Technological Mediation and Commercial Development in the Early Internet Access Market

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Enough time has passed to begin evaluating business conduct during the commercialization of the Internet. Are there any general lessons about how new and emerging technology markets evolve during turbulent periods? What market forces shaped the sources of value? How did firm strategies for constructing viable business enterprises align with the factors shaping market structure?

"Technological mediation" describes firm behavior associated with standing between a changing technical frontier and unique user needs. This can involve many different activities. A vendor may provide a simplified version of a more complicated service. A vendor may assess the user's operations and provide advice about which configuration of equipment and services meets the user's particular needs. The vendor may also generate fees for a consulting service associated with more efficiently using frontier technology. More often, a vendor combines economic activities, as when a vendor sells advanced capital equipment to a user, installs it for them, and makes it operational.

Technological mediation synthesizes ideas from three strands of the economics of technology markets. Many models of intermediaries have analyzed how vendors provide a "matching service" and "monitoring service."[1] "Co-inventive activity" is a concept used by Bresnahan and Trajtenberg[2] and

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Bresnahan and Greenstein[3] to describe adaptation activity that customizes general-purpose technologies. Greenstein[4] emphasizes firm incentives to differentiate from common competitors in technologically intensive environments.

Internet Service Providers

Internet Service Providers (ISPs) provide a good example to illustrate the importance of technological mediation. ISPs provide access, maintain it for a fee, and develop related applications as users require. While sometimes this is all they do, in some situations they do much more. Many end-users do not want to (and do not know how to) set up and maintain Internet access themselves, nor are many Internet end-users familiar with all the possible ways in which Internet access can change their business operations or their daily lives. Hence, ISPs are in a position to also install, operate, and maintain many other things related to what a user does with Internet access. ISPs may help customize Internet technologies to the unique needs of organizations, solving problems as they arise and tailoring general solutions to idiosyncratic circumstances.

The early experience of ISPs is interesting because it defies easy analysis. First, this market grew *rapidly*, attracting thousands of entrants and many users, quickly achieving mass-market status. Second, firms offering this service became *geographically pervasive*, a diffusion pattern rarely found in new infrastructure markets. Third, firms *did not standardize* a menu of services to offer, which is indicative of the lack of consensus about the optimal business model for this opportunity. Why did this market grow so fast and so extensively in spite of all the restructuring?

The peculiar origins of the Internet intensified the importance of technological mediation in the early commercial access market. While uncertainties over commercial possibilities acted as a bottleneck in the growth of ISPs, technical limitations largely did not. While the technical challenges were most salient when the market grew explosively, the commercial and structural challenges—such as developing operations with viable revenue and cost structures or developing a range of services that match target user needs—continue to vex many firms.

Surveys show that as of 1998 no more than 10 percent of U.S. households get their Internet access from university-sponsored ISPs,[5] with almost all of the remainder going to commercial providers. Virtually all businesses use commercial providers as well. The dial-up market for ISPs was between 3 and 5 billion dollars in 1997[6] and between 6 and 8 billion in 1999.[7] While this is still relatively small compared to the entire communication and computing industry (which involves annual expenditures in the hundreds of billions of dollars), all observers expected revenues to rise substantially.

When ISPs first emerged in 1993-1994, only a few commercial enterprises offered national dial-up networks, mostly targeting the major urban areas. At that time, it was possible to run a small ISP on a shoestring in either an urban or rural area. These firms were devoted primarily to dial-up. By the fall of 1998, there were scores of well-known national networks and scores of less-known national providers covering a wide variety of dial-up and direct access. There were also thousands of local providers of Internet access that served as the links between end-users and the Internet.

Providing basic dial-up access required a modem farm, one or more servers to handle registering and other traffic functions, and a connection to the Internet backbone.[8] Expanding existing networks could involve building new facilities or making (sometimes expensive) arrangements to carry calls over long-distance telephone lines. This might require some familiarity with the non-proprietary standards of the web, but, generally speaking, this was not difficult to obtain. Anyone with some computing experience could use them or learn them quickly.[9] In contrast, direct access (e.g., providing a T-1 line to a business) was a more difficult market to enter, as it required some advanced engineering skills associated with installing and operating broadband data services. As it turned out, these skills were not rare for long, especially for engineers with experience in local area networking or other data communications markets. However, the capital and equipment requirements for this service were much larger than they were for dial-up. As a result, some but not all of the larger Internet access firms also offered direct access to their service offerings. Due to the expense, these were targeted primarily at business users.

Technological Mediation

Learning processes and adaptation behavior shape commercial technologies. These processes take place within the context of commercial behavior and reflect commercial motives.[10] The commercial activities pursued by vendors who mediate unique user needs and an advancing technology can best be understood through a conceptual framework of opportunities, strategic responses, and challenges.

Opportunities for Mediation

Three key factors underlie the opportunities for technological mediation activity.

First, opportunities for technological mediation arise due to gaps between what a technical frontier makes possible and a user's capability. This gap underlies the value chain for technological mediation. Users place value in being exposed to new technological advances and learning about their potential. The mediator is better educated about the technological capabilities than the user and, in effect, sells that general knowledge to the user in some form, either as part of a regular service or as a separate additional consulting service.

