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Venture capital and the birth of the local area networking industry

Urs von Burg [a,1], Martin Kenney [b,c,*]

[a] University of St. Gallen, St. Gallen, Switzerland
[b] Department of Human and Community Development, Davis, CA 95616, USA
[c] Berkeley Roundtable on the International Economy, USA

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Abstract

Venture capital has played an important role in funding the development of a number of US high-technology industries. Economists and business scholars utilizing models based in traditional economics have studied venture capital from the perspective of investment decision-making. These models provide significant insights, and yet they do not explain the actual operation of venture capital. This case study of the creation of LAN industry utilizes a synthesis of the dominant design and social constructionist perspectives to create a more nuanced explanation of how the practice of venture capitalists operates to create firms and industries.

Keywords: Venture capital; Local area networking; Industry; Dominant design; Social construction

1. Introduction

In the mid 1990s, personal computers and other devices linked through a local area network (LAN) had become the dominant computer architecture in institutions. Twenty years earlier, LANs were nearly non-existent with their deployment almost exclusively confined to mainframe computers and terminal-to-host switching. Only a few engineers envisioned the demise of the then-dominant computing paradigm based on central computers serving many dumb terminals and its replacement with an alternative architecture of large numbers of networked, distributed computers. The deployment of a new technology in a set of newly created firms, which then becomes a new industry, is often accepted as unproblematic or natural. But, the manner by which a technology is embedded in social institutions is not predetermined. The expression of a technology in new firms entails the creation of firms and products simultaneously. This paper examines the role venture capitalists played in facilitating the emergence of the local area computer networking (LAN) industry in the United States and the issues they faced in funding startups. [2]

* Corresponding author. Department of Human and Community Development, University of California, Davis, CA 95616, USA. E-mail: mfkenney@ucdavis.edu

[1] E-mail: uavonburg@ucdavis.edu.

[2] Some of the major inventions in the development of LAN industry, such as Token Ring were developed in Europe, however, few significant European firms were created. The most important European startup was the Token Ring-based Madge Networks, established in 1986.

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For a study of the firm and industry formation process the LAN industry is a particularly appropriate, because it is a clear case in which entrepreneurs funded by venture capital out-maneuvered the large established companies. This paper shows the myriad ways in which the venture capitalists were actively involved in creating new firms in conjunction with entrepreneurs, and how the investment decisions were contingent and often hinged upon quite idiosyncratic criteria. In larger terms, this is an examination of how venture capitalists contributed to the construction of an entire industry.

We use the structural theories that trace their lineage to Joseph Schumpeter and its inheritors, especially those of the ‘‘dominant design’’ paradigm (see Abernathy, 1978 for an early exposition), and the social construction of technology line of study (Bijker et al., 1987). Henderson (1995) articulated the compatibility of these perspectives and we follow her line, with the exception of extending it to a new industry and the role of venture capital. Neither of these lines of explanation have been explicitly been applied to the role of venture capitalists in the construction of innovatory firms or new industries. Our particular interest is the venture capital decision-making in the pre-dominant design phase, when no industry exists, and then later when the industry is taking shape.

To understand the venture capitalists' role in the creation of the LAN industry, this paper is organized in roughly chronological order. Section 2 reviews previous theories of new industry formation. Section 3 briefly describes the research methodology. Section 4 provides an overview of the role of venture capital in funding new firms. Section 5 sketches the institutional roots of local area computer communication. Section 6 describes the beginnings of LAN industry, as the established firms grasped for a strategy to succeed in this new business space.

Section 7 examines the movement to create networking protocols and the standardization of Ethernet, which set the stage for a wave of startups exploiting Ethernet. Section 8 describes the venture capital process experienced by 3Com, the first startup dedicated to Ethernet. Section 9 examines other startups established slightly later to exploit the Ethernet standard, which resulted in the creation of the LAN industry. Section 10 discusses the role of venture capitalists in funding the final critical innovation in the emergence of Ethernet as the dominant design and the defeat of the IBM-supported alternative of Token Ring. The conclusion summarizes the role of venture capitalists played in the construction of the LAN industry based on Ethernet, and how the LAN industry evolved into the highly dynamic computer networking business today.

2. Dominant design, social construction, and new firms

Social scientists, at least, as long ago as Schumpeter (1964) recognized the role of technical innovation as a powerful trigger for new firm formation and, in some cases, entire new industries. Despite the emergence of multidivisional firms investing enormous sums in R&D and committed to offering new products (Schumpeter, 1975; Chandler, 1977; Chandler, 1990), there has been a counter-tendency of an increasingly complex industrial division of labor and the emergence of a number of new industries (Hounshell, 1995). Often, new fast-growing firms have constituted industries in fields directly adjacent to those of existing large corporations and established industries, e.g., the relationship between the computer industry and the new computer networking industry. [3] The established companies had the technical core competencies necessary internally, but were unable to mobilize these capabilities and to deter entry by swarms of independent startups. As Schumpeter repeatedly pointed out, the firm is not the only institution that might be created. If the economic space is sufficiently large, this wave of creation can be so powerful as to launch an entirely new industry, thereby deepening the industrial division of labor (Smith, 1776; Young, 1928). Schumpeter (1964; 1968) termed this the creation of ‘‘new economic spaces.’’

Explaining the linkages between sociotechnical innovation and new firms is a difficult task for the social sciences. One model for explaining technological innovation and industrial organization is associ-

[3] For a discussion of this process in the biotechnology industry, see Kenney (1986a).

ated with William Abernathy and his colleagues who coupled Schumpeterian insights with product-cycle theory observing that at different stages in the cycle different types of innovations and industrial organization were prevalent (Abernathy, 1978; Abernathy and Utterback, 1978; Abernathy and Clark, 1985). [4] The cycle begins with a discontinuity resulting from a technological development that creates an environment with low entry barriers facilitating new entrants and much experimentation and uncertainty. In these periods it is difficult to forecast demand, prices, or even the eventual technological outcome (Tushman and Anderson, 1986). This period of ferment ends when one design becomes the standard (or dominant) and innovation shifts to incremental product and process innovations. At this stage there are far fewer new entrants to the industry (Utterback and Suarez, 1993).

Schumpeter carefully separated the role of the entrepreneur from that of the financier, but treated the financier as a relatively passive participant in the new firm formation process (Kenney, 1986b). In more recent literature the financial backers of new firms are treated as unproblematic. If an innovation is sufficiently attractive, then it is assumed that the financial backing will be available — it is simply a matter of understanding the investment criteria of venture capitalists. Given the level of analysis and topics of interest at which this perspective operates it is understandable, however, if the black box of the new firm formation process is examined more closely and from the perspective of the participants, then it can be seen that the attraction of financial support is far more tenuous and open to the forces of vagary, chance, and agency. The entrepreneur must recruit the venture capitalist.

In contrast to the previous rather structuralist positions, a group of sociologists argue that technology is socially constructed (Bijker et al., 1987). For them, the macrolevel forces detected, when analyzing technological evolution in broad terms, are not nearly so visible at the microlevel (Misa, 1994). A closer examination of the black box of technology development and adoption reveals that the dominant design of a particular technology or technological artifact is the product of an interaction between its social environment and technological development — with neither determinant. Rather than being invented or innovated, they found it more descriptive to say an artifact is socially constructed. The adoption of a new artifact should be seen as the creation of a network of linkages between human actors and artifacts (Cowan, 1987; Latour, 1993; Latour, 1996). This is a process of trying to both create an environment for the artifact and create an artifact for the environment. In this sense, the social construction of technology is the creation of networks including various actors, such as producers, consumers, and others. Within these networks there is a bargaining process through which an artifact and an economic arrangement to supply the artifact emerges (Bijker, 1993). As part of this process the supporters of the artifact must recruit resources and adherents (Foray, 1991). To pursue economic activities, one of the most important resources to be recruited is financial support, because of its role in binding actual productive resources such as employees and inputs to the project. This makes social actors such as venture capitalists important constituents for the entrepreneur wishing to actualize an innovation in a freestanding firm.

