Predicting Bandwidth Demand and Network Planning Implications on the Internet

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This white paper, prepared by Merit, provides detailed information that will help organizations use traffic predictions in network planning.

A. Introduction

This section reviews the available literature on future demand for Internet bandwidth. There is a stark lack of quantitative information on anticipated demand in various market segments looking out far enough into the future and from which firm projections of future network capacity requirements can be made. The reasons for this lack of information are discussed.

However, indications of future demand can be inferred from the rate of deployment and expansion of use of the Internet generally. In addition, the trajectory of bandwidth growth is important in predicting future demand, because typically users' initial deployment is at a "slow" rate, and as they gain experience and begin to perform additional functions, their requirement for speed/bandwidth increase. The rate of bandwidth growth has been consistently steep over the years since the Internet became public, regardless of economic conditions surprisingly. This rate of deployment and trajectory of bandwidth growth are discussed. In addition, two key trends that cross-market segments are discussed: 1) network-based application serving and, 2) the trend towards Converged Networks. Lastly, a review of typical Internet applications used today and their respective growth and demand is presented.

In short, leadership in network planning is required that understands the applicability of historical trends, looks beyond the current business context and the immediate future, and envisions the future in which businesses will have fundamental business applications delivered over Broadband and when a converged, shared infrastructure for all electronic communications will reduce costs and increase accessibility.

B. Bandwidth Projections by Market Segment

An ideal scenario for a network planning engineer would be to have definitive market research on the amount of bandwidth that users will require in two, five and ten years. This ideal scenario does not exist. Further, even the use today of broadband by market segments is no clearer. "Distribution of Broadband access among various sectors of the business community is unclear at this time. Data differentiated by business character and size are not available" (BJK Associates 1). Two key reasons for this are discussed in the following section, i.e., the complexity of application environments and the complementary technologies they require in various market segments which are not easily "translated" into network capacity requirements; the difficulty of users to foresee long term technological requirements.

B.1 Complexity of Market Segment Applications

Few researchers have translated market application scenarios into concrete network requirement projections. It is a complex task to do so because of the many interdependencies of the software and hardware applications as well as policies and practices within the business itself. These complexities must then be set against the quickly evolving realm of network technologies, and thus the researcher must be an expert in both the market segment and the network technologies. As such, this type of market research is significantly costly if done well.

For example, it is received wisdom that medical imagery, X-rays, CT scans, MRIs, etc. will be exchanged over data networks for the purposes of remote consultation, archiving, and so on. An open standard for image exchange, Digital Imaging and Communications in Medicine (DICOM) has been available since 1996 for software and hardware producers to use in their medical imaging products. Further, it is well known that the average file size of a DICOM-compliant image is on the order of one Gigabit.

While the raw data on applications is apparent, translating it into a clear set of network requirements is complex, perhaps more so in the healthcare market segment than others. Some typical questions that a network planner would have would be, how many of these one-Gigabit images will be sent in an hour, day, week; who will need access to them; will the readers always be in one spot (i.e., always at some expensive machine) or will the reader be able to view it anywhere; can it be a compressed image or would there be malpractice ramifications in that some (humanly imperceptible) amount of data could be lost through compression; what security/access requirements must be in place in the network; and may others. In addition, regulatory and competitive issues make this sort of data collection particularly difficult in this market segment.

This complex task is the same for other market segments. For example, farming is another potential growth area for networking relevant to many places in the State of Michigan. But projecting bandwidth requirements for "smart farming" requires an in-depth knowledge of the crop cycles, soil management, the ways farmers manage their finances, planting schedules, what ties to securities exchange entities such as the commodities futures are required, what are requirements for reporting chemical and pesticide usage to regulators, how do farmers work with agronomy and seed advisers, how much do they interface with extension universities, what are their ties to chemical and equipment manufacturers, lenders, and many other areas. Again, to project bandwidth demand by market segment requires a very in-depth understanding of the market segment.

Another factor in the complexity of projecting bandwidth requirements per market segment is that market segments are not homogeneous in their demand for bandwidth. There are advanced businesses and non-technology driven businesses, and these exist even in the same geography where network supply would be relatively equal. Therefore, generalizations are difficult to make. For example, using healthcare again, the implementation of network-based applications and networks is uneven across healthcare systems of similar size. In Michigan, three hospitals of roughly equal staff and number of beds in the same urban area currently utilize widely different levels of Internet access. Of the two largest hospitals, one consistently uses 15 Mbps per while the other uses only 4.5 Mbps. The third, a bit smaller than the others but a self-proclaimed leader in technology uses 7.5 Mbps.

As another example, a small automotive supplier tucked away in the woods of northern Michigan uses only the Internet for the exchange of engineering data with auto manufacturers and with its contract-engineering firms. Designs are exchanged quickly and make their way into production sometimes in only a matter of hours.

Another larger automotive supplier located nearer to the auto companies in Southeast Michigan still relies on courier-delivered bundles of engineering output in its interactions with the manufacturers. The annual revenues of the large company are 10-20 times that of the smaller one, and its failure to implement advanced communications technology is a puzzle that serves as an illustration of the unevenness of technology implementation in a market segment.

Because market segments are not homogeneous in their use of technology, no clear consensus has emerged as to the network requirements for individual market segments.

It seems a safe assumption that all market segments will eventually make use of advanced networking and telecommunications in the same way that all businesses eventually came to have voice telephones. It is anticipated that the network may well differentiate businesses within market segments, though, in the near term.

B.2 User Difficulty in Predicting Demand Accurately

As stated above, one reason for the difficulty in predicting demand by market segment is the requirement for a market research to have a very in-depth understanding of the market segment. A solution might be, then, to simply *ask the users* in the market segment what they need. One would assume they would have this in-depth knowledge of how their segment is anticipated to operate over the years relative to the network. However, this typically is not the case -- users of course understand their business, but they typically 1) do not have the detailed knowledge of network evolution potential that is available; 2) are not able to envision significant business transformations that might be available due to network evolution.

Most business users have difficulty projecting their future networking requirements more than about two years out. Often times, users indicate incremental increases in bandwidth requirements when asked, and suggest tactical business uses. But statements that would indicate greatly increased network capacity are not typically obtained from user studies, although this is the data that network planners would like to have. Yet actual network usage does indeed grow at exponential vs. incremental steps. So why do users typically not foresee what actually happens? Part of the reason users have a relatively short-term view of bandwidth needs may be an education/awareness issue, but it is not solely a matter of education.

Rather, it is difficult for users to articulate their demand for the business transforming services that will be available with widespread Broadband deployment *precisely because* the services will transform their business in ways they cannot anticipate. In 1990, few businesses would have anticipated that within five years a position called "Webmaster" would be required on their staff, and part of the advertising budget would be allocated to on-line information.

