Advanced Communications Technologies

December, 2006

A Report By

The Connecticut Academy of Science and Engineering

For

The Connecticut General Assembly
Commerce Committee
Energy and Technology Committee

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This study was initiated at the request of the Energy and Technology Committee and the Commerce Committee of the Connecticut General Assembly on June 8, 2006. The project was conducted by an Academy Study Committee with the support of Zachary Morowitz, Project Study Manager. The content of this report lies within the province of the Academy's Communication and Information Systems Technical Board. The report has been reviewed by Academy Members Juha Javanainen, PhD, and Chandra Roychoudhuri, PhD. Martha Sherman, the Academy's Managing Editor, edited the report. The report is hereby released with the approval of the Academy Council.

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EXECUTIVE SUMMARY

STUDY OBJECTIVE

During the past several years, Connecticut has identified and implemented strategies for growing its economic base and for achieving a leadership position in the rapidly evolving global economy. As part of that effort, the Energy & Technology Committee of the Connecticut General Assembly asked the Connecticut Academy of Science and Engineering (CASE) to "conduct an assessment of the benefits of creating a world-class digital/communications infrastructure (WCCI) for businesses and individuals in Connecticut, and to identify what needs to be done to accomplish that goal."

SUMMARY OF FINDINGS

Features of a World-Class Communications Infrastructure (WCCI)

A WCCI includes the following features:

- at least one viable option for broadband Internet connectivity for virtually all citizens and businesses
- wireless broadband access that is sufficiently available to create a business-friendly environment and to provide mobile workers and other traveling professionals access to large volumes of information
- ultra-broadband connectivity, i.e., Internet access at speeds of 100 megabits per second (Mbps) or higher, which is available and cost-effective for those businesses that want it, regardless of the size of the business
- infrastructure development process that anticipates and provides the dramatically higher residential bandwidth needs that can be expected over the next 5-10 years

Benefits of World-Class Communications Infrastructure (WCCI)

Virtually every aspect of modern life—work, school, home, entertainment and play—is becoming increasingly dependent on the creation, manipulation and transmission of digital information. The ability of Connecticut's citizens to quickly send and receive large quantities of data from a broad variety of fixed and mobile locations will profoundly impact the state's ability to compete and thrive in the emerging global economy.

The availability of widespread, broadband Internet access in selected geographic regions is a relatively recent phenomenon. Consequently, economists are at only the initial stages of understanding and quantifying the economic benefits of this capability, but early indications are that broadband is clearly related to economic growth and vitality.

A WCCI delivers clear benefits across a broad range of applications for business, government, education and leisure activities, including the following:

- facilitating universal participation in the full range of the Internet's benefits
- enhancing communications options such as Voice Over Internet Protocol (VoIP) that provide increased functionality at lower cost
- enabling distance learning capabilities that can reduce the student performance disparity among the state's school districts, supplement the curricula of the state's colleges, and facilitate access to Connecticut's abundant higher education resources by students both within and outside the state.
- improving the delivery of government services including public safety and transportation management
- promoting telecommuting as a means of combating transportation shortcomings
- spurring economic development by creating a business-friendly environment
- fostering the development of new commercial services and business models
- promoting new entertainment activities and services such as Internet Protocol Television (IPTV) and gaming

Developing a World-Class Communications Infrastructure (WCCI) for Connecticut

While Connecticut's level of broadband deployment is among the best in the United States, it significantly trails many other regions in the world with whom Connecticut must now compete. Given the competitive significance of widespread broadband deployment, it is suggested that the state should actively promote the development of a WCCI on an ongoing basis.

Numerous municipal broadband projects have been launched in the United States, including several in Connecticut, but they tend to lack clear objectives and well-defined metrics to measure success. Wireless coverage problems in urban landscapes have been dramatically underestimated, leading to unrealistic expectations about the usefulness of the network. While municipal fiber projects are also being explored in a number of venues, no business model has emerged to make this an economically feasible option.

Although the Study Committee believes there are no compelling reasons to suggest a major state spending plan to grow Connecticut's communications infrastructure, it is suggested that there are many actions that state government can and should consider to accelerate the development of WCCI.

Most of these actions involve creating a regulatory and legislative environment that promotes investment on the part of private enterprise. These actions would lower the barriers to investment and make Connecticut a location for businesses that could take advantage of the WCCI. A WCCI could also encourage start-up companies and new enterprises to be created and grow in Connecticut to take advantage of these networks and services, or to develop them.

The Study Committee believes that implementation of its suggested actions properly positions the state for the present. However, the rapid pace at which these technologies are evolving makes it critical that the state periodically revisit this subject. The on-going development of a WCCI is essential to Connecticut's continuing economic development and competitiveness.

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I. INTRODUCTION

BROADBAND AS A KEY COMPETITIVE ADVANTAGE

Since the late 18th century, Connecticut has been one of the world's leading centers for commerce, research, education and the arts. As Connecticut strives to maintain its position of leadership into the 21st century and beyond, its communications infrastructure will play an increasingly central role in the state's ability to successfully compete on a global level. With today's knowledge-based, global economy ever more centered on the creation, manipulation and transmission of digital information, networks that provide broadband Internet access have joined such traditional infrastructure elements as highways, ports, railroads, utilities, water and sewers as key enablers for commerce, education, recreation and government. Regions that are able to deploy a truly world-class communications infrastructure (WCCI) will have a clear competitive advantage well into the future.

When comparing Connecticut to other regions in the United States, it is clear that the state possesses a sophisticated communications infrastructure that provides comparatively high levels of broadband Internet access. In 2004 the Connecticut Office for Workforce Competitiveness (OWC) published a report, *Connecticut's Broadband Infrastructure*, which studied the supply and demand for advanced telecommunications services in the state. This report concluded that Connecticut has "significant amounts of network backbone" compared to similar states, and that the state has "exceptional broadband population coverage at 94.6%," meaning that this large fraction of the population can access a broadband connection if they choose to connect. A more recent study (http://www.websiteoptimization.com/bw/0608) placed Connecticut 3rd among the 50 states in broadband penetration, trailing only New Jersey and Hawaii, and far surpassing the nationwide average.

Yet given the truly global nature of today's competitive environment, the state can ill afford to take comfort in such a comparison. Today's environment demands that both the United States and Connecticut look beyond our country's borders to compare our capabilities with the regions across the globe that have the most sophisticated and developed communications infrastructures. This comparison reveals a far bleaker picture.

The United States was largely responsible for the birth and initial development of the Internet, and through the 1990s, led the world in broadband deployment. By 2001, this lead had evaporated, with the United States falling to 4th place among countries in per capita broadband deployment. Since then, the standing of the United States has continued to deteriorate rapidly. In the past year, the United States fell from 17th to 20th place, falling behind Sweden, the United Kingdom and Luxembourg — this despite the fact that residential broadband penetration in the United States grew more than 27%. While our growth in broadband access may seem impressive, the United States is simply not keeping pace with more aggressive efforts in other regions.

Asia has emerged as the world leader in the large-scale deployment of high-speed broadband. South Korea and Hong Kong boast penetration rates surpassing 80%, while the United States

rate is less than 50%. South Korea has provided high-speed wireless networking in most major buildings. In 2003 Japan surpassed the United States in percentage of homes with broadband, and through aggressive leadership and ambitious goal setting has continued to widen the lead by deploying an affordable and widely available fiber optic "ultra-high-speed" broadband network (i.e., Internet access at speeds of 100 megabits per second [Mbps]). In the area of Internet access through mobile phones, Japan is also dramatically ahead of the United States. In terms of absolute numbers of broadband users, China has now passed the United States. These Asian countries, by enabling large numbers of their citizens to take full advantage of the benefits of broadband Internet access, are aggressively positioning themselves to be leaders in the new, global economy.

II. WORLD-CLASS COMMUNICATIONS INFRASTRUCTURE (WCCI)

BENEFITS OF A WORLD-CLASS COMMUNICATIONS INFRASTRUCTURE (WCCI)

The availability of widespread, broadband Internet access in selected geographic regions is a relatively recent phenomenon. Consequently, economists are at only the initial stages of understanding and quantifying the direct economic benefit of this capability. For example, a study published in Broadband Properties in December 2005, "Measuring Broadband's Economic Impact," while acknowledging the current limits of such research, was able to conclude that "broadband is clearly related to economic well-being and is thus a critical component of our national communications infrastructure."

However, it is abundantly clear that virtually every aspect of modern life—at work, at school, at home and at play—is becoming increasingly dependent on the creation, manipulation and transmission of digital information. The ability of Connecticut's businesses and citizens to quickly send and receive large quantities of data from a broad variety of fixed and mobile locations will profoundly impact the state's ability to compete and thrive in the years ahead. As Thomas Friedman put it in his recent bestseller *The World is Flat*:

> We are entering a phase where we are going to see the digitization, virtualization, and automation of more and more everything. The gains in productivity will be staggering for those countries, companies, and individuals who can absorb the new technological tools. And we are entering a phase where more people than ever before in the history of the world are going to have access to these tools—as innovators, as collaborators, and, alas, even as terrorists. You say you want a revolution? Well, the real information revolution is about to begin. (p. 47)

As Friedman points out, the primary creators of wealth, knowledge and entertainment will increasingly be those with this ability to master these new technological tools, and broadband Internet access is the key enabling infrastructure element.

Thus, it is quite evident that the benefits of a WCCI will be broad, profound, diverse and compelling. At one end of the spectrum, a WCCI has the potential to drastically reduce the "digital divide" by providing fast, affordable and easily accessible links to the Internet for all of Connecticut's citizens. At the other end of the spectrum, a WCCI holds the promise of helping Connecticut assert a leadership position as a center of commerce and innovation in the knowledge economy. And in between, a WCCI can enable a myriad of applications that promote business activity, enhance education and improve the quality of life.

