A Large User Perspective On Broadband Telecommunications Service

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A Large User Perspective on Broadband Telecommunications Services

by

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Introduction

Few would deny that the United States is uniquely positioned to take advantage of what has been variously called the Information Revolution, Information Age, Telecommunications Explosion, etc. yet only an astonishingly small number of players have accurately perceived the risk to this digital millennium should adequate infrastructure not be in place synchronously with declining costs of technology and growth in demand.

The rather myopic focus to date in the engineering, research, and academic arenas on residential services, when planning,forecasting, and marketing future broadband (i.e., >100Mb/sec.) networks is surprising and ultimately reckless, given the long known 80% / 20% ratio describing the distribution of revenue opportunity between institutional and residential users of basic services. Not only does the deployment of broadband infrastructure to the residential marketplace as a first strike assure negative cash flow for some considerable start-up period, but involves offering services for which at present there is little or no demonstrable demand, and places early content providers at risk of competitive disintermediation by operators of alternative delivery conduits, since all but the entertainment-based services are of a sufficiently narrow bandwidth to be carried by cable, rf broadcast or more traditional "narrow band" technologies on a piecemeal basis.

While it is clear that with the shift of the Western economic base off of manufactured goods and on to services a new monetary standard is at hand, the "Information Standard," efforts in planning for telecommunications in the 1990's and beyond, in the United States, seem to be highly fractured and not at

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all cognizant of the manner in which this so-called revolution is going to evolve. Though this may be but one more example of man's unique ability not to accept information which is in conflict with his preconceived notions of change, the stakes have never been higher, as we confront a limited window of opportunity, in the face of multiple off shore competitive factors.[1] This window has started to close, partially because off-shore equipment providers have already started to implement the first phases of their plan to stimulate a market in the United States by providing entertainment producers with MUSE-based production equipment at little or no cost. This window shall become increasingly difficultt for U.S. interests to crawl through because of what historically has been a lack of aggressive participation by the U.S. in the standards-setting process, which is now fairly "locked in," so far as broadband packet, i.e, SONET, ISDN, and HDTV are concerned. The timetable below depicts both the few milestones which portray the evolution of regulatory, networking, and broadband issues since disvestiture, and through itallics, points to a set of policy and regulatory initiatives which could lead to the United States retaining its position of leadership as telecommunications, information, and entertainment move towards technology homogeny.

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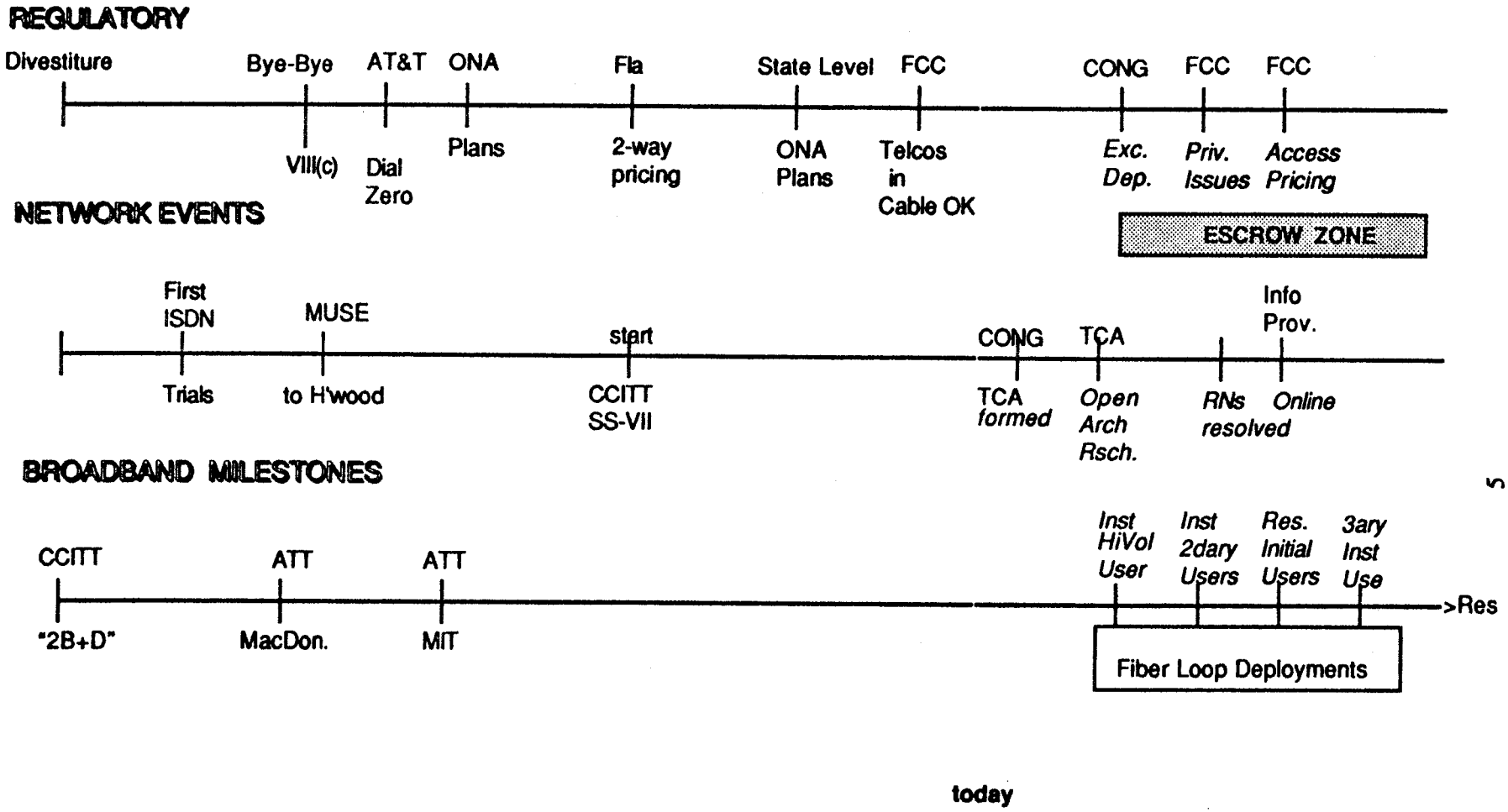
BROADBAND DEPLOYMENT SEQUENCE



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While the stakes are tremendous, having far-reaching implications in areas as diverse as employment, defense, robustness of US GNP, consumer electronics, and whether the United States remains the center of world financial information flows, the purpose of this discussion is a modest one: to describe the future of broadband services from the perspective of those closest to the issue, the users.

In order to fully grasp the nature of the problem at hand, one must be capable of simultaneously weighing issues in advanced telecommunications technology, law and regulation, computer and display science, information marketing, economics, as well as international trade and telecommunications policy. It's a tall order requiring a form and style of problem solving foreign to most professionals who until now have only played in one sandbox. The author was recently asked at a seminar on broadband how one might identify senior executive and policy-makers who would be adept at reaching optimal solution sets to these problems, and was reminded of the following classical problem used in clinical psychology to demonstrate both the concept of perception contiguity, and divergent thinking style. The problem is perhaps all too well known now, but it does demonstrate the basic idea.

Those aspiring to piece together the elements of the broadband issue might attempt this puzzle first, for if they are successful, then moving on to the issues of the day, ISDN/BISDN, HDTV, broadband pricing, fiber distribution economics and outside plant architecture, information gateways, bottleneck facilities, price cap regulation, and many more, might seem a bit less confusing! Bear in mind though that this is an old puzzle and that its authors were demonstrating that if you don't solve it within the first few minutes of trying, the

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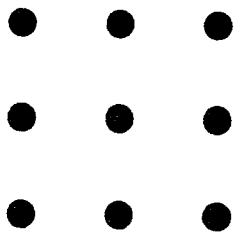
likilhood of succeeding later diminishes with time. Obviously, solving the puzzle is a matter of perception.



Connect all 9 dots with 4 straight lines, without lifting your pencil from when you begin to when you finish.

The Broadband Information Marketplace

Although massive amounts of data have been developed pertaining to the "information services marketplace," little of it is broken out in terms of narrow-band v. wideband, while most of it stems from origins in various experiments or "trials" where the methodology contaminates the validity of the results, and are of questionable quality . Typically, demand side information generated by these trials, often modelled on the early Knight Ridder and AT&T videotex efforts is of little value since usage sensitive fees were priced below provider cost. Other

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reasons also tended to invalidate the data, such as the AT&T choice of Ridgewood, New Jersey, which had a disproportionate number of AT&T employeed within its central office district. Although these data are cited both to support and detract from arguments in favor of universal broadband networks, depending on the viewpoint of the presenter, none have addressed important yet subtle dynamics which seem to be unique to information services, i.e., fixed demand decay, linked to the technology. We shall have more to say about this in discussing "home banking."

The Corporate Committee of Telecommunications Users (CCTU) has undertaken a study of broadband markets anticipated or currently being serviced by its members. The CCTU represents some thirty of the largest users of telecommunications, measured in terms of revenues paid to common carriers, in the United States. Among others, its members include the nation's largest financial institution, municipality, private university, hospital / health care group and consortium of grain farmers. In addition, it represents a significant number of telemarketing operations, the third largest insurance company, two of the largest car rental companies, and members of the growing audio conferencing industry. It does not at present represent any members of the manufacturing sector, nor the retail chains. In the aggregate, in pre-divestiture numbers, the CCTU represented in excess of 17% of AT&T's long distance revenue, with each major member of the CCTU having an annual telecommunications budget between $20million and $250million. Today these revenues are of course distributed over multiple inter-LATA service providers, however the annual growth rate in switched inter-LATA traffic, averaged across all CCTU members has hovered between 7% and 12% per year.

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Based upon the CCTU effort and its previous study of Competition in the Telecommunications Industry[2], sixteen discrete information services market segments have been identified as noted below. 1987 revenue figures are actuals based upon data gathered from ADAPSO and Link Resources, and cross-matched with proportional CCTU data. 1992 revenue projections are extrapolations based upon segment-by-segment growth in actual numbers reported by ADAPSO between 1985 and 1987. They have not been cross-matched with CCTU figures (because they were not collected prior to year-end 1987) nor have they been adjusted for any inflationary/deflationary effects, or cross elasticities with changes in the price of required terminal equipment, software, or communications/transport tariffs. Accordingly, though Annual Gross Revenue movement and Coefficient of Robustness figures are presented, they should not be considered reliable for research purposes. The distinction between a robust (CAGR%) and stable (μ) market sector becomes operant in an analysis such as this one because of the need to amortize a large capital investment within what will likely be short term depreciation environments. As μ is calculated to be an inverse function of the number of elements of demand (i.e., customers) which will move to other sectors outside of the model in

response to either precipitous changes in price (>20%/ 6 mos. or >33%/ yr.) or equivalent drop offs in revenue, it is noteworthy that some of these information sectors may experience difficulty in generating external capital. For example, commercial banks providing leveraged or venture capital funds will generally not fund new lines of technology based business having a μ<.66 - .70 on an unsecured basis. (Venture capital by definition results in held equity.)