The concept of ‘‘embeddedness’’ developed by Granovetter (1985), which has never been applied to the relationship between venture capitalists and entrepreneurs, offers powerful insight because the actors are actually trying to embed the technology and the firm into the environment. Reputations and social connections are vital in securing funding and in facilitating the startup's success. [5] From a different but congruent perspective, Van de Ven and Garud (1989) propose an ‘‘accumulative theory of industry formation’’ based on conceptualizing an industry ‘‘as a social system consisting of three loosely coupled hierarchical subsystems: Instrumental, resource

[4] An important further extension to this line of thought explaining the industrial organization of regions such as Silicon Valley is Langlois and Robertson (1995, especially Chap. 7).

[5] For discussions relevant to this idea, see Kenney and von Burg (1999), Suchman (2000), Cohen and Fields (2000) and Kenney and von Burg (2000).

procurement and institutional subsystems.'' This study of the formation of the LAN industry focuses only on the resource procurement subsystem and the role of financiers, the venture capitalists. However, to adequately explain the role of the venture capitalists, we must repeatedly refer to the other subsystems.

3. Research methodology

Our research methodology comprised of two components. The first component was a review of all the industry journals, consultant's reports, and other written materials available. Of particular use were the US Securities and Exchange Commission (SEC) S-1 files. However, these were not sufficient to understand the industry and were often contradictory, especially in the details. The second component were telephonic interviews with entrepreneurs, venture capitalists, and senior corporate officials (who were not entrepreneurs). Our requests for interviews were largely successful, but five persons rejected our requests. However, for every firm we interviewed at least one founder and one of the original investors (except in the case of Interlan). We conducted 46 interviews with entrepreneurs, venture capitalists, and LAN industry executives from 1995 to 1999, all of which were taped and transcribed (a list is available from the authors by request). None of the interviewees asked for anonymity; however, each one quoted was sent the entire article for vetting, but only three responses were received clarifying errors of fact. In two cases, the entrepreneurs sent us copies of their business plans. We have no reason to suspect bias, but the difficulty of recalling events nearly 20 years ago could introduce inaccuracies, though all answers did agree with archival materials especially with the SEC S-1 files.

4. Venture capital

A striking feature of the postwar US national system of innovation has been the emergence of a set of financiers, the venture capitalists, specializing in providing the capital to entrepreneurs founding new firms. In quite a number of cases, these firms coalesced into an industry. [6] Before the emergence of organized venture capital, the only sources of capital for an entrepreneur were informal, such as family, friends, and wealthy individuals. Financial institutions, such as banks or stockbrokers, generally were not organized to take risks on firms with little or no collateral (for further discussion, see Wilson, 1985; Florida and Kenney, 1988; Bygrave and Timmons, 1992). [7]

The venture capitalists only invest when they believe that the firm has potential to grow, and thereby rapidly increase the value of their equity investment. Venture capitalists aim to be at what the venture capitalist, Carano (1995), termed, ''the intersection of a dislocating long-term advantage and an explosive or compelling market application.'' The firms funded by venture capitalists include some of the fastest growing technology firms, many of which were key for constituting entirely new industries, such as biotechnology, hard disk drives, relational databases, workstations, and minicomputers, to name a few. Chronologically from a relatively inchoate group of private investors, venture capital coevolved with the growth of high-technology businesses in Silicon Valley and Route 128 to become an organized set of financiers (Kenney and von Burg, 1999).

The current scholarly research on venture capital concentrates upon the investment decisions and their outcomes. For the most part, this has been treated as a principal–agent problem. As Sahlman (1990) notes in venture capital there are actually two investments involved: investment in the venture capital limited partnership and by the limited partnership in startups. The various contract provisions and procedures help sort out the skills and intentions of the participants (Sahlman, 1990, p. 518). Gompers and Lerner (1996) examined limited partnerships covenants and found that both agency problems and supply and demand for fund managers, i.e., labor availability, were sig-

[6] Venture capital-financed entrepreneurial innovation has been so successful that it became a part of the US national system of innovation, see Lundvall (1992) and Nelson (1993).

[7] Though the bulk of formal venture capital investments are in the high-technology arena, they do not confine themselves to technology investments. For example, Federal Express was started with venture capital funds and a number of funds invest in franchising startups.

nificant factors in the use of covenants. Hellmann (1998) shows through an abstract mathematical model that entrepreneurs with less financial means are likely to surrender more control to venture capitalists, i.e., give the principal more power. These contributions by economists to understanding the investment decision are significant, however, they address neither the larger issue of how venture capitalists actually undertake their activities nor their role in the creation of firms and industries.

From the venture capitalists' perspective investment decisions occur in an environment of imperfect information, entrepreneurial visions, and educated guesses — it is exactly here that the entrepreneurs construct their firm. In contrast to neoclassical models in which time is largely irrelevant for venture capital investing time and timing are critical (Freeman, 1999). Not surprisingly, there is also an important evolutionary and path-dependent element in the activities of venture capitalists as they continually seek to build upon previous investments by funding the next step in the progress of the technology (Nelson and Winter, 1982; David, 1986; Arthur, 1994).

Venture capitalists differ from traditional investors in that they are not passive. In effect, after being recruited (or recruiting themselves into the deal) they become active social constructors. In other words, they try to shape the future in ways that improve the outcome of their investments. To do this they offer advice, become involved in critical corporate decisions, assist in corporate recruiting, even at times reassure an important prospective customer or supplier that they stand behind the firm, and undertake various other tasks (MacMillan et al., 1988; Sapienza, 1992). In effect, they try to influence the market outcome in favor of their investment.

The common view is that the venture capitalists are risk takers and, at one level, it is correct that they take larger risks than do ordinary bankers. But as our study of the LAN industry indicates, generally speaking, most venture capitalists are risk averse. The venture capitalist's craft is to balance between errors of omission, not investing when one should, and errors of commission, investing when one should not. There is another twist, namely that the greatest successes are almost always those in which the market growth is unforeseen by most investors, because if the success was foreseen the true value of the firm could have been judged. Not unexpectedly, those ''foreseeing'' the future have a high likelihood of being wrong.

5. Early networking and the invention of LAN technology

The history of networking goes back one and a half decades before the invention of LAN technology in the early 1970s. In 1958, the US Air Force installed the SAGE network, an air defense system that connected radars to central mainframe computers over telephone lines. Eventually, the SAGE network spanned over one million miles. Based on the innovative SAGE technology, in 1964 American Airways installed the SABRE network, which connected terminals to a mainframe for reservation purposes. Similarly structured reservation and transaction networks followed in other industries including banking and hotels, but SAGE's most critical contribution to networking was the development of the time-sharing concept. Like the SAGE and SABRE systems, time-sharing used terminals to connect users to the computer, but in contrast to the former two systems, time-sharing was implemented on generic computers that could be used for any application (Abbate, 1994). Then in 1969–1970 ARPA installed the ARPANET, which later evolved into the Internet. Many technologies that were adopted in LANs can be traced to the ARPANET (Hafner and Lyon, 1996).

Despite the development of networks in the late 1950s and 1960s, there was little commercial interest in networks. In fact, most computer manufacturer did not expand into networking adjacent to their product, nor did they set up network divisions in their enterprises. [8] Likewise, the development of the early networks did not trigger the formation of start-ups attempting to capitalize on the new technology. [9] To

[8] The important exception was IBM, which had developed the SAGE concept for the Air Force and then commercialized it by developing SABRE for American Airlines.

[9] The most significant exception is the Boston-area firm, Bolt, Beranek and Newman, which was the primary commercial firm involved in the ARPANET.

a large extent, the reasons for this commercial neglect can be found in the computer paradigm and industry of the 1960s. Compared to the hundreds of millions of computers installed today, in the 1960s, the installed base of computers was quite small — in 1960 only 5950 mainframe computers were shipped and in 1970, the number roughly doubled to 11,760 (Juliessen and Petska-Juliessen, 1994, p. 317). At the time, most computers, even when manufactured in large numbers, were conceived of as stand-alone machines and in the era of batch-processing typically lacked the means for communication with the outside world. This meant that the market potential for networking was small.

