Technological Mediation and Commercial Development in the Early Internet Access Market

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Abstract

The study interprets the early experience of Internet Service Providers (ISPs) in terms of the market for technological mediation. A firm involved in technology mediation takes advantage of gaps between general technological opportunities and particular user needs in specific places at particular times. If the economic opportunities are renewed frequently, then the business can grow and adapt to take advantage of them. This concept provides a framework for explaining many facets of business behavior accompanying the diffusion of Internet access technology.

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1 Introduction

Rather typical of nascent markets, the Internet has become associated with both large commercial opportunities and challenges. It is only a slight exaggeration to say that vendors pursue one of two strategies. In one strategy a vendor takes advantage of new opportunity by devoting resources to developing a new service with wide applicability. The vendor then performs the service many times, each time for a different user, customizing the service across a wide set of uses and circumstances. The vendor does well until the demand dries up, gambling that demand will not dry up sooner than expected. In a related strategy a vendor develops expertise that positions the vendor towards repeat business; the vendor both provides one service and plans to provide another complementary services which arise with later opportunities. In effect, he devotes resources to being the vendor to whom a customer comes with problems repeatedly. In this case the vendor gambles that future demand will not diverge from the array of services in which the vendor has invested.

Though it is difficult to distinguish between the two strategies at first, they do eventually diverge. The first strategy is associated with incremental improvement over the past, but its benefits are realized in a few years. The disruption associated with new services are fleeting or, at best, these new services lead to temporarily large gains and apply to a diverse set of uses. Then firm activity settles down to a predictable pattern of behavior. In contrast, when many firms pursue the second scenario, technology is a threshold to a new series of promising disruptions marked by continual technical change and renewal of new commercial possibilities. The disruption are both large and recurring, brought on by new technology which enables new commercial opportunities. When these disruptions continually arise, strategies change many times until all participants understand the full consequences.

How are analysts to understand the broad array of market conduct associated with these strategies? This essay introduces the concept of "technological mediation." Technological mediation describes firm behavior associated with standing between a changing technical frontier and unique user needs. A vendor may assess the user's operations and provide advice about which configuration of equipment and services meets the user's particular needs for access. The vendor may also generate fees for this consulting service. 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. The paper then uses the concept to understand the evolution of the structure to the Internet access market, distinguishing between different types of challenges and different business conduct.

Internet Service Provides (ISPs) are the principal commercial providers of Internet access in the United States. 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 users and their organizations, solving problems as they arise, tailoring general solutions to idiosyncratic circumstances. Sometimes ISPs call this activity consulting, charging for it separately, sometimes it is not distinct from normal operation of Internet access services.

The first few years of the commercial Internet access market are a good case to examine because its early experience defies easy analysis. For one, this market grew *rapidly*, attracting thousands of entrants and many users, quickly achieving mass-market status. Second, firms offering this service became *nearly geographically pervasive*, a diffusion pattern rarely found in new infrastructure markets. And third, firms *did not settle* on a standard menu of services to offer, indicative of new commercial opportunities and also a 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 taking place? All three traits -- rapid growth, geographic pervasiveness and the absence of settlement -- do not inherently go together in most markets. The presence of restructuring should have interfered with rapid growth and geographic expansion. Hence, explaining this market experience is also interesting in its own right.

The analysis emphasizes three themes. First, the essay argues that the peculiar origins of the Internet exacerbated the importance of technological mediation in the access market. Upon its commercialization Internet technology displayed an uneven maturity in commercial uses. The rapid growth and entry which did occur was largely associated with the mature part of the activities. Second, while uncertainties over commercial possibilities acted as a bottleneck on growth of ISPs, technical limitations largely did not. The marginal costs of providing dial-up services were low and the marginal costs of expansion fell quickly; hence, ISPs had strong incentives to open facilities in many locations and did. Third and finally, despite extremely competitive supply of basic access, new opportunities arose in many related services. These were often due to gaps between technical frontiers and unique supplier skills and unique users needs, inducing ISPs to customize their offerings to local market conditions, to local users and to

particular specialties an ISP could offer. Thus, not all markets experienced the same type of competitive choices, nor did all ISPs see the same opportunities, a result of variation in the ways that ISPs reacted to new opportunities.

Technical mediation synthesizes ideas from two strands of economics, the literature on firms as intermediaries, and the literature on general purpose technologies. Many models of intermediaries analyze how vendors provide a "matching service" and "monitoring service" between the user and one of several possibilities (See e.g., Spulber [1998], Hagerdorn [1998], Demsetz [1988],). This study focuses on such matching behavior when an advancing technical frontier alters the potential value of mediation. Many models of general purpose technology also analyze co-inventive activity, a concept used by Bresnahan and Trajtenberg [1995] and Bresnahan and Greenstein [1997] to describe third party, end-user, tool developer, managerial and in-house staff adaptation activity which customizes general purpose technologies to unique circumstances. This study focuses on the features of such activity at third-party vendors, ISPs, who are one of many potential third party actors in Internet markets. It also resembles Bresnahan, Stern and Trajtenberg [1997] who emphasize firm incentives to differentiate from common competitors in technologically intensive environments. In contrast, this study focuses on strategic issues of how firms struggle to construct and build viable business enterprises.

2. What is known about Internet Service Providers

By 1998, surveys showed that no more than 10 percent of US households get their Internet access from university-sponsored ISPs (Clemente, 1998), with almost all of the remainder going to a commercial provider. The market for ISPs was between 3 and 5 billion dollars in 1997 (Maloff, 1997) and 5 to 8 billion in 1999 (Forrester, 1999). This is still relatively small for the communication and computing industry, which together involve expenditures in the hundreds of billions of dollars a year, but all observers expected revenues to rise substantially.

What are commercial ISPs? For the most part, they are firms who provide Internet access for a fee. Access can take one of several different forms, dial-up to a local number or 1-800 number at different speeds, or direct access to the user's server using one of several high-speed access technologies. In these years users contracted for commercial Internet access for one or more of several purposes:

! Receive and participate in general communications functions using the Internet: Users could accomplish this through either through email, proprietary and non-proprietary chat-rooms or through

posting to bulletin boards, or participating in other virtual communal activities.

! Reorganize and develop a sales or supplier channel: Access to the Internet was a two-way street. Many businesses established a virtual presence for both buying and selling. This allowed a business to alter its channel strategies. ISPs provided many business users with opportunities to coordinate their supply chains or their sales channels with an additional means of communication.

! Gain access to goods and services with greater convenience: Many users, either for private or business reasons, obtained Internet access as a means to take advantage of the virtual commercial activities organized by another business. These gains took several forms. Users in low-density areas and users with unusual buy/sell opportunities gained access to a "thicker" markets, as Internet markets became central meeting areas for transactions. Users also could avoid some transaction costs by contracting to buy/sell using electronic means.

! Take part in on-line entertainment or on-line content: Many users took advantage of the widespread free content on the world wide web. This took a variety of forms, as games, as trade journals, as news sites, and so on. Some of the largest of these began to use advertising as a revenue source.

Accordingly, the minimal standard bundle of services at ISPs involves an email account, FTP and Telnet and web access. It also involves a few other technologies inherited from the bulletin boards, the commercial predecessor to ISPs, and the academic modem pool, the non-commercial predecessor to ISPs. When ISPs first began entering 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 shoe-string 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. The standard bundle involved all the same functions plus access to streaming technologies or games, advanced guidance, and possibly multiple services related to use of web technology.

Entry costs have remained low, particularly for a small ISP. For many ISPs the dial-up technology did not serve as a barrier to entry, nor were there prohibitive costs to hiring mainstream programming talent. 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.[1] 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 (Kolakota and Whinston [1997]). In the mid 1990s some observers put estimates of minimum efficient scale at 200 customers, which was easy to obtain in all but low density cities.[2]

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 was much larger than it was for dial-up; As a result -- some but not all -- of the larger Internet access firm also offered direct access to their service offerings. Due to the expense, these were targeted primarily at business users.

After a few years the costs of geographic expansion were also relatively low. First, it was not costly to expand on an existing network by building new facilities nearby. New capital equipment was the main expense. Operators could often be put on automated monitoring devices, reducing monitoring expenses. 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 head-quarters (e.g., for traveling users). This also lowered the costs of geographic expansion.

Finally, one other commercial factor is worth noting. The transaction between an ISP and user put the ISP in a unique position relative to other third-party vendors. When a user contracted with an ISP, the two parties could have repeated contact. Sometimes this involved extensive discussion; sometimes it simply involved the user employing facilities prepared for it by the ISP on a daily basis. ISPs varied in their

[1] For example, see the description in Kalakota and Whinston [1996], Lieda [1997], the accumulated discussion on www.amazing.com/internet/faq.txt, or Kolstad [1998] at www.bsdi.com.

[2] 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 stand-alone dial-up operation. See www.bsdi.com or www.amazing.com/internet/faq.txt.

strategies for the managing these contacts. Some ISPs used these discussions as opportunities to offer services which enhanced the user's Internet experience, charging a premium for installing hardware or software associated with enhanced services. Others ISPs bundled a variety of activities with access, not charging a premium for the enhanced qualities until it got beyond a specific threshold. Still others operated services other than access and hoped to operate those for the user, charging those who wanted extra service but not those who did not.

