Understanding the Evolving Structure of Commercial Internet Markets

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Written for:
"Understanding the Digital Economy:
Data, Tools and Research"

This draft: August 18, 1999

Abstract

This papers provides a framework for organizing empirical research on structural change in electronic commerce at the nexus between infrastructure and virtual activity. The framework identifies several key questions for understanding the evolution of the value chain underlying electronic commerce. The paper illustrates this framework on one example, the development of the commercial Internet access market. It also organizes its discussion of future research using the same themes, encompassing many classes of open issues. Policy for electronic commerce requires analysis for an evolving dynamic market, where the frameworks are rooted in an understanding of the economics of diffusion, adaptation and industry evolution.

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* Associate Professor, Kellogg Graduate School of Management, Northwestern University. I would like to thank the Institute for Government and Public Affairs at the University of Illinois, the Council on Library Resources, and the Consortium for Research on Telecommunication Policy at Northwestern University for Financial Assistance. Thanks to Oded Bizan, Erik Brynjolfsson, Tim Bresnahan, Greg Crawford, Barbara Dooley, Tom Downes, Brian Kahin, Mike Mazzeo, and Dan Spulber for useful conversations and to many seminar participants. Angelique Augereau, Howard Berkes, and Chris Forman provided outstanding research assistance. All errors are mine.

1. Introduction

While there is no shortage of attention paid to the Internet in popular media, few commentators provide frameworks and data for understanding how commercial processes translate Internet technologies into economic value. The essay highlights four general questions which are central to understanding the structure of virtual activity and changes to it. These are: What factors influence how firms organize the "value chain" for delivering electronic commerce? How does the creation of value in this market depend on commercial behavior? Why do vendors approach similar commercial opportunities with similar or different strategies? How does adaptive activity translate technology into a developing market?

The essay presents commentary on these four questions, then illustrates them on a familiar story, the rise of the commercial Internet access market, a key element in the value chain of electronic commerce. In only a few years commercial providers now supply the vast majority of Internet access in the United States, so this is a useful and important place to illustrate the framework. The essay finishes with a survey of open research topics. This part of the essay highlights the untapped potential for additional research on the key questions. It emphasizes the need for the development of measurement methodologies, for more data and for policy assessment.

The essay emphasizes that policy for electronic commerce requires analysis for an evolving dynamic market, where the framework is rooted in an understanding of the economics of diffusion, adaptation and industry evolution. Firms and users select only a few of many possibilities enabled by new technology. Firms package new offerings, launch new services, and tailor the new technology to their particular market. Users survey their options, seek information about possibilities, and, when they are a business, take actions that respond to competitive pressures. Commercial factors play a central role in determining these outcomes. This approach dispels a number of myths about electronic commerce, while also highlighting the many open avenues for empirical research.

2. Questions about the structure of electronic commerce

This essay focuses on electronic commerce after the "commercialization of the Internet," a phrase that is shorthand for three nearly simultaneous events: the removal of restrictions by the NSF over use of the Internet for commercial purposes, the browser wars initiated by the founding of Netscape, and the rapid entry of tens of thousands of firms into commercial ventures using technologies which employ the suite of TCP/IP standards. In the first few years after the commercialization of the Internet, the products changed

frequently, many firms changed strategies, and the market definition adjusted . The purpose of this section is to identify questions these events raise:

! **Value chain:** The commercialization of the Internet gave rise to a value chain for delivering electronic commerce. A "value chain" is comprised of the many activities necessary for the delivery of a final good. What factors influence how firms organize the value chain for delivering electronic commerce? Is this concept useful for understanding this new activity? If not, why not?

First, the value chain, if one can be sensibly defined at all, will look quite complicated. It is comprised of at least two dozen distinct categories: client applications, client operating systems, browsers, client hardware, client processors, distributed technologies such as Java and Corba, distribution and maintenance of this hardware, network access, inter-networking operating systems using TCP/IP and W3C standards, data transport facilities, local area network operating system, server operating system, server database management software, server system hardware, groupware, custom software, enterprise software, enterprise middle-ware, system software and support, search software, domain name coordination, data transport, retailing intermediaries and so on. A table of some of these, modified from Bresnahan [1999], is shown in Table 1.

This value chain is not settled for several reasons. Partly this is because there is no single firm who dominates all phases of this chain or who has stamped its unique vision on the organization of transactions. Leading firms include Microsoft, Dell, IBM, Intel, Sun, Compaq, AOL, Uunet, MCI, AT&T World Net, Cisco, Novell, Oracle, Hewlett Packard, EDS, Andersen Consulting, SAP, Peoplesoft, Baan and Computer Associates, as well as many others. Consequently, it is not obvious that this picture will be the same in ten years. Indeed, nobody in the industry expects it to be close to the same. That is symptomatic of the fluidity of the organization of the value chain.

More to the point, because firms specialize at different layers of the value chain, there is no consensus about how that chain should be organized. This is a situation of "divided technical leadership" (Bresnahan and Greenstein, [1999]), where many firms possess roughly similar technical capabilities. With only a few notable exceptions, if a firm gets too far from the technical frontier or from satisfying its immediate customer base, it will be replaced relatively quickly by another more sprite and better organized entity from a nearby competitive space.

The vintage of this value chain also affects its stability. It consists of something old and something new, something borrowed and something blue. To be sure, there is new technology here, especially in the

wires, cables, hubs, routers and new switching equipment. Yet, it is also a retrofit onto the old telephony communications system, as it is an incremental change to the established methods for data transport system and to the operations of many users existing client/server systems. It is blue because this design makes a technical perfectionist unhappy; if one were going to build a system from scratch around Internet protocol, this is not how one would do it. Thus, there is continuing tension between those firms who pursue incremental improvements that retrofit to old designs and those firms who pursue strategies that try to bring dramatic technical advance to user through green-field developments.

This value chain is quite confusing to outsiders because it defies existing classifications of economic activity. It changes too rapidly to be given stable definitions. Moreover, economic activity involves a mix of tangible durable assets and intangible business processes or operation procedures, a combination that tends to defy documentation by all but the most sprite consultant. In addition, the mergers occur regularly. As of this writing, there is hardly an end in sight to this type of restructuring.

