Selected Summary of

Information Superhighways: The Economics of Advanced Public Communication Networks

by

Bruce Egan
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ABSTRACT

Ultimately, the U.S. will have a universal broadband network (UBN). Egan addresses transitional problems in his recent book, *Information Superhighways*. First, we need to know the extent to which consumers would value a UBN network. Who should bear the risks associated with massive infrastructure investments? Next, there are questions about whether demand-pull technological progress will be rapid enough to establish and maintain a UBN network. Technology-push progress is also expected to reduce costs in the long run and to improve quality of service. Egan reminds us that some stakeholders will gain and some will lose during the 1990's. The regulatory policies adopted in the coming years will influence the pace and pattern of investment in advanced public communication networks in the U.S. Egan argues that it is important that policy discourage fragmentation within the network.

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Change is the fundamental feature of the telecommunication industry, so analysts can only take snapshots at a point in time, and can predict only the broad outlines of future developments. However, it does seem clear that the next stage will involve the development of universal broadband network (UBN). In order to reach that stage, we must first consider steps needed to get there. Bruce L. Egan described such transitional considerations in his book, *Information Superhighways: The Economics of Advanced Public Communication Networks*. The following summarizes selected portions of the book. First, we survey the major technological components of this future UBN system. We then explain key features of likely cost structures and describe demand-pull considerations. A breakdown of major supplier-stakeholder groups and their roles in this transition period follows. The final two segments highlight possible setbacks and emerging alliances as well as alternative scenarios arising from additional developments. Implications for future public policy initiatives also are discussed.

TELECOMMUNICATIONS TECHNOLOGY

Egan suggests that future communication networks will have three major components: fiber optics, microwave radio technology, and satellite technology. The three technologies have advantages and disadvantages.

Fiber Optics

The current trend in fiber optics is the rapid decline of per unit cost. As the demand for fiber optics service rises, we further expect decline in costs (demand-pull progress). Furthermore, we expect exogenous and induced innovations stemming from scientific advancements to further lower costs (technology-push).

Compared to copper wire transmission, fiber optics offers more high-capacity network applications: "In general, fiber optics provide for more capacity, reliability, flexibility, and functionality than ... copper and coaxial cable." (p.11) Furthermore, capacity on fiber networks can be increased merely by expanding end-of-transmission electronics. Fiber optic cables are not sensitive to electromagnetic interference and are smaller than copper and coaxial cable. In terms of engineering, furnished and installed (EF&I) costs, fiber optics is comparable to copper. Further reduction in deployment costs arise from its interference-free transmission; fiber optic wires could possibly be carried on electric power distribution facilities. Another cost consideration in favor of fiber optics is its low signal attenuation properties that permit repeaterless transmission lines which operate over relatively long distances.

However, the major disadvantage with fiber optics is the current cost of lasers, optoelectronic signal converters, many optical components, and costly splicing procedures. But as fiber optics become more cost-effective through multiplexing and unit cost reduction, the high-quality nature of fiber optics certainly offers more advantages.

Microwave Radio

Microwave radio transmission is most suitable for high-capacity, short-haul applications. "Microwave technology is used for narrowband and broadband services, and uses both digital and analog technology." (p. 12) A major advantage for microwave technology is its relatively low construction costs; a microwave tower can easily be easily erected on rooftops. Furthermore, microwave technology does not necessitate the use of actual physical cable wires--which reduces deployment costs significantly. Costs in general are falling, and the useable spectrum for microwave systems increases with data compression improvements. Since microwave facilities offer more flexibility and mobility, they can easily change as technology changes.

Microwave technology is disadvantageous for long-hauls because of electromagnetic interference and possible loss of privacy. For areas with high barriers (trees, buildings, etc.) transmission could be disrupted because of the line-of- sight interference. Another possible consideration for radio waves is low-power digital technology and low-power cellular radio technology. Current applications of both are very limited and will not become significant before the year 2000.

Satellite

The current and future use of satellite transmissions is in geographically remote markets and for international transmission. Satellite transmission is most cost-effective in long-haul applications because initial manufacturing and launch costs are high, but marginal costs are minimal. Ku-band satellite system, though requiring more power, will eventually be preferred to the C-band system because Ku-band allows for direct broadcast satellite (DBS) service. Another future application of satellite transmission is the Ka-band satellites that are able to perform like "central office switches in the sky, interconnecting virtually everyone over a large geographic area in one big 'mesh' network." (p. 14)

The major disadvantage in satellite service is delay time, limiting its use in on-demand servicing, and two-way transmission. These features are essential to telecommunication networks of the future. Thus, satellite use within the future communication infrastructure will probably be for one-way point-to-multipoint data and video services.

