ISDN in the United States: Strategies for Success

Part II: The Deployment and Adoption of ISDN

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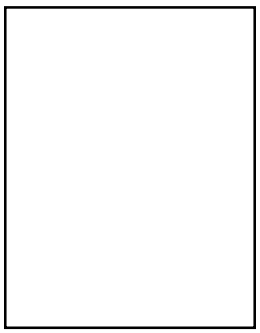

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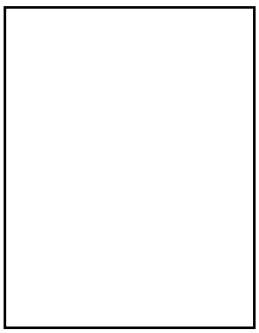

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This paper continues Dr. Harris' and Mr. Enriquez's discussion on ISDN deployment (installation of ISDN capability in the public switched network) and adoption (purchase of ISDN equipment and service by end users) in the United States. The authors distinguish between deployment and adoption because each, while interrelated, is affected by different factors. In Part I: The Diffusion of ISDN, published in the fourth quarter of 1994 (4Q94), Dr. Harris and Mr. Enriquez reviewed ISDN basics and discussed the process of deployment and adoption of ISDN. In Part II, they discuss the features characterizing current U.S. deployment of ISDN technology and examine the factors impacting ISDN adoption.—Ed.

Several features characterize current U.S. deployment of ISDN technology.[1] After an initial adoption and deployment spurt of custom ISDN, adoption has slowed relative to deployment of ISDN nationwide and relative to adoption and deployment efforts in Japan and major European countries. A significant acceleration in deployment has been announced by several RBOCs during 1993. Wide disparity in deployment levels has emerged between RBOCs. Through 1991-1992, introduction of ISDN capability appeared to be running approximately at levels projected in 1989.[2] In 1989, the RBOCs projected ISDN line shipments to grow rapidly, but not explosively, through 1994. Growth in line shipments has been much slower than projected. This runs counter to expected adoption patterns of technologies with network benefits in which growth would accelerate as the technology becomes widely available and suggests that, in its current form, ISDN's network benefits may be limited.

After an Initial Lead, Deployment Running Behind Europe and Japan

Initial U.S. adoption of ISDN appeared to lead the rest of the world in its early, customized version. In

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Table 1
Deployment of Network Technologies, United States Versus Selected Countries—Percentage of Total Access Lines

	Connected to Digital Exchange		Access to SS7		Access to ISDN	
	1991	1994	1991	1994	1991	1994
France *	78%	87%	100%	100%	100%	100%
Japan **	39%	83%	N/A	N/A	76%	100%
United States Former Bell System	47%	57%	44%	77%	23%	67.5%

* Data for 1994 from December 31, 1993; 1991 SS7 coverage includes all trunk circuits but not some local circuits.
** Data for 1991 ISDN coverage is end-1990 figure. Digitalization in 1991 is for FY91; reported figures are for local switching systems only.

Sources: France: France Telecom and Interviews; Japan: NTT; United States: FCC Docket No. 89-624 (Digitalization) and Yankee Group (SS7); For ISDN Access: France and Japan: Noam (1992); United States: Bellcore

this stage, deployment was limited to private network operators and some large Centrex users who participated in customized trials provisioned by PTOs. Unlike current deployment patterns, during this early period, there was not a significant difference between adoption and deployment. That is, any organization deploying ISDN was either simultaneously adopting ISDN or, as was the case with a telephone company, was installing capability (deploying) in tandem with installation of lines (adoption). The U.S. overall economic and technological leadership created a significant pool of large technologically sophisticated users that found ISDN an attractive option for their private network needs. The size of these networks provided enough incentives to install ISDN and reap network benefits even in the absence of connectivity to the PSTN. Combined with a more competitive environment for the provisioning of new technologies, this made ISDN available sooner and attractive to proportionally more users than in most other large industrial countries.

While detailed adoption data are not available, these large users still appear to account for a significant share of total adoption in the United States. Furthermore, in the United States, anecdotal evidence suggests that significant adoption has occurred outside the RBOCs' service territories by large institutional users.[3] Even where ISDN was deployed in the public network, large users often pulled local telephone companies into deploying ISDN to support enhanced Centrex services.

As ISDN technology has migrated to a standardized public network service offering, the early U.S. lead has slipped behind Japan and France and other EEC countries for deployment and adoption of ISDN in the public network. This lag is also exacerbated by slower U.S. deployment of underlying complementary technologies at the local level: digital switching and SS7.

There Exists Wide Disparity in Deployment Plans Between RBOCs

RBOC deployment appears to be distinguished by several salient features. First, there is a significant difference between the leading deployers of ISDN (Ameritech and Bell Atlantic) and the other RBOCs. Second, deployment figures mask significant differences in the deployment of ISDN connectivity and functionality.

