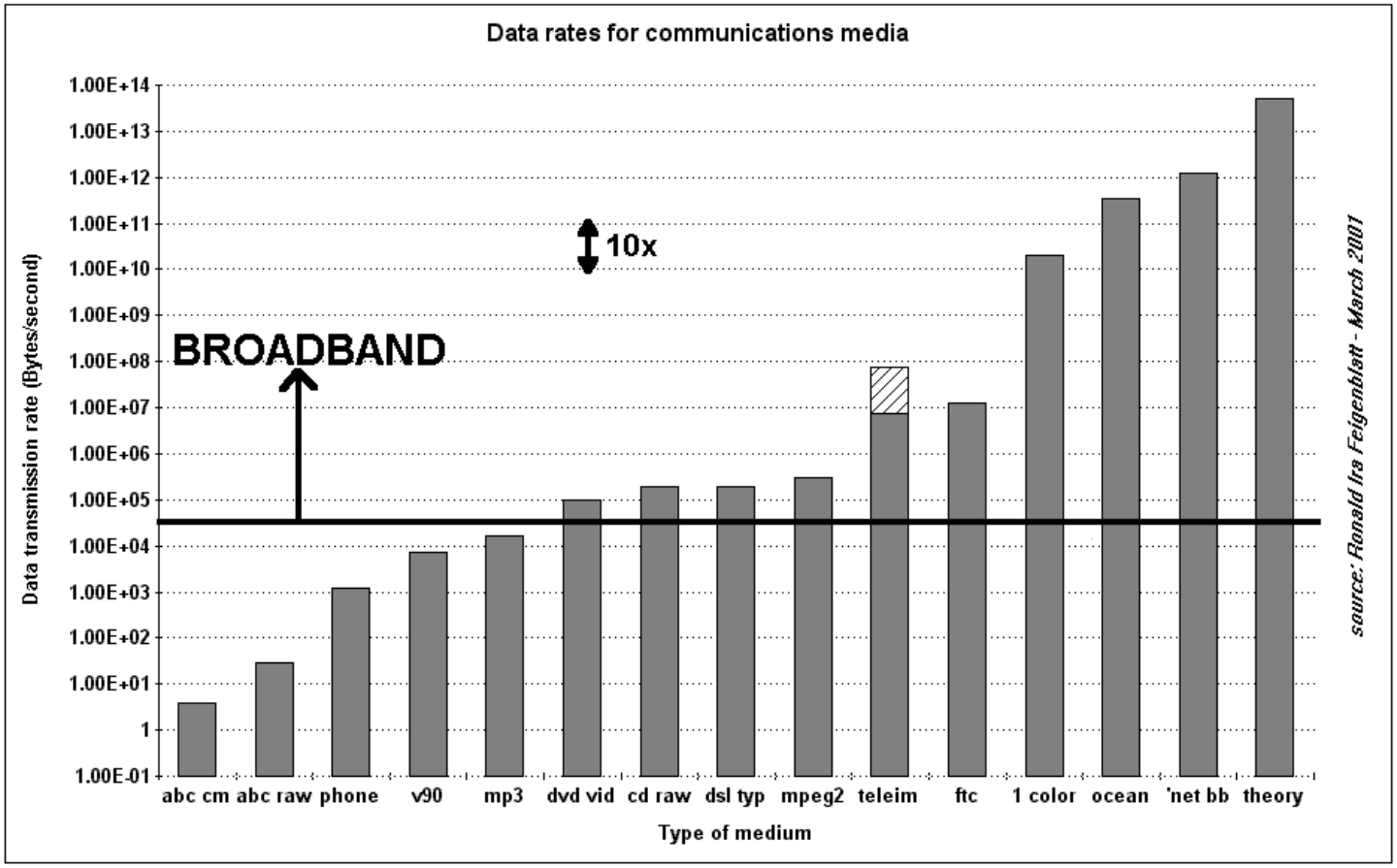
Reflections on the newly-financed Haralson County Development Authority fiber-optic network and the future of economic development (March 2001)



MEDIA COMPARISON CHART LEGEND

The attached figure charts the data rates of the various communication media we have discussed, as well as some others. Because of the vast range of speeds, the vertical range is logarithmic - each gradation line represents another *multiplicative* factor of ten. In describing data speeds below, we use several common abbreviations: megabit = million bits; gigabit = billion bits; terabit = trillion bits. A heavy horizontal line is drawn at a speed of about a quarter megabit per second, at which point decent teleconferencing becomes possible; speeds above this threshold are properly called "broadband". The figure charts 15 media, each with its own vertical bar, whose size represents the data rate of that medium. Using their labels for identification, they are:

1. "abc cmp" - The recently late Claude Shannon, founder of modern information theory, once estimated that English text carries only about one binary digit (bit) of information per alphabetic letter used. At the typical human reading speed of about 300 words per minute, this means reading communicates only a few bytes (8-bit-groups) of information per second!

2. "abc raw" - If we code reading material with one byte for each letter, rather than exploiting redundancy, the data rate of reading is about 30 bytes per second. Early telephony modems operated at about this speed.

3. "phone" - The tariffs for BellSouth's ordinary telephone service guarantees line quality only good enough that a certain data rate can be achieved by a properly operating modem - 9600 bits, or 1200 bytes per second.

4. "v90" - Modern dial-up modems use the V.90 standard. On many telephone lines, this allows one to receive data over the phone lines at almost 56,000 bits, i.e. 7,000 bytes, per second. However, many other dial-up users cannot achieve a data rate more than half this, even on clean telephone lines, because of issues like double D/A conversion.

5. "mp3" - Compact disks achieve very high sound quality using raw encoding of sound pressures. Later, an encoding scheme called MPEG-1, Layer 3, or MP3 for short, was developed to use less space to record sound at little loss in audible quality. Files using this MP3 format became the able vehicle for pirating commercial music in recent years.

6. "dvd vid" - The latest Microsoft streaming video compression schemes claim to achieve near-DVD quality using an Internet connection of about 100,000 bytes per second.

7. "cd raw" - This is the speed at which ordinary CD players read sound recordings from compact disks.

8. "dsl typ" - Digital Subscriber Line technology allows ordinary, albeit conditioned, telephone wires to transmit data much faster than is done with conventional dial-up modems, over a limited distance. BellSouth now provides service in parts of the county at up to 1.5 megabits per second using Asymmetrical DSL, or ADSL. This happens to be the same speed as a CD player, cf. item 7.

9. "mpeg2" - Older video technology like direct broadcast satellite television, dating from the mid-1990's, uses an aging video compression scheme called MPEG-2.

10. "teleim" - The National Tele-Immersion Initiative experiment described above provided an image updated about 3 times per second using this data rate. A full-motion system operating at 30 times per second might require up to ten times the data transmission speed, the size of the space between chart gradations.

11. "ftc" - Already, there is limited deployment of fiber-optic-cables all the way to residences, conventionally called "fiber-to-the-curb". They operate as fast as the rate shown here, 100 megabits per second. BellSouth began an experiment with 300 homes about two years ago, where this service was provided for $60 monthly. Massive bandwidth of this size, and more, would be required for systems of the type described in item 10 above.

12. "1 color" - In late 1999, Bell Labs set a record for the speed of data transmission over an optical fiber line using only a single color of light. They achieved a rate of 160 gigabits per second, over a fiber 300 kilometers long. By using many different colors of light at once, perhaps as many as a thousand, the future achievable data rate can be multiplied by the same factor. Carriers are already deploying field systems using multiple colors of light over their long-distance fiber-optic networks.

13. "ocean" - To get an idea of the magnitude of long-distance global communications capacity, one can add up the data transmission speeds of all the communications cables which span the ocean floors of earth to connect the continents. Neglecting cables with capacities under 20 gigabits per second, an aggregate of 2800 gigabits per second, shown here, was achieved in 2000. That was over a factor of TEN higher relative to the year before!

14. "net bb" - The 'backbone' of the Internet in the US is used to exchange data over long distances. In 2000, it had the approximate capacity shown here, 10 terabits per second. This capacity will grow rapidly.

15. "theory" - By using multiple colors of light in an optical fiber, each of which transmits a tremendous amount of information in its own right, astronomical transmission speeds can be achieved over a SINGLE optical fiber. In the lab, several terabits per second have been demonstrated. Here we show the theoretical maximum of as much as 400 terabits per second.

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As we look to the deployment of a fiber-optic communications network in Haralson County, we are well counseled to consider the impact design decisions will have on the future of economic development. In particular, it is important that the people who will make key decisions about things like how many lines are run through which sections of the county, be educated in the potentials and limitations of the technology, as well as aware of the ways in which it might be put to practical use, often in a fashion which runs in the face of long-held tacit assumptions. As Thoreau wrote famously in "Walden", "We are in great haste to construct a magnetic telegraph from Maine to Texas; but Maine and Texas, it may be, have nothing important to communicate." Finally, one is well advised to know about the distinctions between what ANY broadband service can provide, and what is peculiar to the amazing potential of fiber-optics in the years to come.

I have been openly promoting the merits of digital broadband (i.e. very fast) communication systems to Haralson County since late 1997. I feel my early advice has been validated by developments in early 2000. Last April, I attended a conference on the role of technology in economic development held at Floyd College, as the representative of the Haralson County Commissioner of Roads and Revenues. (I will not repeat here the points I made in my extended report of this conference, which contents I still commend to the reader for relevant background information, especially if he has a limited education in modern high technology.) The conference was the occasion for Dr. James Foley, director of Georgia's Yamacraw Project, to announce a change in direction. Rather than concentrate on integrated circuit technology per se, Yamacraw would focus on fostering companies in Georgia that would work on broadband digital communication infrastructure, as this seemed to be the only sure bet of the emerging Internet age. Surely if EVERYONE will be using this stuff to advantage, we here in West Georgia might be well advised to leverage it as well. The other development early last year was Governor Barnes' announcement of an initiative funded by BellSouth capital investments and tax incentives provided through Georgia's Business Expansion and Support Act (BEST), which was established to encourage investment in rural parts of the state. Tens of millions of dollars would be spent annually to build a broadband infrastructure throughout the state and deliver high-speed Internet access to rural Georgia residents and all of Georgia's approximately 1,800 K-12 schools. It was claimed the project would be the largest statewide deployment of broadband capability ever in the nation.