3. A sketch of technological mediation

Many studies of the commercialization of technology emphasize the situated nature of technological development. Technologies do not simply spring out of the ether; instead, learning processes and adaptation behavior shape them. Users and suppliers routinely tailor technologies to short term needs, making decisions that reflect temporary price schedule or idiosyncratic preferences, resulting in technological outcomes that can only be understood in terms of these unique circumstances and origins.

Technological mediation encompasses activities where a vendor stands between unique user needs and a menu of uses for advancing or new technology. It is part of what studies of organizations label mediation services in fluid environments (e.g., Demsetz [1988], Hgerdorn [1998], Spulber [1998]). This type of activity is also frequently labeled "adaptation" because businesses frequent change the structure of their transactions in response to lessons learned about the salient features of market-mediated choices.[3]

This study focuses on one of several activities which comprises technological mediation: Monitoring technical developments, distilling new information into components which are meaningful to unfamiliar users, and matching unique user needs to one of many new possible solutions enabled by advancing technical frontiers. Sometimes this involves heavy use of the technological frontier and sometimes not. Sometimes it involves customizing a general solution to a wide variety of circumstances and sometimes it involves solving a new series of problems over time. In general, it depends on the firms involved and how it matches the needs of the user, all of which depends on circumstances, existing capital investments, the costs of adjusting to new services and other factors which influence the match between

[3] Adaptation has long been a topic of discussion in the economics of technology and economic growth (Bresnahan and Trajtenberg [1995]), as well as in the management of technology (Hagerdorn, 1998). Studies of this behavior have antecedents in classic studies about diffusion and learning by Griliches [1957], Rosenberg [1977], Nelson and Winter [1982] and many others.

user needs and technological possibilities.

Is it possibly to provide a taxonomy for technological mediation? This is difficult because in information technology markets, the agents of change typically come from one of several groups: end-users within an organization, professional staff (such as the MIS group) within an organization, or third party vendors outside the organization. If the end-user or their staff does much of the activity, it becomes an extension of other operations and investments. In contrast, when third parties perform mediation services, it may accompany several different activities: equipment sales, consulting about business processes, or both. This study highlights technology mediation performed by one of many third parties, ISPs. Because of their position as a firm with whom a user must interact in order to gain use of many Internet functions, ISPs are an especially interesting vendor to examine.

Below I describe technology mediation in general terms. This conceptual sketch leads to three sets of empirical predictions about challenges one should observe in markets where technological mediation influences behavior.

A conceptual sketch

Three key factors underlie the opportunity for technological mediation activity: First, mediation activities are due to a gap between the technical frontier and the end-user. Second, different users adopt frontier technology for different purposes and at different costs; said another way, the value of technological mediation differs across users. Third, there is inherent uncertainty over the economic value of technological mediation activity.

! **A gap between the technical frontier and user capability:** Opportunities for technological mediation arise due to gaps between what a technical frontier makes possible and a user's capability. The state of technology defines what is possible in a particular location at a particular point in time.

At its simplest level, technology mediation may involve providing a user with their first exposure to a new technological possibility and educating them about its potential. More often it goes beyond exposure, as technology mediation may include installing equipment, providing maintenance and training, as well as undertaking application development. In all cases, 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.

Filling technical gaps can involve more than one project or transaction, though repeated transactions need not necessarily be planned. Users may only need to learn about a technical possibility

before they then decide whether to pursue it or not. In other cases, the opportunity may involve periodic and planned review of the user's state of technology relative to new frontier developments. Some repetition can be contingent on early experience. If circumstances have changed significantly and unexpectedly, users may contract for new services with a familiar provider.

! **Variation in the value and cost of technological mediation:** Technological gaps set the stage, but do not solely determine it. Not all feasible alternatives are desirable, nor are all desirable alternatives feasible. This depends on the relative costs of achieving each possibility and its relative benefits to the user.

The value and cost of technological mediation differs across users. Specifically, the motives for adopting new Internet applications depends on the competitive situation of the user's enterprise, their legacy IT applications, their product line and many other features of the firm. Technology mediation typically involves adapting existing and non-frontier IT to circumstances for which it may or may not have been designed. Difficulty may arise from the amount of customization needed, not necessarily (nor at all) from the technically demanding features of the technology.

Two features of users tend to drive up costs of adapting solutions to problems in a business networking environment: (1) the complexity and (2) the uniqueness of the organization's applications and business processes. Complex activity tends to involve more personnel and require changes to an organization's operations to make a technology useful. Unique applications tend to be costlier because fewer tools exist to help the staff who are doing the mediation. Unique circumstances also tend to be problematic because outsiders can bring fewer lessons from other circumstances to bear on the inventive activity needed.[4]

The benefits from new applications may also differ by user. As with many new applications of new IT technology, new Internet applications may not be primarily cost-reducing. Often the use of new IT permits improvements in quality and reliability of products, especially services, which some enterprises believe are valuable and others do not.

At the user level, which may be a firm, these new services may provide permanent or temporary competitive advantages. When the new services are reasonably permanent, the firm may see returns to the investment in increases in final revenue or other strategic advantages. If they are quickly imitated by all

[4] See Bresnahan and Greenstein (1995, 1996) for an example where the costs of altering complex and idiosyncratic business processes influence the costs of co-invention in computing and networking technology.

firms, the new product or service may become a standard feature of doing business in a downstream market. In this case, the benefits from the new technology are passed onto consumers in the form of lower prices and better products. The benefits to adopters do not necessarily appear as an increase in revenues; they may come from the avoided losses.

! **Unpredictability of the value proposition:** Because a general technological advance may enable applications which have few or no historical precedents, contemporary users of a new technology find it difficult to imagine or estimate the future elasticity of demand for the services enabled by mediation activity. Even early versions of a technology -- which have partially diffused to leading adopters -- may be uninformative about the future value of the very same activity.

The rest of potential adopters, who will be using the technology when the prices drop and capabilities expand or mediation costs fall, may have different characteristics and needs. They may require entirely different complementary inventions. In other words, vendors may expect to face a different set of problems tomorrow than today.[5]

The supply of firms who perform mediation service may change over time, which places another type of uncertainty over the competitive value of services at any particular firm. If third parties sell mediation to users, it may arrive in several different forms, sometimes as equipment, sometimes as consulting about business processes, and sometimes as complements to both. If the end-user or their IS staff does much of the mediation, it becomes an extension of other IT or networking investments, operated and organized by personnel within existing groups administrating information systems. This too places a constraint on the room for a third parties, depending on the factors that lead an organization to use out-source services. More to the point, contracts with third parties complements in-house activity and simultaneously substitutes things that might be done by in-house staff.

A Taxonomy of Open Challenges

What characterizes markets in which technological mediation plays an important role? The above

[5] For example, ISPs today find it is very difficult to forecast the qualitative nature of the demand for cheap, capable, long distance networked computing applications. Forecasters can only look at the earlier experience with cheap computing (e.g., PCs, workstations) and expensive and difficult high-speed networked computing (e.g., EDI or ISDN), but this hardly represents the cost conditions and economic opportunities that future users will face after the deployment of extremely cheap computing capabilities and low-cost high-bandwidth fiber and wireless communications technologies.

sketch, as with much of literature on adaptation, does not predict whether large or small firms will be more efficient, nor whether incumbent firms or new firms will have advantages in the provision of mediation services. The sketch also does not suggest whether firms in the mediation business will provide a narrow range of services for specialized niches, or a combination of services. Outcomes depend on how firms handle a number of challenges. In general, label these as *technical, commercial* and *structural challenges.*

Technical challenges often arise during commercialization, particularly when a technology originates from government subsidies, as this one did. Government users, government procurement and government subsidies result in technology with many features mismatched to commercial needs. Products possessed features for which vendors or users have no need. Alternatively, commercial vendors and users do need other features. Thus, as a technical or engineering matter, a technology which is mature 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. If these requirements are considerable, then commercialization may occur slowly because an *additional* amount of invention is needed to bring such a product design and to bring its manufacturing to a price/point with features that 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 put technologies into use. In other words, government users or users in a research environment often tolerate operational processes that do not translate profitably to commercial environments. After this technology transferred out of government sponsorship, it was not clear how to balance costs and revenues for technologies that had developed under settings with substantial subsidies underwriting losses, and research goals justifying expenditures. Resolving this uncertainty requires considerable experimentation with business models before they begin to grow, if they grow at all.

New technologies are also vulnerable to *structural challenges* that impede pathways to commercialization. Commercial and structural challenges are not necessarily distinct, though the latter are typically more complex. Structural challenges are those which require change to the bundle of services offered, change to the boundary of the firms offering or using the new technology, or dramatic change to the operational structure of the service organization. These challenges arise because technologies developed under government auspices may presume implementation at a particular scale or with a set of technical standards, but require a different set of organizational arrangements to support commercial applications.

