Future Video Networks
An Alternative Scenario

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Chapter 1: Introduction

Broadband systems have emerged as the blueprint for future telephony networks. Using fiber as the transmission medium, the network would in theory be capable of transmitting all types of information, including voice, data, and video, to both business and residential customers. The primary reason for their emergence in the past two years has been the realization in the telecommunications industry that fiber could be placed in the local loop. First implemented just over a decade ago, the price of fiber optic cable has since dropped dramatically in price, while its capacity has substantially increased.[1] Because fiber is already used in the telcos trunking and interexchange networks many are now assuming that its diffusion in the local loop is inevitable.[2]

The importance of the new networks is clearly in their potential to transmit video, and specifically, entertainment video, through the phone network. The planned integration of voice, data, and image over a single pipeline sounds nice, but it is not at all necessary for most business or residential users. Standard ISDN, operating at either 144 Kb/s or 1.5 Mb/s will be quite sufficient for voice and data needs. Few households will want 150 Mb/s in order to download expert system software for the purpose of browsing through a data base. Videotelephony is also a sexy application which seems appealing. Having been available since the early 1970's, however, it is not clear that residential users demand such a service. The essence of fiber networks is the distribution of video to the home providing users with a better signal quality and program selection.

The prospect of the telephone companies distributing video to the home has naturally alarmed both the cable companies and some policy makers. The cable companies, invoking the Cable Act of 1984, which bans telcos from operating a cable franchise in their local exchange area, argue that the phone companies could subsidize their fiber network with telephone revenue and undercut the local cable franchise. The telcos respond that a fiber connection to the home could provide viewers with more viewing options, that is, through their cable system, as well as enhanced services like video on demand or high definition television (HDTV). [3]

There is a common assumption, then, that the telcos and the cable companies are set for a confrontation to determine who delivers video to the consumer. The company which first wires the home with fiber, it is thought, will effectively control all access to it. The trade press, eager to report such a battle, eggs the two sides on with magazine covers like 'Will Telcos and CATV Square Off?'[4] Meanwhile, policy makers wonder about the economic utility of having two transmission mediums, each capable of delivering video, linked to the home.

The discussion about broadband networks, however, has reached the point where too many assumptions are being made about a future which is far from certain. Current debates about fiber based systems are being discussed from the telcos perspective which assumes that these networks are inevitable. Similar to the early days of ISDN, the telcos, through their researchers at Bellcore, are dominating the literature, seminars, and conferences with various fiber scenarios. Critics, who must first digest the implications of such scenarios, naturally react to them as if they were already in place. It is prudent of commentators who wish to mold future networks for the public good to assume that they will come to pass. But there is also the danger in looking at the future from one perspective.

Alternative scenarios are needed to challenge the assumptions about fiber based networks which have arisen in the past two years.Such a scenario would not posit a future in which either the cable companies or the telcos have the upper hand, nor would it argue for a specific local loop architecture. At this point, the best method for constructing a plot is to start at the present and plod forward making modest assumptions about technology, law, and economics.

Much of the broadband literature ignores the role that current video players will play in the development of video transmission over fiber. Cable companies, to be sure, are mentioned prominently as one combatant in the future battle over who will control video access to the home. But when discussing cable companies, commentators are considering them as they would exist in the future, and not as they exist today. Baer expressed this assumption well. 'It's very clear that the future of wired broadband distribution will be all-digital, switched and probably fiber optic. But today we start with a video distribution system which is one-way, analog, and based on coaxial cable. So how do we get from where we are today to the broadband ISDN vision of the future?'[5] Why is the evolution from the present to the future such a puzzle? Assuming that we will not wake up one day to find that the telcos or the cable operators have installed a digital, switched two-way video system, then it is safe to think that fiber based systems will evolve from current video networks.

Another player completed slighted in the broadband literature is the broadcasters. Although they have been in the business of providing video programming since the 1930's, there is little mention of their presence in the brave new world of broadband networks. But it should be obvious that the networks will play a part in the evolution of video over fiber from the present to the future. The broadcasters are an established, resourceful, and powerful player, who have, in fact, already installed fiber into parts of their network. Like the cable operators they will have much to say about the initial diffusion, and subsequent development of video transmission over fiber.

The fixation with the telephony scenario has also obscured the technology which will drive future video networks. The telco industry rants and raves about the power of fiber as a transmission medium for video. It will be more than capable of delivering HDTV. The future of entertainment television does not, however, lie with the adoption of HDTV. The innovation will certainly influence the industry. But the influence will be similar to that of color television. Viewers will like it, and pay for sets which are compatible with it, but will it induce them to watch more television?

The problem with the HDTV argument is that it assumes that viewers respond more to the appearance of a program than to the ability to determine what that program will be. The lesson of the past fifteen years is that viewers want alternative programming sources. While critics may argue that there is little difference between network, cable, and independent programming, the rise of the latter two argues that viewers perceive that there is. The rapid diffusion of the VCR in this decade further testifies for viewer demand for alternatives.

The important technology for the future of entertainment television is the computer chip. The chip will allow video producers to give the viewer more control over what they want to see. The implication for something like video on demand is that viewers could request a program and have it sent to them by the vendor. This is a processing, as opposed to a transmission, application. The ability to manipulate video as a digital bit stream will be critical in the process of supporting viewers with more programming options.

The third thing missing from the current debate is any sense of history. Because the debate is conducted from a future point of view, here is seemingly no need to discuss broadband systems in relation to past telecommunication technologies and services.

Looking at such systems from the present, however, one can not help but be impressed by recent history. For it is precisely this perspective which identifies the chip rather than fiber as the crucial future video technology. The value in the historical view is that one can examine the way that innovations actually diffused, if they diffused at all.

