The Economic Value of Information Networks[1]

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Abstract. Value comes from people working with and caring for one another. Information multiplies human abilities by enabling people to do more and to learn from others. Networks are the means they use to collaborate and access information. The paper analyzes how information networks create economic value. A general theory for value creation is proposed. It includes recommendations for the network of the future.

The Value of Information

"Value" generally refers to the worth of some thing or service in terms of something else, such as the "fair market value." "Economy" and "economic" generally relate to the production, development, and management of material wealth, as of a country, household, or business so that the "economic value" of information relates to the ability of information to produce wealth.

In the most basic sense, people create value through work. Work is easily measured in physics by the formula Work = Force times Distance so that the amount of work required to plow a field is the amount of force applied to the plow times the distance plowed. When someone came up with a way to use animals to pull plows farmers were able to do a lot more work so that the idea of using animals in this way multiplied the farmer's capabilities. Increasing power, efficiency, and enabling new or improved goods and services are common ways that knowledge creates value. Access to knowledge is one of the most important factors for the creation of wealth in modern society.

Federal Reserve Board Chairman Alan Greenspan illustrated this in a 1996 speech that led some to describe the US as having a "weightless economy." In 1948, he said, the primary output of the US economy was large, heavy things. Even radios, which then used vacuum tubes, were many times larger than today. Accordingly, "while the *weight* of current economic output is probably only modestly higher than it was a half century ago, *value* added, adjusted for price change, *has risen well over threefold*" (emphasis added).[2] It is the information component, which is weightless that created this surplus value.

Knowledge has some very interesting properties: it is weightless, can be freely shared and accumulated over time so that knowledge creation accelerated with the widespread adoption of common languages, writing and the printing press. American agriculture and the personal computer industry provide two dramatic examples of the cumulative nature and value of information that shapes our world:

> "In 1930, over 2,300 counties—more than three-fourths of all rural counties — depended on agriculture as their primary source of income. There were 30.4

[1] All opinions expressed are the sole responsibility of the writer.
[2] Greenspan, Alan, "Technological advances and productivity," An address at the 80th Anniversary Awards Dinner of the Conference Board. The Federal Reserve Board, October 16, 1996, New York, NY.

> million people living and working on 6.3 million farms. The rural farm population represented over half the rural population and a quarter of total U.S. population. However, improvements in agricultural technology and productivity over time mean that in the early 21st century, far fewer (and much larger) farms produce an ever-increasing amount of farm goods. In 2000, 3 million people lived and worked on 1.8 million active farms, and represented only 1 percent of total U.S. population."[3]

Farm productivity (see text box[4]) has been one of the great success stories for well over hundred years. Many people who once made a living on farms are doing other things, producing goods and services that make a better life for people across the globe even as agricultural production grew. They are doing more work, producing greater value than they could without the knowledge acquired by many generations of farmers. That knowledge is also now embedded in equipment, fertilizer and seed, as well as supply, market and distribution networks that enable farmers to buy supplies and sell products across the globe.

Economists define productivity as the rate at which goods or services are produced especially output per unit of labor. Improving average wealth, as measured by the per capita gross domestic product (GDP) is the result of increased average productivity. Productivity improvements require change – the adoption of improved methods. "This process of Creative Destruction," noted economist Joseph Schumpeter wrote, "is the essential fact about capitalism."

The personal computer industry also illustrates both the cumulative nature of knowledge and the way knowledge becomes embedded into all sorts of things. Intel Corporation co-founder Gordon Moore drafted a proposal in 1965 that became known as Moore's Law while director for research at Fairchild Semiconductor in which he predicted that the number of transistors that we can pack into a single integrated circuit would continue to grow at a rapid exponential rate for the foreseeable future and that this would create dramatic growth in capabilities and a corresponding reduction in the cost of computational power:

> "The future of integrated electronics is the future of electronics itself. The advantages of integration will bring about a proliferation of electronics, pushing the science into many new areas. Integrated circuits will lead to such wonders as home computers—or at least terminals connected to a central computer—automatic controls for automobiles, and personal portable communications equipment. The electronic wristwatch needs only a display to be feasible today."[5]

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[3] Economic Research Service of the US Department of Agriculture, "briefing room," http://www.ers.usda.gov/briefing/Adjustments/overview.htm, July 20, 2004.
[4] Schumpeter, Joseph, from *Capitalism, Socialism and Democracy* (New York: Harper, 1975) [orig. pub. 1942], pp. 82-85, as quoted on 1/27/2005 at http://transcriptions.english.ucsb.edu/archive/courses/liu/english25/materials/schumpeter.html.
[5] Moore, Gordon E., "Cramming more components into integrated circuits," Electronics, Volume 38, No. 8, April 19, 1965

This is precisely the world we live in today, an incredibly accurate prediction 40 years ago. The Intel Corporation has made Moore's Law a core strategy, doubling the number of transistors in microcomputer circuits roughly every 18-24 months. A single Intel processor chip produced in 2003 contained over 400 million transistors, representing a huge increase in stored knowledge as well as capability over the approximately 2000 transistors contained in microprocessors built in 1971.

Value of Information Networks

People create value by working and caring for one another. Networks are the means they use. Networks take many forms: social, transportation, utility (water, electric, sewer), economic (financial, distribution, supply), and information (telephone, broadcast, Internet). Networks multiply the value of human efforts by enabling access and collaboration.

The first networks were families and tribes banding together to help and defend one another. As people discovered the value of specialization and division of labor they also began to grow a variety of crops and make a variety of products from a variety of inputs. Differing skills and conditions created incentives to trade. Networks began to take physical form as roads and ports. Cities prospered around good trading facilities, which became critical infrastructure. Cities developed central water, sewer and electric utilities, another form of networks that greatly improved comfort, health and productivity.

Information and networks are highly synergistic. While information multiplies man's power and efficiency, networks multiply man's abilities to work with and care for others and his access to information. Electronic information networks provide instant access to information, improved educational access and more effective collaboration. People anywhere in the world today can access many times the equivalent information stored in the entire US Library of Congress 50 years ago. Electronic information networks also reduce the impacts of time and distance and enable higher quality collaboration.

A General Theory for Value Creation

Proposed general theory: value is the product of collaborative effort multiplied by valuable information. Valuable information takes many forms including knowledge, the spoken and written word, procedures, and agreements between people (including money, which is a promise to render fair value in exchange for goods or service). Valuable information is also embedded in products, tools and infrastructure.