In addition, users may indeed see strategic changes for their business, but they may not recognize the network implications of these changes. For example, many medical practitioners say it is highly desirable to have dictated medical notes be automatically transcribed, *accurately,* into a patient record. Of course this requires application development and significant advancement in voice recognition technology. But a network planner would see that for efficient and broad deployment of the capability, the voice recognition technology would likely reside on servers on a high-speed network. When answering a question of how much bandwidth their offices may need in the future, a doctor may well not think of the dictation application as a networking requirement.

A college professor trying to get her students to understand the unforeseeable role of technology in economics tells the story of the Swedish scientist who in 1860 surveyed local farmers to ask them how science could best help them to remove the large glacial boulders that dotted their fields. The most common response was that he should concentrate on animal husbandry to develop a stronger breed of horses so as to be able to pull the rocks away. Not one suggested that he should work in chemistry to identify a way to nitrate toluene to be able to produce a safe yet powerful explosive. Another Swedish scientist, Alfred Nobel, would do that, and by 1870, the farmers were using 2,4,6-Trinitrotoluene (TNT) to obliterate the boulders, increasing their arable land and raising their yields.

That story may be a parable, but the story of the Tennessee Valley Authority (TVA) is real as well as more contemporary, and it too conveys the paradoxical issues involved with attempting to forecast demand for new technology with traditional demand assumptions.

The TVA was a Depression-era dam project that promised to make the Tennessee River navigable all the way from the Mississippi River to Nashville *and* to bring electricity to a portion of the South that hadn't seen significant investment since the fall of the Confederacy. It was the largest economic development project ever proposed, and developers predicted it would raise the fortunes of everyone it touched.

Those to be touched were something less than receptive. The flooding of the valley would dislocate thousands and disrupt the agricultural economy that was already reeling from the Depression. In the context and scale of their 19 th century agricultural economy, potential users did not see that electrical power could potentially improve crop yields, productivity, or quality of life. The dizzying array of electrical devices that would eventually find its way into American homes, businesses and farms was impossible to conceive. They fought TVA in state legislatures, in Washington, and in the valleys where surveyors for the project were chased away and their equipment destroyed. But the visionaries carried the day, the project became reality, and the transformations happened.

Users' lack of ability to envision a transformed future through technology is not unique. Even leaders in a technological field sometimes dismally fail to see the shape of things to come:

- "This 'telephone' has too many shortcomings to be seriously considered as a means of communication. The device is inherently of no value to us." - Western Union internal memo, 1876;

- “I think there is a world market for maybe five computers.” - Thomas Watson, President of IBM, 1943;

- "There is no reason anyone would want a computer in their home." - Ken Olson, president, chairman and founder of Digital Equipment Corp., 1977.

In summary, simple surveys of users asking what bandwidth requirements they will have in the future will likely fail to identify accurately how the business will evolve in terms of their networking requirements. Focus groups, which are more cost effective, can help to identify strategic changes that have networking implications, although they are not *quantitative* studies. Detailed studies of applications and business evolution in market segments would be the most accurate predictor of bandwidth demand. But these are most likely cost-prohibitive. Sometimes even industry leaders do not see the future accurately. So how do network planners anticipate demand for broadband networking? The following discussion addresses this challenge.

C. Deployment and Speed Increases Use and Demand

While even leaders in their a fields have, in hindsight, missed some pretty obvious transformational shifts in technology, individuals who are exposed to Broadband are quick to explore and use the Internet more and in ways they did not expect (Pew "The Broadband Difference" 2). It is likely that the experience will be the same for businesses as they respond to offer Broadband-enabled services to consumers (Crandall 16).

C.1 Deployment

Dial-up Internet access users represented 80% of all home Internet users in 2001 (A Nation Online 35). These users express the most dissatisfaction with their Internet experience, with the most common complaint being slow access times. Maximum dial-up speed is 56 kbps. Satisfaction rates rose from 57% to 92% when those same users switched to DSL, which has a typical range of speed between 200 - 500 kbps (SBC).

With faster access speeds, one would expect that Broadband users would have to spend *less* time online to complete Internet tasks. However, the opposite is true. Broadband users report spending more time online because they can do more online once they have Broadband. They spend more time online compared to dial-in users, 95 minutes versus 83 minutes, and they are more than twice as likely to have several online sessions per day than dial-up users (Pew "The Broadband Difference" 4).

Broadband users report higher rates of almost every Internet activity: email, information searching, online transactions, and watching video. This last activity is pursued by 28% of Broadband users on a daily basis while the number of dial-up users who do so is so small as to be immeasurable (Pew, "The Broadband Difference" 13).

Online transactions are much more common among Broadband users than dial-up: 43% of Broadband users will make a purchase or do online banking on any given day compared to only 18% of dial-up users. One factor may be that the increased speed of Broadband makes browsing online merchandise faster, but Broadband, by virtue of its "always-on" connection, is more accessible, and users think to use it more often for a variety of tasks (Pew "The Broadband Difference" 6).

There is much research on connectivity in the home, and those planning for business expansion may feel this is somewhat irrelevant to their goals. However, telecommuting is a key, growing application, and broadband access in the home is a requirement. Twenty percent of IBM Canada's workforce telecommutes, and their surveys and pilot studies indicate that employees can be as much as 50% more productive when they work in telework environments. American Express telecommuters handled 26% more calls and produced 43% more business than their office-based counterparts. IBM US says there is a 40-60% reduction in real estate costs per site due to telecommuting. IBM summarizes the experience by saying, "For the first time ever, productivity, customer satisfaction and employee satisfaction all increased." Retaining qualified and talented staff is a goal in every organization. In one study, fifty-three percent of teleworkers said the ability to work at home was important to their employment choice, and an overwhelming majority (nearly 80%) feel a greater commitment to their organization and most say they plan to stay with their current employer (Bauer 28).

Experts understand that the use and sophistication of Internet technologies increases exponentially when individuals have access to Broadband technologies (ECom-Ohio 6).