Generally, those telcos planning more aggressive deployment of ISDN are also planning speedier conversion to digital technology, implementation of CCSS7, and adoption of the more advanced version of SS7 (TR-NWT-000444) as well as faster deployment of NISDN. Some RBOCs have slower deployment rates than the two leaders, but have deployed ISDN in a way to maximize its functionality and connectivity for end users. For example, BellSouth has deployed SS7 (TR-NWT-000444) on 100% of its ISDN switches, ensuring that users will at least reap full functionality of ISDN between central offices. At the other extreme,

Table 2
Projected Deployment of ISDN

Regional Bell Operating Company	1991*			1994**		
	Access Lines (000's)	Percent with Access to ISDN	Percent with National ISDN	Access Lines (000s)	Percent with Access to ISDN	Percent with National ISDN
Ameritech	15,120	21.4%	N/A	17,800	80.0%	79.0%
Bell Atlantic	17,420	48.7%	N/A	18,790	87.0%	86.6%
BellSouth	18,000	13.3%	N/A	20,000	53.2%	28.4%
NYNEX	15,460	2.1%	N/A	16,360	55.4%	55.4%
Pacific Telesis	14,300	30.1%	N/A	15,200	78.2%	49.3%
Southwestern Bell	12,400	12.9%	N/A	13,600	60.0%	14.0%
U S WEST	12,900	28.7%	N/A	14,229	57.1%	48.5%
Total Bell System	105,600	22.8%	N/A	115,975	67.5%	52.9%

* Bellcore: ISDN Deployment Data, Issue 2
** Bellcore: ISDN Deployment Data, Issue 4

Sources: Bellcore, RBOCs

Table 3
Projected Deployment of Complementary Technologies

Regional Bell Operating Company	Percent of Access Lines Served by Digital Switching *		Percent of Access Lines Served by SS7		Percent of ISDN Switches Equipped with ISUP SS7	
	1991	1994	1991	1994****	1991	1994
Ameritech	44.5%	54.5%	53.6%	88.4%	31.0% **	99.0%
Bell Atlantic	52.1%	88.0%***	80.0%	100.0%*****	0.0%	99.0%
BellSouth	56.1%	66.3%	74.7%	97.1%	100.0%	100.0%
NYNEX	60.4%	70.2%	13.7%	82.0%	17.0%	100.0%
Pacific Telesis	38.6%	42.9%	33.8%	75-80%	0.01% **	59.5%
Southwestern Bell	29.9%	44.9%	15.8%	64.0%	N/A	26.0%
U S WEST	40.2%	44.0%	20.0%	76.2%	35.0%	54.5%
Total Bell System	47.1%	56.9%	44.0%	84.8-85.4%	N/A	84.9%

* Based on 1989 projections reported to the FCC.
** 1992 figures.
*** Estimate based on Bell Atlantic figures.
**** SS7 figures based on FCC filing and review of open network architecture plans CC-Docket 88-2 phase.
***** FCC estimate not available; estimate from Yankee Group.

Sources: Bellcore, FCC, RBOCs, Yankee Group

Southwestern Bell projects only 26.0% deployment of the ISDN User's Part of SS7 in its ISDN switches.[4]

In addition, while no marketwide data have been compiled, RBOC installation of ISDN lines (adoption) appears to be lagging projections in other countries. NTT Japan has projected approximately 1,000,000 ISDN lines in service in Japan (generating approximately $1.2 billion in revenue annually) for the end of 1995 (for a penetration rate of approximately 1.8% of total lines).[5] For the United States to reach similar penetration rates in RBOC territories, approximately 2.0 million lines would have to be installed by 1995.

U.S. Versions of ISDN Appear to Be More Feature-Laden than the Versions Being Deployed in Other Countries[6]

As mentioned earlier for the United States, all versions of ISDN (customized ISDN in the United States, current national versions of ISDN in the EEC, EuroISDN, National ISDN, and Japan's ISDN) are compatible with CCITT recommendations. Due to implementation gaps, however, these versions are not compatible with each other. Their interfaces, implementation standards, and features differ between each version. The types of features included in the ISDN implementation are closely influenced by the market structure facing a service provider and standard setting body. It appears that U.S. versions of ISDN are more feature-rich than European or Japanese versions.

For instance, many of the early customized ISDN versions deployed by large users were Centrex versions of ISDN. These versions of ISDN are not available in Europe and Japan. Since these versions were aimed at large users and often were deployed as a competitive response to the risk of losing a large customer to private network alternatives, these versions often involved many enhanced features attractive to such users. Even where deployment of ISDN has been carried out in private networks, large users have installed a large array of features. The large PTOs in Europe and Japan, since they have targeted ISDN from the start at the mass market rather than large users specifically, appear to have chosen to deploy simpler versions of ISDN that could be made available sooner and more widely throughout the country.

Some early adopter influence may also have played a role in the relative feature-richness of proposed National ISDN versions. These early adopters were large users that had significant stakes in promoting wide availability of features to ensure backward compatibility (and reduce the loss in functionality from eventually switching over to the public network version) with their own customized versions. While this pressure can be significant by large telecommunications users anywhere, the absence of a centralized entity designing or planning ISDN strategy simply may have made the relative influence of large users in the United States more significant in determining ISDN functionality.