Benefits of a WCCI include the following:

End the "Digital Divide"
As personal computers and Internet access have become essential tools for education, business and communication, ending the "digital divide"—the gap between those with access to these tools and those without—has long been a concern of many in society and government. While efforts to eliminate the "digital divide" have shown significant success, a second divide has emerged between those with a high-speed connection and those without.

Previously, a dial-up connection was sufficient to take advantage of the Internet's main functions: using email or viewing Web pages. The Internet today is a much more interactive environment, filled with multimedia content where users are routinely uploading and downloading vast quantities of data in the form of videos, podcasts, images and music files. In addition, many applications are now Web-based, where the software resides remotely with on-line accessibility instead of on the local computer/server on which the user is working; most of these services are unusable without a fast connection.

A WCCI that provides ubiquitous broadband Internet access would allow everyone in the state to fully participate in the Internet as it develops and matures. This means not only enabling full access to the exploding variety of on-line resources, but also promoting the contribution of user-generated content to the on-line world.

Enhance Communications Options
Broadband provides the foundation for new telecommunications technologies such as Voice Over Internet Protocol (VoIP), which may reduce the cost of phone service and has the potential to provide a better integrated set of computing and communication tools.

Enable Distance Learning
In an economy that depends on knowledge and innovation to generate wealth, a highly educated workforce is an essential economic driver. Distance learning, i.e., education that takes place over the Internet instead of in a classroom with an instructor, has emerged as a key element for meeting the educational needs of the state's citizens.

A major challenge for Connecticut is the K-12 student performance disparity in the state's various school districts. Some urban districts experience shortages of qualified teachers, while lower enrollment in rural districts can limit the diversity of their course offerings. Distance learning can help level this playing field by providing accessibility to a broad array of instruction and other educational resources to every district in the state at a relatively low cost.

Distance learning can also augment higher education in two important ways. First, it can be used to supplement the curricula of the state's colleges by giving students access to instructors and material from anywhere in the world. Second, as education becomes more of a continuing lifelong process, distance learning can provide individualized access to higher education to those people who for logistical reasons (i.e. distance, time and scheduling due to work, family and travel) are unable to physically attend classes. Finally, distance learning can be an important export for the state. With a variety of universities, including those which enjoy international reputations or close ties to the

high technology companies in the state, telecasting to countries that do not have this level of human capital can be an important benefit. This requires significant bandwidth from many classrooms and campuses to make the experience and the volume of activity worthwhile.

Improve the Delivery of Government Services
A WCCI can enable government to improve service delivery in the following areas:

- enhancing public safety through real-time access to building plans, incident management reports, and hazardous material information
- delivering streamlined constituent services by providing self-help channels for information and interaction with government over the Internet
- streamlining transportation management by monitoring traffic with wireless sensors on roads and highways, such as for incident and work zone areas
- increasing productivity through workforce mobility

Promote Telecommuting
Telecommuting has emerged as an important strategy for combating highway congestion and the lack of adequate mass transit. These transportation shortcomings can form a significant barrier to economic development, and to retaining skilled workers who cannot work conventional commuting schedules. In most cases, telecommuting requires a broadband connection to be available.

Advanced videoconferencing capabilities, enabled by very high-speed "ultra-broadband" connections, are ushering in a whole new generation of telecommuting. At the most sophisticated sites, virtual meetings can now be conducted with a high degree of spontaneity, transparency and productivity, drastically reducing the need for people to physically gather.

Provide Channels for Exporting Intellectual Capital
While broadband connections have provided the means for US companies to outsource certain functions overseas, they also make it possible to export our intellectual capital to foreign markets. Connecticut is today a well-recognized leader in medicine and higher education. A world-class communications infrastructure dramatically increases the prospects for marketing these services to areas outside the state and the region.

Spur Economic Development By Creating A Business-Friendly Environment
Business leaders recognize that today's global economy — driven by knowledge and innovation, and dependent on the seamless and instantaneous collaboration of individuals and businesses around the world —requires a communications infrastructure that supports the easy transmission of vast amounts of digital information. Increasingly, more professionals will be mobile workers who work at customer, supplier, or client locations, yet access information and images through their own or public networks. Consequently, many governments around the world are actively engaged in working to enhance their communications infrastructure as a key means of attracting more business and creating an effective environment in which they can operate and excel.

Enhance Quality of Life
Broadband access provides numerous services, including video entertainment, gaming, and recreational learning that enable people to enhance their leisure-time options. Such access can act as a significant differentiator between communities as people, especially mobile newcomers, decide where to locate.

It is important to note that the information revolution is still in its infancy. Technological and commercial innovation is happening so rapidly that it is simply impossible to predict with any certainty the future impact of the information revolution on business, education and leisure activities. Most predictions of the impact of information technology infrastructure have been woefully shortsighted, including those by leading proponents such as Bill Gates. What is certain is that a WCCI will form the essential foundation for any region that wants to be a leader in the emerging global economy.

FEATURES OF A WORLD-CLASS COMMUNICATIONS INFRASTRUCTURE (WCCI)

A WCCI includes the following features:

- At least one viable option for broadband Internet connectivity for virtually all citizens and businesses, enabling universal participation in the Internet's benefits.
- Wireless broadband access that is sufficiently available to create a business-friendly environment and to provide mobile workers and other traveling professionals access to large volumes of information. The availability of such technical capabilities is expected to spur the development of new commercial services and business models.
- Ultra-broadband connectivity that is available and cost-effective for those businesses that want it, regardless of the size of the business. This entails Connecticut becoming a leader in driving high bandwidth channels such as fiber and broadband wireless "the last mile" from providers to customers.
- The emergence of the Internet as a vehicle for the transmission of enormous data files including high-definition, on-demand, and two-way video, will increase the need for residential bandwidth by orders of magnitude. While estimates vary, most analysts predict that average households will need 50–100 Mbps by 2010. Planning for a WCCI must anticipate these dramatically higher bandwidth needs that can be expected over the next 5-10 years.

CURRENT INTERNET CONNECTIVITY OPTIONS

Dial-Up

Dial-up access is available to anyone with a computer, modem and standard telephone line, but is limited to speeds of up to 56 Kbps. Although this is sufficient for such rudimentary applications such as email and viewing Web pages, it is inadequate for using many of the Internet's more sophisticated services and applications.

DSL

Digital subscriber lines (DSL) work over standard copper telephone lines. Data signals are sent at a different frequency than voice service, allowing the two to coexist on a single line. Users must be within about a mile of a switching station or remote electronics to send and receive data using DSL, making DSL availability distance sensitive. Some providers now deliver speeds up to 6 Mbps.

Cable Modem

Cable companies use coaxial cables that pipe TV and movies into homes to deliver Internet access at speeds up to 4 Mbps. Performance can vary by provider and neighborhood due to the fact that bandwidth is shared by a pool of users.

Wi-Fi

Wi-Fi "hotspots" provide wireless, broadband Internet access using available spectrum in unlicensed bands. They are commonly found in coffeehouses, airports and other public spaces, and are often offered free to users or with a small access charge. Most municipal efforts to proliferate broadband access use a large number of Wi-Fi hotspots in an attempt to create near-continuous wireless coverage.

Wi-Fi transmitters are designed with a short working distance (300 feet) because they operate in unlicensed bands. The signal has difficulty penetrating into buildings, making in-building coverage problematic. However, buildings can be fitted with internal antennas to provide excellent indoor wireless service. In these cases, some businesses have found that workers can operate with only a company-issued cellular phone that is their single reach number. The protocols and financial responsibility for wiring buildings, be they government or enterprise, have not been well developed in the United States, delaying progress in in-building coverage that is well developed in countries like Korea and Japan.

Wi-Max

Wi-Max is a long-distance (up to 30 miles) version of Wi-Fi, although unlike Wi-Fi it may operate in both licensed and unlicensed frequencies. There will be both fixed and mobile versions of the protocol and devices, so it has the potential to challenge and/or complement conventional cellular service providers in mobile access for voice and data. At some higher frequencies, Wi-Max may have line-of-sight requirements between the access point and the wireless terminal. Commercial deployments of Wi-Max are in their very initial stages, but this is a technology that could provide a major paradigm shift in the access to information and the providers of this access. Wi-Max could initiate a distinct shift in the way that mobile broadband data and voice are delivered, and it would be important to assure that Connecticut is at the forefront of this shift in both availability of new services and the enterprise that evolves to deliver them.

Fiber Optics

While fiber optic service is broadly available for businesses throughout the state, residential fiber service is in its infancy. Fiber systems offer the promise of ultra-high bandwidth, and thus are "future proof." Data transmission rates can range from five to hundreds of megabits

per second, which is up to hundreds of times faster than traditional broadband services. The extraordinary capacity of fiber opens the door to applications that require high definition streaming media such as interactive TV. In addition, fiber can enable an entire new class of workers to have the option of telecommuting due to the ultra-high bandwidth they would enjoy at their residences.

Verizon has announced its FiOS service, with download speeds of up to 30 Mbps available for $200 per month, and speeds of 15 Mbps costing about $50 per month. The complexity, cost, and logistics of installing a fiber optic line into every home, known as "fiber to the home" (FTTH), guarantees that availability will be limited for some time to come.

AT&T's Project Lightspeed is another nascent residential fiber service. While new construction in neighborhoods served by AT&T will have fiber lines installed into homes, existing neighborhoods will have fiber brought into the neighborhood (known as "fiber to the node"), with existing copper wire being used for the final connection to the homes. Projected bandwidth to each household will be in the same range of Verizon's FiOS service, and both will be dramatically faster than existing residential broadband options.