In summary, firms in the mediation business are uncertain about the appropriate solutions to technical, commercial and structural challenges. Some economic opportunities will exist temporarily, for example when users upgrade their networks to a new incremental advance in the frontier by making one key new investment. The resolution of a previous technical challenge may inspire users to try yet more new applications, renewing the economic opportunity again at a later time, potentially leaving an ISP with further technical and commercial challenges. Some foresighted firms who supply mediation services may even explicitly follow a strategy of trying to profit from providing services associated with these one-time adjustments, doing well in one period while also positioning themselves for the next adjustment. Other ISPs will try to anticipate the structural challenges and offer services which both have value today and lead users back to the ISP tomorrow.

There should be considerable heterogeneity in the behavior of ISPs, partly as a reflection of real differences in economic conditions and partly a reflection of different evaluations of similar, yet uncertain, economic circumstances. Beyond such a general statement, the framework provides guidance about which factors were likely to matter most to ISPs' conduct. That said, which factor matters most is largely a historical question about the saliency of different challenges to particular firms in particular places at a particular points in time.

4. Commercial Internet access as technology mediation business

When the technology became commercialized in 1992-94, many new uses and users outside of the research community became aware of the potential set of applications. Prior to that, mediation activity was focused narrowly on users whose needs were quite different from the average commercial user after 1994. In other words, commercialization created a mismatch between the frontier and new potential users outside the research community. The unexpected invention of web technology widened the gap. These unique historical events created circumstances ripe for commercial exploitation by technological mediators.

Related to that, the Internet was a malleable technology. Internet access technology is not a single invention, diffusing across time and space without changing form. Instead, it is embedded in equipment which uses a suite of communication technologies, protocols and standards for networking between computers. This technology obtains economic value in combination with complementary invention, investment and equipment. This type of technology combined with this setting enabled vendors to use the technology for a variety of purposes, which, as it turned out, enabled vendors to tackle many technical,

commercial and structural challenges simultaneously.

The origins of the TCP/IP technology

For many years TCP/IP was an obscure invention of little interest to anyone except a small research community. It arose out of DARPA (Defense Advanced Research Projects Agency) experiments aimed at developing communications capabilities using packet switch technology.[6] In 1969 DARPA began the first contracts for ARPANET, which involved a few dozen nodes. The first email message arrived in 1972. After a decade of use the protocols that would become Transmission Control Protocol/Internet Protocol (TCP/IP) were established and in regular use. By 1984 the domain name system was established and the term Internet was used to describe the system. In the early 1980s DOD began to require the use of TCP/IP in all Unix-based systems which were in widespread use among academic research centers. This helped demonstrate its value more generally, which then lead to a call to move the technology out of military and into civilian hands.

In 1986 oversight for parts of the network moved to the NSF, which established a series of regional research networks. The NSF pursued policies to encourage use in a broad research and academic community, subsidizing access to the Internet at research centers outside of universities and at non-research universities. The NSF policies had the intended effect of training many network administrators, students and users in the basics of TCP/IP technology. The NSF also sponsored development of changes to TCP/IP that enabled it to apply to more varied uses. Thus, this period saw the development and diffusion of a variety of disparate technologies, most of which embodied non-proprietary standards, reflecting the shareware environment, research or academic culture in which they were born. Most of these, such as Telnet, FTP and so on, would soon became necessary for the provision of basic access.

All of these subsidies from NSF came with strings attached. Despite working with several private companies, the NSF retained policies restricting use of the Internet to research purposes. At some level, the Internet was official government property on which no advertising for commercial products was allowed, nor was sales and distribution of products. This was always a bit vague, because the Internet backbone was not a particular or specific asset, and, in any event, some of the Internet was built and operated by

[6] As is commonly stated, many in DOD were interested in developing communications networks which could survive partial destruction in wartime. Though the researchers themselves may never have had such motives, the network R&D was sold within DOD with this as a justification, among other reasons. These are well known stories. See Meeker and Dupuy [1996] or Rybaczyk [1998].

third parties -- such as MERIT, MCI and IBM -- under contract with the NSF. Nonetheless, this restriction hindered development of complementary technologies for uses outside of the research community. If the Internet would be "transferred" from a research community to the commercial community it was necessary for government stewardship to also "transfer" stewardship over the Internet out of government hands and onto commercial users.

The unanticipated invention of the World Wide Web associated a new set of capabilities, display of non-textual information, with Internet technology. This was first invented in 1989 for the purpose of sending scientific pictures between physicists (though some alternatives were also under experimental use at the time). By the time the Internet was commercialized, a new set of experiments with browsers at the University of Illinois had developed the basis for Mosaic, a browser using web technology, something which made the whole suite of Web technologies easier to access. Mosaic was widely circulated as shareware in 1993-94 and quickly became a *de facto* standard, exposing virtually the entire academic community to the joy of sending pictures. The commercial browsers that eventually came to dominate non-technical use, Netscape and Internet Explorer, sprang from these technical beginnings.[7]

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, following on informal policies in the late 1980s which already moved in that direction. These plans were made prior to the invention of web technology and, indeed, date back to the transfer of stewardship to NSF, when the regional network structure was adopted specifically to enable decentralized support of the network outside of Washington. The privatization of the network was implemented at about the same time as the diffusion of the browser, with one of the final pieces being a congressional rider in 1992 that ratified lifting the use restriction.

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.[8]

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[7] If not by this path, then by another. To be sure, something such as this would have arisen eventually, as the technology had origins in three decades of developments within computer science.

[8] 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

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 which makes up the standard bundle? How would the whole system would 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 digital communications.

Partly this perception was an unintended artifact of NSF policies. Prior to its commercialization TCP/IP had applications build on top of it which 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 commercial setting, many developers and users in the commercial world did not know of the potential uses of this technology.

To be fair, however, TCP/IP applications also were not the only potential solution to many users problems and its 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 US (e.g., see Boardwatch magazine, various years). Services such as Prodigy, CompuServe and AOL had several million home customers across the country by the early 1990s (Meeker and Dupuy [1996]). 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 (Ventresca et. al. [1998]). There was also many developments in electronic commerce, especially in business to business transactions.[9] In networking equipment markets, many of these developments involved proprietary networking solutions from large and small firm alike (von Burg [1999]).

Perhaps most importantly, the client/server revolution was beginning to take hold and gain

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(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.

[9] 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.

momentum with business users around the early 1990s (Bresnahan and Greenstein [1998]), exposing many enterprises to the benefits of networked computing. TCP/IP offered an alternative or possibly complementary technology for further connectivity in a networking environment, but it was not obvious to many commercial observers that TCP/IP would be such a fruitful technological path to pursue.

In summary, 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 uneven maturity is a typical pattern for new information technology (Bresnahan and Greenstein, 1999), 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 in the early 1990s further stretched the possibilities for potential applications, exacerbating the gap between the technical frontier and the potential needs of the less technically sophisticated user. These events set the stage for many technical, commercial and structural challenges.

How its origins framed early challenges

The early users of these 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. But commercial challenges remained. 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. These are inherently questions that cannot be resolved in anything other than a market-mediated experiment.

The commercial opportunities for ISPs in 1995 called for what looked like 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 such 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 required some experimentation to address challenges. After widespread access was achieved in many communities outside of research, the potential value of many new opportunities

would become apparent, if any further opportunities existed at all.

Thus, the value of being in the Internet access business was quite uncertain at the outset. It depended on a one time business opportunity, translating the technologies associated with Internet access into a reliable and dependable standard service for non-academic users. This opportunity was an artifact of the development of the technical capability in an environment that expressively forbid its use for commercial purposes. That factor was distinct from commercial uncertainty associated with customizing technology in new ways with a new set of users. The value of those long run business models was uncertain because TCP/IP technology touched on many business processes, generating experiments in the use and the delivery of Internet access. 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, 1995. Like the contemporary founding of many other firms using browser technology, Netscape took advantage of a business opportunity which depended on a number of coincident events. Almost certainly Netscape's first business opportunity – which was selling the browser – was fleeting (whether or not Microsoft responded as it did). Accordingly, Netscape had a strategic opportunity to grow, but it was short window of opportunity. As extensively analyzed by Cusumano and Yoffie (1998), 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 and repeated business opportunities, such as in server software applications, which took advantage of later changes in the technical frontier for Internet access.

This reinterpretation provides a much richer definition of a "window of opportunity," a popular and unclear term commonly used to describe a strategy in an evolving market generally, and the Netscape episode in particular.[10] A "window of opportunity" arises as long as there is a gap which underlies the commercial opportunity. The window then depends on how fast vendors fill in the demands of users with complex and idiosyncratic needs. Almost by definition, that gap narrows as it is filled by different commercial entrants with different solutions to user needs, as vendors learn from each other, and as vendors customize frontiers to unique user problems, creating standardized solutions.

Similarly, and perhaps more whimsically, this same interpretation suggests that had the NSF not

[10] Further development of these points can be found in Bresnahan and Greenstein [1999], Bresnahan [1999], or Cusumano and Yoffie [1998].

had a restriction on users then the Internet might have commercialized sooner – say, almost immediately after NSF received governance for parts of the network from DARPA. Indeed, the diffusion of the browser might have played out much differently, less burdened, as it was, 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 diffused gradually over time to commercial users many years earlier, as commercial users would have had the option to use it sooner. If the diffusion had been gradual, there would have been a gradual sequence of adoption and customization.

