Public Policies to Encourage Cable and ISDN Residential Internet Access

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Abstract

This paper analyzes inter-firm alliances for providing the home computer user with an innovative new telecommunications service: a high-speed connection to the Internet. After providing an overview of the Internet access provider industry, it discusses the split of competencies needed to deliver this new service, between monopolistic infrastructure (cable and local telephone) companies and entrepreneurial Internet service providers. It finds that the asymmetry in market power between the two partners holds up the diffusion of this innovation, and can best be remedied by more open access to both the subscriber and provider sides of the cable network, along with increased competition in all forms of local communications infrastructure.

1 Introduction

This paper analyzes inter-firm alliances for providing the home computer user with an innovative new telecommunications service: a connection to the Internet at higher speeds than the 28.8 Kbps maximum available with ordinary telephone modems. These alliances are driven by the split of competencies required to deliver this innovation, between monopolistic infrastructure (cable and local telephone) companies and entrepreneurial Internet service providers. The paper discusses the organizational and policy issues involved in the development of such alliances. Starting from an analysis of limiting hold-ups, the paper argues for regulatory changes needed to foster the diffusion of this telecommunications innovation.

The paper begins with a brief overview of the highly dynamic Internet access industry, differentiating between the home and business market segments. It discusses what capabilities organizations need to provide high-speed access to Internet users in their homes, instead of their offices. These competencies are then compared against existing organizational boundaries, highlighting the need for inter-firm alliances.

The framework developed in [1] is then applied to analyze these alliances. The threat of incumbent entry is analyzed from both an economic and an organizational perspective, building on the work of [2], [3], [4], and [5].

The paper concludes with a discussion of the policy implications of the analysis. While policy issues related to market structure have been discussed in a number of recent studies of the cable and telephone industries, these writings have concentrated on traditional video and telephony services.[1] Popular data services such as the Internet and America OnLine have emerged only recently, and the role of local infrastructure networks in providing residential access to these services has not yet received much attention. Presciently, in 1983 Pool discussed the market structural issues for residential data services in general terms.[2] This paper builds on and updates his analysis in light of actual data technologies and services that have developed in the intervening 12 years, concluding that more open access to cable networks, on both the subscriber and provider sides of the network, would accelerate the diffusion of high-speed residential Internet access.

2 Overview of the Internet access industry

The Internet grew out of the ARPANET, a research network originated by the Advanced Research Projects Agency (ARPA) of the U.S. Department of Defense. From the ARPANET's original charter of serving the defense and computer networking research communities, the Internet has grown to encompass the broader research and education communities as well as connecting corporations and individuals.

In the late 1980's, the U.S. National Science Foundation (NSF) awarded contracts to establish a system of about a dozen regional networks. These networks connected academic and research institutions to the NSFNET, which at that time served as the core "backbone" transmission facility of the Internet.[3] As the NSF relaxed its rules (called the "Acceptable Use Policy") governing the use of its networks for commercial traffic, many of the organizations operating regional networks transitioned from not-for-profit cooperatives to profit-making providers of Internet connections to and from commercial institutions. Thus were born the first wave of Internet access providers, each with a *de facto* monopoly in its region.[4]

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1 See, for example, [6]; on p. 103, numerous econometric studies of vertical integration in the cable industry are cited. [7], [8], and [9] address market structural issues in telephony.

2 See [10] pp. 166-88, especially p. 175.

3 The regional networks were also referred to as "mid-level" networks, since they logically fit between the "top" level NSFNET backbone and the local intra-university or intra-company networks that provided the "bottom" level of connectivity to the user.

4 Examples of regional networks in the northeastern U.S. are NEARNet (originally, the New England

The monopoly didn't last long. A smaller number of providers are attempting to cover a nationwide scope by operating interconnection points in many U.S. cities.[5] This strategy builds stronger brand awareness and allows subscribers who travel to use the service elsewhere without paying long-distance telephone charges. Although it is risky to give examples in an environment in which information is correct only until next week's trade rag comes out, examples at the time of this writing include PSI, UUNET Technologies Inc., Netcom On-Line Communications Services, Sprint (whose scope is actually international), and MCI.[6]

Given the explosive expansion of the Internet customer base, most access provider companies are experiencing rapid growth, with market shares highly fragmented and changing hands fluidly, and many new providers emerging. The Maloff Company estimates the following revenue and share figures for the market leaders, based on surveys of providers done nine months apart over the Internet.[7]

Table 1: Internet access provider market share is highly fragmented and volatile

March 1994		
Internet Access Provider	**Revenue (in millions)**	**Market share (% of total revenue)**
PSI	$15.4	13
UUNET	$14.3	12
Sprint	$14.3	12
IP Resellers	$11.9	10
ANS	$10.7	9
Netcom	$8.3	7
Other	$44.0	37
TOTAL	**$118.8m**	**100**

January 1995		
Internet Access Provider	**Revenue (in millions)**	**Market share (% of total revenue)**
UUNET	$46.8	9.5
Netcom	$31.2	6.4
Sprint	$29.9	5.7
PSI	$22.9	4.7
Supernet	$10.4	2.1
ANS	$10.3	2.1
Other	$369.9	69.5
TOTAL	**$521.4m**	**100**

Since most of these providers are either privately held or divisions of larger companies, this financial data is difficult to verify. To illustrate the uncertainty of these figures, consider that Dun and Bradstreet's 1994 Million Dollar Directory (1993 data) lists PSI and ANS as having $6.4 and $20 million in sales, respectively.[8] The overall market growth, however, is roughly consistent with the average growth rate estimated above.[9]

Among the many different axes along which the different providers can be segmented, a major differentiator is whether they market to individual customers or only to organizations. While many of the national-scope providers (e.g. Netcom, PSI) do sell service to individuals, the largest regionals do not [13]. This has led to the emergence of a third type of company, typically a small start-up, selling local access to individual, often home-based, customers. Most of these companies do not offer as full-featured a service as the bigger players, both in terms of customer support coverage and the technical nature of the Internet connection.[10] These small companies resell Internet access purchased from either a regional or national Internet provider, while

Academic and Research Network), operated by BBN Internet Services Inc., and JvNCnet (originally, the John von Neumann Supercomputing Center network), operated by Global Enterprise Services Inc.