Broadband Over Power Line

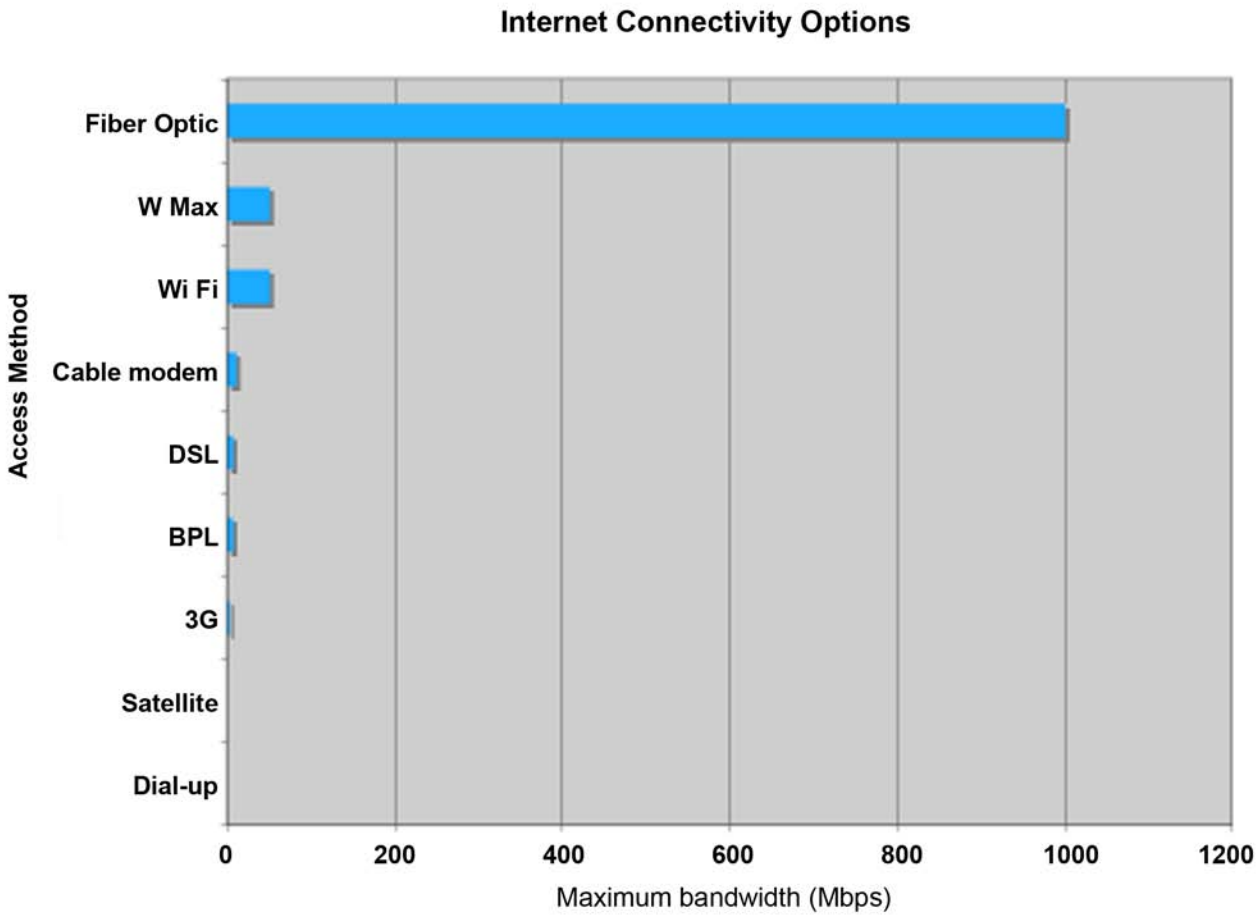
Broadband Over Power Line (BPL) capitalizes on the same phenomenon that allows DSL to share a common wire with voice traffic, since electricity and data signals travel at different frequencies. Power companies around the country have been conducting tests to determine the viability of offering broadband via the existing electrical wires that come into every home. This service is currently available in a limited number of cities with speeds ranging up to 3 Mbps, and with prices generally in the same range as DSL and cable. While a potential option for areas without DSL or cable availability, issues with the data signal producing broadcast interference have yet to be fully resolved. In addition, power companies lack the service bundling possibilities of phone or cable providers, calling the viability of the business model into question.

Satellite

Satellite is usually the only broadband option for those in rural areas without DSL or cable service. Data rates range up to 500 Kbps, which exceeds the FCC 200 Kbps definition of broadband, but which is significantly slower than other broadband options. Satellite is more expensive as well. The delay introduced by the distances involved makes it unsuitable for certain applications such as VoIP, gaming and other forms of real-time two-way communications.

3G Cellular Data Services

3G (third generation technology) is a broadband wireless data service with speeds up to 700 Kbps that is offered by cellular service providers. Coverage remains limited to specific areas, but is becoming more widespread. Prices are generally higher than DSL and cable and there are physical and technical limits to how many broadband subscribers can be accommodated on the limited frequency spectrum allocated for these services.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W Max
Wi Fi
Cable modem
DSL
BPL
3G
Satellite
Dial-up
0
200
400
600
800
1000
1200
Maximum bandwidth (Mbps)

III. MUNICIPAL BROADBAND

MODELS FOR MUNICIPAL BROADBAND

Municipal Wireless

The growing importance of broadband connectivity has prompted hundreds of government entities around the world, including more than 300 in the United States, to become directly involved in efforts to support and promote Internet access. These efforts have become intensely controversial for a number of reasons, including the potential competition between government entities and private providers, the ability of governments to manage complex technological undertakings, and the suitability of having governments subsidize Internet access.

Municipal efforts to increase Internet access have largely focused on promoting deployment of wireless broadband networks. While in some cases cities have subsidized municipal Wi-Fi networks, the more common arrangement is for the cities to grant a private company exclusive use of city property for the placement of transmitters in return for free use of the network by city agencies.

The network providers, in turn, rely on subscription fees, advertising revenue, or a combination of the two for revenue. Initially, providers focused on subscription fees as their primary revenue source, but they have generally been disappointed in their ability to attract paying customers. In addition, cities like to tout their ability to provide "free wireless Internet access" to their citizens and visitors. Consequently, there has been a pronounced shift toward models that provide a combination of fee-based and free, ad-based service.

Municipal Fiber

Cities such as Seattle, Berkeley, Ft. Wayne and Palo Alto, as well as the state of Utah, have begun to explore municipal fiber to the home (FTTH) as an alternative to municipal Wi-Fi. Municipal fiber projects seek to overcome the technical limitations of Wi-Fi, and to deploy a much more robust and long-term broadband infrastructure. The belief is that affordable access to ultra-high bandwidth will foster a surge of revolutionary Internet applications that will drive the next generation of commerce. In the opinion of these cities, private companies have not shown a willingness to invest in residential fiber installations at a satisfactory rate, and government intervention is needed. Some rural communities have also invested in FTTH systems for similar reasons.

EXAMPLES OF MUNICIPAL WIRELESS PROJECTS

Efforts to evaluate municipal broadband projects are complicated by the diversity and fluctuating nature of the goals. Broadly stated, cities hope to help less affluent people gain access to the Internet, improve the delivery of government services, and help make their city more business- and tourist-friendly. But in none of these cases are there agreed upon standards for what constitutes success.

While free broadband access would constitute notable progress toward bridging the digital divide, service that provides only spotty coverage, low bandwidth, and an ad-intensive environment would dramatically reduce its utility and benefit. To date, the ability of municipalities to bridge the digital divide by providing free, broadband service to a significant number of citizens has yet to be proven. Similarly, using a wireless broadband network to improve the efficiency and quality of government service delivery is also a work in progress. Finally, the objective of using municipal broadband to attract business activity and stimulate economic development has been equally difficult to quantify and realize. While cities have certainly received substantial public relations exposure by their efforts to become a leading "unwired" city, it is unclear whether these projects have been an actual stimulus to economic development. Conversely, the enterprise models and forms of work that take full advantage of this untethered capability are only emerging now, so it is still too early to assess their longer-term impact.

Some examples of municipal wireless broadband projects are as follows:

Philadelphia
Philadelphia hired Earthlink to fund, build and manage a wireless network that will cover the city's 135 square miles. Earthlink estimated it would cost $10-$15 million to build the network, and would offer 1 Mbps service for about $20 per month, or $9.95 for low-income residents. Earthlink also plans to rent access to other Internet service providers, and to charge business travelers and tourists for use. Originally scheduled to launch in summer 2006, testing began on a 15 square mile proving area in fall 2006.

San Francisco
San Francisco Mayor Gavin Newsom announced a free wireless access project called TechConnect in August 2005. Specifications called for 95% outdoor and 90% indoor coverage, as well as seamless coverage for users traveling 30 miles per hour.

In April 2006, the city provisionally accepted a joint Google-Earthlink proposal in which Google would provide free, ad-based Wi-Fi service running at 300 kbps. Earthlink would build the network hardware and would offer much faster megabit-per-second service for $20 per month. The network would be mounted on city-owned light poles and traffic lights. While claiming to meet the city's overall coverage specifications, there would be no guarantee of reaching above the second floor of buildings.

Critics charge that promised service levels are unlikely to be met, that privacy issues have not been addressed, and that effectively granting Google-Earthlink a ten-year monopoly on wireless Internet service makes little sense given the rapid pace of technology advances.

Hartford
Hartford's Wireless Downtown/Blue Hills Wi-Fi Network, in partnership with IBM, launched a pilot program in October 2006. The cost of installing this system has been estimated at approximately $1M.