Second, the value and cost of technological mediation differs across users and over time. Within a business, the motives for adopting new Internet applications depends on the competitive situation of the user's enterprise, their legacy information technology (IT) applications, their product line, and many other features of the firm. Technological mediation typically involves adapting existing and non-frontier IT to circumstances for which it may or may not have been designed. Moreover, filling technical gaps can involve more than one project or transaction, and it may require unplanned and recurrent transactions. In other cases, the opportunity may involve periodic and planned review of the user's state of technology relative to new frontier developments.

Third, there is inherent uncertainty over the economic value of technological mediation activity. Vendors expect to face a different set of problems with each user and a different type of problem every day. Early versions of a technology often do not present any indication of their future value. Potential adopters—who might use the technology when the prices drop, capabilities expand, or mediation costs fall— may eventually have different needs. Furthermore, new Internet applications are often not primarily cost reducing. The benefits do not necessarily appear as an increase in revenues, but rather may show up as avoided losses. Often the use of new IT permits improvements in the quality and reliability of services that some enterprises believe are valuable and others do not.

Strategic Responses

Following the literature on mediation services in fluid environments,[11] there are several activities involved in technological mediation: monitoring technical developments, distilling new information into components that are meaningful to unfamiliar users, and matching unique user needs to solutions enabled by advancing technical frontiers. Given the uncertain value from mediation activity and the variety of challenges, it is not surprising that different firms might respond with different strategies to the same opportunities. There are three groups of strategic responses.

First, the vendor *offers similar solutions to different users.* For example, a vendor will take advantage of an opportunity by developing a new service with wide applicability and will then customize the service for each user. Unique applications tend to be costlier because fewer tools exist to help the staff who are doing the mediation.[12]

Second, the vendor is positioned to *be the solution provider to the user over time.* Developing expertise positions the vendor towards repeat business from complementary services. This strategy presumes that change to the technological frontier acts as a key event, ushering in a series of promising disruptions marked by new commercial possibilities.

Finally, the vendor *uses mediation to complement sustained and regular revenue-generating activity.* Mediation services may accompany several different activities such as equipment sales and consulting about business processes. The repeated contact between an ISP and a user puts the ISP in a unique position relative to other third-party vendors. At its most basic level, an ISP may charge for access and hope to the use mediation activity to enhance access demand. Some ISPs use regular access as an opportunity to offer services that enhance the user's Internet experience, charging a premium for installing hardware or software. Others ISPs bundle a variety of activities with access, charging a premium for the enhanced services.

Types of Challenges

Markets for technological mediation are characterized by technical, commercial, and structural challenges.

Technical challenges often arise during commercialization. A technology that is mature enough for exclusive non-commercial uses—such as a military application—may appear primitive in civilian use. It may require complementary inventions to become commercially viable. A technical challenge arises when an *additional* amount of invention is needed for a product design to meet more cost-conscious or less technically stringent commercial requirements.

Commercial challenges arise when commercial markets require substantial adaptation of operation and business processes in order to make technologies viable as operational services. In other words, it may not be clear how to balance costs and revenues for technologies that were developed in settings with substantial subsidies underwriting losses and research goals justifying expenditures. Resolving this uncertainty requires experimentation with business models before they begin to grow, if they grow at all.

Structural challenges are those which require changes to the bundle of services offered, changes to the boundary of the firms offering or using the new technology, or dramatic changes to the operational structure of the service organization. Commercial and structural challenges are not necessarily distinct, though the latter are typically more complex.

Commercial Internet Access as a Technological Mediation Business

Internet access technology is not a single invention. Instead, it is embedded in equipment that uses a suite of communication technologies, protocols, and standards for networking between computers. The technology obtains economic value in combination with complementary invention, investment, and equipment.

Plans for commercializing the Internet—which principally involved privatizing the domain name system, lifting the use restriction, and privatizing the data-exchange points—were put in place in the early 1990s. These plans were made prior to the invention of web technology and date back to the transfer of stewardship to NSF, when a regional network structure was adopted specifically to enable decentralized support of the network outside of Washington. The privatization of the network was implemented just prior to the diffusion of the browser, around 1992.[13]

It would be fair to characterize these plans as minimalist in regards to commercial developments, taking a hands-off approach to the development of complementary Internet technologies by commercial decision makers. The resulting explosion of commercial activity in 1994-95 caught much of the information policy community and many mainstream and potential market participants by surprise.[14]

Part of that surprise was over the format, not the function. The commercial opportunity for electronic commerce and other digital communication had been forecast by futurists for some time, but there was widespread disagreement over its specific form. What type of architecture would govern the design of the complementary components that makes up the standard bundle? How would the whole system work as an operational matter? Would it be compatible with existing communication and computing equipment and at what cost? There was certainly no consensus that TCP/IP was a panacea for all open issues; there was genuine surprise that TCP/IP turned out to be useful for so much of digital communications.

In part, this perception was an unintended artifact of NSF policies. Prior to its commercialization, TCP/IP had applications built on top of it that were suited to academics and researchers. These applications provided some demonstrable uses, but the NSF restrictions prevented any commercial firms from pursuing alternative technological approaches to existing on-line services. In other words, without a demonstration of TCP/IP in a commercial setting, many developers and users in the commercial world did not know of the potential uses of this technology.