The telco broadband network would be a system of vast complexity. Its installation would entail the retrofit of the majority of current plant, as well as the diffusion of new hardware and software in the network and among consumers. History suggests that such a system will evolve in stages, over a long period of time. The first stage of development will almost certainly occur in the plant of potential service providers. For it hard to think of telecommunication service involving both transmission and processing which did not first seep its way through the network and then appear as an application. Current scenarios are completely ignoring this fact, and are treating broadband networks as if they were in some way blessed.

What is needed, then, is some good short term, contrarian analysis. This paper will examine the distribution of entertainment video over fiber in the next ten to fifteen years. The paper builds a scenario by using the present as a baseline case, and then proceeds into the future. This is in contrast to standard broadband scenarios which assume some future and then work back to the present.

The paper addresses three major questions: what will diffuse, how it will diffuse, and what effect the diffusion will have. Chapter 2 examines the first question. It considers the future from the perspective of current video players, and specifically the use of fiber by the players in the short term. The chapter establishes that a telco broadband network is at least a decade away. Given this time lag, it is not too speculative to assume that the broadcasters and the cable operators will themselves install fiber to cut costs and improve quality. But it also follows that the players will develop the video processing technology necessary for the something like video on demand. Considering the future from this perspective, then, two things will diffuse in the next decade: the use of fiber as a transmission medium for video, and the digitization of video programming.

Chapters 3, 4, and 5 discuss the actual diffusion of fiber and video processing. Chapter 3 looks at some past telecommunications innovations as a guide for how innovations diffuse. Lessons pertaining to why innovations are initially used, where they are placed, and how they effect applications are then applied to both fiber and processing.

Chapter 6 then looks at the implications of the scenario. It addresses how the use of these innovations will affect the roles of both the broadcasters and the cable companies. It seeks to establish some basis for determining the relationship between a the video players and the telco if the latter implements something like a broadband system.

The paper's purpose is more to provide some foundation for determining what will happen in the next ten to fifteen years than it is to comment on the merits of some scenario. it is hoped however that policy makers will find some use in an alternative scenario.

Chapter 2: The Case For Current Players

The future of entertainment video lies in the diffusion of both fiber as a transmission link, and of the digitization of video so that it can be processed. This chapter will develop the argument that the evolution of the distribution of video over fiber will be initially driven by current video players, namely cable operators and networks. While the rest of the paper discusses how technology will diffuse, this chapter examines what technologies will diffuse.

The basis for the assertion that the cable companies and the networks will drive the short to medium term evolution of video over fiber is simple. Broadband systems, that is, public telephony networks operated by the regionals, are least a decade away. The chapter's first part gives a detailed assessment of the hurdles that must be overcome before such a network could be installed. During this time current players will install fiber into their trunking networks not to build their own broadband systems capable of transmitting voice, data, and video, but to cut costs and improve picture quality. Fiber will initially diffuse because it will be competitive as a transmission medium in certain situations than other, existing media.

As time passes, however, the networks and cable companies will see that fiber is the best medium for transmitting digital video. In this context, digital video does not refer to standard analog video which has passed through a codec. Digital video will be signals which are recorded and edited by the producers for the purpose of being processed by users. At first this processing may involve something like picture within a picture on a television screen, but the capabilities will increase to the point where something like video on demand is entirely possible. Having used the technology for several years, current players will be in a good position to profit from it.

Enthusiasts' claims notwithstanding, the installation of a switched, digital, fiber optic telephony network faces huge barriers. Five factors which argue against its immediate diffusion are insufficient technology, high costs, lack of demand, regulatory uncertainty, and lack of players.

The technology for such a network is simply not yet available. Much work needs to be done on optoelectronic devices, switches, and multiplexers. While the telcos claim that they have the switching capacity now for high bit rate services, the switches are in fact rudimentary prototypes whose capacity is limited. When asked about the Heathrow trial conducted by Southern Bell, for example, an executive for the company admitted that its 'broadband switch' was in fact capable of providing video on demand to eight customers at a time. When the customer wants to signal the network, the executive continued, he must place a telephone call. At this time the network will release an analog video signal which can be switched. [6]

Further technological problems include the complete lack of experience with video signal processing which will be necessary, almost no software to run the switches, and the hardware necessary to direct the signal from the user's interface to appropriate terminal in the home. [7]

While the price of fiber cable itself has fallen dramatically over the past decade, the cost of installing a fiber network capable of distributing video is currently extremely expensive. Any assessment of the cost of a broadband network assumes some architecture, that is the type of switch, the bandwidth available etc. Sirbu [8] estimates that a network capable of 150 Mb/s which reaches 60% of the customer in a local loop would cost about $1500 - $2000 per subscriber. Lynch estimates that a network providing two channels to 200 homes would cost $7000 per residence. [9] Northern Telecom, on the other hand, states that a complete, digital system using wave division multiplexing would cost $18,000 per subscriber. [10] Because Northern Telecom assumes a system which would work under the assumptions of a functional broadband network, that is, high capacity switches, sophisticated optoelectronic devices, digital video, and other necessary hardware, their numbers are probably the most accurate. The cost of installing a system in one exchange area today, at $18,000 per customer, assuming one local loop contains 10,000 customers, would be $180 million.

Even if a system were installed it is not clear that there would be sufficient demand for its services. Those who have seriously attempted to forecast future demand state that, conservatively, about 30% of those connected to the network would use its enhancements. While this figure assumes services like video telephony, and thus understates the use of something like video-on-demand, it is prudent to believe that initial demand will be low. [11]

A fourth factor is the legal uncertainty of a fiber network which would deliver video programming. Any move by the telcos to provide such services would surely be contested by both cable operators and broadcasters, both of whom would turn to Congress and the courts for protection. Because many parties, including the courts, Congress, the FCC, the Justice department, are currently involved in the regulation of telecommunication policy it is far from clear how the issue would be resolved. This uncertainty would be sufficient to block telcos from offering video services. While the telcos may receive waivers to conduct tests, as GTE has in Cerritos, the installation of an operational network would probably need more authority than a waiver from the FCC.