COST STRUCTURE

Technologies and input prices determine the cost structure of the future universal broadband network (UBN). Though the actual production equipment has yet to be fully specified, we can still examine some basic cost characteristics of UBN's. Costs can be further broken down into two components, those associated with access to the UBN, and these required for access to the interoffice core network. The actual interoffice core network consists of digital switches and interoffice links.

Customers would purchase or lease access facilities to the host broadband switch (gateway). Generally, telephone companies will provide the necessary bandwidth requirement for individual customers through a combination of physical fiber links and electronic and photonic devices. Customers may also purchase hardware and software packages to further allocate the bandwidth specific to their individual applications. Two methods are available to increase bandwidth: either place additional fiber cables or upgrade the necessary electronics and lasers at the ends of existing fibers.

Once a customer obtains access to the gateway switch, the telephone company is responsible for having sufficient core network capacity to provide *reliable* service. The telephone company then must consider how to *efficiently* allocate the engineering capacity of the gateway or host switch. The telephone company must also continuously upgrade the system as technology progresses. Processing *capacity* of switches, electronic signaling devices, peripheral devices, remote switching/signaling nodes, and interoffice transmission must all be continually updated and upgraded. As technology allows for further bandwidth capacity, additional production equipment must be added to the system. Since industry analysts observe a glut of telecommunication transmission capacity for the 1990's, the telephone companies must also address this concern.

The UBN system may also have a peak capacity cost problem. If demand became high enough as to cause congestion and blocking during specific time intervals, the capacity of the entire network system, including switches and interoffice transmission capacity, must be further expanded. In theory, the problem could be met by technological improvements enabling switching and transmission to be so fast that congestion would not be possible. If such a "super" network is constructed, then economic pricing strategies would be completely different, determined by software applications and demand-side considerations. Value of service becomes the focal point of telecommunication when incremental costs are essentially zero. A two-part pricing scheme for access and usage would result. The access charge would be associated with actual hook-up charges, and costs of various administrative and operational functions and activities. The usage charge would cover the minimal marginal cost. Note that the marginal cost would be expense (out-of-pocket) rather than capital-related costs. "Accordingly, a producer can recover all costs and make a profit through customer price discrimination or value-of-service pricing." (p. 38) Though the actual existence of a "super" network is hypothetical, it is useful to consider the pricing and cost recovery implications of alternative technologies.

For now, incremental network capacity costs are still important; according to Egan, demand-based pricing should be emphasized over cost-based pricing. The main cost and capacity problem will be congestion of the host UBN processor. For a network producer to handle all demand contingencies would involve inefficient capacity, so one solution is an efficient pricing scheme. For example, the costs associated with switching are most sensitive to peak-hour demand. Since future networks allow for more direct customer control, this peak-demand problem is further aggravated. "A dynamic capacity charge has been proposed as one pricing solution for this important supply problem." (p. 39)

DEMAND-PULL CONSIDERATIONS

If we assume that eventually a Universal Broadband Network (UBN) will be deployed, we must then also examine the demand-pull aspects of telecommunication progress. As with most new breakthrough technologies, we expect initial innovative progress to be dominated by technology-push, or supply side, factors. However, since customer service applications are critical to the long term viability of any telecommunication network, Egan argues that we must be concerned with certain demand-pull factors that are evolving.

Certainly, forecasting future demand for communication services is very difficult because of the rapid pace of technological changes. Furthermore, only limited information from telecommunication demanders is available. Some relatively new telecommunication services (e.g. data, facsimile, information, database, etc.) are adequately handled by narrowband network facilities, thus offering little insight into services that will be demanded from a broadband-capable network.

The demand for the residential broadband network market is most heavily influenced by developments in both broadcast and interactive entertainment video. Some interactive services that require a relatively minimal degree of customer interaction include "dial-up" movies, pay-per-view video, and video library-type services. Other applications that are likely to emerge include: remote video browsing through stores or real estate for sale at distant locations, sophisticated interactive videotext, and dramatically expanded graphics capabilities.

