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The Dumb Network Paradigm

Based on the Internet Protocol, stupid systems gain extra-sensory powers. . .

David Isenberg's concussive essay, "The Rise of the Stupid Network," in June sent seismic shock waves through the telco establishment and illustrated the power of an idea unleashed on the Internet, where his bosses had innocently permitted him to hide it. No one will notice, they must have assumed, if a brilliant engineer of intelligent networks at Bell Labs calls for a new reign of stupidity. But Isenberg made his point. Based on the Internet Protocol, stupid systems gain extrasensory powers–a paranormal phenomenon familiar to people who in pursuit of information spurn late night psychic lines in favor of AltaVista, **Infoseek** (SEEK), **Excite** (XCIT), and **Yahoo** (YHOO).

One way or another, the world flocked to Isenberg within hours of the posting of his article. Harry Newton, the computer telephony impresario, asked to publish it in his magazine and Isenberg said no. But Newton speaks only in a kinky Australian dialect of English and there was some part of Isenberg's "no" that he did not understand. So sure enough there was Isenberg's article in the pages of the August issue *Computer Telephony*. The essay made him famous (or notorious) in the industry and impelled us together (see GTR 9/97). At the time, he had no idea that I had been writing about dumb networks for years (beginning with *Why Cable Will Win*, Forbes, 1990; *The Coming of the Fibersphere*, ForbesASAP, December 7, 1992). But the data led both of us to the same observation: that a bandwidth explosion was overthrowing the telephone company paradigm of scarce wires.

As Isenberg put it, "Telcos invented the stored program control switch in the 1970s...and then fell asleep at this very switch." None the less, amid the sibilant lapping of erlangs on the shores of the network, there occasionally rings out an alarm. Someone at a telco or other bastion of intelligence has noticed some anomalous pattern of telephone usage at the periphery, signifying a highly suspicious and possibly felonious application of IQ in the field of communications.

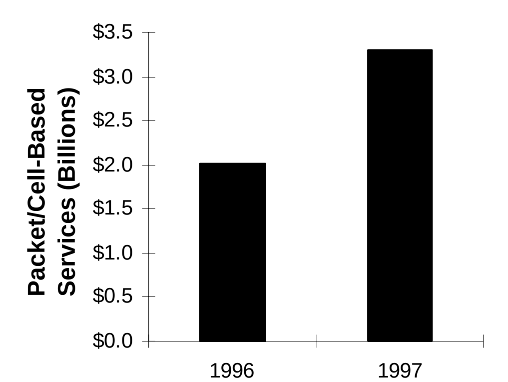


Chart 1
US Packet Telecommunications Market

Source: IDC

When the telcos try to call the cops, though, they discover that emergency 911 service is crowded out by customers who leave their computers off the hook. Meanwhile everybody in the Washington constabulary is busy reading FCC official Kevin Werbach's "Digital Tornado" article or Charles Ferguson's fiery screed on the telcos as obstacles to innovation and growth in the US economy. Even Ira Magaziner at the White House has gone nethead. The telco sirens wail: "Stop Internet Telephony! It will block 911 calls!" "The Internet is a porn racket for the sticky keyboard set; it competes unfairly against 900 numbers!" "The Internet is a cable TV system; make it queue up to pay for the mayor's campaign for re-election like everyone else!" "Tax ISPs on every bit (many layers of income taxes alone will not suffice to block their ruthless scheme of unfair competition

Qwest is *stupidly* pushing capacity to the utmost as a strategic weapon that both confounds and deters competition. . .

and tax evasion; they are a juggernaut going broke at any cost!)." But few seem to be listening to such complaints any more.

It is hard to oppose intelligence. But Isenberg says "Stupid" is better. I say strip the network of unnecessary vowels and make it "DUMB." Digital Ubiquitous Mega Bytes to every home and office. Then fertilize it next year with DUNG (Digital Universal Naked GigaHertz). Meanwhile, I am desperately working to finish my book for an early February deadline, allowing Isenberg here to join me as coauthor of this report, distilling the wit and wisdom of his decade in Bell Labs. But don't blame him for errors or unsavory puns and opinions. The last word was at Gilder Technology Group–GG.

Visit the Phone Company of the Future

Scouring the world for supreme dumb, we quickly came on **Qwest** (QWST) EVP of Products, Nayel Shafei. Our kind of people, Shafei is a genuine idiot savant, who struggles unsuccessfully to conceal his MIT doctorate. But it takes a smart man to build a dumb network. When Shafei gets excited, his whole body oscillates in a kind of strange heterodyne mode, chiming, smiling, twitching, gesticulating, and sometimes stressing out the mixers and transponders of his listeners.

Qwest claims to be fielding more dumb bandwidth than all the other Inter-Exchange Carriers (IXCs) put together and Shafei cannot wait to tell you about it: "We are not in the museum business. We are not doing natural history around here. We are leveraging the greatest currency of all–our unlimited bandwidth–to shape the future of telecommunications." Qwest has now lit its network from Los Angeles to San Francisco, Denver, Kansas City (crowding Sprint) and Columbus, Ohio. It will be selling phone-to-phone Internet telephony in most or all of these markets by the end of the month. By 1999, it will have 125 cities lit with 16,000 miles of fiber, which is some 20 percent more than **MCI**'s (MCIC) network today. This fiber is arranged in huge, self-healing SONET rings, that are splayed across the US Map in Shafei's office. And in mid-1998, Qwest will turn on its 1400 mile Mexican backbone. Other international plans, all supremely dumb, will be announced soon as well.