The final source of confusion arises because the value chain is not "vertical", as found in most manufacturing, for example. A "vertical" value chain implies that activities must be performed in a hierarchical sequence, a sequence often characterized as linear, leading from upstream to downstream. Instead, the value chain underlying electronic commerce is must closer to being a "platform". A platform is a common arrangement of components and activities, usually unified by a set of technical standards and procedural norms, around which users organize their activities (Bresnahan and Greenstein, [1999]). Platforms have a known interface with respect to particular technologies and are usually "open" in some sense. They are typically associated with substantial externalities, whose value is difficult to capture. Later, this essay will distinguish between owned technologies as one extreme and non-propriety specifications as another.

The provision of many activities on the emerging Internet platform are somewhere between telecommunications and standard commercial transactions. Like telecommunications services, much activity is geographically based, with great opportunities for location-specific differentiation and packaging, as well as geographically situated marketing. Like many intermediary commercial services, much Internet services are bundled to provide not just value to the customer but a kind of channeling of the customer's attention. This presents the supplier with a constellation of opportunities for expanding or marketing the relationship, opening up the boundaries for the initiation of new supplier services. That is, many Internet services, while layered over telecommunications services, actually compete in the

multidimensional, multidirectional market that lies above them. This phenomenon will be illustrated further below.

! **Creation of value**: Next consider how this delivery of services creates economic value for society. How does the creation of value in this market depend on commercial behavior?

The first key detail is so familiar that few observers comment on it: data transport services are cheaper at higher volume. This arises because there are economies of scale in aggregation/density. This was true in the voice network and it is still true of data networks, whether it has a PC at the end of it or a mobile intelligent Internet device. It should continue to hold in the future, no matter what structure the TCP/IP network takes (See Aron et al, [1997]). In other words, we can expect the high volume/high density parts of the emerging Internet platform to contain only a few suppliers in any given location.

The second key detail is somewhat new: the "last mile" of data transport, where the densities are not too large and the volumes are not too high, is becoming a good business in some niches of electronic commerce. Several decades ago it simply was not possible. Now it is, and possibly on a wide scale and for a wide scope of activities, though there is considerable commercial uncertainty over precisely how wide the scope and scale can get. As of this writing, it is already clear that business applications, such as automation of routine business-to-business transactions, can grow considerably. There are also many bets that many other activities will shortly display similar economies, even activities such as retailing of goods, delivery of entertainment, organization of virtual games, and development of virtual communities and organizations.

In the commercial world, this new possibility gives rise to hundreds of vexing business decisions. Does it make sense for a small/medium sized firm to have a large on-line presence? Does it make sense for someone to get in the business of helping a rural farmer check the financial markets regularly with a palm pilot? Does it make sense for a cable company to delivery high-speed data over their cable lines to neighborhoods where only 25% of the households have a PC? There is no consensus on how to resolve these issues, even among experts.[2] The key observation is that this uncertainty raises vexing issues for on-going policy making about electronic commerce, which can no longer be based on old assumptions about the boundaries of commercial behavior.

[2] Note that these decision get much attention from policy makers for good reasons; this is where many have/have not split gets decided. For example, commercial markets have so far determined who has Internet connection to the home and who does not, which regions of the country have easy access and which do not, and so on.

An important technical enabler for this structure are the standards and processes underlying data-interchange, which is why this is a key part of the emerging Internet platform. These are comprised of TCP/IP, W3C & many other non-proprietary standards, mostly inherited from pre-commercial days. At many user sites, these are comprised of more proprietary standards, such as AOL's software, Windows, and so on.

If left entirely to market forces, there is no natural reason why any particular piece of the dominant standard had to be non-proprietary, nor for it to stay this way except that there are strong forces of inertia behind the status quo. An interesting tension arises because plenty of firms would love to overlay this system with their own proprietary material, if they could. The recent disputes between TCI/AT&T and AOL over interconnection have elements of this tension. So too does the dispute between Microsoft and AOL over the use of community chat software. So too the dispute between Microsoft and Netscape over the design of browsers and complementary components. The adoption of standards for streaming audio and video have also been influenced by these motives.

That said, today, at least for now, interconnection is easy and does not reside in any firm's unique domain, at least, not as of this writing. However, as one can see from Table 1, the possibility exists for some firms to acquire dominant positions in one part or another of the value chain. This environment raises alarmist fears in some circles that particular firms may act as a bottleneck on the creation of value. Others see great gains from the privatization of incentives to invest in the emerging platform. This debate will continue for the foreseeable future (E.g., for a variety of views, see Eisenach and Lenard, [1999]), highlighting the need for careful thinking about standards building processes in the emerging Internet platform.

Though everyone understands that value is being created, it is quite difficult to document even the basic trends. Prices change frequently and it is not at all clear what economic activity gets priced and which do not. The diffusion of new technology has rapidly moved across income, geographic space and type of application. Just as there is no consensus on how to develop these markets, there is no consensus about the best way to record their progress in creating value.

! **Same opportunity, different strategy**: Why do vendors approach similar commercial opportunities with different strategies? What we see is partly a reflection of the newness of the market and its gold-rush hype. In the present era it is not hard to start something on the web. Entry costs are low in all but the most technical of frontier activities. It is cheap to put up a web page. It is cheap to open an ISP. In

most urban areas it is not hard to find programming talent. And, for most users of electronic commerce, new applications have been only an incremental change in their lives. Hence, many small firms can give it a whirl and, at least, get a start.

Variety exists for another reason, which is somewhat less faddish. Many vendors are deliberately targeting unique user need, tailoring their service to the peculiar needs of local markets, to their own special niche, or to bringing their own peculiar background to the fray. Whether this is associated with a different visions of the future, or a different core-capability, it results in variety.

Variety thrives because of divided technical leadership. When so many different firms possess similar technical capabilities, only commercial factors distinguish them from each other. This gives commercial firms strong incentives to develop strategies for electronic that strongly differentiate themselves.