Certainly, the largest source of broadband service demand is high-resolution video services like HDTV. Though HDTV services are entangled in controversy over adoption of standards in the U.S., the revenue forecast for HDTV services are very impressive. Further implications will become apparent once the Federal Communications Commission decides on which consortium will be designing the compatibility standards and backbone infrastructure of the HDTV network.

Potential applications emerging from the government (especially the Defense Department) and some business customers are wide-ranging: high-speed, high-resolution imaging, medical imaging, image transfer, and full-motion color videoconferencing. Customer demand-pull may create niche markets for these applications, and high-speed digital capability may be deployed earlier in certain network locations.

As noted earlier, new customer service applications are critical to long term viability of UBN's because capital recovery is necessary for further progress. The actual production cost structure and public policy considerations will be the initial determinants of UBN's deployment. Note that the initial deployment of a broadband-capable network will not solely be restricted by the type of service offerings. The growth of the system will ultimately cause the replacement of copper with fiber and analog with digital technology.

Once network capability is available, most analyst believe that sufficient demand for broadband services will follow. History shows that a fundamental technological change indeed may cause large and long-lasting increases in demand. Some regard broadband communication as a new paradigm. Since history shows that the eventual demand for a new technology might be higher than initially anticipated, some analysts project dramatic impacts of the UBN. Furthermore, demand-pull factors become extremely important once the technology is available to many. Of course, we must not exclude historical examples of market failures either: not all technologies "take-off." We should not estimate future demand in broadband communication by today's consumer demand because technology and demand are related in ways not fully understood.

SUPPLIER-STAKEHOLDER GROUPS

Let us turn to the potential suppliers of and stakeholders in broadband networks and services. Most analysts seem to assume that customers will have very little say in who and how UBN's will ultimately be deployed. Furthermore, the lack of any strong public consensus on the deployment process of UBN technology will undoubtedly leave those decisions in the hands of key stakeholder and supplier groups. Federal and State regulators will respond to these pressures and provide their own policy suggestions.

Whether one universal broadband network is achieved or multiple branched, but interconnected, networks are achieved, an immense amount of capital will be needed. If we assume initial capital recovery is slow, then a continuous capital inflow must also be available during the early years of UBN deployment. Thus, along with various other investors, we expect UBN suppliers to be key stakeholders. It is necessary for UBN suppliers to be stakeholders not only because of present available revenue base, but also to monitor capital expenditures. In Egan's view, the role of bureaucrats, regulators, and other government representatives will serve primarily to reflect market concerns of potential UBN suppliers, as expressed through lobbying efforts.

If supply-side consideration will weigh more heavily than demand-pull factors in the early years of UBN deployment, then it is important to examine who those UBN suppliers are going to be. One important supplier-stakeholder group affecting deployment of UBN technology is network service suppliers (NSS). NSSs represent the bulk of potential revenues and investment funds.

The first subgroup, public NSS, includes common carriers: local exchange carrier (LECs), other common carriers (OCCs), and AT&T. Among the LECs are the Bell operating companies (BOCs) and independent companies (ICOs). Note that LECs and AT&T represent telecommunications companies which are as partially regulated entities and thus provide telecommunication service to all demanders. Other common carriers (OCCs) include competitive interexchange carriers and cellular radio carriers.

This first subgroup, public NSS, will be the primary provider of future broadband networks. Currently, these organizations have a formidable communication infrastructure and together as a group, have the most expertise and experience in telecommunications. If they are to be regulated as a public utility, they will be obligated to provide high-quality, low-cost service. They also represent the largest asset and revenue base in the communication sector, thus enabling them to finance the huge capital requirement of UBN deployment.

The second subgroup is private NSSs. Among private NSSs are local area networks (LANs), metropolitan area networks (MANs), and value added networks (VANs). Private NSSs provide network communication on a private, as opposed to *strictly* common carrier, basis. The important difference between common carriers in public NSSs and private NSSs is that public common carriers face many regulatory restrictions, while the private carriers face none. As technology, deregulation, and distributed network processing advance, we expect further growth in private NSSs. The role of private NSSs in UBN technology is unclear; but certainly, they will serve to extend the functionality of UBNs to the customer. They may also play an important role if UBN "islands" become the trend in technology adoption.