Boston
A task force has recommended that the city create a nonprofit organization to supervise

the building and management of a citywide, low-cost wireless network. Officials believe that using a nonprofit instead of a private service provider will help the project meet its goals while steering clear of special interests. Other cities have created various layers of oversight to control subscription fees and to ensure coverage in low-income areas. The organization will need to raise approximately $20 million from foundations and businesses to finance the operation.

Orlando
The city of Orlando closed its free downtown Wi-Fi service in January 2005. An average of only 27 people per day used the service at a cost to the city of $1,800 per month.

Taipei, Taiwan
In 1998 Taipei launched CyberCity, an e-government initiative, in an effort to aggressively position itself as an international technology hub. In 2003, the city hired Q-Ware to build an extensive wireless network with 4,100 hot spots that reaches 90% of the population. Taipei provided Q-Ware with access to city property to install antennas and cables. Q-Ware invested about $30 million to build the network, which reaches all subway stations, hospitals and public buildings.

Despite such broad coverage and the relatively low fee of $12.50 per month, only 40,000 of Taipei's 2.6 million citizens have signed up for the service. The company needs approximately 500,000 subscribers to break even. The availability of free Wi-Fi in coffee shops and other public areas has proven to be a difficult barrier to overcome for a fee-based service. In an effort to attract more subscribers, Q-Ware is developing services such as online games, downloadable music and low-priced Internet phone service.

Sunnyvale, CA
Network supplier MetroFi switched in 2005 from offering a subscription-only service to also offering an ad-based service. About 10,000 consumers currently use MetroFi's service in Sunnyvale and neighboring cities of Santa Clara and Cupertino, with about 80% subscribing to the free ad-based service.

RESULTS OF MUNICIPAL BROADBAND PROJECTS

Despite the large number of municipal Wi-Fi projects underway, a small but growing group of critics believe that these projects are shortsighted and flawed in three respects:

- There is no successful economic model that has yet emerged for running a municipal Wi-Fi network. Subscription-based models have not met expectations, and ad-based models have yet to be fully implemented.
- Coverage problems are sure to arise given the technical limitations of Wi-Fi. Many providers explicitly do not guarantee coverage in back rooms and in upper floors of buildings, leading skeptics to question exactly how extensive the coverage will be.
- Most importantly, fiber proponents maintain that only fiber networks can meet future bandwidth needs. They argue that to fully enable the Internet's potential for residential users, broadband capacity needs to be in the 100 Mbps range, far faster than the 1-5 Mbps offered by DSL, cable and Wi-Fi.

As with Wi-Fi, municipal fiber projects face numerous hurdles, including the lack of a viable economic model and the technical complexity of deploying, developing and maintaining these networks. While a number of communities that have installed a FTTH system claim that their programs are successful and well subscribed, making this an economically feasible option remains unproven.

IV. SUMMARY OF FINDINGS AND CONCLUDING REMARKS

FINDINGS AND SUGGESTED ACTIONS

A world-class communications infrastructure (WCCI) will dramatically enhance Connecticut's ability to compete successfully in the evolving global economy by delivering clear benefits across a broad range of business, government, education and leisure applications.

The United States has fallen significantly behind other regions in the world in broadband deployment, and the gap continues to grow. While Connecticut's level of broadband deployment is among the best in the United States, it significantly trails many other regions in the world with whom Connecticut must now compete. Given the competitive significance of widespread broadband deployment, the state should actively promote the development of a WCCI.

Municipal broadband wireless projects have been launched in hundreds of locations across the country, but tend to lack both clear objectives and well-defined metrics to measure success. In addition, the difficulties involved in attaining broad coverage in an urban landscape have been dramatically underestimated, leading to unrealistic expectations about the usefulness of the network.

Municipal fiber projects have been launched in a small number of cities, and are being explored by several others. No model has yet emerged to make this an economically feasible option, but the communities that have installed the fiber believe the systems will have a positive economic impact. It will take a few years to gather meaningful economic impact data since these fiber systems are so new.

Building a WCCI for Connecticut and keeping it world-class over time is a complex undertaking that will involve scores of private companies and dozens of rapidly- evolving technologies. Neither the state nor the cities are likely to have the requisite management and technology expertise to successfully oversee these types of projects.

Consequently, while there are no compelling reasons to suggest a major state spending plan to grow Connecticut's communications infrastructure, there are many actions that the state government can and should consider to promote the development of a WCCI. Most of these actions involve creating a regulatory and legislative environment that promotes investment on the part of private enterprise. These actions would lower the barriers to investment and make Connecticut a location for businesses that would enable them to take advantage of the WCCI. A WCCI could also encourage start-up companies and new enterprises to be created and grow in Connecticut, where they could take advantage of these networks and services and develop them.

There is tremendous value in the state being a leading site for the two major types of infrastructure that will likely make the most difference in spurring economic development:

- FTTX – fiber to the node, the curb, the home.
- Ubiquitous high bandwidth wireless access at affordable rates.

The following suggested actions are offered for the state's consideration to encourage deployment of FTTX:

- Assign responsibility to a state/industry council administered by a state agency to assess needed links in the state's fiber network. Where appropriate, encourage those managing, owning or creating potential Right of Ways (ROW) (roads, rail lines, water line trenches, utility trenches) to add fiber and fiber devices during construction projects and repairs.
- Create policies that encourage anyone creating a ROW to auction or award the right to lay fiber. Provide tax incentives for those making the investments in this infrastructure to encourage its rapid development.
- Secure agreements with major utilities and network suppliers to add fiber to major trench projects that create needed links in the fiber network.
- Create tax policies that promote the building of FTTX as a critical need of the state.
- Undertake a study to develop specific recommendations on how to make the state the leader in FTTX.

The following suggested actions are offered for the state's consideration to encourage the development of ubiquitous, high-bandwidth wireless access:

- Seek and support the early trials of Wi-Max, mobile Wi-Max and other promising wireless technologies as they become feasible. Allow antennas, access points, and back-haul infrastructure to be installed in the trial areas by easing zoning regulations that are obstacles for deployment. Overseas competition will not face such restrictions.
- Ease zoning restrictions that make it difficult to install new antennas that promise much greater bandwidth by forming beams directed at high bandwidth users. The deployment of new antenna technology is stalled because service providers fear legal and zoning battles over larger antennas.
- Make Connecticut a leader in in-building wireless coverage. Particularly for businesses, In-Building coverage could lead to a single mobile phone reach number for each employee, and superb mobile Internet anywhere within a building. This has the potential to provide businesses that currently fund both desk phones and mobile phones for most employees with major communications cost savings.
    a. Provide tax incentives to encourage developers to construct In-Building wireless broadband facilities that enable service providers to implement services and achieve a reasonable return on investment.
    b. Develop a tax incentive plan to encourage service providers to provide broadband services in areas populated with citizens who are unlikely to be able to afford such services.

- Use the Connecticut Venture Group (CVG), the Connecticut Technology Council's (CTC) Fast Track Program and Connecticut Innovations to encourage start-up and entrepreneurial initiatives that address emerging wireless technology.
- Undertake a study to develop specific recommendations on how to make Connecticut a leader in next generation broadband wireless technologies.

Several state government initiatives provide useful models for the type of activity that could actively promote a WCCI in Connecticut:

- The Film Division of the Connecticut Commission on Culture & Tourism has successfully persuaded media companies to use the state as a filming location through a combination of logistical support and financial incentives. They provide comprehensive information on locations and available resources, as well as offering significant tax credits to qualifying companies.
- The Governor's Energy Vision for Connecticut, which was released in September 2006, provides a blueprint for the state's energy future. It provides a broad list of aggressive goals, and details educational programs, financial incentives and other government-supported initiatives to support efforts of the state's citizens and businesses to reach those goals.
- The Connecticut Hydrogen – Fuel Cell Coalition, which is administered by the Connecticut Center for Advanced Technology, facilitates contact between stakeholders from industry, labor and government who share an interest in developing this industry in the state.

CONCLUDING REMARKS

The Study Committee believes that implementation of its suggested actions properly positions the state for the present. However, the rapid pace at which these technologies are evolving makes it critical that the state regularly revisit this subject. A continuously evolving WCCI is essential for Connecticut to keep its status as an attractive and globally competitive economic entity.

Some possibilities for regular reporting to the General Assembly on advanced communications technologies include the following:

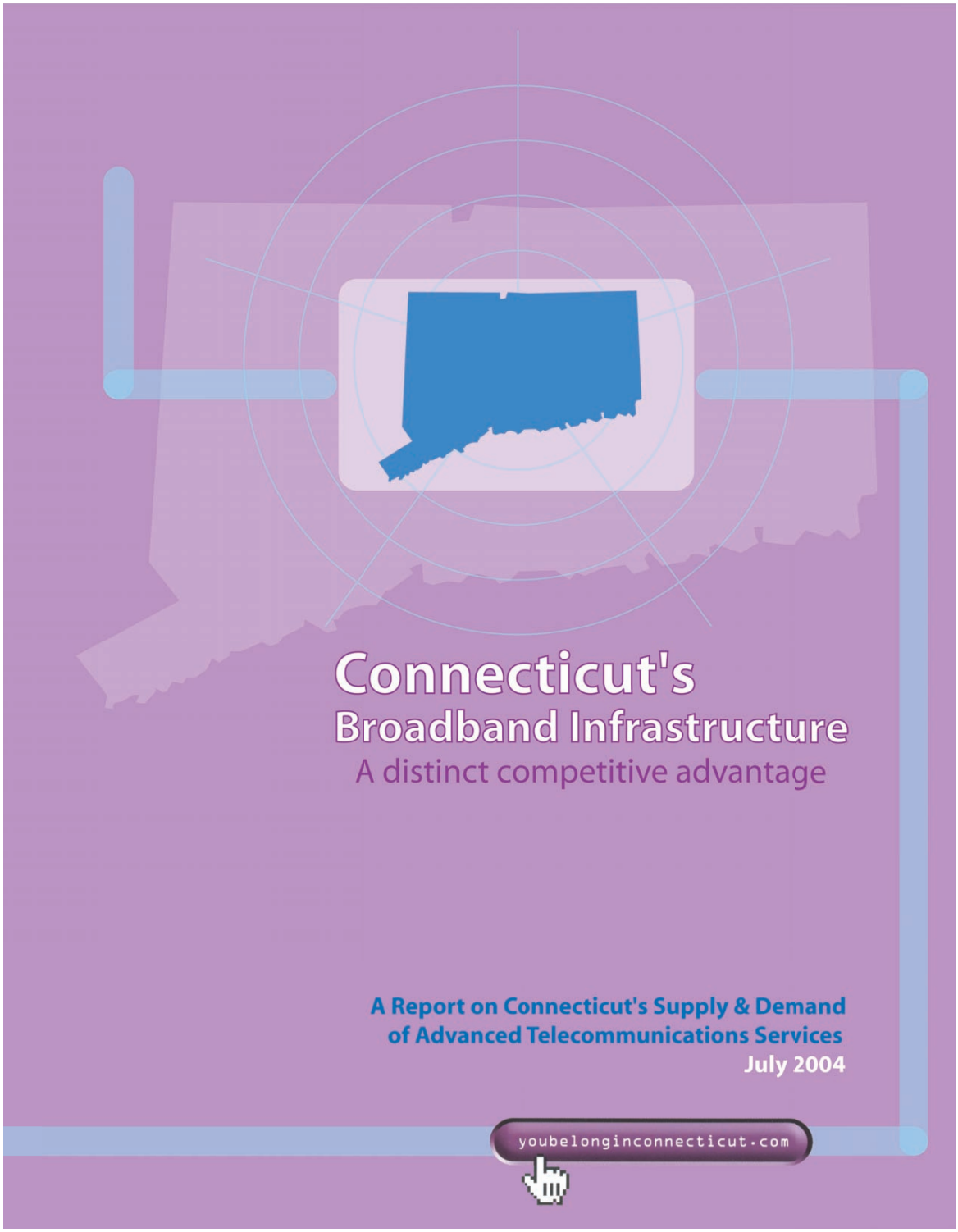
- Identify and map the state agencies and General Assembly committees that have responsibilities related to advanced communications technologies. Create a focal point — a committee or agency — responsible for policy development and assessing future needs to assure the state's continuing position as a leader in the deployment of these technologies.
- Develop an Advanced Communications Infrastructure Advisory Group/Board, including representatives from both the public and private sectors, which would be charged with producing a periodic report. This group would monitor trends and developments, and make recommendations to ensure that Connecticut keep pace with worldwide competition.

The critical importance of broadband policy was recently underscored by an executive order issued by California Governor Arnold Schwarzenegger in November 2006 entitled "Twenty-First Century Government: Expanding Broadband Access and Usage in California" (Executive Order S-23-06), designed to stimulate the growth and utilization of broadband networks throughout that state. The study committee believes that this critical topic warrants equally high-profile attention in Connecticut.

GLOSSARY

BPL:	Broadband over Power Line
DSL:	Digital Subscriber Lines
FTTH:	Fiber to the home
FTTX:	Fiber to the node, the curb, the home
Kbps:	Kilobits per second
Mbps:	Megabits per second
ROW:	Right of Way
VoIP:	Voice over Internet Protocol
WCCI:	World-Class Communications Infrastructure
3G:	Third generation technology

APPENDIX A:
CONNECTICUT'S BROADBAND INFRASTRUCTURE



location

Connecticut - A Great Place to Locate on the World Wide Web

Connecticut boasts the high levels of information infrastructure necessary to support the critical business and educational applications of today and tomorrow. Connecticut's proximity to many large metropolitan regions has created a robust network backbone and high levels of broadband access for Connecticut's businesses and citizens. Ninety-five percent of Connecticut's residents have access to broadband services. Connecticut is also home to a sophisticated workforce that can utilize this infrastructure to create a distinct competitive advantage for Connecticut's current and future businesses.

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The Connecticut Broadband Assessment is an important stepping stone in a process to ensure that Connecticut's businesses, households and citizens have access to the critical information infrastructure that will continue to facilitate growth in a knowledge-based economy. The Connecticut Office of Workforce Competitiveness (OWC) identified a need to assess, build and capitalize on Connecticut's information and telecommunications infrastructure to strengthen the state's ability to attract and retain businesses and a workforce that can operate efficiently and effectively for Connecticut's future success. This assessment begins that process.

This report highlights Connecticut's supply and demand for broadband services and identifies challenges and opportunities for Connecticut's digital future. The information contained in this report represents a current "snapshot" and should be used as the basis for creating a strategy to become a leader in the digital economy.

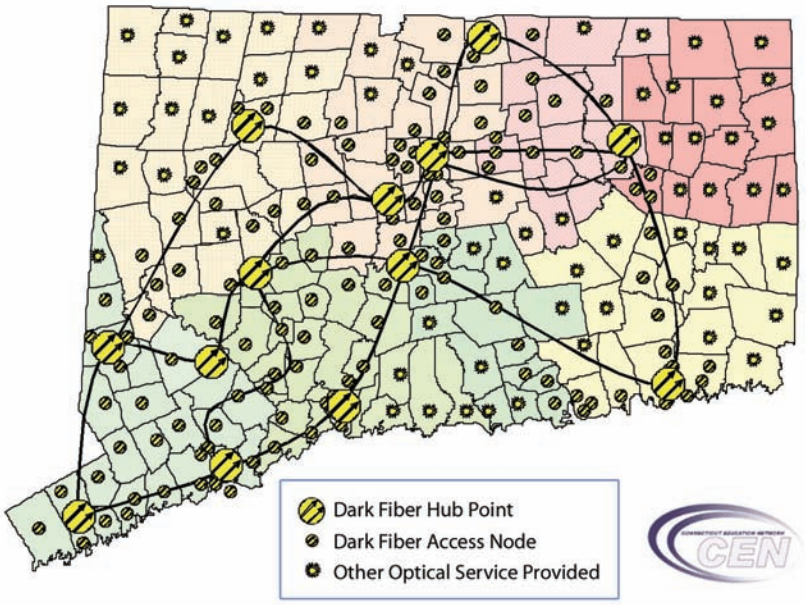
SZD Public Policy Consultants, LLC (www.szd.com/services/policy.html) prepared this report based on the data provided by the Technology Policy Group at The Ohio State University. Both organizations have completed similar assessments in other states and regions. The Connecticut Department of Economic and Community Development also helped provide the resources to make this report possible.

Table of Contents

What is broadband and why is it important?

Broadband services refer to high-speed Internet connections. For the purposes of this report, The Federal Communications Commission (FCC) definitions of "advanced telecommunications capability" and "high-speed" were used to define broadband services. The FCC defines "advanced telecommunications capability" as data transmission services with upstream and downstream speeds exceeding 200 kbps. "High-speed" denotes services with over 200 kbps capabilities in at least one direction. Broadband is important because many new web-enabled tools require high-speed connections for the application to work. Strong levels of broadband access will allow more businesses and individuals in Connecticut to participate in online technologies such as business-to-business (B2B) transactions and distance learning at a more robust and satisfying pace than using dial-up services. The use and sophistication of Internet technologies increases exponentially with access to broadband. You can learn more about the differences between broadband and dial-up services in the glossary of this report.

Connecticut's Education Network (**CEN**)



Connecticut currently is building a robust broadband network to support its K-12 and post-secondary education systems. Through the acquisition and long-term lease of dark fiber, the state has created a world-class information infrastructure for education that is second to none. The Connecticut Education Network (CEN) is bringing state-of-the-art optical networking technology into every Connecticut community under a state program to enhance educational technology. Through fiber optic connections, the program provides next generation Internet access, web filtering, distance learning and multimedia capabilities to each public school district and higher education campus in Connecticut. Large urban school districts are utilizing this connection to replace copper based connections with optical networking connections that are infinitely expandable. The CEN model is based on the use of private-sector providers.

2

Network Infrastructure

Connecticut's Information Infrastructure

Connecticut's network infrastructure is critical to supporting economic development and expansion in the state's changing economy. Roads and sewers once provided the transportation that fueled Connecticut's economy. Today, new economic expansion and jobs are being created through increased efficiencies in manufacturing and services. Broadband is helping to create many of these new efficiencies, and Connecticut is well-positioned for the future.

Connecticut's information infrastructure has three components (Figure 2). The "first mile" consists of global infrastructure that links major network access points in the U.S. to global Internetworking points worldwide. The "middle mile" in this report refers to Connecticut's primary network backbone, as referenced in Figure 3. This network layer connects Connecticut's ISP's and large private networks to the first mile global commodity Internet. The "last mile" connects every desktop, unwired laptop or PDA, home, school and office to their ISP for connectivity to the Internet. Last mile broadband connections to all of Connecticut's businesses and households will ensure Connecticut's future competitiveness.

Connecticut's Network Backbone

Since Connecticut is situated between major metropolitan regions in New York and Massachusetts, Connecticut has significant amounts of middle mile connectivity. Fortunately, many of the county's major network backbone providers have off ramps or PoPs (Internet Points of Presence) from this level of the Internet in Connecticut (Figure 4). This is a critical asset for Connecticut today due to the current telecommunications downturn.