A year ago, when the fiber-optic network was just a notion, there was NO inexpensive wired broadband Internet service ANYWHERE in Haralson county. The situation now is entirely different. By November 2000, BellSouth had started provisioning DSL service in Bremen and environs. They tell me that the Tallapoosa CO (Company Office) will be upgraded as well on 27 September of this year. By the end of 2001, Charter Communications should have converted the old Falcon service areas (from Bremen to Buchanan) to two-way capability so that cable modem service can be offered. These facts alone change the landscape so much, that the role envisioned for the fiber-optic network should be carefully re-examined.

In particular, areas in the county which at this year's end will still have NO cheap wired broadband Internet access from private carriers WHATSOEVER can rightfully ask that their needs be weighed before a third broadband service (the fiber-optic network) is provisioned in well-served areas!

BROADBAND NIRVANA

Dr. Arun Netravalli, president of Bell Laboratories, the organization which has done so

much to advance electronics in the 20th century (e.g. invention of the transistor, on which ALL our modern computing and communications is based), recently described his vision of the coming 25 years. We quote excerpts from the copy you can get on the Internet's World Wide Web here: http://www.lucent.com/minds/techjournal/jan-mar2000/pdf/paper12.pdf.

> **"In the next 25 years, communications networking will break down the ultimate barriers between people, as well as between people and the natural world.... a mega-network of networks... will enfold the earth in a communications 'skin' with ubiquitous connectivity and enormous bandwidth. This 'skin' will consist not only of the network of [fiber-optic] networks, but also of countless sensors and other devices connected to it... In addition, tiny wireless base stations will be connected directly to optical fibers... Indeed, the implication for this mega-connnectivity is that, within the next decade, there will be so many interconnected devices that the volume of 'infra-chatter' among communicating machines will surpass communications among humans... The interfaces for connecting all the sensors and other devices to the mega-network will become so cheap that just about anything that can be connected to the network - such as thermostats, pressure gauges, pollution detectors, cameras, alarm systems, household appliances, and automobiles - will be... Finally, all these advances will lead us into the Age of Virtuality, which will transform the way people live and conduct their business -with virtual enterprises and virtual travel, virtual business conferences, virtual offices, virtual universities, and a host of other virtual experiences. Distance will become irrelevant and place will no longer be limiting... In this era, the concept of telecommuting will take on a different character, as people will be able to live - and work - wherever on earth they wish. The traditional office building will give way to the virtual office building..."**

"Scientific American" runs an article very approachable by the lay reader titled, "The Triumph of The Light: Extensions to fiber optics will supply network capacity that borders on the infinite", at: http://www.sciam.com/2001/0101issue/0101stix.html. It reports that:

> **"[Bell Labs' parent company] Lucent estimates that if the growth of networks continues at its current pace, the world will have enough digital capacity by 2010 to give every man, woman and child, whether in San Jose or Sri Lanka, a 100-megabit-a-second connection."**

Already today, some firms are providing 100-megabit-a-second "fiber-to-the-curb" service to limited numbers of residential customers, as described in these two places:

> **http://www.techreview.com/articles/ma00/hecht.htm**
> **http://www.teledotcom.com/413/news/tdc413na_optical.html**

Just how fast does a communication channel have to be to qualify as "broadband"? Who should care about broadband and why? Why is broadband Internet communications important? How does the rapid development of other electronic technologies bear upon broadband?

We can start to answer these questions by examining the channel speed requirements of various sorts of tasks.

COMMUNICATION MEDIUM TYPES

Much of the most important information any of us acquire about the world is through reading. Human reading speed does not vary all that much between various people and is about 300 words per minute. How fast a data line do we need to communicate information as fast as a person can read? Surprisingly little. Since the average English word has about 5 letters, a speed of 300 words per minute is a letter rate of (5+1) x 300 = 1800 characters per minute, counting the spaces, which is the same as 30 characters per second. We can encode this stream of characters as a series of binary digits, also called bits. (Unlike a decimal digit, which ranges over ten values, a binary digit merely ranges over two; a decimal digit can label one of ten things, while a binary digit can only label one of two.) By convention, we call 8 bits a byte. It takes no more than a byte to encode a character, even if we include all upper and lower case letters, numbers and many special characters. Thus we read at a rate of no more than 30 bytes per second (30 Bps).

The earliest dial-up modems used to send digital information over telephone lines operated at roughly this speed, following similar performance of teletype machines. It was argued there was generally little advantage in communicating text faster than someone could read it - or type it, for that matter. Of course, there were exceptions. It was possible to record a long document sent by teletype on a punched paper tape, a mechanism similar to that of a player piano. If on a later occasion we had reason to send this document to a new party, using this tape to play back the message saved us typing - and the typing could be done at machine, not human, speeds. Of course, with the ability to type and record messages with a mechanical gadget, there might be a good reason to transmit messages much faster than a person could read. A single teletype shared by a large organization might continuously generate incoming messages. It would be useful if they could come in and be printed as fast as possible, so that the firm need not buy a second teletype and communication line. One person could start reading a previously printed message while the next one came in. There was no need for people to queue up one by one to wait for their turn to read - they could read their respective documents simultaneously.

A lone computer user had another reason to yearn for faster communication. His machine could read and process textual information much faster than he could himself! For example, he might want to use his computer to compute the average temperature recorded by a remote sensor during a 24-hour period. If the sensor took measurements once a second, that would be 86,400 numbers! When he dialed up the memory bank of the distant sensor appliance to spit out all those numbers, he would want to receive them as fast as possible, so that his computer could compute the average as fast as possible!

And not only would computer users want a fast communication line to receive data, they would also desire a fast line to download new programs that instantly educated their computer how to do new things. Again, such instructions might include thousands or even millions of characters.

And even if we ourselves were the only digesters of remote text, there are some plausible reasons for requiring that the text flow very much faster than the speed at which we can read it. That's because we are used to reading two-dimensional pages. We can scan such a page much faster than we can read it - and might even recall, on which part of a page we have read many times before, where the text we want to read is roughly located. It would be good if

when we "turn a page" in a remote "book", it were to appear whole almost instantly. Believe it or not, it was once incorrectly argued that electronic computer displays that show text intended for a single viewer need never show more than one line at a time - this argument ignored the page scanning rationale we have just presented.

As a result of these pressures, computer modems increased in speed from the early 300 bit per second (bps) units to the 56,000 bps V.90 modems we use today if our telephone line is good enough. These modems transmit at roughly the maximum speed allowed for error-free communications on a telephone voice channel, given typical levels of noise, according to Shannon's famed channel capacity theorem. A standard page with 66 lines of 80 characters, each of which can be encoded with a single byte, can be transmitted in a tad under a second. With compression, which takes out redundancies using the able computing power we have at hand, we can improve things a few fold more. So overall performance is not that bad if all we ever want to do is have a human read text.

But now our computers are fast enough and have enough memory that they can deal with media types other than simple text. What if we wanted to transmit sound, like high-quality music, accurately to our computer from a remote source? We know that the old-fashioned telephone is fine for transmitting low-quality voice, but can it do this as well? Electronic audio communications systems work by measuring the air pressure with a device called a microphone and reproducing that pressure remotely with a device called a speaker. To preserve the audible quality of the sound, the measurements must be made 20,000 to 40,000 times a second, with an intensity accuracy of one or even two bytes. With two stereo channels this might be a data rate as large as 40,000 x 2 x 2 = 160,000 bytes per second (Bps), (about the actual uncompressed data rate of CD audio), many times the 7,000 Bps = 56,000bps / 8 which we can do using ordinary telephone audio. Transmitting good music in real time requires a much faster communication medium than an ordinary telephone channel provides.

And transmitting imagery, especially motion pictures intended for a human viewer, is a far more demanding task yet! Electronic imagery transmission works like a knitting pattern. The picture we want to transmit is dissected into a two-dimensional array of very numerous rows and columns. The intensity and color of the light at each row-column intersection, called a picture element, or pixel, is measured and then communicated one after the other. These measurements are then used to "knit together" a reproduction of the image at the destination, because they are communicated in a known order.

And if the picture changes over time, a new "knitting pattern" must be sent again and again! Because what we call "persistence of vision" is so much longer than what we might call "persistence of hearing", we do not have to revise the picture as fast as we need revise the pressure measurement when transmitting sound. We must measure a moving picture only 10 to 30 times a second compared to 20,000 to 40,000 times a second for sound. But while sending sound involves only a single measurement at any one moment - the sound pressure - sending a picture requires as many million measurements as there are knit elements in the picture! This makes the demands of sending pictures much more severe than that of sending sound! The speed at which measurements are transmitted over a traditional broadcast TV channel is about 1,000 = 6MHz / (2x3KHz) times that of a telephone line!

How many elements do we need to specify an image, and how accurately must we measure the intensity and color of each? Well, if we are willing to settle for a very fuzzy and very posterized image, we can get away with quite a lot. A famous very-low-resolution black-on-white cameo of Abraham Lincoln's profile uses under a hundred bilevel (one-bit) elements; but

it only works because the image is so very well known! Since the early 1990's people have been using ordinary telephone lines to do very-low quality videoconferencing by tolerating fuzzy, posterized pictures updated slowly - and this is acceptable for some applications. But if we want an image that approaches reality, we may have to space picture elements as little as one minute of arc apart and use a byte or more of amplitude resolution for each of three primary colors. This can total many millions of bytes of data. Even when we use computing power to remove redundancies within an image and between successive images, we still must send information very fast. Using satellite-TV's aging MPEG-2 compression scheme requires maybe 300,000 Bps to achieve the quality of VHS VCR Video. Even with its best technology today, Microsoft claims obtaining "near-DVD" quality requires almost 100,000 Bps - still an awesome data rate!

One should also keep in mind that while the resolution of US broadcast TV has not changed in over a half-century, computer display resolutions have, and the best monitors now far exceed the clarity of US TV. (Aside: Actually, a so-called high-definition TV (HDTV) standard now exists, but is failing because of the enormous cost of a receiver massive enough to view with benefit from across a living room.) A user might use that added computer screen detail acuity to accommodate multiple video feeds at once, multiplying his need for communications bandwidth by that same factor. Or he might even simply desire a single video stream of greatly enhanced visual detail.