5 Some of these providers are themselves spin-offs of regional networks, e.g. Performance Systems International (PSI) from NYSERNET (the New York State Educational and Research Network).

6 See [11]. The major online service providers (America OnLine, CompuServe, and Prodigy) may move towards this business as well; see [12].

7 The Maloff Company is a Michigan consultancy focusing on business and the Internet. This data is derived from summaries of their "Internet Service Provider Marketplace Analysis" (1993-4 and 1994-5) which are available on the Internet at http://www.trinet.com/maloff. Note that market shares expressed by number of customers might look quite different, given the greater dollar value of corporate customers.

8 Note that the sale of ANS to America OnLine for $35 million was announced in late 1994.

9 A 10% monthly growth rate leads to a tripling (300% increase) every 12 months; Table 1 show an annual increase of 250%.

10 Most of these services sell "shell accounts," so called because they originally forced the customer to use a "login shell" instead of a graphical, window-based user interface. The limitation arises because the customer's computer does not run the Internet protocol suite and connect directly to the Internet ; instead, it connects to the service provider's computer, which runs the protocol suite on its behalf, relaying data to and from the Internet. This setup limits the Internet applications usable by customers (in particular, Mosaic cannot be supported by a shell account). While it is technologically possible to run the Internet protocols over low-speed dial-up lines, and some providers do offer this service (called "SLIP" or "PPP" connections), it is less common because the additional overhead requires more sophisticated equipment and therefore greater expense. See [14], p. 3, for more details.

relying on public infrastructure (e.g. the local dial-up telephone network) to provide the connection from their premises to the user's computer.

This segment, which is characterized by low barriers to entry, is also highly volatile and growing rapidly.[11] Estimates of the number of firms vary widely.[12] An example of this type of service in the Boston area is "The World," operated by Software Tool and Die, Inc., a low-priced service which opened its doors in 1990 and now supports 10,000 subscribers connecting through dial-up modems.[13]

As a comparison of Figure 1 with Figures 2 and 3 illustrates, the model of connections to individuals is fundamentally different from connections to users within organizations. In the organizational model, the user's computer is assumed to be connected to an enterprise network, and the Internet provider only needs to use telecommunications infrastructure (often a leased line, but sometimes a dialup telephone circuit) to connect once to the enterprise network, not to each individual computer. In addition, the organization is assumed to have internal technical support resources, providing a centralized support interface for the Internet provider to deal with.

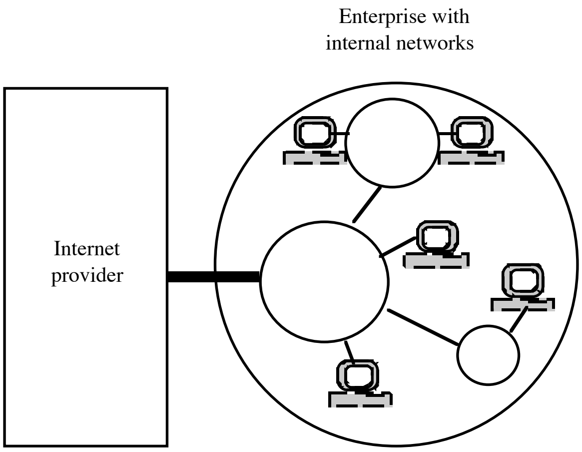

Figure 1: Model of connections to users within organizations

In contrast, when serving individuals, there is no enterprise to provide either the "bottom level" physical connection or a technical support buffer. Consequently, the provider targeting individual subscribers not only relies much more heavily on public telecommunications infrastructure, but also needs to have a much stronger capability for offering technical support to customers.

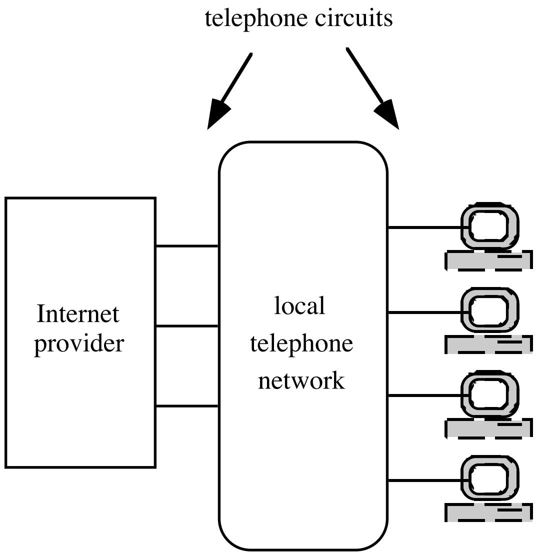

Figure 2: Telephone model of connections to individual users

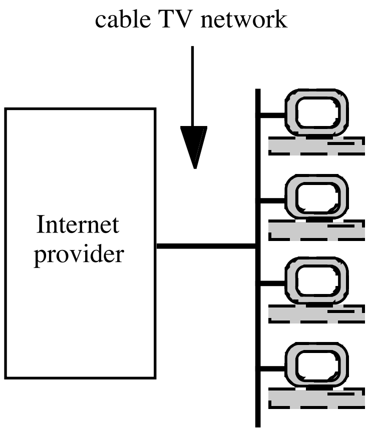

Figure 3: Cable model of connections to individual users

While high-speed connections, ranging from 56 Kilobits per second (Kbps) to 10 Megabits per second (Mbps), are commonplace for organizations connecting to the Internet via leased circuits, most individuals have until recently been limited by the speed of dialup telephone modems (ranging from 2400 bits per second to 28.8 Kbps). An annoying inconvenience in the past, this limit is now a serious impediment to the use of bandwidth-hungry multimedia services, including the Internet's popular graphical information browsing and retrieval system known as the World Wide Web.[14] This demand

11 [13] estimates that "a big corporation would need only about $40,000 to start its own Internet-provider operation." See also [15].