Only when time-sharing appeared, did commercial interest in networks begin growing. So, in the early and mid 1970s as time-sharing replaced the previous batch-processing mode, networking became an integral concept for computing. Most computer manufacturers developed protocols to connect terminals to host computers and to build hierarchies of terminals, front-end processors, and host computers. In 1974, for example, IBM introduced its SNA protocol, followed by DEC's DECnet in 1976, as did other major computer vendors. This made networking an integral part of computer manufacturers' business, but their employment of time-sharing did not lead to LAN technology. [10] The communication between terminals and hosts was not very data-intensive and thus did not require high bandwidth. Besides, the early systems were still relatively small. As the following discussion shows, LAN technology only emerged when users began interconnecting computers instead of terminals.

Given this lack of interest in LANs in the late 1960s and early 1970s, it is not surprising that researchers outside the corporate sector developed the first LAN technologies. For example, in 1971, David Farber of UC Irvine built the first operational LAN, which was based on a Token Ring technology. His LAN, transmitted at 2.3 Mbps, that is, 46 times faster than the ARPANET, itself a relatively fast wide area network (Farber, 1972; Farber, 1975). Farber designed a relatively high-speed network because he built a locally distributed computing system based on minicomputers. In other words, his system connected computers instead of terminals and distributed the processing over several machines. In 1973, Robert Metcalfe at Xerox PARC developed the second major LAN type, Ethernet. [11] Ethernet used a fundamentally different topology and transmission and access method, but it transmitted at a similar speed, namely 2.94 Mbps. Like Farber, Metcalfe needed the high networking speed because he built a distributed computing system, but unlike the system of Farber, PARC's system was based on connecting Xerox Alto personal workstations. PARC commissioned the development of a LAN because it needed the means to link the Alto computers with laser printers, which were the output devices for its ''office of the future.'' With this distributed computing system, based on personal computers and intended for the office use, PARC had invented what eventually became the dominant environment in which LANs would be deployed (Hiltzik, 1999). LANs were initially used to connect minicomputers and to switch terminals to a host computer, but the LANs' main application would eventually be the connection of personal computers (that, is, IBM PCs) in the office environment. This client/server architecture would overthrow minicomputers and time-shared systems.

As in the case of the initial (wide area) networks, Farber's and Metcalfe's invention of LAN technology failed to trigger the rapid commercialization of the new technology. Farber had no commercial interest in his LAN technology, which was only a side product in his distributed system. Simultaneously, Xerox delayed the introduction of the office system developed by PARC. Moreover, in the mid 1970s, the incumbent computer manufacturers were focused upon central time-shared systems.

[10] LAN technology differs from time-sharing and the wide area networking technologies, because LANs must transmit at very high speeds but need only cover short distances.

[11] Metcalfe could have adopted Farber's Token Ring, but in this experimental stage, he rather wanted to invent something different (Farber, 1997).

6. The beginning of LAN commercialization

In the late 1970s, most computer manufacturers finally began experimenting with the new LAN technology or even prepared their introduction. In 1977, Datapoint offered a LAN technology called ARCnet to integrate its small business computers into a homogeneous computing environment, allowing users to share files and peripherals. In 1980, the computer workstation startup, Apollo Computer, introduced a line of workstations using a LAN technology called DOMAIN to connect its workstations together. Likewise, in 1979, minicomputer manufacturer Prime Computer introduced a LAN called Primenet with the express purpose of networking their minicomputers (Clarke, 1998). Contemporaneously, IBM at its Zurich research lab began experimenting with the technology in 1979, but for a number of reasons this project did not receive the highest priority.

It is not surprising that the computer manufacturers should begin developing LANs. Customers with more than one computer at a site wanted them to communicate at speeds greater than that available over modems connected to the telephone system. Moreover, by the late 1970s, the number of terminals had increased so dramatically that higher network speeds to connect terminals to a host computer became very desirable. At the time, to most observers, networking appeared to be mere extension of the computer industry's existing a business, and from this, it seemed natural that the computer manufacturer would dominate the networking space. They had the technical skills, they controlled the LANs' primary market including the interfaces, they interacted with the customers, and they controlled the machines to be networked.

Despite the overwhelming advantages of the computer makers, a few entrepreneurs believed there were market opportunities, which prompted them to establish firms and to launch LAN products. The computer makers though proclaiming their decisions to provide LANs were slow at introducing products. Moreover, they aimed to provide proprietary systems capable of only connecting their own computers. In other words, the LAN would be used to lockout competitors and lock-in their customers. Thus, a space for the entrepreneurs opened as customers searched for solutions to their on-site interconnection problems, which involved multiple computer brands.

The first start-up to offer LANs was Network Systems, which was established in 1974 in Minnesota by some former employees of Control Data and Univac. The founders believed that data centers would be interested in a technology allowing them to connect their various mainframes. Network Systems believed it would be possible to compete successfully with the computer manufacturers especially IBM because as a specialized LAN vendor they could interconnect the vendors' incompatible mainframe computers, a gateway function the computer manufacturers did not want to offer. Network Systems experienced much difficulty raising venture capital. Despite being established in 1974, only in 1976 did the firm receive funding from the local Minneapolis venture capital fund, Norwest Venture Capital Management. This meant that for nearly 2 years the entrepreneurs had to bootstrap the firm. However, the mainframe networking market remained small, thus limiting Network Systems' growth.

In 1979, Ungermann–Bass (UB) was established by Zilog alumni Ralph Ungermann and Charles Bass to create high-speed local area access between terminals and minicomputers. However, before discussing UB, the role of Zilog in the creation of the LAN industry should be highlighted. Zilog was established in 1974 by Frederico Faggin (one of the co-designers of Intel's microprocessor) and Ralph Ungermann with venture capital from Exxon as part of its quixotic attempt to use its oil crisis-related windfall profits to design the ''office of the future.'' In the late 1970s, Zilog developed a LAN based on its already successful communications peripheral chip for input/output devices (Ungermann, 1995). A group of engineers including Charles Bass developed not only an operating system called Leo for controlling a number of microprocessors, but also a personal computer LAN, the ZNet. However, ZNet had technical problems and was not marketable (Ungermann, 1995). Then Ungermann and Bass left in 1979. Zilog hired William Carrico, Judith Estrin, and Eric Benhamou continued working on the Znet until they left to establish Bridge Communications in 1981. Whereupon Zilog hired a group of engineers including Kanwal Rekhi, who left within a year to join a team of Indian engineers to start Excelan. Zilog proved to be an important seed company for an entire generation of LAN companies (see Fig. 1) and, as is so often the case, Exxon reaped little benefit from its large investments.

Upon leaving Zilog, Ungermann and Bass wrote their business plan with the venture capitalist, Neill Brownstein of Bessemer Ventures. Their explicit strategy was to start the company in a field with great potential but no entrenched competition (Ungermann, 1995), while avoiding an extended pioneering effort (Electronics News, 1980: 17).[12] This strategy, though excellent from an entrepreneurship perspective, made it difficult to secure venture capital, since there were no benchmarks or other LAN companies against which to value the company and there was no obvious market. Technically, the lack of a protocol or standard to be used for data transmission meant that there was no way to predict which protocol would be adopted. Obviously, few observers believed a startup would successfully induce larger players to adopt its protocol. According to Ralph Ungermann (1995), ''everybody in the venture community turned us down because they believed that the International Standards Organization (ISO) standard was coming and the computer companies would build the network that would interconnect each other's equipment. So, there [would be] no room for a stand-alone networking company.''