For now, Qwest is lighting each of their fiber pairs with 8 Wavelength Division Multiplexed (WDM) bands of optical carrier OC-192 (each around 10 gigabits per second, for a total of 80 Gigabits–or over a million simultaneous phone calls–on each fiber), and a typical fiber optic cable holds 96 individual fibers. If you want to launch your own telco, or start up as a new Internet service provider, Qwest will sell you the bandwidth to do it. "We'll sell you OC-12 [that's 622 megabits per second]," says Shafei, "Do you know any other company that will even sell you OC-3 [155 megabits per second]?"

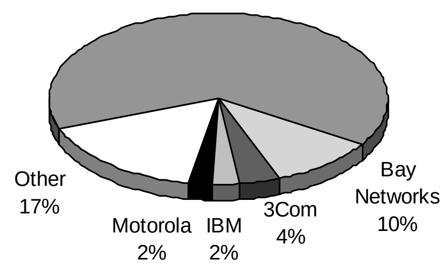
We don't. We recently visited a New York ISP that hosts several high volume web sites, and it has to buy 30 T-3's (45 Mbit/s) to do it. A single OC-12 would have carried all this and more, plus it would have been lots simpler and lots cheaper–but sorry, not available. MCI says it will have OC-3 available to customers in mid-1998. For now its OC-12 is restricted to its Internet *backbone*, which commands dual OC-12 lines (a total of 1.2 gigabits per second).

Apparently unaware of Qwest, however, MCI also announced that its 170 mile route linking Los Angeles and Rialto, California, is the first to carry live traffic at OC-192 rates muxed onto eight wavelengths for 80 gigabits per second down a single thread. MCI says it is on the way to deploying 1.2 terabits per second on an unspecified schedule. "Using WDM and other technologies over the past 10 years," reports MCI chief engineer Fred Briggs, "we've been able to put 70 times the capacity on our fiber plant at one seventh the cost of adding new fiber. There is no shortage of capacity. However, there is no glut. We add capacity only as we need it using WDM."

Chart 2

Router Market Share

3Q97: $1.3 Billion



Source: Dell'Oro Group

Very smart. That is intelligent network thinking. MCI had better get over it before joining up with the dumber hicks at **WorldCom** (WCOM) and competing with Qwest. Qwest is stupidly pushing capacity to the utmost as a strategic weapon that both confounds and deters competition and opens up the huge elasticities of lower priced communications. For starters, its long distance phone service runs at seven and one half cents a minute, 25% below the usual bargain basement rate.

If you want to know on which side of the fence any telco resides, ask its CEO whether he believes demand for telephony is elastic or inelastic–that is, whether lower prices yield higher or lower profits. Based on exquisitely calculated marketing models, conventional wisdom among the over-the-hill gang is that lower prices are a perilous tactic. The new dumb telcos are all united in their faith in positive strategic elasticities, in their belief that the lower prices can expand markets and unleash innovations that transform the business.

Launching an Internet telephony exchange company called **ITXC**, for example, Tom Evslin agrees with the dumb agenda, cutting prices as a strategic weapon. Like Qwest CEO Joe Nacchio, Evslin is a renegade from the fast track to the top at **AT&T** (T). Unlike Nacchio, Evslin managed to coax initial funding from AT&T and Internet telephony software pioneer **VocalTec** (VOCLF) of Herzlia, Israel and New Jersey. Evslin asserts that the key to success in the new era is price. Lower prices not only expand the market, he explains, they also call forth new markets through innovation. "You get secular gains in traffic that are multiplied by breakthroughs in new services." On the way to becoming an important paradigm company, ITXC is eschewing direct customer service to supply the fabric between the thousands of ISPs and others who will be offering IP phone connections as clear as the telcos today.

Consumers will access Qwest's IP long distance service by making a local call on a normal telephone, dialing into a circuit-to-IP platform made by **Vienna Systems**, a **Newbridge Networks** (NN) affiliate. Newbridge has long preened as the prime champion of asynchronous transfer mode (ATM), an additional smart layer between the customer and the hardware. But the Vienna platform will simply packetize the raw, 64 kbit/s signal, and send it via IP.

The Qwest network runs native Internet Protocol (IP) directly over SONET, the standard physical signaling and redundancy layer of the network. Evslin sees this as an industry trend. Long-haul carriers are dispensing with smart ATM middleware. Sprint, for example, recently went ATM-less on its SONET/IP backbone. This is both because physical layer infrastructure is becoming more abundant and more capable, and because IP is gaining new capabilities to handle different kinds of traffic. As MIT's David Clark explains, IP is now reaching its potential as "the great spanning layer" between the glass fiber below and the bitstream of ideas above. Designed from the outset as an internetworking technology to link disparate hardware and software, dumb IP is the great enabler of intelligence at the endpoints of networks.

"Anybody who's got an idea, but has been frustrated by limited bandwidth, should contact me immediately," Shafei says (shafei@qwest.net). Yes! Abundant bits-in, bits-out bandwidth–to liberate innovation–this is the future of telephony.

Shafei looks right at us and says, "It's your idea–the Stupid Network. We're doing it!"

Dumb as a River

A Stupid Network feeds on plentiful infrastructure–cheap bandwidth and switching–that is about as smart as a river. The water in a river, or the data in a Stupid Network, gets to where it must go, adaptively, with no intelligence, and no features, using self-organizing engineering principles, at virtually no cost.

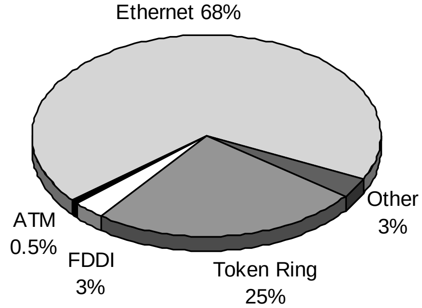
Modern, computer controlled telephone network equipment was designed in an era of scarcity. Imagine, for a moment, that you are in the late 1970s. The computer you use is a VAX that takes up a whole room. It has maybe 32 kilobytes of "core" memory and a refrigerator-sized hard disk. Your monochrome terminal, with a fancy new 8-bit processor, sits on your desk, connected to the world by a 300 baud modem. "Modern" telephone company digital network infrastructure was conceived in this era.