An example of multiple video feeds with enhanced acuity of each feed at the same time is a super-high-end video teleconferencing setup called a "teleimmersion" system. A prototype was demonstrated last spring by the National Tele-Immersion Initiative, and is described here:
http://www.newscientist.com/features/features_226149.html
This system provides 3 image updates per second, and requires a data transmission rate of 60 megabits/second. Increasing the image "refresh rate" to 30 Hertz (times per second), to achieve the appearance of full motion, might increase the data rate to as much as an astounding 600 megabits/second, or 75,000,000 Bps! This massive data rate is MANY times the 100-megabit-a-second fiber-to-the-curb connection speed that was cited above for the fiber-to-the-curb deployments.

Imagery, especially video, is probably the "bandwidth hog" that will economically justify provisioning such fast data transmission lines. It is difficult to think of anything else that is not very exotic (and hence of limited appeal) that will come close in justifying huge "data pipes" to *every* individual user.

In a distant future, whole-body-haptic communication might also demand massive amounts of communications bandwidth. Right now, haptic devices are rare, except for simple force-feedback joysticks and mice, typically used with video games or for the benefit of blind computer users. Far in the future, haptic media may require broadband for communication because it takes perhaps 400 actuators to stimulate just a single fingertip and some phenomena require the actuators move up to 1,000 times per second. But I suspect that enormous compression will be possible.

Finally, note that buildings which house a large number of people can require huge amounts of aggregated bandwidth, typical of fiber-optic feeds, even if individuals within that building might be served well enough by more modest broadband technologies like telephone DSL or a cable TV modem.

Any proper business plan must understand and anticipate what alternatives present credible

competition for the enterprise one is proposing. Digital broadband communications is no exception.

Originally, many types of electronic media encoded text, sound and images using the simplest possible scheme. For example, conventional US broadcast television worked by immediately displaying an image on receivers the very second a camera was capturing the image. Further, the receiver "knit together" exactly the same tiny portion of the image as was being dissected by the camera that very moment. No mechanical calculations involving storage need be done to make this method operate. The scheme had the merit of using the simplest possible machinery in an age where electronics was very expensive. The drawback? It turns out that such a method is wasteful of communications channel capacity.

As the cost of electronics fell dramatically, it became plausible to do this:Store an entire image electronically, analyze it for redundancies, create a compact description that exploited them, transmit this economical description and then reassemble the image at the receiver end - and all on the fly as well. This, for example, is exactly what your satellite TV receiver does: it receives a stream of numbers it submits to a calculating engine in your set-top box, which performs dozens of millions of arithmetic operations per second to reconstruct the image which the camera originally recorded. In a few seconds of operation, it does more arithmetic - without error - than any human in the history of the world ever did manually in his entire lifetime, accountants and clerks included. By going through all this trouble, the transponders in the satellite can broadcast hundreds of TV channels, rather than just dozens, for a given amount of microwave transmission spectrum.

This technology, called media compression, is only the first step in reducing the need for broadband communication channels. The computer doing the work doesn't know what any of the features in the pictures it is processing mean; it only knows how to create a description that can be used recreate the original appearance of the image with only invisible distortions. For all the math it must do, the computer manifests limited intelligence in doing its job.

But people are now going further, and giving computers an ever increasing understanding of the *semantics* of images. Automated image understanding is an emerging technology with roots in decades past. As the cost of digital computing and storage has continued to plummet, incredible amounts of brute force have become available for application to this exciting -and sometimes frightening- branch of artificial intelligence. As early as 1997, West Virginia began a five-year program to use face recognition in conjunction with automobile driver licensing. Quoting from CMP Techwire:

> **"When drivers first apply for licenses, their photos will be taken by a digital Polaroid camera. The digital images are then analyzed by facial recognition software, which determines a set of measurements between facial features, such as the distance between a person's nose and mouth.**
>
> **"These measurements form a template, which will then be stored in a central database. When the same individuals come to renew their licenses, a second digital image will be taken and will then be compared against the existing facial template using the facial recognition software. If the images don't match, no license will be issued..."**

An even more astonishing application is the Advisor project, funding at $4 million by various

prominent European institutions and firms. Quoting an article in Forbes about it:

> **"The Underground [London subway train] is hoping to use the software to help detect when a person on a platform may be preparing to throw himself in front of a train. Suicide attempts are an almost weekly occurrence on the London tube. Other goals are to detect shoplifters before they snatch and to spot obstructions such as loitering teens or bulky merchandising displays before crowds can form around them."**

And such technology is coming to your very office in not too many years! Quoting:

> **"This month Microsoft unveiled new technology that lets people manage and filter their digital message traffic by encouraging their computer to observe them with cameras and microphones... The Notification Manager studies a user's location, his current activity level, the presence of other people, ambient noise levels, and other such factors to determine whether he's working, thinking, or meeting with other people. Based on this assessment, the application concludes whether the user might be doing something such as eating, sleeping, dining, or traveling in a car. All the information is then used to determine which, if any, means of communicating with the user would be most appropriate at the moment..."**

Primitive image understanding is *already* being used in the *toy* market! In 1999, PC-based videogames were introduced that use a video camera to photograph the user's body and matte it into the game on the computer screen. As the player moves his limbs, he interacts with objects on the cartoon screen with which he makes "contact" (like ballooons or karate opponents.) The camera plus software sells for little more than $100.

This Christmas, a new PC program will observe your face with a video camera, and use the motions of your facial features to control whatever cartoon face ("avatar') on your computer screen you elect to use. As you speak, your electronic marionette's face will move its mouth in synchronous imitation. Arch your eyebrows or close your eyes and it will do the same. The "little man behind the curtain" will no longer have to frantically throws all those many levers; the Wizard of Oz will appear just by making faces!

Depending on how fast such automated image understanding technology advances, the need for high-end broadband communications may be greatly diminished. If a computer attached to a camera can judge what it is seeing, it might simply need a rather slow communications line to inform a remote human being (or even another computer) what is happening with a brief text summary, rather than transmit any images at all!

Another way video bandwidth may be reduced is by watching the user who is looking at the video feed. It turns out we have very acute vision in only a very small region of our visual field, called the fovea. If the electronic display at which we are looking accurately knows where our eyes are pointed at all times, we can obviate providing extensive image details elsewhere in the visual field! This would allow it to instruct a remote camera transmitting the feed not to bother sending a lot of data about such details, saving enormous amounts of transmission bandwidth. Such a system of course requires adequately small latency in the transmission system. Latency can be due to network congestion if one does not have reserved bandwidth, to computational delays required to do image compression and decompression, and ultimately to the finite speed of light itself, not a negligible consideration if we are watching

other places on the globe, especially via geosynchronous satellite.

Note that when reading, our eye saccades about 5 times per second or more. A system of this type would have to respond to such eye motion in a very small fraction of a fifth of a second (say, a thirtieth of a second) to work. Lest you think this is all nonsense, a local system of this type was experimentally demonstrated at the MIT Media Lab in the 1980's.

Even when we view video directly, the data rate required can sometimes be a lot less than at first glance.

For example, video looking out on a quiet pastoral scene will only change very slowly, and in a few places at that. Video compression algorithms can exploit this by sending only the small differences between successive images rather than the entire image each update.

Even some types of scripted video can have very low data rates too. Leaving television aside for a moment, consider someone giving a talk using slides in a dark room. We cannot see his face well in the dark - but we do not much care. Instead, our eyes are fixed on the projected slide, perhaps watching how the speaker moves a pointer while we listen to his voice. Often, slides consist of little more than austere text and graphics, and stay up on the screen a long time each. Because the imagery is so simple, and audio does not require a high data rate, we can create a digital version of such a presentation using very little bandwidth indeed.

We can also describe a type of interactively generated video that needs limited bandwidth as well. Consider a remotely controlled vehicle carrying a camera. One might use a drone like this to examine some equipment in a location a person cannot access, like a broken pump in a chamber at the end of a narrow access duct. It might be quite acceptable to use a partially blurry moving picture to drive the vehicle roughly into position and then use a high-resolution still camera to get a detailed look at the scene when we are there. Since we never need both high resolution and high refresh rate at the same time, limited bandwidth communication will do fine. I know an engineering firm in Canada actually considering such a scheme to spare expensive repair people lost time travelling to do field inspections.

All this is not to say there aren't times a great deal of bandwidth is needed for video. Entertainment footage of a sports game is one example. A teleconference in which you want to see someone's face well enough you can better guess if he is lying is another. A telemedicine examination in which you are trying to diagnose a subtle skin blemish by panning the camera might be a third. But sometimes we get away with using very little bandwidth indeed.

So far we have been considering what one might call one-user applications, in which a user is trying to obtain information from elsewhere for his personal needs. But someone may also want to transmit information to others from his location - even many thousands of others at once. One example is running a popular Website. At any given moment, people from all over the world may be soliciting the transmission of thousands of different computer files from your Web server computer at the same time. Being a publisher/broadcaster puts great demands on one's communication lines.

But even in such circumstances it's not obvious one needs massive bandwidth at *everyone's* location. If the published files do not change rapidly, one is better served by transmitting each once to a remote hosting center attached to very fast communication lines. At the hosting center, the files can be transmitted to many requesting users very fast without

the need for very fast communications at the publisher's office! Indeed, these days it is common to automatically mirror the content of popular Web sites at many caching locations all over the world, and pass on service demands by requesters to the cache copy nearest to them, reducing worldwide Internet traffic as well as user latencies.

Hosting centers can benefit from locating where multiple very high capacity lines converge. Independent of the Haralson County Development Authority network, Bremen might have interesting potential as a hosting center, because Level 3 Communications is using the Plantation Pipeline right-of-way to lay long-haul optical fiber cables. What makes Bremen special is that it is where four pipelines meet, potentially favoring it as a data hub.