As of this writing, two types of strategies tend to characterize electronic commerce entrants. First, a firm may try to combine electronic commerce with non-virtual activity in some unique way. For example, established media is full of half-breeds like the Wall Street Journal, The New York Times, Business Week, and so on, who try to maintain both a virtual and non-virtual presence and play them off each other. There are also plenty of less established media doing the same, such as Industry Standard, Wired, Red Herring.

Half-breeds exist too in retailing, where some firms use their web presence to give users a shopping experience that complements their non-virtual experience. Dell computer's establishment of a presence on the web is among the best known of this sort. Like most on-line retailers there is an important non-virtual part to their business: in this case, the assembly and delivery of a physical good. But there have been many other firms which pursue different specialties of non-virtual activity, such as E-Schwab, Microsoft Network, AT&T Worldnet and so on.

Then there are the pure electronic commerce plays, tailored to visions of unique on-line needs. The most successful strategies so far have been associated with firms that acquire a role as broker or aggregator of information or web experience. Amazon is among the largest of these firms, as they build a large one-stop shopping experience across books, videos and plenty of other things. E-bay, the auction house, is another, as they try to establish their position as a central virtual location for exchanging unique goods. AOL has pursued a related strategy associated with aggregating entertaining content, simplifying the shopping experience and establishing virtual communities. There are tens of thousands of other firms trying similar strategies in many fields, from horticultural clubs to healthcare advice.

Characterizing these strategies should continue to provide challenges for policy research. The distinction between electronic commerce and Internet infrastructure will not be very hard and absolute, nor especially useful. Popular conceptions based on electronic retailing by AOL, Amazon and E-bay, etc., are necessarily incomplete. Moreover, much key economic strategy will lie just below the transaction, in the transactions which build the bridges between the virtual world and the non-vritual, especially as the distinction between electronic commerce and infrastructure becomes more blurry in the future. This will be further illustrated below.

The heart of success strategies may lie in combinations of activities that cannot be replicated easily, combining infrastructure and processes in unique ways. Indeed, there may be no meaningful distinction between the firms who provide Internet access, the organization of the experience by search engines, and the organization of the retail experience. In the future these firms will be called AOL/Netscape, TCI/@home/Excite, and so on. Similarly, Microsoft has put its interests into cable modems, WebTV, through mobile devices in CE, satellite through Teledesic, and they are a large content provider too. It is not an exaggeration to say that we are headed towards an extraordinary set of arrangements involving confrontations between the strategies pursued by Microsoft, AOL, AT&T and many others. These confrontations of private interest will situate a number of vexing policy problems.

! **Adaptation:** How does adaptive activity translate technology into a developing market? This last question is perhaps the most important. Adaptive activity is central to growth. Yet, it is also most often the activity that goes undocumented.

What is adaptive activity? Firms take an adaptive role when they stand between the many possibilities enabled by new technology and the unique needs of the user. Firms do this when they package new offerings, when they launch new services, and even when they survey a business and tailor the new technology to the user's peculiar needs. These activities may be situated in particular problems, but may generate large spillovers to others in different locations, facing different problems.

Adaptive activity mattered a great deal in the period just after the commercialization of the Internet. Some firms specialized in making electronic commerce easy to use while other seek to push the technical frontier. Some vendors sought to specialize in a small set of activities while others sought to offer general solutions. Vendors devised strategies to take advantage in the large gaps of knowledge between themselves and their users.

That said, there seem to be one type adaptive role that many firms take and one which many firms

do not. The uncommon role is to be a tool builder, a specialist the emerging platform, defining standards for equipment makers, ISPs, operators of web services, network users and others. Cisco, Microsoft, Oracle, Sun, IBM, Netscape/AOL and many firms listed in Table 1 desire this role.

The more common adaptive role is consulting, or more concretely, translating information about the new technical frontier into information which a user finds valuable. This is not a bad thing, though most commentators under-emphasized it. It is the essence of economic development. Consulting services can be either offered as a stand alone service or bundled with the sale, installation and operation of equipment. The key observation is this: in a dynamic changing environment, every active market participant sells knowledge along with other services, translating technology into value, the key part of economic growth.

Markets for knowledge have generally defied characterization and will likely continue to do so for many reasons: First, the private value of a technology license will diverge from its economic value. Second, the gains from efficient brokering are hard to measure. Third, the value of consulting services vary across location, provider and over time, but bring unmeasured benefits to different locations. Fourth, the transfer of knowledge, especially about the processes necessary to make use of a new technology, is often intangible and invisible to outsiders. This observation will also be illustrated below.

3. The Internet Access Business after Commercialization: An interpretation

The purpose of this section is to interpret one facet of the value chain of electronic commerce, Internet access. This will illustrate the essay's larger themes by showing in one concrete case how commercial behavior translated the technology behind electronic commerce into actual goods and services. In particular, it will illustrate how this market cannot be understood without using insights and frameworks from the economics of diffusion, adaptation and industry evolution.

The most recent surveys show that no more than 10 percent of US households get their Internet access from university-sponsored Internet Service Providers, ISPs, with almost all of the remainder going to a commercial provider (Clemente, [1998]). As of 1997, this ISP industry was somewhere between a three and five billion dollar industry (Maloff, [1997]). What are commercial ISPs in practice? 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.

Right after commercialization only a few commercial enterprises offered national dial-up networks with Internet access, 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. Within a few years, however, there were dozens 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 many local providers of Internet access that served as the links between end-users and the Internet back-bone. Local shoe-string operations seemed less common.

Several key factors shaped the structure of this industry in these years. These factors were: (1) There was an uneven maturity to applications which had commercial value; (2) There was a loosely coordinated diffusion process; (3) A significant set of activities involved intermediary functions; (4) The supply of access approached geographic ubiquity; (5) National, regional and local ISPs specialized in different markets niches; (6) There were several fleeting business opportunities; (7) Adaptive activity is not yet a fleeting business opportunity; (8) Different firms pursued different strategies for offering new services. These are discussed below in turn.