Value creation is maximized by collaborative effort that accumulates (learns) and applies valuable information in a purposeful and disciplined manner. Purpose in a capitalist society includes profit maximization, providing satisfying work and value to society. Discipline occurs through feedback loops: the entity fails if it loses money, cannot retain suitable workers or society determines it is undesirable.

Opportunity for All: Inclusive, educated, motivated, innovative communities prosper

Nations and communities maximize value (wealth) by enabling their people to innovate and maximize the value of their collaboration. This occurs when the people maximize the creation, access and productive application of valuable information, which requires motivation, excellent education and communications systems: an inclusive and innovative society with expanding and improving collaboration, that is also highly adaptive to change.

This theory explains value creation in nature as well as the human economy, suggesting a general theory for value creation. Life also depends upon valuable information, in the form of genes used to organize and control molecular interactions. The human genetic structure, for example consists of about two billion "words" organized to define the human species and each individual, as well as control all the processes needed to sustain life. This complex genetic structure was acquired over millions of years of adaptation. Healthy ecosystems similarly demonstrate complex interactions between many species, each finding its niche to maximize life within the system. A healthy economy is very similar in this respect to a healthy ecosystem.

This proposed theory also makes sense from theological and ethical perspectives, lending even greater credence to its potentially universal applicability. Man has always been fascinated with the power of words – with good reason as it is words that differentiate and ultimately give mankind power over all other living creatures on the planet. It's understandable therefore that words; in particular "God's Word" plays a major role in religions. Words in the general sense are units of information, which may or may not be valuable and may represent data or instructions. Religions in general prescribe beliefs concerning higher purpose, the potential for life after death and rules for civilized, fruitful and altruistic behavior including rules like the golden rule and admonitions to "love one another" that if followed generally encourage inclusive, collaborative behavior.

Creating Value with the Internet

Collaboration, not content is key to improved productivity – increased output with the same or fewer resource inputs using the Internet. While we once thought that video and web conferences would replace business travel, we are finding instead people use these tools to interact more and continue to travel because they recognize the value of improved collaboration. Andrew Odlyzko, of the University of Minnesota, who has studied and written extensively about the history of communications, particularly from an economic perspective, writes:

> "Historical analogies as well as current expenditure data also suggest that in the "digital convergence" of broadcasting and point-to-point communications, it is the latter that will dominate in shaping the evolution of the Internet. The current preoccupation with professionally produced "content" is probably more a distraction than help in planning for the future. Content has never been king, it is not king now, and most likely will not be king in the future. The development of the Internet is likely to be determined by the same

> growth of the myriad unpredictable commercial and social interactions that have fueled other communication services."[6]

People today collaborate remotely on complex activities that once required everyone work in the same location. This has enabled global teams to leverage highly specialized experts and systems, and efficient production facilities to boost productivity and accelerate knowledge creation and product development. The auto, computer, communications, sports clothing and equipment industries have all become global entities that have accelerated worldwide growth and employment, and provide improved products at lower prices to rapidly expanding markets.

Global collaboration creates not only new producers but also new markets in a virtuous cycle of value creation. China and other Asian countries have long represented huge, untapped potential markets. The expansion of Western companies' production and other facilities into China and other Asian nations like Korea and India created new wealth that is transforming these nations into consumers as well as producers. It's hard to imagine in retrospect China, for example becoming a major new market for consumer products had globally oriented companies like Nike, Hewlett Packard, Intel, General Motors and General Electric not expanded operations in Asia creating the wealth needed for a new generation of consumers. The improved quality and reduced cost of collaboration via the Internet has been a major factor in this process.

The combination of information and networks has additionally enabled entirely new business models such as e-commerce and is making established systems like banking and travel reservations vastly more efficient. Where you once might have used a travel agent or called the airlines to make reservations today you are much more likely to book yourself via the Internet, effectively replacing the people it once required to do this work for you. Is this a bad thing that they have been effectively displaced? Well, changing jobs is sometimes unpleasant but most of those people are now doing other things so that the total work done —value created— is increased and society as a whole is richer. Information networks make it possible to rededicate whole groups of people to other work who once manipulated information that can now be handled with computers. The result is often improved productivity, faster service and happier customers.

New patterns and expectations for how business is done evolve with new capabilities so that the world becomes increasingly dependent upon information networks. If all the computer information networks failed tomorrow we'd have global economic disaster as banking, travel reservation and shipping systems, among others ground to a halt because we no longer have available many of the people who once made their living manipulating this information for others.

People ask three basic questions when they consider whether to use a network: can I connect; what can I do with it; and does it cost less than the alternatives? Viewed from this perspective, the Internet is no different from other information networks. The

[6] Odlyzko, Andrew. "The history of communications and its implications for the Internet," June 16, 2000, http://www.dtc.umn.edu/~odlyzko/doc/history.communications0.pdf, page 1.

capabilities of the networks available to us including our perception of their availability (do I even qualify for that 'club?') dictate our perceptions of our opportunities and therefore the very work we attempt so that network availability, accessibility and capability are fundamental to all economic decision making.

Robert Metcalfe, the inventor of Ethernet implicitly addressed these questions when he wrote a proposition that became known as the "Law or Network Effects" or "Metcalfe's Law" that "says that the value of a network grows as the square of the number of users.[7]" The logical basis for Metcalfe's Law is the potential number of unique "conversations" that can occur on the network. Consider, for example the value of a phone system. A phone system that connects me to work, for example, is useful but one that connects me to anyone in town is much more useful, or to the whole world more useful yet. Mathematically, the number of uniquely possible conversations, if A calling B is considered a different conversation than B calling A, is the number of users (or phone lines) squared.

While there are clearly many people in the world I will never call, having a phone system, or an Internet that provides the potential to access the global community is uniquely valuable because it offers the opportunity to access and offer services and information. The perception of the network affects the value of the network. David Reed proposed a variation on Metcalfe's Law that potentially would create value even more rapidly than Metcalfe's because it was based upon the potential for groups of varying size to collaborate using the Internet. Some, including Odlyzko, have criticized both proposals on the basis that we have not seen the high rates of growth these laws seem to predict. My own view is that both laws are very informative and show the potential value that could be created over time and with theoretically perfect communications technology. We've seen throughout history that it sometimes takes decades for new technologies to fully change ways of doing business and current technology is far from perfect.