Until 1992, Deployment Projections Were Running Approximately on Par with 1989 Projections but an Acceleration Became Evident in 1993

The number of access lines with access to ISDN has remained approximately at the levels projected in 1989.[7] Beginning in early 1993 and continuing into late 1993, the projected rate of ISDN deployment accelerated. Most RBOCs appear to be deploying ISDN ubiquitously.[8] The slight increase in deployment rates was actually caused by a convergence in rates of deployment for most RBOCs. That is, those companies that had projected lower deployment rates in 1989 (such as NYNEX and Southwestern Bell) have accelerated their deployment, while those that had projected relatively rapid deployment rates have either maintained those projections or slowed those rates down slightly.

Wider availability of ISDN should reduce lack of access as an obstacle to adoption. However, as mentioned earlier, two other obstacles remain even if ISDN is ubiquitous. These obstacles are the conversion to National ISDN by the RBOCs, and the installation of the ISDN Users' Part (ISUP) of SS7 on the network.

While the United States is proceeding with accelerated ISDN deployment plans, it will still be behind leading adopters such as Japan and France. In France, ISDN is already available ubiquitously and, in Japan, ISDN was already available at the end of 1991 in 97% of Japanese cities with more than 30,000 inhabitants and available to 76% of all access lines.[9] Thus, the accelerated deployment will allow the United States to approach levels observed in the leading adopters. Uncertainty and variability of these rates is one of the causes behind skepticism about the commitment to ISDN by the RBOCs. These problems appear partially resolved as deployment rates have accelerated.

Adoption and Deployment Are Projected to Rise Steadily through 1994, Accelerating after 1994

The number of ISDN-ready lines appears to be growing rapidly but unspectacularly through 1994 (relative to the size of the national network and to the

Table 4
Variability in Deployment Forecasts

		1991	1992	1993	1994	1995
Percent of Access Lines with Access to ISDN	**1989 Projections**	20.9%	N/A	N/A	56.3%	N/A
	1992 Projections	22.8%	30.4%	43.9%	56.8%	N/A
	Beg. 1993 Projections	N/A	30.9%	48.3%	62.7%	68.3%+
	End 1993 Projections	N/A	31.0%	52.0%	67.5%	75.1%
Number of Central Offices Planned to Have ISDN Presence	**1989 Projections**	1,591	1,746	1,952	2,197	N/A
	1992 Projections	806	1,070	1,694	2,245	N/A
	1993 Projections	N/A	1,129	1,923	2,476	2,794+
	End 1993 Projections	N/A	1,137	1,923	2,514	3,000

Sources: FCC, Bellcore, *Network World*

number of lines projected to have access). While no projections past 1994 are available for U.S. adoption, projections for the EEC suggest rapid growth in the second half of the decade. Total BRI ISDN lines in France were projected to increase from 36,000 on January 1, 1994 to 248,000 by January 1, 1997 and to 1,705,000 by January 1, 2000. (These ramp-up projections have actually been proven to be conservative: at the end of 1992, France Telecom had 56,000 BRI lines in service and 8,000 PRI lines.[10]) Similarly, the number of BRI ISDN lines in the EEC is projected to rise to 1,171,000 by 1997 (from 120,000 in 1994) and to 7,632,000 by 2000.[11] U.S. adoption may lag these rates due to the connectivity and deployment problems dicussed earlier, but should exhibit a similar pattern as network externalities increase the attractiveness of ISDN.

Growth in Japan appears to be more rapid. NTT has announced a target of one million ISDN lines by 1996. In March 1992, there were 101,000 BRI lines (already a significant increase over 33,000 lines in March 1991) in NTT's service territory. Growth since 1992 has been significant. In March 1993, there were 312,300 INS-Net64 (BRI) lines and 6,800 Ins-Net1500 (PRI) lines installed in NTT's service territory.[12] An upper target of nearly nine million lines has been projected by NTT for 2000. To reach such targets, with a network approximately twice the size of Japan's, the United States would have to be considering installation of approximately 18 million ISDN lines by the end of the century.

The steadiness of the projected early rate of adoption suggests that, in its initial form, ubiquitous network benefits from ISDN would be limited, at least in the early years. If network benefits were significant, projected introduction rates could be expected to accelerate past some critical level of penetration, which is the forecast after 1994 for most advanced industrial countries. Limited connectivity in the United States may delay the achievement of network effects significant enough to allow ISDN to take off after 1994. This means that, while the United States will not fail to adopt ISDN, it may delay significant adoption by a few years relative to ramp-up rates in other leading nations. This doubly affects deployment rates since, in the absence of significant adoption, PTOs need to justify the cost of upgrades to support ISDN to skeptical PUCs.

Adoption in the United States

There are several factors affecting ISDN adoption. Among these are:

- Service pricing and availability both in terms of deployment and connectivity.
- Applications development.
- Cost and reliability of terminal equipment.

Public policies have had a negative impact in all three areas. This section will summarize some of the adoption expectations for the U.S. market as well as key obstacles to adoption facing U.S. providers.