Perhaps the sequence would have mirrored the patterns seen in the adoption of client-server technology, which began in the late 1980s (e.g., Bresnahan and Greenstein [1996] and [1997]).[11] The technology then would have moved gradually to other users as prices declined, co-invention costs declined, capabilities expanded and co-inventive lessons were learned and passed between users and vendors. There certainly would not have been as large a gap between unmet user demand among commercial users and technical capabilities, as there was in 1994-95.

What would have happened if TCP/IP technology incubated in an environment in which commercial applications drove development? 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. This feature of the Internet is partly an artifact of the platform's genesis in an academic and shareware culture. TCP/IP could have involved tussles among different proprietary version or standards battles between different platform approaches, as is typical for commercial computing.[12] Plenty of other successful computing platforms were founded in technically-intensive engineering environments, but outside of academics, and most of these have had large elements of

[11] There the earliest experimentation took place at green-field sites, at experienced computing users with low co-invention costs and generally at enterprises where the net benefits to adoption were high. Sites with high adoption costs and high benefits came later.

[12] 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, 1999). 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.

proprietary technology in them (Bresnahan and Greenstein, 1999). Occasionally communities of firms have grown up around non-proprietary standards too, but usually this involves several dominant firms turning parts of these communities towards their proprietary interests. There was no particularly reason why that pattern could not have been re-established in digital communications technologies too.[13]

Even though this is speculation, there is an important point behind it. Technological mediation involves solving many challenges and the invention of many complementary services, the details of which cannot be anticipated. Commercial markets will focus vendors on the unique problems faced by commercial users, which will necessarily differ from those face by users in non-commercial settings. This is because commercial markets are comparatively good at identifying specific user needs, focusing efforts on the problems associated with meeting them and coordinating information from disparate or decentralized sources. As noted by many authors who write on adaptation processes (e.g., Rosenberg [1995]), this is especially true in technically uncertain environments, when technology is still primitive, when these needs involve complementary inventions and systemic invention, and when the new application requires movement of technological capabilities from one application to another.

More concretely, firms within markets could not perform these activities until the NSF commercialized the Internet because there was little incentive for any developer to focus their efforts on the needs of users outside the research community. The explosion of activity after commercialization was symptomatic that commercialization came later than necessary from the standpoint of when experimentation in the commercial setting would have resolved primary technical and commercial challenges.

Changes in Internet access over geographic space

The US 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) engender 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 represents a gap between what is technically possible and what many users desire. This was a commercial

[13] 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.

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 build facilities to meet local user needs. In the dial-up Internet access industry these facilities were called "points of presence" or POPs.

This leads to two related predictions about geography. First, ISPs should stress the geographic coverage of their services. As a strategic matter, ISPs will deliberately choose to have either extensive geographic coverage or not. Second, as entry becomes easier, coverage should move to less lucrative locations, which means the areas that were more costly to serve, i.e., less dense areas. As I will argue below, both patterns are 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 US except in a few low-density places. How did this come about? As it turned out, the dial-up market is an example where the commercial opportunities for technological mediation were largely fleeting.

What happened? First, the geographic reach and coverage of an ISP became recognized as one of several important dimensions of firm strategy. 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 thin markets the absence of competition did not discipline the pricing as much, nor did ISPs lose customers very often to other firms (Bernier, 1997a, Noer, 1997). At the same time many local ISPs thought they could thrive with high-quality service and higher-prices or with many value-added services (for such a view see Stapleton [1997]). 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 (Stark, 1997). 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.

Some statistical evidence can be brought to bear on these trends. In order to track the geographic spread of ISPs, Downes and Greenstein [1999] compiled a list of telephone numbers for dial-up access and their location.[14] It shows the geographic distribution of the POPs across the continental US. Since the main interest is in the spread of Internet access to all users, this exercise concentrated on the dial-up market, which is the market service appealing to the marginal user. We asked the following questions: "How many suppliers have POPs in a county?" and then "How many counties have at least one supplier with a POP within them?"

Figure 1a and 1b illustrates the density of location of ISPs across the continental US at the county level for the fall of 1996 and the fall of 1998. Black areas are counties with competitive markets. Gray areas have a few providers, which might or might not be competitive. White areas have none. The picture illustrates the geographic coverage of the ISP industry. ISPs tend to locate in all the major population centers, but there is also plenty of entry into rural areas. The map also illustrates the importance of changes over time. Many of the areas which had no coverage in the fall of 1996 were covered by a commercial provider in the fall of 1998. Many of the areas which had competitive access markets in the early period were extraordinarily competitive by the end of the period. 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.

Tables 1a and 1b provide parts of the raw data behind the maps. In the fall of 1996 of the 3110 counties, 1760 do not contain a single POP supported by any ISP, 514 have only one, and 188 have two. As evidence that low (high) entry is predominantly a rural (urban) phenomenon, there is an inverse relationship between the percentage of counties that are rural and the number of suppliers who enter.[15] Not surprisingly, a small fraction of the population resides in these counties. Just under 25% of the US

[14] 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 Fall of 1996 and the summer of 1998 of *Boardwatch* magazine. For further documentation of these methods, see Greenstein [1997], and Downes and Greenstein [1998]. The fall 1996 data covers over 14,000 phone numbers for over 3200 ISPs. The fall 1998 data cover over 65,000 phone numbers for just under 6000 ISPs.

[15] This employs the broadest definition of "urban", as defined by the US census. About a quarter of the counties qualify as urban under this definition. As noted in Downes and Greenstein [1998], the number of urban counties with low entry is somewhat an artifact of the procedures used to identify the location of phone numbers in one county. Every single urban county with low entry is next door to another major urban county with plenty of entry. There is a slight bias towards attributing the location of an ISP to the central county rather than the outlying county or area of recent growth.

population lives in counties with three or fewer ISPs. By the fall of 1998 the situation had changed. 928 counties do not contain a single POP supported by any ISP, 740 have only one and 401 have two. In the spring of 1998 under 17% of the population lives in counties with three or fewer ISPs. In two years time this is a remarkable example of diffusion and a remarkable sense of the spread of ISPs over time.

As shown in Downes and Greenstein [1998], tables 1a and 1b are too pessimistic. They do not provide a precise summary of the percentage of US population that has easy access to commercial ISPs. Tables 1a and 1b understate the true level of access because they do not account for the US population living in counties with very few suppliers that border on competitive markets. Similarly, they overstate access in counties in which the suppliers are predominantly in one area, such as within a central city, while some part of the population resides in other areas of the county, such as far outside the central city, separated by a long distance phone call. Once one accounts for these neighboring effects, the picture looks even more optimistic. In the spring of 1998, for example, Downes and Greenstein [1997] show that more than 92 percent of the US population had access by a short local phone call to seven or more ISPs. No more than five percent did not have access to a few choices.

An unexpected pattern accompanied this rapid growth in geographic coverage. First, the number of firms maintaining national and regional networks increased over the two years. Though it is unstated in the tables, tables 1a and 1b concern the activities of 32 national firms in fall 1996 and 175 in fall of 1998. The number of regional firms increased from 186 to over 600.[16] In 1996 most of the national firms were recognizable; as they were such firms as IBM, AT&T, AOL, and other established firms who 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 and few of these new firms were recognizable to anyone other than a long-time follower of this market. There was also a clear dichotomy for growth paths of entrepreneurial firms who became national and regional firms. National firms grow geographically by moving to major cities across the country and then progressively to cities of smaller population. Firms with a regional focus grow into geographically contiguous areas, seemingly irrespective of its urban or rural features.[17]

[16] In this table 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.

[17] Some ISPs have told me in interviews that this growth was initially in response to customer requests for local phone numbers for accessing networks (e-mail mostly at first) when these customers traveled outside their

Surprisingly, most of the coverage of rural areas comes from local firms. Figure 2 illustrates this point with data from the spring of 1996 and spring of 1998. In 1996 the providers in rural counties with under 50,000 population are overwhelmingly local or regional. Only for populations of 50,000 or above does the average number of national firms exceed one. In spring of 1998 the equivalent figures was 30,000 indicating that some national firms had moved into slightly smaller areas. In other words, Internet access in small rural towns is largely done by a local or regional provider. The inference is that it does not pay for many large national providers to provide dial-up service for the home whereas many small local firms in other lines of business (e.g., local PC retailing) can afford to add Internet access to their existing business. The national firms would just as soon bring out a dedicated line to a large business in a small rural area if there was sufficient demand for it. It may also indicate that the local firm may have an easier time customizing the Internet access business to the unique needs of a set of users in a rural setting.

These geographic patterns indicate that the commercialization of the Internet created an economic and business opportunity for providing access. However, this opportunity was fleeting at best and unprofitable at worse. The costs of entry into low quality dial-up access were low, and commercially oriented firms filled voids in specific places. For any firm with national ambitions, coverage of the top fifty to one hundred cities in the US was a fleeting advantage and quickly become a necessity for doing business. For any local or regional firm in an urban market, many competitors arose. It seems unlikely that any firm in the future can get much strategic advantage from the scope of its geographic coverage in the US. For any firm with a local or regional focus, there are countless others within every urban area providing similar services, so geographic scope did not provide a unique position relative to competitors.