! **Uneven maturity in applications which had value to commercial users:** 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.

When the electronic commerce first developed based on TCP/IP standards 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, a typical pattern for new information technology (Bresnahan and Greenstein, [1999]). 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.

! **A loosely coordinated diffusion process:** Unlike the building of every other major communications network in the U.S., Internet access was built in an extremely decentralized market environment. Aside from the loosely coordinated use of a few *de facto* standards, (e.g., World Wide Web),

government mandates after commercialization were fairly minimal. ISPs had little guidance or restrictions. They had the option to tailor their offerings to local market conditions and to follow entrepreneurial hunches about growing demand.

As a technical matter, there was little barrier to entry into the provision of dial-up access. This was the first obvious adaptation of Internet technologies to commercial use. As a result, commercial factors, and not the distribution of technical knowledge among providers, largely determined the patterns of development of the basic dial-up access market immediately after commercialization.

! **A significant set of activities involve intermediary functions:** The commercial transaction for Internet access between user and vendor could be brief but most often it was repetitious and on-going. A singular transaction arose when the vendor performed one activity, 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.

In many cases, an ISP was better educated about the technological capabilities than the user. In effect, the ISP sold that general knowledge to the user in some form which customized it to the particular needs and requirements of the user. At its simplest level, this provided a user with their first exposure to a new technological possibility and educating them about its potential. More often it went beyond exposure to electronic commerce, and included the installation of equipment, provision of maintenance and training, as well as undertaking application development. These types of transfers of knowledge typically involved a great deal of nuance, often escaped attention, and yet, were essential to developing electronic commerce as an on-going and valuable economic activity.

! **The supply of access approached geographic ubiquity:** 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. Hence, Internet access providers had a strong interest in reducing expenses to users by providing local coverage of Internet access for a local population. Unmet local demand represents a gap between what is technically possible and what many users desire. This is a commercial opportunity for an entrepreneurial ISP, a situation where building appropriate facilities could meet local user needs.

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.[3] Colored areas are counties with providers. 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 maps also illustrate 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. Indeed, 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 such access. Almost certainly the true percentage of the population without access to a competitive dial-up market is even lower than five percent.

This near ubiquitous supply of competitive access had two consequences for policy discussions. It raised the issue that some low density areas of the country were getting left behind quickly. Second, in most parts of the country access to the commercial Internet was determined by demand factors -- i.e., whether the user thought the benefits exceeded the expenses, whether a user could learn how to use the Internet quickly, and so on.

! **National, regional and local ISPs specialized in different markets niches:** 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. Tables 2a and 2b contain 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.[4] In 1996 most of the national firms were recognizable; as they were such firms as IBM, AT&T, Netcom, 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.

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[3] 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.

[4] 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.

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.[5]

As it turned out, most of the coverage of rural areas comes from local firms. 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 fall 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. 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.

! **There were several fleeting business opportunities:** 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. 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 will get much strategic advantage from the scope of its geographic coverage of its dial-up network 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 does not provide unique position relative to competitors. There was much debate among ISPs about the value of providing geographically dispersed service. Some ISPs deliberately chose to focus on small geographic region and develop a reputation at that local level. Other ISPs attempted to create national brand names, focusing their

[5] 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 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.

attention on expanding their franchises or geographic reach.

! **Adaptive activity is not yet a non-fleeting opportunity:** A significant set of activities of many providers in the commercial Internet market involve "adaptation.". What activity comprises adaptation?[6] Adaptation services involve one of several activities: 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 adaptation involves heavy use of the technological frontier and sometimes not. In general, it depends on the user, their circumstances, their background, their capital investments, the costs of adjusting to new services and other factors which influence the match between user needs and technological possibilities.

Adaptation does not happen on its own. In information technology, 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 (Bresnahan and Greenstein, [1999]). If the end-user or their staff does much of the adaptation activity, it becomes an extension of other operations and investments. In contrast, if third parties sell related services to users, adaption may take several different forms: equipment, consulting about business processes, or both. In this case, third parties, ISPs, took on a central role.

ISPs commercialized their adaptive role through offering new service. Services at ISPs can be grouped into five broad categories: basic access, frontier access, networking, hosting, and web page design (See appendix of Greenstein, [1999], for precise definitions). Table 3 includes lists of activities associated with each cateogory.

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

[6] 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. For development of these view of the ISP market, see Greenstein [1999].

data-carriers; it also includes ISP who offer parts of their own "backbone" as a resale to others.[7]

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.

! **The rise of different strategies for offering new services:** By 1998 different ISPs had chosen distinct approaches to developing access markets, offering different combination of services and different geographic scopes. Table 3 shows the results of surveys of 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]).Virtually every firm in the samples provides some amount of dial-up or direct access and basic functionality, such as email accounts, shell accounts, IP addresses, new links, FTP and Telnet capabilities, but these 3816 seem to under-represent both very small and quasi-public ISPs (e.g., rural telephone

[7] Speed 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.

companies)[8].

Of the 3816 ISPs, 2295 (60.1%) have at least one line of business other than basic dial-up or direct Internet access. Table 3 shows that 1059 provide high speed access, 789 networking, 792 web hosting, 1385 web page design. There is some overlap (shown in Figure1): 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 different ways to combine non-access services with the access business.[9]

These activities contain much more complexity and nuance than Table 3or Figure 3 can display. ISPs in urban areas have a greater propensity to offer new services. The largest firms – defined as present in 25 or more area codes – also offer services at slightly higher rates, which is also consistent with the hypothesis that urban areas (where large firms are disproportionately located) tend to receive higher rates of new services. See Greenstein [1999], for further details.

! **The research agenda for understanding Internet access:** These features of the access business portend an interesting future for this part of the value chain. The locus of adaptions is shifting from developing and maintaining access into related functions. Many ISPs in this business seems to be moving 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.