The focus of this section is on small and medium-sized businesses and on high-probability residential households, since these customer groups are likely to present the largest potential market for narrowband digital communications. This section relies considerably on ISDN mass-market research and will consider the above obstacles by drawing on the results of a Bellcore market study on those two groups of potential users. Thus, for each group, this section will discuss potentially attractive applications, willingness to pay, desired timeframe for availability, and reliability.[13]

Adoption Expectation of RBOCs

In 1989, the RBOCs expected rapid but not explosive adoption of ISDN through 1994, despite significant deployment efforts. ISDN subscriber lines were projected to increase relatively steadily.[14] This would suggest limited availability of service and of network connectivity, both of which reduce network benefits from increasing the number of ISDN subscribers. While no figures for ISDN adoption in the public network are available, it is apparent that RBOC projections for adoption were optimistic in light of the obstacles that have since become apparent. In fact, informal industry interviews suggest that the total actual line shipments for both the public network and private users have been on the order of one million BRI lines.[15] Of those, many have not yet been installed, and a large share has actually been deployed by private users.

Adoption Plans of Large Corporate Users

While this article does not focus on large users, they have been among the earliest adopters. In addition, due to the early cost of ISDN terminal equipment and the fact that many telcos have offered ISDN as a Centrex feature,[16] the attractiveness of ISDN has, at least in these early stages, been limited to large users.[17] Some lessons learned from their deployment efforts provide insights for encouraging mass-market adoption. This has been because, in most cases, the efforts and capabilities of the internal telecommunications offices of these organizations largely determined the level of acceptance and ISDN support within the private network and the rate of introduction of new applications. In the mass market, such a role would have to be played by a large stakeholder, either an equipment manufacturer or, more likely, the public network operator. Furthermore, large user demands have influenced the establishment of standards and deployment patterns of ISDN by the RBOCs.

Users generally identified several key factors affecting ISDN adoption.[18] Among these were:

- The role of ISDN technology in a user's communications strategy.
- The tradeoffs in cost, functionality, and connectivity that using ISDN would impose over other alternatives.
- The availability of technology support (measured against a user's own capabilities and requirements for external support).
- The closeness of strategic partnering with either the service provider or the equipment manufacturer or manufacturers.
- The intensity of internal selling efforts (by the telecommunications office of the organization) affected both the acceptance and the availability of applications within an organization.

Additional factors emerged from discussing internal ISDN acceptance *after* adoption by the organization. These included:

- Pricing relative to alternative applications available to end-users.
- Resource availability of the internal sponsor of ISDN technology (i.e., its technological capabilities, managerial aggressiveness, and closeness of the telecommunications office to qualified outside support).
- Equipment cost to end-users.

ISDN adoption by large users can be described in three phases: strategic assessment, initial deployment, and an expansion/enhancement phase. In the strategic assessment, most adopters decided on ISDN as a

stepping stone toward digitizing and unifying parts of their internal communications without tying up hardware that would need short-term replacement.[19] While much discussion on ISDN tradeoffs has focused on technical advantages (which exist and are significant in many instances),[20] it appeared that the decision to go ahead with ISDN, once the technical advantages had been factored in, was strategic. Larger networks were often looking for a unifying/integrated solution that had only one set of applications and hardware rather than several PBXs, Centrex, and other facilities.[21] Despite early disadvantages relative to advanced PBXs (for example AT&T's Definity PBX), ISDN was chosen because it was more compatible with the long-term growth and upgrade plans of network managers. This appeared to be a key driver of adoption: ISDN's flexibility to "grow" with the network's demands. Some users mentioned that enhancements to ISDN's capabilities have been gradually reducing the functionality gap with PBXs.[22] Centrex was often adopted because custom tariffs offered to them were highly competitive with non-ISDN alternatives.

In the initial deployment phase, no users even considered outside connectivity and intercampus connection in their adoption decision. Given limited deployment and connectivity of ISDN in the public network, ISDN was evaluated purely on internal communications performance rather than as a standardized public network solution. In fact, even now, several users did not have test projects with the local telephone company to evaluate potential outside connectivity (such as telecommuting). In one of the few cases where off-campus applications were being tested in a large program, this was due as much to internal aggressiveness of the telecommunications office as to the aggressiveness of the local telephone company which was the main strategic partner of the large user.

Despite this, all users saw eventual connectivity to the public network as a positive and potentially significant effect on ISDN usage within their networks. Several, in fact, would not see much growth in internal penetration in the near future unless broader deployment in the public network increased. This would change the internal economics of an ISDN line. Most users were planning to migrate to NISDN relatively rapidly (within six months to one year), but they were concerned about the loss in functionality that this would entail (some users mentioned that the conversion to NISDN would "lose" them approximately one-half of the features available in their customized version). As discussed earlier, the strategic role that ISDN was assigned often outweighed functionality shortcomings in the short to medium run.