Development of new services and other structural challenges

The contact between user and vendor could be brief but most often it was repetitious and on-going. A brief transaction occurred when the vendor performed one activity, such as setting up Internet access or attaching Internet access to an existing computing network. If the ISP also operated the access for the user, then this on-going operation provided frequent contact between the user and vendor, and it provided frequent opportunity for the vendor to change 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

primary area. More recently, it is also common to have ISPs discuss the possibility of developing a large customer base for purposes of "selling the base" to a high bidder in some future industry consolidation.

technological capabilities than the user, one would expect to see ISPs move into offering a variety of services associated with those new needs. These concerns framed the primary structural challenges for ISPs.

Some statistical evidence can be brought to bear on these predictions. Industry trade publication distinguish between two types of additional activities an ISP can offer other than basic access.

! *Offering technically difficult access:* High-bandwidth applications present many technical difficulties which challenge the skills and capital constraints of many ISPs. The slow diffusion of commercially viable high-speed access markets is widely regarded as a major bottleneck to the development of the next generation of Internet technologies.

! *Offering services that are complementary to basic access:* Providing additional services became essential for retaining or attracting a customer base. Many ISPs have tried to develop additional services, such as web-hosting, web-design services and network maintenance for businesses. Any of these were quite costly, as they had to be properly assembled, maintained, and marketed. Many of these services push the boundaries of existing telecommunications and computing market definitions.

To characterize these choices in a quantitative way, I and some research assistants examined the business lines of 3816 Internet service providers in the United States who advertise on *thelist* in the summer of 1998 (see Appendix of Greenstein, 1999). This site, maintained by Meckler Media, provides the opportunity for both large and small ISPs to advertise their services. ISPs fill out a questionnaire where the answers are partially formatted, then the answers are displayed in a way that allows users to compare different ISP services. Virtually every firm in the original and analysis samples provides some amount of dial-up or direct access and basic functionality, such as e-mail accounts, shell accounts, IP addresses, new links, FTP and Telnet capabilities. 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.

I grouped services into five broad categories: basic access, frontier access, networking, hosting, and web page design (See appendix of Greenstein, 1999, for the product code). The presence of these activities is interpreted as evidence that an ISP is broadening its activities into services other than access. This is also offered as evidence of vendor experimentation with different approaches to offering services to users.

! *Basic access* constitutes any service slower than and including a T-1 line. Many of the technologies inherited from the pre-commercial days were classified as complimentary to basic access, not as a new service.

! *Frontier access* includes any access faster than a T-1 line, which is becoming the norm for high-speed access to a business user. It also includes ISPs which offer direct access for resale to other ISPs or data-carriers; it also includes ISP who offer parts of their own "backbone" as a resale to others.[18]

! *Networking* involves activities associated with enabling Internet technology at a users location. All ISPs do a minimal amount of this as part of their basic service in establishing connectivity. However, an extensive array of these services, such as regular maintenance, assessment of facilities, emergency repair, and so on, are often essential to keeping and retaining business customers. Note, as well, that some of these experimental services could have been in existence prior to the diffusion of Internet access; it is their offering by an Internet access firms that makes them a source of differentiation from other ISPs.

! *Hosting* is typically geared toward a business customer, especially those establishing virtual retailing sites. This requires the ISP to store and maintain information for its access customers on the ISP's servers. Again, all ISPs do a minimal amount of hosting as part of basic service, even for residential customers (e.g., for email). However, some ISPs differentiate themselves by making a large business of providing an extensive array of hosting services, including credit-card processing, site-analysis tools, and so on.

! *Web Design* may be geared toward either the home or business user. Again, many ISPs offer some passive assistance or help pages on web page design and access. However, some offer additional extensive consulting services, design custom sites for their users, provide services associated with design tools and web development programs. Most charge fees for this additional service.

Descriptions of each ISP's services on *thelist* were classified into standard "phrases" which are then mapped to particular services at particular ISPs. In other words, an ISP offers networking services if that ISP uses one of the “phrases” which corresponds to networking activity. As similar exercise followed for hosting, web design, frontier access and so on. An ISP could be in more than one service. Table 2a lists the most common phrases for each line of business. (See the Appendix of Greenstein, 1999, for the

[18] Speed and capacity (i.e., T-1 line v. T-3 line) is the sole dimension for differentiating between frontier and basic access. This is a practical choice. There are a number of other access technologies just now becoming viable, such as wireless access, which are slow but technically difficult. Only a small number of firms in this data are offering these services and these are coincident with offering high speed access.

complete product code.)

In general, these methods should *undercount* the offering of any particular service line since many phrases were uninformative. In other words, this method will only record a service line if the ISP clearly states it as such .[19] In addition, the lines between different services are often, but not always, sharp. This warrants a cautious interpretation, because ambiguities in definitions naturally arise.

By definition, every ISP has at least one useful phrase indicating activity in the access business. On average, an ISP had 8.6 useful phrases (standard deviation of 4.6, maximum of 40). The main statistical findings from applying the classification scheme are listed in Table 2a for three different samples, including the original sample. These findings are also illustrated by Figures 2a and 2b.

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 2a shows that 1059 provide high speed access, 789 networking, 792 web hosting, 1385 web page design. There is some overlap (shown in Figure 2): 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. The analysis sample has similar percentages. For such a cautious method, this reveals quite a lot of experimentation with non-access services by firms in the access business.[20] It also reveals extraordinary lack of uniformity in business model of 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) are in either networking, hosting or web design – 60 do only one, 18 do all four activities. 115 provide high speed access, 59 networking, 63 web hosting, 94 web page design. That is a higher rate than the whole sample, but consistent with the hypothesis that ISPs in urban areas (where large firms are disproportionately located) tend to offer more services at higher propensities. This hypothesis receives further attention below in the analysis sample.

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[19] The approach depended on the ISP describing in concrete terms the businesses they offer. For example, no additional line of business was assigned to a ISP who advertised "Call for details" or "We are a friendly firm." The vast majority of unused phrases were idiosyncratic phrases which only appeared once with one firm, defying general characterization. There were 1105 such phrases (and 6,795 unique useful phrases), which occurred 1406 times (out of 35,436 total phrases). In other words, most of the unused phrases occurred only once and described attributes of the firms which had nothing to do with their lines of business (e.g., HQ phone number, contact information or marketing slogans). The most common unused phrase was “etc.”

[20] One of the most difficult phrases to classify was general "consulting" -- i.e., consulting which did not refer to a specific activity. Of all these vague consulting cases, all but 12 arose in the 1836 firms who provide networking, hosting and web design. Hence, the vast majority of consulting activity is accounted for by the present classification methods as one of these three complementary activities, networking, hosting and web-design.

The above indicates that using the ISPs as the unit of observation may provide a partly distorted view of the geographic diffusion of new services. To develop the point further, Table 2a lists another column which weights experimentation – admittedly, coarsely – for geographic dispersion. The product line is weighted by the number of area codes in which the ISP provides service. Since this is the only data available about geographic dispersion for all 3816 ISPs in *thelist*, this is the most one can do. This weighting is coarse because not all area codes are equal in square miles, nor population.[21]

In the original sample, ISPs are in 7.6 area codes on average. There were 28,967 " ISP-Area Codes." Of these 17,343 (77.2%) have at least one additional line of business other than dial-up Internet access or routine direct access, higher than found in the un-weighted sample. Even emphasizing how cautious these methods are, this second way of representing the data reveals quite a lot of experimentation in non-access business. Table 2a shows that, using 28,967 as denominator, 15,846 ISP-area codes provide high speed access, 8334 networking, 8188 web hosting, 13,809 web page design. In all cases, these are higher percentages than the original sample; in the case of high speed access, this is a much higher percentage. Because the firms in a larger number of regions tend to do more experimentation, this suggests that most users, especially those in urban areas where the national firms tend to locate, probably have access to some form of experimentation.[22]

Table 2b examines the relationship between different types of services, as illustrated in Figure 2. In the sample the fraction of firms in networking, hosting, and web design is higher among those in high speed access, but the relationship is not very strong. Table 2b shows that in the original sample, of the 1059 in high speed access, 59.8 percent (633) provided networking, hosting or web design. By comparison, of the 2757 not providing high-speed access, 44.8 percent (1236) did so. Similarly, of the 1869 providing networking, hosting or web design services, 33.9 percent (633) provided high speed access. Of the 1947 not providing networking, hosting and web design, 21.8 percent (426) provided high speed access.

For comparative purposes, Table 2b also lists the same correspondence for the data in ISP-area

[21] Though there is, roughly speaking, a maximum limit on the total population associated with any given area code, this maximum only binds in a few locations. In general, therefore, area codes are not determined in such a way as to result in anything other than crudely similar population sizes and geographic regions.

[22] However, this is only a hint and not a concrete conclusion. Without a complete census of new services at all ISPs, it is not possible to estimate precisely how much of the US population has easy access to local provision of these services in the same way that Downes and Greenstein [1998] estimate the percentage of the population with access to basic Internet services.

codes and for the analysis sample. The same qualitative results remain. These reinforce the point that different firms carry different non-basic services. Expanding an access firm into the networking, hosting and web design business overlaps somewhat with providing high speed access, but not exactly. For some firms these two strategies are complementary, but for many others the two strategies are distinct. These may take different skills and talents; these may be marketed to different customers demands. More research will have disentangle the different factors determining those choices.