The design assumption was that only a certain proportion of telephone lines, maybe one in ten, would be active at any one time. That the average business call lasts 2.5 minutes. And the average residential call lasts 8.5 minutes.

In the 1970s, computer controlled switching endowed telcos with the power to do "intelligent" things with calls. In time, they could accomodate 800 numbers, give callers choices before the call is completed ("push one for domestic reservations, etc."), control payment options by voice, verify calling cards in real time, and supply calling party numbers to customers for database lookup (which is why I must verify from my home phone that I got my Citibank card in the mail). Nearly all the features involve call set-up or billing, or both.

Chart 3

Network Topologies Planned



Source: Computer Intelligence

All this intelligence actively impedes innovation. Everything affects everything. For example, until recently, you could not get Caller ID for an incoming call when you were on the phone. To fix this, **Bellcore** had to invent a low tech, low functionality, high complexity protocol called Analog Display Services Interface (ADSI) so you could receive Caller ID information for a call waiting call. Call waiting with caller ID would be a total no-brainer under Internet Telephony, but it is incredibly complicated in the circuit switched world.

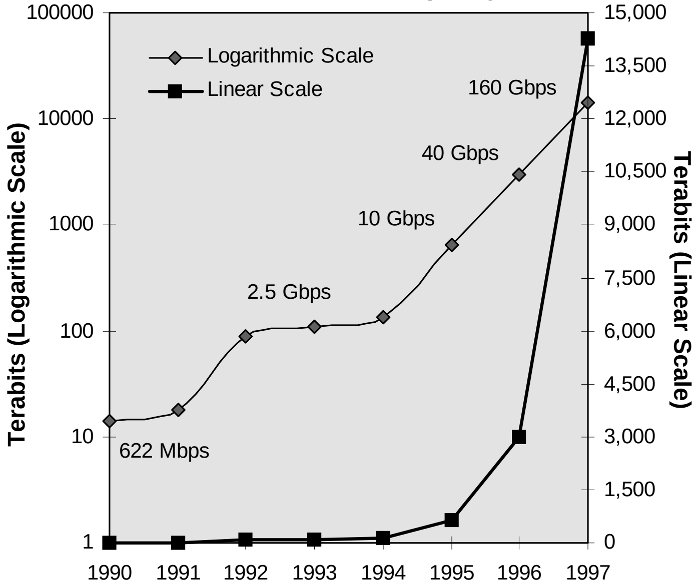
Telcos have a word for this problem– "feature interaction." Entire bulging issues of telco technical journals are devoted to it. Telcos dread new features because every feature must be tested with every other feature for "feature interactions." Every new feature in the Intelligent Network needs a business plan, a marketing plan, a provisioning plan, an operations plan and a maintenance plan and these feature interaction plans interact as well.

A Stupid Network doesn't have many features. Innovation is easier, because it occurs on the periphery of the network, isolated from the middle of the network by layered protocols and clean interfaces. You'd think that telephone company engineers

On the way to becoming an important paradigm company, ITXC is eschewing direct customer service to supply the fabric between the thousands of ISPs and others. . .

Chart 4

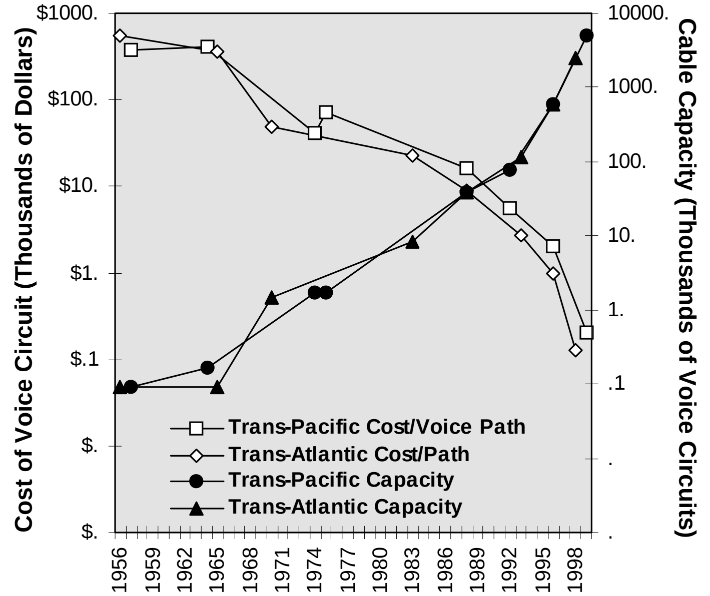
US Telco Fiber Capacity



Sources: FCC, GTG

Chart 5

Trans-Oceanic Cable Cost/Capacity



Source: TeleGeography 97

The Law of the Telecosm, *that each year will bring a 3-4 fold increase in bandwidth with concomitant plunging prices is reflected in the charts on this page. Increasing telco fiber installations only tell a partial story. Thanks to WDM (wavelength division multiplexing) the laboratory demonstrated capacity of a single fiber thread tripled from 1 to 3 terabits per second in less than one years' time. The capacity of commercially available fiber transmission systems has risen from 10 Gbps (gigabits per second) in 1995 to 40 Gbps in 1996, with Qwest installing 160 Gbps systems at the end of 1997. MCI's announcement of a 40 Gbps installation at the beginning of 1997 was overshadowed by their December 9, 1997 announcement of a 80 Gbps route as a mere step towards an eventual migration to 1,280 Gbps (multiplexing 40 Gbps into 32 wavelengths).* **Chart 4** *shows–using both logarithmic and linear scales–the combined effect of new fiber by US telcos and the rise in capacity of commercially available transmission systems. It shows how much data could be carried at any one instant–imagine pumping bits as fast as you can into a fiber thread until they begin to spill out the other end, then count the bits in the fiber. Multiply total installed fiber (miles) by transmission speed (bits/sec) and the inverse of the speed of light (sec/mile) and the result is the total capacity (bits). At any one moment, the US telco fiber could hold some 14,000 terabits of data, more than the total 1997 US Internet traffic.*