In the expansion/enhancement phase, most users reported limited applications usage beyond enhanced voice call features.[23] The majority of users appear to be using ISDN as a quasi-PBX platform for the central office. Data communications was the next most common application, but these tended to be limited mostly to users that had aggressive technology "sponsors." These sponsors could either be the internal telecommunications office or a close outside supplier or service provider. In general, the more technically sophisticated and the more resources a telecommunications office had, the more enhanced features beyond voice had been implemented on the ISDN platform. This sets an important parallel for future efforts by RBOCs to reach the mass market. Almost all "off-the-shelf" applications needed to be customized before they could be deployed internally. The more sophisticated users considered these adjustments to be trivial. The less resource-rich users (or those that did not have a relatively close working relationship with suppliers or service providers) found these adjustments to be significant obstacles to applications enhancements and internal deployment. As the core of users becomes less technically sophisticated, the applications offerings must become more transparent and easy to use. Growth in the mass market itself will facilitate this process by standardizing applications requirements and mass-producing ISDN equipment.

Most users that reported significant adoption also priced ISDN services aggressively (either priced it below standard voice service or "gave it away"). In many cases, internal pricing decisions overcame the reluctance to adopt ISDN due to higher equipment costs (although in some cases, prices were not an obstacle—users were "glad to get rid of their key sets"). In general, more sophisticated users seemed less deterred by high equipment prices (if a user was going to use voice and data over an ISDN line, then equipment prices were less of a consideration in adopting ISDN).

Adoption by Small and Medium-Sized Businesses and Residential Households

Adoption decisions consider the following issues among others: cost and reliability of equipment, potential applications available on ISDN, and timing of availability. While it is hard to quantify the value of

widespread connectivity in adjusting the figures reported in the following section, this must be considered when discussing the attractiveness of applications since ubiquitousness determines, to a significant extent, the value of any application or terminal equipment. Furthermore, reliability is extremely important. ISDN equipment, unlike non-ISDN sets, requires outside power to operate. Power outages do not interrupt current communications service, but could shut down ISDN equipment.[24]

Equipment Pricing

The upper limit price for mass-marketing ISDN terminal equipment appears to be $250 for an ISDN telephone. At $250 per set, 45% of all businesses and 35% of households would consider buying an ISDN telephone.[25] At $250 per telephone set, 58% of businesses with four to 20 lines would be interested in ISDN service. While the responses need to be evaluated carefully, a 35% interest in ISDN equipment suggests that potential ISDN markets may be quite significant. If only 10% of households were willing to pay for such a set, that would still translate into approximately 10 million residential ISDN lines. NTT Japan already markets an ISDN telephone, the S-1000, for ¥30,000 (approximately $230 to $250).[26] The set is viewed as the first building block of a range of terminal equipment developed by NTT. For data communications, additional price reductions in the price of network terminating interfaces and terminal adapters are required before they are fully competitive with modems. As mentioned before, a major drawback of voice equipment, however, is the need to power the unit at the subscriber's location. Thus, figures on market potential can be reduced significantly unless some technical uncertainties can be addressed.

Reliability

One of the major technical obstacles is the inability to maintain normal network operations through a power outage. Unlike POTS, ISDN equipment needs to be powered at the subscriber's location. While only 65% of small business users deemed back-up power as essential, most of the other 35% actually intended to purchase the ISDN phone as an addition to POTS so their concerns for reliability were mitigated.[27] Among the 65% who deemed it essential, the ability to switch

Table 5
Likelihood to Subscribe and Willingness to Pay

		Likelihood to Subscribe		Cumulative Percentage Willing to Pay Price for ISDN Telephone		
		High	Moderate	$1,000	$625	$250
Residential Market	Segment Households *	24%	36%	10%	17%	47%
	Other Households	10%	24%	7%	10%	33%
	All Households	13%	25%	7%	11%	35%
Small Business Market	4-20 Lines	30%	39%	22%	28%	58%
	1-3 Lines	13%	29%	10%	16%	41%
	All Businesses	17%	32%	12%	19%	45%

* Segment households include those with advanced call management (more than one telephone line or subscribed to two or more network-based phone services), personal home management (computer with modem), and work-at-home (owned computer and at least one member used it for work). Segment households represent 17% of total U.S. households.
Note: The number of U.S. households with telephones is approximately 85.9 million; the number of small businesses with telephones is approximately eight million.

Source: Bellcore

back to POTS was considered more of an acceptable alternative than having a battery for backup power. A sizable segment found loss of service due to power outages to be unacceptable, which may increase equipment costs and reduce willingness to pay. Reliability has been a major consideration in telecommunications regulatory policies in the United States. Significant political pressures may create problems to widespread ISDN deployment unless this issue is addressed.