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INFORMATION SERVICE SECTORS*

PROJECTED REVENUES

($MM)

Sector		1987	1992	CAGR	μ
01	Online Trans. Processing	2,980	9,845	27	.89
02	Alarm Monitoring/Telemetry	700	1,739	18	.68
03	Answ. Serv. & Telemessaging	918	1,014	02	.91
04	Voice Messaging	70	175	20	.42
05	EMAIL/Elec. Messaging	296	910	27	.39
06	Database Services	5,362	13,483	20	.61
07	Videotex Services	113	542	41	.28
08	Audiotex	404	1,136	22	.41
09	Ele. Data Intrchng.	39	354	54	.61
10	Processing Services	9,080	15,717	04	.37
11	Full M. Video Serv.	14,551	17,917	04	.63
12	Marketing Services	8802	190	20	.44
13	DB Management	300	117	-10	.12
14	Network Mgmnt.	115	615	38	.40
15	Facil. Mgmnt.	2,197	3,985	13	.72
16	Pvt. Virt. Nets.	108	185	12	.66
	TOTALS	38,113	69,984	$\bar{X}$= 19.5	

(Fig. 1.)

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Notes:

*"Information Serevices Sectors" is used here in the broad, categorical sense and is not limited to text or image based systems, but includes digital full motion entertainment (movies, etc.) process control, and private virtual networks used to provide access to information services. Accordingly, line items such as #11, may in fact involve a shift from other economic *into* the Information Service Sectors.

All that should be deduced from these data is that there are multiple information marketplaces, several of which are both sufficiently large and robust to justify multimillion dollar capitalization plans *if* the distribution and processing infrastructure is available to support them. Independent venture capital providers working in the technology sector often operate below μ.66, but are not restricted to the same ceilings as commercial banks, and often receive considerably higher equity levels. This difficulty will not pertain when the new information business is a subsidiary of a highly capitalized parent, however one must not forget that in the case of the Regional Bell Operating Companies (RBOCs), information content origination remains prohibited under the terms of the Modified Final Judgement of the U.S. District Court for the District of Columbia. Judge Greene seems reluctant, probably with good reason, to dissolve this restriction under Part VIII of the MFJ.

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The phenomenon of technology demand decay has only recently been studied[3] and as a consequence of some recent trends in the Home Banking arena which have caused concern among bankers. Firstly, it is noteworthy that home banking is not included in the Information Services Sectors table above for a number of reasons. Firstly, in recent years home banking has come to offer multiple services which overlap the categories represented in the table, essentially in an attempt to become a value-added packager of multiple offerings. Secondly, most financial institutions either will not release revenue figures associated with these efforts, or do not know them. Perhaps more importantly, on a unit cost customer basis home banking is not profitable. Not only did several institutions have to literally give the service away as an initial strategy, but had to also offer telecommunications hardware as part of the deal. The service is almost without exception priced below cost, with New York banks "losing" an average of $6 to $16/mo/customer. "Losing" is used advisedly however as most of the institutions are delighted with having the ability to cross-market other financial services to their "upscale yuppie" customers who own personal computers and not surprisingly, tend to keep high DDA balances, and make use of all sorts of lines of credit. The banks are quick to point out that they might otherwise easily spend as much on focused direct marketing to this base.

What has been the cause of concern to financial institutions offering these services has been an erosion in per-subscriber usage taking place simultaneously with a continued growth in the number of customers, which leads to a considerable increase in the cost of common equipment and

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administrative costs. Indeed, this dynamic was in large measure responsible for the recent announcement that one of the most highly thought of home banking systems, *Pronto,* offered by Chemical Bank, would be shutting down in February 1989.

While a recent feature in the New York Times[4] links the erosion phenomenon to the failure of home banking to become "paperless," inquiries by this writer of customers who subscribed to home banking services and then ceased to use them revealed that in over 50% of the cases where the user ceased to use the computer at all, customers said they liked the system but either were more comfortable having a cancelled check, or did not aggregate their bill-paying activities in the past and felt that computerized bill-payment forced them to do so (which they did not like) since it was too much trouble to "get into" the computer to pay one bill. Asked whether they continued to use the computer for other things, with the exception of those who used the machine for games and entertainment said "no."

The following table, combining the Times / Jupiter Communications[5] data with the results of our inquiries of 106 users who continue to subscribe, but not use the service, proves informative.

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USAGE DECLINE & HOME BANKING

Bank	Subscribers	Users	% Decay* 6mo	1yr.	Net.
CITI	29,000	20,000	18	14	32
CHEM.*	27,000	15,000	28	16	44
B OF A	24,000	18,000	29	11	40
CHASE	8,500	5,500	16	19	35
MHT	6,500	5,000	14	9	23
OTHERS	30,000	20,000	18.5	14.5	33
TOTAL	*125,000*	*83,500*	*$\bar{X}$=20.6**	*$\bar{X}$= 13.9 **	*$\bar{X}$=34.5 **

** Non-weighted means.*

(Fig. 2.)

NOTE: 1. Decay for purposes of these stats includes users who have abandoned use of the system (not used it once) for the period indicated. This is not necessarily the first 6 mo. or year.

2. Because of 1.) above and the possibility of changes in fee structure, service levels, etc., no conclusion may be drawn as to the relative degree of customer satisfaction between institutions.

As the notes above point out, this collection of data is dangerous because it tempts one to draw conclusions which cannot be made, because of the lack of controls in data collection. It was not meant to be a research effort, but does

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permit concluding that roughly one third of the users will drop out after 18 months, and that decay is positively skewed towards the first 6 months of what appears to be a phenomenon lasting slightly over a year. Non-users a re still considered subscribers unless they call and to serve notice of the cancellation, which also ends a small monthly service charge. (Though this does not compare unfavorably with cable t.v., where an even higher level of "churn" is expected.) Several trends were discernable but not verified:

1) Lower DDA balances decayed faster.
2) Age is inversely proportional to velocity of decay, with the exception of one of the banks reporting.
3) There appeared to be no significant correlation between the number of 'value added' services and decay characteristics.

An observation worth noting is that a very similar curve was reported in relation to consumer behavior generally for families purchasing their first microcomputer[6] at Sears Department stores, most of which have discontinued all but the private label product line.

It is important to stress that the information services marketplace and the broadband marketplace are not the same. If the development of broadband infrastructures were financially or technologically dependant upon growth in the information businesses alone, we might never see beyond a pair of copper wires. On the other hand the incremental marginal cost associated with adding a unitary information service such as home banking to a pre-existing fast

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packet-based channel of >100Mb/s is so low, that it might well no longer be necessary to "price below cost" in order to reach a price point where market penetration and decay phenomena would be problematic factors. We shall discuss these dynamics further shortly as we take up the general topic of pricing.

Institutional Applications and Demand for Service

Today's Market

Fortunately the future of broadband need not be linked to the hype surrounding consumer information services, as there are "other games in town" for which broadband is far better suited and for which a valid business case can be made today. To understand the size of the potential institutional market for digital data communications bare in mind that the ratio of annual telecommunications expenditure on usage sensitive elements to the current value of installed computer and related data communications equipment hovers around >2:1 for most large users. Among the CCTU membership, which is admittedly skewed towards the service sector and does not include a sample of manufacturers, the ratio averages 2.30:1. Out of the 54 largest computer installations in the United States the distribution of present installed value is as follows[7]:

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DISTRIBUTION OF 54 LARGEST U.S. MIS OPERATORS

		Annual Aggregate		
		Revenue	Earnings	Employ.
Installed Base	n(companies)	Billion$	Million$	(Thous.)
>$200million	4	177	6,529	1,691
>$100million	19	361	19,122	2,572
>$80million	10	206.2	7,271	776
>$60million	21	176.8	8,084	1,372
TOTAL	54	921	41,006	6,411

(Fig. 3.)

NOTE: Totals are non-cumulative, i.e., $361billiob Revenue is only for 19 companies.

The CCTU has found that within the service sector, a ratio of approximately 1:9 defines the relationship of gross revenues to telecommunications recurring expense. Applying the CCTU ratio for annualized telecom expenditures a net telecommunications revenue opportunity of just under $11 billion exists, simply based upon the largest U.S. 54 data center operators, though not all applications would be initially carried on the broadband network.

In terms of sectorization, the top four consist simply of AT&T, General Electric, General Motors, and GTE: two industrials and two telecommunications giants. The group of 19 companies with over $100 million in data center assets consists of 12 manufacturing, 5 service, and 1 retail player.

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Tomorrow's Market

Forecasts for growth in potential demand for end-to-end digital data transmission on the institutional side are once again best linked to two indices: computer hardware forecasts, and a secondary dynamic, the cost of information storage in terminal devices. Based on information provided by the Data Analysis Group,[8] an overall growth rate between 1988 and 1991 of 40% can be expected, however this is mean growth and is not at all even across technology sectors. For example, microcomputers, which should be viewed as terminal devices, are expected to see a 59.2% growth rate during the period, while "large computers," (defined as costing >$50,000) are expected to see net growth of only 23.4% through the period.

The growth rate in the terminal device / communicating workstation sector will provide a further impetus pushing communications bandwidth and speed requirements even higher than the above projections would indicate. Between 1984 and 1988 the cost of on board high-capacity drive based (not RAM) memory declining from $21.08/meg to $5.49/meg. If this trend continues than costs of $1.40/Meg. could be in sight by 1992,[9] having the effect of driving telecommunications usage up further. It is noteworthy that RAM costs as much today as paper did in Guttenberg's day, yet digital libraries have hardly even been considered nonetheless looked at seriously by technologists. [The U.S. remains the most illiterate industrial nation on the planet. 100,000 books = 100Gb which, if trends continue, should be ownable for a few thousand dollars in as few as ten years.] [10]Some technologists also assert that "workstation speed"doubles every year[11]:

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YEAR	CHIP	SPEED	(Claimed)
1985	68010	1 MIPS	
1986	68020	2 MIPS	
1987	80386	3.5 MIPS	
	68020	4 MIPS	
1988	SPARC	6 MIPS	
1988/9	88000	14	(17) MIPS
	R3000	16	(20) MIPS
1989-90	E.SPARC	30	(50) MIPS
1991	ECL88000	80	(100) MIPS

Note: Today's popular VAX 11/780 = .5 (1) MIPS

(Fig. 4.)