Further development of commercial Internet access will accompany and be accompanied by several other activities on the boundaries of these ISPs. This 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

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[8] 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. From comparison with other sources, such as Downes and Greenstein [1998], *Boardwatch Magazine* and the National Telephone Cooperative Association directory on Internet Services in rural areas (NTCA [1998]), it appears that these 3816 ISPs are not a comprehensive census of every ISP in the country.

[9] One of the most difficult phrases to classify was general "consulting." 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.

continually advice them on how to change their business processes. What will the structure of this industry look like then?

4. The research agenda for electronic commerce

In this section the essay resorts to a broader focus, characterizing the room for original and fundamental empirical research about the changing structure of electronic commerce. While this environment raises many challenges for future research, regularity to patterns of behavior help frame many empirical research issues about changes in market structure. [10]

! **Measuring changes to the technical possibilities frontier and to pricing:** There is a well known literature in econometrics associated with hedonic estimation. This has been frequently employed to measure computing industry outcomes. This method provides some insight into the rate of technical improvement in hardware across a class of products. It has also been useful for describing several complementary markets.[11] Since the Internet equipment industry, like the rest of computing, has experienced a dramatic decline in price per unit of features, hedonic curves are a simple way to summarize that change over time. Hedonic techniques also account for changes in prices along the entire product line. This is one tool for focusing attention on improvement in upstream equipment and transmission facilities--along a wide spectrum of sizes, applications and firms – which almost everything is getting better and cheaper. There has been less attention paid to product turnover – i.e., entry and exit of new designs as a transmission mechanism for diffusion of new technology – leaving considerable room for further empirical research on product cycles, generally.[12] These methods have yet to be applied to the wide class of equipment underlying electronic commerce.

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[10] I am grateful to Tim Bresnahan for bringing some of these issues to my attention over the course of many years. These set of issues partially overlap with our literature review of user-oriented and valuation studies in information technology, as found in Bresnahan and Greenstein [1999].

[11] There are many estimates of price changes in computing using hedonic estimates (e.g., Triplett [1989], Dulberger [1989], Gordon [1989], Berndt et al [1995]]. Recent research suggests that many of the same trends are found in PC software [Gandal [1994], Brynjolfsson and Kemerer [1996], Groehn, [1999]. On communications and transmission equipment see Flamm, [1989, 1998] and also Aron, et al., [1997]. For some reservations on the use of hedonic estimation, see Bresnahan and Greenstein, [1998] or Triplett, [1989], especially.

[12] For example, see Stavins [1995], Greenstein and Wade [1998], de Figueiredo and Kyle [1999].

! **Changes in the Geography of the provision of Internet Infrastructure:** There is wide interest in understanding the Internet's geographic features, as they have consequences for the development of a "universally accessible" Internet, and for the locus of growth and economic development in a region.[13] These issues need data collection and new frameworks. The most commonly cited information on the geographic diffusion of the Internet comes from the Matrix Information and Demography Services (MIDS) of Austin, Texas, which has been analyzing the location of 'hosts', computers connected to the Internet. Yet, it is not clear that there is any relationship between location of host computers and access to Internet technologies for business and personal use, nor is there any necessary relationship to degrees of economic advance in the region. Considerable more work is possible here, which geographers have begun to investigate.[14]

! **The nested adoption of electronic commerce:** General purpose technologies, such as Internet technology, do not diffuse immediately without change. Often the critical factor influencing their adoption are "co-inventive" activities, inventions which adapt the technology to specific unique users (Bresnahan and Trajtenberg, [1997]). Co-invention takes time and necessarily occurs in sequence. As the conditions that determine one first diffusion pattern change, and as users co-invent in reaction to new opportunities, so too do the conditions that determine the adoption of Internet technologies.[15] Hence, a latter episode of diffusion can be nested within the factors that determined the first episode. More to the point, any sufficiently complex co-invention activity will result in the nesting of some adoption episodes in others. For example, innovations in personal computing and networking influence the diffusion of on-line retailing. Innovations in search engines leads many firms to alter their web pages, which further induces changes in interactive access technology, which induces further adoption of software and so on. There has been very little attention paid to the how the sequence of development of electronic commerce shapes its performance. Is the United States gaining short term advantages or long terms disadvantages by being the strong first mover? How are there biases presently in the resolution of tensions between retrofitting and green-field

[13] See, e.g., Moss and Townsend [1996, 1998], Moss and Mitra [1998], Greenstein, Lizardo and Spiller [1997], Downes and Greenstein [1998].

[14] See http://www4.mids.org/. Also, see http://www.cybergeography.com/atlas/atlas.html for cyber-geography and for international commercial statistics, see http://www.telegeography.com/.

[15] See Jimeniz and Greenstein [1998], Clemente [1998], Kridel [1997] and Tedlow [1996].

development of the value chain of electronic commerce?

! **Variation in business models:** Does the availability of new services differ across regions of the United States? Across time? Investment in digital infrastructure induces entry of complementary goods or it produces demand-enhancement which differs by company and region. Aside from those identified in the example above, there is room for many more studies of the determinants of differences in the form of commercializing electronic commerce. This topic is difficult partly because the key issues resist data-collection, requiring that researchers measure adaptation expenses, how the benefits from new technology get captured by the business, and how these benefits are distributed to the purchasers of the final products. There seems to be opportunities to arbitrage between the broad knowledge of consultants and the specific needs of academics and policy makers.[16]

! **Variation in user requirements at the home:** Some statistical research has analyzed the patterns of adoption of IP technologies for non-business use.[17] This is clearly an important determinant of industry structure in electronic commerce, as the diffusion of so many business models and new applications presumes ubiquity or an experienced user base. Yet, adoption and use of the Internet at home depends on historical or previous investments, particularly in such key infrastructure such as PCs, cable lines and local digital phone equipment. That is, the diffusion of electronic commerce had historical determinants in the diffusion of PCs, which was not oriented towards the diffusion of electronic commerce for many years. These were determined by many factors, such as the age, income and profession of residents of a household, as well as the conditions of schools, libraries and retail service facilities in a local region. Does this portend development of non-PC based models of electronic commerce at the home? Will the have/have-not split in access to electronic commerce be determined by the factors which shape PC adoption?