The Computer Systems Policy Project (CSPP), an affiliation of world-leading information technology CEOs, says that while the world has already been changed by the Internet, the process has only begun that will transform economies, society, government and personal relations:

> "Driving this new reality is the Law of Network Effects, which states that value is created at an exponential rate each time an individual or device connects to the network. This effect offers unparalleled opportunity for growth and learning as increasing numbers of individuals become networked. It also operates as an instrumental tool—along with education—in efforts to bridge the "digital divide." The powerful force of the Networked World will drive inclusiveness due to the fact that value is created whenever someone comes online and adds their contributions to the broader community. Thus, networked businesses realize their greatest value by encouraging customers, vendors and suppliers to be likewise networked, and government institutions will improve speed and efficiency of

[7] Metcalfe, Robert, "The Internet After the Fad," Remarks at the University of Virginia, May 30, 1996, http://americanhistory.si.edu/csr/comphist/montic/metcalfe.htm#me7.

> operations—ultimately benefiting citizens—by offering networked services and communication." [8]

Metcalfe's Law builds on the reach, flexibility and ability to foster innovation of the Internet, which makes it easy for people anywhere to offer information, services and applications to the world. While this is possible using the phone system, the Internet has key advantages: the ability to find and access information (a single ubiquitous, searchable network), services and applications with an easy-to-use graphical interface; flat all-you-can-eat access charges (which encourage use); and a very flexible, open, end-to-end architecture that makes it possible to offer new applications and services, usually without any action required by the networks between the supplier and consumer.

The combination of these advantages provides tremendous opportunities for innovation and the creation of new or improved business models compared to previous networks. Imagine, for example trying to find and buy books from Amazon.com by telephone using interactive voice response while paying long distance charges. Seems silly in retrospect and probably no one seriously contemplated creating a consumer-oriented global online bookstore before the worldwide web.

One of the newest innovations is the "blog." "Blog," which is short for "web log," was recently named word of the year because of the impact "bloggers" had on the 2004 US presidential election. Blogs evolved as personal diaries. However a number of bloggers have been highly successful not only as political commentators but also as product reviewers such that cell phone manufacturers, for example, have begun to court bloggers for favorable treatment for their products. Some bloggers, operating on personal computers from home, earn income monthly from advertising on their sites. Blogs may well evolve to displace much traditional news media if people continue to find bloggers more timely, interesting and believable than other information sources. This evolution, a free speech revolution in some respects is only possible because of the open, end-to-end architecture and single searchable Internet.

All News is Local

News today requires vast organizations to collect, edit, produce and distribute. These become unnecessary in a fully converged world where all media use the Internet and local reporters become global stars. Future local TV stations, for example may exist only for reporting local news that is transmitted over the Internet. Trust will be a very important issue, as it is increasingly with all things Internet. Automated grading based on source track record and related reports might be an effective approach for news.

The Internet has made it feasible for people anywhere to become global entrepreneurs assuming the network can deliver their wares, which in some cases requires good quality of service. This is a key question as new applications increasingly expect end users to connect at high speed with high quality end-to-end. The Internet is still young and opportunities are still developing. While the Internet began mainly as a method to access

[8] Computer Systems Policy Project, "Living in a Networked World," www.cspp.org, June 2000.

e-mail and download files, and later the worldwide web, new multi-media applications require increasingly larger file sizes and some like voice and videoconferences need adequate quality end-to-end. Voice telephony over the Internet, called Voice Over Internet Protocol (VOIP) is rapidly gaining critical mass in the US due to efficiency and advanced capabilities. VOIP could have tremendous economic impacts, if for no other reason the potential money saved. The total volume of information communicated on the Internet surpassed the total volume of voice communications a few years ago, and is now several times greater. The amount of money historically spent on leased telecommunications, mostly telephone circuits however is ten times the amount spent on the Internet.[9]

Quality of Service (QOS)

QOS is a key point of disagreement between those that advocate the traditional phone network architecture with an intelligent core and those that advocate the "stupid" network with the intelligence at the edges. Many disagree that QOS is even a problem. However there are today no performance standards for VOIP or video over IP between networks and no one guarantees that they will work. There are three methods used today to improve QOS: provide much greater capacity (bandwidth) than technically needed, shortcut routing to minimize the likelihood of encountering problems and bandwidth reservation. Those who believe in the "stupid network" (see text) advocate the first two.

This is because in contrast to the telephone system the Internet is unregulated, competitive and does not require the expensive central office switches required by the traditional phone system. Rather, voice over the Internet is sliced into "packets" that are individually routed from the originator to the receiver where they are reassembled, with little manipulation or expensive equipment required between, resulting in potentially dramatically lower capital and operating costs. Where the phone system was designed as an intelligent network, the Internet was in contrast designed as a "stupid" network with the intelligence at the edge devices. This encourages innovation because people anywhere can implement new services and applications without any modification or added services required of the network.

The economic advantages of the Internet, particularly VOIP, are transforming the telecommunications landscape with new companies like Vonage and Skype and old companies like Verizon, Qwest and Comcast seeking new opportunities. Traditional leased circuits, including some used for sensitive and critical data applications, are giving way to "virtual private network" connections over the public Internet. The productivity gains from the Internet may be even more significant than the cost savings because the architecture of the Internet encourages innovation. VOIP, for example enables advanced multi-media capabilities, "follow me" and messaging services that will give people access to rich information where, when and however they want. One unresolved issue, however,

[9] Odlyzko, Andrew. "Pricing and Architecture of the Internet: Historical Perspectives from Telecommunications and Transportation," http://www.dtc.umn.edu/~odlyzko/doc/pricing.architecture.pdf, August 29, 2004, page 6.

is how will rural service providers adapt as the universal service fund supplied by traditional regulated telephone service declines, since VOIP is currently exempt from these fees?

VOIP, as well as some data applications, interactive videoconferences and future real-time interactive multimedia communications applications, requires reasonable quality of service, specifically low latency, jitter and bit loss. Latency and jitter refer to the delays across the line and the variation in those delays. Most human communications expect something less than about 180 milliseconds (just under a fifth of a second) for a response. While people will tolerate occasional delays of a couple seconds for satellite calls, such delays are generally unacceptable for regular use. When latency varies significantly, this is called "jitter," which can cause problems with applications like videoconferences.