The last major subgroup of NSSs are the Video NSSs, which offer different distribution and delivery systems. Video NSSs include cable television, broadcast television, and satellite television. These are politically potent entities, and have already begun to vertically integrate into MANs. Cable firms are rapidly deploying fiber-backbone for their systems. Technological developments since the publication of Egan's book suggest that ATT and the cable industry together could form a formidable competitor to LECs.

Besides the NSSs, other supplier-stakeholder groups include the powerful print and movie industries. Newspaper, as electronic mass media providers, have a vested interest in keeping advertising out the hands of telcos--witness their opposition to telco video yellow pages. Similarly, the suppliers of information (i.e., Enhanced Service Providers) and entertainment (i.e., movie distributors) have a stake in current arrangements: new entry could change the distribution of rents to current suppliers. In general, public policy cannot block innovations for extended periods, but policy does determine the timing, specific form, and ownership patterns of new technologies. In some cases, delays have been extremely costly.[1]

SYSTEMS IN TRANSITION

As supplier groups and stakeholder groups identify their optimal strategies in the deployment of UBN (broadband) technology, Egan expects certain issues to arise. The deployment of narrowband ISDN capability will only complicate matters, since broadband capabilities will cut into this market. The ultimate adoption of national and international standards on UBN technology will facilitate the deployment of UBN technology, damaging those who are locked into narrowband. Certainly one of the most important issues concerning any new technology is that whether regulators understand the potential benefits stemming from associated investments. The perceived value of new technology is likely to be low initially, deflating the demand for applications of the new technology. Egan argues that the true social value of the technological capability is much higher. This creates a tension between those "visionaries" who see vast potential (including a high option-value for UBN) and "realists" who desire cost-effective communication technology today.

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[1] The magnitude of the cost has been estimated at greater than $86 billion for the FCC's 10-15 year delay in licensing cellular telecommunications. See "Estimate of the Loss to the United States Caused by the FCC's Delay in Licensing Cellular Telecommunications," by Jeffrey H. Rohlfs, Charles L. Jackson and Tracey E. Kelly, National Economic Research Associates, Inc., November 8, 1991.

While it is true that UBN technology will offer new revenue opportunities for suppliers, suppliers must also deal with finding a niche for current narrowband technology. Considering the amount of capital invested and the infrastructure already built, current suppliers might not be as eager as expected to deploy UBN technology which creates substitutes for their services. Note that UBN's will be capital-intensive and that capital recovery cannot be unduly delayed, since capital shortfalls would stall technological progress for UBN.

The next question considered by Egan is fundamental: Is a comprehensive national plan or an array of little plans best for deployment of UBN's? A "catch-all" *Comprehensive Plan* may be better able to mesh narrow and broadband technologies together into one reliable system. Furthermore, a comprehensive national plan may minimize total capital requirements, and may be better able to coordinate a concerted capital recovery plan. An array of little plans, financed through private markets, may be unable to raise sufficient capital, given the risks of delayed capital recovery. Egan notes that with a national plan, some stakeholders and suppliers may be left out; this raises the question as to whether a national plan can satisfactorily address the concern of all involved. Though no public consensus on this matter has emerged, it is reasonable to assume that even in a competitive environment, long term customer contracts and/or regulatory mandates (and/or oversight) will still be necessary.

"Little plans" that emerge from the free market also have merits. The debate over high-definition television (HDTV) between using digital signals and analog standards offer some insights that favor competitive settings. The Japanese and soon-to-follow Europeans, aided by government industrial policies, have created HDTV using analog technology. Certainly, evolving digital technology is the better of the two, but politicians, joined by Japanese industrialists who were unable to see beyond their sunk costs, were unwilling to take leadership in the newer digital HDTV technology. The political design of a industrial policy may yield a gerrymandered system that so sub-optimizes that the resulting UBN is a Universally Botched Network! Competitive markets allow better technologies to evolve--unlike the singlemindedness of an "industrial-bureaucratic complex." They also encourage firms to explore demand elasticities, since markets are less susceptible to bureaucratic inflexibilities. On balance, however, Egan recommends a comprehensive infrastructure approach to the network--recognizing that multiple centers of initiative would promote service innovations once the network is in place.