C.2 Internet Use and Deployment

By all measures, across many studies, Internet use continues to grow, and the rate of growth is accelerating. The following statistics refer to Internet growth in general, not necessarily broadband usage, but indicate that the historical growth in Internet access and utilization has not slowed despite the economic downturn of the last three years:

18.6% of U.S. households had Internet access in 1997; by 2002 that number was 50.5% and climbing (A Nation Online 3);

- Since 1997, growth in Internet use among people living in rural households has been increasing at an annual average rate of 24%, and the percentage of Internet users in rural areas, 53%, is now almost even with the national average, 54% (A Nation Online 2);

- The Internet use rate grew 25% for low income households from 1998 to 2001, and accelerated from August 2000 to September 2001 while higher income households saw only an 11% growth rate with no evidence of acceleration (A Nation Online 12);

- While the under 25 age group continues to have a higher Internet use rate than those over 25, this gap has not widened since 1997, and the growth rate for all age groups is the same from the 1997 baseline; millions of Americans across all age groups have begun to use the Internet since 1997 (A Nation Online 14);

- Males were more likely than females to be Internet users in 1997, but since August 2000, males and females have had virtually identical rates of Internet use (A Nation Online 15);

- Internet use for adults with a Bachelor's degree or higher grew at annual rates of about 12% from 1997 to September 2001 while Internet use for those only with a high school diploma grew at an annual rate of 30% over the same period (A Nation Online 17);

- From 1997 to 2001, growth in Internet use rates was faster for Blacks and Hispanics, 31%, than for Whites and Asian American and Pacific Islanders, and there was a significant acceleration between August 200 and September 2001 (A Nation Online 19).

Thus, Internet deployment and usage is generally growing. After initial deployment and use of dial-up services, users typically desire faster and faster speeds. Historical figures on demand in general show a steep increase in the requirement for bandwidth after users connect.

C.3 Historical Growth in Traffic

Historical patterns of Internet utilization and growth are the most likely predictors of future growth and demand. Those patterns are well documented in the many studies that have sought to understand the phenomenal emergence of the Internet. There is some variance in experts' assessment of growth rates because of differences in the methodology for assessment, but there is consistency in the overall conclusion that growth has been steep and is anticipated to continue.

Measurements by Dr. Lawrence Roberts, who led the team that designed and developed ARPANET in the 1960s which was the precursor to the NSFNET and commercial Internet, suggest traffic on the Internet increased as much as an unprecedented four times annually through the first quarter of 2001.

Roberts' data shows traffic (which in this case means data traveling the Internet's "network of networks", not just traffic to Web sites) has been doubling every six months on average across core IP (Internet Protocol) service providers' networks, or in other words, growing by four times annually (Pastore, “Traffic Grows”). The research is based on special access Roberts received to top scientists at the leading data carriers. Beginning in 2000, he and his team obtained nondisclosure agreements with the top 19 data carriers and began the process of polling them for their network topologies, trunk utilization and traffic. Network traffic was sampled in April 2000, October 2000, and April 2001.

Peter Sevcik, another ARPANET alumnus, finds that Internet bandwidth growth figures are often hyped to make a case for investment, but even his less optimistic assessments suggest that Internet data traffic doubled every eight months from 1997 to 1999, then slowed somewhat so that it was doubling only every 11 months from 1999 through 2000 (Sevcik 1). The Internet industry may see this as a slowdown, but other industries would relish that level of growth and demand for its services.

Using another measure, Insight Research in October 2001 estimated total U.S. Internet traffic at 20,000 terabits per day, and they projected that by 2006 that number would rise to 1.5 million terabits (Pastore, “Bandwidth Expands”).

While there is dispute on the means of measurement and the exact rate of growth, all agree that the Internet continues to grow. Even the most pessimistic growth rate exceeds that for other industries. Some consternation resulted from a 2003 JPMorgan Securities report that said IP traffic growth has passed a peak. But a recent analysis in *Broadband World* (Hold 2003) presented a systematic analysis of both the historical assumptions that "Internet traffic is doubling every three or four months (or a factor of 8-16 every year)" and suggested a framework for projecting traffic demand for the future. Some key individuals, "leading wisemen of the industry," were interviewed: Scott Bradner, Vint Cerf, Larry Roberts, David Farber and Ross Callon. In the end, the experts said at worst the Internet is not quite doubling every year, and at best it is doubling every six months. The opinions were supported by various quantitative assessments. Of course the key to the future is not so much this projection, but the development of businesses cases to determine how businesses will make use of -- and providers will make money off of -- the tremendous bandwidth that is and will be in place.

More common than studies on growth rates are studies on Internet utilization. However, large-scale publicly available studies on Internet utilization have tended to focus on the usage habits of *individuals* and the macro socio-economic impacts of the Internet rather than on utilization and economic impact in specific market segments. Leading studies such as *A Nation Online* from the U.S. Department of Commerce, *Surveying the Digital Future* (the UCLA Internet Report), and *The Pew Internet Project* tend to focus on the demographics of Internet users, the Internet habits and styles of utilization for individuals, and societal impacts.

We do know that as of 2002, 50% of U.S. businesses had only dial-up Internet access; 19% had dedicated connections of T1 or greater, and 27% had cable modem or DSL. However, there was no correlated detail at the national level on the size and type of neither these businesses nor their location. For the state of Ohio, more detail was available in regards to business size: only 29% of firms of 25 employees or less had Broadband, but there was little more refinement with regard to market segment (ECom-Ohio 6).

Missing from much of this research are numerical estimates of expected benefits of the impact of the Internet on business practices and operations. The MSU Policy report (Bauer, et al) points out that one approximation of the benefits of broadband is the change in social surplus (consumer plus producer surplus). The report notes, however, that Crandall and Jackson (2001) is the only study that uses an estimate of consumer and producer surplus to assess broadband. Using two different estimation procedures to calculate the benefit, the total annual benefits from all forms of broadband range from $272 billion to $520 billion. "However, the vast literature on broadband typically does not use such a stringent, operational notion," (Bauer, et al 2002; p.69). In other words, strict, mathematical economic measures of the benefits of the Internet are still to be devised.

C.4 Broadband Bandwidth Demand

Bandwidth demand among what are typically broadband users has had a steep trajectory and continues to grow. Some key highlights are:

Academic and research backbone bandwidth has grown at 60% per year – doubling every 18 months – for the past two and a half decades, and forecasts are that it will continue to grow at that rate (Bruce 23).

The traditional measure of the "size" of the Internet was the number of hosts "visible," (i.e., machines that have a discrete Internet address. By that measure, the growth may be slowing. However, it fails to take into account the growth of bandwidth not through the addition of more hosts, but greater bandwidth to each host (Metcalf). In other words, the number of machines being connected to the Internet may be slowing, but they may be more capable and may have more bandwidth among them.

Overall network bandwidth (voice and data lines) increased in 2002 and broadband deployment led this growth. In the U.S., high-speed lines connecting homes and businesses to the Internet increased by 55% in 2002. When that data is narrowed down to account for just homes and small businesses, high-speed lines increased by 58%; clearly the focus of growth is moving from large corporate customers to a wider diffusion of high-speed connectivity. While these percentages may seem phenomenal, the actual broadband coverage is somewhat dismal with DSL serving 6.5 million users and cable modem serving11.4 million (FCC). Total Broadband penetration is 27% of all U.S. homes.