National network backbone assets were researched and providers were surveyed for this project to elicit the level of middle mile capacity within Connecticut, which includes PoPs and the capacity or speed within these middle mile lines. The data was then aggregated to compare the middle mile connectivity to other states or regions. In addition to the network backbone data provided by other service providers within this report, SBC - Connecticut's largest incumbent local telephone provider - has made significant investments in creating a digital network that is almost ubiquitous in Connecticut. This overall level of Internet connectivity is critical to states because these national providers supply the high bandwidth services to large businesses, governments, Internet service providers and other demanding network users that are critical to economic expansion within the state.

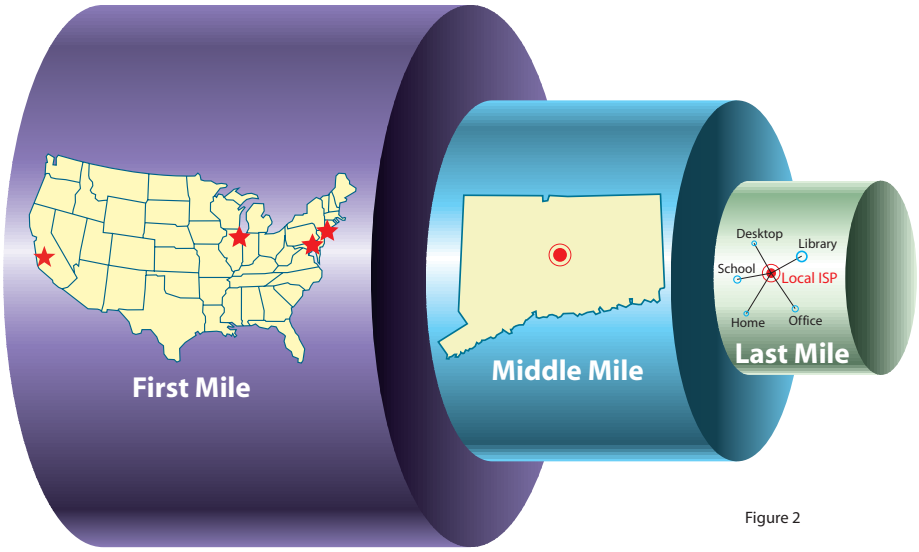


Figure 2

3

Connecticut's Primary Network Backbone - September 2003

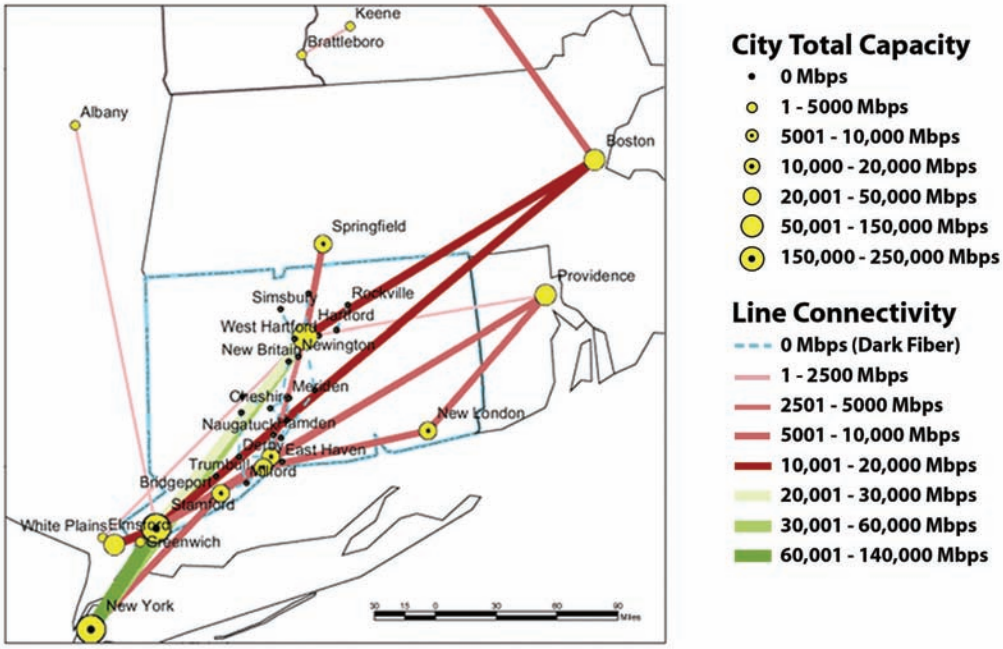


Figure 3

City	Connections	Total Mbps
Bridgeport	4	15000
Greenwich	1	2000
Hartford	15	101366
New Haven	6	26244
Stamford	38	207176
West Haven	1	10000

To gauge Connecticut's level of middle mile connectivity, a 90-mile region including these cities were aggregated to compare to other metropolitan regions that have completed similar analysis. Connecticut's 90-mile region has 65 major connections to the Internet with a total of 361,786 Mbps capacity. By comparison, the Cleveland metropolitan region has 176 major connections with a total of 336,214 Mbps capacity and Indianapolis has 74 major connections with a total of 201,286 Mbps capacity.

Connecticut's Major Backbone Providers

360 Networks
AT&T
Broadwing
Cable and Wireless
Cogent
Fibertech Networks
Global Crossing
Globix
Infonet
Level 3
MCI
NEON Communications
PIS Net
Savvis
SBC
Wiltel Communications

Figure 4

4

Connecticut's Last Mile

Dial-up network performance

Dial-up Internet connection performance was tested as a key issue in Connecticut. While 95 percent of Connecticut's citizens have access to broadband services, many individuals and businesses use dial-up to connect to the Internet. To measure the quality of service these users are experiencing, dial-up services were tested in nine locations throughout the state, ensuring a mix of telephone providers in urban, suburban and rural locations. Proprietary hardware and software developed by the Technology Policy Group was deployed for 24 hours a day during a two-week period for testing. Measurements included modem connection speeds (Figure 5), file transfer performance (Figure 6), and fluctuations in file transfer speeds at particular times of the day or between different Internet Service Providers (ISPs). Throughout the state, most ISPs that had a local access number were tested, ensuring a mix of local, regional and national providers.

Significant performance differences exist between the best and worst areas tested for Connecticut. The Waterbury locations for example, reported connection speeds 50 percent slower than the fastest locations in Danbury, New London and Stamford (Figure 5). Connection rates to download times varied significantly at some locations (Figure 5). Performance testing also showed some ISP's have load balancing issues, causing slow downs on the network at varied times throughout a 24-hour testing cycle. Overall, the testing sites in Connecticut mirror the range of dial-up performance seen in similar tests throughout many states. Dial-up connectivity will not serve Connecticut's users well for the emerging business and educational applications coming on-line today. In Connecticut, using the average connection speed across all nine testing locations still takes an average of 25 minutes to download a five megabyte file, the size of some distance learning applications. A broadband connection, by contrast, could transfer a five megabyte file in two minutes or less (Figure 7).

Testing Locations

Danbury CT Works Center
Danielson CT Works Center
Hamden CT Works Center
Hartford CT Works Center
Litchfield - Education Connection
Meriden - Residence
New London - ePath Learning, Inc.
Stamford - City IT Department
Waterbury CT Works Center

Average Connections Speed by Location

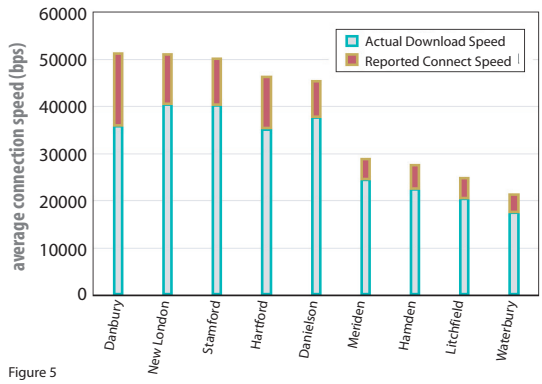


Figure 5

Percent Available Bandwidth Utilization

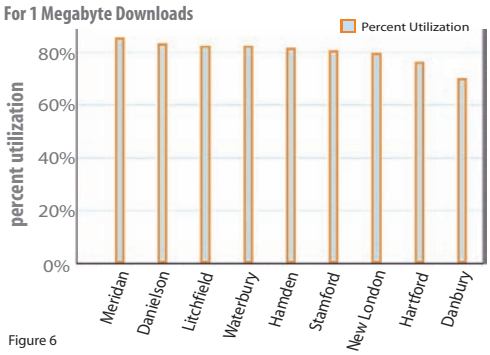


Figure 6

File Size vs. Download Time (overall average)

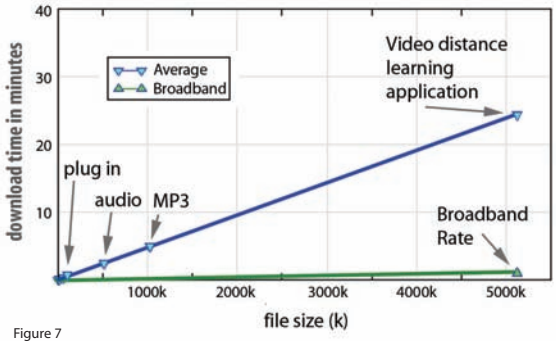


Figure 7

5

Broadband in Connecticut

Connecticut boasts extremely high levels of broadband access compared to states with similar urban/suburban/rural demographics (Figure 8). For this assessment, cable modem and Digital Subscriber Line (DSL) technologies were inventoried and mapped throughout Connecticut to gain insights into broadband access for Connecticut's household and business consumers. Connecticut's broadband providers were surveyed to ascertain their current and future plans for investment in broadband services.

DSL broadband is a technology provided by telephone companies that boosts the level of data transmission over the copper telephone line infrastructure. DSL is viewed as critical, particularly for small businesses without the resources or need for a higher bandwidth, point to point connections. Although disparities still exist in more rural locations regarding DSL access, Connecticut has significant DSL coverage – approximately 90 percent of households in Connecticut have access – primarily provided by SBC, with Verizon providing limited access, due to their small service area in the state (Figure 9). In addition, businesses can purchase point-to-point direct Internet connections.