Finally, there is a lack of available players. The telco scenario assumes that they will have programming to offer users, either direct broadcasting or video-on-demand. There is some question about where such programming will come from. If, as currently seems likely, the networks and cable operators oppose the network described above, then the telcos would have to purchase programming from willing producers, many of whom might not want to jeprodize relationships with their distributors. The result would be that the telcos would offer vastly inferior programming.

The immediate prospects for a complete, fiber network, then, are not bright. The diffusion of some of its parts in the short term, however, is a distinct possibility. For fiber, like the satellite, is not exclusively a telephony technology, it is a telecommunications technology. Contrary to the assumption by many that video distribution by fiber is some kind of natural step in the evolution of the regional operating companies, fiber is available to current video players, who see it as an alternative to other media for specific, well defined plant applications.

The reason for the emphasis on the telcos as future video distributors is that many are fighting the last war. Having just witnessed the creation of the data communications industry, many see video as another type of data which could be transmitted through the public telephony network. The name 'Broadband-ISDN' speaks volumes about the assumed telco role in video transmission by fiber.

Twenty years ago it was entirely natural for the phone company to provide data services, such as DDS, to users who increasingly wanted to send computer files from one location to another. As computers, mainframes and minis, diffused, so did the demand for links between them. With the tacit acceptance of computer manufactures, and the encouragement of users, the telephone industry both modified existing analog lines and built new digital lines, and essentially created a new network.

While regulators recognized the need to limit the extent to

which the telephone companies could control this new network, there were few voices disputing the claim that the telcos should build data networks at all. For who would have built them? It was not until the mid 1970's that packet networks began to diffuse, and computer manufacturers like
IBM, DEC, or Sperry did not have the technical or economic resources to enter the data communications market.

The video communications market is completely different. It is currently ruled by powerful and resourceful players. As a transmission medium by which to distribute video to homes, fiber at this time offers little benefit to cable operators and no benefit to broadcasters. But as a distribution medium for feeder applications, fiber now offers some cost and quality advantages. As the medium's price further declines and it power increases in the future, the broadcasters and cable operators will find more advantages to using fiber in their own trunking systems.
The role of the telcos in the establishment of the data communications market was to provide links to users where none had previously existed.

The situation in video is almost the exactly opposite. There are several distribution media of which fiber is the most innovative. Current video players, to be sure, are not going to retrofit entire systems to install fiber. But they are also not going to ignore the present and future benefits of using the medium now in parts of their networks. As the telcos develop the technology for a broadband system, the cable and broadcast players will be driving the initial diffusion of video over fiber.

The essence of a broadband system is that video could be sent over fiber and switched at some point to provide users with the ability to request specific programming. If fiber is in place there is an assumption that the hardware is the vital element in a system capable of effecting user video requests. 'Cable systems have the video distribution links without the switches,' the argument goes, 'and telcos have the switches without the video links.'[12] But it is important to realize that the switch itself will only serve to redirect digital bit streams. An important and often overlooked question is where those bit streams will originate.

The common assumption is that standard analog video will be sent through a codec to produce the desired signal. It is unlikely though that the digitization of video will be limited to its transmission. The past five years in fact have witnessed the rise of the digitization process at the production end of video. Technologies like the videodisc and computer graphics, both of which merge analog and digital signals, are guides to the direction in which video production is heading.

The influence of these technologies on entertainment video has to this point been minimal. As chips become less expensive and more sophisticated their diffusion among cameras, editing machines, and other equipment used in video production will accelerate. Fiber's role in the future will be to transmit signals which will already be digital.

As video producers themselves as well the primary distributors of others' video, the cable companies and broadcasters will certainly use the latest production technology. They will be the ones who will develop and use the technology required for the transmission of a digital bit stream which can be switched. Like the use of fiber as a transmission medium, however, the players will not initially use video processing technology with an eye toward how they could use it in a future system. The technology will take years to develop, and it will first be used for very mundane purposes like piecing together a news story which requires vast amounts of editing.

Video over fiber entails both the use of the medium as a distribution medium, and the digitization of the programs which will be transmitted through it. While fiber is blessed with tremondous bandwidth, its long term role will be to transmit digital programming. Evolving separately, the two technologies will soon complement each other, and form the basis for new networks.

Chapter 3: Lessons from the Past

The particular path of development of fiber and digitization will depend on the manner in which each diffuses. Before considering the ultimate effect of these two technologies, it is necessary to first identify why they will diffuse and how they will diffuse. This chapter will look at past telecommunication innovations as guide to questions about diffusion. The discussion is more concerned with general principles which can be applied to both fiber and digitization. The clues found from past diffusions will be used in the next two chapters to chart the technologies' course.

Two types of innovations will be examined: transmission and processing. The innovations considered below are taken from the broadcast, cable, and telephony networks. The objective in this chapter is to determine the differences, if any, between the diffusion patterns of processing and transmission innovations. Special attention will be paid to why new technologies are used, where they are initially placed, how they effect applications. While the factors influencing an innovation will have much to do with the particular industry in which it was employed, there are some similarities shared by several industries. The cable, broadcast, and telephone industries, for example, can all be crudely divided into plant, feeder system, and distribution system to the user. Lessons from innovations which diffused in the plant of telephony networks can be applied to innovations in the cable or broadcast plant.

One must first recognize, however, that, in terms of diffusion, there are two types of innovations. The first represents the substitution of a new type of equipment, while the second requires the change in the behavior of the user. [13] The first kind of innovation replaces what had existed; normally its diffusion is transparent to the user. The word 'transparent' means that the user who receives the service from the network's distribution system has no knowledge or perception that the substitution has been made. A good example of a transparent innovation is the use of digital switches by interexchange carriers. Though the replacement of crossbar switches with digital switches was a major step in the evolution of the telephony networks, the affect on the user was minimal. The new switches were placed in the network without the user's knowledge and served only to lower the cost of switching for the telcos.