! **Variation in user requirements in business:** The literature has made interesting progress on

[16] There is a long list of commercial firms with active research programs in characterizing business models in electronic commerce at a national or international level, including Juliussen and Juliussen, Forester, the Maloff group, Jupiter Communications, Ziff-Davis, IDG, Boardwatch, Meckler Media, Gartner Group, and many more.

[17] Some recent contributions include Kridel, et al [1997], Goolsbee and Klenow [1999], or Goolsbee [1999]. Also, see Clement [1998] or Maloff [1997].

the determinants of adoption of new IT in business.[18] These studies could be extended to many of the open questions about the relationship between the diffusion of electronic commerce and its benefits/costs to specific users, especially in different types of business activities. Some buyers may be waiting for adaptation costs to decline, which occurs as the supply of complementary goods increases. In computing, for example, the costs of transition from old technology to new were much higher in complex organizations with idiosyncratic applications. These costs slowed adoption of new technology by some of the very firms who could benefit most from it, inducing a potentially long lag between the invention of new capabilities and their use. These explanations may provide a framework for understanding development of new services in such key industries, such as financial services, transportation and print and publishing.

! **Markets for adaptation services:** It would also be interesting to examine the pricing, business models and success of the custom software and related services in a variety of applications to electronic commerce – how effective are they in making adaptions to local conditions and why? Did national firms need to change their sale, service and organizations to try to commercialize this new opportunity? Similarly, there is a need to examine the ability of companies to find and use programmers in their local markets, or enterprises' ability to deploy managers in the kinds of roles required by new IT. While most data do not directly measure adaptation activity, such activity may leave shadows in features of software, labor practices, management policies, changing job definitions, wages and output qualities. Further studies of the organization of the software industry, training, labor practices, and other adaptation activities would be very useful.[19]

! **Intermediaries, local economic growth and subsides:** The diffusion of an Internet technology is largely shaped by the geographic diversity of local markets and the heterogeneity of firms who commercialize that technology. This dispersion shapes the customization of technology to new users and established businesses. This process is central to the understanding of economic growth, especially as electronic commerce influences information-intensive activities within firms, such as inventory

[18] See, e.g., Bresnahan, Brynjolfsson and Hitt [1999] on the degree of centralization or decentralization within corporation, Hubbard [1998] on the use of computing and global-position-systems for coordination benefits, Bresnahan and Greenstein [1997] examine the idiosyncratic factors slowing down/speeding up diffusion of networked IT at mainframe users.

[19] For example, Mowery [1998], Siwek and Furchtgott-Roth[1998], Autor [1999], are steps in this direction.

management, sales and distribution and other coordinative activities.[20] It is also a source of great policy concern in the telecommunications industry, as this relationship shapes the creation and targeting of subsidies associated with new services at schools, libraries and hospitals, as proposed in the 1996 Telecommunications Act.[21] If the lower propensity to find new services in low-density areas is due to an absence of local firms with appropriate skills, then policies might either induce commercial firms to expand from high-density areas to low density areas, or they must induce incentives/vision/investments from other stake-holders who are already located in low-density areas If, on the other hand, the absence of new services in low-density areas is due to an absence of local demand for these services or the absence of local infrastructure, subsidies run the risk of not changing the propensity to experiment in such areas. Indeed, in that case, the subsidy can be very wasteful if it induces the offering of services which few want.

! **Restructuring of intermediary functions:** Many observers forecast that TCP/IP-based services will lead to radical restructuring of the formats for, and delivery of, final goods which are information-intensive, such as music or radio, telephony, broadcast television, video gaming, newspapers, magazines and other print media. Some of this restructuring is symptomatic of the upheaval that is typical of high-technology industries, raising many strategic issues for investors and managers, but no substantive issues for policy makers. Some of it raises issues where regulated monopolies interact with otherwise competitive market environments. There is a need for frameworks and data to understand the key determinants of market structure: the entry and exit of new firms; the value ownership over, and horizontal concentration of, key assets; the persistence of old services and resistance of incumbent firms to new services, and so on. However, unlike many of the other topics just raised, this area has already attracted considerable attention from researchers, as it overlaps with traditional regulatory concerns regarding the ownership of key assets in the delivery and transmission of information. Indeed, this literature is too large to summarize here. That said, if the past is any predictor of the future, the demand for empirical research on related topics will exceed the supply for the foreseeable future.

! **Regulation of interconnection, access and content:** Much regulatory communications policy in

[20] For recent contributions, see, e.g., Roller and Waverman [1997], Moss and Townsend [1998, 1999], Greenstein, Lizardo and Spiller [1998], Greenstein [1999].

[21] This is a growing literature and a topic that is far from settled. For recent contributions, see Werbach [1997], Esbin [1998], Weinberg,[1999], and for the perspective of rural telephone companies, Garcia and Gorenflo [1998].

the United States presumes and reinforces a distinction in ownership between the firms who provide transport services and the firms who make use of those services in delivering content. As noted, this distinction seems vague, at best, in the emerging Internet platform. At worse, it is simply antiquated. This trend raises the question about the wisdom of employing legacy regulatory categories to the behavior of firms, such as ISPs, who cross legacy boundaries. Accordingly, much policy debate has been concerned with redefining the distinction between traditional telephone services and computing services (e.g., see Weinberg, [1999], or Sidek and Spulber [1998], for a recent summary and critique). Should there be a new and possibly *sui generis* regulatory approach to ISPs, Internet content providers, and providers of new services which combine elements of the old platform with the new, such an IP-based telephony? If firms are pursuing business models with only a mild relationship to the regulatory boxes and previous business lines, how should regulators think about these experiments? Is this the key market mechanism for developing the complementary Internet services and translating technical advance into economic value? Is it in society's interest to have these experiments develop and in society's interest to let them have sufficient time to generate potential information spillovers or should the cost of that input be incorporated into the industry's investments and other strategic commitments, minimizing distortions? There is a need for framework here, and as with the last topic, this area has already attracted considerable attention. Again, it is fair to predict that the demand for research on this topic will exceed the supply for some time.