POSSIBLE SETBACKS AND THE FORMATION OF ALLIANCES

Since UBN capability requires fiber access for users, there are a few possible scenarios in which UBN deployment may be hindered. The contingencies may affect the demand for and capital funds available to UBN suppliers. First, continued reliance on coaxial cable for cable television service will delay the transition to fiber optical cables. Second, expanded use of rooftop dish reception for direct broadcast services (DBS) will further reduce UBN demand. Third, evolving private digital radio carriers to support "wireless loops" for narrow and broadband communication will also reduce UBN demand. Though all three serve as viable competitors in the telecommunication market, Egan recommends that we not lose sight of the long-term social value of an UBN system. The existence of all four technologies (fiber, coaxial cable, DBS, and "wireless loops") competing will promote technological advances; but, these substitutes may hinder the growth of a UBN system. To the extent that a UBN system has characteristics of an intertemporal public good, the added external benefits of an UBN network may not be realized initially. Therefore, the long-term success of any of the three contingencies will diminish the demand, and revenue support, for UBN deployment. However, with increased concern for *reliability* today (i.e., an adequate back-up system), having multiple independent technologies may be advantageous.

However, if the broadcast industry aligns itself with the telephone companies to use fiber distribution network, then the continued expansion of cable television or other local distribution technologies would have a smaller negative effect on UBN deployment. These broadcast-telephone coalitions are not yet assured. The broadcast industry itself is a very competitive business. Satellite technology also is very competitive on an international scope and may deter the broadcast industry from pursuing coalitions with telephone companies. In the video entertainment industry, being first with a new product is essential in retaining market share. Thus, if a suitable distribution alternative gets a firm first to the market, then that system will be preferred initially. Seeing that DBS, coaxial cable, and VCRs will probably be first to utilized advanced television (ATV) products before fiber, then fiber may not win much support from the broadcast industry. This development would reduce the chances of broadcast-telephone coalitions.

Another strong reason against the emergence of these coalitions is that many broadcast firms view telephone company-provided UBNs as a substitute, rather than a complement, to their business. However, broadcast firms also view telephone networks as another distribution channel, and as an alternative to cable. Alternatively, broadcast firms may merge with the cable industry, if broadcasters buy into DBS production, programming and distribution interests. Furthermore, if telephone companies vertically integrate into programming and production, they would threaten the broadcast industry and alienate some other stakeholder groups. Recognizing that many service supplier groups would only advocate UBNs as long as they are distribution networks being offered on a common carrier basis, support for UBNs would vanish if telephone companies vertically integrated.

ADDITIONAL ISSUES

No brief survey can capture all the insights from what may be the most comprehensive book on the subject to date. So we wrap-up by examining some additional issues which complicate private and public decision-making in this emerging sector. Consider UBN technology adoption and deployment, the current trend is for telephone companies to be primary UBN infrastructure providers. But as more stakeholder coalitions are formed and supplier cooperation expands, society will be confronted with dramatic new technological opportunities. Egan argues that public policy should be aimed at eliminating current status quo stance that encourage "fragmentation of public communication networks." He believes that "current political and institutional arrangements are not compatible with the new technological considerations." However, how does one ensure that public policy is both flexible (accommodating to new technology) and predictable (enabling firms to make the capital commitments needed for UBN)? Egan comes down on the side of public infrastructue investment--based on LECS. He also foresees competition among service supplier groups--providing a wider range of broadband service applications than in centralized (unitary) communication networks of other countries.

Problems exist in this transition scenario. As noted, telephone companies initially will be the primary UBN infrastructure provider, and thus vertically integrated. Cooperative and productive deployment might be delayed as some stakeholders seek favorable treatment via political processes. Incentives for further technological advances could also be curtailed under some forms of regulation. If other supplier groups feel threatened by telephone company entry into their business, then support for UBN deployment would be highly unlikely. Most notably, the cable television industry may very likely view telephone company entry as a business risk to its viability. Currently, financial arrangements between the two industries are promoting some cooperation, but this situation is fragile.

Two further issues in the deployment of the UBN infrastructure are the effects of direct broadcast service (DBS) technology and the adoption of advanced television (ATV) technology. Certainly, the feasibility and timing of replacing traditional broadcasting facilities with the UBN network complicate the transition. In addition, customer information and copyright protection on works transmitted over the UBN network remain problematic. However, if free marketeers and social infrastructure advocates can avoid excessive polarization, there is hope. Egan identifies links between industry structure, corporate behavior, and market performance that can serve as guideposts for decision-makers.