Roughly 24 million Americans (21% of all Internet users) have high-speed connections at home. From June 2000 to February 2002, Broadband penetration increased four-fold. Internet users in rural areas are less likely to use a Broadband connection: only 11% or rural Internet users have a Broadband connection compared to 29% for urban Internet users (Pew The Broadband Difference 9,10). Cable modem providers and companies offering DSL are more likely to deploy those services in densely-populated areas where the capital investment in equipment is seen to have a higher potential for return when it is leveraged over a larger potential user base (Pinkham 3).

Strategic Analysts predicts that the 2002 27% penetration rate for Broadband in U.S. homes will increase to 38% by the end of 2003 and to 70+% penetration by 2008.

Broadband penetration, while generally regarded as disappointingly slow, is actually extremely fast by most standards, faster than cell phone diffusion at a comparable stage (Odlyzko).

More anecdotally, a major ISP in the State of Michigan recently reduced pricing in response to competitive pressure. It was anticipated that users would order more bandwidth for the same price. However, by a significant percentage, users tended to not only order a small incremental increase to match their previous spending, but to make a more significant increase in total bandwidth even though their monthly bill would increase.

A key challenge continues to be deployment in rural America. The National Rural Telecommunications Cooperative supports more than 1000 rural utilities and affiliates in 46 states in delivering telecommunications and information technology solutions to their communities. The NRTC members serve more than 35 million customers. In testimony before the U.S. House in July 2003, the NRTC president commented that most rural areas still lack access to the same telecom infrastructure or technologies enjoyed by those living in urban areas, and that the statement can easily apply to most any state in the Union. The testimony references significant demand in these areas, and technology and funding initiatives to answer the demand.

No research indicates less demand in rural areas as a reason for less deployment. Clearly the business case for the rural areas is the key challenge in getting services deployed cost effectively for a population that is not concentrated. Concentrated groups of users are simply more profitable for providers. However, this same testimony quotes an Iowa study concluding that, "Small rural telephone companies have done a better job of providing universal telephone service than large companies serving rural areas." In rural areas served by large telephone companies (e.g., units of the Regional Bell Operating Companies), DSL deployment has been very slow, while small, independent telephone companies serving those areas have been much more successful in speed of deployment as well as penetration (Pinkham 4). Smaller rural providers are committed to serving their communities. Policy initiatives can encourage this service deployment.

D. Deployment Drives Deployment -- Who Goes First?

The available research indicates that Broadband availability promotes more intensive use of Broadband and leads to discovery of new applications. The problem is that, in the absence of having Broadband, users can't fully know the potential of Broadband. This presents a “chicken-and-egg” problem with regard to investment. The Pew Internet Project reports:

A problem facing providers of high-speed home connections—public or private, before the Web or after its development—is the “chicken-and- egg” dilemma with respect to consumer demand. Companies or towns considering the sizable investment in high-speed infrastructure for homes have reason to pause, since it is hard to predict how many consumers would want such connections and what information services they would demand once they had them. Consumers, for their part, might be willing to pay for innovative online services, such as video-on-demand, online shopping, or home health care. But potential providers of such expensive online content do not want to incur the cost of creating those applications without assurance that the high-speed networks are built out and ready to serve customers” (Pew, The Broadband Difference 8).

Further, BJK Associates reports:

Small business' need for Broadband Internet service remains latent at least partially because of the lack of available Broadband access. Although demand for services is usually the driving force for supplying services in a market economy, for new technology-based services, demand may not appear until the service demonstrates apparent value to the user. Thus, demand arises only after the service becomes available and the user recognizes its value. So, unless a supplier believes that an untapped market exists and is willing to raise its awareness sufficiently to generate demand, the market will not provide services that may in fact have a latent demand (BJK).

Even suppliers who believe that untapped markets exist are reluctant to build in the belief that demand will come. Investment capital is too scarce and the dot-com bust is too recent in memory for most suppliers to be able to convince their investors. This is an instance similar to the TVA where leadership must transcend individual suppliers and businesses and look to the needs of the larger community.

E. Trends that Cross Market Segments

There are two key trends in business development that cross market segments and that have a significant implication for network planning: application serving and network convergence.

E. 1 Application Serving

Currently, software applications are installed and run on servers or workstations at the office or home of the user.

The management and upkeep of the applications and the operating systems is the responsibility of the individual or the business. Because the key software applications are, by definition, fully integrated into the operations of businesses, they must be regarded as critical business assets. Businesses therefore spend millions annually in technical support, software updates and patches, and maintenance of recovery and data backup systems.

Individuals and small businesses may make a financial decision to forego software upgrades and backup systems, and systems do not perform optimally and/or become outdated quickly.

Application Service Providers (ASPs) are entities that will place key business software applications on servers, connected by high-speed networks, so that any business anywhere can subscribe to the application vs. buying one that would be locally resident. Many applications have been discussed for this purpose, but the ones most likely to touch all businesses and have the greatest financial impact on users are those that are required in most every business: customer relationship management (CRM) software, financial/accounting software, customer billing software, supplier and supply chain management (e-procurement) software, and sale forces automation software.

Application Serving is not a new idea. In the mainframe computer era, software applications did all their processing and storage on the mainframe computer, and remote users networked to it operated only with "dumb" terminal, little more than a keyboard and monitor.

The emergence of the personal desktop computer (PC) in the early 1980's put unheard-of-for-its-day processing power in the hands of individuals, and applications moved from the mainframe to the desktop. Processing power was located near the user, and, because networks were few and not interconnected, software was delivered on diskette or CD and had to be installed on a per workstation basis. Likewise software patches and updates were delivered by disk and had to be installed on a per workstation basis.

For organizations with many computers, the burden of desktop software support was enormous. Technical staff was required to "touch" every workstation in order to support the software and the end user.

The de-centralized storage of PCs, with data on hard disks scattered across an organization, made it difficult for organizations to establish and maintain authoritative records for key business information. If two users start with the same document or spreadsheet and work independently, modifying data or even application settings, the data records diverge, and the productive value of that information to the organization as a whole decreases.

Organizations that faced these problems in the beginning of the PC era modified existing mainframe-centered Local Area Networks (LANs), or they built PC-based LANs to manage applications and data and maintain authoritative data centrally.

Because PCs were often as powerful as any of the centralized servers, the software application and data were stored on the server. When a user started the application from his or her desktop PC, the copy of the software application instruction set was transferred from the central server over the network to the PC and then loaded onto the PC operating system. The instructions were executed on the PC *not* on the server, and when the user was finished, the modified data was copied over the network to the centralized authoritative storage area.