The second type of innovation is more complex. For the purposes of this paper these kinds of innovation will describe new services which do not entail a substantial change in behavior. The introduction of a new cable television channel, devoted exclusively to baseball, for example, is hardly transparent, but on the other hand, its diffusion does not entail a tremendous change in behavior; the change in behavior will be watching the new channel instead of others. This is in contrast to an innovation like videotex which clearly does require a substantial change in behavior. In the discussion below, then, transparent innovations describe the use of technologies whose initial use has no affect on users, while behavior changing innovations describe new services for which the change in behavior is not drastic.

Processing innovations describe new products which use digital technology to in some way manipulate information for some intended effect. These kind of innovation fundamentally change the internal operations of a product or service. The T-1 carrier, the digital switch, and packet switching are all examples of processing innovations. While the T-1 carrier describes a transmission service, the first carriers were used to digitize analog signals for multiplexing purposes. There are four notable items about processing innovations.

The first is that they are transparent to the user when initially used. They are substitutions for old equipment. The T-1 carrier, for example, replaced analog lines operating at a much lower speed. The digital switch replaced dated electro-mechanical cross-bar switches which had become obsolete. In both cases, the user had no knowledge or perception that digital technology was being used. Processing innovations are first driven by cost and quality; they provide the same service to the user with quality matching, if not better than, their predecessor. The innovations are used because the vendor wants to provide more efficient service.[14]

Following naturally from the first item is that processing technologies are implemented first in the deepest bowels of the network and work gradually toward the user. The innovations are used to cut costs in strategic parts of the network where new technology can help make the network more efficient. The T-1 was applied to long distance traffic where AT&T could realize immediate gains from multiplexing more signals from say, New York to Los Angeles. Similarly, the first digital switch, the 1ESS, was installed at the highest levels of AT&T's hierarchy, where the maintenance and labor costs of switching inter-toll traffic was high. Having been applied to the lines and equipment most embedded in the network, processing technology has gradually moved toward the user where today almost half of the central office switches are digital, and interexchange calls are digitized.

The reason for the movement from within the network toward the end user is that the use of processing innovations creates a momentum which is hard to stop. The introduction of digital transmission lines led to the introduction of digital switches. Having worked on digital toll switches, the phone company applied the technology to class 4 switches and finally to class 5 or central offices switches. There comes a point, which is by no means inevitable, when the network will be defined by the initial innovation. In the early 1960's when the T-1 carrier arrived, few perceived the telephony network as an emerging digital system. It is also not the case, however, that digitization will extend all the way to the user to the point where phone calls are digitized in the local loop. This is the trap that the fiber scenario is caught: that because fiber is in the network feeding system it will inevitably be placed in the local loop. The important point here is that processing innovations create an irresistible momentum so that if the technology works at one level of the network it will applied to other levels to the point where the network, excluding the final link to the user, will incorporate the applications of the first innovations.

The final point is that the applications which these innovations effect are both slow in developing and rather ordinary in their appearance. The '800' service, which has blossomed in the past five years, is the direct result of innovations first introduced in the 1960s. Audiotex is another example of an application whose arrival in the past two years follows from digital technology, but in relation to sexier applications like videotex or celluar telephony, is rather ho hum. Processing applications first influence the network before they influence, by means of applications, users.

The effect of transmission innovations depends on the context in which they are used. If they replace other media and perform the same function, they will diffuse gradually and transparently. The innovations will be driven by cost and quality factors, and be installed in the plant. An example of such an innovation is the introduction of the satellite by the telephone company. The satellite offered a cheaper way to transmit phone calls between distant locations. It replaced microwave transmission for long haul connections, but performed the same function as its predecessor. The use of the satellite merely allowed AT&T to transmit calls at faster rate, it did not allow the phone company to offer new phone services to existing customers.

In other contexts, however, transmission innovations can immediately effect applications. The use of a new transmission medium can permit communication which had been infeasible with existing media. Two good examples of this kind of innovation are digital transmission lines and the use of the satellite by broadcasters and cable operators. The T-1 carrier introduced digital transmission. While its impact on voice users was minimal, it instantly provided data users with a link which had not been feasible with analog lines. Companies with mainframe and mini computers used the digital services of the phone company to send large files at high speeds.

The use of the satellite by the video players also gave them the ability to immediately offer new applications, which in their case was new programming. For the broadcasters, this meant the ability to provide live coverage of news, special events, and sports. The transmission of the first man walking on the moon, the signing of an important treaty between the Americans and the Russians, or the broadcast of an Olympic event undoubtably gave the networks a boost.

The cable operators parlayed the satellite into more significant gains. In the 1970's the industry used satellites to efficiently connect various local networks. The rise of HBO, Cinemax, Showtime, and ESPN was the direct result of the ability to cheaply transmit programs to geographically dispersed locations. While the cable operators in the 1960's had given users a clearer signal through coax, they did not have programming even remotely comparable to the networks. A major reason for the increase in programming quality was that operators could use the satellite to transmit programs to selected locations. This created economies of scale for operators who could use the satellite to transmit programming from a single location to many locations without having to construct a microwave or coax feeder network. With more local systems being fed by a single earth station, programming costs could be spread over more users. The satellite, then, quickly effected new applications for the cable industry by creating a distribution system which had not been feasible with existing media.

The difference between processing and transmission innovations is that the later have the potential to more rapidly create applications. Processing innovations are almost always substitutions for existing equipment. Their installation is directed by the network's desire to cut costs and improve quality, and is transparent to the user. If they succeed in reducing costs they will be applied to other parts of the network, and may possibly become the technology by which the network is defined. The applications which follow from processing innovations are incremental and develop slowly, but in the long term are significant.

Transmission innovations differ from processing technology only if they can create links which had not been feasible with existing media. If the transmission innovation cannot, meaning that there is not sufficient demand for the new application, then these innovations act very much like their cousins. They are substitutions, and go into the plant where they gradually influence the network's direction.