These results 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 being provided along with many other complementary services, where the combinations have not yet taken on a set pattern.

These findings strongly suggests that the further development of commercial Internet access will accompany and be accompanied by several other activities on the boundaries of these ISPs. It also raises questions about changes to the activities of end-users within organizations. As ISPs grow closer to offer more services which integrate 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 bringing in-house the creation of new Internet activities or allowing the ISPs to continually advice them on how to change their business processes. What will the structure of this industry look like then?

A summary of early developments in the ISP market

! **Why did the Internet access business grow quickly?** Stated simply, exclusive use did not lead to isolated technical and operational developments. Hence, commercializing Internet access did not give rise to any difficult or insolvable technical and operational 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 using phone lines -- migrated to commercial uses without much technical modification.

! **Why did geographic ubiquity arise?** To summarize, 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 geographically concentrated service. Internet access was feasible in a wide variety of organizational forms, either large and small. Small scale business opportunities thrive with the help of entrepreneurial initiative, which tend to be widespread throughout the US -- including many low density 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 too were available throughout most of the US 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 low cost experimentation of the technology in new uses, new locations, new market settings, new applications and in conjunction with other lines of business. 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. Such malleability motivated experiments with new organizational forms for the delivery of access services, experiments which continue today. Finally, the invention of the World Wide Web brought new promise to the technology. Not only did new business models arise to explore and develop its primitive capabilities and expand them into new uses, but it motivated firms to experiment with Internet access along side new business lines.

! **Why did market forces lead to such extensive growth?** This case illustrates the role of technological mediation in implementing new ways of delivering technologies. These activities have immense social value when there is uncertainty about technical opportunities and complex issues associated with implementation. In addition, 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. More generally, commercialization transferred development into an arena where decentralized and unregulated decision-making took over. This was precisely what was needed to customize Internet access technology to a wide variety of locations, circumstances and users. 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 apply 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.

! **In what sense did the NSF get lucky?** 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. Competitive forces sorted through new uses of this opportunity in particular places, enabling some businesses to grow and unsentimentally allowing unsuccessful implementations to fade. To be sure, some of these developments were heavily shaped by non-profit institutions, such as the World Wide Web Consortium or the Engineering Internet Task Force, but profit motives still played a prominent role. Said another way, had NSF stewardship over the Internet continued there would have been some experimentation at computing centers found at universities and government laboratories, but it would not have been possible to replicate all the exploratory activity that did arise in commercial markets.

Reinterpreting the Early History of the ISP Market

Once viewed through the lense of technological mediation, it appears as if the ISP market has gone through two waves of change and, as of this writing, are 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 did this, taking the basic technology for access and charging a fee for its use. This was easier to do than forecast, filled with technical and commercial challenges, but free of unsolvable ones which might have acted as a bottleneck on development. So the first phase was associated with the fast development of the market and its spread almost everywhere.

In retrospect, the entry of AT&T Worldnet in 1995-96, with a marketing campaign that emphasized the professionalism and reliability behind their dial-up service, probably marks the end of this 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 of reliable service. Though this service was successful and attracted well over a million customers, it did not initiate industry consolidation. This was symptomatic that there was more to the Internet with commercial users than simply charging for basic service.

The second wave came quickly. It saw the adaptation of the basic technology to a wide variety of circumstances, depending on the users, supplier skills, and other market conditions. These were the first steps towards customizing the technology to a new set of users with different requirements. This activity

often involved new functions and novel business models, but also many of the same functions as before. ISPs offered different combinations of services, some deliberately growing from small bases into larger markets, others simply following the demands of local buyers.

To the surprise of many observers, many regional ISPs developed national services and did not merge with others. Many local ISPs expanded into regional providers. A complex market structure arose and it seemed to persist, populated by hundreds of national firms, hundreds of regional firms and thousands of local ones. Some ISPs had a wide array of services and some did not. Many of these new services took advantage of recent technical developments, such as advances in employing web and hosting technology. Some simply combined access technology with non-virtual activity, such as networking. No single pattern characterized these business models.

In the first and second phase many vendors devoted resources to developing new services. Many vendors expanded their product lines and performed service many times, each time for a different user, customizing the service across a wide set of users and their circumstances. In the second phase many vendors developed expertise that positioned them for repeat business with the same customer. The vendor devoted resources to being the vendor to whom a customer comes with problems repeatedly. The first and second phases were characterized by disruptions, continual technical challenge and renewal of new commercial possibilities. The disruption was both large and recurring, and associated with unanticipated new possibilities. Strategies changed many times and participants did not understand the full consequences of their choices until later.

As of this writing, the market appears 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 to the home. Many of these services combine a number of innovative web technologies in original ways. Some of them -- such as e-commerce hubs, instant messaging and interactive gaming -- take advantage of the pervasiveness of the Internet among a specific population, developing applications that would not have been valuable without large numbers of users. Some of them -- such as Internet fax, IP telephony, 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 for access providers to profitably offer, such as co-location hosting or virtual private networking. Hence, as we enter a third

phase, but unlike the earlier experience, it is not at all obvious that this situation lends itself to explosive growth of unexpected new services. Nor is it obvious that ISPs will continue to have a relevant and central role as mediator between technical frontier and user, or whether another third-party will assume that role.

The disruptions associated with early history of the Internet access were partly an artifact of its peculiar origins. However, the restructuring associated with the market appears to have outlived the origins. ISPs are experimenting with new ways of delivering basic functionality, new lines of business, and new pricing strategies. While a number of large national firms have emerged, such as such as AT&T Worldnet, MCI WorldCom/UUNet, Mindspring/Earthlink, and PSINet, there are also thousands of regional and local firms, each developing their business model with different local lines of service. There does not yet seem any inherent reason to expect these firms to be close substitutes in user eyes, nor to expect restructuring to cease.

Finally, these changes depend on changes to the underlying technical frontier. While nobody believes the frontier will cease moving outward any time soon, it could change in a way to favor some types of firms and disfavor others. For example, as of this writing, 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 done with end-to-end ownership (e.g., either for IP-conferencing or multi-user applications) and users desire these services, this would alter the incentives to be a national provider with one's own facilities.

5. Conclusion

Many important questions, both for economics and for management science, are wrapped up in understanding the competition to create, control, and distribute activities embodying technological mediation. As with other young markets, participants must learn how to organize new activities through experience. Technological mediation represents an important component of this learning activity. Historical context shapes how the activity arises, where it is performed, and the requirements associated with the applications undergoing change.

Technology 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 economic value from TCP/IP technology. Viewing the Internet access business as technology mediation illuminates several patterns in this market. First, it helps us to understand the explosive events just after the commercialization of the Internet. The technology underlying TCP/IP incubated in research laboratories but today's commercial industry has propelled it into common use.

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 non-academic 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 most geographically isolated regions of the country was the easy part of developing this new business; the growth of low-quality access leveraged off the existing telephone network. Suppliers are now adapting their business models to changes in the frontier and the evolving needs of users in markets other than low-quality access. This latter activity is not necessarily easy.

More broadly, many technology enthusiasts have been waiting for the on-line revolution for a long time, welcoming the possibilities for new businesses, new services and new types of communications. Now that it is here, a commercialized Internet may not be precisely what many enthusiasts had in mind. The economic benefits associated with new frontier technologies are diffuse, uneven and uncertain. It is only a slight exaggeration to say that adaption is difficult and time-consuming, even when it does not employ frontier technology.

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Table 1a and Table 1b
Number of Providers per County

Fall, 1996

Total number providers	Counties with this number	Population Percentage	Cumulative Population Percentage	Percent Urban Counties
11	308	59.3	59.3	98.1
10	19	1.0	60.3	68.4
9	17	0.9	61.2	58.8
8	23	1.7	62.9	82.6
7	24	1.5	64.4	91.7
6	41	2.6	66.9	53.7
5	44	2.1	69.0	61.4
4	65	2.5	71.5	44.6
3	107	3.0	74.5	33.6
2	188	3.6	78.1	22.2
1	514	7.9	86.0	18.7
0	1760	13.7	99.7	12.7

Fall, 1998

Total number providers	Counties with this number	Population Percentage	Cumulative Population Percentage	Percent Urban Counties
11	486	69.3	69.3	85.2
10	26	1.1	71.4	50.0
9	28	1.2	71.6	42.9
8	41	1.4	73.0	41.5
7	51	1.5	74.5	43.1
6	40	1.1	75.6	32.5
5	76	1.9	77.5	28.9
4	98	2.0	79.5	20.4
3	224	3.6	83.1	18.3
2	401	5.0	88.1	15.2
1	740	6.5	94.6	13.6
0	928	5.7	100.0	11.6

Table 2a
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.