However, TCP/IP applications also were not the only potential solution to many user problems and their general usefulness would have been hard to forecast. In the commercial world, there were parallel developments in bulletin boards, which already numbered in the thousands in the United States.[15] Services such as Prodigy, CompuServe, and AOL had several million home customers across the country by the early 1990s.[16] The on-line database industry was also over several decades old, had developed mature rules for selling information in a commercial setting, and was still moving into many new service territories.[17] There were also many developments in electronic commerce, especially in business-to-business transactions.[18] In networking equipment markets, many of these developments involved proprietary networking solutions from large and small firms alike.[19]

Perhaps most importantly, the client/server revolution was beginning to take hold and gain momentum with business users around the early 1990s,[20] exposing many enterprises to the benefits of networked computing. TCP/IP offered further connectivity in a networking environment, but it was not obvious to many commercial observers that TCP/IP would be such a productive technological path to follow. When the Internet first commercialized, it was relatively mature in some applications, such as e-mail and file transfers, and weak in others, such as commercial infrastructure and software applications for business use. This was due to the fact that complementary Internet technology markets developed among technically sophisticated users before migrating to a broad commercial user base. While this is a typical pattern for early development of new information technology,[21] in this instance it was also an artifact of the origins of the Internet and the NSF restricting use of the Internet to a research environment. As it turned out, the invention of the World Wide Web further stretched the possibilities for potential applications, exacerbating the gap between the technical frontier and the potential needs of less technically sophisticated users. These events raised the value of activities associated with technological mediation, setting the stage for many technical, commercial, and structural challenges.

Early Challenges and Responses

The early users of TCP/IP applications were scientists and engineers, primarily in higher education and laboratories. These users had resolved many technical issues and developed many basic capabilities such as e-mail, FTP, and the web. However, the commercial challenges lay ahead. What Internet activities would be most highly valued? What business model would most profitably provide Internet access, content, and other services to users outside the academic or research environment? No consensus had emerged prior to commercialization, nor should such a consensus have been anticipated.

The commercial opportunities for ISPs in 1995 ostensibly called for a one-time expenditure to set up connections and access for commercial and home users. A very large installed base of researchers and educational users already provided the foundation for growth of the user population. This expansion involved solving problems associated with setting up the network in many different locations for many different applications and customizing it to existing information networks. The commercial value of this activity was unknown, and it required some experimentation to address the challenges. After widespread access was achieved outside of the research communities, the potential commercial value became apparent.

The value of being in the Internet access business depended on translating the technologies into a reliable and dependable standard service for non-academic users. This opportunity was an artifact of an environment that originally forbade its use for commercial purposes. The value of long-run business models was uncertain with home users because TCP/IP technology potentially altered many information-intensive activities such as the delivery of music, news, entertainment services, and the conduct of communications. Hence, the development of a viable access business would spur other complementary developments whose economic value remained unknown for some time.

This view reinterprets one of the key events of commercialization, the commercialization of the browser, highlighted by Netscape's IPO in August of 1995. Almost certainly, Netscape's business opportunity and initial advantage would be fleeting (whether or not Microsoft responded as it did). Accordingly, Netscape had a strategic opportunity to grow, but it was short-lived. As extensively analyzed by Cusumano and Yoffie,[22] expansion into related lines of business, such as Intranet software, was inevitable and necessary for the company to survive. Netscape had to develop customer relationships and translate these into more enduring business opportunities, such as those in server software applications, which took advantage of later changes in the technical frontier for Internet access.

The Netscape story provides a much richer definition of the concept of a "window of opportunity" in an evolving market.[23] A window of commercial opportunity stays open as long as there is a gap between the technological frontier and users with complex and idiosyncratic needs. The window then narrows depending on how fast vendors fill in the demand with different solutions to user needs. As vendors learn from each other and as they customize technologies to unique user needs, they create standardized solutions that continue to narrow the gap.

Had the NSF not had a restriction on users, then the Internet might have commercialized sooner. Indeed, the diffusion of the browser might have played out much differently, being less burdened by the careful steps NSF pursued to interconnect the existing research network with private firms and privatize key functions in the Internet. The activity of 1994 and 1995 would not have been as explosive if the technology behind TCP/IP had been gradually diffused to commercial users many years earlier. The sequence of adoption and customization would also have been more gradual. Perhaps the sequence would have mirrored the patterns seen in the adoption of client-server technology, which began in the late 1980s.[24] In that situation, the technology moved relatively slowly to other users as prices declined, co-invention costs declined, capabilities expanded, and as co-inventive lessons were learned and passed between users and vendors.

What would have happened if TCP/IP technology incubated in an environment in which commercial applications drove development? TCP/IP could have involved tussles among different proprietary version or standards battles between different platform approaches, as has been typical in commercial computing.[25] Would application development have responded to early user needs in the commercial environment in the late 1980s? There is a common presumption that the majority of Internet technology had to be founded on loosely coordinated non-proprietary standards, such as TCP/IP, World Wide Web, and so on. However, this feature of the Internet is partly an artifact of the platform's genesis in an academic and shareware culture where preservation of the "end-to-end" architecture thrived.[26]

Plenty of other successful computing platforms were founded in technically intensive engineering environments outside of academics, and most of these have had large elements of proprietary technology in them.[27] Occasionally communities of firms have grown up around non-proprietary standards, but usually this involved several dominant firms turning parts of these communities towards their proprietary interests. There was no particularly reason why this pattern could not have been re-established in digital communications technologies as well.[28]

Speculation aside, the explosion of activity after commercialization demonstrated that commercialization came later than necessary from the standpoint of when experimentation in the commercial setting would have resolved primary technical and commercial challenges.