Taking an historical look at under-sea telecommunications cables, we see a similar explosion of capacity and the consequent plunging of costs. Unlike terrestrial fiber networks, which can theoretically reach maximum available capacity, under-sea cable capacity and costs are generally fixed at the time of construction but reflect the development of new technology over time. **Chart 5** *graphs–using logarithmic scales–the capacity and costs of successive trans-Atlantic and trans-Pacific cables.*

*The end users of data communications observing the glacial advance of analog modem technology have not yet seen this dramatic explosion of bandwidth or plunging costs. The true end-user bandwidth explosion comes with the evolution from archaic circuit switched telco networks to packet switched networks, best epitomized by ethernet. The transition from analog modems and ISDN (connected to the switched network), to xDSL systems (diverting data away from the switched network at the central office), to cable modems (emulating ethernet over relatively dumb cable networks), to 100 Mbps fast Ethernet (on a true data network), clearly demonstrates the explosion of bandwidth and cliff of costs that is possible for end user connections (***Chart 6***).*

*End users perceptions are also clouded by the telco monopolies' focus on the high prices they currently charge for high bandwidth connections. Telcos fail to see the vast potential for sales in the business and consumer markets. Computer Intelligence (CI) surveys of nearly 38,000 businesses during the course of 1997, offer a picture of the current size of the data communications market. CI's research indicated that 3 million small and mid-sized companies (with less than 1000 employees) are using some 7 million local dial lines/trunks for data communications. The small penetration of high rate ISDN and T-type data lines is dwarfed by the massive reliance on low bandwidth modem links (***Chart 7***). When evaluating telco reluctance to drop broadband prices for fear of cannibalizing current ISDN and other T-x services, those services total US penetration must be compared to the vast potential of over 6.5 million business data lines, plus another 18 million (and gaining) households already using the Internet.*

Chart 6

Network Adaptor Price-Performance

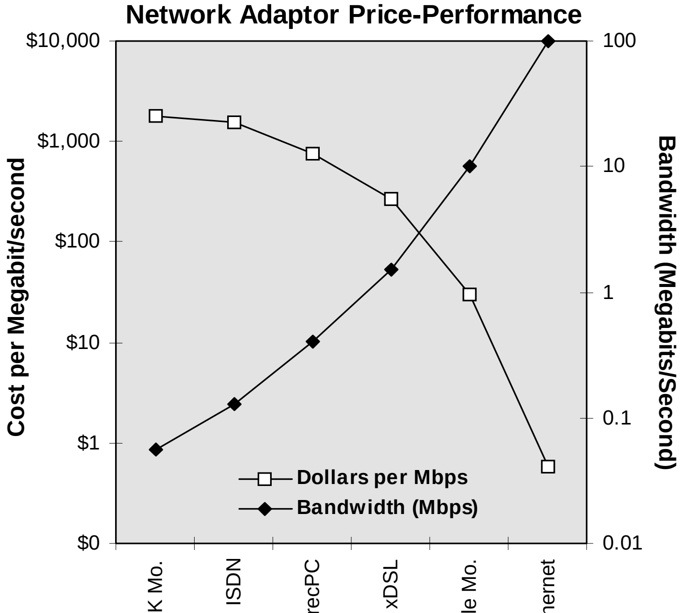
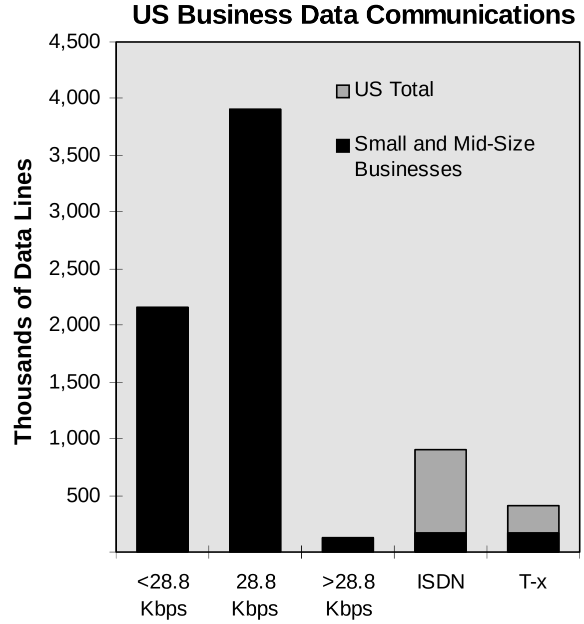