Not surprisingly, most venture capitalists could not envision the economic space and could not believe that a startup could construct such a market. Ungermann (1995) contacted virtually ''every venture capitalist in the United States and in the world really'' with little success. It took 8 months to close the deal. The market and technical problems were one set of issues, but Brownstein (1998) recalled that some venture capitalists believed Ungermann's association with Zilog was also negative because of its relative lack of success, though Brownstein now believes this was a rationalization for not wanting to invest. This agrees with Burton et al. (1998), who found that an entrepreneur's past employer had a significant impact on the venture capital funding decision.

Because Brownstein assisted in developing the business plan, he was committed to the venture, but his policy was only to coinvest, so other investors were required. The other lead investor came to UB by a very different route. In the Fall of 1979, James Swartz, a venture capitalist, attended a McGraw-Hill Conference on data communications in New York, where Robert Metcalfe, the inventor of Ethernet at Xerox PARC, presented a seminar and proselytized for the adoption of the Ethernet protocol. One slide listed the small companies that had adopted Ethernet, which included UB. Since Swartz was interested in computer networking, he decided to visit the listed companies.

Swartz was uniquely prepared to see the potential of LANs because in 1978, he had made an investment in Amdax, a company commercializing a broadband technology for factory automation. Soon after the investment, the founder died and Swartz managed the company until a successor could be found. As the temporary CEO, he was immersed in the networking business and was convinced of its potential.[13] So, by the time he visited UB, he was primed to make an investment. Swartz (1995) described his meeting with the two founders:

> I met Ralph and Charlie [and discussed their business]. At the end of the day I said, 'Jesus, this is terrific. I really like what you guys are doing. You are absolutely right on everything. I can tell you I want to do this.' So, I called Fred (Fred Adler, his partner) that evening and told him what I was doing. He said, 'fine go do it.' And so that evening or the next day, I called Ralph and committed to him.

Since Bessemer Securities had already committed, the deal was quickly finalized with Oak Investment

[12] UB's business plan listed the following potential customers: Ford, Hughes Aircraft, State Island Hospital, Sytek, LII, TRW, Chase Manhattan, Chemical Abstract Service, Library of Congress, Western Union, Employers Insurance of Wausau, Boeing Aerospace and Boeing Computer Services, Wells Fargo, US Navy Ship R&D Center, Martin Marietta, Citibank, Tymshare, Control Data, Shell, GTE Services, University of California, San Diego. See Ungermann–Bass (1979).

[13] In 1983, UB acquired Amdax.

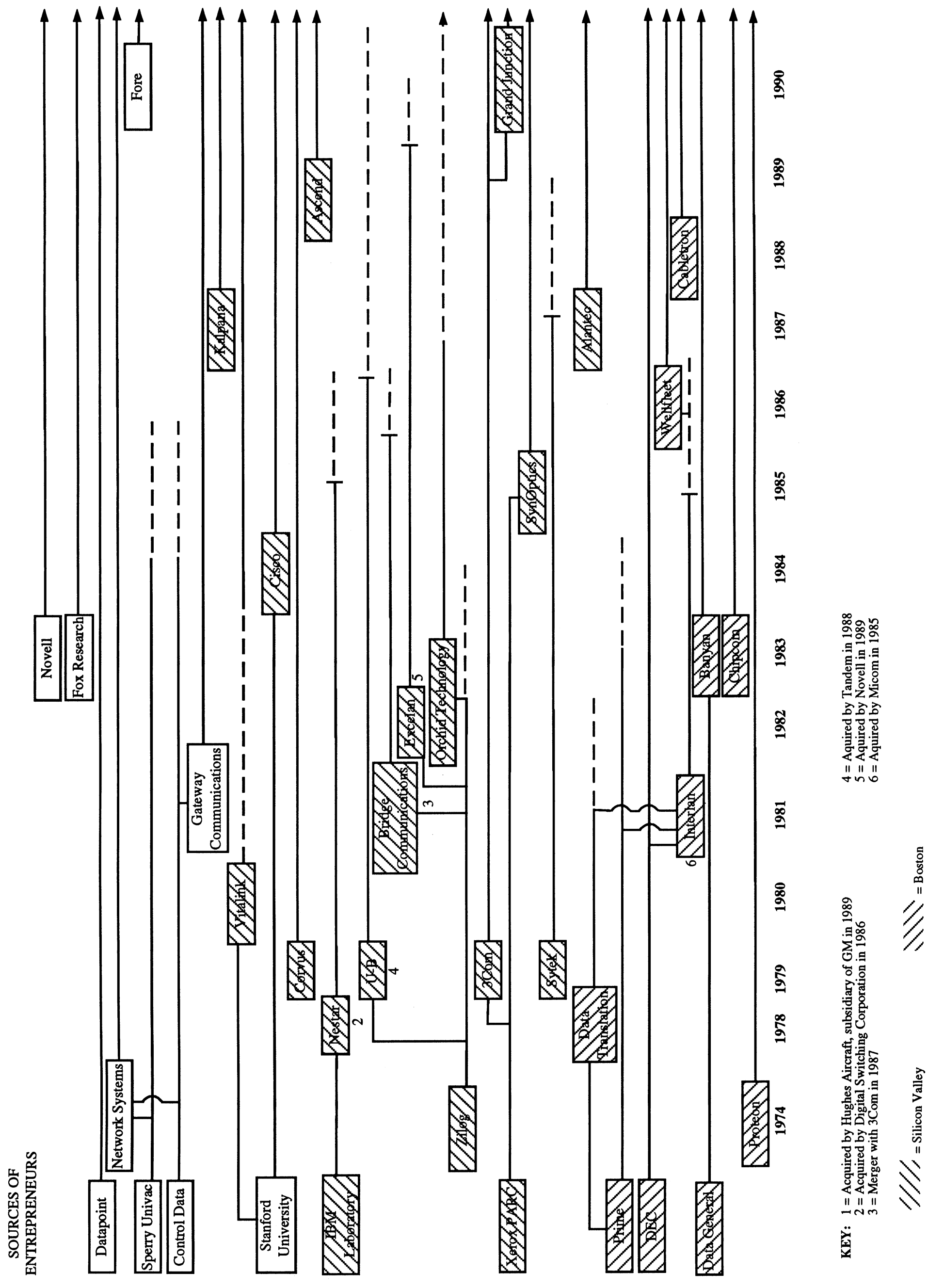


Fig. 1. Genealogy of startup LAN companies.

also joining (Ungermann, 1995). Swartz, Neill Brownstein of Bessemer Venture Partners, and Stewart Greenfield of Oak Investment Partners invested an initial US$1.5 million in February 1980. In total, the investors committed US$10 million before the company went public in June 1983 with a total valuation of US$48 million (Hofmeister, 1989).

In sectors where there is no industry and no market, the investment decision is inherently difficult. Swartz (1995), when asked about whether he contacted personnel in large companies, such as IBM, DEC, or Xerox regarding the feasibility of the business plan said, ''if I had tried to do that kind of due diligence, I would have been absolutely convinced that [the UB investment] was something I should not do.'' Since Swartz believed in the potential inherent in the technology, he described the decision-making process in this way, ''[the investment] became a people thing, who [the founding team] are and what they have done — classic resume tracking. And then it becomes a very gut-level feel of, 'gee, are these credible people. Do they have the right integrity and right ethics?''' Brownstein also said it was difficult to effectively research an almost infant technology, but he was sensitized to the possibilities of LANs due to Bessemer Ventures involvement with Telenet Communications, which was founded in 1979 (Brownstein, 1999).

Despite great difficulty, Network Systems and UB succeeded in securing venture capital. However, funding was not a foregone conclusion. During the same period another firm, Nestar, established in October 1978, never found venture capital. Inspired by the feverish experimentation with microcomputers in the Silicon Valley area, Nestar's founders, Harry Saal and Leonard Shustek, recognized that an important limitation for these microcomputers was the high cost of peripherals such as hard disk drives and printers. At the time, Saal was developing interactive time-sharing systems for mainframes at the IBM Palo Alto Laboratory and then later the IBM Santa Teresa Laboratory. They were intrigued by ''the idea of building large distributed systems of personal computers, networking them, and connecting them together'' (Saal, 1995). He tried to convince IBM to let him work on these ideas, but IBM was uninterested. So, Saal resigned and convinced Shustek (1999), a Stanford physics graduate student who had become an assistant professor at Carnegie Mellon University, to found Nestar to develop and market microcomputer LANs.