A Commercial Challenge Quickly Resolved: Geographic Coverage

The U.S. telephone system has one pervasive feature, distance-sensitive pricing at the local level. In virtually every part of the country, phone calls over significant distances (i.e., more than thirty miles) generate per-minute expenses. Internet access providers had a strong interest in reducing expenses to users by providing local coverage of Internet access for a local population. Similarly, unmet local demand represented a gap between what is technically possible and what many users desire. This was a commercial opportunity for an entrepreneurial ISP, particularly when the Internet first commercialized. Someone with appropriate technical knowledge only had to move it to the right location and build facilities to meet local user needs. In the dial-up Internet access industry, these facilities were called "points of presence" or POPs.

This led to two related strategies for commercial service. First, ISPs stressed extensive geographic coverage of their services. Second, as entry became easier, coverage moved to less lucrative locations, i.e., the lower density areas that were more costly to serve. Both strategies were borne out in this market. Indeed, commercially oriented firms attacked untapped locations in the country so fast that by the spring of 1998 there was almost no difference in access across the U.S. except for a very few low-density areas. As it turned out, the dial-up market is an example where the commercial opportunities for technological mediation were largely fleeting.

In 1994, it was possible to survive in an isolated market by providing low-quality service with few value-added services. In competitive markets, this strategy could only succeed if the ISP charged low prices or targeted a specialized under-served user body. In some locations, these users could be located in remote office buildings or apartment buildings; in other locations, this could be a type of user who needs specialized applications. In low-density markets, the absence of competition did not discipline the pricing as much, nor did ISPs lose customers very often to other firms.[29] At the same time, many local ISPs thought they could thrive with high-quality service and higher prices or with many value-added services.[30] This strategy targeted users with particular needs or backgrounds, particularly in dense, urban areas. ISPs used the provision of dial-up ISP business as a complement to other more profitable services, such as the design, deployment, and maintenance of a large user's communication and data network.

By late 1997, many trade publications predicted that low-quality dial-up local service could not survive except in rural areas or isolated markets. The high-quality local ISP could still thrive but doing so was expensive, necessitating a minimum scale of service.[31] Many features of Internet commerce, such as web-page design using basic HTML, quickly become standardized, giving advantages to low-cost national designers. At the same time, the trade press discussed how local firms tried to reflect local needs. Local firms also developed reputations for quicker service in emergencies, friendlier site visitation or user-instruction, and customized technical support.

After a few years, the costs of geographic expansion were also relatively low. Operators could often be put on automated monitoring devices. In addition, the industry began to develop agreements to share facilities across locations, enabling some small companies to make local phone numbers available in remote locations far from headquarters (e.g., for traveling users). These factors lowered the costs of geographic expansion.

Some statistical evidence can be brought to bear on these trends. Downes and Greenstein compiled a list of telephone numbers for dial-up access and their location.[32] Their research shows the geographic distribution of the POPs across the continental United States. ISPs tended to locate in all the major population centers, but there was also plenty of entry into rural areas. The ISP industry's location was largely a function of population and commercial industry, not a function of the location of universities or research laboratories, the users who had spawned the industry in the first place. In the spring of 1998, for example, Downes and Greenstein show that more than 92 percent of the U.S. population had access by a short local phone call to seven or more ISPs.[33] No more than five percent did not have access to at least a few choices.

The number of firms maintaining national and regional networks increased between 1996 and 1998. There were 32 national firms in the fall of 1996 and 175 in the fall of 1998. Over the same period, the number of regional firms increased from 186 to over 600.[34] In 1996, most of the national firms were recognizable. Firms such as IBM, AT&T, AOL, and other established firms entered the ISP business as a secondary part of their existing services, providing data services to large corporate clients, often with global sub-divisions. By 1998, many entrepreneurial firms maintained national networks, although few of these new firms were widely recognized. There was a clear difference in growth paths. National firms grew geographically by moving to major cities across the country and then progressively to cities of smaller population. Firms with a regional focus grew into geographically contiguous areas, irrespective of their urban or rural features.

Not surprisingly, most of the coverage of rural areas came from local firms. It did not pay for many large national providers to provide home dial-up service in areas where many small local firms in other lines of business (e.g., local PC retailing) could afford to add Internet access to their existing business. The national firms preferred only to bring out a dedicated line to a large business in a small rural area if there was sufficient demand for it. Meanwhile, the local firms had an easier time customizing the Internet access business to the unique needs of a set of users in a rural setting.

For any firm with national ambitions, coverage of the top hundred cities in the U.S. was a fleeting advantage and quickly become a necessity for doing business. For any firm with a local or regional focus, there are countless others within every urban area providing similar services, so geographic scope has not provided a strategic advantage relative to competitors.

New Services and Other Structural Challenges

If the ISP operates the Internet access for the user, this on-going operation provides for frequent contact between the user and vendor, and thus it provides frequent opportunities for the vendor to modify the delivery of services in response to changes in technology and changes in user needs. If an ISP's business depends on the vendor being better educated about the technological capabilities than the user, one would expect to see ISPs offering a variety of services associated with those new needs. These concerns frame the primary structural challenges for ISPs.

Greenstein examined the business lines of 3816 Internet service providers in the United States who advertise on *thelist* in the summer of 1998.[35] These ISPs offered five broad categories of services: basic access, frontier access, networking, hosting, and web page design.[36] The presence of these activities is evidence that an ISP is broadening its activities into services other than access. This is also evidence of vendor experimentation with different approaches to offering services to users. The main statistical findings from applying the classification scheme are listed in Table 1.