With internal processing speeds approaching the rates cited above, low speed analog telecommunications would not only be inefficient, but would act as a bottleneck, throttling applications and ultimately the growth of services themselves. The threshold of 'throttling' of course depends on the loading factors associated with partular services. For example, given that compressed, i.e. vector quantized, full motion imaging is an even intermittantly used element of the services being carried, packet transfer rates of at least 100Mb/s to 130Mb/s are needed, given todays technology, to avoid throttling. Going to lesser quality image production would vastly reduce the minimum required transport rate, given today's state of the art.

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Closed Community Networks

Otherwise called "specialized business networks," large scale interstate and international telecommunications networks set up by large corporations are often typified as malevolent "bypassers,"whose plans would make the evolution of universal broadband services more difficult, rather than easier to bring to fruition. Neither time nor our topic permits the detailed discussion which the phenomenon called "bypass" deserves. A few points need be made briefly.

1. The first corporate-owned large scale networks came about as a result of a need to convert unpredictable and spiralling variable costs to a fixed base. The unpredictability stemmed from the nature of state-level regulation, which was often under the influence of political forces.

2. Pre-1987 Investment Tax Credits were important to corporations which tended to be overcapitalized, i.e., petroleum and some financial institutions.

3. Through the late sixties and early seventies, telephone companies were reliably unreliable in providing any form of specialized service. As a result, vendors of services dependent upon leased or other specially ordered facilities were made to look tardy, inept, or even negligent because of the inconsistent performance of local telephone companies.

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4. Direct costs were not cited as the primary reason for construction of private networks, as indeed many of these networks were more costly than the alternative of continuing to procure services from a regulated common carrier.

5. Most regulators and public policy makers consistently fail to recognize the difference between end-to-end bypass, carrier bypass, and long-haul bypass.

Research undertaken by the CCTU revealed the interesting finding that so-called end-to-end bypass, in the long run, may benefit RBOC's because of the so-called high-way effect. Backbones on specialized business networks typically, are of a far greater size than can be justified on the basis of traffic numbers at the inception of the network design process. As a result, traffic tends to build on these networks at a far greater rate than that typical of public switched networks. (PSNs)

Among traffic engineers the "60% / 40% split" between on-net to off-net traffi is well known. This statistic is old, and stemsfrom the days prior to both divestiture and the major shifts in the U.S. economy towards the "service sector," and away from heavy manufacturing. If the 60% / 40% on-net to off-net ratio persists in a service sector company, it would signal a terminal illness for such companies obviously gain no profit from talking to themselves!

An internal effort launched by Citicorp slightly more than 2 years ago demonstrated that among Citi's service companies (i.e., Diners Club, VISA,MASTERCard, Person-to-Person, etc.) this ratio had shifted to nearly

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90%:10%. If any change has taken place since then, it is in the furtherence of this trend, which is a generally good sign.

The momre subtle effect tough is that although the bulk of the inter-LATA traffic is no longer creating revenue for inter-LATA carriers, and in recent years has been carried by company owned or leased facilities, any growth in the traffis benefits a LEC at the distant end. The growth in distant-end "hop-off" is subject to the "highway effect," spurred on by the backbones both being a fixed cost and, in unit cost terms, being inversely proportional to distance.

$$[k \sim \frac{d_2 - d_1}{\Delta t}]$$

[k=operating cost; d=route distance; t=time]

The combined effect of this phenomenon,increasing rate and volume,has resulted in an increase in traffic for large corporate networks which prior to divestiture would have been justification for CCSA networks; since divestiture large corporate networks belongin to CCTU members have grown (volumetrically) by from 17% to 52%, well above growth rates for the PSN during the period.

NETWORK ARCHITECTURE

Though our focus has not been on the engineering implications of broadband, the technical issues are so important in this case that an overview imparting basic familiarity of how network architectures will be effected is a clear prerequisite to perceiving how services might be delivered, and at what costs.

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Switching

Little need be said about switching in this non-technical discussion except that significant progress is being made on this front. Bellcore claims the world record in the switching olympics of 4.5 billion bits per second on a single chip.[12] The first sign of real progress emerged several years ago when two engineers from Bell Laboratories replaced the rem reeds in a #5ESS machine with specially cut monomode fibers. Since then,of course,the movement has swayed totally away from what where then mostly mechanical solutions. With the higher bandwidths made possible by improvements in the refraction gradients of monomode fiber[13] and later in electro-optical bridges and in microprocessors, including large-scale user programmable gate arrays,[14] impressive gains have been scored in banyan switching[15] and in the development of algorithms supporting enhanced forms of high-speed packet switching, up to 3 Gb/s.[16]

Fortunately, significant progress has recently been reported on two fronts which have traditionally been major technology hurdles in this field: efficient video coding for high-speed packet transport[17] and point-to-multi-point fast packet routing or so-called "broadcast" fast packet.[18] Given the trend towards high resolution terminal devices, raster-based processing and other directions becoming prominent in the graphic representation of information, traffic and economic overhead issues have, to date, somewhat lurked in the background. While by no means "solved," productive approaches to these problems are being conceptualized and worked on in the U.S., Japan, and Holland.

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A recent multi-service, multi-bandwidth experiment based in Belgium has produced perhaps the first set of packet specifications based on "real" numbers taken while the test was up and running. A full blown experiment is slated for 1992, as a large scale follow-up. In brief, the effort demonstrated that several changes had to be made in planning assumptions and that specifications should be modified along the following lines, prior to the 1992 project:

1. Fixed cell lengths with minimal functions built into the header.

2. Short header, i.e., 2 bytes within an overall cell length of 32 bytes.

3. Switching and transmission speeds of 600Mb/s could be justified, based on demand, traffic, etc.

4. Deterministic demand allocation will probably prove to be more workable than statistical allocation, particularly if $n_{services}$ is high.

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It is essential to be able to predetermine whether network performance will remain acceptable following the granting of a connection request from a user *before* the request is granted and slotting undertaken. This raises a new question for research, namely methods of low-level preconnection flow control on the terminal level in the Asynchronous Transfer Mode.[19]

Distribution Plant

Perhaps having a more direct bearing on the user/provider relationship to broadband networks are the rather fundamental changes in store for what has historically been called the "outside plant" or local loops and feeder plant. Considerable effort has been expended looking at this issue, particularly as it relates to residential service.[20] Since our purpose is other than to review the literature addressing this extremely critical issue, we should skip ahead only noting in passing a few characteristics which all of the warring factions in the 'residential' camp can agree upon:

1. Residential services will be comprised of a rich mix of services which in addition to POTS shall include information-based applications.
2. Information services will be two-way. ("Information based Services" in the sense that any form of data is made available to users on a "for hire" basis.)
3. The proliferation of personal computers and other information consuming, microprocessor devices will necessitate multiple virtual simultaneous data channels, even into the residential marketplace. (Average growth in

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revenue of online services in the U.S. was 21.8% in 1986 and 19.2 in 1987.)[21]

4. The only non-POTS "enhanced" service for which there is a demonstrable demand today, resulting in a price point within range of distribution costs, plus margin, is entertainment: movies, porno, and games.

5. The existing copper pair belonging to local telephone companies, given typical loop lengths, loading coils, etc., cannot reasonably transport more than 56/64Kb/sec.

North American loops (both residential and business) have a Mean Working Length of 10,787 feet, a Mean Feeder Length of 10,448 ft.
plus a Mean Distribution Length of 1,888 ft. and a Bridge Tap Length of 1299 ft. While insertion loss between the frequencies of 1kHz and 4kHz grows from 3.45 dB to 12.85dB, these numbers become far more catastrophic at ISDN frequencies.[22] Attenuation loss over legs which can pass IDSN-like frequencies migrate from means of 18.5 dB @ 40 kHz to 29.8 dB @ 200 kHz, but even above 120 kHz maximum attenuation loss factors of from 64.7 dB to 75.7 dB are often encountered.

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Obviously one theoretical solution is to increase signal strength, but this clearly poses the problem of likely cross-talk and inductance phenomena, especially where plant is older (major cities where the concentration of users is greater) which would be totally unacceptable, especially given the prospects for CCITT SS-VII protocols on the subscriber "D" channel.

Extensive filtering also presents a theoretical solution, but results of the 1987 Subscriber Loop Survey (based on 1983 data) show such variance in the overall nationwide system that it would be virtually impossible to implement one unified filtering scheme. In short, the idea is impractical.

Perhaps most noteworthy is a result recently reported by the Swiss PTT from which it is best to quote directly:

> *"Transmission signals as defined in I.430 [CCITT ISDN standard] may give rise to electromagnetic compatibility and communications security problems when using in-house installations for the ISDN.....the transmission signal specified by the CCITT at the S reference point is not* (emph. mine) *compatible with Swiss specifications and also other European specifications.....signals emitted from ISDN equipment and lines can be received and recorded at some distance."* [23] [24]

(See Exhibit #1)

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What may be concluded from this is that copper loops are woefully inadequate for the delivery of broadband services regardless of where one stands in relation to the debate over whether full-motion, high resolution imaging and graphics will be part of holy grail of information services piped into the home of the not so distant future. (Nobody debates the need for this on institutional / large-user loops, given the current direction of sophisticated, on-line information services.) Copper, it would appear, is fundamentally inadequate for transmission at even the "narrow-band" ISDN "2B+D" rate. Such being the case, *it makes no sense not to deploy fiber which is fully capable of even higher bandwidths at zero incremental cost.*

Indeed, as the Swiss experience demonstrates (and additional data is needed with respect to cable and isolation specifications of the European equipment studied) even the development of narrow band ISDN over existing copper plant may be dangerous.

Accordingly, only outside plant environments consisting of end-to-end fiber facilities will meet the needs of the 1990's and beyond without at least pockets of serious problems. The regulatory and public policy implications of this finding are important, and shall be discussed shortly.