In 1978, while building their first LAN prototype for the Commodore PET, they tried fruitlessly to raise venture capital in Silicon Valley and New York. They later began networking Apple II computers, but as Saal recalled, ''[the venture capitalists] really did not believe that these types of computers would ever be used in a real commercial-type environment or that people would have large numbers of them networked together. I got a fantastic rejection from all of them. They said this [company would] not go anywhere, that these toy computers were never going to be serious and if they were serious, nobody would have many of them at a time together'' (Saal, 1995). Further, they questioned the reasons IBM did not invest, if the idea was so good. [14] Only later, did Nestar receive capital from the Rank organization in the United Kingdom.

Nestar was too early. The microcomputer was still the province of hobbyists, and there was not a large installed base (see Fig. 2). To be legitimate in the business world, microcomputer LANs would have to wait until IBM introduced the PC. Nestar never had revenues greater than US$10 million and was eventually merged with another company and closed in 1986. [15] Saal and Shustek were the typical pioneers that had all the elements right, but they were unable to recruit resources and to unify them into an economically viable system. Since it was early, Nestar had to wait for the microcomputer market to grow sufficiently large, and it had to develop all of its own hardware and software. Nestar provides an interesting example of how venture capitalists often are unwilling to support an entrepreneur's vision that ultimately proves to be quite accurate. With suffi-

[14] This was the period when IBM appeared invincible.

[15] Failure is often not final. In 1986, Harry Saal and Leonard Shustek left Nestar to start another LAN, Network General, with ''with a blank piece of paper (Saal, 1995).'' At Network General, Saal and Shustek controlled nearly 60% of the stock. For the most part, they boot strapped the company and only brought in TA Associates of Boston later. Network General went public in 1987 and merged with McAfee Associates in the late 1990's. Both Saal and Shustek have since left Network General.

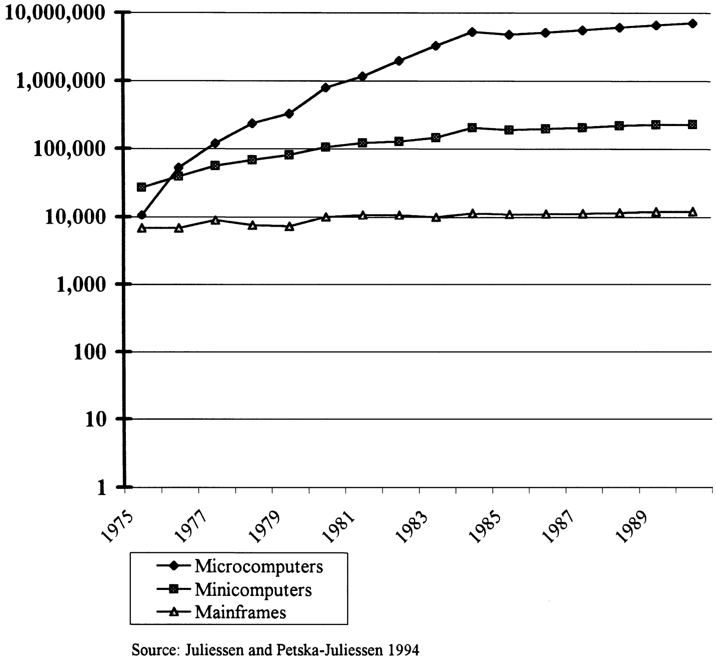


Fig. 2. Annual US shipments of microcomputers, minicomputers, and mainframes, 1975–1990.

cient funding Nestar might have had the wherewithal to find a market for their LAN.

There were other early startups, which had proprietary LANs that met with limited success. For example, another early startup, Corvus, was a hard disk drive manufacturer, which had a LAN system meant to link its hard disk drives to an office network. The LAN sold well especially for linking Apple II computers. Because of its internal status, it did not need venture capital. However, when the disk drive business failed, the LAN business also failed. Another very early Boston-area LAN firm, Proteon, was established in 1972 by Howard Salwen. Initially, the firm consulted on networking for the U.S Department of Defense. In the late 1970s and early 1980s, Proteon developed a Token Ring LAN system and began marketing it. It only began looking for venture capital in 1983, and the deal was closed in 1984 (Proteon, 1991; Bayless, 1998).

There were a number other startups with proprietary protocols. Examples include Sytek (1984), a Silicon Valley spin-off of Ford Aerospace incorporated in 1979, with funding from General Instrument (50.8% of total equity at time of IPO). Another firm was Gateway Communications (1985) of Irvine, California, which was financed by the entrepreneurs and the Noorda family trust of which Raymond Noorda, the president of Novell, was the trustee. Gateway also had a proprietary protocol that was not accepted in the market. Still another firm was Xyplex (1991) established in the Boston area in 1981, which at its inception focused connecting DEC computer systems using a proprietary LAN protocol. Xyplex received funding from a number of Boston-area venture capital partnerships, including Claflin Capital, Matrix Partners, BancBoston Ventures, and Charles River, and the California partnerships, Menlo Ventures and Sigma Group. It only went public in 1991, after a long period of continually losing money.

To conclude, by 1980, a few LAN startups had been founded and even had begun shipping some products. But by large, the computer manufacturers appeared far better positioned to capture this economic space. They controlled interfaces and customer base, and had all the required financial and technical capabilities. The computer manufacturers' better position clearly reflected on the venture capitalist's assessment of the business opportunities of startups. There was no standard at the time, and the various proprietary LANs introduced by the startups had significant difficulty gathering outside support. Not surprisingly, though the venture capitalists funded a few firms, they were hesitant and did not see LANs as a promising investment field.

7. Xerox changes the equation

In the late 1970s and early 1980s, two events occurred that changed the prospects for new entrants. Like IBM and the other computer manufacturers, DEC became interested in LAN technology. However, rather than designing its own protocols, in 1979, DEC began to discuss licensing Ethernet from Xerox for networking their forthcoming VAX computers. As an outcome of discussions, Xerox came to believe its strategic interest would be served, if Ethernet was adopted widely. Therefore, it eschewed royalties and set a low licensing fee of US$1000 (Liddle, 1995). The widespread adoption of Ethernet was in Xerox's interest because at the time most customers were locked into the proprietary systems offered by Wang, DEC, and IBM (Sirbu and Hughes, 1986). Adoption of the open Ethernet system would free customers to purchase eclectically. [16] To assist in popularizing Ethernet, Xerox and DEC recruited Intel to form the DIX group. DEC and Xerox, which intended to sell minicomputers and printers, respectively, hoped an open network protocol would ignite competition in component manufacturing, thereby lowering price and encouraging innovation. Also, for DEC it solved the problem of having to design its own protocol.

While the DIX group was preparing to announce Ethernet as an open standard, a second critical process was underway, namely an Institute of Electrical and Electronics Engineers (IEEE) committee meeting (called IEEE 802) on creating a LAN standard. The DIX group decided to offer Ethernet to the IEEE. However, this created a rift between the DIX group and another group led by IBM advocating a Token Ring standard. Very soon, the IEEE committee divided into two separate groups, each of which issued their own standard. Ethernet's advantage was its openness and that it was already available. Token Ring was not yet in production but it had support from IBM and had superior network management technology (von Burg, 1999). The decision to create open standards doomed the proprietary firms.

In hindsight, the IEEE 802 standardization was a fundamental event in the creation of the LAN industry. The Ethernet standard shifted the balance of power between the LAN specialists and the incumbent computer manufacturers, as the licensing and standardization of Ethernet provided a ''language'' around which an economic community could coalesce. Whereas most early LAN entrants excluded other firms from using their standard, Ethernet welcomed all. For startups this meant they did not have to develop a protocol from scratch. Also, DEC and Xerox systems were now a market, and for suppliers uncertainty was reduced. Also, there was the promise of being freed from the control of computer makers' proprietary systems. DIX had issued an open invitation to entrepreneurs to begin developing Ethernet-compatible products.