Videoconferences can also be very sensitive to packet loss. Since multimedia information is streamed across the Internet in packets, any congestion or rerouting along the way can cause packets to be delayed or lost. This is no problem with e-mail, since e-mail is not "real time" and the applications can request individual packets retransmitted. Real-time multimedia applications however, can only wait a brief time, depending on the size of their buffers, which are storage areas built into the program. When accessing streaming media, for example the player software typically loads several seconds of the stream into storage so that the user will have a smooth playback even if Internet performance is marginal. We've all seen, and sometimes still see erratic performance with streaming media due to transient network problems and congestion. Buffering is even less effective for real-time interactive conversations because the buffers are necessarily much smaller. Lost information shows up as "dropouts" (blank areas or distortion) on the screen or in some cases dropped calls altogether.

Since most voice calls are "local," service quality between local callers is becoming increasingly important. Consider calls to work, friends, physician or school. Most of these are "local" calls for most people. These people-to-people interactions are also by far the most important applications for the future Internet. While we have historically given a lot of attention to web pages, streaming video and other entertainment feeds on the Internet, it is day-to-day communications that matter most—which is also why people, when business is included in the total spend much more for telephone service (particularly if cellular is included) than they do television. If they had to choose between cable TV and phone service, most would keep the phone and cancel the cable.

The need for high quality local-to-local connections could be a problem for states like Oregon that are a long distance from major Internet interconnection points as VOIP becomes dominant because we are, from an Internet perspective the end of the line. This is due to our close proximity to major markets in California and Seattle. Because Internet equipment was very expensive in the early years and demand relatively small, the major Internet exchanges (locations connecting multiple networks) and aggregations points were naturally located in the major markets so that Oregon customers were served via tail circuits—in effect the end of the line.

Before NWAX, our regional Internet exchange, when I connected via the Internet from OHSU to Portland Community College, also in Portland, the path frequently traversed 29 routers (network equipment that routes packets across the Internet), going to Sacramento, San Jose, San Francisco and Everett, Washington. This path introduced substantial (historically up to 300 milliseconds) delay and lost bits causing videoconferences to fail. We've seen a number of examples of convoluted routes that would not adequately support interactive voice and video in seeming contravention to claims by some that location no longer matters. Electronic communications travel near the speed of light, however, each stop along the way can lead to problems, over which Robert Metcalfe voiced concern:

> "Because one of the phenomena of the new Internet is the number of hops between sources and destinations is growing. And there are arguments that this does not matter. But I know that it matters. Because I know that every hop is a source of delay. It is a source of risk. It is a source of congestion."[10]

I've been tracking this particular problem regionally since 2000 and while Internet performance in general has improved, and routes seem to have flattened somewhat I do not think we can say this is no longer a problem. If all works well, then performance may be transparent, but each router hop along the way increases delay and the likelihood of problems. Recent improvement may also be a side effect of the over-building that occurred on the backbone networks in the late 90s, because applications perform better even if the routing is long and complex when there is plenty of excess capacity (see earlier text box on QOS).

Since Internet demand continues to double about annually, it seems likely that supply and demand will come into balance, especially with consolidation of the network backbone service providers that we are currently seeing (SBC acquisition of AT&T and pending purchase of MCI by Verizon or Qwest). I've seen recently a route (using a large national service provider) from rural Oregon to Portland with notable delays and jitter by way of Denver and Chicago that caused unusable voice performance during videoconferences. We were able to solve the problem in this case buying a faster circuit than is technically needed, essentially "throwing bandwidth" at the problem. There are no guarantees this will always work, however. A Portland area child psychologist has periodically used videoconferences via NWAX to counsel teenagers in Eastern Oregon. While this has worked fine using the direct routing through our local NWAX exchange point we've never succeeded using an ISP not connected to the exchange for this connection.

Location matters on the Internet, which is why most Internet-intensive businesses locate servers at or near data centers housing the largest global Internet exchanges—in order to have the best possible quality at the lowest cost. This is significant, as the Internet will not achieve full potential unless people anywhere can affordably offer high quality information, applications, and services to people anywhere. It is also potentially critical for local economic development as differences in local performance or cost may become important discriminators for some future business.

[10] Metcalfe, op cit.

A local startup that hosts multi-user Internet action games is a case in point, as the owner has already begun to relocate servers from Portland to Chicago and Atlanta near major internet exchange points because in gaming, "ping wins." Ping refers to a popular Internet application used to measure round trip time; important in multi-player "shooter" games for example. He is concerned that his customers may encounter excessive ping times on his Portland servers.

The problem is far more significant than Internet games however. Global collaboration is increasing productivity worldwide. Nike, Tektronix and Intel all depend upon global relationships, particularly in Asia where rapidly growing markets and industry have become critical to world economic growth. Oregon is a leader in trade and collaborative arrangements between Asia and the United States so the quality and cost of our connections to Asia have become increasingly important to our economic future. While these corporate giants can afford their own dedicated highspeed networks, the problem raises the cost of doing this sort of business in Oregon relative to other locations and may be a key factor for smaller, newer efforts or for Asian companies looking to locate operations in the US.

Healthcare and biotechnology, two of the most information-intensive industries today, will also benefit from information technology. Healthcare today is about where banking was in the 1960s when it comes to information technology. Most patient records are still paper-based and there is little or no information exchange between providers. The US department of Health and Human Services has estimated that about $140 billion could be saved annually with improved healthcare information technology with an added saving of many thousands of lives due to fewer medical errors and improved care. Healthcare today is one of Oregon's leading economic activities so improved connectivity between Oregon healthcare providers would have substantial economic benefit for the state.

Biotechnology, an area that Oregon would like to grow that is closely related to healthcare, is also highly knowledge-intensive. Improved links between biotech companies, to universities, hospitals and national laboratories would be a substantial asset to biotechnology in Oregon. Networking these industries would improve network infrastructure both within Oregon and with the Internet and provide a substantial advantage for Oregon business. Some of the international broadband leaders are already creating national and regional health networks to improve care and also promote the use of highspeed network technology.

Case Studies

Leaders of the world’s largest economies clearly think high quality, high-speed Internet access is important although they do not in general seem to have clear ideas about what specific economic benefits will result. Rather, the worldwide drive for “broadband” access to business and consumers seems largely based upon the conviction that valuable new capabilities, applications and services that we cannot predict now will emerge: you never know what vehicle will use the road just as we don’t know what application will

use the wire, but it will benefit someone somewhere. This is a leap of faith, similar to the leap of faith behind the US Interstate Highway system, that if we enable highspeed network connections everywhere they will be used.