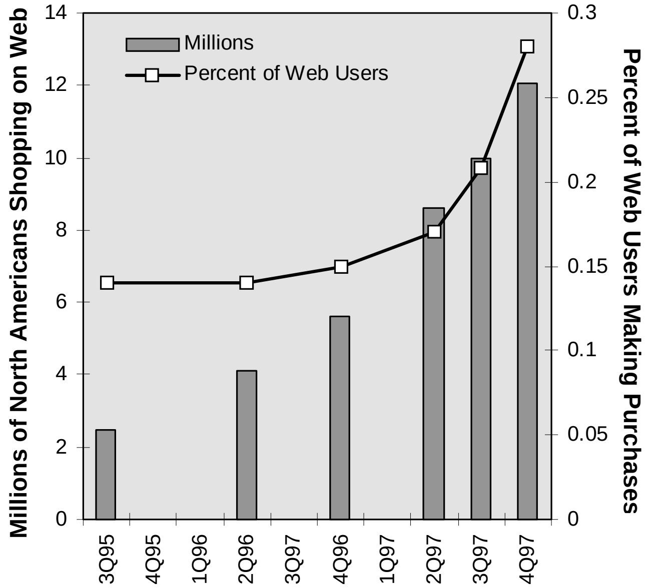
Chart 7

US Business Data Communications



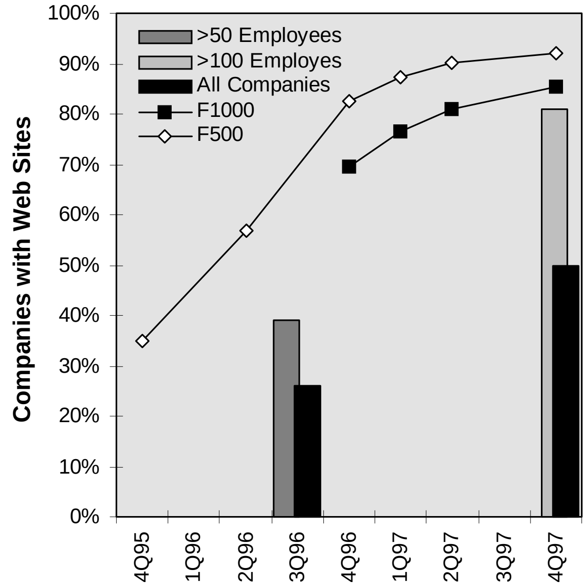
Source: Computer Intelligence, GTG

Chart 8
Internet Shoppers



Sources: Nielsen/CommerceNet, Intelliquest, Navidec, NetRatings

Chart 9
US Companies on the Web



Source: IDC, GTG, AT&T,RHI Consulting

E-commerce *celebrated an historic first, in early November, 1997, when cosmonauts onboard the MIR space station purchased two Gateway computer systems marking the expansion of Internet-base e-commerce to space. On Earth, Thanksgiving marked the start of the online buying season. According to Paul Graham of Viaweb, his customers' e-commerce sites' daily sales doubled from $55,000 before to $110,000 a day during the three weeks following the holiday. In the first week of December, Dell Computer reported several days with web sales of $6 million, up from an average of $3 million/day in 3Q97, $2 million in 2Q97 and $1 million in 1Q97. About 6% of consumers plan to buy gifts online in 1997, according to American Express, about the same as the NetRatings survey. In the US, some 28% to 30% of Web users or 12 to 13 million people have now made online purchases (***Chart 8***). The Consumer Online Usage Study by Simmons Market Research Bureau, similarly found some 11.9 million people have made an online purchase in the last twelve months, averaging $800 per year or some $9.52 billion in total spending. This is 87% higher than IntelliQuest's finding of $5.1 billion annualized rate of spending in 2Q97 and almost 6 times the $1.6 billion spending of 2Q96. Projections for 1997 consumer online spending by Yankee Group ($2.74 billion), Jupiter Communications ($2.6 billion), and Forrester Research ($ 2.4 billion) underestimate online spending.*

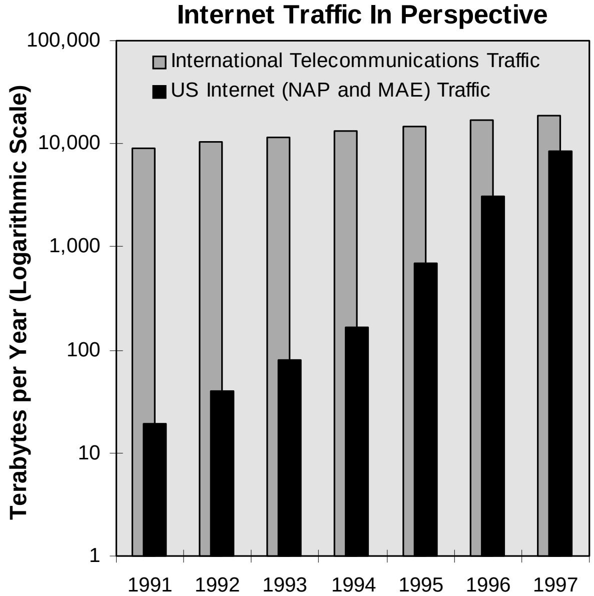
Half of US companies now have web sites *according to RHI Consulting. Penetration rises further with company size (***Chart 9***). Marketing has been the initial aim of most deployments with e-commerce expanding with consumer and business demand. Of some 300 retailers analyzed by Computer Sciences Corporation, over half had web sites but only 12.5% were offering online product ordering. Among retailers with catalogue operations 66% allowed online transactions and most of the remainder indicating that online ordering was coming soon. Dell estimates web sales were evenly divided between home and business users, but despite the jump in holiday spending, it is likely big-ticket business to business Internet sales–including Cisco's sales totaling some $3 billion–outstripped consumer purchases in 1997.*

The explosion of the Internet *is no longer a secondary phenomenon in telecommunications.* **Chart 10** *shows a mere subset of Internet traffic, the data flowing through US exchange points, graphed against total international telecommunications traffic. While Internet traffic is still somewhat less, the momentum is clear.*