Applications

Among the basic features most attractive to businesses are simultaneous voice and data communi-

Table 6
Attractiveness of Selected Applications in the United States Versus Current Applications in Japan

	United States Survey*						NTT Japan's INS Net 64 Applications		France Telecom ISDN Applications	
Surveyed Applications	Residential			Business			Applications	Share of all applications usage	Applications	Share of all applications usage
	Segment	Other	All	4-20 lines	1-3 lines	All				
Simultaneous Voice and Data Comm.	38%	24%	26%	51%	29%	34%	Data Transmission	74.1%	Telephony	65.7%
Data Transmission Speeds	41%	24%	27%	50%	27%	32%	- POS - Data file transfer	24.5% 21.6%	Data Transmission	48.8%
Messaging	49%	36%	38%	48%	32%	36%	- Backup - Other Data Trans.	18.0% 10.0%	- Data file transfer - Lease-line Backup - LAN-LAN	39.3% 11.8% 5.8%
Multiple Device Support	37%	20%	22%	45%	28%	31%	Group IV Fax	13.5%	- Transpac B-channel accs	1.4%
Key Set Functionality	34%	24%	26%	45%	26%	30%	CPE Development	4.2%	Group IV Fax	2.6%
Two Voice Calls At Same Time	44%	31%	33%	42%	31%	33%	Voice	2.5%	Archive Comm.	0.2%
High Quality Graphics	40%	22%	25%	34%	22%	24%	Video	2.4%	Telemainte-nance	5.8%
Simultaneous Access to Multiple Databases	29%	17%	19%	28%	15%	19%	Other Applications	3.3%	Voice Server Audio Conf.	1.4% 2.0%
Video Transmission	37%	33%	33%	22%	14%	16%			Video - Video Conf. - Other Image transmission	1.6% 1.2% 0.4%
									Other Applications	3.6%

* Percentage reported is for survey respondents expressing high interest in an application.
Note: France Telecom figures do not add up to 100% because of rounding.
Sources: Bellcore; France Telecom; Kawasaki, *ISDN in Japan* (1992); and NTT

cations, increased data transmission speeds, messaging services, and multiple device support. Households appear to be interested in similar applications, but households are generally less interested in any particular application. Businesses with more than four lines were considerably more interested in many of these applications than those with fewer lines. In fact, over 50% of business subscribers expressed high interest in simultaneous voice and data applications and increased data transmission speeds. This represents a market of approximately one-half million businesses, with at least two million lines between them. No single application dominated: both businesses and households seem to be interested in the array of features ISDN offers rather than a particular "killer" application.[28] Video applications do not appear to be particularly attractive either to businesses or to residences. As discussed earlier, users, in general, adopt an incremental approach to technology deployment. They first use new platform technologies to replace existing applications. Once they are familiar with the technology, and the supply and market for new applications develops, they move on to new applications.

In Japan, data transmission applications (including Group IV fax) seem to dominate existing usage (with nearly 75% of all applications in use and 88% if Group IV fax is included) and appear to be major drivers of ISDN demand. While some image transmission applications appeared to receive attention in France in 1991,[29] this may have resulted from the fact that the centralization of application development efforts through France Telecom (and the sharing of cost) allowed the emergence of such image databases.[30] As ISDN became more widely available, however, most new usage was for enhanced voice and data communications and the pattern of usage again centered around variations on traditional usage of telecommunications.

Timing of Availability

A little more than one-third of all households surveyed would "never" be interested in ISDN. The Bellcore study identified a potential market of approximately 9.5 million lines.[31] Similarly, approximately 14% of businesses representing 1.1 million businesses would be interested in ISDN within two years. So, the potential total market for ISDN lines within the next two years could be nearly 10.5 million lines. However, technical limitations on the availability of ISDN will probably push back this date. Furthermore, pricing of ISDN service will be crucial to determine its acceptability. Treating ISDN as a supplemental service rather than a new basic service (much like touch-tone is treated today) could slow adoption significantly.

Only recently have RBOCs introduced single line tariffs for the mass market.[32] A potential market of 10.5 million contrasts starkly with the limited plans to ship ISDN lines in the near future.[33] This limited penetration would severely reduce the benefits of some of the applications discussed above and, by itself, presents a significant barrier to adoption. The interest in ISDN by residences and businesses should be qualified: many of the applications and the willingness to pay depend significantly on the attractiveness of available applications and the ability to interact, through an ISDN platform, with other users. Without tariffs to allow ubiquitous on-demand usage, with limited deployment schedules, and technical constraints on interoffice connectivity, significant near-term deployment for residences now appears less attainable.

Barriers to Adoption

Despite the existence of potentially significant demand for ISDN applications, current deployment strategies present significant adoption barriers. Limited deployment has created ISDN islands, reducing network benefits and the attractiveness of ISDN applications technologies. Traditional deployment methods have led to such islands. ISDN upgrading of central offices in high-usage areas (a traditional approach followed successfully for digital switching, for example) delivers ISDN capabilities to that CO service territory. For example, the financial district/downtown CO may be upgraded in anticipation of demand from business. In large U.S. cities with diffuse centers of economic activity, this has led to COs being deployed in several distinct non-adjacent geographic areas. This has limited the connectivity and functionality of ISDN to a particular CO's service area. By not considering communities of interest in areas adjacent to the initial deployment, traditional CO upgrading strategies have limited the attractiveness of ISDN. This would occur even if the local network had been upgraded using SS7 TR-NWT-444 allowing interoffice connectivity. The acceleration in deployment will mitigate this obstacle, but relative to other leading adopter nations (where ISDN is nearly ubiquitous by now), the United States has failed to catch up and deploy the ISDN platform.