President Bush has proclaimed a national goal for universal broadband access by 2007.[11] The European Union Council of Ministers endorsed "The eEurope Action Plan" in January 2003 with the aim to "make the European Union the most competitive and dynamic knowledge based economy in the world. A core objective of the plan is to connect everyone to everything online so that Europe becomes a better and more efficient place to live and do business. The eEurope plan is predicated on improving widespread availability of broadband networks by the end of 2005."[12] "In January 2001, the (Japanese) government put forward "e-Japan Strategy", with the main objective of making Japan the most advanced IT nation in the world within five years (2005)."[13]

International Case Studies

Table 1 compares broadband penetration among the top 15 countries in 2002.[14] Japan is an interesting case because while total "broadband" penetration is not especially high at #13 compared to #11 USA according to the International Telecommunications Union (ITU), Japan leads the world in mobile Internet penetration. Korea has the distinction of leading the world in broadband.[15] "Lagging" broadband penetration has been the source of great angst in the US, Europe and Japan. An Australian web site proclaims "our broadband shame" at declining in the ITU ratings and a site in India, where current broadband penetration is 2 per 10,000 asks, "Can India catch up?"[16]

So, what seems to make the difference? Why have some countries been so much more successful than others? Reviewing ITU studies on broadband penetration and policies in Korea, Canada, Hong Kong and Iceland at http://www.itu.int/osg/spu/casestudies, I suggest the following are probably the most important underlying factors that determine why different countries have varying rates of broadband adoption:

1. Cost to deploy
2. Anticipated return on investment
3. Competition

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[11] The White House, "Promoting Innovation and Competitiveness: President Bush's Technology Agenda," http://www.whitehouse.gov/infocus/technology/economic_policy200404/chap4.html, September 22, 2004.
[12] European Union, "eEurope 2005," http://www.eeurope2005.org/intro.html, September 22, 2004.
[13] International Telecommunications Union (ITU), "Shaping the Mobile Information Society: The Case of Japan,"Document: SMIS/06, http://www.itu.int/osg/spu/ni/futuremobile/general/casestudies/japan.html, September 22, 2004
[14] ITU "Top 15 Countries by 2002 Broadband Penetration," http://www.itu.int/ITU-D/ict/statistics/at_glance/top15_broad.html, December 10, 2004. These statistics are nearly three years old so the rankings may be much different. US broadband adoption, for example has surged dramatically.
[15] ITU, Japan, Op Cit.
[16] ZDNet India, "Broadband: Can India Catch Up?" http://www.zdnetindia.com/print.html?iElementId=107302, September 22, 2004.

Table 1. Top 15 Countries by 2002 Broadband Penetration							
		Broadband subscribers				Broadband households	
	Economy	Total 000s	Change 2001-02	Per 100 inhabitants	% all subscribers	% with Internet	% all
1	S. Korea	10,128	24%	21.3	94%	83%	43%
2	Hong Kong	989	38%	14.6	42%	68%	36%
3	Canada	3,600	27%	11.5	50%	41%	20%
4	Taiwan	2,100	86%	9.4	28%	59%	31%
5	Iceland	25	138%	8.6	21%	12%	9%
6	Denmark	462	107%	8.6	19%	24%	16%
7	Belgium	869	90%	8.4	51%	41%	17%
8	Sweden	693	48%	7.7	23%	20%	13%
9	Austria	540	123%	6.6	22%	28%	14%
10	Netherlands	1,060	127%	6.5	10%	29%	19%
11	USA	18,700	46%	6.5	18%	19%	10%
12	Switzerland	455	308%	6.3	5%	9%	4%
13	Japan	7,806	176%	6.1	27%	18%	5%
14	Singapore	230	73%	5.5	26%	*35%*	*20%*
15	Finland	274	426%	5.3	5%	15%	8%

First, with respect to the cost to deploy broadband, given that countries all over the globe have access to essentially the same technology, what factors affect the cost to deploy broadband? One recurring theme that emerges from the studies is the relatively high market concentration of the most successful countries. Korea and Hong Kong, for example have densely populated cities with large numbers of apartment dwellers that make it cheaper to deploy broadband to lots of customers[17]. Iceland is a small island. Even Canada, which is one of the most thinly populated countries overall has most population concentrated in a narrow strip near the US-Canadian border making broadband less expensive to deploy for most of the population.

A ruling by the Canadian Radio-Television and Telecommunications Commission (CRTC), which regulates telecommunications in Canada, restricting community fees to recovering costs for right of way also mentioned in the report, has encouraged network providers to deploy fiber through Canadian communities according to the report. Bill St Arnaud, Senior Director Advanced Networks for CANARIE Inc., Canada's Advanced

[17] Korea, however is the largest and least densely populated as well as relatively poor compared to the other four Asian "Tigers," which include Hong Kong, Singapore and Taiwan, considered rapidly emerging economic stars of Asia in the 80s and 90s. Korea also started further behind with telephone penetration just .36 per 100 in 1960. There are clearly other factors behind the amazing Korean success story.

Internet Development Organization whom I contacted via e-mail, confirmed this success. Many communities in Canada and the US used franchise fees as a significant revenue source during the Internet boom of the 90s. Some levied high fees to allow access to poles and buried conduit. Since anything that raises the cost of deploying network facilities raises the breakeven point from a business perspective, these fees discourage broadband deployment. Keeping these fees low encourages more broadband investment. All four nations have made development of broadband capabilities a major policy initiative. Korea, Canada and Iceland have invested directly in broadband Internet infrastructure, notably national fiber backbones and research networks that can lower costs to deploy broadband. Korea has also made a point of reinvesting telecommunications fees and proceeds from spectrum sales into infrastructure and Iceland has paid for much of the fiber connecting the island.

Return on investment is largely a factor of customer demand for broadband deployments, sometimes measured as "take rate." A typical broadband deployment might pass near several thousand potential customers. The take rate is the percentage of units passed that subscribes to the service. A high take rate generates a high return on investment.