Given a fiber-based outside plant environment, individual residential subscriber loops between each serving end office and subscriber makes no sense, either economically or in terms of efficient use of bandwidth. Several excellent discussions of this issues are available.[25] [26] [27] A Double Star configuration appears to be optimal for residential subscribers with Remote Nodes (RN) located between clusters of subscribers and serving end offices. All manner of

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services would be resident in the RN ranging from basic POTS, including all on-demand information services, private messaging, specialized live feed broadcast, digitized movies ("paperback movies,") high resolution audio, as well as a large number of pay-by-view services. Home security, energy management and preauthorized financial transactions/payment systems could all be accessed remotely while subscribers are away from home, be they at work or thousands of miles away on holiday, etc.

"DOUBLE STAR" LOCAL NODES

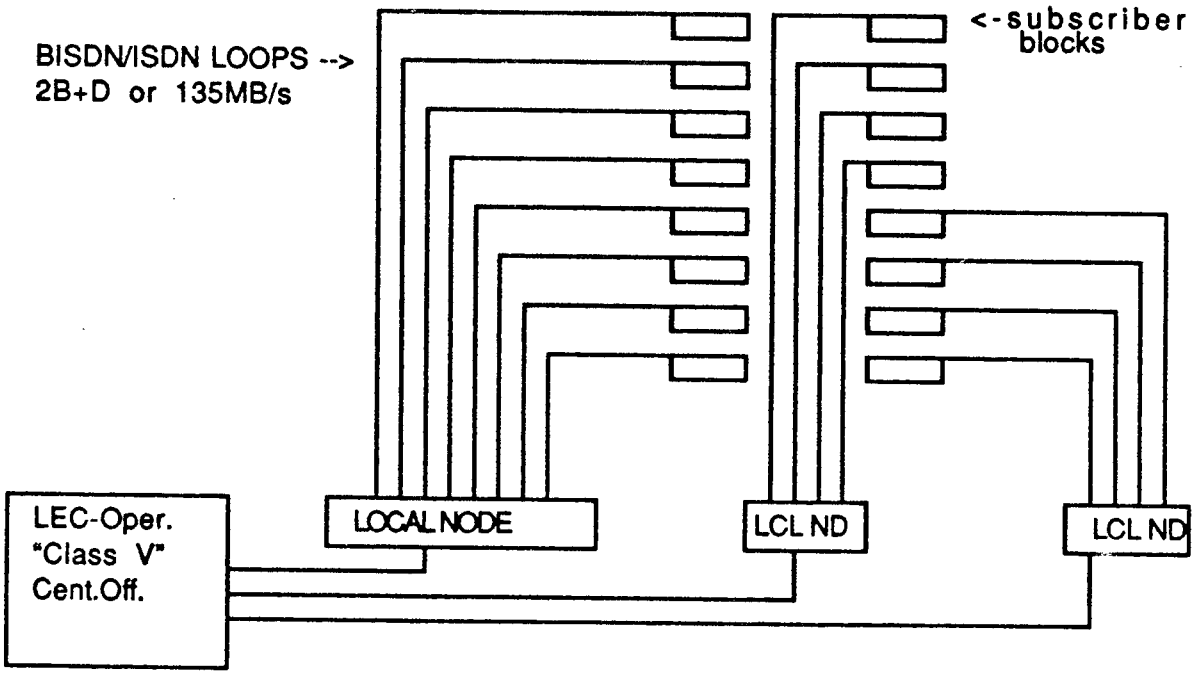

Fig. 5.

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Bit streams moving beyond the RN to common carrier and other inter-LATA facilities would be multiplexed at the RN onto backbones to serving offices and POPs at D-3 rates and above. This would have the beneficial effect of vastly reducing the common equipment requirements at the central offices and points of presence.

The institutional "large user" is actually far simpler from the standpoint of outside architecture, as the equivalent of a RN would essentially be located on the subscriber premises, much as T-carrier equipment has already been. An interesting question from an outside plant networking viewpoint will have to be addressed when the time comes to connect multiple information and service providers to the potentially enormous numbers of RNs. Similarly, the question of interconnection of non-adjacent multiple sites belonging to a single corporate user shall become critical.

The decision to insure compatibility between the CCITT 802.6 standard and ISDN makes sound intuitive sense, even if the ISDN standard is inadequate in its present form.

For the large user LAN/MAN standards issues shall become most critical. While LAN-based issues will more directly effect the terminal equipment market, MANs and where their underlying broadband backbones are procured will have fundamental implications for the telephone business.

Regulatory issues (i.e., degree of exclusivity of original LEC franchises), technology trends, (i.e. photo-optical subcarrier muxing), and economics will all arrange MAN alternatives in differing orders of desirability depending upon the

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traffic and pricing characteristics of the individual services (for providers), and demand spectrum of services required (for users).

In short, all that can be said is that developments in Metropolitan Networking technology should be taken very seriously by large users as should any attempt by service providers to structure bottleneck facilities or sole-source gateways offering protocol conversion services or the like. Such strategies are the likely undisclosed plans of the Regional Bell Operating Companies.

BARRIERS TO BROADBAND SERVICES DEPLOYMENT

At present a number of obstacles lay in both the narrow and broadband ISDN paths. Just as a problem isn't a 'problem,' unless by definition, it has a solution, obstacles must be able to be removed. Based on who is going to have to do the removing, the following categories of obstacles deserve our attention:

- Technical Obstacles
- Industry-related Obstacles
- Regulatory Obstacles
- Standards Obstacles
- Tax Policy Obstacles

Although some of these differ on a country-by-country basis, our scope does not permit more than a generic discussion of each of these areas.

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Technical Obstacles

So as to establish realistic priorities, it is important to bear in mind that so-called technical obstacles are merely temporary, time-linked hurdles and rarely, if ever, "show stoppers." Anyone who comes to you with the statement that some technological achievement can 'never be done,' should be subject to your greatest suspicion and, if a paid consultant, fired -- as it cannot be relied upon that any other advice he might give you would be any more valuable.

Buffering and bandwidth allocation management have essentially been left unaddressed from an ISDN viewpoint. As the trend towards integrated terminal devices continues, bringing into the picture the concept of an "Open Architecture Receiver" combining such devices as personal computers, television sets, Compact Disk machines, FAX, reprographics, and Modems/DSU's, and CAD/CAM integrated workstations, demand for on-board storage capacity will skyrocket. As this takes place the issue of link level flow control will become increasingly critical as the more 'bursty' the traffic becomes, the greater the probability of high rates of pack loss.

This writer has not uncovered a wealth of research on the effects of randomly multiplexed bursty sources on performance dynamics of high speed packet nets.

An issue bound to emerge, given the double star network approach we spoke of is the sharing of very short term buffers at the RNs, and quite possibly at local serving offices. As terminal devices increasingly approach the Open Architecture Receiver, not only will storage capacities increase, but processing

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environments will shift to multi-processor cubic array-like nodes, quite capable of multi-tasking and multi-processing, which bodes of multiple channel telecommunications interfaces. This is another economic and engineering inducement in favor of fiber subscriber loops, as these will likely be "virtual" given the, economic realities of traditional local loop distribution economics. All of this implies highly variable session lengths, unpredictably asymmetrical uplink: downlink ratios, erratic "busy hours," and the need for sophisticated buffer management in the nodes, and possibly in the terminals, themselves.

Point to multi-point has never been addressed sufficiently within the broadband realm. On face value one could conclude that so-called broadcast modes are ill suited for broadband, however there is no intrinsic reason why this is so, except that broadband protocols do not exist enabling one managerial node to simultaneously monitor the bandwidth and other parameters of a specific node or junction on the network.

Finally, if the benefits of broadband are ever to reach the users through applications, great strides in developing low-cost high resolution display devices shall have to be made. This of course implies highly efficient signal and data coding, which really does not exist outside of laboratories today, either. Pixel densities of 2000 X 3000 with frame rates of 60/s should be anticipated.

Industry Related

One might quite legitimately ask, "which industry?" Indeed, the future of broadband services depends upon a matrix of industries which are now so interdependent and commingled that all forms of boundaries between them are

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disappearing. This, in and of itself is not a barrier to broadband, though it is often used as a rather lame excuse.

In the traditional telecommunications sandbox, one can observe domestically, one of the few instances in which multibillion dollar corporations haven't a clue as to how to position themselves in competitive marketplaces and, acting out of a sense of entitlement, seek to use the techniques of a past era to ensure that competition in the local loop, unbundling of critical services, and collocation of equipment do not take place.

Indeed, to this end, ironically, one of the greatest obstacles to the deployment of Broadband ISDN, is narrowband ("2B+D") ISDN. For some time, in the United States at least, the RBOCs had been receiving messages from their principal technical advisor Bellcore, that 56Kb or 64Kb, the maximum bandwidth conveniently delivered into residences over the existing copper pairs would be sufficient for all of the information and voice services needed, for the foreseeable future – despite the fact that high resolution and moving images would not be accommodated. Such advice, tempting as it is, could, if heeded, present the major obstacle to broadband, fiber-based services as once the capital investment is made in the electronics to transmit 64Kb/s over the copper, years would have to go by before that investment became fully amortized, rendering it a candidate for replacement. By then of course, there would be no telling what would likely happen to the U.S. competitive position in information services and consumer electronics as a result of the dominant portion of the potential marketplace not being able to use other services and terminal devices which had continued to evolve in step with broadband technology agendas.

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As we shall see later, a significant component of this risk stems from the possibility that the Local Exchange Companies (LECs) will be hoodwinked into believing that narrowband switching 64Kb services will be adequate in the residential marketplace. Such a view would, of course, inject a delay equal to or greater than the period of depreciation or full amortization, whichever is longer — during which the United States' information services industry could surely loose its position in world markets.

European nations with their PTTs are in an even worse position, with a couple of exceptions, most notably Holland and England, where the limited "privatization" of the former and competitive ownership of long haul transport in the latter at least do not make competitive broadband services an oxymoron.

The Pacific Basin is an interesting piece of this puzzle as not only do growth rates in both traffic and infrastructure exceed those of any other ITU region by double digit percentage points, but the expiration of the land lease agrements in Hong Kong represent an additional prize essentially yet to be awarded. Several of the major players in Hong Kong, i.e., Cable & Wireles, are looking towards forging joint ventures, or even participating as a fianncial partner in "privatizations" in one or more places poised to replace Hong Kong. The extent to which this will pose any competitive threat to U.S. interests will depend on many futures, i.e., pricing, marketing, and the absence of regulatory constraints Australia bears mentioning as your author has recently visited and discussed this subject there. He found the Post Office and OTC both willing and ready to spin off switched broadband services. At the same time, the land of Oz is confronted with a rather unique demographic dilemma: a country the physical size of the United States and a population only slightly larger than New York

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City. Government-connected agencies are all too willing to relinquish broadband for fear of having to cross-subsidize to an extent that no place on earth might have to, as they have done in the past simply providing early telephone service. A number of interesting regulatory proposals and experiments have come out of Australia, just because of this unique problem, but those to be discussed shortly.