4. Conclusion

This essay provides a set of questions, an illustrative example, and a guide for future empirical research. This essay has taken just one of many steps towards framing empirical guidelines for analyzing the developments in electronic commerce. The essays' themes provide a framework for summarizing key issues for empirical research into structural change in electronic commerce. The study identifies many different areas where fundamental research is possible and desirable.

In closing it is also worth noting that the nexus of this essay's questions identifies a particularly vexing and important set of policy issues. That is, electronic commerce will undergo considerable change in the next decade as firms respond to better information about demand and the emergence of new technical capabilities. Society benefits from the intermediary activities that firms pursue and from the variety of ways different firms try to meet user needs. It is precisely that juncture of variety and mediation which keeps observers guessing about the direction of structural change in commercial markets, and which raises

the value of empirical research that tries to understand it.

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Table 1
Selected Layers of the Value Chain of Electronic Commerce[22]

Client Application	MS Office
Client OS	Windows
Browser	IE, Navigator
Client System	Dell, IBM, Compaq
Client Microprocessor	Intel, AMD
Distributed Technologies	DCOM, Corba, JAVA-RMI
Distribution & Fulfillment	Dell, Compaq, Gateway
Network Access	AOL, ISPs, MSN
Inter-networking OS	CISCO, Lucent
LAN OS	Novell, Windows NT
Server OS	UNIX, IBM 3090, Windows NT
Server DBMS	Oracle 8, DB2, MS SQL-Server
Server System	HP, SUN, IBM, Windows NT
Groupware	Notes, Many
Custom Software	EDS, Perot Systems, Andersen
Enterprise Systems	SAP, Baan, Peoplesoft, many
Service & Support	IBM (ISSC), Compaq, HP, many
Domain name coordination	Network Solutions, others
Data transport and backbone	Worldcom-MCI, Qwest, Level3, AT&T, many
Internet Search and organization	Yahoo!, Excite, Lycos, Netscape, MSN, AOL, @home
Retailing Intermediaries	Amazon, E-bay, Yahoo!, MSN, AOL, many

[22] See Bresnahan, 1999, for related material.

Table 2a and Table 2b
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

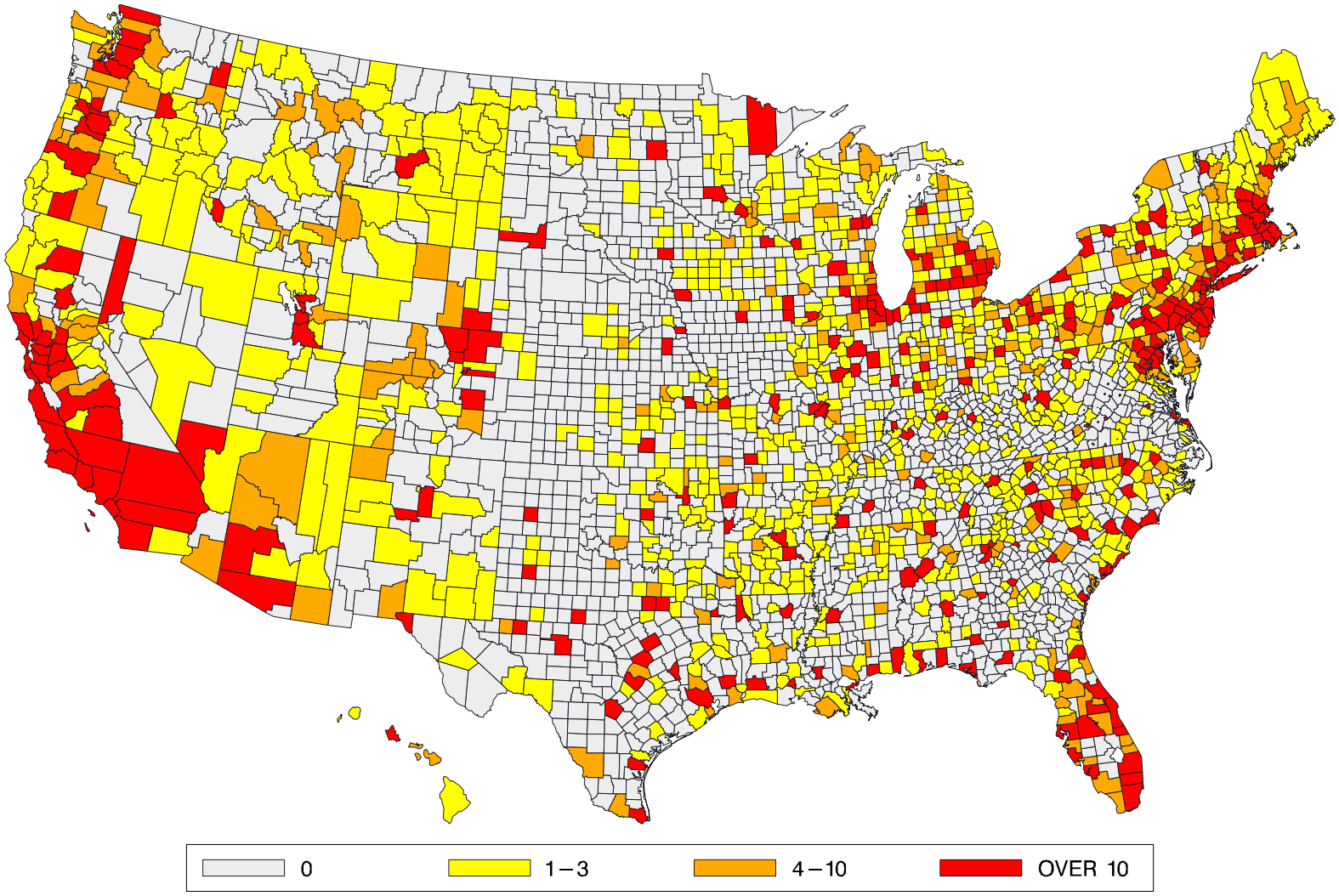
Fall, 1998

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 3
Product lines of ISPs

Category definition	Most common phrases in category	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.	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	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	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	1385 (36.3%)
High Speed Access	T3, DSL, xDSL, OC3, OC12, Access rate > 1056k	1059 (27.8%)