Fiber-optic lines provide high-speed data transmission capabilities, but there are very pedestrian electronic alternatives if immediacy is not requisite. A blank recordable compact disk, or CD-R, which costs a small fraction of a dollar, can record about 680 million bytes of information! That is roughly enough space to record the human genome, or provide many thousands of hours of textual reading material! Thus, prerecorded materials might still better travel by old-fashioned parcel post in certain circumstances. The argument against this is that delays are often no longer tolerable in a world that moves faster and faster. With 100-megabit-a-second fiber-optic service at one's location, the full contents of such a disk can arrive in its entirety in less than a minute after a request for it is made. With say, the 1.5-megabit-a-second rate typical of telephone line DSL broadband downloads, the delay is much of an hour - still faster than parcel post, but hardly what one would call instant.

And as wireless Internet access everywhere becomes more common, there may also be another reason the demand for very high bandwidth may be mitigated. If I want to watch a long video on my laptop computer during a railroad trip, I may need to download the whole thing over the Internet onto a CD before I leave for the train station, and want to do that very fast at home. But if the train itself can economically receive Internet transmissions fast enough to stream the movie in "real time", it is not clear I need the CD at all. If we are never disconnected from any of the data we might desire, the need to locally replicate and physically carry the data we require may simply vanish!

In summary then, virtually any data communication system we call broadband, with say, a transmission speed exceeding 30,000 Bps, is capable of transmitting a useful video feed. For many purposes there is little advantage in paying for a higher data rate unless the costs are negligible. But for at least some very-high-end video applications we can imagine, much higher data rates yet, associated with fiber-optic technology, rather than telephone line DSL and cable TV modem technologies, are plausibly useful. As the cost of fiber-optic electronics plummets in the years ahead, communities that deploy fiber-optics "to the curb", rather than just for use as community backbones, will be able to upgrade their electronics for better performance without ever replacing fiber-optic cables that have not been physically broken, in contrast to other types of "last-mile" wiring technologies.

One should note that developments in fiber-optic technology are extremely rapid, and improved technologies become economically feasible fast. The article cited above titled "Triumph of the Light..." reports:

> **"A five-year study period reveals the speed of information flow over an optical fiber (in bits per second) per dollar spent ['bang per buck'] DOUBLING EVERY 9 MONTHS..."**

The West Georgia Telecommunications Alliance, (cf. http://www.wgta.org), which since 1994 has strived to promote broadband communications for Haralson, Carroll and Heard counties, has learned a great deal about this in the last year. A $20,000 study was undertaken to design a fiber-optic community backbone network and system on paper. Subsequent investigations in recent months have revealed that rather than provide parallel SONET (Synchronous Optical Network) and Gigabit Ethernet networks as proposed in the study, developments now seem to favor altogether avoiding SONET, a legacy technology beloved by telephone companies, focusing instead on the use of Gigabit Ethernet and eventually on subsequent generation 10Gigabit Ethernet gear. By using single-mode optical fiber, the same lines can be re-used by successive generations of ever-faster opto-electronic terminals attached to it. The Haralson County Chamber of Commerce is a member of WGTA and enjoys full access to these detailed discussions recorded on the World-Wide-Web-based bulletin boards at:

http://groups.yahoo.com/group/WGTA-Announcements
and http://groups.yahoo.com/group/WGTA-Discussion

With an understanding of these technical basics, we are now able to discuss how potential applications which exploit a broadband infrastructure can impact how we work, play and learn in the years to come.

ECONOMIC DEVELOPMENT

Traditionally, economic development in a rural Georgia county might mean something like landing a large new plant to take up residence in an industrial park. Current business patterns in Haralson county reflect this heritage, with an emphasis on blue-collar employment in manufacturing firms. But the US is changing, with the rise of the service economy. Harris Johnson, regional director of the Georgia Tech Economic Development Institute, writes this at: http://www.wgta.org/resources/publications/econdev/what-ed-means-to-you.htm

> **"Less than 20 years ago jobs in large manufacturing firms accounted for 26% of American payrolls. But after downsizing, rightsizing, mergers and moving overseas that figure is now less than 10%... Now when you read in the paper... about economic development... the company they are talking about might be a new legal service or a new real estate operation just as well as an industrial firm."**

Michael Dertouzous, director of MIT's Laboratory For Computer Science, estimates that so-called "knowledge workers" now produce 60% of US economic output. While certainly not every county in the United States has to reflect the national economy as a whole, those areas which resist changing to accommodate history will find that the only way they can remain competitive is to endure endless erosion in pay, assuming even that works.

In another paper, Johnson makes the following observation: http://www.wgta.org/resources/publications/econdev/trends-today.htm

> **"The days of the huge integrated manufacturing complex in this country are numbered. They are simply not economical... Far beyond making micro-machines and increasing computer chip density, we must consider extending miniaturization from shrinking lot sizes to shrinking whole factories and moving them closer to the customer. (Examples include The Mattress Factory and the host of 1-hour Film Processing locations.)"**

Thus the massive industrial park loses some of its importance as economic development is dispersed more. It is just as important to provide the utilities that these smaller commercial sites need to prosper, as it is to provide services to the giant park.

Finally, Johnson notes in the same paper:

> **"Young knowledge workers are no longer satisfied with just a competitive starting salary... According to an August 1998 KPMG survey, the three top reasons for selecting an employer were: 1) career opportunities, 2) training and development opportunities, and 3) effective management.**
>
> **"...Traditionally, employee training meant either a trainer came to the company or employees went to a formal class. The trend to distance learning is more a flood than a flow... today's mix of computer-assisted web or video-based training is a close rival to classroom effectiveness at a significantly lower cost. Distance learning has the additional advantage of delivery when and where needed."**

Access to distance learning is becoming a key factor in attracting the knowledge workers critical to many firms today. Wharton Business School Professor Richard Shell says: "In today's market the most valuable component of many high-tech companies is the human, or intellectual capital, which means a firm's main asset can now simply walk out the door." These same workers will expect that the infrastructure (the Internet) which makes distance learning possible will be as available in their homes as in their offices, as they try to balance busy lives.

The Internet is becoming critical to family life among modern young workers as well. This year the Los Angeles Daily News reports that:

> **"[Web moms] ' tend to feel they're stretched too thin and are using the Internet to simplify their lives and bring them closer to their families,' said Melissa Grimes, a senior analyst who researched [a] report [by Cyber Dialogue Inc.], which surveyed 2,010 people, 1,500 of them women, in December [2000]... An overwhelming number of respondents [said] that they increasingly use the Internet to comparison shop, plan activities for the kids and even find their own fun... Almost 70 percent of women said they use the Internet almost daily for information on how to better care for their family. Many also use the Web to conduct research before making purchases at regular retail outlets..."**

EDUCATION AND OTHER LEARNING

Education is an important key to economic development in the future. While the nature of learning will change in the world to come, doing much more of it will be necessary to enjoy the opportunity to work at jobs and wages people will prefer. This leads many people to expect an increase in learning-related employment, including fields like teaching, marketing, writing and evaluating.

Of course It is a mistake to look at one group of people and assume all others will live and

adapt the same way. That said, it is still instructive to examine the current professional lives of a group of people with whom I am familiar - the so-called "new media" workers who do things like create World Wide Web sites. An article this year in "The Boston Globe" cites a Economic Policy Institute study of 300 such people now employed in New York City's so-called "Silicon Alley" (sic).

One key finding: New media workers work an average of 53 hours a week, with 15 hours of that time devoted to keeping up with the latest technological innovations. They spend another 13.5 hours outside the office doing the same. It is interesting to try to quantify the annual cost of this renewal of "human capital". Let's say, for argument's sake, a worker is said to invest in education what he spends in hours of study, based on his wage when doing productive work. (This neglects the cost of instruction materials and the labor of teachers he pays.) The average person considered here does 38=53-15 hours production and 28.5 = 15+13.5 hours recapitalization per week, or about 1900=38x50 hours and 1425=28.5x50 hours respectively, per year.

The American Electronics Association study called Cybercities examines the wages of high technology employees on a city-by-city basis. (cf. http://www.aeanet.org/aeanet/aeacommon/display.asp?file=/aeanet/PressRoom/statmk0198_cc_newyork.htm) It reports:

> **"New York [City]'s 6,500 high-tech establishments paid an average wage of $74,800 in 1998, or 44 percent more than the average private sector wage."**

At $74,800 annual salary, 1900 hours of production cost $39.37 each. That means 1425 hours of annual study might be assigned an investment cost of $56,100 PER YEAR, under the assumptions here. That's a HUGE amount of spending just to stay active in one's craft!

An interesting aside: I do not know how many hours the average private sector worker in New York City puts in every week, or how many hours of study he must do to maintain his position. But *if* he does 40 hours of production and need not do *any* study, he actually has a higher hourly wage than the "new media" worker, counting production and study time together! But high tech workers sometimes enjoy dramatically higher wages in cities other than New York. The same Cybercities study also reports on:

> **"...Seattle, where the average annual income of $129,330 gave tech workers far more money to spend... Although Seattle's high-tech workers led the nation in average annual salary, that number was boosted by 31,000 software industry employees who earned an average of $234,000 in 1998..."**

As for the country as a whole,

> **"The annual average wage for the nation's high-tech workforce was $58,000 in 1998, compared with the average private sector wage of $32,000, an 82 percent differential."**

Returning to the main point, what about the additional cost of stuff like tuition paid by new media workers? The EPI study has some interesting findings germane to that:

> **"Some 87 percent of workers say self-education is the most important source of acquiring new skills - and 73 percent learn on the job. Only 17.2 percent of workers learn at industry workshops and even fewer pick up new skills from coursework."**

While not all the occupations of the future will be exactly like that of the new media worker, many of us are moving in that direction. That means we will be spending more time learning - not just ONCE in trade school or college, but for all the rest of our active working lives. Moreover, because the need for continuous learning will be elicited by changes in the field we already practice, the information we will have to absorb will not have been sifted by expert teachers generation upon generation, but will sometimes have to be digested as best as possible in uncomfortably raw and sometimes even misleading form to be sufficiently timely!