The Internet has become the killer ap for PCs. *The Internet and the PC industry reached a milestone mid-year 1997 when the penetration rate of Internet access on home PCs with modems topped 80% (***Chart 11***). Nearly all PC users with the hardware to access the Internet are doing so. Henceforth, increases in PC sales and Internet access will be linked. A full 60% of new customers of the UK Internet service provider (ISP) Prestel bought a PC in the previous three months and cited online access as their primary reason for doing so. Internet access is driving PC sales among both new users and the 56% of purchasers buying replacement and additional PCs. Most modem-less PCs are older machines, with 68% of the PCs without modems over two years old and 50% purchased in 1994 or earlier. And users without modems are less likely to install one.*

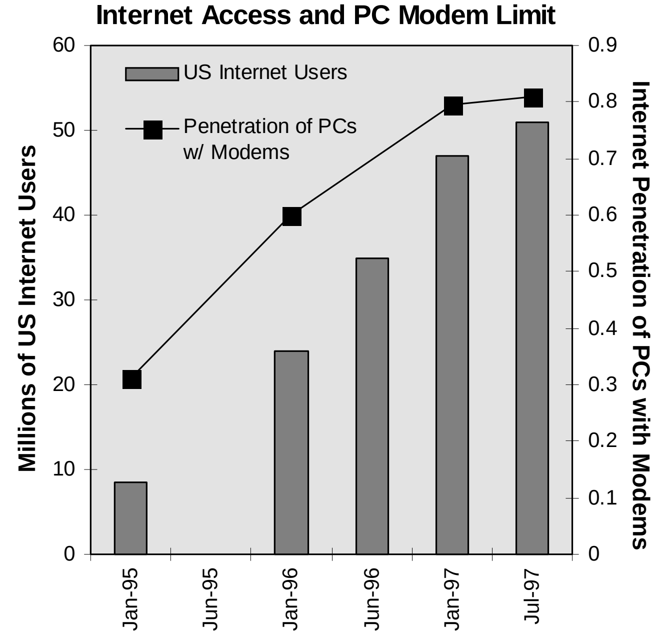
-KE

Chart 10
Internet Traffic In Perspective



Sources: GTG, TeleGeography 97

Chart 11
Internet Access and PC Modem Limit



Sources: Computer Intelligence, IntelliQuest

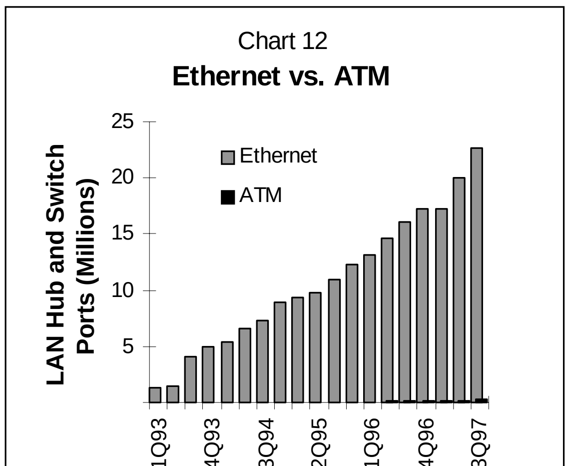
Dumb nets are underspecified. So is a system of roads. Its traffic can be anything from cars . . . to monster trucks. Each vehicle, like each packet in an IP network, is under its own control.

would embrace a Stupid Network, where the main "feature" was that the bits that you shoved in one end would come out intact at the other end. It would make their lives easier. Or do them out of a job.

Nonetheless, these systems and assumptions of scarcity and intelligence served well for decades. But let the assumptions change temporarily (e.g., there is an earthquake in California), or structurally (calls to **America Online** (AOL) last several times longer than voice calls–especially since AOL went to an all-you-can-eat for $19.95 pricing plan). Then the network hits a wall.

Now the earthquake has become permanent: an endless avalanche of new traffic. MCI estimates that it now carries some 580 trillion bytes of traffic every month. The entire Internet is approaching four petabytes (4 times 10 to the 15). You have to anticipate fully a thousand fold increase in traffic every three years. The scarcity model crashes.

At the same time, however, the solution is at hand. The computer and networking industries have supplied equipment based on fiber optics, wavelength division muxing, and other advanced technologies that allow you to put as many bits on a single fiber thread the width of a human hair as you put on the entire global network, on average, just three years ago.



Source: Dell'Oro Group

Switching used to be scarce too, but now it is abundant as well. A human operator used to be able to set up maybe 100 calls an hour. Modern computer controlled switches, such as **Lucent**'s (LU) 4ESS, can now complete about 1 million calls an hour. But if you consider a packet network, where the routing of each packet is equivalent to setting up a call, then modern packet switches can set up more than 3 trillion calls per hour.

Switching costs, too are declining, even as switching capacity grows: In a classic telephone company switch, the equipment to support 64 kbit/s of throughput costs a few hundred dollars. But if you use today's technology, you can buy 1000 chunks of 64 kbit/s throughput on a Gigabit Ethernet switch for $1.00. Ten voice channels for a penny. The throughput of a 10,000 line local office for the price of lunch.

Dumb nets are underspecified. A river is an underspecified network. So is a system of roads. Its traffic can be anything from pedestrians to cars to monster 18-wheel trucks. The owner of each vehicle determines the vehicle's contents. Each vehicle, like each packet in an IP network, is under its own control. And like the Internet, the system of roads is a self-organizing system. There is no controlling authority that sets up the route of every vehicle before it enters the network. And like the Internet, sometimes there is congestion, and sometimes there are crashes. But on the whole, the ability of each vehicle, or each packet, to self configure and self route is massively useful. Considering the big picture, the convenience of underspecification more than makes up for the occasional traffic jam.

Telcos don't do bits-in, bits-out. Enshrined in telco doctrine is the belief that *people want cheap telephones*. But the inexpensive terminal–the analog telephone–is based on two-wire technology that produces echoes when the incoming voice signal "leaks" into the outgoing voice path somewhere in the network. So the telephone company puts echo cancellers on the line which mean the smart network definitely does not deliver the same bits that were sent. The assumption is voice, not bits-in, bits-out.