The "CPE" side of broadband is a particularly confusing entanglement of special and political interests. One of the few points agreed upon is the critical role which high-definition display devices are going to play in all of this. While there is a definate need for these display devices in a number of areas, i.e., medical imaging, CAD/CAM, and in military satellite-based reconnaissance to name but a few, consumer electronics is not basucally one of them. The notion that consumers are willing to pay a premiumto replace somethings that they are not inherrently dissatisfied with makes little sense. Wathing Monday Night Football at 2000X2000 pixels just isn't going to result in sufficient market stimulation without millions of dollars of advertising hype.....which just *may* be in the offing. Only very recently has the "sputnik complex" begun to take hold here, as many Americans have learned that the Japanese have given away bundles of free production goodies to Hollywood production houses, while special interests in the broadcast industry attempt to forge secret alliances with both domestic and overseas players in an attempt (probably in vain) to guarantee themselves a position in this future market having to present demand curve.

An example of this sort of activity is a sub-group (dominated by the television networks) of the FCC's Advanced Television Committee (ATV) which, without any official mandate, visited the Soviet Union in an attempt to gain support for

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the delegation's special interest standards position. [28]Some of these players have been major backers of the Japanese MUSE standard, and even convinced the State Department to endorse it as the Production Standard for High Definition Television. This may be reversed as of this writing, as a number of other players, perceiving that ultimately, the non-broadcast implications of broadband may far outweigh image transport from the perspective of national security, telecommunications, and possibly even revenues.

The entertainment industry, as we have seen, holds the only card which anyone will bid against, is proceeding in a somewhat more sensible manner. Owning valuable intellectual property, the movie production houses are not, with few exceptions, locking themselves into a future position which might exclude the possibility of distribution over differing modes of broadband transport. Key to their reaping maximum return on investment will be the formation of very creative joint ventures with owners of the RNs, which your author believes should be cooperatively owned, cable interests, and/or a breed of player yet to show his head, who will provide interactive gaming and related communications services linked to primary events.

A few business plans are begining to cross the transoms of venture capitalists seeking funding for future assymetrical networks in which betting pools, opinion polls, lotteries, and similar interactive revenue sources will function secondary to "paperback movies," supplied to users from the RNs as well as traditionally syndicated television series. One such player has even developed the interactive gaming software and demonstrates real-time betting on the outcome of the who-done-it series, "Murder She Wrote."

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The enormous success of "900 Services" in which callers pay to register their behavior on some subject, demonstrates the underlying frustration of the "couch potatoes" with not being able to guess who is going to solve a mystery plot, win a ball game, or even enter an online bet in the local lottery. If broadband comes to pass, and these "900 Services and their more exotic replacements take off, clinicians such as your author, and sociologists interested in mass audience behavior could have an absolute field day with the resulting data.

So too, may the lawyers, as a much neglected but all important facet of the yet to dawn "Information Age" is that of the ownership and definition of secondary forms of information pertaining to the behavior of users of systems, often generated, repackaged, sold, or used to sell additionally deduced information without the user's knowledge or informed consent. One might argue that to some extent this goes on now in the mailing list, or "direct marketing" business, however this fails to meet the test of being a comparable case, as when a customer of a telephone company or computer information service, or public library uses the services offered, there is a presumption of privacy harking back at least to the time when the user initially obtained the service.

Literally dozens of privacy and related questions attend in the basic narrowband ISDN offering. For example, putting aside the issue of ownership of secondary informtion, such questions as whether the originating station identification information in the packets transmitted with each call on the "D" Channel can be used for authentication has enormous implications for financial and security industries. Identification typically does not imply authentication, as anyone could pick up your phone, call a service provider or fulfilling agency and

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order something. The D Channel data would be matched in a database with your credit card account number, telephone company account number, or bank account for debiting. For this reason, if D Channel data is to be used to authenticate financial transactions, then telephone sets and other terminal gear would have to gain security functions such as password access control. Whether users of telephone would like the notion of having to insert a passcode before using the instrument remains to be seen. Of course, use of such data for authentication has implications for banks, credit card companies, and authorizatiion services as all of this could now be provided by the telephone company, or by the owner of the RN.

Little public debate has stirred surrounding this issue because it has yet to intrude into the electronic communications sector in any major way...yet. However, both the recently approved Open Network Architecture (ONA) Plans of the RBOCs as well as the "Dial Zero Access" plan filed at the Federal Communications Commission contemplate the use and sale of this sort of information. The CCTU has raised these issues both in testimony before the FCC[29] and in informal comments based upon a hypothetical case now referred to as the Case of the Hot Socks, subtending the elimination of the Part VIII (c) waiver provisions of the Modified Final Judgement.[30]

Should any player in the unfolding drama of broadband either appear rapacious in his lust for the fast buck, or abusive in his use of information pertaining to private citizens or corporations, that player will contaminate the operating field much as the airlines and Wall Street inside traders have done for the overall concept of deregulation.

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Regulatory Barriers

From an international viewpoint, attempts to regulate information services as forms of trade, possibly based upon content, is a major step backwards, and a reaction based upon panic. As the disappointing results of the latest WATTC will eventually be recognized as such, protectionism in telecommunications-based markets is based upon the false premise that there actually are multiple markets. When opportunities for international information arbitrage can be measured in seconds[31] the notion that separate distinct markets exist coincident with geopolitical boundaries is simply false.

The U.S. Problem

The key regulatory question, which admittedly, areas of public policy, taxation, and even technology could also lay claim to is that of getting the required fiber infrastructure in place in as timely, cost effective, and competitive manner as possible. In a few words, how do we rewire America with fibers? The answer of course, is " not all at once."

This is a regulatory question unique to this country because of the special form of regulation, recently altered drastically, under which the first telecommunications infrastructure, copper, was deployed.

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Space does not permit retelling the fascinating history of telecommunications regulation, however suffice it to say that the Communications Act of 1934 had to be drafted over a very short period of time and, as a result, was practically a word for word rephrasing of the pre-existent Interstate Commerce Act of 1888. As others have pointed out,[32] the original model of analog telephony was very much based on 19th Century conceptions of transportation.

Indeed the very term "Common Carriage" stems from traction law - the archaic field of law dealing with the regulation of streetcars and trolleys - which to this day prohibits the collocation of telecommunications cables and transport power feeders in the same conduits in the older cities where surface transit had to be *converted to* electrical power. Following the conversion of such transport to electrical power in Chicago, and the arrival of a large population of Polish immigrants into what was then (turn of the Century) a neighborhood outside of the central city not serviced by the newly converted lines, the recently arrived citizens staged a violent protest at City Hall. An entrepreneur, who later was discovered to have been in collusion with the City Supervisors, stepped forward and offered to finance a new traction line out to where the Poles had recently settled, *if* the City would make an interest-free loan available. Construction soon began.

Some three years later, when service was inaugurated, the patrons of the new line quickly discovered that at the point where the new line should have connected onto the pre-existing municipal line, they had to get off and pay an additional fare, because the tracks were of a different gauge. A near riot broke out. The result: The Chicago Traction Common Carriage Act, "assuring all citizens (of the city) universally available transportation at rates under tariff."[33]

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Replacement of the copper loops under today's regulatory environment can neither be financed by interest free loans from the government (though it is important to note that the Rural Electrification Act, which essentially did just this, remains on the books), nor by the local telephone carriers, who may no longer cross subsidize such capital programs with revenues from long distance service, which they are now prohibited from providing. Given the required capitalization and the historical 20-depreciation cycle, it is not likely that such a massive program could be carried out over a short period of time, even if ratepayers and legislators were permissive of the "rate shock" such an arrangement would produce.....which they are not.

SOLUTIONS & POLICY ALTERNATIVES

LEC Provision of Fiber Loops

Coordinated with changes in tax policy and pricing of services discussed below, regulators should permit the introduction of fiber into the local loop by telephone companies on a gradual, staggered, basis under which large users, who clearly comprise the bulk of the demand would be provided loops first. Regulators would grant only modest price decreases in high speed data services, with the local telephone companies being allowed to retain the bulk of that revenue in escrow to fund, along with bond offers, the eventual deployment of fiber into the residential marketplace. Telephone companies should also be

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allowed accelerated depreciation of related newly installed equipment. We shall discuss this further in the context of coordinated tax policy.

This idea should not be confused with the highly problematic subsidies which for far too long characterized the U.S. domestic telecommunications industry. While this approach would admittedly achieve some of the same effects, there would be no 'injured' party. The demand for capital for deployment of fibers would be satisfied out of newly generated revenues, rather than existing cash flow. Consequently, rates to all existing consumers would not go up. In fact, the faster fiber-based high speed services to large users can be integrated into new fiber backbones, the larger could be the *reductions* passed along, given residential fiber capital requirements. This is also a politically acceptable solution as it involved no rates increases.

Cable Via Electrical Utility Entry-The Untapped Tap

The differences in regulatory status between a dominant telecommunications provider and a dominant electrical utility provide many as yet unrecognized opportunities possibly leading to cable-based fiber provided by a subsidiary of an electrical utility. While the obvious electrical utility asset, the rights of way, have already been tapped as a resource by players seeking to enter, or those already stakeholders in the inter-regional fiber optics-based transmission industry, the many options open to the "power sector" have been totally overlook, most notably by that industry itself.

Eletrical power utilities could become catalysts in the effort to deploy fiber into the residemtial marketplace by forging alliances with cable service providers. The dominant electrical power providers are an ideal source of capitalization for

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upgrading existing cable systems to fiber, something which the cable companies alone cannot due; it is unlikely that funds would be forthcoming from traditional banking sources for this purpose either. In addition, it occurs to your author that there is nothing stopping the electrical utilities from forming "fully seperate" subsidiaries which would function as asset holders for switches interconnecting the smaller regional fiber operators. Somewhat analogously to the position of the three dominant television networks, who are non-licensed except for their owned broadcast stations, such an entity could remain totally free of telecommunications regulation, as it would only operate switches and not transmission facilitiules. At the same time, the utilities themselves would be in the position of selling off "excess capaity" on their own digital microwave systems, which have grown considerably over the past four years.