Chapter 4: Fiber as an Alternative

Having put forth a crude model explaining why and how certain innovations diffuse, it is now fitting to consider the actual diffusion of fiber within the cable and broadcasting plant. The concern here is not with the installment of fiber as it might exist in the future, that is, transmitting video digitally, but solely with its use as a substitution for other media. The focus is on fiber as a transmission innovation.

The actions of both video players in the past year confirm the assumption that the medium will initially be used in specific contexts and perform such mundane functions as improve costs and quality. There is little indication in the plans of either player that fiber represents the crucial link to the future of their business, in the sense that forestalling its use will displace them. Having placed fiber as an innovation into its proper context, the chapter will examine the evidence of its recent use, and then suggest how the players will expand the mediums role in the near future.

One must first consider, then, the nature of fiber in relation to current video players. From this perspective, it is clear that fiber is just another transmission medium. It competes with existing media like microwave, satellites, and coaxial cable. Fiber at this time is not a transmission medium whose immediate use could develop new applications, like a new source of programming, which are currently not feasible using existing media. This is certainly true for the broadcasters whose distribution system is based entirely on radio frequency. But it is also hard to see how the cable companies could use fiber now as a means of introducing new applications which would not entail a significant change in behavior.

The initial diffusion of fiber will most likely be transparent. The medium will serve as a substitution for existing transmission systems. It will replace old equipment. Driving the diffusion of fiber will be the desire by cable and broadcast operators to reduce costs and increase quality. The initial deployment of fiber will likely be in the network feeding system. For cable operators this would entail placing fiber from the headend to specific distribution points in the network. The broadcasters would lay fiber between specific parts of their network.

Empirical evidence confirms this assumption. ABC, for example, recently replaced its New York to Washington microwave link for its 'Nightline' program with an fiber cable purchased from AT&T. The reason for the switch to fiber was a 30% reduction in savings. 'Cost is the key,' explained an ABC engineer, 'we will stay with fiber as long as it saves money.' [15] ABC's decision to use fiber for this link is indicative of how fiber will initially diffuse in broadcasting networks. It is significant that ABC approached the situation strictly as a test to determine if using fiber to link Washington and New York for one late night program would save money. It was not the case that the network perceived the new link as a test bed for the delivery of HDTV or even as a substitute for all microwave or satellite links. Like the introduction of T-1 carriers, the initial use of fiber by ABC was in response to a particular network function, far removed from the network's users. Encouraged by the reduction in cost for one program, the network has now moved other programs including the evening news from microwave to fiber. In one context, fiber has proved superior to microwave. As the price of fiber decreases, it will prove to be superior on a cost basis in other contexts.

The use of fiber by ABC at the 1988 Winter Olympics is another example of the manner in which the medium is initially diffusing. Fiber's advantage in this context is again cost and quality. Instead of using either satellite or microwave to link events far from the studio, like skiing, the network used a fiber cable. The network also used fiber to connect all the sites close to the studio in a sort of local area network.[16] Like the link from New York to Washington, the use of fiber in this context is embedded deep within the network and completely transparent to the user. Like the intercity link this type of use of fiber will only increase in the future.

The use of fiber by cable is also accelerating. While cable magnates like Irving Kahn rant about how cable systems will consist entirely of fiber in fiver years, the majority of system operators seem to have a more pragmatic view of fiber's use in the next decade.[17] The industry, to be sure, does acknowledge that there is some kind of distant threat from the telcos, but most of the attention is focused on how fiber can be implemented in the next few years to increase network functionality and the quality of the video signal. At this time the industry is looking at fiber as to replace coax in the backbone network, and as a trunking medium.

The backbone network of a cable system is the connection between the headend and the various nodes in the field which serve to both regenerate the signal and further distribute it to the user. It is roughly analogous to the interexchange network of a telco. System operators are considering using fiber because it is cheaper than coax with no sacrifice to quality. The reduction in cost comes from the increased efficiency of a fiber backbone. A breakdown in a coax system might affect a disproportionate number of customers while a fiber backbone would affect relatively few. The reason is that a fiber backbone separates the network into more nodes, and more effectively isolates outage problems. A fiber system further cuts cost by reducing the number of amplifiers which are required to regenerate the signal. [18]

Supertrunking, the connection by fiber of a number of system headends, is the other way in which fiber is initially diffusing within cable systems. ATC, the second largest system operator in the industry, is considering placing fiber into 10-20% of its trunking network. [19] Warner Cable, which holds the franchise for cable television in part of New York City, recently installed a fiber trunk between its headend and its earth station. In relation to microwave or satellite, fiber is a more productive medium; it can pass more channels with less maintenance costs. [20]

Fiber will continue to diffuse in the near future in cable and broadcasting plants. Two applications of the medium by the players seem almost certain to develop in the next five years. The first is the use of fiber in situation specific events. In Washington, for example, the players might install a fiber link from both the White House and the Capitol. Rather than using a microwave link from these sites to their up-link site each time the President addresses the nation or the

Congress debates some important legislation, the players could lay a cable. This would increase the quality of the picture, and reduce the cost of establishing the link. Fiber would also work for sporting events where the vendor knows that each year it will transmit from a specific site.

The second application is the use of the medium as link between strategic points in the network. The networks, for example, will continue to use the medium to connect points where traffic is high. From New York to Washington, they will extend the medium from New York to Los Angeles or New York to Atlanta. For point to point applications the medium will increasingly be more attractive than microwave or satellite. The cable operators will use fiber for both backbone and trunking applications. In the former case, the operators will extend fiber farther and farther from the head end to the user. In trunking applications fiber will replace satellite links from, say, Los Angeles to Denver or San Francisco.

The diffusion of fiber among cable operators and broadcasters has almost nothing to do with new user applications. It is perceived by the vendors as an innovation which in certain contexts will reduce costs while increasing quality. As such it will diffuse within their plants, and coexist with existing media for some time. While fiber will allow cable operators to offer more channels, its use will not permit a new kind of programming, like sports or news, to be delivered over those channels.