12 For example, [16] lists 47 Internet access providers, of which about 27 would fall into this segment after subtracting the approximately 20 regional and national providers; one month later, the Wall Street Journal [13] estimated the total number of providers at about 100 companies; while various lists (such as "pdial") maintained on the Internet itself estimate closer to four or five hundred providers.

13 Telephone conversation with Chetty Ramanathan of Software Tool and Die, Inc., 12/9/94. Maloff (*op cit)* estimates that The World holds about a 1% share of Internet access revenue.

14 The Web system is more commonly known by the

pull, combined with technology push in digital information transmission, has led in the past year to two types of high-speed individual Internet access becoming available in a few areas. The first uses a more advanced form of dialup telephone circuit, called ISDN, that allows data transmission at rates up to 128 Kbps.[15] The second uses a special type of modem to transmit and receive data over a cable television network, at rates from 500 Kbps to 10 Mbps (depending on the model and price of modem chosen). This modem can only be used over cable TV plant that has been upgraded to allow subscribers to send data, instead of just receiving broadcast signals.[16]

As Figure 2 implies, with low-speed dial-up access, both the provider and customer need only to connect standard modems to ordinary telephone lines, so no special relationship between the provider and the local telephone company is necessary.[17] In contrast, where high-speed residential Internet access has become available, it has usually been through some form of inter-firm coordination between an Internet provider and an infrastructure (cable or telephone) company. While a spate of "data over cable" trials and partnerships have been announced,[18] the only commercial service offering announced to date is PSICable (Internet over cable), sold by PSI in conjunction with Continental Cablevision in Cambridge, MA.[19] On the telephone side, a small number of providers in a variety of regions (both in the U.S. and Europe) offer Internet over ISDN, including Internex, Inc. a Silicon Valley startup experiencing rapid growth in sales of Internet over ISDN, in conjunction with Pacific Bell. PSI also offers Internet connections over ISDN in approximately 35 U.S. cities through its "InterRamp" service (Lindstrom, 1994).

The nature and extent of the relationship between the Internet and infrastructure providers varies across these different offerings. The following sections explore the drivers shaping these relationships.

3 Competencies

Table 2 compares the portfolio of competencies and assets needed for high-speed residential Internet access against current organizational boundaries. The clear split between competencies held by infrastructure and Internet providers explains why high-speed residential Internet service is typically offered under a cooperative arrangement of some sort.

Table 2: Key competencies are split across organizational boundaries

Competency or asset needed	Who has it
Physical communication infrastructure	Local telephone and cable companies
Customer service organization	Local telephone and cable companies
Internet technology:	
Connectivity with rest of Internet	*Internet providers*
General Internet know-how	*Internet providers*
Technical customer support	*To limited extent, Internet providers*
Internet over {ISDN, cable} know-how	*Under development*
Marketing and sales	Unclear
Brand name	Unclear

Each of these competencies is now discussed in more detail.

Physical communication infrastructure: The distribution network for Internet service is embodied in the fiber optic, coaxial, and copper cabling used to reach individual homes. This wiring is owned and operated by local telephone and cable companies.[20]

names of its popular user interface programs, such as Mosaic and Netscape.

15 ISDN stands for Integrated Services Digital Network.

16 This same technology can be used to provide connections to on-line services such as America OnLine and Prodigy.

17 As the provider grows, it needs a larger number of connections to the local telephone network, and thus may become more of a "special customer" of the local telephone company. However, such a relationship is not essential when a small provider business is first started.

18 See [17] and [18]. Several companies have also run trials connecting schools to the Internet over cable, including Jones Intercable with ANS in Alexandria, VA, and Media General with Sprint under the auspices of NSF's Global Schoolhouse project.

19 Despite this service being announced as a commercial offering at a Cambridge, MA press conference (which I attended on March 8, 1994) . and the availability of pricing and marketing literature, the service is currently unavailable to individual customers (on December 12, 1994, a PSI telephone sales representative informed me that the individual service is in "beta test"). Current unavailability of reliable 500 Kbps cable modems appears to be one of the problems. A 4 Mbps service is available for sale to organizations, although it appears to have attracted few, if any, customers.

20 Wireless companies should also be considered as infrastructure providers, but wireless data is new enough that I have not yet seen any Internet providers offering wireless Internet access. As [19] writes: "Many wireless networks use different transport protocols, thereby requiring proprietary modems for specific carriers' services. Software vendors have been slow to support wireless networks because doing so would require that developers write to each modem protocol."

***Customer service organization*:** Cable and telephone companies each have the organizational competence to serve thousands of customers in all the usual ways: billing, taking customer orders and complaints, maintaining a fleet of repair trucks and technicians, etc.

***Internet technology*:** This capability is subdivided into four components, held to varying degrees by Internet access providers:

Connectivity with rest of Internet: The provider needs equipment to connect itself to the rest of the Internet, consisting of one or more Internet Protocol routers (the Internet equivalent of a telephone switch) and long-haul data circuits. This equipment may be owned and operated by the access provider, or the entire connection may be achieved through a relationship with a larger Internet provider reselling its service.

General Internet know-how: Internet providers know how to deploy and manage the technologies described in [20], such as configuring Internet Protocol addresses, debugging routing problems, setting up domain names (such as “mit.edu” or “ibm.com”), securing corporate connections, etc. Although this technology is mainly in the public domain, it changes extremely rapidly. Thus, the ability to both track and drive fast-paced change has to be part of the provider’s organizational competence.

Technical customer support: While Internet providers have some of the same customer service capabilities as infrastructure providers (e.g. billing, taking orders), they must also have the specific technical competence to support the Internet technology used by their customers. Scaling both types of customer service capabilities to large numbers of residential users is a critical challenge for the Internet providers. While alliances with infrastructure providers might help with the routine components of customer service, the technical component requires specifically-skilled staff. Given the rapid growth of Internet services, such people are likely, at least in the short term, to be in greater demand than supply.[21] Poor support is a pervasive customer complaint in this industry, especially from individuals who purchase service from providers that are expanding rapidly. Thus, development of a cost-effective customer support organization and corresponding reputation is an important strategic investment for competitive strength and differentiation.