Distribution of ISPs
September 1996



Distribution of ISPs
October 1998

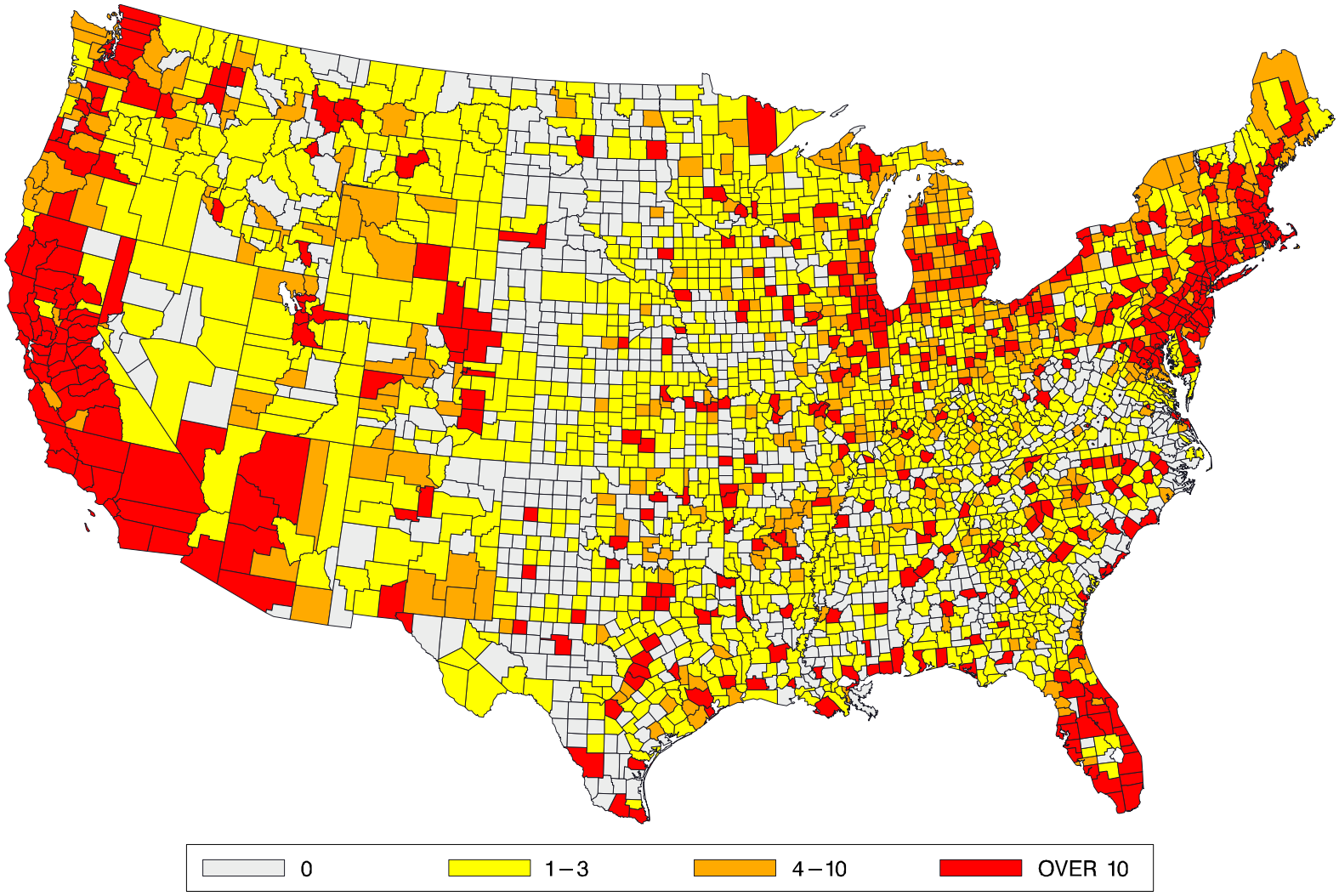


Figure 2a
Experiments with new services by ISPs without frontier access technology

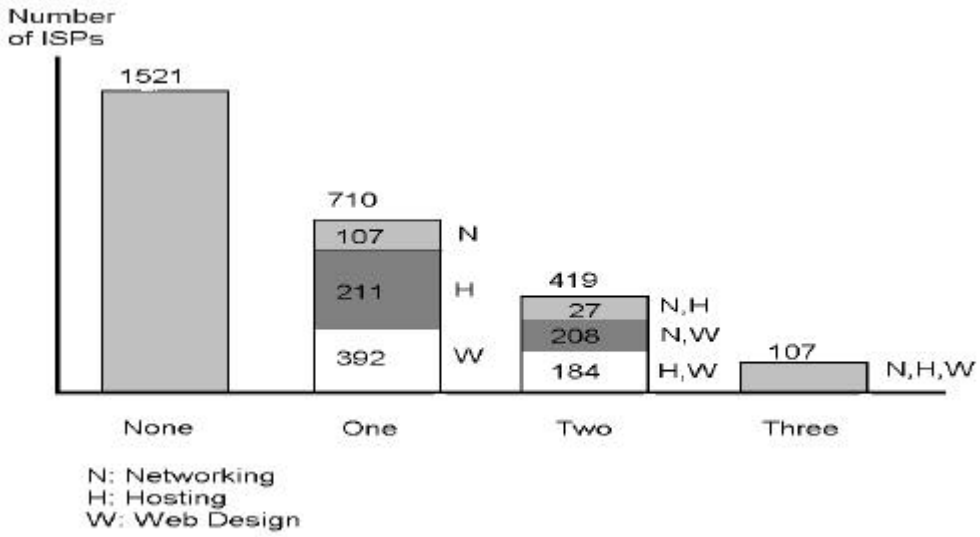


Figure 2b
Experiments with new services by ISPs with frontier access technology