It is significant that the cable operators are installing fiber to transmit analog video signals. This will almost certainly change in the future, simply because digital transmission will be cheaper, but it signals with great clarity the intentions of the industry with fiber. Interestingly, ABC's fiber link is digital, operating at 45 Mb/s. For both players, however, the medium will be used solely as a means to transmit current video programming. On its own it will not have the capacity to provide new services.

Chapter 5: The Emergence of Video Processing

Video processing is the manipulation of video information by the producer for the benefit of the user. Early examples of it include the television replay where sports fans can watch the home team score the winning touchdown over and over again, or the use of super slow motion where the tape is replayed at a about a quarter of its original speed. The VCR is also an example of primitive video processing. Television viewers can tape programs, and possibly omit the commercials, erase them, and tape something else. In both cases the video content is being managed for some effect.

In the past two years, however, this processing has developed to the point where, in certain special situations, the actual content of the video is either being directly altered or created by computers. The most esoteric example is the work on image processing by the space program. Using sophisticated hardware and software the Jet Propulsion Lab takes pictures sent to it by a spacecraft orbiting Jupiter and creates a video of very high quality depicting what it would look like to fly over the planet at an altitude of one thousand feet. More mundane applications have been Ted Turner's move to add color to older films which were shot in black and white. There is also the development in advertising where commercials are essentially a series of computer graphics placed on a video tape.

This chapter examines the emergence of video processing. Using the model put forth in chapter 3, it will first determine the initial implementation of the technology, and comment on the subsequent evolutionary path in terms of the technologies influence on applications. It will then examine the empirical evidence of processing's diffusion in terms of production and transmission.

Video processing will be driven by integrated circuits. These chips will perform analog to digital and digital to analog conversions, control complex editing functions, and provide the memory for video storage. As a processing innovation the chip will diffuse gradually, which is to say that its initial diffusion will take five to ten years. Like other processing innovations, the chips will be used because they will be cheaper and offer better quality in relation to the equipment they will replace. Their effects will at first be transparent to television viewers. If they perform well in their initial use, video chips will diffuse further throughout the production plant. While the initial applications will be incremental, the technology will almost certainly redefine the manner in which video is produced and transmitted.

Video production describes the way that video is recorded and edited. This role is currently performed by production companies, who create programming and sell it to the networks or the cable operators, the players themselves, who produce news, sports, and other special interest programming, and by advertisers who create the seemingly endless number of commercials primarily for the broadcasters.

In the past year chips have emerged in broadcast quality cameras. The initial use for them has been to perform very precise functions like white balance, registration, black balance, and auto centering. The chip allows the user to programm certain specifications to which the camera will respond in the event of a change in the lighting.

Last year electronic news gathering (ENG) cameras began using a imaging chip called the charge-coupled device. Replacing the vacuum tube as the means by which images are translated into electrical pulses, the chip yields a much higher quality image for moving images like sporting events. The advantage of the charged-coupled device is cost. The chips rarely need maintenance. Unlike vacuum tubes they never go out of registration. The chips last as long as the camera. Using less power, the innovation reduces the number of times that the camera must be recharged, and reduces the camera weight. Used mainly by networks and local affiliates for gathering news in the field, the chips will be introduced next year in cameras used in the studio.[21]

Digital video tape recorders (VTR) have been on the market for about two years. Sony delivered the first digital VTR in late 1986. Other vendors have introduced VTR's in the past year, thus upsetting the fragile standard for the digital recording which had been put forth by the Society of Motion Picture and Television Engineers. The first VTR's had recorded in a component format, meaning that the luminance and color signals were segregated all along the recording process. The second generation models, however, record in a composite format, where the three components are encoded together. The composite format is compatible with existing analog plant, and thus may be used, assuming the necessary digital to analog conversion is made, with current cameras or monitors. [22]

The VTR digitally records video. More advanced digital editing systems have recently appeared on the market. No less than five vendors have introduced digital video effects systems for use in on-line editing. The machines, which are basically advanced personal computers modified to work with video, allow the editor to manipulate a picture in terms of resolution or borders. Special effect generators and edit controllers have also appeared to complement the VTR in post production work. The former creates limited effects on the picture like graphics, while the latter automates the processes of the VTR. The edit controller, for example, will keep track of the edit decisions so that the location of the edit on the tape, and the actual edit, can be accessed from a disk. More sophisticated digital manipulation appeared last year with digital video interactive (DVI). DVI provides about one hour of full motion video on a compact disk. The signals are digitally recorded, unlike the videodisc, allowing processing such as zoom, rotate, invert, freeze, or other modifications. DVI is being marketed as a consumer product, and it is not clear to what extent technology like it is being used by professional producers. [23]

One application of digitization will be on the video production process. Another application will on the transmission of video. Most of the fiber which is initially placed into feeder networks will transmit video as it is, which is to say in analog form. Over time, however, digital transmission will become cheaper than analog.
The reason is that analog transmission requires costly repeaters to boost the signal while digital transmission does not. The initial diffusion of processing innovations in the production plant will culminate in the complete digitization of the video program. Prior to this development video will probably be sent in analog form over

digital lines. The first work which must be done, then, is to derive methods by which digital transmission of analog signals can be effected.

To this end, the first standards for the digital transmission of video were advanced in March 1982 by the International Radio Consultative Committee, CCIR. At this meeting the body unaminously adopted Recommendation 601, which specifies the sampling rate for digitizing component video. For recommendation 601, the luminance is sampled at 13.5 Mhz, and the two color components at 6.75 Mhz. The samples are quantized in 8 bit words. The resulting bit rate is about 216 Mb/s, which does not conform to the digital telephony hierarchy, and which is a little high for current fiber links.