Often, we will not have the luxury of waiting until someone within our local community is qualified to teach us what we need to know. And the more arcane or even merely parochial the knowledge we seek, the more acute this problem will be. This will lead us to heavier reliance on published materials like Web sites (and maybe one day even more helpful automated aids like effective interactive teaching programs, one hopes). But when in such a situation one wants to turn to a human teacher, whether for access to material not yet published in final form, or for the benefit of a dialog with someone who understands the material, one can exploit economical Internet communications to access such a rare resource, wherever in the world that teacher is based.

These days, the Internet makes international communications available at almost ZERO incremental cost. Since the early 1990's, folks have used a facility called Internet Relay Chat, which lets two or more people type text live to one another. And nowadays things are better yet. A friend of mine is an 'Army wife' living with her kids at Fort Benning; her husband is stationed in Korea. By getting onto the Internet using a simple dial-up modem, he can talk to his wife on her United States telephone at no additional charge via a service called Dialpad, rolled out in October 1999, to which I introduced them. It uses advertising to pay for the minimal cost of providing service. And with fast enough Internet connections and cameras, people can actually videoconference with one another, gesticulating if needed.

But this hardly argues against building a technical education school in Haralson county. There are still many things that can benefit from the use of literal hands-on experience in a way that cannot be done electronically, particularly when it involves complicated or expensive equipment whose cost must be shared by many students to be practical. And people are only now beginning the process of exploiting the type of 'distance learning' described above, anyway. But as time goes on, not only will local students start to study more and more from teachers in other parts of the world using broadband communications, but the local school will also start to realize more revenue, providing an increased source of employment, by exporting its expertise around the world in the very same way. It will also serve local students better through broadband for those times when the physical presence of the student is really not needed, and is actually impractical on account of responsibilities owing to ongoing health, family or employment considerations. If your flu does not let you drive to school, but is not so bad you cannot concentrate, you may well elect to attend the local school via teleconferencing, either live so you can participate in class, or via a recording if you only get well enough to study after class is dismissed.

This is not as blue-sky as you may think. A couple years ago a new, rather cheap device was introduced that digitizes the writing one does on a white/blackboard of whatever type used. I spoke to a friend about how it might be the basis of a business opportunity for him. In the 1990's, he had started a company that provided laptop computers and other services to the K-12 school market; it eventually grew to branches in three US cities employing 60, and served clients throughout the US. I remarked to him that when I was a child, my school would receive funds based on the number of child-days of physical attendance they could record. Perhaps, I said, if you could help schools teach sick children at home using this technology, you could be paid with the funds they might gain if they used the money formula in practice when I was a child. My friend didn't take up my suggestion, and sadly his firm folded with the collapse of demand last fall, which is why he is weighing an executive position with NetSchools in Atlanta right now. But Georgia Tech has greatly fleshed out the basic idea with its "Classroom 2000" project, which even now is deployed for actual teaching there, as well as being replicated by other schools across the country. I think widespread use of stuff like this is only a matter of time.

Distance learning is a special gift to people who have given up on institutional education for their minor children, and assumed the burden of home-schooling. Their reasons for home schooling are varied. Some don't want their children to identify with peers from families which espouse destructive values. Perhaps they want to keep their innocent young away from the premature exposure to sex and illicit drugs, as well as the ordinary but very dehumanizing criminal bullying, they might well face in a massive penitentiary-style public school. Some want to rule out victimization by even rarer events like deadly terrorist acts by other children. Others object to the state brainwashing their children about what is true and false, good and bad, beautiful and ugly, deeming it a totalitarian human-rights abuse. But by instructing their child at home, these folks may have to give up some advantages of economies of scale and specialization of labor. The Internet in general and broadband in particular, offers a means for home-schooling parents to enjoy the benefits of these large-institution products while not surrendering control over content or social environment - what one might call take-out-cafeteria-style education. And for parents still unable to bear the burden of personally educating a child, broadband access at their church (or Leninist cell meeting house!) might provide them with what they consider a safe and wholesome physical and social atmosphere which still allows them to defend their most precious treasures against episodic hazards, or even a mainstream culture they may consider sufficiently mad or evil or both. Now, former US Education Secretary William Bennett and Yale's Professor David Gelertner have committed themselves to improving elementary education with technology through a new commercial firm called K12.com, despite their past roles as vocal critics of techno-education.

The "online" flavor of distance education is not just a research experiment; it is already an industry. This month, online tech new leader CNet.com writes:

> **"Investors have given the e-commerce sector failing grades, but the online-learning niche may be headed for another straight-A semester. Stock in many education companies is hovering near 52-week highs, and analysts are lavishing praise on the small but growing industry... Business degrees and technical training are among the most common programs offered online...**
>
> **"The University of Phoenix, which has 19,000 online**

> **students and a total of 75,000 students at more than 100 physical campuses [is a division of] the most high-profile education company... 'For a while people would roll their eyes at the University of Phoenix, but among corporations and middle-level managers, it has gained a lot of credibility,' [said Trace Urdan, education analyst for San Francisco-based investment bank WR Hambrecht.]**
>
> **"According to recent research from Merrill Lynch, more than 2.2 million college students will be taking courses online by 2002, a 210 percent jump from 710,000 in 1998. Students can already pick from more than 6,000 accredited college courses on the Web, and 84 percent of four-year colleges will be offering online courses in the next two years."**

Many technological changes have made distance learning cheaper. Improvements in computing power, data storage, data communications and sensors have all played a role. A color TV camera with sound on a manual positioning jig with a 60-foot cable, perfectly capable of creating a US television quality signal, does not cost thousands or even hundreds of dollars now. You can buy a single unit at retail for only $40. And if you want to replace the cable with a short-range (100 foot) wireless microwave link for added flexibility, it costs only $44 more for the transmitter/receiver pair!

An opinion piece in the current issue of MIT's "Technology Review" asserts:

> **"Digital cinema could do for movies what the photocopier did for print culture. In the 1970s and '80s, we saw the explosion of newsletters and 'zines, documenting the experiences of folks living in retirement homes, working in minimum-wage jobs or slam dancing in mosh pits. Now, the introduction of cheap and lightweight digital video cameras, PC-based digital editing software, and streaming-video distribution on the Web puts the resources of filmmaking in the hands of an equally broad range of citizens and thus expands the potential for grassroots creativity."**

But just because the gear needed to create video content is cheap, doesn't mean that high-production-value video is! I produced my first industrial film in the late 1980's, to document a research project I had led. It was created with the conventional analog equipment used back then, and took many *hours* of work for each minute of screen time. When you figure in scripting, shooting, editing and titling, doing good work all adds up to quite a lot of work! Even with modern tools, producing good content is very *labor* intensive - and hence expensive! In March 1996, "New Media" magazine wrote:

> **"...multimedia training can be less expensive than bringing employees and instructors together in one classroom... how much will it cost? If you ask for estimates, you often get the usual 'it depends'... When pressed, many will cite the bandied-about figure of 300 hours of development for one hour of training and $40,000 per instructional hour. But... because**

costs are coming down, your mileage may vary."

Because the production of scripted programming is so expensive compared to extemporaneous video, the latter may well prove far more common, just as spoken communication often trumps written communication today. Perhaps the reason Georgia Tech's Classroom 2000 work has proven so successful is that it endeavors to seamlessly interface with a traditional "chalk and talk" culture, while providing important new benefits like indexing, annotation, hyperlinking and space/time shifting.

Computer technology holds the interesting potential for improving the learning experience - even in the context of an old-fashioned 'face to face' seminar (whether taking place in one room or in many places across the world at once via videoconferencing) in which an instructor leads a class in a Socratic discussion. In the future, it is not beyond imagination that each student may be constantly examined by an individual camera, tied to a computer that will attempt to read the nonverbal communication arising from facial expression and body language. Even if the teacher is not astute (or superhuman!) enough to carefully watch each and every student in the class simultaneously while also thinking about what the current speaker is saying and where the discussion might next go, he may benefit from a computer assistant that sparingly summarizes the demeanor of each and every student, occasionally saying things like the following into an earphone the teacher wears: "Compared to ten minutes ago, three times as many students appear distracted or even sleepy - perhaps they are bored or confused". It is not infinitely far from the "video marionette" technology we discussed above to this sort of more serious application. If something like this system eventually works well enough, it may no longer be necessary for a teacher leading a videoconference discussion to see each student's actual face - and the value of broadband may diminish on that account.

THREATS TO INTELLECTUAL PROPERTY

A big wild card in the economics of education, as well as every other field which licenses and sells intellectual property to a mass audience at popular prices, is the question of whether a functioning copyright regimen can survive, *despite* any laws and sanctions that could be put into place. This issue recently rose to very great prominence in the popular mind with the confluence of several technical advances which led to the "casual", but extremely widespread copying of copyrighted music between non-vending parties. Naturally this has horrified the recording industry, who would rather sell a million copies of a CD, rather than one copy which is copied with no compensation to them a million times over!

Two key technical factors set the stage for this copying spree. First, the 'MP3' file format, which digitally encodes music very efficiently at high quality. Second, a computer program called Napster, which facilitates 'sharing' copies of files over the Internet between parties who don't really know one another.

Two other technical factors have catalyzed the process to higher rates. First, the massive rollout of broadband communications, which makes copying faster yet. Second, the continuing rapid fall in the price of all types of permanent storage, most especially recordable (CD-R) compact disks. A single CD-R disk can hold a copy of very many conventional CD music disks if the MP3 format is used, and a blank disk costs only a few dozen cents!

Napster relies on the existence of centralized computers, called servers, at well-known

permanent locations on the Internet, to coordinate the rendezvous of music-swapping parties. But now there are also alternative computer programs that operate without the need for such permanent targets for legal injunctions! Moreover, even though Napster now labors under just such an injunction, swapping continues to go on simply by slightly misspelling the name of the piece of music parties would like to 'share'.

Naturally, what can be done to music can be done to ANY type of intellectual property that can be digitally recorded. This includes motion pictures, computer programs, books, et cetera. And surely the Napster phenomenon has terrified the owners of content delivered by these various media.