Internet over ISDN or cable know-how: While Internet technology is designed to be layered above a wide variety of physical communications media, the knowledge of how to achieve this layering over residential communications infrastructure is specialized and only now developing. Special protocols and equipment are needed, such as dial-up ISDN servers and cable modems. These are newly emerging technologies, and getting them to work requires a cooperative effort between the Internet and infrastructure providers. The dividing line of responsibilities is often fuzzy. For example, if a cable modem appears not to be working, the problem could lie anywhere from the settings on the amplifiers internal to the cable TV plant to the communications protocols used to send data over the network. Or, if a customer is having problems connecting to the Internet over an ISDN circuit, the problem may lie in the user’s hardware or in the circuit’s settings in the telephone company’s switching office.[22] Clearly, the success of a high-speed residential Internet access offering is critically dependent on how well the partner’s incentives line up to resolve problems quickly. If anything in the relationship leads to information hiding or finger pointing, the service offering is unlikely to get very far.

In addition to technological competence, Internet access providers have two ordinary business needs that are not currently well-filled by either themselves or infrastructure providers.

***Marketing and sales*:** Although infrastructure providers certainly have order-taking sales organizations, as protected monopolies they have not developed strong marketing arms. And Internet providers, typically small growing companies, are often understaffed and inexperienced in this area [13]. In short, neither partner really has this capability.

Brand name: While cable and telephone infrastructure providers are household names in their familiar services (TV and telephony), it remains to be seen whether that customer recognition will transfer to innovative services such as high-speed Internet access. Such a transfer, however, is much more probable than having current Internet providers quickly become household names.[23]

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21 This point was suggested by my conversation with Chetty Ramanathan of Software Tool and Die, *op cit*.

22 This type of interdependence is an excellent example of a “connection among technologies,” one of the factors Teece identifies as driving operational coordination for innovation. See [21], p. 13.

23 Because many people on the Internet use a connection supplied by their workplace, even the biggest Internet providers’ names are unfamiliar to a large portion of the “digerati.” A more credible scenario for brand-name development runs the other direction: the major online service providers leverage their name recognition among residential computer users to diversify into selling Internet access. In fact, with America OnLine’s purchase of ANS (formerly an independent Internet provider), and CompuServe’s recent diversifications into Internet access, this scenario already appears to be taking shape. MCI and Sprint also have big brand-name advantages compared to other Internet

4 Analysis of alliances

Teece notes that a technological regime shift can create innovative opportunities for entrants that can only be fully realized by linking with the complementary assets controlled by incumbents.[24] As Table 2 shows, high-speed residential Internet access fits this model very well: the entrant Internet providers are poised to provide an innovative service, but require the use of the incumbent's distribution system—residential cable and telephone networks—to deliver the innovation to customers. In this situation, which company is most likely to profit depends on the appropriability of the innovation and how tightly held the complementary asset is.

The Internet is a prototypical open system. As Comer explains:

> The internet technology described in this book is an example of *open system interconnection*. It is called an *open system* because, unlike proprietary communication systems available from one specific vendor, the specifications are publicly available. Thus, anyone can build the software needed to communicate across an internet. More important, the entire technology has been designed to foster communication between machines with diverse hardware architectures, to use almost any packet switched network hardware, and to accommodate multiple computer operating systems.[25]

In other words, Internet technology is hardly appropriable at all. At the same time, the complementary assets are quite tightly held: both cable and (local) telephone companies hold local monopolies in their respective services, with enormous barriers to entry.[26] Given that combination, Teece's framework predicts that the owner of the complementary asset—i.e. the cable or telephone company—is much more likely to profit from the innovation.[27]

Although cable and telephone networks each constitute a monopoly infrastructure, control of the distribution asset might be considered less tight if the two infrastructures are viewed as competing against each other in a single locale. Two realities, however, make this an overly idealized view. First, at present it is a rare community that has both ISDN and a suitably upgraded cable plant (the latter is especially rare). Second, and more enduring, the two types of networks are not exact substitutes; cable can provide higher shared bandwidth at lower cost, enabling services that ISDN can't match.[28] Because of this difference, an Internet provider may prefer to work with both types of infrastructure providers to reach customers with different service and price preferences, instead of using each infrastructure provider as a foil to the other.

Even in situations where the two networks do co-exist, two is still a small number of competitors, especially compared to the much more robustly competitive Internet provider industry. Thus there is a fundamental asymmetry inherent in any relationship between Internet and infrastructure providers.[29] This situation leads to the classic small-numbers bargaining problems predicted by transaction cost theory [23]. The Internet provider, a small company in a competitive industry, is

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providers. None of these four companies are offering high-speed residential Internet access, but several online companies are gaining experience by trialing high-speed residential access to their online services through various alliances with cable companies [17].

24 See [1] and[21], p. 13.

25 [20], pp. 1-2. In [22], pp. 7-9, Tony Rutkowski describes Internet standard-setting as an open process of trying different approaches and adopting those that work. Participation in this process is fluid and open, and relevant technical documents are freely available on the Internet itself. Thus the growth of the Internet helps to disseminate technical knowledge about the Internet, fueling further growth. This open environment is one reason the technology moves so quickly—partly because of efficient information distribution, and partly because participants must "race to innovate"—e.g. by providing a more secure service than the current Internet standards specify—to try to gain some form of competitive advantage, however temporary.

26 These barriers are not only economic—the enormous cost of installing wired infrastructure—but also legal. The failure of telecommunications reform legislation in the fall of 1994 means that many states still prohibit competition in local telephony. Most cable companies operate as sole franchisees for a community; no other cable company can get permission to dig the streets, hang wires on utility poles, etc.