Of the 3816 firms in the original sample, 2295 (60.1%) have at least one line of business other than basic dial-up or direct Internet access. Table 1 shows that 1059 provide high-speed access, 789 provide networking, 792 provide web hosting, and 1385 provide web page design.[37] This reveals quite a lot of experimentation with non-access services by firms in the access business.[38] It also reveals extraordinary lack of uniformity in the business model of such firms.

The largest firms—defined as present in 25 or more area codes—offer new services at slightly higher rates: 159 of 197 firms (in this sub-sample) provide high-speed access, networking, web hosting, or web design; 60 offer only one, 18 offer all four. Of these firms, 115 provide high-speed access, 59 networking, 63 web hosting, and 94 web page design. This represents a higher rate than the whole sample, but is consistent with the hypothesis that ISPs in urban areas

TABLE 1. Product Lines of ISPs

Category Definition	Most Common Phrases in Category	Weighted by Service Territory*	Original Sample
Providing and Servicing Access though Different Channels	28.8, 56k, isdn, web TV, wireless access, T1, T3, DSL, frame relay, e-mail, domain registration, new groups, real audio, ftp, quake server, IRC, chat, video conferencing, cybersitter TM.	28967 (100%)	3816 (100%)
Networking Service and Maintenance	Networking, intranet development, WAN, co-location server, network design, LAN equipment, network support, network service, disaster recovery, backup, database services, Novell Netware, SQL server	8334 (28.8%)	789 (20.6%)
Web Site Hosting	Web hosting, secure hosting, commercial site hosting, virtual ftp server, personal web space, web statistics, BBS access, catalog hosting	8188 (28.2%)	792 (20.7%)
Web Page Development and Servicing	Web consulting, active server, web design, JAVA, PERL, VRML, Front Page, secure server, firewalls, web business solutions, cybercash, shopping cart, Internet marketing, online marketing, electronic billing, database integration	13809 (47.7%)	1385 (36.3%)
High-Speed Access	T3, DSL, xDSL, OC3, OC12, Access rate > 1056k	15846 (54.7%)	1059 (27.8%)

* Unit of observation is ISP-Area codes, as found in *thelist*. For example, if an ISP offers local dial-up service in 29 area codes, it will be 29 observations. If that same ISP offers high-speed access then it will count as 29 cases of high-speed access.

(where large firms are disproportionately located) tend to offer more services at higher proportions. Because the national firms that serve a larger number of regions tend to do more experimentation, most of their customers, especially those in urban areas, have access to some form of experimentation.[39]

Expanding an access firm into the networking, hosting, and web design business overlaps somewhat with providing high-speed access. For some firms these two strategies are complementary, but for many others the two strategies are distinct. They may require different skills and talents, and they may be marketed to different customer's demands. The surveys show that the locus of technological meditation shifted from developing and maintaining access into related functions. Many ISPs in this business moved away from their specialization on only low-quality access. Access is provided along with many other complementary services where the combinations have not yet taken on a set pattern.

Further development of commercial Internet access will accompany several other activities on the boundaries of these ISPs. As ISPs offer more services that are integrated with the business processes of their users, it creates enduring links between the users and their ISPs. Users will then be left with the option of either developing new Internet activities in-house or allowing the ISPs to continually advise them on how to change their business processes.

A Summary of Early Developments in the ISP Market

- *Why did the Internet access business grow quickly?* Put simply, exclusive use did not lead to isolated technical and operational developments. Hence, commercializing Internet access did not give rise to any difficult or unsolvable technical and commercial challenges. This technology grew among researchers and academics without being isolated from commercial suppliers. That is, the technology grew without generating a set of suppliers whose sole business activity involved the supply of uniquely designed goods for military or government users. Related to this was the fact that the basic needs of researchers and academics were not so different from early commercial users. Hence, simple applications of the Internet invented for academic users—such as e-mail and file transfer—migrated to commercial uses without much technical modification.
- *Why did geographic ubiquity arise?* The Internet access business was commercially feasible at a small scale and, thus, at low levels of demand. This meant that the technology was commercially viable at low densities of population, whether or not it was part of a national branded service or a local service. Internet access was feasible in a wide variety of organizational forms, both large and small. Small-scale business opportunities were widespread throughout low-density regions and isolated cities in otherwise rural areas, which were largely not being served by national firms. Small-scale implementation also depended on the presence of high-quality complementary local infrastructure, such as digital telephony and interconnection to existing communications infrastructure. These were available throughout most of the U.S. due to national and local initiatives to keep the communications infrastructure modern.
- *Why did the Internet access business not settle into a common pattern?* Technological mediation thrived. Part of this was due to the absence of technical and commercial challenges, which allowed for low-cost experimentation in new uses, new locations, new market settings, and new applications. More generally, the technology was quite malleable as an economic unit. It could stand alone or become part of a wider and integrated set of functions under one organizational umbrella. This malleability motivated experiments with new organizational forms for the delivery of access services. Finally, the invention of the World Wide Web brought new promise to the technology and gave rise to new business models.
- *Why did market forces lead to such extensive growth?* As the literature on general-purpose technology would put it, co-invention problems are best situated with those who face them. In this case, those actors were ISPs who knew about the unique features of the user, the location, or the application. Removing the Internet from the exclusive domain of NSF

administrators and employees at research computing centers brought in a large number of potential users and suppliers, all pursuing their own vision and applying it to unique circumstances. In addition, it allowed private firms to try new business models, restructuring in ways that nobody at the NSF could have imagined. As it turned out, the NSF commercialized the Internet access industry at a propitious moment, during the growth of an enormous new technological opportunity, the World Wide Web. To be sure, some of the competitive forces and growth opportunities were heavily shaped by non-profit institutions, such as the World Wide Web Consortium and the Engineering Internet Task Force, but profit motives still played a prominent role.