Typical LAN speed was 10 Mbps, more than fast enough to make the Application Server process just as fast as if the software loaded from the PCs hard drive. In many LANs, the 10 Mbps bandwidth was shared by all users, making actual per user speeds much lower depending on how many were on the same network, and in those instances Application Serving impeded performance.

Despite any shortcomings, Application Serving solves these problems:

- **Software maintenance** - software can be maintained as a 'single copy' for all users, and updates and maintenance of the software can be done at one computer rather than many, greatly reducing tech support expense and improving performance and robustness;

- **Authoritative data records** - key business information/records reside as a single copy in a central location for all users;

- **Data integrity** - backup/storage systems for data records can be done more efficiently and reliably at a single point;

- **Software licensing** - organizations that pay software license fees per installed desktop or per simultaneous user can manage the number of licenses in use;

- **Security, privacy, and confidentiality** - access to data can be managed on a per user basis from a single point ensuring only authorized access and modification.

Until recently, Application Serving was rarely done over the Internet because Internet bandwidth was usually far below the 10 Mbps bandwidth available on a LAN.

The limitation of Internet speeds bred a new model for software processes that became know as *client-server*. In client-server network computing, applications run on both the central server and the desktop PC, and data files are delivered from the server and also created locally on the desktop PC.

Using the World Wide Web (WWW) is the archetypal client-server computing experience. The web browser software running on the desktop PC connects to a web server on the Internet requesting the data on the server. The data files are delivered over the Internet to the web browser software on the desktop PC, which displays the information, text, images, streaming video, etc. on the PC monitor. As the WWW user continues to 'surf' through the web pages, information is transmitted back and forth between the server and the client and processing occurs on both server and client. Most of the time, the exchange is asymmetrical with the server sending a greater volume of data to the client.

LAN bandwidth rates have increased and shared bandwidth issues have been addressed with 'switched' networks. Internet bandwidth rates are increasing as Broadband becomes more widely available. This creates an environment ripe for taking advantage of the benefits of application serving. With Application Serving over the Internet, the benefit will be distributed (potentially) over the vast number of Internet-connected computers. The scale of Application Serving will be so large as to provide more powerful and reliable software applications at lower unit cost. Further, businesses will no longer have the bother and expense of maintaining local servers, only desktop PCs.

Application Service Providers (ASPs) will maintain Internet servers that provide software applications to hundreds and thousands of users. As stated earlier, the most important applications that underlie every business are likely to be:

- Customer Relationship Management (CRM) software
- Financial/accounting software
- Customer billing software
- Supplier and supply chain management (e-procurement) software
- Sale forces automation software

Rather than purchase a license or licenses in a one-time purchase of software, the ASP model will be more of a service subscription model like phone service, providing constantly updated software with the latest productivity enhancements to keep businesses competitive.

Application Serving will provide more powerful, reliable, and robust software to businesses at a lower cost than they can obtain under the current software sales model. These software applications would be available on a shared subscription or transaction basis. Small and medium sized businesses will have powerful software previously available only to the largest corporations who could afford the staffing, hardware and other infrastructure necessary to run such software. Application Serving will accomplish this with centralized servers located on the Internet that will leverage the connectivity-power of Broadband to deliver fundamental applications required by all businesses

LAN-based Application Serving has seen a renaissance in the past few years with application servers like Citrix, and Internet ASPs began to launch services in 2000.

The business model for Application Serving is still developing. It presents a conflict with the current paradigm for software sales, where typically a per-user fee is charged.

The large software companies are wrestling with a paradigm shift in that they see a potential loss in revenue if ASPs provide applications from a centralized point to a wide customer base vs. their individual sales of licenses to those customers. Thus, the software companies are not aggressively pursuing the business model of third-party ASPs. However, it appears that there has yet to be a thorough business case of the opportunity by these software companies. For example, many of these software products are simply out of reach of a typical small business. A business may very much desire an Oracle-based Customer Relationship Management system integrated with sales reporting and financial reporting. But the cost of acquiring it, customizing it, and maintaining it is most likely cost-prohibitive to a small to medium-sized business. At present, they simply are not customers for the product. However, in an ASP-provided scenario, the software company will tap into a customer base that was previously unreachable.

Very large companies may likely still purchase their own licenses, but with ASPs, the smaller business can also avail themselves of it. It is anticipated that this shift in software "sales" will be an impetus to broadband deployment in all locales. In addition, from a business development perspective, small to medium sized businesses could then achieve the operational efficiencies the software products afford to their larger competitors.

E.2 Network Convergence

In the high-speed telecommunications industry, “convergence” means the merging of the traditional voice and data networks into one shared infrastructure. The value of this convergence is in efficiency and cost savings. A major long distance carrier representative stated at a major conference the implication of convergence in large networks. He said that if there were actually a single network in their company for all voice, data and other applications -- a truly 'pie-in-the-sky' view since it probably cannot every be 100% true -- he estimated that a converged network for all services would save in the neighborhood of 70% on administration (far fewer boxes to manage) and 40-50% on maintenance and operations. So if providers and users could even achieve *half this efficiency* it results in tremendous savings on these primary operating expenses.

This impact is reflected in typical customer premises scenarios. For example in many buildings there is cabling, PBX or Centrex equipment, telephones, equipment rooms, and staff to engineer, maintain, plan budgets, plan strategy, manage change, etc., to support the voice infrastructure. Then there is cabling, routers, switches, computers, equipment rooms and staff to engineer, maintain, plan budgets, plan strategy, manage change, etc., to support the data infrastructure. If these two environments -- voice and data -- could be provided over the same infrastructure, the savings would be immense. These two worlds are historically separate for many reasons including technology, political-economic development and social dynamics. In addition, the requirements for quality provisioning of constant-bit-rate services such as voice, as well as the expectations of the end user, are very different from those of bursty data applications. Both are respectively complex.

But service providers envision this 'one world' and strive to be the single provider. For example, regulated voice phone companies have talked about and attempted to do data for decades. ISPs have toyed with voice. Cable companies are one entity that has come close to being a ubiquitous provider of both services well, but most of their offerings are still in the trial stages. Migrating current infrastructures to a single technology is a great challenge. But what that single technology *should be* is becoming less and less a topic of discussion.

Data networks have become critical to business, and some would say perhaps more important than the voice network. Many businesses could do without their dial tone for half an hour, but if their servers or routers went down, it would be a disaster. Home users use "data" with each email or web browse. The *de facto* protocol for data networks is TCP/IP, the protocol of the Internet.