Some people look to encrypted files and stand-alone "black box" media players to solve the copyright problem for digital content. This will only work for a limited time. As long as content is fixed and finite in nature, once it is rendered as sound and pictures, increasingly powerful personal computers will be able to capture and digitize this content, merely by observing it the same way a human user would. It is already practical to do this - just not quite simple enough for the average user to undertake the effort to produce a high quality copy casually. While underground commercial interests may be deterred from doing this by the threat of the law, individuals making a single copy will not. Because broadband will make it so easy to move such copies across the Internet at virtually no cost, such copies will spread in the manner that Napster-mediated songs do now. Unless things like the "Sony doctrine" and the Digital Home Recording Act are modified to redefine what copyright law calls "Fair Use", some will even argue that such users are clearly operating WITHIN the law as well.

Thus I expect that things like books, songs and movies will be at the mercy of massive low-risk copying by isolated home users. This will destroy the economic model which depends on massive sales of copies by the vendor, making high production values impossible. Even ideas like embedded advertising will not work. It is possible to edit such things out when making a copy, first by hand, and eventually automatically by computer program. It would seem such content would then have to rely on non-profit sponsorship (e.g. a chemical industry consortium, eager to facilitate the education of new chemists, would sponsor a chemistry textbook and then make it free to the entire world) or by professionals seeking to improve and publicize their reputations, for the sake of enhanced consulting fees for other work.

On the other hand, I see an out for developers of things like spreadsheet programs and video games, and in general, any digital product NOT fixed in nature, but contingent on the nature of input from the user. These wares can be provided over the Internet by what are already called "Application Service Providers" (ASPs), who do the actual computation on their own computers, so that the remote users NEVER have a copy of the computer program performing the work, and hence, cannot make and distribute free copies of it to others. (Goodbye for-profit shrink-wrap software distribution!) This is a key reason why even a PC-centric firm like Microsoft is pushing its Internet-centric "DotNet" technology. Of course, if even only ONE copy of such an ASP program is pirated by a disloyal employee of the firm (like a mole), the cat will be out of the bag - if it can run on a simple general-purpose computer like a home PC. Copies can be distributed at virtually no cost over the broadband Internet very quickly, destroying the value of this work. The economic motivation for such vandalism? How about a protection racket?

But if such piracy and extortion can be prevented, we might see things like high-production-value movies replaced by interactive high-production-value video games. Even now, the market sizes for the two are comparable. Don't doubt that video games will threaten movies

with comparable visual quality before many of us are gone. Even today, things like the soccer game simulation (for the Sony Playstation 2) called FIFA 2001 from Electronic Arts, reaches a high level of realism, even if it still is distinguishable from actual human game film footage. (cf. 4MB video clip at http://europe.ea.com/fifa2001/fifa2001.mpg). But the austerity of Pac-Man is nothing but antediluvian history now.

Perhaps one day things like natural language processing by machine may be good enough that intelligent INTERACTIVE teaching programs could be provided remotely via the ASP model, so that production of such things could be financed by leasing their use. But short of that, perhaps soon anyone who seeks to author an economics textbook or develop a medical dissection video might as well give it away for free, as essentially perfect copies will rapidly circulate across the broadband Internet shortly after publication.

Aside: An important thing one should keep in mind is that as time progresses, unsequestered video footage becomes ever more subject to replacement by a false synthetic substitute. Remember that Tom Hanks as Forrest Gump could shake hands with President Johnson, long after the latter was buried. Quoting from "Lying With Pixels" in MIT's Technology Review, http://www.technologyreview.com/magazine/jul00/amato.asp:

> **"Deleting people or objects from live video, or inserting prerecorded people or objects into live scenes, is only the beginning of the deceptions becoming possible. Pretty much any piece of video that has ever been recorded is becoming clip art that producers can digitally sculpt into the story they want to tell, according to Eric Haseltine, senior vice president for R&D at Walt Disney Imagineering in Glendale, Calif. With additional video manipulation technologies, previously recorded actors can be made to say and do things they have never actually done or said...**
>
> **"So far, real-time video manipulation has been within the grasp only of technologically sophisticated organizations such as TV networks and the military. But developers of the technology say it's becoming simple and cheap enough to spread everywhere. And that has some observers wondering whether real-time video manipulation will erode public confidence in live television images, even when aired by news outlets. 'Seeing may no longer be believing,' says Norman Winarsky, corporate vice president for information technology at [RCA spinoff] Sarnoff. 'You may not know what to trust.'"**

RETAIL SHOPS

Of course some types of 'educational' material are rather parochial and the producer would like nothing better than for copies to circulate at will. This includes stuff like 'infomercials' and other types of product descriptions. "Interactive Week" reports in its Oct. 23, 2000 issue that 1100 of Radio Shack's 7000 retail stores already have broadband Internet connections. They provide employees with information on products, as well as other types of training through video-on-demand. Given rapid product churn in this line of retailing, it is useful for sales associates to enjoy such "just-in-time" training!

Any type of chain store selling nonfinished goods (like components) might benefit from a

broadband Internet connection - especially if it is too small to support full-time technical experts. When a customer needs help, a videoconference discussion with an expert at a central corporate location might save an important sale that would otherwise be lost.

Take Home Depot for example. I once needed help learning how to disassemble a plumbing fixture before I could feel okay buying it, because of water supply precipitate problems which had occasioned this very potential purchase. I spoke to someone at the store identified as a master plumber - but he was stumped how to do what I wanted, despite his assurance to me it could be done. I would have GLADLY paid $5 to talk to a qualified guy on the other side of North America for 5 minutes via videoconference for the knowledge I needed to make my purchase!

Retail stores are getting smarter all the time. Wal-Mart rose to greatness in the 1980's on the strength of its ability to track inventory along its entire supply chain, from manufacturer to the moment an item was checked out at a sales counter. Of course, it did this using computer and communications technology, and I am sure the lesson was not lost on all major national retail chains, whatever sort of wares they sold.

But even if a store follows such practices in principle, it does the customer no good if in practice human error screws the system up. Once I wanted to buy a part to do some home remodeling. I telephoned the nearest Home Depot (which then was an hour drive away in Rome) and inquired if they had inventory on this part. Indeed they did, came the answer. Their computerized inventory system showed they had 14 units in stock, a quantity highly unlikely to sell out that day. So I hopped into my car, drove to Rome and walked over to the shelf where such parts were kept. There were NONE on the shelf. Distressed, I complained to an employee, whom I asked to check the inventory system again. Just as before, 14 units were shown in stock. I groused about coming home empty-handed after a two-hour shopping trip. He responded by spending the next half hour looking for the misplaced parts. This wasted an additional 30 minutes of my time, as the parts were never found. Knowing that the Rome expedition was split milk I could never drink, I asked about the nearest sister store. I would drive there to get my part - but only if they ACTUALLY had one in stock. I had the store employees call ahead to confirm this - not by looking at computers, but by actually WALKING over to the shelf where the parts were kept. That day I finally got my part, but rather than needing 2 hours as I had thought, my little expedition consumed almost 5 hours - more than half a regular working day. I put twice the mileage on my car I had intended, and increased the highway traffic and air pollution in a way I would never have done had I known the store nearest to me had no inventory that day.

It will be a long time before I believe the Home Depot inventory computer again, but sometimes it is hard to use the telephone to get a store employee to walk over to the shelf where some parts sit to verify inventory, when they are trying to help "live" customers right there in a store rather than a *hypothetical* customer on the phone. It would be wonderful, one dreams, if it were possible to look at the shelf without driving all the way to the store.

Now I don't expect to get a video feed of the Home Depot store shelves anytime soon. And surely, it would seem that if the inventory system could be made to work as intended, and could even be queried via the Web or by automated telephone response, that would be the cheapest way to do things. But the day might well come when we can go shopping by video proxy to forestall wild goose chases like the one I describe above. If a company cannot describe new items on its Web site databases in adequate detail (or at all everywhere, as STILL is the case for Home Depot), then maybe it would be nice to rent a remote-control video

camera to tour the store!

Remotely piloted vehicles such as described above are NOT science fiction, NOT just research projects, and NOT just limited to use by anti-terrorist squads. The firm iRobot (cf. http://www.irobot.com/) sells a small, self-propelled indoor vehicle, connected by wireless broadband within a building, which you can control from anywhere in the world using an Internet connection. It includes a video camera with audio on a movable stalk to let you look around. The robot can even climb up and down stairs unassisted, something one doesn't even need in a one-story "big box" store. The price is $5,000 and might be rather less if one needn't do stairs. For example, a product that might be re-engineered for this task is the $1,000 Probotics Spy-Cye (cf http://www.probotics.com). Ownership of such a gadget is not impossible for something like a Home Depot store, which, on average, turns over $40 million of inventory annually.

Of course the idea of motorized telepresence is not new, and even consumer applications have long been envisioned. Nolan Bushnell, founder of the video game firm Atari, and the automobile navigation firm Etak, proposed a cheap form of tourism using such robots maybe twenty years ago. At long last, we are living in an age where such a scheme is possible - if not yet practiced.

Naturally one can also imagine cheaper halfway measures that might be adopted sooner. If parts and models churn so fast that a retailer like Home Depot cannot rapidly enough create a Web page for each, then maybe when I call the store an employee can take a wireless video camera to a certain aisle in my behalf and remotely show me the new stuff they just received. Each Home Depot associate already carries a wireless phone - adding a camera and boosting bandwidth would not be an insurmountable task, especially now with the in-building wireless broadband networking explosion of the last couple years. I would even pay a couple bucks by credit card on the Web, for 5 minutes access to this service, rather than drive 30 miles and back for nothing.

Even small, independent retail shops might benefit from appropriate onsite Internet access. In recent years this type of enterprise has lost out as giant malls within driving distance offer customers a dazzling array of choices that a small store cannot match. But the small shop can partially redress this balance by moving from simply selling goods, to selling a special service: the knowledge of the clerk or proprietor of his line of wares, and how best to use them to improve his customer's life. With the Internet and good shipping services, every small shop can be cash register for a much wider world. Rather than have a customer walk out of the premises without buying something - or not even walk in at all - how much better to steer such a customer to appropriate online goods, delivered later by express parcel service, on which the local salesperson can realize some sort of commission or referal fee. Perhaps not everyone will be comfortable or even capable of using the Internet to shop. The local merchant can use his knowledge of goods and the trust his customers have in him to help such people buy online, much as public scribes wrote letters for the many illiterates of the 19th century.