The differences in regulatory environments between the electrical industry and that portion of the telecommunications industry remaining subject to regulation offers several advantages to the former, as a partner with cable players: firstly, in executing a leaseback arrangement with a cable company, a regulatoed telecommunications common carrier has to offer the buy-out option, while no such requirement attends the electrical company, or its subsidiaries.. Secondly, the extent to which the Federal Communications Commission has concerned itself with the regulation of utilities involved with cable has been to monitor "pole attachment" rates. Indeed, the FCC would lack jurisdiction under the above scenario, as the asset structure could relegate the vast bulk of the transmission activity to the intrastate sector. (Most of the regional fiber network owners in the private sector do not even file FCC Form #214.)

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Should Congressional modification of telephone/cable cross ownership policy and law shift towards liberalization, (in the direction the FCC has already tipped its hat,) this partnering could shift onto the local exchange companies. While lifting of the information origination ban on the RBOCs by the Greene Court looks doubtful at this time, such an initiative would further stimulate the aliance forming process.

It is worth noting that a regulatory precedent for the type of escrowing suggested in relation to the LEC provisiong of fiber loops mentioned above exists in the electrical utility area. The recent merger of the Utah and Pacific Power and Light Companies was conditional upon access being provided to other carriers, as well as funds being placed in escrow for sole use in funding additional backbone growth.

Taxation and Telecommunications

Oddly, for reasons not at all obvious, discussions of telecommunications policy by regulators, legislators or users tend to never include tax policy. This must change, and probably will, with the U.S. Supreme Court poised to rule on the right of the State of Illinois to impose a state tax on interstate telephone calls. [Several states already do: Arkansas (4%), Florida (5%), Hawaii (pending), Illinois (5%), Minnesota (6%), New Mexico (3.75%), Ohio (4%), Oklahoma (3.25%), Texas (6%), Washington (6.5%) and Wisconsin (5%).] In addition, New York State amended its Real Property Tax Law so as to include telecommunications equipment on commercial subscribers' premises in the assessment for real property. The fact that a rate case involving Centrex, a service in which all switching equipment resides in the telephone company

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central office, was before the New York State Public Service Commission at the same time should not be considered coincidental.

Discussions between the CCTU and several of the Regional Bell Operating Companies produced comments on the subject of broadband, to the effect that given Rate of Return regulation (ROR) as it presently functions on the state level, and current tax treatment of new and advanced technology and equipment, ubiquitous deployment of subscriber fiber loops could not be anticipated in the foreseeable future. The telephone companies have long cited the inability to accelerate depreciation as a major factor influencing this capital investment picture.

The large users agree with the LECs that uniform depreciation makes no sense given the ongoing need to upgrade plant in today's technology environment. Part of the solution to the overall issue of "rewiring America," clearly consists of acknowledging the need for differential tax treatment for various elements of the telephone / communications business. It no longer makes any sense, for example, to simply depreciate all equipment as if it was the same. The event horizon for change which renders a given piece of gear obsolete is totally different for each class of hardware.

To this end, we also made inquiries of the office of the Deputy Director of the Internal Revenue Service asking what the agency's position would be on a corporate return coming from a communication common carrier in which a newly deployed fiber plant was carried on a three or five year straight line depreciation schedule, as opposed to the 20-year schedule traditionally used for outside plant. We first offered the explanation that new digital switching

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equipment had already been allowed accelerated depreciation, based on presentations by AT&T and others, that the generational time span for such machines was much shorter, even though the expected life of the equipment was longer. To that end, we explained that the fiber itself should no longer be considered separately from the switch, since unlike copper-based outside plant, the fiber could convey light generated directly on a board comprising the backplane of a processor, while copper was physically separate in the sense that MDFs, IDFs, and all sorts of distribution equipment on telephone poles and in manholes were involved.

Internal Revenue Officials indicated though such a filing would be questioned and probably disallowed at the local office level, that if our presentation concerning the nature of fiber loops was correct, little or no additional paraphernalia was required between the serving office and the customer premises, then an adjustment in depreciation policy might be warranted.

The remaining problem of course, deals with the opto-electronics, however an even clearer case can be made for obsolescence here, since we are dealing with active devices frequently replaced by more efficient, less costly substitutes, whereas in the case of the actual fiber strands all that is likely to improve over time is refraction indices and other physical properties of this basically passive technology.

Other areas of tax policy must be coordinated with telecommunications policy. Instead of viewing the taxation of telecommunications in the short-sighted manner of being a new revenue opportunity for state and local governments, communications intensive lines of business should be granted abatements

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under the Real Property Tax Laws (RPTL) and other inducements, as the relative gain generated by telecommunications taxes, particularly where large users are concerned, will be more than offset by losses in personal income, sales, and excise taxes, as the large users either relocate, or decide to construct new facilities with the tax picture in mind.

In short, multiple line accelerated depreciation policies should be employed when looking at the communications business. Accelerated depreciation is needed in order to provide telephone companies with the incentive to move ahead with the advanced technologies of the Information Age. The cost of this acceleration need not produce rate shock in local rates, and could be buffered either by special tax credits based on recognition of the overall "public good" stemming from the fiber investment, or from the ratemaking method discussed above wherein escrowed funds brought on by deployment in large users sectors would be applied for these and other purposes leading to the deployment of fiber to the local loop on a universal basis or some combination of both approaches.

Technology & Market Futures in Broadband

While technology, regulatory, and user identities are all serving to dissolve clear lines between traditional markets, a three-tiered typology is clearly discernable if one moves away from a market segment view and looks at the broadband landscape from the perspective of conduit, knowledge engines, and content. (See Fig. 6.) Unfortunately convenient classifications of the past such as competitor/customer, user/provider, dominant/non-dominant, basic/enhanced (value added) in the broadband context, meaningless. Service-specific

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networks, processors, and even architectures are non-existent in the "virtual" environment of high speed switched packet networks. Indeed the basic distinction between the originating and terminating party will, with the evolution of broadband networks disappear, as all parties will be part of multiple networks simultaneously sharing information at the velocities nearing the speed of light. As information content changes from network to network, information about information, its location, and control of the networks themselves will become more valuable than the information itself, and will result in self-modifying use of the network.

In order to grasp the nature of information about information, and its valuation we would have to divert to a discussion of technology futures in decision support systems and machine authorship. The ability of one system to extend beyond its own boundaries and search for additional soucres in other other networks is addressed futuristically by John Sculley, Chairman of Apple Computer in his book, *Odyssey*[34]. Information about information can be productive of knowledge. Machines which are particularly well suited to develop this type of information will differentiate themselves in the future marketplace and will, obviously have to be particularly adept at offering a telecommunications interface or toolbox for transparent use by non-technical users. In order for all of this to happen a great deal more needs to be known about basic units of cogniton and processing. An excellent feeling for how this might take shape is implicit in Marvin Minsky's *The Society of Mind* [35]

Predicting demand, estimating traffic loads, quantifying profit margins, measuring elasticity, and targeting price points shall require rethinking fundamental economic and pricing assumptions, the topic of our next section.

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In examining the typology presented here, it is important to understand that as marketplace barriers become increasingly amorphous, previously proprietary customer bases vanish. For example, participants in information exchange would gain access through a conduit provider, seeking information, data, knowledge, etc., resident at multiple content providers (but not necessarily owners), and receive a product back having been created by an operator of one of the Knowledge Engines, via the same or another conduit provider.

For purposes of conceptualization, between the top tier of the model (Conduit) and the central tier (Knowledge Engines) there exists broadband information highway technologies, i.e., high capacity fiber / Gallium Arsenide LED multi-carrier light emitting diodes, Broadband RF nets, high density cellular systems, etc. Similarly, between the central plane (Knowledge Engines) and the lower level (Content) reside the information Media, I.e., HiCap RAM, Molecular Memories, WORM drive technologies,
volatile optical laser based disk system, and of course the entire family of magnetics.

It should become clear that in this world the term "value added" if meaningful at all, takes on heuristic implications; information about information and navigational tools used to analyze, hypothesize and ultimately, synthesize will have value far exceeding the information resident in the various sources. Similarly the nature of pricing will alter drastically, as shall forms of payment stemming from the ownership of intellectual property. Levels of authorship will evolve within broadband processing networks in which the lion's share of revenue or royalty may not for the first time be returned to the original writer,

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composer, or creator. While this indeed represents a major opportunity for the information entrepreneur, it may hold in store serious and as yet undiscovered implications for the arts and forms of original scholarship. On the other hand, machine authorship enhanced by broadband networking, aided by the proper terminal devices promises savings of several orders of magnitude in the physical and biological sciences where enormous research databases already exist. Specifically, these savings will accrue from lower baseline telecommunications costs, decreased processing expens,es, and lower passed along access fees for use of information databases. This will likely be one of the first applications of the digital library.