8. Ethernet startups

Although IBM's and DEC's adoption of an open standard put the startups on an equal basis, from a theoretical perspective the computer manufacturers still had significant advantages vis-à-vis startups. They had enormous marketing power and had access to potential customers. Also, they had strong research and engineering capabilities, so it was reasonable to expect them to overwhelm the startups and occupy the industrial space. Yet, both were relatively slow in getting products to the market. In its insistence on developing a perfect technology, IBM spent several additional years at the IEEE standardizing Token Ring. Hence, standard Token Ring did not become available before 1986. Given Ethernet's faster standardization, DEC could have acted faster, but it also responded slowly and did not ship products until late 1983.

[16] For a discussion of standards and lock-in, see Farrell and Saloner (1986), Katz and Shapiro (1986) Arthur (1989), David and Greenstein (1990) and Shapiro and Varian (1999).

While the two computer giants moved very slowly, startups were very fast. UB immediately switched to the Ethernet version and introduced an Ethernet-compatible product in 1981 months before anybody else. UB's reaction to Ethernet was not surprising as DEC systems were a very important part of their business, and a standard legitimized them to their Fortune 500 customers. Ethernet was the logical choice for UB because it was available, whereas the ultimate Token Ring standard was still being developed. Finally, the UB founders were well acquainted with Metcalfe and Xerox PARC.

The Ethernet market was far more attractive than Token Ring because it was far nearer to becoming a defacto standard. Ethernet clearly had the backing to become a dominant design, but there was no guarantee that startups could be successful in competition with larger established firms such as DEC. If the startups were to be successful, it would be necessary to recruit the capital that could be used to develop an operational firm. Given the support by the DIX group and the IEEE standardization process underway, one might expect venture capitalists to leap at the opportunity to participate in the construction of a new industry space and, if fortunate, an entire dominant design. However, as we shall show, at this early stage venture capitalists were reluctant to invest.

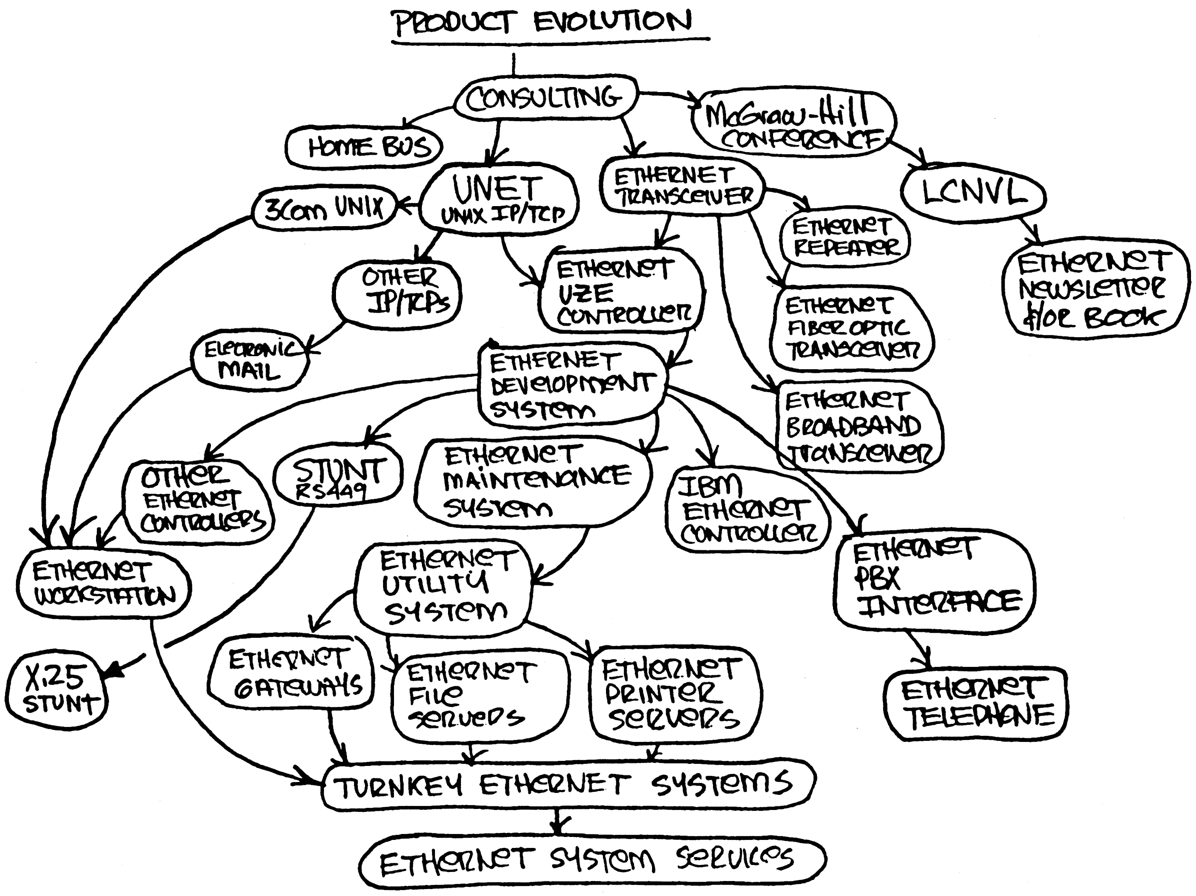
3Com was the first of the new Ethernet-dedicated startups. It was founded by Robert Metcalfe, the inventor of Ethernet, and Gregory Shaw on June 4, 1979 (Crane, 1995). After leaving Xerox PARC and prior to founding 3Com, Metcalfe had consulted for DEC and helped make DEC's new VAX minicomputer product line compatible with Ethernet. Metcalfe established 3Com to exploit the Ethernet standard, which he had encouraged Xerox to license at favorable terms. The 3Com founders had never started or managed a company. Metcalfe's experience had been in the university and research environment, and he had no experience as a business manager.

The founding team had never raised venture capital or written a business plan. Charney (1995), the original Secretary and Vice President of Operations, described their presentations to the venture capitalists as ''meandering.'' They intended to target desktop computers, but in October 1980, there was only a small installed base, as the IBM PC had not yet been introduced. Written in the last quarter of 1980, 3Com's business plan was necessarily vague, because the market was not yet formed. According to the October 6, 1980 3Com briefing document for David Arscott and Leal Norton, a venture capital partnership, 3Com planned to capitalize on Xerox's Ethernet to provide multi-vendor compatibility in local networks [3Com, 1980]. Given the vagueness of the business plan, the lack of a clear market, and fears that large companies such as IBM and DEC would control the market, Arscott and Norton and many others decided against investing (Richman, 1989). This was not surprising. One of the original venture capital backers, Richard Kramlich, remembered his first meeting with Metcalfe:

> He [Metcalfe] told me about his background and where he had been. He sketched out his Ethernet idea. I will never forget because he brought in his business plan and it amounted to a series of clouds. I was trying my best to understand what he was talking about and I had a vague understanding of it. But I did not know any of the technology at the time.

Fig. 3 is a reproduction of a page in the original business plan and shows that 3Com was proposing to undertake a large variety of tasks. In fact, another very successful venture capitalist, Dougery (1998), said he had met Metcalfe and remembers talking ''with people at Mayfield (a very successful venture fund) who looked at it and they didn't understand what the hell Metcalfe was saying.'' This provides an indication of how great the task was, not of building, but simply of explaining what a useful LAN was at the time.