27 See [1], Figure 11, p. 297. In this situation, Teece suggests contracting to limit exposure, but predicts that the innovator is likely to lose to the asset holder in any case.

28 [15] explores this topic in more detail, showing that for the same average bandwidth of 128 Kbps, a cable system allowing 500 Kbps of peak bandwidth costs less to provide than an ISDN system allowing only 128 Kbps of peak bandwidth per subscriber.

29 The asymmetry extends to entry barriers as well. The capital requirements to enter residential Internet access provision depend on router and wholesale Internet connectivity prices [15], both of which are dropping with improving technology and hot competition. And, of course, the technical know-how is freely available.

critically dependent on a complementary asset controlled by an infrastructure provider—a large, entrenched monopolist. Although when possible the Internet provider may try to play the two infrastructure providers off against each other, once an agreement has been inked, three types of relationship-specific assets lock the Internet provider in, inviting opportunism.[30]

The first relationship-specific asset is the knowledge of contacts and procedures at the partnering firm. Although this asset applies to both parties, its value is greater for the Internet provider, since the infrastructure firm is larger and more bureaucratic and therefore more difficult to navigate.[31]

The second sunk asset is the investment in infrastructure-specific technological know-how. Expertise in getting Internet connections to work over cable modems does not transfer at all to an ISDN environment. Once invested, an Internet provider's threat to leave the relationship in favor of a different technology is not terribly credible.

The third asset is the networking equipment that is specific to the chosen infrastructure (e.g. cable modems). This equipment is the main component of marginal capital cost [15]. Who owns this equipment is thus a key structural question for the relationship. If the infrastructure provider owns it, then that firm can relatively easily exit the relationship and transfer its assets to a relationship with a competing Internet provider. On the other hand, if the Internet provider owns the equipment, the infrastructure provider has less to offer a competing Internet firm and is less likely to leave the relationship. If it does, however, it may leave the Internet provider with a large stranded investment.[32]

The power of the infrastructure providers is further demonstrated by a different kind of hold-up that is already occurring: not entering relationships in the first place. Customers may be asking for high-speed Internet over cable, but unless the local cable company decides it wants to play, Internet providers have no power to offer this service. The situation is captured well by this quote from a recent newswire story:

> "It takes a lot of cable bandwidth...to run a great deal of data quickly down the pipeline," said Albert Young, a product manager at Cox Communications, one of the nation's largest cable system operators. "You could use that more profitably for a video channel."[33]

For ISDN, the local telephone company's tariffs can serve a similar blocking function. ISDN pricing varies widely across the different Regional Bell Operating Companies (RBOCs) and GTE service areas. Some RBOCs (e.g. BellSouth, Pacific Bell) have set tariffs that encourage ISDN adoption and use, while others (e.g. NYNEX) have set prices so high that they form an effective barrier to adoption.[34] Not surprisingly, companies offering Internet connections over ISDN are typically found in the regions with reasonable ISDN tariffs. Diffusion of Internet access via ISDN would accelerate if all regions adopted aggressive ISDN pricing.

4.1 Incumbent entry

Teece's theory predicts that infrastructure providers will retain any profits from high-speed residential Internet access. Given the lack of appropriability of Internet technology, one mechanism that could lead to this outcome is for the infrastructure firm to absorb technological competence from the partnering Internet firm, then use it to enter the Internet provider business themselves. This section discusses two issues: is this a credible threat, and if it is, should current Internet providers be wary of entering strategic alliances because of it?

4.1.1 Is the threat credible?

From a strictly economic perspective, the threat of entry from infrastructure providers—especially telephone companies—is very real. To provide Internet connections to subscribers over ISDN, the Internet provider must connect its equipment (e.g. its Internet router) to the local telephone network. This connection generally involves expensive leased circuits. If the provider equipment were located on

30 A national Internet provider may try to play off same-technology providers in different regions (e.g. Pacific Bell vs. Ameritech for ISDN, or TCI vs. Time Warner for cable), but a local or regional provider is less likely to have this option.

31 Lest the reader underestimate the value of this asset, consider that many ISDN users have reported (in discussions on Internet newsgroups) that it typically takes 4 phone calls to the local telephone company to find someone who knows what ISDN is. A firm like Internex, Inc., which resells Pacific Bell ISDN circuits to create Internet connections, adds value for customers by hiding this complexity.

32 An Internet provider covering a broad geographic scope is less vulnerable to stranded investment, since it can presumably use the same equipment in another region. Even less risky would be to allow the customer to own this equipment. Cable companies, however, are unaccustomed to that mode of operation.

33 From November 30, 1994 Bloomberg newswire, reporting on the Western Cable Show in Anaheim, CA.

34 See, for example, [24]. Per-minute usage fees are often part of ISDN pricing, discouraging residential usage.

the same premises as the telephone network (i.e. in telephone company central offices), the service could be offered much more cheaply. Co-location is clearly an option for the telephone company; whether it is an option for Internet providers is less clear.[35] In any case, at least one telephone company (Ameritech) appears to be adopting this approach.[36]

Such incumbent entry is also supported by economic theory. As predicted by Arrow's theory [2], the telephone and cable companies—incumbent monopolists with blockaded entry—had weak incentives to (and did not) originate the Internet service innovation. But now that the visible success of Internet providers has increased the certainty of this innovation, the frameworks of [3] and [4] predict a much greater incentive for its adoption by incumbents.[37] This is especially true since, far from cannibalizing existing services provided by the incumbents, Internet connections can have a synergistic effect.[38]

From an organizational perspective, however, Internet providers may be forgiven if they greet the threat of incumbent entry with a bit of skepticism. Table 3 contrasts qualitatively the environments in which Internet and infrastructure firms operate:

Table 3: Internet and infrastructure providers operate in different environments

Environmental attribute	Internet providers	Infrastructure providers
Competition	Significant	Very little
Technology generation	1.5-3 years	15-20 years
Government role	Funding stimulus	Regulator
Firm size	Small	Huge

These environmental differences lead to significant differences in organizational culture and capability. For example, regulation fosters a mentality of always looking over your shoulder to keep the regulator happy, as opposed to creative, rapid innovation.[39] Skepticism about the ability of large, bureaucratic infrastructure firms to play in the fast-moving Internet industry—including either growing or attracting and retaining the necessary engineering talent—is well-founded.[40]

The packet-switching communications technology used in the Internet is also an architectural innovation. It uses the same components as telephony—switching and transmission—but configures them into a different type of system: best-effort, variable-performance

35 Co-location rights are often hotly contested, but usually encouraged by regulatory policy; see [7], p. 262. Most cases have involved competitive access providers, who are accustomed to courtrooms and regulatory proceedings; most Internet service providers are less comfortable in this arena. At the least, securing these rights will require a contractual negotiation between the Internet provider and the local telephone company.