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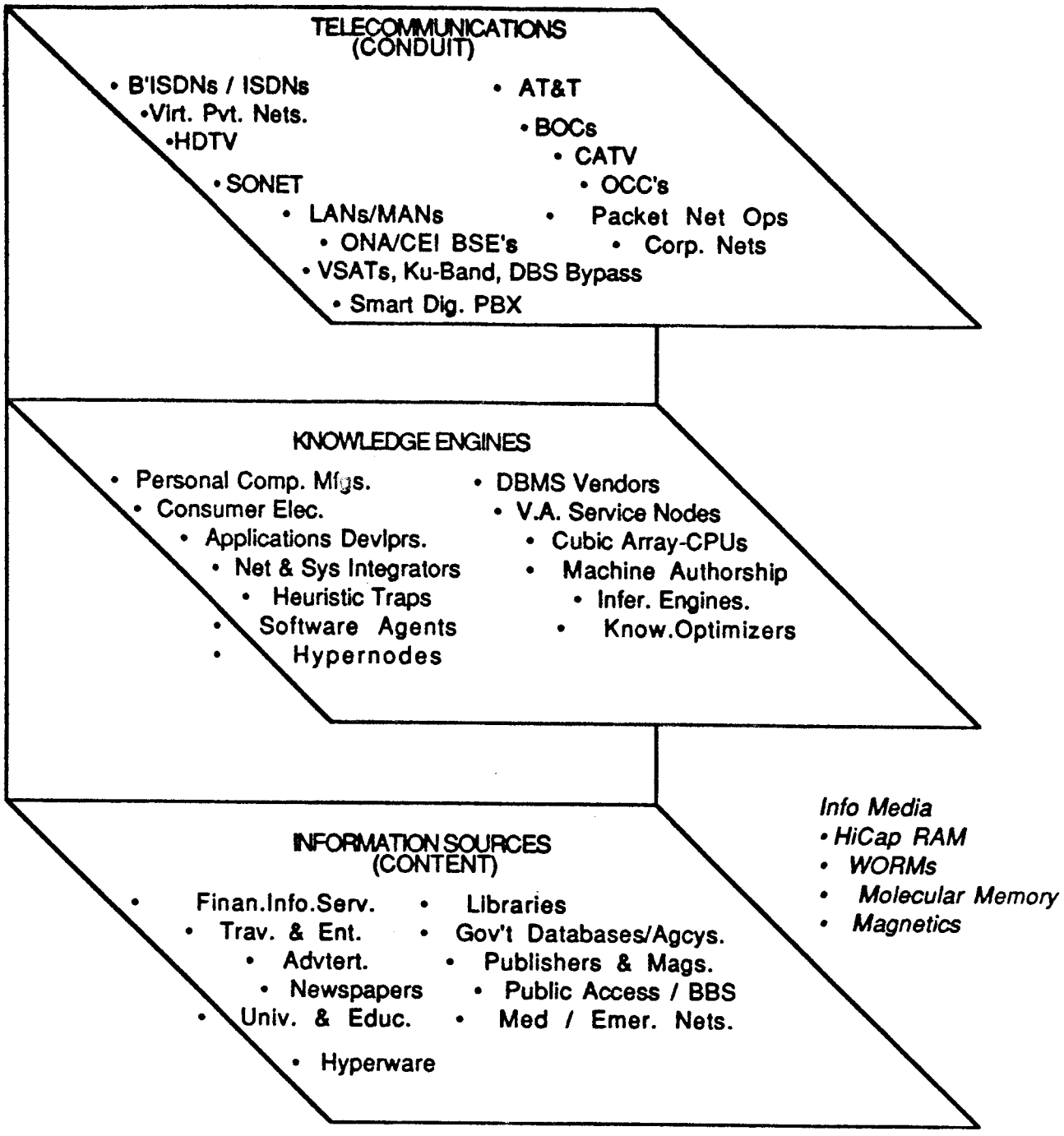

Fig. 6.

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TERMINAL TECHNOLOGY

The large user perspective on so-called terminal devices considers these technologies no longer to be end-devices, or input/output utilities, but rather an integral portion of the network around which many shall design their services. Because advance planning is essential, while the committed capital investment will be made over several years and exceed earnings for several players, issues of standards become central.

Since the notion of traditional marketplace demarcation no longer makes sense, the importance of *universal open standards* is amplified. For this reason, the issue underlying the name "High Definition Television" is so important. While it is not likely that broadcast television will be one of the important Information Highway Technologies mentioned above, for broadband services, the terminal device will, in all probability, have to receive enhanced resolution RF signals. Since the television set enjoys a level of penetration even higher than the telephone, and since entertainment is the information sector for which there is demonstrable demand, and profit, today, this "tail" is likely to wave the elephantine broadband terminal market for some time to come.

Nonetheless, although the large user community fully sees the importance of numbers, which may only exist in the residential market at a high enough order of magnitude to attract initial investment and R&D capital in this area, and fully recognizes the inevitability of telephone, television, CD, personal computers, and other information utensils coalescing into one receiving and processing

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device, an open-architectured terminal standard fully embracing additional business functions is required. A hypothetical functional schematic is presented below, illustrating basic functions, as well as communications inputs and outputs.

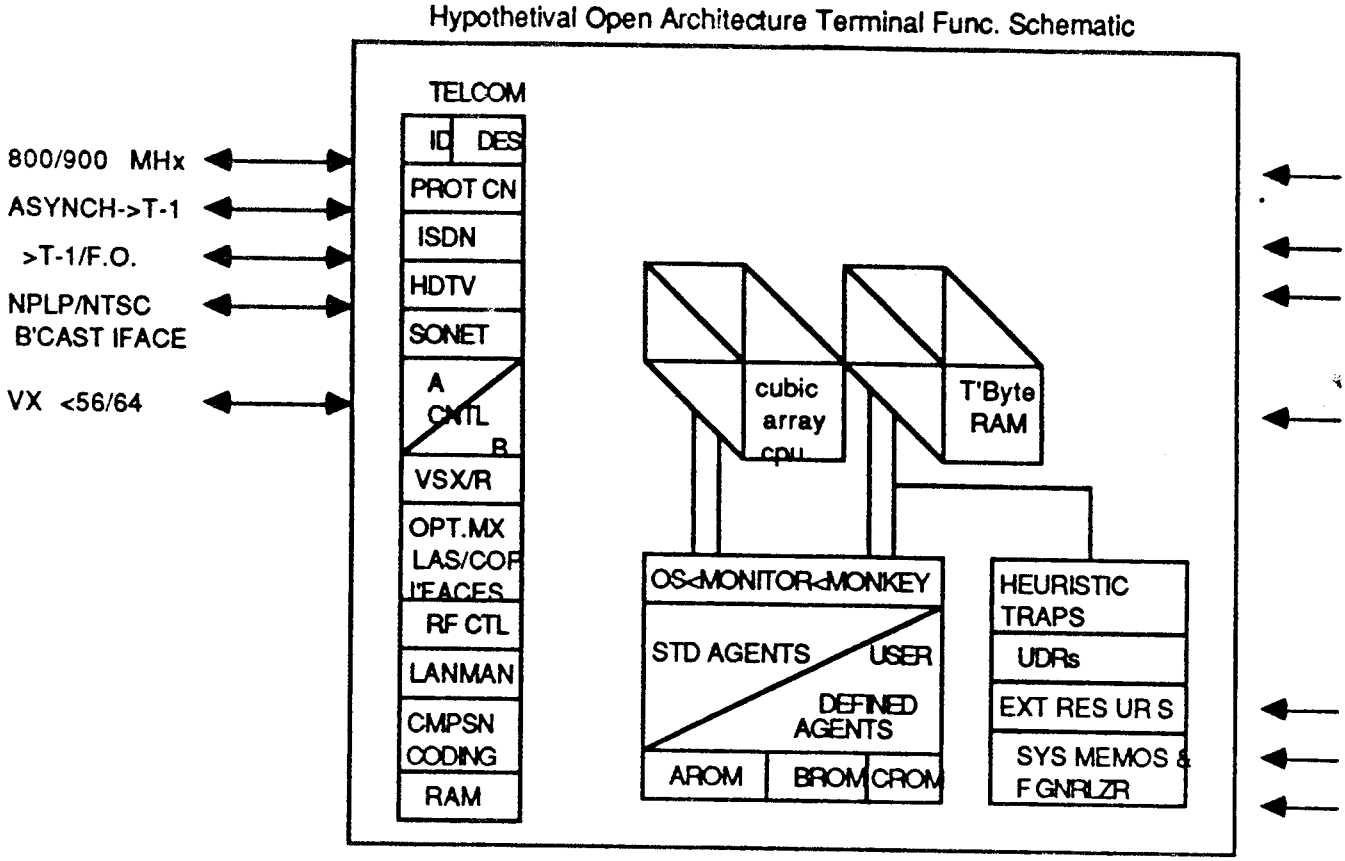

Fig. 7.

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Space limitations do not permit a full discussion of either the pricing implications of the open architecture terminal, or of the additional functionalities view as optional to the development of this device, yet assuming it to be synonymous with what will eventually emerge as a standardized "High Definition TV" receiver, the United States is in serious trouble, competitively speaking.

In addition, the HDTV receiver is considered to be crucial to various defense efforts, because of the implications for the development of important new display devices having a myriad of applications in military systems.[36] [37] The AEA predicts that based upon a fall U.S. debut in 1993, following a launch in Japan in 1990, the price per unit would be approximately $4000 in 1990, dropping to $2500 in 1995, $1500 in 2000 and $600 by 2010. (1990 Dollars.) It predicts markets of 10,000 of $14million in 1993 to world sales climbing to 11million units @ $6.6billion in 2010.

Perhaps more interesting is the projection that the U.S. share of the world personal computer market will be cut in half if U.S. companies end up with less than 10% of the world HDTV market. Similarly for the U.S. share of the world semiconductor market. The loss of the projected computer business alone could exceed $100billion by 2010. At present the United States garners 70% of the personal computer market that will likely reach $315 billion by 2010. To maintain this 70% level, U.S. entities shall have to retain 50% of the HDTV market. [38]

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While the several special interest groups, primarily from the commercial broadcast world, have attempted to protect their shrinking profit base, offshore developers have seeded a substantial fraction of the film production houses in California with *production standard-level* equipment compatible with the Japanese-advocated MUSE standard. For reasons best left undefined, because insufficient evidence exists to make a claim, the U.S. Dept. of State, at the urging of the broadcast community and the FCC has endorsed the Japanese standard, at the production level, having been misinformed as to the ease with which signals can be reformatted should the transmission and production standards not turn out to be the same! While the offshore strategists game is clear, to stimulate a market which at present does not exist, through producing video-tapes of first run movies which are already available for a couple of dollars an evening, in simulated higher resolution using a "black box," which by the way we have learned is sealed and may contain 356K ROMs, the stakes are much higher than placing the U.S. consumer electronics industry at risk. After all, the only company manufacturing television sets in the U.S. is now Zenith, whose future is unclear.

Should MUSE become the degratia standard achieving significant marketplace acceptance and penetration while the rest of the world sits around conference tables at the CCITT trying to set the "real" defacto standard, serious problems will attend the development of a worldwide *transmission standard* for broadband networks, because of the pointer and other fixed field requirements of MUSE, at the transport level. In other words, if MUSE is adopted at the production level, the likelihood of a truly open standard at the transport level is significantly reduced. It is noteworthy that the offshore manufacturers of video equipment and Hollywood production houses are by no means the only

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stakeholders. When we move up from the production level to the transport level, the field then expands to include the sectors of the three-tiered broadband model discussed above. Conduit operators, knowledge engine providers, and information (content) sources all have a stake in the action.

So far, most of these players are yet to realize that the rug is being sold out from under them, though the "old dominants," IBM and AT&T have small staffs entirely dedicated to working this issue. Financial information service providers, and personal computer manufacturers are yet to become involved because they have not heeded advice given them concerning the importance of this issue. Preconceived ideas are sometimes hard to change, and harder perhaps when held by large corporations.