Vint Cerf, one of the fathers of the Internet, believes that the Internet is the vehicle for convergence:

“What is the future of the Internet? It will become the 21st Century's telecommunications infrastructure. It will become our medium of commerce and education, of research and medicine. It will become a repository of the knowledge, wisdom and creativity of the human spirit. Internet will be there, for everyone” (Cerf).

Much work in the standards arena, in trial environments and emerging products support voice over the Internet Protocol, or "VoIP". The "data over voice" standards of several decades ago are virtually forgotten. It is anticipated that the protocol for both voice and data networks -- and for any converged network -- will be highly dependent upon, and perhaps even totally reliant upon the TCP/IP protocol. Thus, expanding broadband data networking today sets the stage for the ability to provide converged services tomorrow.

But convergence is not just for businesses. These same providers want to be *the single* provider for residential voice, data and video applications. Thus broadband data services to the home are as important a driver of convergence as to the business.

The trend toward convergence will continue because the cost savings of one network for data, voice, and all applications is significantly attractive from the standpoint of building, maintaining and operating this key business infrastructure component.

F. Typical Internet Applications – Growth and Demand

Following is a summary of typical Internet applications today as well as some projections of demand. Even "basic" applications usage is anticipated to grow and to expand into new areas. The utility of Internet use by businesses and individuals is proven.

Further, the history and growth of these applications suggests a pattern of communications technology growth that has defied the prognostications of the so-called experts. Time and again, it is the “market force” of the user community, not the pronouncements of the experts that have driven applications growth and demand for network communications. None of the pioneers of data networks envisioned email, yet it rapidly became the “killer” application on early networks as users embraced it as a fundamental communication tool. The web browser was a simple combination of existing programs designed for easier information access vs. historical information access on the Internet that required some level of programming knowledge. No one foresaw the impact on the network, but users found the graphic interface irresistible, more and more information became resident on servers in the network because it was easily accessible due to the browser, and network planners spent the next five years playing catch up as web browsing drove bandwidth consumption (and the term world wide web was spawned).

Thus even "typical" applications will drive demand as they continue to be deployed. The following is a description of these applications.

F.1 Email Communications

Despite its current ubiquity and popularity, the pioneers of data networks did not anticipate email 30 years ago. In 1971, the Advanced Research Projects Agency network (ARPANET), the forerunner to the public Internet, existed for the exchange of (mostly) defense research information among a handful of research centers across the United States. The creation of email was not a response to demand for a mail-like messaging utility on the ARPANET. Rather, ARPANET scientist Ray Tomlinson cobbled together some existing programs to allow a user or users working at one host computer on the ARPANET to leave mail for users at other host computers because, he said, "It sounded like a neat idea" (Tomlinson).

This neat idea caught on quickly and soon became the most popular application on the ARPANET (Hafner 45).

Thirty years later, email is still the most popular and most commonly used Internet application. In 2001, 45.2% of Internet users reported email as the primary application for which they used the Internet. (1) Estimates of email volume vary widely, with some sources reporting as many as 31 billion emails sent daily on the global Internet and growth to 60 billion expected by 2006 (Farrell).

Some 48 million Americans send and read email each day—that is 87% of Internet users who access the Internet on any given day (Pew, "Tracking Online Life" 20).

Email has taken the place, in many cases, of both the telephone and traditional mail, and it has characteristics of both. It is neither as formal as a traditional letter nor as informal as a phone conversation. It requires less cost and effort to send compared to traditional mail and yet the turnaround time for any chain of correspondence is closer to the real-time experience of the telephone. Further, unlike the telephone, email is much better at conveying detailed information and providing a record of a dialogue. The result is an improvement in social relationships and enhanced information and work flow (Pew, "Email at Work" 13).

While email is not the most technologically sophisticated or functionally impressive Internet application, it is a powerful force in both the social and business realms of Americans' lives.

A March 2001 study found that fully 84% of email users have used email to stay in touch with family members and 80% have used it to contact friends (Pew, "Getting Serious" 5). The same study found that as users became more experienced with email, they used it for more serious personal purposes such as soliciting family members and friends for advice and to express worries.

In the workplace as in personal life, research shows that email extends and strengthens social ties (Pew, "Email at Work" 13).

"Most American employers have provided Internet access with email accounts to employees hoping that this will help them become more collaborative with colleagues and customers, and thus more productive in their work" (Pew, "Email at Work" 5). More than half of those who use email at work say that email improves teamwork (Pew, "Email at Work" 13).

A 2000 study designed to measure worker productivity showed the potential for a 14% to 20% gain in productivity from the use of email (Ferris). Further, the anecdotal evidence from email workers' experiences indicates that workers believe email has made them more productive: 86% report that email saves them time, 62% report that it makes them more available to co-workers, and 71% consider email a positive force in the workplace (Pew, “Email at Work” 15).

However, the literature is also filled with concerns about drains on productivity caused by email overload or inappropriate personal use of email. For up to about a third of workers, email can be stressful, encourage gossip, or otherwise create situations that distract from work (Pew, “Email at Work” 15).

Email spam, the flood of computer-generated ads and sales pitch messages, also impacts email productivity. A 2003 study of 76 different U.S. companies reported a loss of 1.4% of each employee's productivity each year due to spam (Roberts). The study further concluded that spam filtering products and services were not effective means of reducing the impact of spam.

Policy, not technology, might be the best means for combating email spam and reducing its impact on productivity and Internet infrastructure. Legislation is pending at the state and federal levels that will make it costlier for bulk emailers to send spam and raise the penalties for unethical technical practices used in spamming (DiSabatino).

While the productivity effects of email are not altogether clear at this time, it is clear that email has been broadly embraced by Americans in their personal lives and in the business world, and its use will continue to spread.

Email is asynchronous communication. That is to say, the recipient delivers the message for reading at another time. From the standpoint of an individual message, it is not particularly dependent on high bandwidth because even the largest message can be delivered on a slow connection. The delivery can be delayed for as much as several hours, but the message will eventually make its way to the recipient. Once in the recipient's mailbox, the speed of the connection is irrelevant.

It would appear therefore, that Broadband has little importance for email. However, the opposite may be true. More and more emails are sent with large file size images or sound or video clips attached. In an effort to limit congestion, ISPs and email services have begun to limit the size of these attachments, much to the dissatisfaction of users. Broadband would allow these restrictions to be lifted, and email volume and user satisfaction would increase.

F.2 Information Gathering and Research

While email easily outdistances all other online activity, online users are also connecting to the Internet to search for a dizzyingly wide variety of information to help them at school, work, and in their personal lives (A Nation Online 31).