36 See [25]. It is not a coincidence that Ameritech is one of the more ISDN-conversant RBOCs, nor that it is one of the four telephone companies (Pacific Bell, Sprint, and MFS are the other three) recently awarded contracts from the National Science Foundation to manage the network interconnection points of the newly-restructured Internet.

37 The certainty of the innovation extends to estimates of diffusion rates. For example, given the puny size of the Internet access market relative to the infrastructure market (an estimated $100 million for Internet vs. $80 billion for telephony and $20 billion for cable), should an infrastructure provider bother with it? If the Internet market is expected to continue tripling in size every year (10% monthly growth rate), the infrastructure provider may feel rushed to get in on the ground floor of a market that will be big soon. Alternatively, if the infrastructure provider thinks the 10% growth rate is a short-lived fad, the "endpoint" market may appear too small to be important. As the Internet's astonishing growth continues over ever more years, it becomes ever more difficult to dismiss as a limited fad.

38 For example, customers may order a second ordinary telephone line, an ISDN circuit, or new cable service in order to gain access to the Internet.

39 Regulation can also impose transaction costs; for example, Ameritech's Internet offering has to contract out the long-distance portion of Internet transport, since RBOCs are not allowed to offer long-distance telecommunications. The regulatory legacy is a factor as well. Although local telephone companies are currently allowed to offer information services (such as Internet), they were prohibited from doing so from 1984-92 by the Modified Final Judgment that settled the U.S. government's antitrust case against AT&T [26]. Deciding to offer Internet service—for a telephone or cable company, since both are subject to regulation—thus requires not only an adjustment to the new reality, but also a belief that this reality will stick around long enough to make the investment worthwhile. Given the massive political swings back and forth in Washington over the last 20 years, this belief may be hard to come by at times.

40 A bearish indicator in this regard is the small number of decision makers in infrastructure firms who have or use full Internet connections. Some Internet services (e.g. navigating the World Wide Web) are so different from users' existing mental models of computer services that their value and power, while trivial to demonstrate, can be difficult to explain and understand in the abstract. Thus an infrastructure provider might easily fail to grasp the importance of technology transfer from an Internet partner, much as IBM managers, most of whom did not have or use their own PCs, failed to grasp the significance of the architectural shift toward desktop computing [27].

packet delivery instead of the highly-reliable, guaranteed-performance circuit switching used by telephony [20]. As [5] shows, it can be difficult for established firms to transition to a new architecture, because of the many architectural assumptions built into the existing organization. This transition will be even more difficult for cable companies, who must also acquire component expertise in switching and bi-directional transmission.[41]

In sum, entry of infrastructure providers into Internet access is a likely scenario, while success of that entry is much less likely. It is quite possible that some nimble Internet providers will establish effective capability in marketing, customer support and reputation well before the infrastructure providers learn to move quickly enough to be serious contenders. Given that the on-line service providers already have strong name recognition, they appear to be especially well positioned should they pursue the Internet provider market. Other important contingencies to track would be:

- The lifting of the long-distance restrictions on the RBOCs, which would further encourage telephone company entry into Internet services by allowing full integration;

- MCI's potential entry into local telephony. MCI has provided Internet circuits for many years and has strong Internet expertise. If they were to start providing local telephone service as well as long-distance, they could be the only player owning all the competencies listed in Table 2 and thus extremely well-positioned to offer high-speed residential Internet access.[42]

4.1.2 Should Internet providers be wary?

While the Internet providers involved in alliances to offer high-speed Internet access should be aware of their infrastructure partner's strong incentive to use them for technology transfer leading to eventual competition, they should not use this as an excuse to opportunistically hide information. Given how non-appropriable general Internet know-how is anyway, the risk of relationship (and thus service offering) failure from opportunism is far greater than the risk of sharing information. Instead, both parties should concentrate on cooperating to make the infrastructure-specific technology work, and to provide excellent customer service and technical support, so that their reputations are enhanced by the offering.

5 Policy implications

Up this point, the analysis has masked some important differences by assuming that both cable and telephone companies control their respective infrastructure assets equally tightly. In fact, two regulatory differences give the cable companies tighter control. First, unlike telephone companies, cable companies are not legally required to be common carriers.[43] Thus, aside from being more geographically available than upgraded cable networks, ISDN service can also be procured for a lower transaction cost: an Internet provider and its customers can purchase ISDN lines on a tariff (i.e. public price) basis, instead of the Internet provider being forced to enter a contractual negotiation.[44]

Second, cable networks, unlike current telephone networks, are not subject to the kinds of open access rules that allow any approved, subscriber-owned equipment to be plugged into the network. This is one reason why the cable modem market is less mature and competitive than the telephone modem and ISDN equipment markets. It is also a reason why an Internet provider assumes greater relationship-specific asset risk in an alliance with a cable company: with ISDN, the subscriber assumes more risk by owning a major component of the ISDN-specific Internet equipment.

This analysis explains two empirical observations of the current marketplace:

1. Internet over cable is typically based on a more contractual arrangement than Internet over ISDN;[45]

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41 Giving subscribers the ability to talk as well as listen involves several significant engineering challenges, including noise ingress and contention schemes for shared access. The technology to address these issues is still in an era of ferment, with multiple candidates vying to become a dominant design.