The reason for the present incompatibility is that Recommendation 601 is a studio standard. It was designed with the transmission of video from one part of the studio to the other. The result is that the standard assumes a component format, when regular NTSC video is composite, and it requires excessive bandwidth.[24]

The initial technology which will drive the digital transmission of video over fiber will be the codec. Until about three years ago, much of the focus on codecs was directed toward the videoteleconferencing business. Using phone lines or satellites as a transmission medium, videoteleconferencing vendors wanted codecs capable of transmitting at very low bit rates like 1.5 Mb/s or 378 Kb/s. Only recently have researchers directed their attention toward codecs capable of high bit rates.

Various vendors have come forth in the past two years with codecs designed to effectively transmit video from the studio to the some distribution point. As is always the case with new technologies, there is no currently no standard like Recommendation 601. The issues surrounding a standard are a proper sampling rate and the quantizization level.

In early 1988, Bellcore, announced that they had developed a codec which transmits video at 90 Mb/s. To achieve this bit rate the codec both samples the components at a slower rate, and quantizes the samples with a 5 bit instead of 8 bit word. The heart of the codec is a multiplexer which accepts the individual components separately and them compresses them. Using current technology VLSI, Bellcore claims that the quality exceeds present NTSC quality. [25]

NEC has also introduced a codec capable of lower bit rates. The system is the one used by ABC for its transmission from Washington to New York. Though the specifications are not available, the codec operates at a rate of 45 Mb/s, which is the DS-3 rate in the digital hierarchy. Retailing for $50,000 the codec is at this time too expensive for local affiliates. [26]

Digital technology has emerged modestly in the past few years in both production and transmission. Like most processing innovations, the effects are completely transparent. The use of the digital VTR is hardly a major step for producers. But as chips become more sophisticated, and digital equipment more powerful, the reduction in programming costs will become more apparent. Assuming that costs are reduced, incremental applications, like better resolution, or multiple pictures on a screen, will begin to emerge within five years.

Chapter 6: The Implications of Diffusion

In the next decade and a half entertainment video will be increasingly produced using computer chips, and transmitted digitally throughout plants over fiber. Far from having a broadband system in which fiber is connected to every home, evolution over the next fifteen years will be focused on new network architectures for current players. The impact of this development will affect the networks and the cable companies much more than the television viewer. While the viewer will notice applications like more channels, picture within a picture, higher resolution, and interactive programs, the digitization of the video plant will indelibly alter the roles of current video players.

This chapter will discuss how the new technologies will shape the video industry in the future. It seeks to determine the logical conclusion of the use of fiber and processing by the networks and cable operators. Having discussed the basis on which the players will use the two technologies it is now appropriate to examine the outcome of the use.

The discussion assumes that both production and transmission technologies will continue to diffuse, gradually but inexorably, within the respective plants of both players. The chapter puts forth a future scenario under this assumption, analyzes what will be important in this scenario, and then discusses the likely effect on the functions of the video players.

The use of fiber by the players will extend farther and farther into their feeder systems. The broadcasters will most likely create a system in which all of their affiliates are linked by fiber. This would of course start with those stations which are owned and operated by the networks. Each network has about six or seven owned and operated stations, all of which are in large metropolitan areas, like Los Angeles, Chicago, and Washington, where the construction of a fiber link will be feasible. From these stations the networks will connect various other major affiliates around the country. The reason for establishing such a network will be cost; fiber links will most likely be less expensive than satellite or microwave.

The cable operators will continue to use fiber in both their trunking and backbone systems. The trunking system will consist of one headend to which a large number of local systems will be connected. The function of the headend will move back toward the programming source. Instead of having many headends serving many cable subscribers, the use of fiber will make it possible to have one headend serving several cable systems. While fiber will also move forward toward the subscriber, it is unlikely, though entirely possible, that existing systems will replace coax with fiber to the individual subscriber. What is more likely is that the feeding system will be fiber up to the penultimate point of distribution.

Processing will similarly advance. Codec standards will emerge, encompassing both the studio and distribution. As chips increase in power random access memories necessary for storing digital video will emerge. The editing process, which is now limited to enhancing the appearance of the image, will include the manipulation of the image itself. Technologies like digital video interactive will have huge storage capacities with which processors could work on specific parts of a picture. The result of these innovations will naturally lead to the ability to 'create' video from existing data. Having shot a scene with actors, processing equipment could change parts of the scene using the original as a guide, instead of shooting another scene. The applications of such an innovation would include having multiple plots for programs from which the viewer could choose. News organizations could also recreate in vivid detail an interpretation of what really happened in something like a highjacking or a natural disaster.

In the short term, then, say three to five years, the networks will have established a network linking them to their major affiliates by fiber. Video over these links will probably be sent in analog form. The cable operators will have a similar fiber video network, linking sources and headends.

Farther into the future, say five to eight years, both fiber and video will be digitized; that is the video will essentially be a digital product, and it will travel through the video plant over fiber lines. At this point applications like multiple plot, news creation, or just the digitization of older programming will begin to emerge. The networks will send a program to its affiliates by fiber where the affiliate will broadcast it to the viewer. The cable companies will similarly send a digitized program to its various headends who in turn will pass it on to the viewer. The final transmission to the viewer may be analog, although over time it will probably be digital.

In the longer term, eight to twelve years, the roles of the players will become increasingly specialized. The success of a video player will depend on what it can send over a network and where it can send it. As time passes the broadcasters will increasingly be at a disadvantage in terms of distribution. While the transmission of a standard video signal will not present a problem, programs which require a higher bandwidth, like multiple plots, will. The networks, furthermore, will have no means to upgrade the network so that a viewer could request a program. The cable operators will have the necessary bandwidth for future programs as well as the means to install a signaling mechanism for its viewers.