Because of Metcalfe's reputation at Xerox PARC, there was interest in the venture capital community. Wallace Davis at Mayfield offered US$7 per share to Metcalfe who rejected the offer as too low. Richard Kramlich at New Enterprise Associates put together an offer for US$13 a share, and Metcalfe turned him down, also. Metcalfe then managed to secure a US$21 per share offer from a Boston venture capitalist. However, the Boston firm never closed the deal. After presentations to nearly 40 venture capital



Source: 3Com Corporation. 1980. “Confidential Briefing for David Arscott and Leal F. Norton”

Fig. 3. Product evolution.

groups, Metcalfe returned to the Silicon Valley venture capitalists; Jack Melchor of Melchor Venture Management, Richard Kramlich, and Wallace Davis, and closed the deal (Wilson, 1985, pp. 177–179). At the end of this 6-month search period, 3Com received US$1.05 million on February 28, 1981 — the same day 3Com actually ran out of money (Charney, 1995).

Kramlich invested in 3Com because Metcalfe and the technical expertise of the team impressed him. Kramlich (1995) attributes his decision to invest to his involvement in Apple Computer, which alerted him to ‘‘the logic of going from a personal computer to a network. Resource sharing was going to be the wave of the future.’’ As with Swartz and Brownstein in the UB deal, Kramlich appears to have had an experience that prepared him for his pioneering investment.

The venture capitalists were intent upon building a complete firm. One important stipulation in closing the 3Com financing was that 3Com hire a seasoned manager to handle the general management issues. The venture capitalists were actively involved in this recruitment, which brought in an executive from Hewlett Packard, William Krause, as the CEO. [17] In this recruitment, the venture capitalists undertook to

[17] In 1995 *Business Week* reported incorrectly that Krause was a 3Com founder.

assist the company in the search and selection process.

Initially, 3Com grew slowly, but changed its strategy dramatically in August 1981 when IBM introduced the IBM personal computer. Almost immediately, Metcalfe decided 3Com should design an Ethernet adapter card for the IBM PC using VLSI circuitry. The reason Metcalfe gave for focusing 3Com's resources upon the IBM PC was that 3Com had not been established to support what Metcalfe believed were the ''dying'' technologies of minicomputers and mainframes. For him connecting terminals and hosts was a poor utilization of the technology. Of course, providing Ethernet connections for the only recently released IBM PC was not immediately a large business because of the paucity of installed IBM PCs. There is another interpretation, Brownstein (1998), an investor in UB, said UB with its headstart had already occupied the existing minicomputer market, so 3Com had little to lose by moving to the PC. Whatever the motivation, this proved to be a brilliant and fortuitous move as 3Com's sales accelerated after 1984, as the installed base of IBM PCs and PC-compatibles grew dramatically.

In the 3Com deal, Metcalfe's reputation was a significant factor in attracting capital, but the process remained difficult. Notice the large spread in valuations and the inability or unwillingness of the Boston-based venture capitalist to close the deal. At this time, there was no consensus or community; finally 3Com looked like a ''me-too'' company as UB was already selling into the existing minicomputer market. Still it was clear that 3Com would adopt Ethernet, so in this sense, the technological question was solved, though it was not yet certain that Ethernet would become the dominant standard.

9. Other early entrants

There were other early startups that entered the LAN business. As mentioned earlier one of the most significant, Bridge Communications, was established in September 1981 by William Carrico, Judith Estrin, and Eric Benhamou, alumni of Zilog's Z-Net (Bridge Communications, 1985). Bridge Communications addressed the incompatibility of the wide variety of LANs using different protocols by building electronic ''bridges'' between them, hence the name, Bridge Communications. During the funding process the entrepreneurs realized that their business plan was flawed because there were not yet enough LANs to interconnect (Brinton, 1981). In this case, the venture capital process uncovered a flaw in the entrepreneur's plans. This did not prevent funding, rather Bridge had to offer other networking equipment and not just focus upon internetworking (Estrin, 1995). Bridge adopted Xerox's Ethernet standard from its establishment (Bridge Communications, 1986). Finding venture funding was a slow process, but after a 6-month search in December 1981, they closed the deal and received US$1.8 million for 60% of the firm's equity from Weiss, Peck and Greer Venture Partners (WPG); Merrill, Pickard, Anderson and Eyre (MPA&E); and later Warburg, Pincus Investors (Hofmeister, 1989). Estrin (1995) felt that, in the case of Bridge Communications, the venture capitalists made their decision on the basis of the people involved, because she thought most of the venture capitalists initially did not understand the technology. [18]

Another important Ethernet startup was Excelan, a Zilog spinout, which was founded in January 1982 by four Indian entrepreneurs, but received venture capital funding only in November 1984. Excelan was formed with the idea of interconnecting various LANs using the TCP/IP protocol. According to one of its founders, Kanwal Rekhi, Excelan had great difficulty securing funding, which he attributed to the entire founding team being from India. When this was mentioned to Dougery (1998), one of the lead venture capitalists in the deal, he said he had heard this rumor, but his response was:

> It [their being Indian] wasn't [a problem] for me. First [sic] immigrants I love it. All they have to do is work hard and they are obviously self-selected being here and, great education, and are highly motivated. I love it. That is a positive for me.

[18] Philip Greer (1996), a co-founder of WPG, readily agreed with Estrin's assessment that he did not completely understand the technology. However, he apparently did understand good entrepreneurs.

Almost immediately after investing the venture capitalists had to fire the CEO, one of the founding team, because of an internal ‘‘revolt.’’ To replace him, they found a manager, who helped them go public before leaving. In essence, the venture capitalists were intimately involved in the firing of two CEOs. Ultimately, due to the management turmoil and an enticing offer Excelan was sold to Novell to which it brought LAN knowledge and the focus upon the TCP/IP protocol.

Another important Ethernet startup in this period was the Boston-area firm, Interlan, founded in May 1981, to network minicomputers. It only became involved in PCs in late 1983 (Seifert, 1995). One of Interlan's founders had already been a successful entrepreneur at Data Translation so he was able to secure capital relatively easily from four East Coast partnerships.

After 1981, few startups chose to develop a proprietary standard. Though not yet dominant, Ethernet was fast creating a community and being accepted as a standard. By 1983 proprietary LANs were fading from the scene as a ‘‘bandwagon’’ formed around Ethernet. [19] Increasingly, new startups concentrated on developing products that were Ethernet-compatible, and venture capitalists would no longer back non-Ethernet firms. In 1983, Ethernet was an adequate, low-cost solution, but it was threatened by a well-designed alternative, Token Ring, supported by IBM. Though the vendors had established a thriving and rapidly growing industry based on the Ethernet standard, it still was not clear that they could survive an IBM-supported Token Ring standard that had significant technical advantages.

10. Fixing Ethernet — the second great wave

The Ethernet startups quickly captured market share, and the proprietary LAN vendors and minicomputer makers such as DEC were becoming increasingly dependent upon them. But in the mid 1980s, IBM had a real chance to recapture industry-dominance. Ethernet, in fact, had serious technological shortcomings. It was difficult to connect a node to the cable; the cable did not bend easily around corners; connections were often unreliable; an ill-connected node could take down the entire network; and finally, Ethernet's bus topology made it difficult to locate network failures. This gave IBM's Token Ring a critical window of opportunity. Designed as an enterprise LAN, Token Ring was far better suited to accommodate the growing networks, and due to its hub topology it also offered better network management and troubleshooting features. If Ethernet failed to improve, there was the potential for Token Ring to become the dominant design. Since IBM tightly controlled the Token Ring standard, it was likely that Token Ring's victory would have shifted the power balance back to the computer manufacturers.

In 1980, Xerox PARC hired Ronald Schmidt to develop an Ethernet version for fiber optic cable. While experimenting with fiber optic Ethernet, Schmidt replaced Ethernet's bus topology with a star topology, in which the cables from each node ran through a central hub. To publish a few academic papers and to help Xerox PARC, which had come under attack in the press for its unsuccessful commercialization track record, he built a prototype. Schmidt even developed a business plan aimed at interesting Xerox's management in commercializing his invention. After some consideration, Xerox decided not to commercialize this new topology, even though Xerox's own real estate consulting unit argued that the new configuration could solve the Ethernet cabling difficulties in their office buildings (Schmidt, 1995).