Information gathering and research is probably the oldest Internet application, and its popularity may be responsible for the early and wide adoption of the Internet by the academic community. Universities have made the Internet widely available to students and faculty, and 73% of college students say they use the Internet more than the library for information searching (Pew, “Internet Goes to College” 3,8). The Internet is also favored by middle and high school students, which regard the Internet as a virtual textbook and reference library. They think of the Internet as the place to find primary and secondary source material for their reports, presentations and projects (Pew, “Digital Disconnect” 6). Academia's adoption of the Internet as an information gathering and research tool in education has been so dramatic that academic and research backbone bandwidth growth has grown at 60% per year – doubling every 18 months – for the past two and a half decades (Bruce 16).

From an initial narrow focus on information for academic purposes in the early 1990's, Internet information gathering now embraces the full spectrum of Americans' interests and pursuits. When they are thinking about health care information, service from government agencies, news, and commerce, about two-thirds of Americans say they expect to be able to find such information on the Web (Pew "Counting on the Internet").

A March 2001 survey showed 82 million Americans had used the Web to get product information before making a purchase. Information about travel services prior to purchase had been sought by 72 million, and 64 million had sought purchase-influencing information on movies, books, and music. Another 64 million had sought healthcare information, although this is not strictly motivated by a need to "purchase." (Pew" Getting Serious" 21).

In fact, healthcare information seeking has a dynamic different from most other product/service-information seeking purchase activities and is growing more rapidly. In a national survey conducted March 1-31, 2002, the Pew Internet Project found that 62% of Internet users, or 73 million people in the United States, have gone online in search of health information. About 6 million Americans go online for medical advice on a typical day. That means more people go online for medical advice on any given day than actually visit health professionals, according to figures provided by the American Medical Association (Pew, "Vital Decisions" 4). Healthcare information seeking increased more than 60% from March 2000 to March 2002 (Pew, "Getting Serious" 21).

Other popular information seeking activities focused on news, stocks/financials, job hunting, home/apartment hunting, and information/services from units of government serving the information seeker (Pew, "Getting Serious" 21).

F.3 Online Transactions

Online Purchases

Given the 82 million Americans who went online for product information in the March 2001 survey, it's not surprising that 58 million Americans (according to the same survey) bought a product online. Travel services were purchased by 46 million. (Pew, "Getting Serious" 21).

The model for most products and services available to be purchased online is similar to the mail order catalogue. Shoppers use a web browser to browse available products and services and obtain detailed information, then "click" to buy. The vast majority of online purchases are made using credit cards, typically submitted through web pages that provide for encrypted transmission of the credit card information.

Largely as the result of privacy concerns, new Internet users are at first hesitant to make purchases online. However, once their first purchase is made, they quickly become frequent online shoppers. The choice to conduct an online transaction is tantamount to a choice to take one's Internet use to the next level (Pew, "New Internet Users" 19).

It is important to note that while online purchasing continues to grow, it still represents only a fraction of the total retail trade: in 2002, when U.S. retail trade was estimated to be $3.5 trillion, online purchases were only $74 billion, 2% of the total (Pew, "Holidays" 6).

Other Online Transactions

Beyond the online shopping described above (which is nothing more than accelerated mail order catalogue shopping with a broader reach), the Internet is also used for online transactions involving banks, stockbrokers, bill paying, and auctions.

Users of online banking systems can perform basically the same banking functions offered by telephone banking systems: transferring funds between accounts, wire transfers, loan application, and other account maintenance activities. To some extent, online banking will replace telephone banking. The March 2001 Pew study identified 25 million Americans who had made use of online banking (Pew, “Getting Serious” 21). According to a December 2001 report by Celent Communications as reported by CyberAtlas.com, virtually all major and second-tier banks (banks with at least $30 billion in assets) have implemented transactional Internet banking. “Banks are discovering that active users of their online banking services are much less likely to jump ship to another institution,” said Neil Katkov, co-author of the report. “A rich Internet banking platform improves not only the stickiness of the site, but more importantly, the stickiness of the bank itself” (Pastore, “Banks”).

The March 2001 Pew study further shows that another 13 Americans million had used online interfaces offered by stock brokers and fund managers to manage their accounts and sell and/or buy securities and fund shares (Pew, “Getting Serious” 21).

It is significant to note that these online banking/financial transactions are of a different character than online shopping. Where online shopping has its mail order catalogue analogue in the old economy, online banking/financial transactions do not. (Despite the parallel services offered by telephone banking, it does not have the same potential as online because it can offer neither the scope of choices nor the flexibility of online.) The sort of service these online transactions offer simply cannot be offered outside the Internet.

Online Auctions

The Internet has also given new life and dimension to auctions, the centuries-old practice (used primarily) for selling commodities of undetermined value. A 2001 Harris Interactive survey as reported in CyberAtlas.com reveals that 31% of online Americans participate in online auctions (Pastore, “Confident”). What is even more striking is that the number of daily auction participants has more than doubled since mid-2000 (Pew, “Holidays” 11). The web offers a solution to the limitations of traditional auctions: it can attract a larger audience of bidders, removes geographical boundaries and can continue for an extended period of time (Fickel).

On eBay, the most popular and best known auction site, items up for auction are displayed on web pages with an interface that allow users to bid and view current bid price in more or less real-time. One of the intriguing features on eBay is the ability for the bidder to specify his or her maximum bid and the increments that the bid should increased by in response to those of other bidders. For example, a bidder bidding on an item for which the current bid is $200 might specify that his or her bid should be incremented by $50 up to a maximum bid of $600. Once the bidder commits to this bid, it enters the eBay system. If the current high bidder for the same item had specified a maximum bid of $300, the new bidder is the new high bidder, and the new high bid is $350. The bid update process is automatic and takes place in seconds, and the pace of the auction is fast.

Auction sites have proliferated on the Internet following the profitable example of eBay, and the variations on this model (combinations of trading interests and types of auctions) are too numerous to be covered here. While the online auction business as exemplified by eBay is a success as one of the few dot-com phenomena to generate real revenue in the short term, the real significance of online auctions is that it points the way to an Internet-based, vast, and rapid market for online procurement used by businesses.

F.4 E-Procurement

E-procurement takes the form of Internet market exchanges, E-auctions, purchasing consortia, and E-procurement software systems. Market exchanges and auctions, for the most part, require a supplier or buyer to monitor the auction or exchange and act manually to sell or buy. Purchasing consortia are simply pooled efforts to reduce unit costs through volume, and they too usually require “manual” intervention in order to execute the sale (Palmer).