Ultimately, the entire manner in which the user communicates with the broadband network, through the receiver/terminal shall alter the nature of visual metaphor as we now know it. The device shall be equipped with "heuristic trapping" software which shall track the style of usage, by user, and present information in future sessions based on the manner of interactions of the past, in accordance with a typology of information usage. Time does not permit discussion of details here, however the author has been working on the development of such a typology for several years, and whether his or some other scheme is ultimately integrated into the heuristic operating system of the navigational device[39], the success or failure of these user-based selfmodifying graphic, aural, and tactile metaphors will ultimately determine the numbers of "haves" as opposed to "have nots" in a world in which wealth and advantage will increasingly depend on access to knowledge.

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PRICING AND ECONOMICS IN THE BROADBAND ENVIRONMENT

As stated before, clear and strong historical linkages exist between telecommunications and transportation within regulation and pricing theory. It is probably at this point, when telecommunications ceases to continue to simply be a transport device for signals, that this partnership will dissolve.

A review of pricing policy in telecommunications, and possibly in transport as well, will reveal the existence of one of the many classical business cycles[40] [41] [42] operating in the oscillation between flat rate and usage sensitivity. Of course, originally when the social objective of "universal service" was the driving factor, prices had to be driven as close to marginal cost as possible. At that time, only a single, basic service was being provided: manually switched voice telephone calling. Marginal cost pricing predominated as the service spread, with built in cross-subsidies across population density sectors, especially for the installation of local loops in rural areas, where individual subscriber access costs could approach thousands of dollars in today's funds. Flat rate pricing, at least for local calling had the effect of stimulating usage, while capital needed for network expansion and construction costs was being generated out of cross-subsidies, and later, bond issues, as well. So-called flat rate made sense for the first several decades of service.

In the early 1960s however it became apparent that due to regional economic effects flat rate could no longer hold prices to marginal costs. Not surprisingly,

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this issue first came to notice in New York City, where flat rate local calling was eliminated first for business customers, and then for all new residential customers. Of course by then, the carrier offered dozens of different services, which is important in terms of classical pricing theory as one would expect that various inefficiencies had crept into the operation, as the number of services increased.

The trend away from flat rate spread, with several other large cities moving to usage-sensitive pricing. Usage sensitivity was built in along three dimensions: length of call, time of day, and distance. This three-dimensional model is largely in place today for POTS, with almost all major cities tariffed under some form of usage sensitive tariffing. Long distance services had some degree of usage sensitivity built in from the beginning and has historically born the bulk of the loading in cross-subsidy formulas.

Whereas either of these basic methods was workable at least when telecommunications were based on physical connections made by thousands of relays clicking away, when narrowband or slow speed packet technologies, beginning with the early AlohaNet developments, it became clear that in terms of an analogy, we were out of the passenger business and into the freight train business, as the packets could, indeed, carry bits and bytes representing any number of commodities, not just voice calls. Yet, such a system could not, of course, be priced as dedicated private lines were, at unit cost on a disaggregated basis, plus some "k"-factor, which was determined by the overall contribution of private lines to the overall rate of return of the company. (Private line pricing, which later became the subject of much controversy because of the opportunity to price well below marginal cost for these flat rate facilities when

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the comparable usage sensitive facilities were not affordable by either individual subscribers or small companies, became the basis for bulk discounting [Telpak Tariffs], which were later ruled to be unlawfully discriminatory, and ultimately, eliminated, though similar schemes are now being sought under the umbrella of "specialized tariffs" by AT&T and the other inter-LATA carriers.)

Some European PTT's actually took on the task of pricing packet services on a usage sensitive basis. In the United States, interestingly the dominant early packet service providers were not the dominant regulated common carriers but rather, Tymnet and Telenet. AT&T's early network architecture and rich mix of switching and transmission technologies made it impossible to establish a dedicated subnet for packets early on in this game. The "VANs" as they used to be called, because they packetized and converted between protocols (mostly asynch to X.27 / X.75, et . al.), and switched using datagramming and virtual paths techniques, thereby "added value, " usually priced as a function of input speed into their network nodes and PADS (packet assemblers/disassembles) and length of session.

Such methods are neither practical nor even desirable when broadband transport is used. Firstly as we mentioned much earlier, the nature of traffic as a function of bandwidth utilization will be largely unpredictable both as to user segments, distance, time of day, and statistical peakedness. In other words even the most rapacious applications will not use the bandwidth either continuously, or with regularity. Anania and Solomon[43] have made this point eloquently in their paper advocating a Flat Rate Structure for BISDNs where HDTV is contemplated. The large user perspective is by and large in

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agreement with their recommendation, however, feels that upon closer examination, such a proposal, based upon maximum instantaneous bandwidth allocation[44] is really a form of access pricing and not "flat rate." Upon practical application, the access rates, regardless of bandwidth consumed may need to be varied depending upon overall network conditions.

For this reason, large users wish direct access to control and signalling channels containing network traffic condition and routing information at all times, so that their production and telecommunications scheduling software agents shall be able to assign transmissions of all varying kinds in accordance with future predicted conditions on the broadband network. Broadband traffic and network forecasters would be one of the software "agents" resident in large user-owned nodes. Today, some 80% of the capacity of the Public Switched Network (PSN) sits idle for 16 hours out of each 24, while businesses in the respective time zones are closed. This will neither be affordable nor desirable in the age of the broadband network.

A number of alternatives have been proposed which bear mentioning, including most recently "Price Cap" regulation, which of course has its own implications for pricing, i.e., floating prices. The large users who would normally endorse price caps have thus far either been reluctant to do so or have outright opposed this alternative for two reasons: firstly, as has been demonstrated in the transportation field, price cap regulation removes most if not all incentives for improvement of service levels, from the provider. This becomes especially acute in areas where the costs of service provision to the carrier are high, and where usage, equatable to ROI is low. Service tends to decline over time in proportion to population or consumer density.

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A number of questions surrounding the price cap issue in England have been articulated, but not answered:[45]

- What is the magnitude of rate reductions and productivity gains by the telephone provider which can be reasonably expected under price caps?

- Are price caps primarily a transitional tool for countries already committed to competition, or are they also relevant for countries which choose not to license alternative services?

- Are price caps an option for state owned telephone companies, or is "privatization" a prerequisite?

- Do price caps actually align prices with costs, and thus reduce cross-subsidies?

- Are price caps less costly to regulate?

Secondly, to put it politely, we are dealing with regulated providers who have recently been divested from a larger conglomerate as a result of settling a Federal antitrust case in which anticompetitive practices and migration strategies, a classical pricing scheme, were employed unlawfully. Large users feel that to go ahead with price cap regulation might be a bit like giving the car keys to one's teen age son who hasn't yet obtained a license. They do not trust

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the formerly dominant service providers, some of whom have even been accused of wrongdoings in charging their own operating subsidiaries.[46]

Pricing under Incentive Regulation is another alternative usually worth extensive examination. Here, profits earned above a stipulated level are essentially shared between customer and stockholders.[47] Instead of a price cap or maximum rate of return, a "target" or basket level is defined at the start of the business cycle. If exceeded, monies are distributed. Given the capitalization that is going to be required to achieve our broadband goals, there surely will be no such surplus. If capital is available after large users are connected to institutional fiber links with rates fixed at near present level until capital expansion is completed, it should be reinvested in further expansion of the fiber loop program, and not returned to either employees of the communications company, their investors, or ratepayers.

Finally, as mentioned earlier, interesting results in this area are to be found in Australia,[48] where a modified form of price caps has been decided upon. By its own admission, the DOTC has stated that "a price cap regime was decided upon primarily in the interests of administrative simplicity..."
Monopoly services' price caps are tied to general cost of living-type indices. With respect to pricing in Australia under price caps, separate price capping plans for residential and business users have been approved, so that "benefits of efficiency changes are equitably shared among consumer groups." The residential caps will have a stipulated maximum specifically for cost of basic access. It is assumed that the customer access (local) network is among the most inefficiently priced services, thus the price cap may need to be an inflation-plus cap to allow for more frequent rebalancing between it and other related

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services. This however is more true undoubtedly in Australia than the United States, due to the concentration of the population in a few large urban centers and the overall size of the country, which is that of the 48 contiguous states in the U.S.

The peek / off-peak distinction will be retained, as will be the inflation minus productivity formula. The need for greater accounting scrutiny under price caps is reportedly recognized by Australia. How this balances with the policy objective of less costly administrative regulation is not known.

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CONCLUSION

For large users, the basic question surrounding broadband services is not "IF?," but "HOW?" Hopefully this discussion, which has developed more questions than answers, has demonstrated the totally interlocking nature of the broadband strategy question with such seemingly remote matters as the robustness of the U.S. consumer electronics industry, pricing within the already robust telecommunications industry, high definition television and its forced marriage and dependency on the entertainment business, and a host of social and business issues surrounding the future global market for information.

Large users seek inexpensive and unfettered access to broadband delivery systems devoid of as much regulation and infused with as much competition as possible. To that end, bottlenecks and gateways priced under usage-sensitive structures, as well as any form of sole-sourcing of transport is generally to be

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avoided. Similarly, any attempt to tax the flow of information, either as a service, or commodity should be met with the greatest resistance possible, as not only will the privacy of the user parties potentially be compromised, but fundamental macro economic trends leading to a more equitable distribution of wealth will be thwarted. Also strong resistance should be applied to avoid the taxation of telecommunications equipment. Those providing the broadband service should be allowed to depreciate equipment in line with the realistic cycle of obsolescence which attends it. Pricing services at or above 100Mb/s should be based upon average instantaneous usage for predefined categories of overall network conditions, with users given access to "D"-Channel interfaces carrying this type of information. Consequently, the traditional concept of the "smart" network is no longer desirable beyond being able to provide detailed traffic and related information.

The trend not to act proactively, until some crisis is at hand cannot be allowed to typify our relationship to telecommunications as it has transportation, energy, and environmental issues. This style of management stems from an inability to conceptualize creative solutions to often straightforward problems which have been conceptualized incorrectly repetitively, for a long period of time, such as is the case with the problem of the nine dots presented at the beginning of this paper.

If you see the nine dots as a square, you cannot solve the puzzle, after all they are only nine dots. Similarly, with the realization that growth in world information flows, coupled with spiralling capacity and declining costs associated with capturing, processing, and repackaging information, are moving in favorably opposite directions, it shouldn't be too difficult to reach the

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conclusion that these markets should be left alone, free from regulation and taxation.

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