In 1985, after deciding it did not want to commercialize the hub, Xerox permitted Schmidt and Ludwick to resign, license the technology, and establish a firm. In return for using its intellectual property Xerox received equity in the start-up (Borsook, 1988; Schmidt, 1995). The company was incorporated in June 1985 by Andrew Ludwick, Ronald Schmidt, Shelby Carter, and Xerox as Astra Communications, but soon changed its name to SynOptics (SynOptics, 1988). Almost immediately SynOptics was profitable (SynOptics, 1988). In fiscal year 1985, it earned US$485,000 on US$1.18 million in sales and grew rapidly thereafter.

[19] For a discussion of standards and bandwagon effects, see Arthur (1989), Bresnahan and Chopra (1990) and Katz and Shapiro (1994).

In the early 1986, SynOptics sought venture capital. As with the previous companies, SynOptics had considerable difficulty finding investors. Many prestigious venture capitalists turned the deal down or missed it. For example, Richard Kramlich at New Enterprise Associates saw the SynOptics deal early because one of his partners was a fraternity brother of one of the founders. Kramlich (1995), a successful 3Com investor and very successful venture capitalist, recalled, ‘‘we should have done it. I knew it was going to be a great deal.’’ However, for a variety of reasons, many of which had to do with valuation and disagreements among the partners, NEA did not invest. Donald Valentine also saw the deal and says he believed it was a good opportunity. But he also did not invest (Valentine, 1995).

There were various reasons for the decisions not to invest in SynOptics. Many venture capitalists believed that the market for an Ethernet system running on fiber optic cable networks and the IBM Cabling System would be small (Jeffery, 1986). In this, they were correct, but SynOptics soon developed a hub-based, 10 Mbps Ethernet LAN on telephone wire. Because the hub was a relatively low technology product, many venture capitalists were concerned that the low barriers to entry would not allow SynOptics sufficient profitability or that competitors would quickly erode its first-mover advantages. These venture capitalists were correct, the hub was not high technology or software-intensive enough to deter the larger, incumbent LAN vendors such as 3Com, Hewlett Packard, or UB. What many did not envision was that the hub could become a platform upon which high-value software and firmware could be added and that the first-mover advantage combined with rapid innovation would permit SynOptics to outrun its competitors in the hub business (Bredt, 1995).

When the venture capitalists investigated the business plan, their concerns were reinforced by the incumbent LAN vendors. These companies thought the hub was trivial and easy to imitate. Ronald Schmidt (1995) described the situation:

> The VC all [talk to] the winners. They went and talked to 3Com. 3Com said it's trivial what they are doing, we can do it with our hands tied behind our back and one-eye blindfolded. And then, that went out to the entire VC community. So you had to find people who would not think as part of the herd instinct.

They escaped this ‘‘herd’’ instinct when John Lewis of Paragon Partners agreed to invest. Lewis was then joined by Thomas Bredt of Menlo Ventures, a prestigious Silicon Valley partnership, and this solidified the deal. The other venture capital firm to join the deal was Rust Ventures from Austin, TX and the investment closed in August 1986.

So why did Thomas Bredt invest when the others did not? Due to his experience with LANs from his previous employment at HP and Dataquest, he said it was obvious that the SynOptics' implementation of Ethernet had significant advantages over the existing technology. The hub and adoption of telephone wire radically simplified the installation and maintenance of an Ethernet LAN. Also, SynOptics inherited a powerful patent position from Xerox, though this proved of little value because securing approval from the IEEE meant freely licensing to all interested parties (Bredt, 1995).

As with the other firms, the SynOptics deal was shopped to many venture capitalists, but most declined to invest. Since the technology was simple, it was difficult to envision how the product's benefits would combine with the increasing number of PCs in such a way as to create an explosion of demand. Further, few foresaw the hub as a site for embedding high value-added software and specialized integrated circuitry, thereby increasing its value to the customer. Finally, they did not grasp the advantage SynOptics would have as the first mover.[20] The decision to fund SynOptics differed significantly from the decisions to fund LAN startups in the earlier period. The investment decision was based not so much on the entrepreneurs, but rather on the technology. The SynOptics' solution addressed two important Ethernet deficiencies. The character of the investment decision changed during this period because now Ethernet was a winning technology, there was a community of firms and individuals to consult (though many offered the wrong advice), and

[20] In today's Internet market, this is simply an environmental condition.

there were some measures with which to evaluate SynOptics (i.e., the previous successes of UB, 3Com, and Bridge). At least some venture capitalists claimed they wanted to invest, though they did not, indicating some awareness of the technology's value. Ultimately, investment decisions were based upon beliefs regarding whether the hub provided a profitable opportunity. The parameters of variation to be considered had narrowed significantly from the 1978–1986 period. Risk, of course, still existed, but the preeminent issues had shifted to execution, moving faster, and adding value.

With SynOptics and Ethernet's improvement, Ethernet prevailed over Token Ring. This meant the startups, then firms with US$100–500 million sales, continued to dominate the industry, and LAN technology was definitely embedded in an industry separate from the computer industry. This would have significance in a myriad of other ways. The venture capitalists' success in these early networking startups dramatically increased their interest in funding other startups such as Cisco and various infrastructure firms and, in the mid 1990s the Internet phenomenon.

11. Discussion

The investment decision and the building of the firm are better understood as an attempt to construct an entity and space. The entrepreneurs recruit resources from the environment and unite them into a working entity. They must convince investors that their vision of the future has the possibility of being actualized. With the venture capitalist, the entrepreneur recruits an active investor who will assist in the construction process.

The construction of these LAN firms was not orderly, rather it had an emergent quality. Rather than constructing, the process seems far less rational, often the actors cobbled things together and engaged in leaps of faith. Venture capitalists undertook due diligence and even calculated possible rates of return, but then they attributed investments to their ''gut feelings'' about the people involved. Since these investments demand an envisioning process, there is a significant component of tacit knowledge in the investment decision that cannot be easily made explicit. If the cobbled together firm experiences some success in attracting capital and sales, i.e., it grows, then it will become concretized, rewarding the cobblers. Success also attracts imitators and extenders (both entrepreneurs and venture capitalists), these create the community — as in the case of Ethernet.

The utility of the dominant design schema for thinking about the venture capital decision-making process is illustrated by the difficulties of the earliest startups in securing financing. With no dominant design the situation was difficult for investors; there was no industry or market for these startups, making it difficult to envision firms dedicated to producing LANs. For many venture capitalists, the claims by the large established companies such as IBM, DEC, Wang, and HP that they could and would provide computer networking appeared all too plausible. The idea of an independent industry became easier to accept after the decision by Xerox to license Ethernet and DEC's adoption of Ethernet. This certified there could be a market. As important, it provided the first indication that Ethernet might become dominant, thereby removing a source of uncertainty.

Before a dominant design emerged, the venture capitalists had to bet on the entrepreneurs presenting the business plan, i.e., bet on people. The difference between a radical innovation with massive capital gains and a mistake with no chance of success is not always easy to discern a priori. Many apparently sure things and great entrepreneurial visions ultimately look foolish, because they find no customers, encounter problems that cannot be solved technically, or come to fruition only years or even decades after the first investments. Thus, often the initial chaos and opaqueness of a technology or market is sufficient to discourage venture capital investors as a group. The critical point, however, is that venture capitalists are evaluated as individuals in partnerships, therefore an individual or partnership can break ranks and provide funding. This means that many alternatives can be tried and failures do not destroy the system.

Drawing upon a synthesis of the theories about design and social constructionism, we used a case study of the creation of the LAN industry to provide a new and richer framework for considering the venture capital process. Our formulation, though not as tightly determined as many more economics-inspired studies, is more appreciative of the contingent and emergent features of economic activity seeking to construct a firm de novo. Hopefully, this contribution will encourage more research on the interaction between venture capital, firm formation, the lock-in of a dominant design, and the creation of new industries.

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