Slower deployment further affects the supply of applications technologies. Lower levels of ISDN adoption resulting from limited deployment deter applications development and equipment production. By reducing the pool of potential ISDN subscribers, applications developers have lacked critical mass to research and produce ISDN applications. But without applications, ISDN adoption is delayed further. In addition, lower adoption reduces demand for equipment inputs. This limits learning by doing and economy of scale effects which can be significant in new technology industries. This keeps terminal equipment prices higher and adoption slower than if an aggressive deployment schedule is followed. This perverse cycle can be mitigated by public policy that encourages deployment of network technologies.

Public Policy Implications

In discussing adoption and deployment of ISDN in the United States, this article has identified ISDN economic characteristics, technology adoption factors, and regulatory and structural market shortcomings that combine to delay and discourage adoption of ISDN in the U.S. public network. Among these shortcomings were:

- Network externalities that created a gap between private benefits to adoption and the social benefits that joining the network created.
- Fragmentation of the telecommunications market which on the one hand increased competition for various segments in the market but on the other reduced the capability to plan a coherent deployment strategy for network technologies such as ISDN.
- Regulatory biases that discouraged aggressive technology policies in the telecommunications network and, in fact, often punished aggressive deployers.
- Organizational shortcomings in developing a mass-market deployment strategy that provided a transparent, easy-to-use ISDN platform for smaller, less sophisticated users.
- Deployment policies that minimized network benefits of ISDN in the short run and hence shut out small users as a potential market.

These are features not unique to ISDN. Future network technologies with similar economic characteristics will face similar hurdles.

As a Result, Public Policies Should Address Current Regulatory/Industry Structure Shortcomings

Acceleration in deployment makes it less of an obstacle in deployment of ISDN; however, delays in deployment did slow ISDN rollout. Adoption and usage by large users appears to be well ahead of other countries. Regulatory policies should encourage adoption of ISDN by small users (the "core" of the ISDN market).

Policies should encourage the sponsorship role by service providers or equipment manufacturers for small users. The scope of its perceived role and aggressiveness of a technology sponsor will be important determinants of ISDN adoption, as they have been in large organizations. Public policies should allow pricing flexibility to determine appropriate levels for ISDN services and permit sponsorship roles for various equipment and service providers. Furthermore, institutional arrangements are necessary to retain some of the lessons learned from delays in ISDN standardization and deployment.

It is Clear, However, that, Given Its Structural Obstacles to Network Technology Ddeployment, the United States Cannot be an Early Adopter of Public Switched Network Technologies

U.S. economic leadership will help mitigate some of the structural obstacles to network technology deployment. It is, however, unlikely that the country will have the institutional capability to overcome all the obstacles. Deployment rates will still be left to individual service providers, and the fragmentation of the telecommunications industry will give rise to strategic behavior by various players as they seek to influence equipment formats, standards, and service features. Large users will continue to wield significant influence in the standards process, and the country's regulatory structure will continue to allow broader input by interested parties. As with ISDN, these characteristics will cause delays in the deployment of future network technology platforms.

Equipment vendors and applications developers should look to early adopter nations or regions to establish competitive positions. Failure to acquire early knowledge of potential applications and equipment technology for new platforms will put U.S. companies at a disadvantage (for example, in Group IV fax in the case of ISDN) relative to suppliers of early adopter nations. Despite this, European and Pacific Rim-based companies will have market entry