42 Sprint could also be similarly positioned, but appears to be concentrating more on selling wholesale Internet to resellers than retail Internet to individuals. MCI has approval to offer local telephone service in four states and has filed for approval in six more, but is initially concentrating on serving business, not residential, customers [28].

43 A common carrier is obligated to provide transmission services in a non-discriminatory fashion to anyone who wants to purchase them; see [6], p. 59. One could argue that the extremely high complexity of ISDN counterbalances its common carriage status, for example by making available only a particular set of ISDN options that happens to be incompatible with the subscriber's equipment. However, standards do finally appear to be emerging for data transmission over ISDN, such as the "Intel blue" configuration described in [29].

44 Not only is a contractual negotiation more effort, but a negotiation stacked in favor of the other party (as the analysis in this paper has suggested) is an even less appealing prospect.

45 PSICable is based on a contractual agreement between PSI and Continental Cablevision. In contrast, InterRamp (PSI's Internet over ISDN offering) is almost completely independent of the telephone companies; PSI supplies the customer

2. Internet over ISDN, while nowhere near as available as ordinary dial-up Internet, is much more available than Internet over cable. This result is partly a consequence of the first observation, as well as the greater maturity of the ISDN technology.

Thus, without regulatory changes to mitigate the current situation of monopolistic hold-up by infrastructure providers, the diffusion of high-speed residential Internet access is unlikely to keep pace with the overall Internet diffusion curve.[46] The analysis in this paper suggests two regulatory policies that can improve the chances of this innovation becoming a more widespread reality:

- Encouragement of all forms of competition in local infrastructure provision;
- Application of open access principles to cable networks.

5.1 Local infrastructure competition

To reduce the monopoly power of the cable and local telephone infrastructure providers *vis a vis* Internet service providers, state regulators should not only allow but also encourage all forms of local infrastructure competition. This competition may come from a variety of local distribution technologies, not all of which may be suitable for Internet access (e.g. direct broadcast satellite), but whose combined effect on market power should lead to a more favorable negotiation for the Internet service provider.

Developments in those technologies that are suitable for Internet access will be important for Internet service providers to track. Two-way wireless networks are a good example. Because wireless networks require less physical infrastructure and disruption, they have much lower barriers to entry than cable and wired telephone technologies. When the federal government's spectrum auctions are completed, several such networks are supposed to be licensed to compete against each other in any given area. This development should translate into new business opportunities for residential Internet service providers.

Incumbent infrastructure providers integrating upwards into Internet service should also be considered as a form of competition to be encouraged. As the analysis above has shown, these firms face a number of internal challenges on the road to becoming fast-moving and innovative enough to succeed in this market. Regulators can help by reducing the restrictions that keep these firms looking over their shoulders, such as the long-distance restrictions that make it more difficult for a local telephone company to offer a full line of Internet service.[47]

5.2 Open access to cable networks

Increased competition alone will not address all the problems identified in the analysis above; open access to local infrastructure is also needed, on both the provider and subscriber sides of the network. Open access is much further advanced in local telephony than in the cable industry. On the subscriber side, since the early 1980's customers have been able to attach their own telephone equipment to the network, resulting in a wide variety of benefits [26]. This ability has been a critical factor in the success of data transmission over ordinary telephone modems and is currently helping to drive the diffusion of a plethora of ISDN-compatible computer networking equipment. On the provider side, the FCC's Computer Inquiry III in 1986 established Open Network Architecture (ONA) as a goal, and regulatory policies since then have been evolving to incorporate the principles of unbundling of services (such as billing and transport) and co-location of competing providers at telephone company Central Offices.[48]

These principles have not been applied at all to cable networks, which, as the analysis in this paper has shown, has hindered the development of the "Internet over cable" innovation. Open access on the subscriber side would accelerate the technological development of cable modems and lower the providers' risks by distributing among subscribers the cost of a large portion of the necessary equipment. On the provider side, open access would strengthen the Internet provider's position relative to the cable firm, so that more Internet providers would be willing to ink contracts.

On the subscriber side, the cable industry has fought against open access using many of the same technological "it will destroy the network" arguments that the telephone industry used to block the connection of customer-owned devices to the

with the name of a contact at the appropriate local telephone company, who is supposedly knowledgeable because PSI has previously mailed that person information about the service. In between these two extremes is Internex, Inc., which has a standard reseller agreement (i.e. a "lightweight" contract, without much need for negotiation) with Pacific Bell, and handles the ordering of ISDN service on behalf of the customer.

46 This prediction assumes that consumer demand is elastic enough to be reduced by the higher prices that will necessarily be charged for high-speed access, both because of its more complex technology and the monopoly power of the infrastructure providers.

47 Further detail on this point can be found in [8], pp. 117-20.

48 See [7], p. 226, and [6], pp. 79-80. Where physical co-location is impractical, regulators have sometimes adopted "virtual co-location" through special tariffs.

network for many years.[49] Given that the predicted problems did not come to pass in telephony, it is clear that mechanisms other than provider ownership of subscriber equipment—such as standardization, FCC equipment approvals, and software-based authorization—can successfully solve network safety and security problems. In this context, it becomes difficult to take seriously the cable industry's arguments against open subscriber access.

The extreme of open access on the provider side would be common carriage, an impractical goal for the existing cable industry [6, 10]. A more appropriate goal is application to the cable industry of the kind of open interconnection rules—such as co-location rights and availability of unbundled billing services—that have been developed under the FCC's umbrella Open Network Architecture. These rules would not in any way prevent cable companies from vertically integrating into content, just as they do not prevent telephone companies from selling telephone service instead of pure bit transmission. However, they would make it easier for Internet service providers to gain access to cable channels.

Two key differences between Internet and video services make easier access particularly important. First, the "content" that the Internet provider has to offer (i.e. access to the Internet) is presumably desirable to the customer, but not unique to that provider; in contrast, the uniqueness of video content gives its owners more power relative to cable infrastructure providers. Second, the large number of channels envisioned for the future consists mainly of downstream channels; upstream channels, required for Internet service, remain scarce. Thus, the argument that a multi-channel future makes open access less important must be examined critically in light of this requirement.