Cable modem broadband is a technology that is enabled by upgrading systems to provide two-way data transmission. The cable infrastructure was initially developed to provide one-way data transmission, i.e. a television signal from the cable plant to the home viewer. Cable companies nationally have been very aggressive in upgrading their infrastructure to provide high-speed data services. Although cable modems are well-suited for household consumers due to the residential deployment pattern, many Connecticut cable firms have been aggressively rolling out business class services. Last mile upgrades for business class services can be expensive due to the construction costs associated with running new cable.

County	Total population with Cable "or" DSL Coverage	% of total population with Cable "or" DSL Coverage
Litchfield	168,783	92.6
Hartford	842,135	98.2
Tolland	131,657	96.5
Windham	52,483	65.0
Fairfield	877,445	99.4
New Haven	821,696	99.7
Middlesex	144,712	93.3
New London	182,867	81.0
Total	3,221,778	
Population Covered (%)		94.6

Figure 8

Connecticut has significant cable modem availability for household consumers. More than 90 percent of Connecticut residents have access to DSL. Similarly, more than 90 percent have access to cable modem broadband service. Connecticut's cable companies have invested significantly in upgrades to their cable plant to provide these services in both urban and rural areas. Cable modem information was collected through the Connecticut Cable and Telecommunications Association direct company contact. The companies surveyed include: Comcast Cable, Cox Communications of New England, Cablevision of Litchfield, Cablevision of Southern Connecticut and Cablevision of Connecticut.

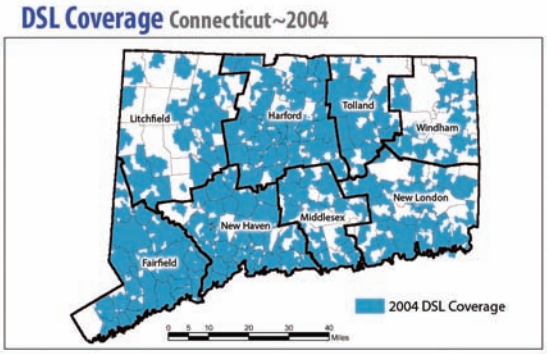


Figure 9

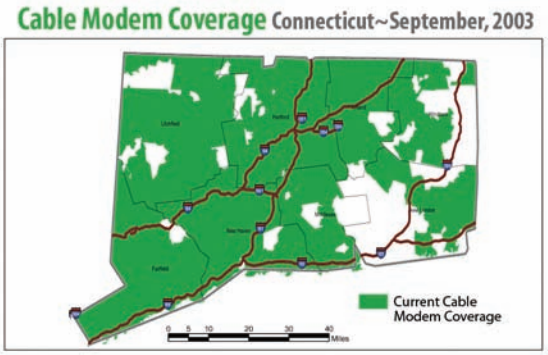


Figure 10

Connecticut Business Online

To better understand the demand for IT and broadband services in Connecticut's economy, a random sample of Connecticut businesses were surveyed for this project. This telephone survey was based on a similar survey developed by the Technology Policy Group that has been administered in several states and nationally from 2000-2002. For comparison purposes, the results from the Connecticut survey administered in 2003 are compared in this report to national results from a 2002 business survey. Additionally, the national surveys further split the results to look at distinctions between small, medium and large firms. Assuming the increase rates reported from the 2000-2002 national survey data remain constant for 2003 national figures and the expected increases in adoption rates due to the larger businesses in the Connecticut sample, Connecticut businesses still appear to be adopting IT and broadband services at higher rates than their counterparts.

Connecticut businesses report very high levels of Internet use. Astoundingly, 100 percent of the businesses surveyed reported using the Internet, as shown in Figure 11. Assuming similar increase rates for national businesses in 2003, roughly 75 percent would be expected to use the Internet in their businesses. Connecticut businesses also connect to the Internet using high speed or broadband connections at higher rates than national businesses in general. As shown in Figure 12, over 70 percent of Connecticut businesses with more than 50 employees use a T1 or direct connection to the Internet. This allows larger firms to use more robust Internet applications that require greater amounts of bandwidth. Even looking at firms with fewer than 50 employees, 40 percent of Connecticut businesses report using direct Internet connections. Given the high level of DSL availability in Connecticut, it's not surprising that over 50 percent of businesses utilize this technology to connect (Figure 12). The highest national averages for DSL use in businesses today hover around 20 percent.

Business Internet Use

Figure 11

Method of Business Internet Connection

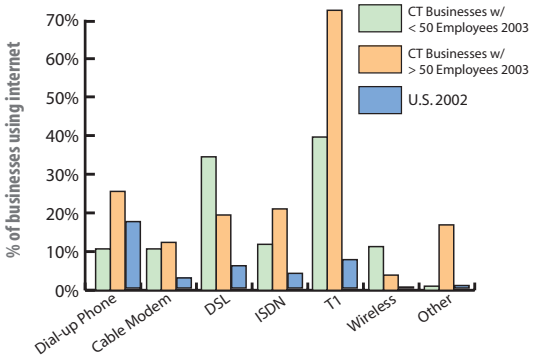


Figure 12

Internal Network Use

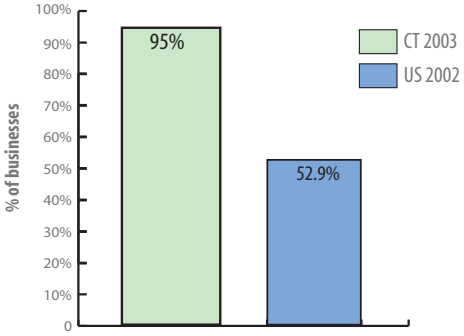


Figure 13

7

Connecticut Business Online (continued)

In addition to high rates of Internet use, Connecticut businesses report very high levels of internal network use. This finding indicates that firms in Connecticut are integrating technology into many business functions throughout the enterprise. Not surprisingly, over 95 percent of the large businesses surveyed report internal network use. **The remarkable finding is that over 90 percent of businesses with fewer than 50 employees report internal network use** (Figure 13). Businesses were given the opportunity to report what tasks they were using the internal network for and they report similar functions as their national counterparts, just at higher rates. As seen in figure 14, almost 100 percent use e-mail as an internal communication tool. Over 60 percent of all surveyed also report using internal networks for accounting, inventory, purchasing and shipping (Figure 14).

Accounting for the larger number of businesses and more recent findings in the Connecticut sample, Connecticut firms appear to have a slight edge in terms of website use (Figure 16). More than 80 percent of all businesses surveyed report having a website. Connecticut businesses are using the Internet for the same kinds of applications as businesses reported nationally (Figure 15). Corporate communication and placing orders were applications reported in use at nearly 90 percent for all businesses surveyed. Historically, businesses have reported using the web for more external facing functions like corporate communication and customer service. Connecticut firms appear to be using the Internet for internal business functions at increasing rates. The fairly high levels of inventory tracking, real-time payment acceptance and on-line meetings indicate a business sample that is sophisticated and understands how to integrate the Internet into daily business functions (Figure 15).

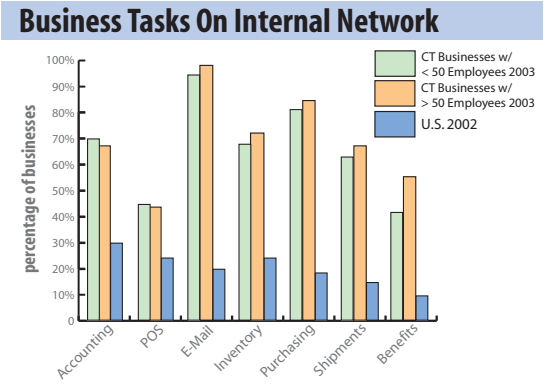


Figure 14

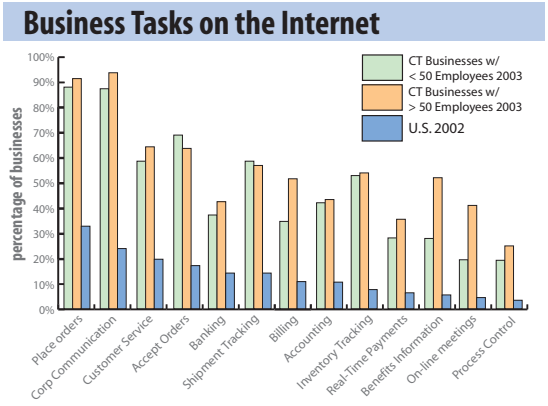


Figure 15

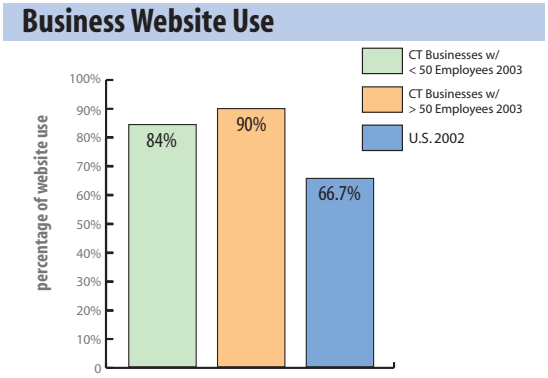


Figure 16

8

Connecticut Business Online (continued)

When looking at the length of website use, it is not surprising that larger firms in Connecticut have reported higher rates of use for longer amounts of time (Figure 17). Larger firms have typically had a web presence longer than smaller firms, but smaller firms seem to be catching up, as indicated by the higher rates of smaller businesses with less than three years of reported use. Greater percentages of national businesses report having had a web presence for one year or less. Again, the age of the national business survey indicates a one year lag in reporting which boosts Connecticut website use lengths.