opportunities if and when the U.S. market for new technologies develops. ntq

[1] It is useful to separate "hardware" from "software." ISDN protocol can be deployed on broadband (e.g., fiber-based) networks. While ISDN is one way to increase the functionality of existing copper-based networks, it can just as easily be deployed on emerging broadband technologies.
[2] FCC Docket No. 89-624.
[3] The existence of the DMS and 5ESS users groups, a number of whose members have their own COs with significant ISDN presence, suggests that large users have been quite willing to adopt ISDN for their internal operations. Such users include Lawrence Livermore National Lab, MIT, Boeing, and the federal government, all of which have significant ISDN networks.
[4] Bellcore, *ISDN Deployment Data*, Issue 4.
[5] See Kawasaki and Tatsuo, "The Japanese ISDN Market," *Japan's ISDN Revolution* (1992), p. 32. This penetration rate is based on approximately 60 million access lines for Japan by 1995.
[6] The information for this section has been obtained through informal interviews with industry sources.
[7] FCC Docket No. 89-624 and *Network World*.
[8] A significant acceleration in adoption schedules has been announced by several RBOCs. The new schedules, however, were unavailable at the time of this writing.
[9] Kawasaki and Tatsuo, "The Japanese ISDN Market" and Nippon Telephone and Telegraph, *Annual Report* (1991).
[10] B. Epstein, "ISDN in France: The Market and Applications," unpublished France Telecom North America mimeo (April 1993).
[11] Commission of the European Communities 1991, *ISDN Yellow Pages 1993* (Boston, MA: Information Gatekeepers Inc., 1992).
[12] This information has been kindly supplied directly by NTT.
[13] Businesses were divided into those with one to three lines and those with four to 20 lines. As expected, larger users of telecommunications expressed more interest and had higher willingness to pay than smaller users of telecommunications offerings. Businesses with four to 20 lines accounted for approximately 23% of all businesses nationwide as projected in the sample. Households were divided into segment households and non-segment households. They were called segment households since they represent a segment of users with high current and potential telecommunications and data communications needs (see Table 6 for a description of segment households). This group accounted for approximately 15% of all residential households. As was the case with "larger" businesses, segment households were more likely to express interest in ISDN. However, a significant number of non-segment households also expressed high interest in ISDN; their large share of total households makes them a significant market despite lower adoption rates.
[14] Based on projections filed with the FCC in Docket #89-624. According to those projections, the public network should have had about 1.5 million ISDN lines by the end of 1992 and 2.0 million by the end of 1993. These projections have not been fulfilled. Even in the absence of compiled data, it is clear that ISDN adoption in the public network is far below the modest levels projected for 1991 through 1994 (one million lines would have had to be in service in the public network for 1992).
[15] No published data are available on actual ISDN BRI lines deployed.
[16] In fact, the RBOCs appear to have focused on ISDN as a competitive tool to keep Centrex customers from abandoning the public network in favor of PBX. As large users, ISDN benefits could be reaped internally. This accounts for the proliferation of Centrex tariffs well in advance of filing other tariff options.
[17] Clearly, medium-sized businesses make significant use of Centrex as well, but Centrex would still tend to raise the size of the business that can consider ISDN. Apart from an effort to prevent migration to PBX by large users, the decision to offer ISDN as a Centrex feature was not unrelated to the obstacles that many telcos face from Public Utility Commissions for introducing new business services. As an add-on feature to Centrex, PUC opposition to launching ISDN is reduced.
[18] These conclusions and findings were drawn from interviews with 12 large users of ISDN. Their average network size was 14,000 lines and the average number of ISDN lines per user was 3,600 BRI lines. The characteristics of the users ranged from not-for-profit universities and research laboratories to hospitals, federal government agencies, and private businesses. Some of the users owned their own switch facilities, and others had customized ISDN Centrex service from the local RBOC.
[19] An often-heard comment was: "As soon as you buy a PBX, you have to start thinking about replacing it."
[20] It is not the object of this article to identify technical advantages of ISDN over its alternatives. However, ISDN offers significant advantages over key sets in maintenance and functionality. Cabling costs are much lower (one user mentioned that multibutton sets could require 25 pairs of cables versus four pairs for ISDN telephones)—and several users considered this "*the* ISDN advantage." Also, ISDN's flexibility in a multiple building campus was considered a key feature by several users of voice and data (a move within the campus could have a new line in one to five days versus up to nine weeks to engineer Ethernet access via a data circuit). Several users identified ISDN as the platform for video, and several had internal video applications using Picture Tel and S56 service (at 112 Kb/s). In one case, video connections were actually carried outside their own campus offices and connected with suppliers, customers, and contractors.
[21] Obviously, this comment would apply only to networks that own most of their facilities rather than those that relied on Centrex.
[22] AT&T's CDX switch (essentially a compact 5ESS switch with up to 10,000 lines but as small as a few hundred) takes the convergence of PBXs and central offices one step further and should facilitate ISDN adoption.
[23] The heavy use of the ISDN platform for voice features is similar in France (see Table 6). Large users appear to be purchasing PRI lines to connect PBXs to the public network (instead of buying E1s) and using the ISDN platform for enhanced voice services (see Epstein, "ISDN in France," p. 9). The motivation in the United States was similar: not to get a totally new platform (i.e., non-voice), but to get more flexibility and more room for growth. As with most new technologies, most initial applications reproduce existing applications on old platforms.
[24] Large users reported that powering was not an issue. A range of batteries was available lasting from 15 minutes to eight hours. Depending on the importance of the connection, ISDN equipment would get assigned a certain battery length. This may not be generally applicable to the public network where reliability is likely to be a much more important public policy goal.

[25] In the United States, large users reported prices that had recently come down to $300 for the simplest ISDN phones. Users reported varying rates of decline, suggesting that, in this early stage of the market for ISDN equipment, market power may be important in lowering prices.
[26] T. Mizuno, "Terminal Equipment Options," *Japan's ISDN Revolution* (1992), p. 65.
[27] Bellcore, *Mass Market ISDN Primary Market Reseach*, Special Report SR-INS-002125, Issue 1 (May 1992).
[28] Ibid.
[29] "All Join Hands...," *Telecom France* (April 12, 1990):27.
[30] While the available data are scarce, the possibility exists that some applications counted as data transmissions in some countries may indeed be image transfer applications.
[31] This is accounted for by 11% of households interested in ISDN in the next two years.
[32] Bellcore, *ISDN Deployment Data*, Issue 3.
[33] The absence of reliable adoption figures for the U.S. network further hampers adoption. Without market data, applications developers, CPE manufacturers, and potential users are uncertain of the benefits of entering the ISDN market.