So what factors improve take rate? Citizens of all four countries have a history, Korea the most recent, of aggressively adopting new technology. Hong Kong, Iceland and Canada were all among the first countries connected to the Internet. The Chinese University of Hong Kong sponsored the Hong Kong Internet Exchange (HKIX), one of the world's oldest, largest and most successful Internet exchanges. I think it would be fair to say that people in all four countries view education and technology as very important to their future success. Hong Kong and Korean citizens are also notoriously competitive.

Education is fundamental to value creation. Korea illustrates the importance of education to obtain the full benefit of the Internet.

Korea has acted in particularly strategic fashion in pursuit of the Internet as an economic strength, investing heavily in training and education of Internet and related Information Communication Technology (ICT) skill not only in school but also in vocational training, for example with a "10 million people Internet Education Project" begun in 2000 that had trained 3.5 million at the time of the report. Korea has also invested heavily in ICT industry, funding the nonprofit Electronics and Telecommunications Research Institute that has over 2000 international patents and transferred 800 technologies to 1800 private companies. The result is that Korea is a world technology leader with companies like Samsung and LG Electronics.

Government as a customer is a common thread in all four countries with especially heavy government investment in connecting schools and also healthcare. Hong Kong and Iceland in particular have ambitious programs to connect healthcare entities throughout the country via secure private Internets.

The ITU studies bring into question, however, a number of our preconceived notions about why people use the Internet. Some writers assumed that Internet early adopters would be largely English speaking, wealthy and highly educated. Korea particularly breaks the mold with relatively low average income compared to the other Asian tigers and low English language use. To the contrary, the success of broadband in Korea and also in Hong Kong is at least partly because of a large number of Korean and Chinese language web sites and services. The top ten sites visited by Koreans are all Korean. Where some historically thought a few US category killers like Yahoo and Amazon would dominate the Internet, it is now clear that local content and services are particularly important, at least in these countries.

It is remarkable that these countries except for Canada are relatively insular and isolated from the Internet "core" in the United States. Internet "transit" (bandwidth connected to the public Internet) from these locations to the US has in fact, historically been very expensive. Korea and Hong Kong reduce the cost, and improve local performance by universal interconnection at their Internet exchanges, which are among the largest and most successful in the world. Iceland has addressed the problem by placing caps on downloads from "foreign" sites – but this evidently has little negative impact on the popularity of the Internet on this small island.

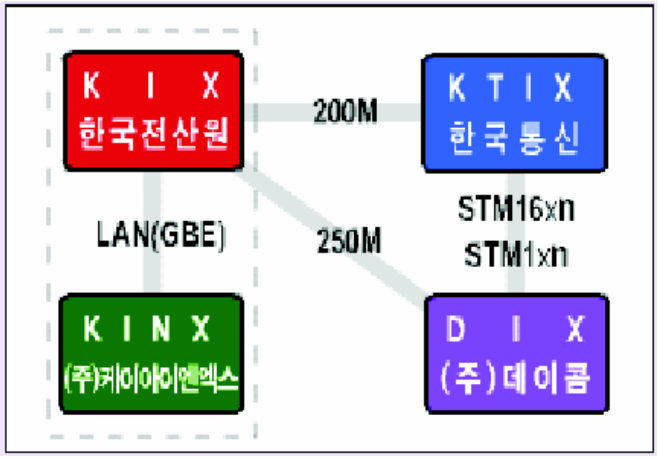
Korea has also broken the mold when it comes to competitive models. While some in the telecommunications regulatory community have assumed that "unbundled local loops," meaning requiring the incumbent phone company to offer wholesale access to local telephone circuits, was the way to promote competition, this has not been the case in Korea where healthy facilities-based competition (where competitors provide their own facilities end to end) has evolved.

> "It may seem unusual to hear a company manager say, "It is part of our business culture to listen to the government." After all, an adversarial relationship between public and private interests is common in many countries. But in Korea, there seems to be a quiet agreement between government and business… a culture of mutual and shared interests where both sides can win.
>
> "Part of this is uniquely Korean …Nevertheless, it is important to understand the government's way of dealing with the private sector, which contributes to this equilibrium. The Korean government's mission is delicate, in which it influences the market without dominating it. Its active intervention is aimed not only at counteracting market failures but also at inducing the private sector to make long-term investments…"

Korea has also broken the mold by fostering very positive relations between government and industry as illustrated in the nearby text box.[18] The presence of very successful Internet exchanges in both Korea (See Figure 1[19]) and Hong Kong also reduces the need for unbundling and the cost of Internet transit. Korean customers at the time of the ITU report paid some of the lowest broadband prices in the world. Internet exchanges allow the participants to exchange

[18] "Broadband Korea: Internet Case Study," Mar 2003, International Telecommunications Union, page 32.
[19] Ibid, pgs 11, 13.

Internet traffic directly so that it is possible for companies to offer services over their competitor's network if the competitor allows. Hong Kong has recently taken an interesting approach to unbundling, requiring that incumbents allow competitors to access wiring within the city's many high-rise apartment buildings. Unbundled local loops are required but not highly successful in both Canada and Iceland, which are both essentially duopolies characterized mainly by facilities-based competition.



"Until the mid-1990s, there was no national Internet exchange in Korea different ISPs was routed abroad. The National Computerization Agency led the drive to establish a public exchange, the Korean Internet Exchange (KIX) in 1995. However, traffic soon exceeded capacity. This led to the Korean Internet Neutral Exchange (KINX) in June 1999. In addition, Korea Telecom and Dacom have established exchanges, KTIX and DIX respectively. All four exchanges are inter-connected (see [above]) and most ISPs connect with each other through the exchanges rather than private peering arrangements."

Figure 1. Korean Internet Exchanges are interconnected

Local Case Studies

While several states and local communities have sponsored initiatives to improve information network connectivity in recent years, few seem to report identifiable economic benefits. Two notable exceptions are Cedar Falls, Iowa and South Dundas, Ontario. Cedar Falls is served by Cedar Falls Utilities, which decided to deploy a broadband community fiber network in the mid 1990s.

Cedar Falls is fortuitously next door to Waterloo, a very similar community geographically, economically and demographically that has no such community fiber network, which makes it relatively easy to see the substantial economic potential. Waterloo population is around 69,000 and Cedar Falls 36,000. Waterloo had the economic advantage before the Cedar Falls fiber network with a majority of the region's major employers.