In a dumb network, when two intelligent terminals–your average $1000 boxes–send voice to each other, they are perfectly capable of keeping the incoming signal separate from the outgoing signal all the way from one end of the network to the other. There is no network echo problem. Bits-in, bits-out, simple and stupid in the middle, and smart at both ends.

IP neatly takes the provider of the physical network infrastructure out of the value pro- position (except for commodity connectivity), and puts users in control of their interactions. Suppose, for example, that two users want to bring a third party into an interaction, they do it. An IP connected user does not need to order special three-way connectivity service from the networking company. All they need to do is write (or install, or use) a program that sends packets to two different destinations, and receives from both of them.

This ability to "just do it" liberates huge amounts of innovative energy. If I have a Stupid Network, and I get an idea for an application, I just write it. Then I send it to my buddy, and my buddy can install it too. If we both like it, we can send it to more people. If people REALLY like it, then maybe we can even charge for it. Maybe we could even start a company. Yahoo! The Stupid Network provides an environment with minimum impedance to innovation.

♦ VocalTec, ITXC's collaborator, is the first company to demonstrate that you could use Internet connections for voice communication. If

I have an Internet connection, and you have an Internet connection and a sound card, and we're both running VocalTec software, we can talk to each other for as long as we like, for no incremental cost, no matter where in the world we are.

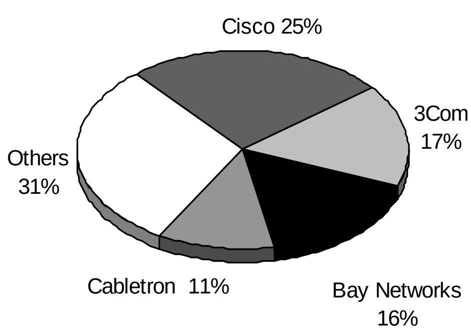
♦ **RealNetworks** (RNWK) "broadcasts" audio for an audience of one. If you have the Real Audio player software, you can access to concerts, record libraries, radio stations, and audio on anybody's web site around the world. Music over RealAudio sounds quite good most of the time, depending on the bandwidth and congestion in the Internet. The excitement of a live performance comes through. The RealVideo player is kind of herky-jerky today, even on a LAN. But surprisingly, it works acceptably on a 28.8 modem and will thrive on new bandwidth. Considering how far the RealAudio player has come since we first heard it in June, 1995, we expect great things from RealVideo which will be the last nail in the coffin of "500 channels." It will give capability for a user-defined channel for everybody! RealNetworks has a strong first-mover advantage in its markets–its servers deliver a predominant share of audio content. It is an open question whether other competitors will emerge effectively in its space.

♦ **PlaceWare** is a Xerox PARC spin-off for interactive multimedia meetings and conferences over the Internet. It mixes Internet telephony with data sharing, presentation graphics, and a crude representation of the meeting spaces. Demos of PlaceWare seem to add a lot to voice conferencing, and it gives a more participatory, less self-conscious feel than a video conference. One of hundreds of companies in this space, PlaceWare exemplifies the creative potential of IP telephony.

Chart 13

Shared Hubs and LAN Switch Market

3Q97: $2.4 Billion



Source: Dell'Oro Group

Beyond Quality of Service to Simple Stupidity

In the journey from separate networks to a single, simple, Stupid Network, Quality of Service (QOS) is an intermediate step. QOS, in standard telco thinking, means a repertoire of different ways of handling each type of data on a single network.

But suppose technology improves so much that the worst quality of service is perfectly fine for all kinds of traffic, without a special repertoire of different data handling techniques. Suppose, for example, that everyday normal latency becomes low enough to support real-time, two-way voice, while, at the same time, there is enough capacity for video, and data integrity is strong enough for financial transactions. A simple, stupid everyday network–with one treatment for all kinds of traffic.

The Intelligent Network skeptics might say that for *this* to happen we would have to see dramatic improvements in networking technology. As if dramatic improvements in networking technology were a rare species.

We're getting there. Routing switches from **Foundry Networks** and **Madge Networking** recently showed performance impressive enough to conclude that routing latency and jitter (variation in packet arrival time) may soon be a negligible issue. At 600,000 IP packets per second, in realistic multi-destination, high load lab tests (*Data Communications*, November, 1997), average latencies were well under one millisecond, and jitter was around ¼ of a millisecond. A worst-case, 20 node trip through a best-effort, really stupid network would generate about 20 msec of delay, plus or minus 5 msec. This is well within the no-problem area for two-way voice.

But these are lab tests, not field usage. And packet losses were as high as 1% under some conditions. Furthermore, even in these lab tests there were some surprising losers. (For example, products from **HP** (HWP), **Intel** (INTC) and **Ipsilon** could not even complete these leading-edge tests.) So we are not there yet. On the way, though, are routers under development for **Cisco** (CSCO) and **GTE** Internetworking (formerly BBN) that can handle as many as 9 million IP packets per second.

Meanwhile, there is a limited repertoire of specialized behaviors that a Stupid Network would need to provide Quality of Service–resource reservation, bandwidth management, service level agreements. Let's call them idiot savant behaviors. Recall that in a Stupid Network, the data is boss. That is, the data tell the network where they need to go. And because the data are boss, they will tell the network, in real time, what kind of service, QOS, they need. And the Stupid Network would dip into its small repertoire of idiot-savant behaviors to treat different data types appropriately.