Table 2b
Product lines of ISPs

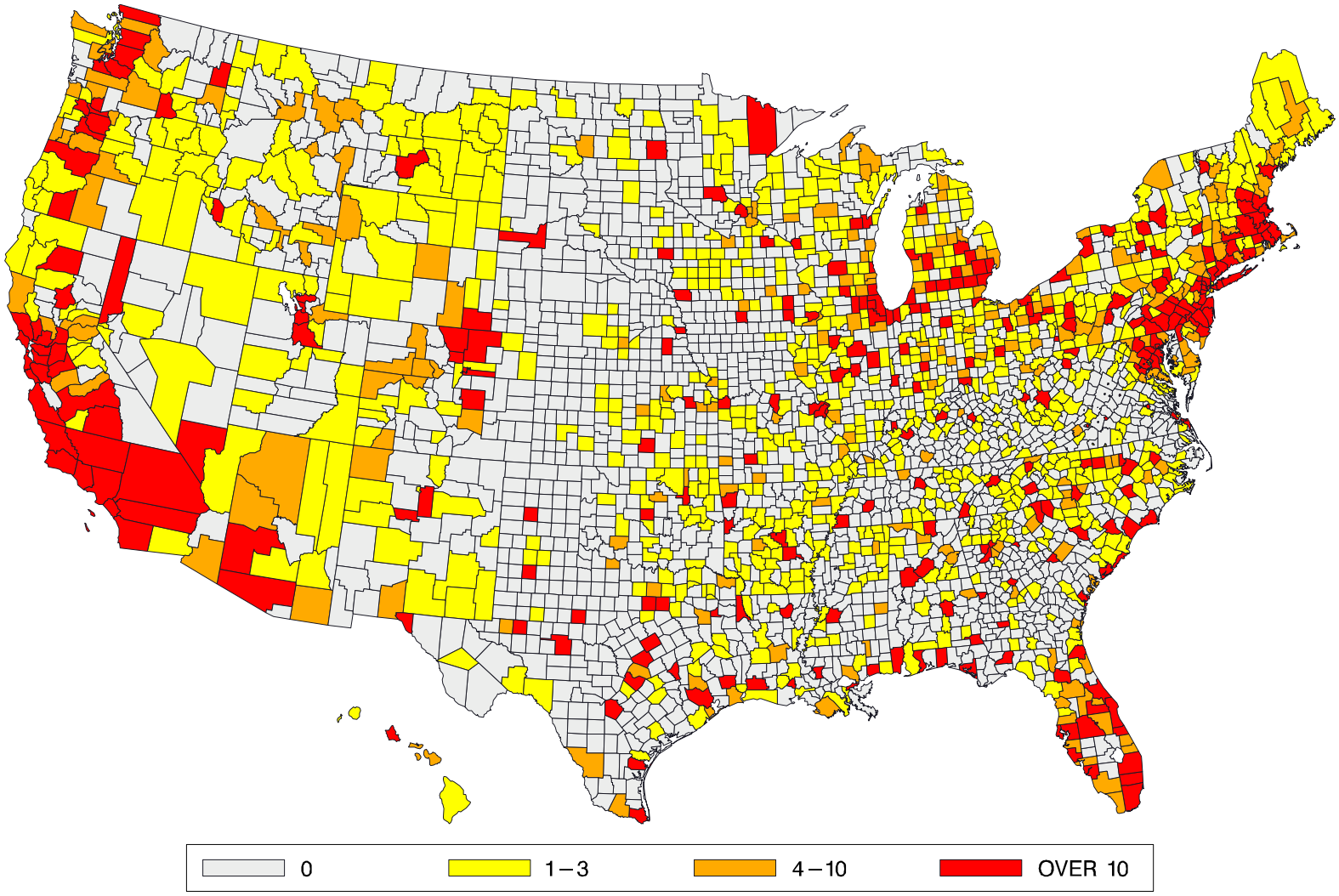
Original Sample

		Network, Hosting, & Web		
		Offers	Does not	Total
High Speed Frontier Access	Offers	633	426	1059
	Does not	1236	1521	2757
	Total	1869	1947	3816