Reinterpreting the Early Growth of the ISP Market

Viewed through the lens of technological mediation, the ISP market has gone through two waves of change and is currently entering a third.

The first wave involved the commercialization of technologies using TCP/IP in a way that employed functions developed under DARPA or NSF stewardship. The earliest ISPs essentially took the basic technology for access and charged a fee for its use. It was a fleeting commercial opportunity where most of the economic profitability has since been arbitraged away.

The entry of AT&T Worldnet in 1995-1996, with a marketing campaign that emphasized the professionalism and reliability behind their dial-up service, marked the end of the first phase and the transition into a new one. Many observers at the time predicted that AT&T's entry would begin the consolidation of the industry toward a few national suppliers. Though this service was successful and attracted well over a million customers, it did not initiate industry consolidation. AOL, Earthlink, Mindspring, and many other smaller ISPs continued to grow. This demonstrated that there was more to the Internet than simply charging for basic service.

The second wave came quickly. It saw the adaptation of the basic technology to a wide variety of users, supplier skills, and other market conditions. These were the first steps towards customizing the technology.

To the surprise of many observers, many local ISPs expanded into regional providers and many regional ISPs developed national services, without the benefit of mergers. A complex market structure arose, populated by hundreds of national firms, hundreds of regional firms, and thousands of local ones. No single pattern characterized these business models.

Some ISPs did well with these temporary opportunities, charging for expansion of e-mail services or up-grades to high-speed access. Others positioned themselves to be the experts across a wide array of services in networking or web design as technologies evolved and perceptions about needs changed. Still others positioned themselves to collect revenue on their ISP subscriptions, adding more and more functionality to basic service, thus making it more attractive than basic services from other ISPs.

Currently, the market is poised to enter a third wave, characterized by the expansion of TCP/IP technologies into completely new uses, especially for electronic distribution of goods, electronic supply chain management, and new information services for home use. Many of these services combine a number of innovative web technologies in original ways. Some of them-such as e-commerce hubs, instant messaging, interactive gaming, and peer-to-peer applications-take advantage of the pervasiveness of the Internet among a specific population, developing applications that would not have been valuable without a large number of users. Some of them—such as Internet fax, IP telephony, and audio streaming—have been forecast for some time, but the business models for providing service remain difficult to work out.

These trends have much uncertainty attached to them. As the frontier becomes more settled, many large enterprises are moving many functions in house, leaving a select set of services to access providers such as co-location hosting or virtual private networking. Unlike the earlier experience, this third phase does not promise an explosive growth of unexpected new services. Nor is it assured that ISPs will continue to have a relevant and central role as a mediator between the technical frontier and the user.

Furthermore, there is no reason to presume that ISPs will maintain the same operational structure under further competitive pressure. Indeed, there is competition from a variety of alternate business models that use dial-up access to subsidize another activity. Some ISPs charge very little for access and make up for the lost revenue with other services such as networking, hosting, or web design. AOL has successfully combined access with its "walled garden" of content and now has merged with Time Warner, the largest media company in the U.S., in the hope of pursuing a unique strategy. AT&T also appears intent on pursuing a unique approach to combining content and access.

Other firms have created innovative versions of the basic subscription model. For example, Netzero.com is the most successful to date of many firms that provide access for free and garner revenue through sales of advertising. There are also many other such experiments altering the explicit definition of basic service, embedding it with games, streaming, deep-linking, and so on. All this has changed the pricing structure. Access itself may soon become absorbed into a bundle of many other complementary commercial services, slowly fading as the stand-alone service it once was in the academic domain.

Finally, there is one more reason to expect business models to remain in flux. Geographic pervasiveness was not a relevant consideration at the outset of commercialization. However, today the pervasiveness of the Internet changes the economic incentives to build applications on top of the backbone and alters the learning process associated with its commercial development. All ISPs now depend on each other on a daily basis in terms of their network security, reliability, and performance. Many new applications—e.g., virtual private networking, long-distance voice telephony, multi-user conferencing, instant messaging, gaming, and mobile IP-communication—require coordinating quality of services across providers. If new business models are needed to take advantage of applications that presume geographic pervasiveness, then it will provide a commercial advantage to the firms with national backbones and assets. Pervasiveness also changes the activities that intensively employ the backbone. It has altered the scale of the market for supplying goods and services to the access industry, altering the incentives of upstream suppliers, equipment manufacturers, or software providers to bring out new services and inventive designs for the entire network.

While nobody believes the technical frontier will cease moving outward any time soon, it could change in a way to favor some types of firms and disfavor others. Currently, for example, the cost structure and performance of high-speed technologies, such as DSL, are still undergoing change. Moreover, technology and new applications may place a different set of decision makers in a position to translate technical frontiers into user needs. This could alter the market structure for mediation services if it alters the potential to take advantage of new commercial opportunities. For example, until now only a small set of users have placed particular importance on end-to-end ownership of facilities by their ISPs expect for very advanced services like virtual private networks between multi-enterprise organizations. If broadband applications are more efficiently produced with end-to-end ownership (e.g., either for IP-conferencing or multi-user applications) and users desire these services, it would create the incentive to be a national provider with one's own facilities.

