p. 202). At the same time, the open standard was a vehicle for advancing the privileged position of insiders within the DIX alliance, thereby contrasting with discourses of universality and community ascribed during Ethernet's development.

Conclusion

The example of "ether" in Ethernet demonstrates the merit of tracking the use of a metaphor from its conceptual history to its deployment during a technology's development and commercialization phases. The longer history of "ether" was mobilized during the development of Ethernet to promote and aid in the understanding of the LAN network. Within the development culture of the Xerox PARC, the metaphor and its attendant meanings were pitched to administrators and patent attorneys such that Ethernet was adopted as the research center's network and foundational patents were supported by the institution. The metaphor served different functions in the commercialization phase, where key players in the fledgling LAN market targeted "ether" and its ascribed meanings to the IEEE and to prospective vendors such that the networking system became both the de jure and de facto LAN standard. The ether discourses represent idealized notions of an information network's ability to provide universal communication so that everyone has equal access. As with any ideal, there are conflicts between a representation and its affiliated social practices, so it goes without saying that the use of Ethernet during its development phase couldn't have realized perfectly a network ideal. However, in the course of Ethernet's commercialization, there is a revealing contradiction between ascribed meanings and social practices that is not present during development and that warrants comparing discourses found during the two phases.

Although the Xerox PARC was a commercial enterprise, it had more in common with institutions such as Bell Labs and Project MAC that were geared toward technological innovation but that had explicit goals to value research over profitability. The ether metaphor helped establish and reinforce a culture of cooperation and collaboration so that the Xerox PARC could be represented according to this academic model. When the meanings ascribed to Ethernet via the ether metaphor were carried into the marketplace, values of universal information access and nonhierarchical modes of communication stood in stark contrast to Ethernet's commercialization strategy. This strategy depended on treating information as private property that is controlled by an elite cabal motivated by self-interest. The ether metaphor functioned in the commercialization phase such that representations of the network belied how the network was monetized. Using a comparative framework to analyze the discourse of "ether" in the development and commercialization phases allows us to see more clearly the formation of the metaphors that help shape the cultural meanings of a technology and how these terms work differently over time and in different contexts. Furthermore, a comparative perspective allows us to better identify the antecedents of a technology's cultural meanings. For example, in 1998, when Al Gore praised Robert Metcalfe for his vision of "computers, communication and compatibility," these values did not reflect the practices associated with Ethernet's marketing strategy but instead had more in common with the Xerox PARC values of Ethernet's development phase.

A closer look at the different functions of metaphor during development and commercialization adds to our understanding of contradictions held in tension within contemporary technology discourse. Terms such as "ether" and technologies such as Ethernet played a key role in shaping the information industry and in constructing the cultural meanings of information in the present age. This research reveals contradictions found in Ethernet's commercialization phase that can still be found today. As much as the Internet is valued as a place for free and open communicative exchange, the contemporary information industry profits from private control of personal data when, for example, a social network mandates in its licensing agreement that users relinquish the rights to uploaded photographs. This example points to a present and persistent incongruity that information is something that should be open to all but that is also often under strict control by private industry. More work needs to be done on the terms used to make sense of and to promote technologies that served as models for the tools we currently use. Of particular import is to look more closely at technologies incubated at research-driven institutions like the Xerox PARC, because the case of "ether" and Ethernet suggests that development discourses generated at such research centers were deployed for strategic purposes in the marketplace.

References

Abbate, J. (1999). *Inventing the Internet.* Cambridge, MA: MIT Press.

Abramson, N. (1970). The ALOHA system: Another alternative for computer communications. *AFIPS 1970 Proceedings: Vol. 37. Fall Joint Computer Conference* (pp. 281–285). Montvale, NJ: AFIPS Press.

Aristotle. (ca. 350 B.C./1983). *Physics: Books III and IV* (E. Hussey, Trans.). Oxford, UK: Oxford University Press. (Original work published circa 350 B.C.)

Bazerman, C. (1999). *The languages of Edison's light*. Cambridge, MA: MIT Press.

Bowker, G. (1993). How to be universal: Some cybernetic strategies, 1943–1970. *Social Studies of Science*, *23*(1), 107–127.

Burg, U. V. (2001). *The triumph of Ethernet: Technological communities and the battle for the LAN standard*. Stanford, CA: Stanford University Press.

Burg, U. V., & Kenney, M. (2003). Sponsors, communities, and standards: Ethernet vs. Token Ring in the local area networking business. *Industry and Innovation*, *10*(4), 351–375.

Busch, L. (2011). *Standards: Recipes for reality.* Cambridge, MA: MIT Press.

Cantor, G. N., & Hodge, M. J. S. (Eds.). (1981). *Conceptions of ether: A study in the history of ether theories 1740–1900.* Cambridge, UK: Cambridge University Press.

Clarke, B. (2002). From thermodynamics to virtuality. In B. Clarke & L. D. Henderson (Eds.), *From energy to information: Representation in science and technology, art, and literature* (pp. 17–33). Stanford, CA; Stanford University Press.

Crovitz, G. (2012, July 23). Who really invented the Internet? *The Wall Street Journal*, p. A11.

Dalrymple, L. H. (2002). Vibratory modernism: Boccioni, Kupka, and the ether of space. In B. Clarke & L. D. Henderson (Eds.), *From energy to information: Representation in science and technology, art, and literature* (pp. 126–149). Stanford, CA: Stanford University Press.

Digital Equipment Corporation, Intel Corporation, & Xerox Corporation. (1980, September). *The Ethernet: A local area network—Data link layer and physical layer specifications, version 1.0*. Santa Clara, CA: Intel.