> "Business growth in the Cedar Valley area was extremely slow in the 80s. John Deere began reducing their work force from 13,000 employees down to approximately 5,000. Rath Packing Company, one of Waterloo's major employers, closed its doors and submitted to bankruptcy. At the end of the 80's the size of Cedar Falls' Industrial Park was approximately 125 acres. There were 25 companies located in the park employing 750 employees.

> "In January 2003, the Cedar Falls Parks had a total of 125 businesses. Three of these businesses, Target Corporation Distribution Center, Principal Financial Group and Ag Services of America, Inc. invested $52 million in facilities. Target constructed a 1,350,000 square foot facility with a price tag of $40 million. They also invested $60 million in machinery and equipment, provided 900 full time and 200 part time jobs with an annual payroll of $25 million. This was the largest project in square feet in Iowa during the last 15 years. Principal constructed a $7 million, 75,000 square foot Corporate Class A office building providing 350 full time jobs and Ag Services constructed a $5 million, 62,000 square foot Corporate Class A office building.
>
> "With the major projects currently under construction, Cedar Falls is projecting that by the end of 2003, they will have 130 companies employing over 5,000 and occupying 4,000,000 sq. feet of building space. In Waterloo, MidPort America has four businesses, five businesses are located in the Waterloo North East Industrial Park and Evansdale Technology Park has one business.
>
> "Since 1996, several companies have relocated from Waterloo or expanded to the Cedar Falls Industrial and Technology Parks including Team Technologies, Principal Financial, Crystal Distribution Services, and Hawkeye Community Business Center. In the same time frame, Cedar Falls has not lost a business to relocation."

Population in Cedar Falls increased 5.3% in 2002 compared to 3.4% in Waterloo and the rest of the county. Both communities are served by the same highways and have equivalent electric, water and sewer rates. Land is significantly more expensive in Cedar Falls but Waterloo has higher tax rates. The only other substantial difference is the fiber-to-the-business and metro Ethernet capabilities offered by Cedar Falls Utilities, which the report author concludes is a key component for growth in a "knowledge driven economy."[22] I asked her if she felt that connections between local people and entities were a significant part of the value of this metro network and while she had no specific data to prove the point she felt it probably was. This arrangement, in my opinion, would be ideal for telework or telemedicine because local-to-local connections would be higher quality.

South Dundas, Ontario Canada, located about an hour south of Ottawa with a population of about 11,000, decided in 2000 to invest $750,000 (Canadian) in a fiber (Ethernet) network. The community was under no illusion that they would recover full costs but rather intended the network to spur economic development. The UK Department of Trade and Industry contracted with a consulting company to study the economic impacts in 2003. The consultants surveyed or called every business in the township with 10 or more employees, attaining a very credible 75% response.

Based upon the survey data, the report concluded that the South Dundas network had the following direct economic effects between 2001 and 2003: 62.5 new jobs; $2.8 million in commercial and industrial expansion and $140,000 increased revenues/decreased costs. The consultants entered this data to an input/output model that projected the following

[22] Kelley, Doris J., "A Study of the Economic and Community Benefits of Cedar Falls, Iowa's Municipal Telecommunications Network," Iowa Association of Municipal Utilities, July 6, 2004.

impacts over 2-4 years: $25.22 million increase GDP for Dundas County and $7.87 for the rest of the province; 207 person-years for the county and 64 for the rest of the province; $3.5 million provincial and $4.5 million federal increased tax revenues. The consultants concluded that these positive results could be viewed as positive returns on the community's investment. They further observed that 50% (19 of 38) of firms with broadband access experienced job growth compared to 27% (10 out of 37) of firms with only dialup access and 5.6% (1 of 18) with no access to the Internet.[23]

Economic Analysis

It is easy to understand that information networks create economic value by providing access to knowledge and services and enabling people to collaborate more effectively and efficiently. It is not so easy, however, to directly measure the economic benefits of information networks because networks like most infrastructures mainly enable rather than create economic value directly. Chicago, Seattle and Portland for example all benefit to a significant degree from being shipping hubs but a lot of the benefit is indirect—it's cheaper to operate many kinds of business near convenient shipping. The same is true for cities with access to very high quality information networks because it is then cheaper to use network capabilities and some advanced applications work better. Some, including myself, maintain that information networks have become critical infrastructure for future economies just as roads and power lines became critical in the past.

It also can take a long time for the benefits of new technology and infrastructures to become apparent. The context of the 1996 Greenspan speech quoted earlier was debate at the time over the benefits, or apparent lack of benefits, from the substantial investments in computer information technology by US business over the preceding 20 years. Some economists were beginning to conclude that we had all been hoodwinked and that mainframes, personal computers and local area networks provided little economic value. It has really been since 1996, that business and the public have begun to effectively use these new capabilities.

Despite the hype, e-commerce is still a small although rapidly growing percentage of total retail and we haven't even begun to reap the benefits of information technology in healthcare. It has always been this way for new technologies and infrastructure with the benefits of railroads and fax machines taking decades to permeate the economy. Just because people have not adopted a technology as fast as we expected does not mean, however, that they won't. There were predictions in the early days of the Internet that soon everyone would work from home and as VOIP first appeared that it would be adopted in just a couple years. Neither occurred on the schedule anticipated. However, VOIP is now deploying rapidly and telecommuting has quietly taken off, particularly since the beginning of the latest recession. Today, "virtual companies" with no physical offices are common and it is becoming rare in some industries to find sales people or consultants who don't work from home at least part time.

[23] Department of Trade and Industry, United Kingdom, "Economic Impact Study of the South Dnndas Township Fibre Network, June 27, 2003, http://www.dti.gov.uk/industries/telecoms/sdcsfi270603.pdf.

Peculiarities of the Network Economy

Modern information networks, particularly in the US, have some peculiar characteristics that make them very different from most industries:

1. The economic benefits of networks accrue mainly to the public and customers rather than the providers. This characteristic is common to various kinds of infrastructures. The impact is that the public and customers may have a stronger vested interest to improve service than the providers, who may of necessity be more focused on revenues and return on investment.

2. "Network effects" cause networks to be more valuable with increased consumption. Sometimes also called the bandwagon effect, this explains why fax machines, as well as PCs and the Internet remained in development for a long time and then suddenly took off as they became generally accepted. As more people go on line, potential market returns for services and applications, e-commerce and online advertising increase, which leads to more innovative services, applications and content. The network becomes essential to everyday living and overall productivity as people use it for critical activities and it becomes expected that people have e-mail and business have web sites. Residential consumers in the US today are happily paying more now for broadband access than they did a few years ago for dialup. However, the benefits go mainly to customers rather than networks, as explained above and price per unit capacity has dropped rapidly as explained in #4, below.