CUSTODIAL CARE

We live in an age of very busy people. It seems the more money people make, the more they seem to desire the services of others to care for those in their family who are too young, too old or too sick to be left home alone. And many are willing and able to pay, too. But we are all

aware of horror stories concerning institutional care of such dependents. That's why people are already exploiting the Internet to transmit images from such facilities to the bill-payers to give them peace of mind. It started with daycare centers. Already four years ago, Kids ``R'' Kids Daycare Center in Marietta was testing the KinderCam System from Roswell-based ParentNet. By the end of 1999, 150 of the nation's 120,000 daycare centers were using systems like this - and perhaps 580 more centers had pending service contracts. Eventually, a similar system debuted in a kennel so you could check on Fido while you were on vacation. Both these types of custodial care are temporary - but there is another type which is essentially permanent - the assisted living facility / nursing home. Surely some people institutionalize their elderly to rid themselves of the horrible sight of age, disease and death. But many others would gladly brave such experiences as the price of greater intimacy with their elderly loved one - if only they didn't have obligations that made such extensive care impractical. For such people, video contact will prove a treasure. With it, one can at last finally see whether one's loved one is getting the care he or she needs. Perhaps we cannot afford to have at home the special equipment our loved one needs at his bedside. But if we have the time to watch them in the nursing home, even if only episodically, we needn't give up the ability to see that caretakers are properly paged to provide the paid services our loved one must have. Continuing broadband Internet deployment will make this increasingly cheap and easy to accomplish.

I myself already use a system not unlike the one I describe. On my homestead in Haralson county there are two small houses - one for me and one for my chronically ill, aged mother, for whom I provide care alone. In recent years I have deployed multiple cameras around her house so that I could watch over her at all times while working at the desk in my house. Mother is no longer able to operate a call button to summon me when she needs help - but I can keep the corner of my eye near the video monitor which lets me know when she needs it. In my case, I am also the custodian who is "paged" when the need arises - but mother could just as well be on the other side of the world if appropriate technology were affordable and deployed, and another caretaker could do the actual physical work when needed. Actually, not every need mother has requires a trip over to her house. I can handle many simple things, like lighting and entertainment devices, from remote controls in my house. And with the roll-out of domestic wireless networking like 802.11b, one can even wear a wireless video headset to stay in touch while cutting the grass or washing the car outside.

A peaceful, clean, safe, rural venue like Haralson county could prove a fine place to locate the nursing homes of the future. Surely there will be plenty of potential customers as the "Grey Tidal Wave" hits with the aging of the Baby Boom generation. Well-paying jobs for medical specialists can make this type of facility attractive for economic reasons - assuming proper financial preparation on the part of the patients and their loved ones in the decades before institutionalization. It will be important that such facilities can enjoy broadband Internet access in the places they might be located.

Even the infirm elderly still living independently can benefit from broadband communication; at least that is part of the premise of Georgia Tech's massive Aware House project, a review of which you can read in Scientifc American here: http://www.scientificamerican.com/2000/1100issue/1100techbus1.html. In the commercial world, groundbreaking for a $22 million, 150-unit smart-home elderly development near Jasper, GA enjoying "very high quality Internet service" was scheduled to happen last summer. Certainly I have found that over the years of my mother's decline, various types of advanced home automation, nowadays called UbiComp (for "Ubiquitous Computing"), which have watched over her, offering help or spoken advice, have proved useful in enhancing her

health, safety and peace of mind.

HOSPITALITY FACILITIES

While we look to broadband to reduce the need for travel, especially business travel, we will not get there all at once and the hospitality industry still has a ways to run. Indeed, hotels are finding that by installing things like top-tier videoconferencing equipment gives them access to local clients they would otherwise not enjoy. In June 2000, Cahners In-Stat Reports noted the following results of a study they did:

> **"73% of hotels are considering offering high-speed Internet access in guestrooms.**
>
> **"For hotels with over 60% business clientele, an even higher majority (82%) are considering rolling out broadband to customers' rooms.**
>
> **"56% of hotels plan to wire at least half of their guest rooms (for the average-sized hotel, that's a minimum of 100 rooms)"**

This year the Atlanta Business Chronicle wrote the following here:
http://atlanta.bcentral.com/atlanta/stories/2001/02/26/focus18.html

> **"Ask almost any marketing manager at Atlanta's hotels and conference centers, and she will tell you high tech means good business.**
>
> **"These days, when a company, association or other organization plans a foray away from the office -- for training or to showcase a new product -- employees expect to find the same tools they have back home. That includes things like high-speed Internet connections, videoconferencing to link distant offices together and video projectors for flashy Power Point presentations.**
>
> **"In the minds of many conference centers, high tech clearly has moved from a luxury to a necessity in staying competitive for the convention and meeting business. It also has become a means for boosting revenue..."**

Not only hotels catering to business people, but truck stops catering to long-distance drivers can benefit by providing teleconferencing infrastructure. Many drivers miss the loved ones they must leave behind to earn a good living, and would enjoy the ability to catch up with domestic life after a hard day's work on the road. Truck stops might make money not only by selling communications per se, but also by vending teleconferencing kits with service referrals, so that drivers could acquire gear for installation on a home PC, that they might do the same things they see their fellow truckers enjoying at the stop. Some people believe that ultimately trucks will drive and unload themselves, but long before this happens, broadband communications will be a common utility which long-ranger truckers routinely enjoy for contact with their families.

PUBLIC AND PRIVATE SAFETY AND CONVENIENCE

Police forces in the United Kingdom have deployed approximately 1,000,000 television cameras in public places - almost exclusively urban areas - to intensify presence everywhere. An individual is already likely to be filmed by up to 300 cameras a day, according to experts. While it has alarmed civil libertarians for obvious reasons, the cameras have been very effective in checking crime. The number of surveillance cameras in Britain is set to double over the next three years, following Home Office approval of a new system that can be run at a fraction of the cost (as little as 20%) of existing networks. The new system is a wireless application which employs mobile phone technology to beam pictures from cameras to portable monitoring devices such as laptops and hand-held PCs. Still, the system uses specially adapted pan, tilt and zoom cameras, costing about £3,000 each, which contain a hard drive and a mobile phone to allow data to be transmitted to remote devices. A police officer can view footage from a camera or maneuver its position - whether he is around the corner or in another country - by dialing it from either a desktop PC, a portable laptop or a hand-held device. Image quality will dramatically increase when so-called 3G ("third generation") wireless communications systems, which enjoy broadband speeds of up to 2 megabits per second, are rolled out in Europe. (European governments squeezed about 100 billion US dollars out of would-be wireless providers in Europe for licensing, and some have predicted such price gouging will doom their commercial viability. This may delay service rollout until new carriers buy the licenses on a secondary market at firesale prices.)

Cameras are even more cheaply deployed within private homes, where weather and vandalism are not factors. They can be used for a variety of purposes in such a setting. First, they too can prove a deterrent to crime by helping to identify and document criminal activities, such as by forced-entry intruders. When the image is transmitted off-premises by broadband, there are no on-site video tapes an intruder can simply destroy. They can also be used to see if the teenage kids are keeping their word about not letting the party get rowdy while Mom and Dad are away on a weekend alone together. Such cameras can help us better use the services of visiting repair-people by reducing the number of truck rolls: One can demonstrate what the rafters in one's attic looks like before the carpenter comes, so he needn't too late discover he must rent a special tool and return a second time. The cameras can also help us proctor the visits of strangers in our absence: if one can let the electrician in and out via remote-controllable entry door, and can see that he doesn't walk out with a family valuable in error, one needn't take time off from a remote workplace to be at home when he visits. By recording the entire visit, one doesn't even have to watch video in real time, save when summoned by the visitor at the start and end of his visit.

It is not even necessary that cameras be monitored -or functioning- for them to deter wrongdoing, based on a principle sometimes called Bentham's Universal Transparency. If you don't believe this, ask school-bus drivers who have been relieved of rowdyism because a black box with a protruding lens watches the kids while the driver is busy attending to traffic. Drivers are spared the dangerous temptation to turn around while the bus is in motion to see who is hitting whom, because no one knows which of the five buses in the local fleet has the real video recording system installed this week - and which four have mock-ups.

Performance in some jobs can be measured without observing the job-holder at work because a palpable output is the specified thing purchased - like the brick wall of a certain size the mason laid, or the written version of an oncologist's audio notes that a medical

transcriptionist created. In other jobs, the behavior of the worker himself is what is being traded - such as the performance of a stage actor - and for such jobs remote video observation can prove useful.

Remote cameras are being used in restaurants so that a manager can see that on-site hourly employees serve customers with courtesy, instead of sarcasm and indifference. They have been placed at construction sites to guard against theft of materials. And such systems can accompany police officers making a dangerous stop which may subject them to the risk of injury - or the need for backup they are prevented from calling by the perps who are restraining them. It can also safeguard quirky citizens who are acting within their rights from brutality at the hands of a police officer with a broken marriage and a drinking problem no one knows about yet.

Cameras will eventually be deployed in automobiles to document things we don't like to think about - traffic accidents. But since vehicles may be extensively damaged in a crash, the very system that could electronically store the last minute of video footage may be damaged beyond repair - the black box might not survive. If wireless broadband were deployed widely, especially at dangerous intersections, cars could transmit such footage off-vehicle before the crash occurs, assuring the survival of the crash history, if not one or more vehicle occupants! Safe drivers who deploy video systems in their car might get a break on their insurance - because their carrier will be able to prove the other party was at fault in a serious crash.

A happier application of on-board-vehicle electronics is crash avoidance, by doing things like documenting tailgating the second it starts! A radar range unit could measure the following distance of the vehicle behind you, your speedometer could be recorded electronically to document the speed, and video footage could be taken and archived to show the violation in progress, including license plate, driver and passing scenery, to back up the speedometer reading. With wireless broadband, this record could even be radioed to the police in real time, who might issue a preliminary ticket pending judicial protest by the accused. Obviously one could also display a lit message in one's rear window reading "STOP TAILGATING - I AM REPORTING IT NOW", in the transition era when such a system is exotic rather than standard. That alone could be enough to prevent most tailgating.

