BY ELI M. NOAM

Overcoming the Last Communications Bottleneck

Exposed as we are to a torrent of victory bulletins from the front lines of R&D labs and marketers, it is easy to believe that the information revolution is being won. Computers get faster, smaller, and cheaper. Fiber optics technology adds enormous capacity and diversity to telecommunications. Television becomes sharper in picture and global in reach. Fax, VCRs, PCs, and laser printers reach distant cottages. Thus, humankind appears to be on the verge of achieving mastery over information, turning the scarcest of all resources—knowledge—into an abundant one. Yet at the same time we seem, in our private and professional lives, to become less the masters of information and more its slaves, forever trying to catch up with the torrents that reach us and usually failing. Why is this happening in the face of the marvels of new technology?

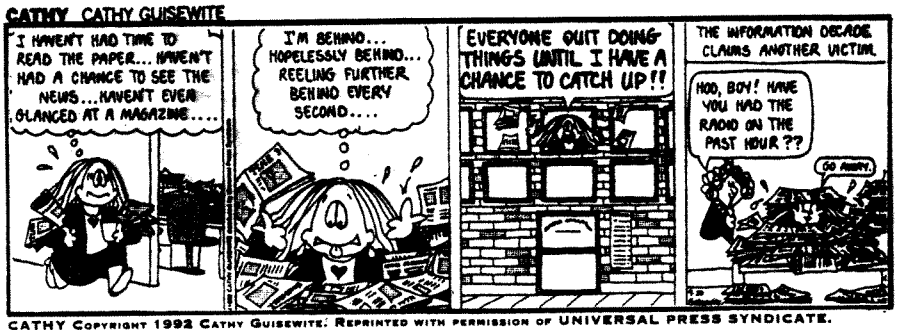
The answer is that progress in technology has been uneven, and, therefore it aggravated rather than solved the handling of information. Electrical engineers speak of "impedance" as a measure for a general resistance of a circuit. If the impedances of parts of a system do not match each other, energy transfer is inefficient. By analogy, we may speak of "information impedance," a non-matching of resistances in various parts of the information chain. The communications process, to simplify considerably, consists of the production of information, its distribution, and its absorption. These functions interact. When, as in the Middle Ages, only a little information was being produced and distributed, societies' absorptive capacity was underutilized and they were backward and unproductive.

In recent decades, technology has made giant strides in the distribution end of information. We are near the point, historically speaking, when the cost of information transport is becoming both negligible and distance-insensitive. Distribution has spurred, in an interrelated fashion, the production of information. The weak link in the information chain is its absorption capacity that lags far behind the requirements of the inflow.

CHANNEL HOPPING

Perhaps the most revolutionary change has been in the transmission of information, where the enormous technical progress is now reaching the residential households. For decades, spectrum scarcity kept television to a handful of channels. But today, a household in Queens, New York can access 150 channels on Time Warner Cable's new Quantum service, using fairly standard technology. In the wings are fiber for the last mile, digital compression, and dial up-access to video libraries. AT&T has developed video compression that can multiply the channel number by a factor of 5 to 13. In Cerritos, Calif., a pilot project run by GTE offers full video-on-demand that permits viewers to access a library of dozens of movies, in addition to 50 regular cable channels at any given moment. A system operated by Videotron in Montreal has enough channels to allow subscribers to choose instantly among different camera angles during a sporting event. In a few years, channel capacities of one thousand channels could thus be readily available, plus access to vast video libraries.

At the same time, the production of information has skyrocketed. In the first half century after Gutenberg, about 20 million books were produced, vastly more than the trickle of the preceding centuries. Yet even that number is dwarfed by today's figure by a factor of about 50,000. In the U.S. alone, about 2.3 billion books were distributed in 1991, more than 50,000 new titles. Around the world, one thousands new books are being published every day. More than 11,000 different periodicals appear in the U.S. alone. According to some estimates, printed information doubles now every five to eight years, and more of it has been produced in the past gen-



eration than in all of the history that preceded it. It has been said that 80 or 90% of all scientists who ever worked are alive today. One study found that in 1980 the mass media supplied to an average American household was about 11 million words per day, including unwatched TV, unread papers, unlistened to radio, etc.—an increase of 267% from 1960.