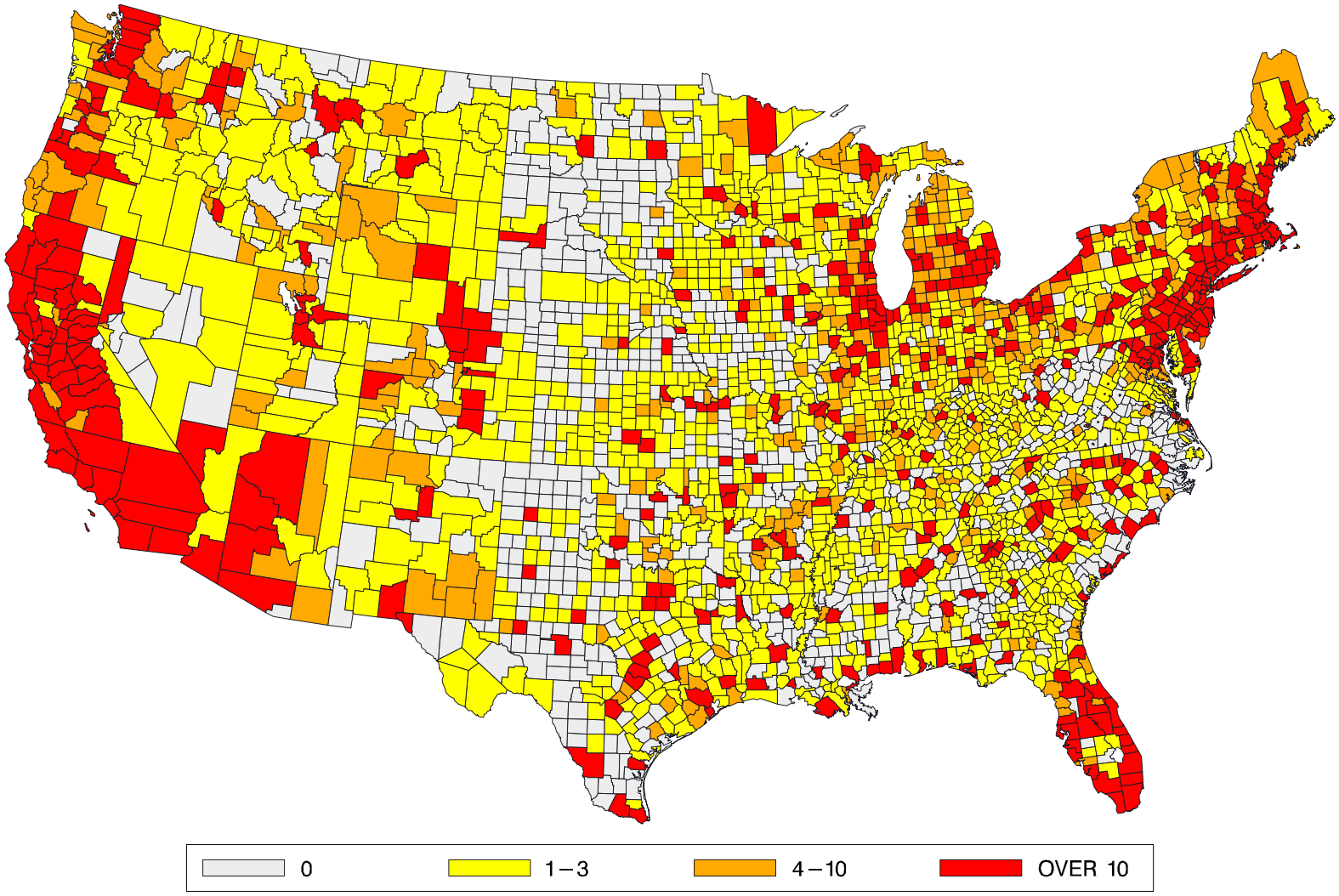
Weighted by Service Territory

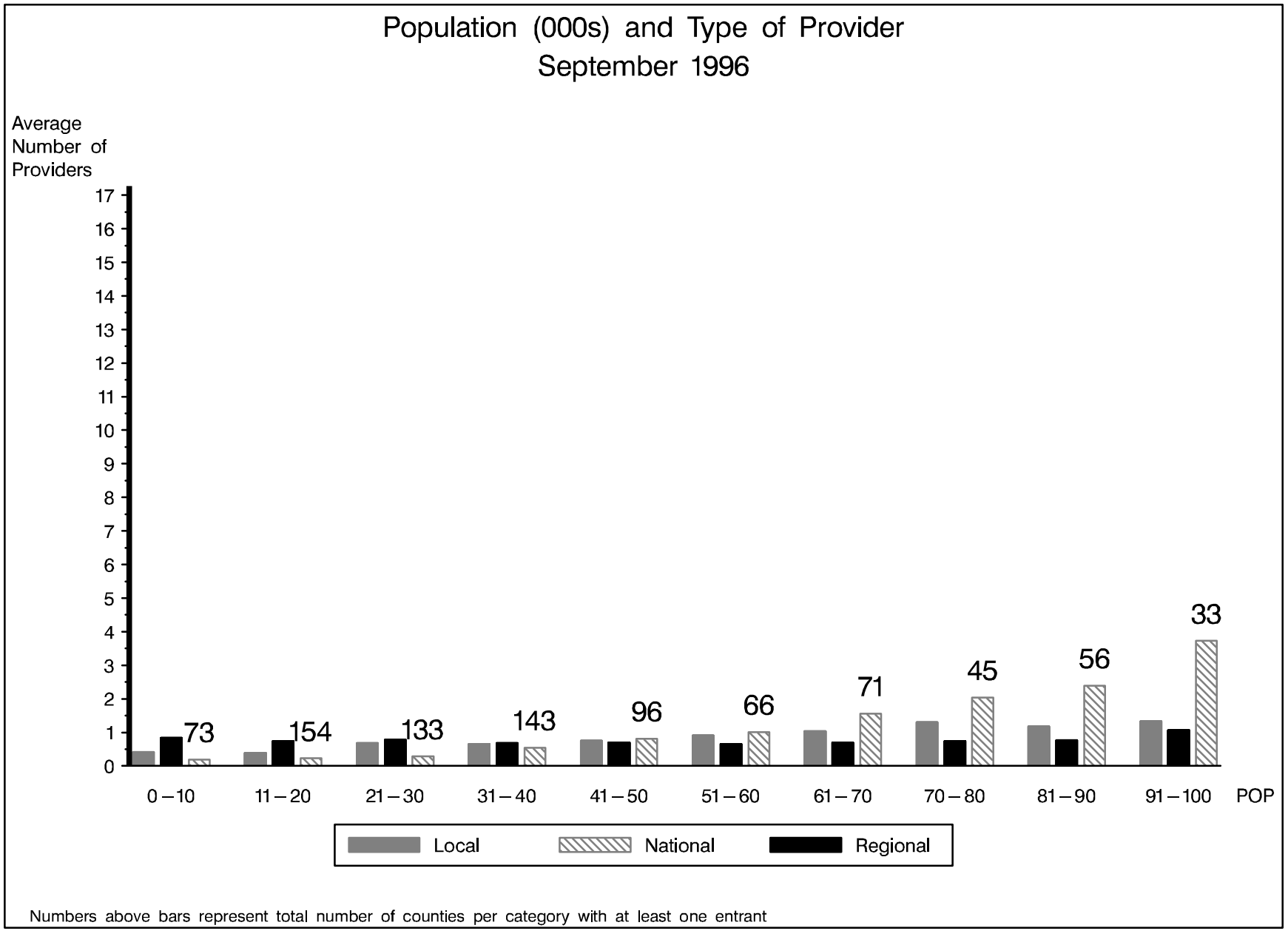
		Network, Hosting, & Web		
		Offers	Does not	Total
High Speed Frontier Access	Offers	10822	5024	15846
	Does not	6521	6600	13121
	Total	17343	11624	28967

Distribution of ISPs
September 1996



Distribution of ISPs
October 1998




Population (000s) and Type of Provider
September 1996
Average
Number of
Providers
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
73
154
133
143
96
66
71
45
56
33
0 – 10
11 – 20
21 – 30
31 – 40
41 – 50
51 – 60
61 – 70
70 – 80
81 – 90
91 – 100
POP
Local
National
Regional
Numbers above bars represent total number of counties per category with at least one entrant

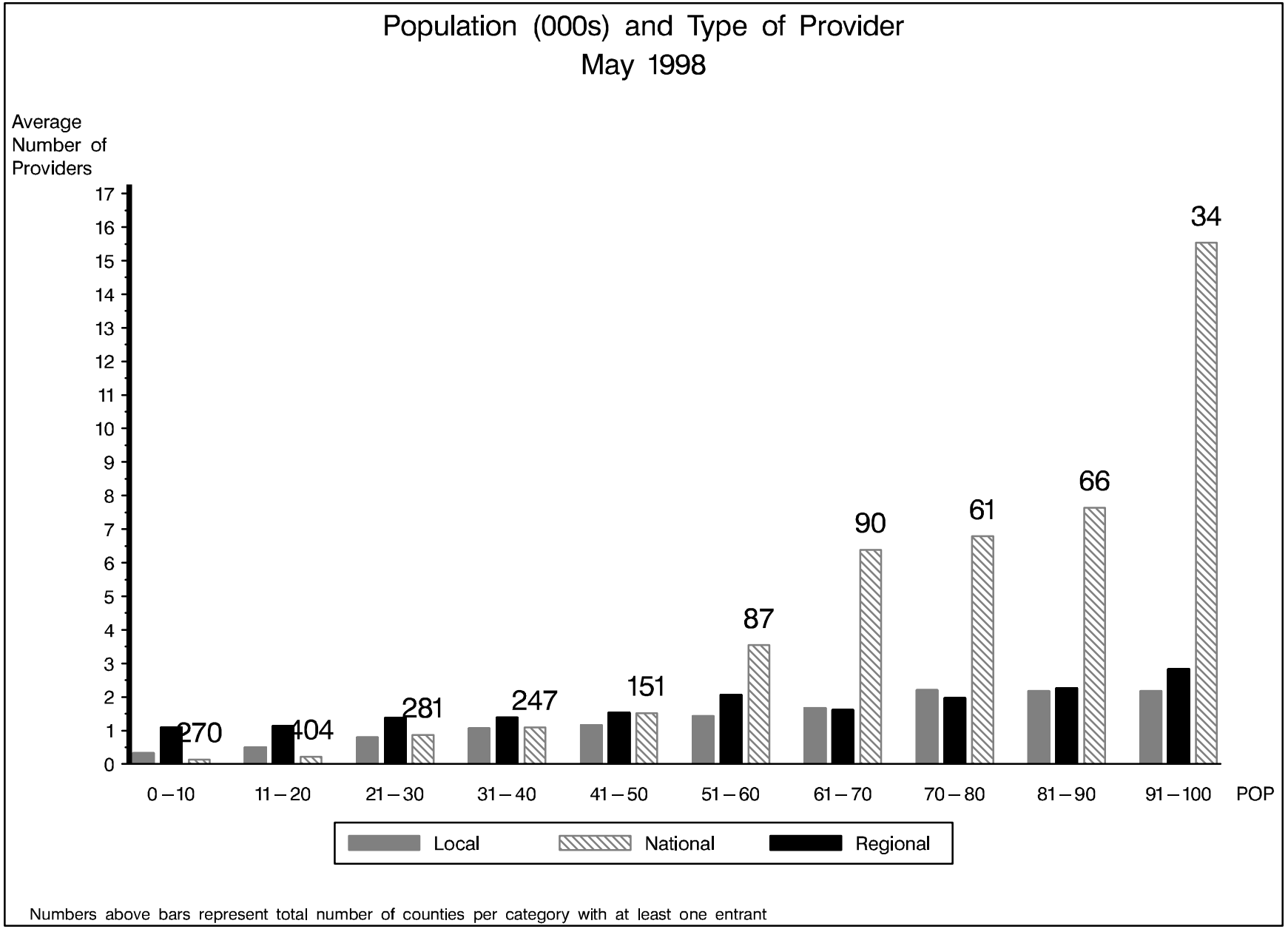

Population (000s) and Type of Provider
May 1998
Average Number of Providers
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
270
404
281
247
151
87
90
61
66
34
0 – 10
11 – 20
21 – 30
31 – 40
41 – 50
51 – 60
61 – 70
70 – 80
81 – 90
91 – 100
POP
Local
National
Regional
Numbers above bars represent total number of counties per category with at least one entrant

Figure 1a
Experiments with new services by ISPs without frontier access technology

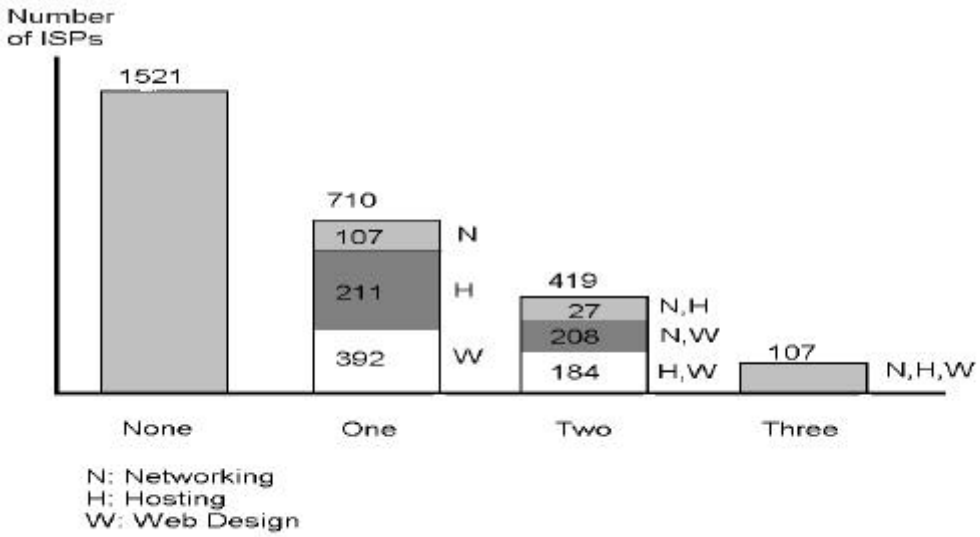


Figure 1b
Experiments with new services by ISPs with frontier access technology