E-procurement software systems, however, reduce or eliminate manual intervention by integrating the purchasing systems of buyers with those of sellers so that a purchasing officer can submit an order on his or her purchasing system, and suppliers' systems can respond. Competitive offers to fill the order are sorted and perhaps even awarded and fulfilled automatically. The four most important reasons for e-procurement investment are expected cost savings, increases in efficiency across the value chain, price reductions on purchased goods, and reductions in fulfillment time (Palmer).

In Cleveland, e-commerce exchanges have been set up for the steel and chemical industries. Geon Corporation, a major polymer manufacturer, set up GetGeon.com to serve as an e-commerce site for its industrial customers. Its main attraction is automated ordering and order filling. In its first three months, GetGeon processed $10 million in orders (Pew, “Cities” 34).

E-procurement has the potential to lower costs dramatically for buyers by expanding the potential supplier-bidder pool Internet-wide. Likewise, sellers can view and bid on order requests Internet-wide, thus expanding their base of customers. However, e-procurement has not taken off as quickly as one might suppose. As of 2001, only about 3% of procurement was done by U.S. businesses using any of the e-procurement strategies described above. Projections made at that time called for a 445% growth rate in two years (Palmer).

That sort of volume has not yet materialized, and sellers/suppliers have been reluctant to participate in an activity that lowers their selling price but does not provide increased unit volume. On the purchaser side, e-procurement requires that the e-procurement system be integrated into existing inventory practices, and e-procurement solution providers have not been able to justify the cost of their systems when price savings are available only on small numbers of the goods they buy (Pastore, “Future”).

As a result, the promise of e-procurement is currently stalled in a “chicken-or-egg” mode in which purchasers and suppliers are waiting for action by one another before dedicating resources to move e-procurement forward. “The full impact of economic conditions are seen in mixed progress by many companies.... While the general trend is positive, I believe there is now more of a tendency to wait and see before making major strides. This does not mean that the goal is being re-assessed, but that the timing may not be as quick as initially planned,” said Edith Kelly-Green, vice president, sourcing and procurement at FEDEX (Pastore, “Future”).

Only the timing of widespread implementation of e-procurement may be in question: the potential efficiencies are too great to be ignored, particularly by purchasers of huge volumes of goods like the Big Three auto companies. They are moving forward to implement e-procurement with their existing supplier base through Covisint, an online clearinghouse focused on e-procurement.

Covisint was formed by DaimlerChrysler, Ford, General Motors and Renault-Nissan. Peugeot Citroen later joined the initiative. If suppliers hope to continue selling to these major corporations, they will have to comply with e-procurement standards set by the purchasers. Compliance by this core group may be the impetus that pushes volume to the "critical mass" necessary to bring about widespread implementation.

F.5 Entertainment

As the Internet has moved from its initial setting in academic institutions to the workplace and more recently to the home, it is becoming a home-based information/entertainment tool, and is less of an extension of work or school. (Pew, "new Internet users" 6) Entertainment uses of the Internet, most of which are pursued at home, run the gamut from arcade-like games to information gathering related to hobbies to listening to music or watching video.

22% of Internet users, or about 21 million Americans have downloaded music online (Pew, "Downloading" 3). 42% of Internet users report that they use the Internet to play games, and 19% report that they watch video or listen to the radio on the Internet. (A Nation Online 31).

Despite the common use of the Internet for entertainment purposes, most users believe the Internet is more important as a source of information than as a source of entertainment. In 2002, 25 percent of users said that the Internet is a very important or extremely important source of entertainment, up from 21.1 percent in 2001, and about the same as in 2000 (24.9 percent) (Cole 36).

However, the Internet as an entertainment source grows as experience online increases. More than triple the number of very experienced users compared to new users considers the Internet a very important or extremely important source of entertainment (Cole 36).

Interestingly, this content is, for the most part, not being delivered to entertainment or gaming consoles but to PCs originally intended for academic and business productivity.

In an odd twist, PCs used for entertainment have moved from the den or home office into the living room or family room. Frequently, users watch TV and use the web for entertainment purposes simultaneously. A May 2002 study showed simultaneous TV and Internet usage among consumers ages 35 to 49 had nearly doubled in six months to 11% (Saunders).

G. Summary and Conclusion

In summary, when users have broadband services, they find ways to use it that they had not anticipated when they were inexperienced with it. Internet deployment – using it – is growing. The trajectory of bandwidth growth shows no sign of slowing significantly. Application Service Providers are refining their business cases, and businesses are beginning to see that network-based applications will allow small to medium sized businesses the back-office advantages of their larger peers. Finally, network convergence is anticipated to continue and strengthen the demand for TCP/IP networking requirements. But hard data to make a "safe" projection and investment are difficult and expensive to obtain, resulting in broadband deployment being stuck in a "chicken-and-egg" scenario from the standpoint of investment and development.

The solution at the local level is for leadership to emerge that takes the first step that takes the risk, which sets in motion the activities that will lead to advancement and economic development. Historically in this country, these leaders and visionaries have transformed industries.

The experience of TVA shows that the results of such leadership can transform an industry and be singly responsible for significant economic development. It was the depth of the Depression, and the federal government under President Franklin Roosevelt had been given a national mandate to take extraordinary measures to get the economy back on track. With the clout of the federal government behind it, the TVA pushed the project through against very strong local opposition. Ten years after the project was completed, the resistance was forgotten, and those that had once been chastised as meddling bureaucrats were now extolled as leaders. The Tennessee Valley economy flourished, growing 204% from 1939 to 1947, compared to a national rate of 180%.

An example of visionary leadership in telecommunications was Theodore Vail, president of AT&T from 1907 to 1915, who made "One System, One Policy, Universal Service" the Bell System credo. As Vail explained, the Bell network was "one system telephonically interconnected, intercommunicating, and interdependent" It's value was to be measured by the possibility of reaching through its connection anyone-at any possible place.

Regardless of one's perspective on the Bell System or regulated monopolies, this vision was integral in achieving near 100% penetration by 1950 and the voice network we enjoy today.

At some point in the future when Broadband deployment is universal, we may look back at attempts to forecast demand based on specific uses of the network as having been beside the point. Did the Vail and the other proponents of a universal voice system at the beginning of the twentieth century try to predict all the possible subjects of future phone calls in order to justify the build out of the voice Public Switched Telephone Network? No, quite the contrary: they saw that the primary value of universal service would be its ubiquity. Only a universal system, they saw, would provide the environment in which businesses and individuals would be sufficiently motivated to develop practices that made use of the new technology.

Similarly, the value of Broadband deployment will not be fully known until deployment is universal or near-to-universal.

The deployment of broadband is not in its infancy, but it is far from mature, and it is far from "universal". As with all significant advances, visionaries are needed to point the way, and leaders are needed to clear the way and to guide the process.