3. Competitors frequently work together to create valuable network applications and services. The Internet, e-mail, and the world wide web would be impossible unless competitors agreed to adopt common standards to make them work. New services often have to be supported by a number of networks to enable critical mass to occur. Sometimes competitors attempting to corner the market shoot themselves in the foot because they fail to reach critical mass. The reverse can also occur where a new application or service can be delivered without substantial changes in the network – such as iTunes, Google or new versions of Microsoft Windows. Proprietary applications and services may tend to become monopolies or a few competitors in oligopolistic competition. VOIP could actually go both ways. Session Initiation Protocol (SIP) widely regarded as the favored approach to VOIP requires substantial infrastructure and cooperation between networks. SIP is a complex body of standards developed with years of effort by several committees. Recently, however, Skype, a proprietary 'peer-to-peer' VOIP solution that requires no action by the networks has emerged as a very popular alternative – and could potentially become the Microsoft of Internet voice.

4. Prices drop rapidly over time while demand soars. Contrary to comments by some, demand (actual consumption) for Internet bandwidth continues to approximately

double annually.[24] However, the cost and price paid by business customers for Internet bandwidth also continues to drop rapidly. Decreasing prices for a given performance level is a characteristic for industries with rapidly improving technologies like computers and communications. Another cause of this is the Internet "dot com" bubble that burst in 2000 and the ongoing consolidation of the backbone ISPs, several of which have declared chapter 11 and re-emerged with few debts hungry for customers. This trend could stop or even reverse if the recent consolidation of telecommunications and Internet networks continues.

5. Uncertainty about what applications can be reliably offered/accessed. The ongoing debate between the traditional telephone ("smart" network) and Internet engineering ("stupid" network) communities has helped create uncertainty about what is required or how to go about reliably providing advanced services like VOIP and video between multiple networks. This uncertainty has slowed adoption and deployment of advanced services and applications in the past. While VOIP seems to be rolling out rapidly now, the absence of accepted performance and security standards may cause a lot of missteps and perhaps give the industry another black eye if customers find VOIP unreliable or they are overwhelmed with security problems and voice spam.

6. Regulatory risk. Uncertainty about potential decisions by federal and state regulators has raised the risk premium for new services and applications. This probably discourages potential startups and venture capital financing out of concern that incumbents may be able deny access. The incumbent local exchange carriers (LEC), as local phone companies are called have also complained that having to potentially offer competitors subsidized access to their facilities has discouraged their investment in broadband services. Recent FCC decisions have effectively reversed this situation causing AT&T and MCI to both exit the residential telephone market and place themselves for sale. Congress is currently considering new telecommunications reform measures. These sorts of earthshaking changes can be very discouraging to entrepreneurs, at least in the US. They may, on the other hand, create opportunities in Europe and Asia by discouraging US innovation and competitiveness.

7. Flat rate pricing stimulates demand, but differentiated pricing generates more revenues. History has shown that consumers have a strong preference for simple, flat pricing. AOL, for example tripled usage in about a year after going to flat monthly rates despite the fact that most customers were effectively paying more with flat rate than metered rates. One reason why local phone service has been so popular and phones are so heavily used in the US is that unlimited local calling is the dominant subscription, in contrast to Europe where metered rates are common.[25]

[24] Odlyzko, Andrew. "Internet traffic growth: Sources and implications," A. M. Odlyzko. *Optical Transmission Systems and Equipment for WDM Networking II*, B. B. Dingel, W. Weiershausen, A. K. Dutta, and K.-I. Sato, eds., Proc. SPIE, vol. 5247, 2003, pp. 1-15.
[25] Odlyzko, Andrew. "The history of communications and its implications for the Internet," op cit. pgs 70-78.

Recommendations

Everyone has a stake in improving the quality of worldwide Internet connectivity because this infrastructure is so very important to creating value for all mankind. The ideal network of the future will have the following characteristics:

1. Distributed, regional interconnection. The ideal future network has highly reliable, redundant, distributed regional interconnection points where local and global networks connect to one another as well as to services and content, greatly improving performance, particularly for applications that need high quality service. Users everywhere are just a few router hops from servers anywhere maximizing global innovation and service.

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2. Multi-modal access. Users connect in many ways including via cellular and wireless data networks, via fiber-optic cables deployed by their phone company, via television cable or via data over power line supplied by their electric company. These networks interconnect at the regional points for open, nondiscriminatory access. Voice, video and data all use IP. This architecture provides high quality, highly flexible service for local connections and services. Users roam seamlessly between services. Flat rate monthly access charges with no usage restrictions encourage network use and innovation.

3. Security and privacy. Improved trust models and an Internet bill of rights improve security and privacy while protecting freedom of speech and anonymity. Spam, cyber attacks and fraud are largely a thing of the past.

4. Governments remove barriers and taxes that hinder access. Internet access is deemed essential economic infrastructure that is promoted and subsidized where necessary. Local access is highly competitive and very lightly regulated.

5. Governments lead in the adoption of network technologies, encouraging communities to do the same. Schools and public education programs focus on skills and applications needed to encourage the use and adoption of new applications and services.

6. User communities of interest spawn valuable new applications and services, for example in healthcare. Patient-centered electronic medical records become the norm, improving care and saving over $140 billion a year in the US alone.

This future network seems far distant from where we are today. Today some networks restrict user applications and some fear that access networks will give preferential access to their own services over competitors, who they might even block. This would be a mistake, as restricting access devalues the network, which harms everyone. Spam, cyber crime, child molesters, fraud and spyware today severely degrade the value of the network, but no one has taken responsibility for finding solutions to these problems that preserve the end-to-end architecture of the network and also assure freedom of speech

and anonymity. Today, most network providers view competition, particularly by government entities, as the enemy when in fact competition encourages everyone to improve the network.

It would be easy to throw up our hands at the obstacles standing between where we are today and the ideal network of the future but, as this paper has shown, the potential benefits are too great to quietly let opportunity pass us by. Now is the time to resolve that we want nothing less than the best network possible because it is the right thing to do and the human costs and missed opportunities of doing less are far too great.