And this is only the beginning. E-mail and fax now add to the information flood. In the reasonably near future, voice recognition technology will reach the state that any random thought could be transcribed as one speaks, and almost instantaneously distributed electronically, broadcast fashion, to hundreds of often reluctant recipients.

The Weak Link

As information reproduction and transmission make extraordinary advances, they leave behind the ability of individuals and of organizations to cope with the information that has been produced and distributed. The weak link in the information chain are humans (and computers, let's be fair) as information processors. Computers are fast but dumb, while humans are smart, one hopes, but slow. Even a highly trained telegraph operator cannot absorb much more than 20 Morse code bits per second. Most people read at 300 words per minute, which can be encoded at about 20 bits per second. Ears are somewhat slower. By far the fastest is the absorption of visual information—a picture is worth a thousand words. Humans are good at recognizing and retrieving images, such as a glimpse of a face. They are slow in absorbing sequential information. Studies on the ability of individuals to absorb signals show a plateauing of absorption at about five inputs per second, and a decline in processing speed if the input rate is increased beyond that rate.

But isn't computer technology solving the absorption problem? Probably the opposite is true. Computers make it easier to produce and store information, but not to absorb it. There are some exceptions, such as in the summarizing of financial or scientific data, but generally computer technology has not been very helpful where underlying information has not been quantitative and well-structured, and questions well-defined. These conditions are rarely met in real life.

Coping Strategies

To deal with the mismatch of inflows and absorptive capacity, individuals and organizations have devised a variety of coping strategies.

■ *Education: i.e.*, make humans smarter. But there are severe limits to this, as one finds out after about two semesters of teaching experience.

■ *Stretch time allocation: i.e.*, spend more time on informational activities. That is clearly happening. The average cable TV household has its set on for an extraordinary 8 1/3 hours per day, longer than for families without cable. Individuals engage in "multi-tasking," for example by scanning correspondence while answering a telephone call while listening to radio news. In office settings, people spend more time on information flow; lunches get shorter, work hours longer. Obviously, there are limits to this strategy.

■ *Tinker with Mother Nature*, by pharmacological means or biological engineering to make humans able to handle more information. This is not only enormously controversial, as subject to abuse, but also limited in its effectiveness as long as our understanding of brain functions is limited.

■ *Symbiosis human-machine*. Maybe one could bypass eyes and ears and somehow connect directly with the brain, thereby expanding its storage and processing ability. Some form of "brain-modem" interface is at least a theoretical possibility (it exists already for sound signals), though one shudders at the totalitarian potential.

■ *Substitute information storage for human reception*. We create ever-increasing piles and files of information. This produces a temporary illusion of a match between inflow and outflow. In principle, it is a reasonable strategy to store rather than to absorb information. Regrets about the implications are plentiful, even going back to antiquity when the advent of writing and printing led to fears about the loss of memory skills. Today's implications are to stress a technology and education that emphasize search skills over knowledge and understanding.

■ *Change the way information gets presented*. Eyes can get visual information at a broadband megabyte-rate. If the TV action is too slow, one gets bored. As mentioned, visual information is by far the fastest input, if it uses the entire bandwidth of the eye's ability. But, importantly, print language does not do that. We are using hopelessly outmoded Phoenician and Latin communications protocols, but we are stuck with them. Instead of junking the Latin alphabet and traditional forms of written language, what is more likely to happen is a shift to a multimedia form of communications with parallel tracking of visual and symbolic information.

■ *Ignorance, alienation, and fads*. Other coping strategies are to ignore information or to reject it, especially when it threatens the stereotype (a time-saving device) used to select information. Another strategy is to focus on some type of information for a very short time. People are therefore famous for 15 minutes only.

■ *Specialization*. Individuals and organizations cope by increasingly narrowing their focus and become specialized. Entire geographic regions can also move in that direction, as Silicon Valley or Wall Street did. Communications networks make possible the emergence of communities of far-flung specialists who interact more with each other electronically that with their physical neighbors.