Edwards, P. N. (1996). *The closed world: Computers and the politics of discourse in Cold War America*. Cambridge, MA: MIT Press.

Ghosh, R. (2011). An economic basis for open standards. In L. DeNardis (Ed.), *Opening standards: The global politics of interoperability* (pp. 75–96). Cambridge, MA: MIT Press.

Gillespie, T. (2010). The politics of platforms. *New Media & Society*, *12*(3), 347–364.

Heaviside, O. (1894). On the forces, stresses, and fluxes of energy in the electromagnetic field. In *Electrical papers* (Vol. 2). (pp. 521–574). New York, NY: Macmillan and Co.

Hiltzik, M. (1999). Dealers of lightning: Xerox PARC and the dawn of the computer age. New York, NY: HarperCollins.

Hunt, B. (1986). Experimenting on the ether: Oliver J. Lodge and the great whirling machine. *Historical Studies in the Physical and Biological Sciences*, *16*(1), 111–134.

Hunt, B. J. (1991). *The Maxwellians*. Ithaca, NY: Cornell University Press.

Kelvin, W. T. (1905). *Baltimore lectures on molecular dynamics and the wave theory of light.* London, UK: C. J. Clay and Sons.

Lyman, P. (2004). Information superhighways, virtual communities, and digital libraries: Information society metaphors as political rhetoric. In M. Sturken, D. Thomas, & S. Ball-Rokeach (Eds.), *Technological visions: The hopes and fears that shape new technologies* (pp. 201–18). Philadelphia, PA: Temple University Press.

Markoff, J. (1998, May 18). Long before Microsoft's Internet war: A peaceful Ethernet. *The New York Times*, pp. C1, C4.

Mayfield Fund. (1998). Ethernet 25th anniversary [Video file]. Retrieved from http://www.youtube.com/watch?v=sDREs6K3js0

Metcalfe, B. (1973a, May 22). *Ether acquisition*. Palo Alto, CA: Xerox PARC Memorandum.

Metcalfe, R. M. (1973b). *Packet communication*. Cambridge, MA: Project MAC MIT.

Metcalfe, R. M. (1985). Introduction. In R. E. Shotwell (Ed.), *The Ethernet sourcebook* (3rd ed.) (pp. ix–xviii). New York, NY: Elsevier Science Publishing Company.

Metcalfe, R. M. (1994). How Ethernet was invented. *IEEE Annals of the History of Computing*, *16*(4), 81–88.

Metcalfe, R. M., & Boggs, D. R. (1976). Ethernet: Distributed packet switching for local computer networks. *Communications of the ACM*, *19*(7), 395–404.

Metcalfe, R. M., Boggs, D. R., Thacker, C. P., & Lampson, B. W. (1977). U.S. Patent No. 4,063,220. Washington, DC: U.S. Patent and Trademark Office.

Michelson, A. A., & Morley, E. W. (1887). On the relative motion of the earth and the luminiferous ether. *American Journal of Science*, *34*, 333–345.

Milutis, J. (2006). *Ether: The nothing that connects everything*. Minneapolis: University of Minnesota Press.

Newton, I. (1687/1846). *The mathematical principles of natural philosophy* (A. Motte, Trans.). New York, NY: Daniel Addee. (Original work published 1687)

Pake, G. (1985). Research at Xerox PARC: A founder's assessment. *IEEE Spectrum*, *22*(10), 54–61.

Perry, T., & Wallich, P. (1985). Inside the PARC: The information architects. *IEEE Spectrum*, *22*(10), 62–75.

Peters, B. J. P. (2008). Betrothal and betrayal: The soviet translation of Norbert Wiener's early cybernetics. *International Journal of Communication*, *2*, 66–80.

Peters, J. D. (2003). Space, time, and communication theory. *Canadian Journal of Communication*, *28*(4), 397–411.

Shoch, J. F., Dalal, Y. K., Crane, R. C., & Redell, D. D. (1981). *Evolution of the Ethernet local computer network.* Stamford, CT and Palo Alto, CA: Xerox Office Products Division and Palo Alto Research Center.

Shotwell, R. E. (Ed.) (1985). *The Ethernet sourcebook* (3rd ed.). New York, NY: Elsevier Science Publishing Company.

Simcoe, T. S. (2006). Open standards and intellectual property rights. In H. Chesbrough, W. Vanhaverbeke, & J. West (Eds.), *Open innovation: Researching a new paradigm* (pp. 161–183). New York, NY: Oxford University Press.

Smith, D., & Alexander, R. (1988). *Fumbling the future: How Xerox invented, then ignored, the first personal computer*. New York, NY: Morrow.

Thibault, G., & Bardini, T. (2008). Éther 2.0: Révolutions sans fil. [Ether 2.0: Wireless Revolutions]. *Canadian Journal of Communication*, *33*(3), 357–378.

Turner, F. (2006). *From counterculture to cyberculture: Stewart Brand, the whole earth network, and the rise of digital utopianism.* Chicago, IL: University of Chicago Press.

Wang's game plan for the office. (1980, December 15). *Business Week*, pp. 84–86.

West, J. (2007). The economic realities of open standards: Black, white, and many shades of gray. In S. M. Greenstein & V. Stango (Eds.), *Standards and public policy* (pp. 87–122). Cambridge, NY: Cambridge University Press.

Whittaker, E. T. (1910). *A history of the theories of aether and electricity from the age of Descartes to the close of the nineteenth century*. London, UK: Longmans, Green, and Co.

Wyatt, S. (2004). Danger! Metaphors at work in economics, geophysiology, and the Internet. *Science, Technology, & Human Values*, *29*(2), 2