In the short term, adoption of Internet access over cable will have to take place within the existing regulatory framework. A first step in this direction might be use of the Public, Educational, and Government (PEG) channels available to municipal cable franchising authorities.[50] These channels are sometimes used to provide data networking between municipal institutions (e.g. town government offices, libraries, and schools), and could potentially be used to connect these same institutions to the Internet. These channels are not, however, designated for residential services.

6 Conclusion

A less lopsided relationship between Internet and infrastructure providers helps to spur the diffusion of high-speed residential Internet service. Access to local ISDN telephone networks—on both the subscriber and provider sides—has been more open than access to local cable networks, which has favored the development of subscriber equipment and services for Internet access over ISDN vs. cable.

Increased competition between both incumbent infrastructure providers and new networks, as well as more open access to cable networks, will benefit Internet and on-line service providers seeking to reach residential customers with innovative services.

References

[1] Teece, D.J., Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. Research Policy, 1986. **15**(6): p. 285-305.

[2] Arrow, K.J., Economic Welfare and the Allocation of Resources for Invention, in The Rate and Direction of Inventive Activity, R. Nelson, Editor. 1962, Princeton University Press: New Jersey.

[3] Gilbert, R.J. and D.M. Newbery, Preemptive Patenting and the Persistence of Monopoly. American Economic Review, 1982. (June 1982): pp. 514-95.

[4] Reinganum, J.F., Uncertain Innovation and the Persistence of Monopoly. American Economic Review, 1983. **73**(September 1983): pp. 741-48.

[5] Henderson, R.M. and K. Clark, Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms. Administrative Science Quarterly, 1990. **35**(March 1990): pp. 9-30.

[6] Johnson, L.L., Toward Competition in Cable Television. AEI Studies in Telecommunications Deregulation, ed. J.G. Sidak and P.W. MacAvoy. 1994, Cambridge, MA: The MIT Press.

[7] Brock, G.W., Telecommunication Policy for the Information Age: From Monopoly to Competition. 1994, Cambridge, MA: Harvard University Press.

[8] Baumol, W.J. and J.G. Sidak, Toward Competition in Local Telephony. AEI Studies in Telecommunications Deregulation, ed. J.G. Sidak and P.W. MacAvoy. 1994, Cambridge, MA: The MIT Press.

[9] Crandall, R.W. and K. Flamm, ed. Changing the Rules: Technological Change, International Competition, and Regulation in Communications. 1989, The Brookings Institution: Washington, DC.

[10] Pool, I.d.S., Technologies of Freedom. 1983, Cambridge, MA: Harvard University Press.

[49] A summary of these arguments can be found in [30], pp. 62-63.

[50] See [6], pp. 8 and 62-5. Under current federal cable law (The Cable Television Consumer Protection and Competition Act of 1992), municipal cable franchise authorities can negotiate the use of channels for public, educational, and governmental purposes.

[11] Rendleman, J., MCI First Carrier to Offer Internet, Communications Week, November 28, 1994, pp. 1, 91.

[12] Flynn, L., In the On-Line Market, the Name of the Game is Internet, The New York Times, September 25, 1994, New York, NY. p. F7.

[13] Mehta, S.N., Small Fish Seek the Big as Internet Industry Consolidates, The Wall Street Journal, June 24, 1994, Chicopee, MA.

[14] Srinagesh, P. Internet Cost Structures and Interconnection Agreements.Telecommunications Policy Research Conference. Solomons, MD: October 1-3, 1994.

[15] Gillett, S.E., Connecting Homes to the Internet: An Engineering Cost Model of Cable vs. ISDN. MIT Masters Thesis, 1995.

[16] Cronin, M., The Internet White Paper, Supplement to Communications Week, April 18, 1994, pp. WP41-WP66.

[17] Markoff, J., Potent PC Surprises Those Betting on Interactive TV, The New York Times, May 8, 1994, New York, NY. pp. F1, F8.

[18] Robichaux, M., Comcast Plans to Send On-Line Services to PCs Over Its Vast Cable-TV Network, The Wall Street Journal, December 7, 1994, Chicopee, MA. p. B4.

[19] Schwartz, J., Wireless Modem Standard Emerges, Communications Week, December 19, 1994, pp. 1, 71.

[20] Comer, D.E., Internetworking with TCP/IP, Volume I: Principles, Protocols, and Architecture. Second Edition. 1991, Englewood Cliffs, NJ: Prentice Hall.

[21] Teece, D.J., Competition, cooperation, and innovation: Organizational arrangements for regimes of rapid technological progress. Journal of Economic Behavior and Organization, 1992. **18**(1): pp. 1-25.

[22] Neil, S., et al., Cooperative/Competitive Standards-Making: Information Infrastructure and the New Reality, MIT Communications Forum, November 4, 1993.

[23] Besanko, D., D. Dranove, and M. Shanley, The Transaction Costs of Market Exchange, in The Economics of Strategy. Forthcoming.

[24] Pappalardo, D., ISDN Still Costly, Hard to Get, Communications Week, March 13, 1995, p. 28.

[25] Messmer, E., Ameritech to launch IP services in 5-state region, Network World, March 21, 1994, p. 62.

[26] National Telecommunications and Information Administration, The NTIA Infrastructure Report: Telecommunications in the Age of Information. 1991, National Telecommunications and Information Administration, U.S. Department of Commerce, Washington. D.C.

[27] Ferguson, C.H. and C.R. Morris, Computer Wars: The Fall of IBM and the Future of Global Technology. 1994, New York: Times Books.

[28] Davis, B., MCI Petitions for Additional Local Markets, Communications Week, January 2, 1995, p. 49.

[29] Derfler, F.J., Jr., Betting on the Dream, PC Magazine, October 25, 1994, pp. 267-287.

[30] Large, D., Creating a Network for Interactivity, IEEE Spectrum, April 1995, pp. 58-63.

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