If you think adding such fancy electronics in ordinary automobiles sounds implausible, you have not closely looked under the hood, so to speak, for a long time.

The first microprocessor appeared in an automobile long ago, in the 1968 Volkswagen 1600. It controlled the air-fuel mixture in an electronic fuel injection system. By 1996 even the typical auto had 10 to 15 microprocessors onboard. In 1998 the Mercedes-Benz S-Class sedan contained, depending on options, between 35 and 40 computers. The Lincoln Continental had 26 microprocessors, which controlled such features as antilock brakes and traction control, engine and transmission management, ride control, a GPS, as well as comfort and convenience features like climate control, interior and exterior lighting, stereo and CD changer, and remote keyless entry. An additional 14 microchips helped manage the data to make all this possible. The total brainpower in these 40 chips allowed the Continental to process more than 40 million instructions each second. For comparison, consider the 2 million cycle per second clock of the on-board navigation computer used on the Apollo moon mission.

In the United States today, more than 1 million vehicles include 'telematic' devices, mostly new OnStar-equipped General Motors Corp. vehicles. OnStar provides wireless computing

services for cars, including navigation systems and voice-activated Internet systems that allow drivers to check email, receive news stories, and get stock quotes, weather updates and sports scores while in the car. OnStar automatically notifies emergency roadside help when a vehicle's air bags deploy, and it tracks stolen vehicles. The new OnStar Virtual Advisor service will soon offer personalized traffic reports so drivers can check road conditions up ahead or for their favorite route home.

THE BACKOFFICE ON THE BACK FORTY

Nearly all the vehicles we use are powered by petrochemicals because of the enormous stored energy density of such fuels. This consumption is a tremendous source of air pollution and a more adverse national balance of payments. Only one-third of the consumption in our country is for moving freight - the remaining lion's share is used to move people. If we could find a way to avoid moving so many people, so far, so often, it would have an enormous impact. Broadband communications provides a way to move in this direction. How metro Atlanta in particular cries out for relief of this kind!

An immediate application of broadband Internet access at home is telecommuting, or as it is called in Europe, teleworking. An enormous amount of the work people do today involves nothing more than processing information. If this information were available in digital form it could be moved anywhere in the world at very small cost by the Internet. Even non-broadband Internet access makes many types of work like this exportable to any place you can find a 'knowledge worker' capable of doing the work. Work done this way can be an incredible opportunity for someone who is blind or paraplegic and has trouble travelling to a distant workplace. Even the rest of us can benefit from such a scheme by foregoing lost time on the highway, not to mention the expense, irritation and danger of travel (about 1% of Americans die in traffic accidents). And our neighbors who cannot telework as we can, will thank us for decreasing traffic congestion on roads they still needs must use. Our employer or contractee will probably also appreciate the decreased need to provide office and parking space for us on their site.

Even if we work at home, the boss can still rest easy if he wants to observe us like a prisoner on suicide watch in the big house: with broadband he can view a continuous video stream of what we are doing from second to second. The increasingly cheap cost of storage even allows him to archive such footage. With broadband and better computing, supervisors can watch their subordinates in ways unimaginable using actual constant physical presence in years past. But what they can't do is send someone to surreptitiously rough up or illicitly threaten their employee, unless they want that documented by the employee's own home recording system, quite unlike the situation today at the centralized workplace or along the regular, predictable commute to-and-from work. For more on high-tech workplace surveillance in recent years, see:

http://www.wired.com/wired/archive/3.03/security_pr.html

The possibilities - good and bad - of extensive computerized monitoring everywhere were explored in Bill Gates' first book, "The Road Ahead". On the lighter side, "Shooting Back", a documentary by University of Toronto professor Steve Mann, which he describes in the May/June 1999 issue of 'Technology Review', takes a whimsical look at what happens when the sales staff in stores using video surveillance find out that one of their own customers is taking video footage of THEM at the same time.

THE GLOBAL WORKPLACE AT YOUR FINGERTIPS

An amazing amount of work of all sorts is now being performed in the most unlikely places. India, despite its army of intelligent, educated people in a sea of sad, benighted poor, has in the past failed to fully exploit such opportunities on account of poor electrical power and communication infrastructures. Her most useful people would typically migrate to our country. But now a new day is dawning. This month the New York Times reports:

> **"In the last two years, India has installed reliable high-capacity telephone lines in most of its major cities. That makes it possible for people [there] to communicate with customers in the United States, by phone or over the Internet, with no discernible difference from a calling center in Nebraska...**
>
> **"[As a result,] call centers are a booming business in India... Jobs in call centers are coveted [even though they pay only] from $1,600 to $2,100 a year. [Per capita income in India is perhaps only $500 annually.] But call centers are only the low end of a much larger industry of Indian software developers, transcribers, accountants, Web site designers and animation artists who work on projects for foreign companies from Indian offices. [India] has created an $8 billion computer software industry virtually from scratch in the last decade."**

I know about working with a global team using the Internet from a charity project I led a couple years ago. At that time, I discovered the blind did not have an easy way to participate in Internet-mediated text chat, so I wrote a computer program, licensed at no charge to them, which renders such chat as synthetic speech, providing essential contextual annotation as well. You can read about it here:

http://www.geocities.com/neohephaestus/ronolog.html

While it was easy for me to write the program alone, testing it was another matter. The genius of the Microsoft Windows operating system environment is that it supports a vast array of hardware and software combinations, giving the consumer almost unlimited choice in customizing his personal computer, creating an extremely broad and competitive market for such variations. The downside is that before Windows 2000, the operating system had to be written in a way which made it vulnerable to certain problems, so that legacy hardware and software could continue to be supported. This means that while I might be able to install and use the program I wrote on my PC, I would have to test it on numerous other PCs to discover potential problems an arbitrary user might face.

To do this testing, I turned to friends and acquaintances around the world I had come to know via the Internet. They deployed and used my software and reported on any difficulties. This vast variation in gear helped me test the robustness of my software. Actually, even technically naive persons are useful in such an enterprise. As long as I have the permission of such a person, I am able to remotely control their PC and do whatever testing is required. Microsoft now provides a free program called NetMeeting that facilitates just that, albeit without broadband, speed of interactivity is tremendously compromised, wasting much time. By using other tools, I am even able to capture the actual audio output on the machine being used, whether it is located in Luxembourg, New Zealand, Denmark, Canada, or even in one of these several United States.

The Internet also provided an excellent means to market the program. The Web site to which I pointed you holds the software and support materials people need. Search engines help people find things like this automatically, and online publications provide venues for promoting them. Even someone like a teacher of the blind in India, who provides testimonial endorsement on the Web site, could help his students benefit from my program.

Yet even today, the overwhelming majority of 'knowledge work' is still prevented from freely migrating to any location - but not for any fundamental reason anymore. A columnist in the 'Boston Globe' recently wrote:

> **"[MIT's Professor Michael Dertouzous estimates that] even now, only about 5 percent of America's white-collar work is done over computer networks. People are still using paper and postage and face-to-face visits for tasks that could be shuffled easily onto a high-speed data network. Over time, companies will figure it out, and hasten their natural transition..."**

It would seem that building the infrastructure now to help a community enjoy the coming telecommuting boom would be a smart move. Broadband connections will assure that no bottlenecks remain on the domestic end of such a work transaction scheme, whatever needs arise for interaction with others.

Generation after generation, Haralson County loses some of its very most talented youngsters, as they depart for urban centers to find opportunities unavailable here. Broadband Internet communications reaching out to the entire developed world will help us keep many more of them home.

WHAT ABOUT ECONOMIC RECESSION?

The fact that the economy seems to be moving toward recession should be considered, but should not dominate thinking in what is a long-term investment. While people tend to get pessimistic when a recession occurs, those who have cash to spend actually are in the driver's seat! For example, asset values fall, perhaps anywhere from 15 to 35 percent, says Adrian Slywotzky, vice president with Mercer Management Consulting in Lexington, Mass. He elaborates by noting that discount applies to companies you might want to acquire, capital projects, or construction you may want to do, or even to talent you may want to attract. If you have the right kind of cash management you can pick up some terrific things at value prices.

Such considerations may actually encourage people with liquid assets to make their move to a place like metro Atlanta from elsewhere during the recession itself, to take advantage of a great buying opportunity.

With the recent release of detailed US census data, the Atlanta Journal-Constitution reported:

> **"Local experts think Atlanta will keep growing rapidly for many more years... [judging that] Atlanta has sufficient water until 2030. Atlanta also has so many other things in its favor that it will keep drawing opportunity seekers indefinitely, says University of Georgia demographer Douglas C. Bachtel. [He] says they'll keep coming because of Atlanta's strong job growth, which**

is fueled by its diverse industry base, strong transportation network, dynamic community leaders, relatively affordable housing, good race relations, pleasant climate and other lifestyle factors that still outweigh traffic aggravations."

While the broadband nirvana described by Dr. Netravalli is coming, it will not arrive all at once. Many of us will continue to live in a hybrid world for many years, where we mix together paper, physical presence, data processing and telecommunications in varying amounts. As Dr. Netravalli claims, when the telecommuting revolution is *complete*, location won't matter at all for knowledge workers. But in the transition period, many will want to be within driving distance of employment centers like metro Atlanta, while at the same time interested in avoiding the disadvantages of living there or driving there whenever possible. Establishing Haralson county as a metro Atlanta telecommuting haven, by providing broadband access in the vast stretches of uncrowded forest that remain our special heritage, might be an ideal way to attract the sort of residents a community would prefer settle, if it is inevitable that outsiders will press in no matter what is done anyway.

I know one Haralson businessman who bought a triple-digit-acre tract of land next to his home and shop that was once imminently destined to be developed in a way many would consider a burden on those of us living here now. He has ambitions to develop it for use by a combination of affordable and upscale housing, and explicitly dreams of being able to offer broadband Internet access to promote the subdivision as telecommuting-enabled. Sadly, it will not be served by either BellSouth's ADSL service or Charter's cable modems in the forseeable future because it is near no incorporated town. As he has little ambition to become an Internet service provider himself, access to a county-wide fiber-optic network would look real good to those like him!