One way voice messages, multi-way voice conferences, two-way video, email, documents, audio and/or video entertainment, whatever, could be mixed and interspersed at will, within and between sessions. You would not have to ask your Stupid Network provider for any special network modifications–its only function would be to, "Deliver the Bits, Stupid." Promoting innovation still further is

In a Stupid Network, the data is boss. That is, the data tell the network where they need to go. . .

ASCENDANT TECHNOLOGY	REPORT(S) Volume: No.	COMPANY (SYMBOL)	Reference Price	Price as of 12/29/97
Cable Modem Service	I: 2, 3 II: 7, 8, 9, 11, 12	*@Home* (ATHM)	19 1/2	25 11/16
Analog to Digital Converters (ADC), Digital Signal Processors (DSP)	II: 3, 7, 12	*Analog Devices* (ADI)	22 3/8	26 3/4
Java Thin Client Office Suite, Rapid Application Development (RAD)	II: 6, 7, 12	*Applix* (APLX)	4 1/2	5 1/8
Digital Video Codecs	II: 5	*C-Cube* (CUBE)	23	16 3/16
Erbium Doped Fiber Amplifiers, Wave Division Multiplexing (WDM)	II: 2, 7, 9, 10, 11	*Ciena* (CIEN)	23 *	61 1/8
Low Earth Orbit Satellites (LEOS)	I: 2 II: 1, 3, 4, 8, 10	*Globalstar* (GSTRF)	21 3/4	45 1/2
Single Chip ASIC Systems, CDMA Chip Sets	II: 8	*LSI Logic* (LSI)	31 1/2	20
Telecommunications Equipment, Wave Division Multiplexing (WDM)	II: 1, 2, 7, 9, 10, 11, 12 III: 1	*Lucent Technologies* (LU)	47 1/8	80 3/8
Single Chip Systems	II: 8, 12	*National Semiconductor* (NSM)	31 1/2	24 15/16
Internet Software	I: 1, 3, 4 II: 1, 4, 6, 7, 8, 10, 12	*Netscape Communications* (NSCP)	53	26 3/4
Telecommunications Equipment, Wave Division Multiplexing (WDM), Code Division Multiple Access (CDMA), Silicon Germanium (SiGe)	II: 1, 7, 9, 11, 12 III: 1	*Northern Telecom* (NT)	92	87 9/16
Wave Division Multiplexing (WDM), Satellite and Wireless Systems, Code Division Multiple Access (CDMA)	II: 10	*Ortel* (ORTL)	20 3/4	16
Point to Multipoint System for 7-50 Ghz, Spread Spectrum Broadband Radios	II: 10, 11	*P-COM* (PCMS)	22 3/8	17 1/4
Code Division Multiple Access (CDMA)	I: 1, 2 II: 1, 3, 4, 7, 8, 9, 10, 11	*Qualcomm* (QCOM)	38 3/4	51
Nationwide Fiber Network	II: 9, 10, 11 III: 1	*Qwest Communications* (QWST)	40 3/4	60 1/8
Java Programming Language, Internet Servers	I: 1, 2, 3, 4 II: 1, 5, 6, 7, 8, 10, 12	*Sun Microsystems* (SUNW)	27 1/2	40
Optical Equipment, Smart Radios, Telecommunications Infrastructures	I: 1 II: 1, 2, 3, 9	*Tellabs* (TLAB)	29 1/8	52 5/8
Broadband Wireless Services	II: 9, 10, 11, 12	*Teligent* (TGNT)	21 1/2 *	24
Digital Signal Processors (DSP), DRAM	I: 2, 3, 4 II: 5, 8, 11, 12	*Texas Instruments* (TXN)	23 3/4	45
Wave Division Multiplexing (WDM) Modulators	II: 7, 9, 10	*Uniphase (UNPH)*	29 3/8	40
Code Division Multiple Access (CDMA) Testing Gear	II: 1, 2, 7	*Wireless Telecom Group* (WTT)	10 3/8	5 7/8
Telecommunications, Fiber, Internet Access	II: 9, 10, 11, 12 III: 1	*WorldCom* (WCOM)	29 15/16	31 3/16
Field Programmable Logic Chip	I: 3	*Xilinx* (XLNX)	32 7/8	36 9/16

* Initial Public Offering

Note: This table lists technologies in the Gilder Paradigm, and representative companies that possess the ascendant technologies. But by no means are the technologies exclusive to these companies. In keeping with our objective of providing a technology strategy report, companies appear on this list only for these core competencies, without any judgement of market price or timing.

Internet Protocol Version 6, stabilized in 1995, which will provide such capabilities as essentially unlimited address space, real time processes, hooks for security functions, multicasting, and easy migration from today's Ipv4.

As Shafei insists, the revolution is underway. Bet on abundance wherever you can find its purveyors. Bet Qwest and Worldcom. Bet on Gigabit Ethernet switching to replace ATM as the vehicle of choice for campus nets and neighborhoods, with players including **Bay Networks** (BAY), Cisco, **3Com** (COMS), **Cabletron** (CS), and **Extreme Networks**. Bet on always-on cable modems and **Terayon** to give the Baby Bell scarcity doctrine a run for its money in the local loop. And watch for the power companies, following **Nortel**'s (NT) announcement of data delivery over power lines (November 1997).

In a world of abundance, you don't need to be intelligent. If space is plentiful, you can sprawl–you don't need to plan every silly millimeter. If transistors are virtually free, you can squander them; you do not have to optimize each of millions of devices on a chip (if you did, you would never get a product to market). You can even splurge on full four digit year fields.

As we observed over five years ago, "In a world of dumb terminals and telephones, networks had to be smart. But in a world of smart terminals, networks have to be dumb." The real value of dumb networks comes from the innovation that it unleashes. Watch this space. It is the largest opportunity for wealth creation in the global economy today.

George Gilder and David Isenberg

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