Conclusion

Many important questions about evolving markets, both for economics and for management science, are wrapped up in understanding the competition to create, control, and distribute activities embodying technological mediation. In these settings, participants must learn how to organize new activities through experience. Technological mediation represents an important component of this learning activity.

Technological mediation is not a part of the common explanation for what happened after the commercialization of the Internet, but it is an essential component to a complete understanding of the value from TCP/IP technology. Viewing the Internet access business through the technological mediation framework illuminates several patterns in this market.

First, it helps us to understand the explosive events just after the commercialization of the Internet.

Second, this framework helps explain why the incubation of TCP/IP technology in an academic setting led to a lengthy set of adaptation activities in a commercial setting. Adaptation takes time, energy, and specialized knowledge, leaving room for ISPs to change their product lines for commercial buyers. Some opportunities in this market were fleeting, while others were not. Supplying access to even the most geographically isolated regions was the easy part of developing this new business; the growth of low-quality access leveraged off the existing telephone network. The difficult part is that suppliers must now adapt their business models to changes in the frontier and the evolving needs of users in markets other than mere access.

Third, in a market characterized by uncertain business value propositions, it is fruitful for analysts to focus on the opportunities that arise, characterize the strategies that developed, and analyze the challenges of firms as they flirt with one fleeting proposition after another.

Similarly, the technological mediation framework helps explain how the commercial opportunities of this earlier era will or will not resemble those to come. Most of the economic and strategic fundamentals leading to structure challenges have not disappeared. The names of the firms may change and so too may the specifics of the strategies, but the absence of uniformity in the development of Internet access business models should persist into the future. New applications for Web technology are still under development because the technology has potential beyond its present implementations. Not all local markets will experience the same type of competitive choices in access, nor should they. Not all vendors will see the same opportunities, and these differences arise for sound economic reasons.

Notes

1. Daniel Spulber, *The Market Makers, How Leading Companies Create and Win Markets* (New York, NY: McGraw-Hill, 1998); Andrew B. Hargadon, "Firms as Knowledge Brokers: Lessons in Pursuing Continuous Innovation," *California Management Review*, 40/3 (Spring 1998): 209-227; Harold Demsetz, "The Theory of the Firm Revisited," *Journal of Law, Economics, and Organization*, 4 (1988): 159-178.
2. Timothy Bresnahan and Manuel Trajtenberg, "General Purpose Technologies: Engines of Growth?" *Journal of Econometrics*, 65 (1995): 83-108.
3. Timothy Bresnahan and Shane Greenstein, "Technical Progress and Co-Invention in Computing and in the Use of Computers," *Brookings Papers on Economics Activity: Microeconomics* (1997), pp. 1-78.
4. Shane Greenstein, "Building and Delivering the Virtual World: Commercializing Services for Internet Access," *Journal of Industrial Economics*, 48/4 (December 2000): 391-412.
5. Peter C. Clemente, *The State of the Net: The New Frontier* (New York, NY: McGraw-Hill, 1998).
6. Maloff Group International, Inc., "1996-1997 Internet Access Providers Marketplace Analysis," Dexter, MO, October 1997.
7. Jeff Camp, Richard Bilotti, Simon Flannery, and Mary Meeker, *The Broadband Report*, Morgan Stanley Dean Witter, Equity Research, May 2000.
8. For example, see the description in Ravi Kalakota and Andrew Whinston, *Frontiers of Electronic Commerce* (Reading, MA: Addison-Wesley, 1996); Brett Leida, "A

Cost Model of Internet Service Providers: Implications for Internet Telephony and Yield Management," mimeo, MIT, Departments of Electrical Engineering and Computer Science and the Technology and Policy Program, 1997; the accumulated discussion on <www.amazing.com/internet/faq.txt>; Rob Kolstad, "Becoming an ISP," <www.bsdi.com>, January 1998.

9. The basic capital expenses involved servers and modems and a backbone connections. Labor expenses to build and operate were a high fraction of the first year expenses. Exact estimates varied, but 200 customers was a "rule-of-thumb" about the number of paying customers necessary to justify the costs of a high-speed backbone connection in a single-POP dial-up operation. Kalakota and Whinston, op. cit.
10. Nathan Rosenberg, *Perspectives on Technology* (Cambridge: Cambridge University Press, 1977); Nathan Rosenberg, "Uncertainty and Technology Change," in Ralph Landau, Timothy Taylor, and Gavin Wright, eds., *The Mosaic of Economic Growth* (Stanford, CA: Stanford University Press, 1996), pp. 334-356.
11. See, for example, Demsetz, op. cit.; Hargadon, op. cit.; Spulber, op. cit.
12. See Bresnahan and Greenstein for an example where the costs of altering complex and idiosyncratic business processes influence the costs of co-invention in computing and networking technology. Bresnahan and Greenstein (1995), op. cit.; Timothy Bresnahan and Shane Greenstein, "The Competitive Crash in Large Scale Commercial Computing," in Ralph Landau, Timothy Taylor, and Gavin Wright, eds., *The Mosaic of Economic Growth* (Stanford, CA: Stanford University Press, 1996), pp. 357-397.
13. This story is well known. For a discussion, see M. Mitchell Waldrop, *The Dream Machine: J.C.R. Licklider and the Revolution that Made Computing Personal* (New York, NY: Viking Press, 2001); David Mowery and Timothy Simcoe, "The Origins and Evolution of the Internet," mimeo, University of California, Berkeley, CA, 2000.
14. The Internet simply failed to make the radar screens of many legal and commercial futurists in the computing and telecommunications industry until the founding of Netscape. For example, as has been widely noted (in the context of Anti-trust scrutiny), TCP/IP received almost no attention in Bill Gates book, *The Road Ahead*, which ostensibly provided a detailed look at Microsoft's vision of the future. Bill Gates with Nathan Myhrvold and Peter Rinearson, *The Road Ahead* (New York, NY: Viking, 1995).
15. See, for example, *Boardwatch* magazine, various years.
16. Mary Meeker and Chris Depuy, *The Internet Report* (New York, NY: HarperBusiness, 1996).
17. Mark Ventresca, Rodney Lacey, Michael Lounsbury, and Dara Szyliowicz, "Industries as Organizational Fields: Infrastructure and Formative Dynamics in U.S. Online Database Services," A Working Paper in the "Business and Government" Series of the Institute for Policy Research, Northwestern University, 1998.
18. In the early 1990s electronic data interchange (EDI) applications were growing at a steady though unexciting pace; These are electronic standards for data-interchange between firms, which help automate commerce. However, EDI was difficult to use and did not seem to offer much benefit to any except the largest firms.
19. Urs Von Burg, *Triumph of Ethernet: Technological Communities and the Battle for the LAN Standard* (Stanford, CA: Stanford University Press, 2001).
20. Timothy Bresnahan and Shane Greenstein, "Technological Competition and the Structure of the Computer Industry," *Journal of Industrial Economics*, 47/1 (March 1999): 1-40.
21. Ibid.