■ *Information screening*. By far the most

important strategy for dealing with information overload is to create screening mechanisms. Here, the alternatives are:

- *Screening professionals*, such as editors, public relations managers, or public figures who package their message in "sound bites" to get past the screen.
- *Intra-organization screens*, such as secretaries and staff. Organizations are created largely around the need for information processing. Governmental and business bureaucracies are established to match information inflows with outflows, including the value-added of decisions and feedback. As information flows increase, institutions adjust. Headquarters grow, meetings multiply, travel increases. As former President Reagan proved, one can boil down any issue under the sun onto one index card. It helps, of course, to have three million people working for you.
- *Economics as a screen*, for example, by imposing an access charge on senders.
- *Automatization* of the information screening process. This is arguably the key technological challenge for the information sector. It is at present in its infancy, relying mostly on the matching of keywords. But the difficult part is how to suppress repetitive or unimportant information. That is, one needs a screening by quality and incremental value. Expert systems and artificial intelligence applications will be useful here, but one should not hold one's breath for their arrival.

AUTOMATED "GRAZING"

Let's look at an example. In television, the mega-channel system made possible by fiber transmission inevitably requires screening systems to sort through the various program options. If subscribers on a 1,000-channel system would "graze" through each channel at a rate of 5 seconds per channel, it would take them over an hour just to scan the offerings! Several approaches are possible.

- *"A La Carte" screening*. Viewers can use menus on the TV screen. There are such systems on the market, including both "dumb" menus, organized by channel number or content categories such as romantic comedies, recent hits, etc. Smart menus could offer program capsules, review ratings, and even video clips. Some of this could be done by the cable television operator determining a viewer's probable top choices and sending targeted messages to alert to upcoming program based on a record of past viewing habits.
- *"Third party" screening*. Here, the viewer delegates responsibility to a "video-editor" to pick their programs. This, of course, is already what program channels do.These video-editors might be organizations with which the viewer associates, such as churches, industry and ethnic associations, unions, or sport clubs.
- *"Invisible Hand" screening*. Market forces will lead channels to establish clear brand identities to simplify choice, even more specialized than today.
- *Automated screening*. Intelligent television sets would process the preprogrammed preferences of a viewer, updated continuously by the feedback from the viewer's selections. A still more active role could be played by "know-bots"—software programs sent out by the viewer or his "smart" TV set to seek out particular programs. A know-bot could be on diligent look-out for a viewer's programs and desired information, and could independently initiate searches of libraries, programs, and real-time events. For example, if a viewer is a tobacco farmer, the know-bot could gather all television items relevant to the subject of tobacco that were presented over a designated day or time period.

Screening software may be able to do "highlight screening" that would be able to pick special moments from program A and insert them into program B that is being watched, such as flashing highlights from several ongoing sports events into a movie in progress. It may also permit a convenient "fast-forward" highlight browsing in a program for selective viewing and skimming.

THE BIG SCREEN

Screening is in its infancy. Right now, no computer in the world can summarize a text. No computer in the world, at any price, can write one of those four-line plot capsules for *TV Guide*. Furthermore, meaningful information screening is highly personal, because even sensational news is an unimportant item to a person who has heard it five minutes earlier.

Thus, information screening requires a lot of brute force matching of the new information with the already existing information base. To screen effectively, a computer needs to know what an individual already knows and what he wants to know. And that probably requires a personal supercomputer of huge strength and storage capacity. One must be connected to it as one goes and walks about one's business, continuously updating its database. Transacting with it will require large bandwidth.

Today, many in the telecommunications industry are worried whether all these fiber lines will be filled, and whether they would then pay for themselves. Those people worry about the wrong thing. Of course the pipes will be filled, but only if there is a decent screening filter available. The problem is not the addition of information, the problem is the subtraction of unnecessary information. If one can screen the informational clutter out at the output stage, one will get the clutter in at the input stage, which means traffic for the fiber networks. Therefore, the golden rule for the future of high-capacity communications networks is: garbage out, garbage in.

To conclude: Openness in networks and in information flows is blocked unless we can overcome the absorption bottlenecks—the last 10 inches of the human mind and the top floor of organizations. Openness of subparts, per se, does not assure systemic openness if one cannot open the periphery, which is "us." Without it, the rest of the system will back up like a sewer pipe. To correct this imbalance will be a major challenge to technologists. The superpipes of information require a super screen—not the sort on which you view information, but a sieve to filter out the information you can manage to live without.

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