The broadcasters will, however, have important software, namely, both news and sports. The networks currently have the most sophisticated news operations among video players. While they have been challenged recently by the Cable News Network, CNN, the network news is the most resourceful and established. The situation is similar with sports. All the major sporting events, the Super Bowl, the World Series, the Olympics, basketball, tennis, golf, and road racing,are all on network television. Cable has recently made in-roads in this area by devoting entire channels to sports, and thus attracting the niche of sports enthusiasts.

The broadcasters and the cable operations are about even in terms of other programming. The networks have libraries of programs, like movies, to which they own the rights, but so does cable; Ted Turner, for example, recently purchased all the movies from a major film studio. The player who digitizes older programs must first purchase the rights to them, and both players will probably spend considerable money for the rights.

In the long term, then, it is likely that cable systems will merge with the networks. This would not happen on a national level, but at the affiliate or local station level. NBC, for example, would not merge with ATC, but ATC would incorporate NBC's local affiliates around the country. To this merger, NBC would bring a distribution network, and a specialization in producing news and sports programing. ATC, would bring cable systems already wired to the home. The cable operator would use the local affiliate as the link between it and the network. Viewers accustomed to tuning to channel 2, for example, could watch it, and even see the network anchor and correspondents. They could also see the local personnel to whom they are so accustomed. But on the same system they could receive programming from HBO, and have a request channel.

The implications for the networks in such a scenario would be that they would exist only as distributors to cable systems of their programming as well as older programming to which they have the rights. They would become something like an electronic Associated Press, United Press International, or Reuters. Their function would be to provide video to local systems, as the press services provide news to local papers. They might in addition produce certain other kinds of programming which would be available for sale to local networks either through their network or some other producers.

The implications for the cable systems would be that they would provide the link to the home through which viewers could either watch certain services, like HBO or Cinnemax, or request video from other producers. Shows which had been transmitted by the networks, like soaps, or prime time television, will most likely be produced by the cable operators, or purchased directly from the production company.

The networks will not whither away only to be replaced by the cable operators. The networks will remain an important video player, both as a producer and a wholesale distributor. While the cable systems will become a more important player, their role will increasingly be to provide the means by which viewers can access programming they want. Producers of regular programming will also become more important. They will be able to sell their programming more directly to the consumer. Starting with the direct transmission of movies, that is downloading what was once a videotape, into the VCR, producers will offer regular programming either daily or weekly, which the viewer can either choose to watch by request or skip.

Chapter 7: Conclusion

In 'Marketing Myopia' Theodore Levit wrote of industries displaced because they misjudged the nature of the service they were providing. The classic example is the railroads. Thinking they were in the railroad business instead of the transportation business, the railroads lost customers to both the emerging airline and automotive industry. [27]

Commentators in the telecommunications industry frequently suffer from what might be called future myopia, which is the misplaced optimism for emerging technologies. These commentators, for whatever reason, latch onto an innovation and claim that it will inevitably displace whatever currently exists. Invoking the principle outlined by Levit, they plot the future as a linear progression from the present.

The last fifteen years is full of technologies and services which were going to change everyone's lives. The videophone was going to revolutionize telephone communication; teleconferencing would change the way people worked; teletext would change the nature of television by making it more interactive; videotext would displace the newspapers and usher in the 'information age', and telecommuting would change the work place. The relatively meek manner in which these innovations have diffused suggests that real change is the exception rather than the rule.

The reason for the poor judgement is that applications of technology are frequently confused with technologies themselves. Rapid change is the result of new technologies. The effects of the microprocessor, automobile, radio, and television, all new technologies, have been very significant. Applications of these technologies, business software, the rotary engine, FM radio, and color television have been less significant. Forecasters frequently take the application of a technology, like videotex, and suppose that it will have the same effect as something like the automobile.

Looking at the big picture enthusiasts fail to realize that it is composed of many smaller pictures. The success stories of the past fifteen years have all been applications which effectively addressed some relatively small market, and whose scope was limited to serving some perceived need. The T-1 multiplexer, for example, which has boomed in this decade, merely provides digital service for users who want to install or upgrade a communication system. Local area networks provide an internal communication network. The VCR gives television users the ability to tape programs or watch movies in privacy.

Real change, then, comes about either through the introduction of some big technology or through the evolution of many, many applications of smaller technologies. The telephony network is a good example. The result of the complete digitization of the phone network, which will take at least a decade more, will be a network capable of sustain something like videotex, where millions of users use the network daily for routine tasks.

Fiber optics and video processing are not big technologies. The application of fiber and processing to video networks will result in real change, when viewers have something like video on demand, where a video network is essentially a distribution system for their requests, only after current video players have installed these innovations into their feeder networks. Like most successful innovations, fiber and processing will initially diffuse because they will reduce costs and improve quality. Fiber will reduce transmission costs and processing will reduce production costs.

The expected confrontation between the telcos and the cable industry is unlikely to happen. By the time broadband networks are in place, the current players will have progressed to the point where they will control both the software needed for such an operation, and a distribution system capable of delivering that software. It is conceivable that the telcos could offer their services for last mile distribution, but that is not likely. For it is entirely possible to create the same services a telephony network would offer without a switch or fiber into the home. Using the VCR or some other attachment as a storage medium, video could be sent as requested, stored in the device, and then played in real time.

The exact evolution of the current players is difficult to judge. What is clear, however, is that fiber and processing will cause more specialization. The effect is likely to be that broadcasters will cease to be retail distributors, and specialize in producing news and sports programming by means of their affiliate network. The cable companies will incorporate these affiliates into their networks. This will give them some local identity while continuing to provide myriad programming choices.

It is also clear that the distinction between broadcasting and cable will become increasingly blurred. It is not inconceivable that future networks will provide an array of services some of which are 'free' and some for which the viewer must pay, either when the program is ordered, or on a yearly basis. It is also clear that processing ability will allow the manipulation of content within the network, and thus render the concept of the common carrier obsolete. Regulators would be prudent to address some of their concern toward a future in which the role of the current players will substantially change, not by the introduction of telcos in to their business, but by the effects of the adoption of new technology.

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