22. Michael Cusumano and David Yoffie, *Competing on Internet Time, Lessons from Netscape and It Battle With Microsoft* (New York, NY: The Free Press, 1998).
23. Further development of these points can be found in Bresnahan and Greenstein (1999), op. cit.; Bresnahan (1999), op. cit.; Cusumano and Yoffie, op. cit.
24. The earliest experimentation took place at green-field sites, at experienced computing users with low co-invention costs and at enterprises where the net benefits to adoption were high. Sites with high adoption costs and high benefits came later. See, for example, Bresnahan and Greenstein (1996; 1997), op. cit.
25. For example, Ethernet and Netware grew up together. One was an open standard and the other a proprietary one, layered on top of it (von Burg, op. cit.). More speculatively, had the browser developed gradually in a commercial environment, it might have emerged as part of a proprietary software program such as the Apple OS or Windows 3.0, for example, or as part of any number of early client/server applications which employed graphical interfaces, some of which were proprietary and some of which were not.
26. Marjorie Blumenthal and David Clark, "Rethinking the Design of the Internet: The End-to-end Arguments vs. The Brave new World," in Ben Compaine and Shane Greenstein, eds., *Communications Policy in Transition: The Internet and Beyond* (MIT Press, 2001).
27. Bresnahan and Greenstein (1999), op. cit.
28. The same logic applies moving forward. Open standards survives due to the power of inertia and on-going attempts by the World-Wide-Web Consortium and the Internet Engineering Task Force in opposition to supplier attempts to offer services employing proprietary standards.
29. Paula Bernier, "Choice Spurs Churn for Providers," *Inter@ctive Magazine*, March 24, 1997; Michael Noer, "Mom-and-Pop Internet," *Forbes Digital Tool*, Section on Technology, Bleeding ISPs, August 11, 1997.
30. For such a view, see Paul Stapleton, "Are Dial-Up Subscribers Worth $280 per Head?" *Boardwatch*, Section on ISP$ Market Report, 11/5 (May 1997).
31. (Stark, 1997) Stark, Thom [1997], "A Tale of Two ISPs," Boardwatch Magazine, August.
32. This study's data combine a count of the ISP dial-in list from August/September of 1996 and May/June of 1998 in *thedirectory* and a count of the backbone dial-in list for the Fall of 1996 and the Summer of 1998 of *Boardwatch* magazine. For further documentation of these methods, see Greenstein (2000), op. cit.; Tom Downes and Shane Greenstein, "Do Commercial ISPs Provide Universal Access?" in Sharon Gillett and Ingo Vogelsang, eds., *Competition, Regulation and Convergence: Current Trends in Telecommunications Policy Research* (Mahwah, NJ: Lawrence Erlbaum Associates, 1999), pp. 195-212; Tom Downes and Shane Greenstein, "Universal Access and Local Commercial Internet Markets," *Research Policy* (forthcoming 2001).
33. Downes and Greenstein (2001), op. cit.
34. A national firm is one who is in more than 25 counties. A regional firm is in more than 3 counties but less than 25.
35. It appears that these 3816 ISPs are not a comprehensive census of every ISP in the country. That said, it does contain many observations from small firms, from ISPs in rural areas and from virtually all the mainstream ISPs from whom the vast majority of Internet users in the United States get their access. See Appendix of Greenstein (2000), op. cit.
36. See the appendix of Greenstein [(2000), op. cit.] for the product code.
37. There is some overlap: 1869 do at least one of either networking, hosting or web design; 984 do only one of these three; 105 do all three and frontier access. See Greenstein (2000), op. cit.

38. One of the most difficult activities to classify was general "consulting"—i.e., consulting which did not refer to a specific activity. Virtually all arose in the 1836 firms who provide networking, hosting and web design. The majority of consulting activity is accounted for by the present classification methods as one of these activities.
39. See Greenstein (2000), op. cit.