Looking at how business data from a company's website is linked into their back office operations is another good gauge of how well Connecticut businesses are integrating web-based technology into their business functions. Directly linking the data, versus manually entering data from the website, indicates a productivity increase through the use of technology. In Connecticut, businesses appear to be linking data directly from the website to the back office at similar rates to national averages, with larger firms ahead of the smaller businesses (Figure 18). As indicated by Figure 19, over 45 percent of businesses in Connecticut report productivity increase as a result of website use. Businesses with more than 50 employees report even greater amounts of productivity increases at 60 percent. Larger firms also reported less "No Effect" responses than smaller firms (Figure 19), both suggesting that the web is having a more profound effect on productivity in larger businesses.

One of the most interesting findings from the business survey was the level at which businesses with fewer than 50 employees reported active participation in business-to-business (B2B) Internet transactions. Business-to-business is defined as an actual transaction taking place rather than just communication over the web between two firms. Over 60 percent of the Connecticut firms sampled with less than 50 employees report being active in B2B transactions,

Length of Web Site Use

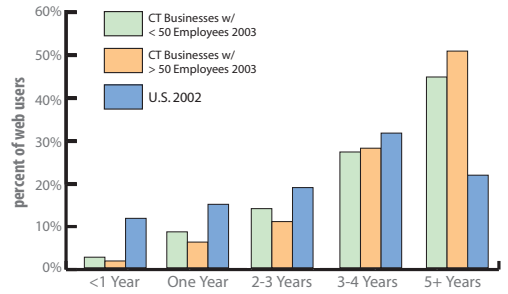


Figure 17

How is Data Linked?

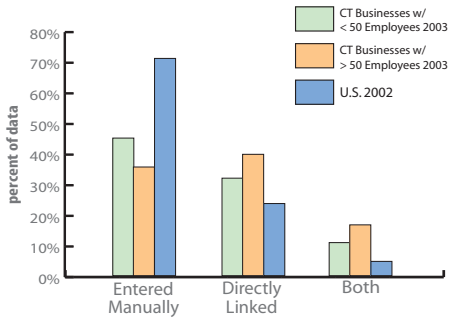


Figure 18

Productivity Increase

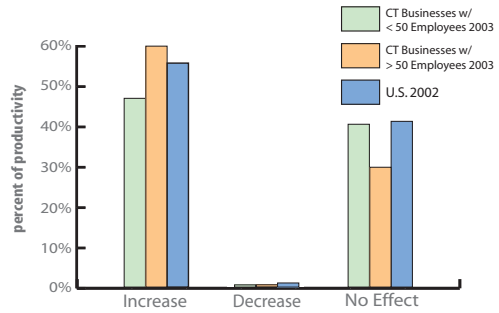


Figure 19

Connecticut Business Online (continued)

while less than 20 percent of larger businesses reported active B2B participation (Figure 20). Intuitively, one would expect higher participation rates from larger businesses. This may be the result of smaller firms being forced to participate in B2B supply chain activities specific to Connecticut's economy, while larger firms are focused on national and global markets.

Finally, Internet training for employees was looked at as an important indicator for Connecticut's businesses and workforce. If businesses are expecting productivity and profit gains as a result of the Internet, how effectively are businesses in Connecticut training employees on Internet use? If businesses expect to maximize the gains that Internet use can provide, how well are they training employees? Not surprisingly, larger firms utilize internal classrooms for Internet training at high rates. Over 40 percent of large firms utilize this method compared to less than 25 percent of smaller firms (Figure 21). Over 25 percent of all businesses in Connecticut utilize on the job training as the primary means for Internet training. Although it may not be the most efficient training method, at least employees without experience are being trained. More than twice the number of small businesses versus larger firms expects employees to have the knowledge when hired. There is also less than five percent of all businesses surveyed that provided no training at all (Figure 21). All of this indicates an experienced workforce and high levels of employee training and support for Connecticut's workers.

Overall, Connecticut's businesses are well-positioned for success in the digital economy. Businesses in Connecticut appear to be adopting and integrating web-based technologies at high levels.

B2B Participation Among Internet Enabled Businesses

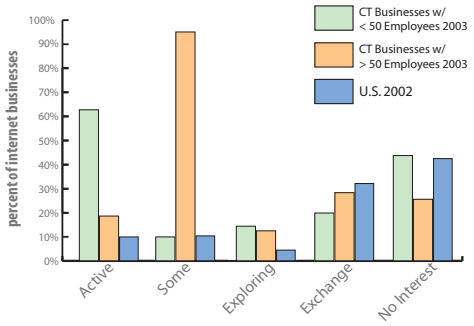


Figure 20

Internet Training

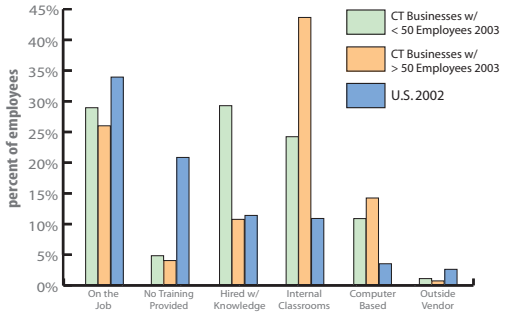


Figure 21

Connecticut businesses report very high levels of Internet use. Astoundingly, 100 percent of the businesses surveyed reported using the Internet.

10

Connecticut Households Online

Technology adoption and computer/Internet use are important indicators in evaluating a workforce in transition. Although Connecticut may have tremendous information infrastructure assets (supply), demand for those critical services can be a much more difficult indicator to improve upon. While infrastructure improvements can be made through new investments, increasing the demand for services can require a significant cultural shift.

Fortunately, Connecticut possesses a citizenry that adopts computer and Internet technologies at higher rates than national counterparts. Over 80 percent of Connecticut households access the Internet from their homes (Figure 23). While citizens in Connecticut utilize the Internet for the same reasons as reported nationally (Figure 24), Connecticut's citizens are more bandwidth intensive Internet users (Figure 25). Over 60 percent of Connecticut citizens engage in e-commerce, compared to 34 percent nationally (Figure 22). The survey results pointed to many indicators suggesting that residents in Connecticut are a workforce prepared to meet the challenges of the 21st Century economy.

Access Internet from Home

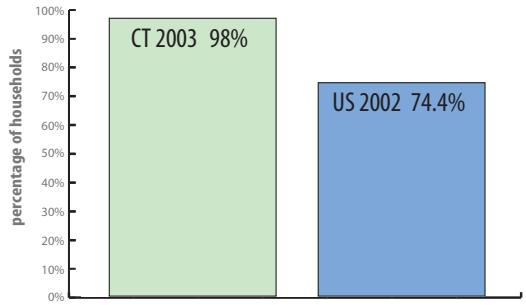


Figure 23

Home Uses of Internet

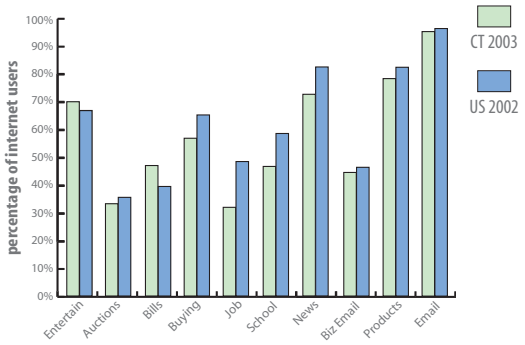


Figure 24

Household E-Commerce

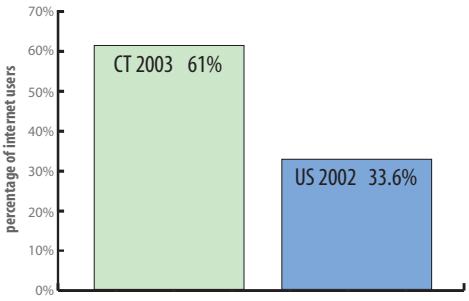


Figure 22

CT Citizens are Intensive Home Users

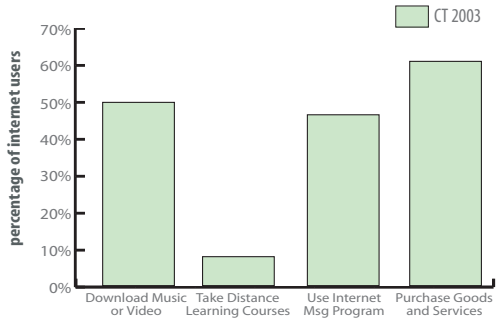


Figure 25

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Connecticut Households Online (continued)

Given these high levels of Internet use, it's not surprising that Connecticut's households utilize broadband services at much higher rates than our national counterparts (Figure 26). Cable modems are the technology of choice for Connecticut residential broadband consumers. Twenty-seven percent use cable modems compared to 12 percent that use DSL. Connecticut citizens are not only accessing broadband at higher rates than national averages, but accessing the Internet in general, at much higher rates. While 50 percent of those surveyed nationally report not accessing the Internet from home, only 10 percent of Connecticut respondents report not accessing the Internet from home (Figure 26). Although this discrepancy signals a population in Connecticut that is very active online, more than 50 percent surveyed still continue to use a dial-up telephone modem.

Cost was reported as the number one impediment to not using broadband. Over 80 percent of rural Connecticut residents that access the Internet from home report service expense as the reason for not switching from dial-up compared to 32 percent of urban residents (Figure 27). Since competition in the marketplace is the main factor in driving down broadband costs, this finding may be related to less competition for broadband in rural markets. The finding may also be attributed to a lower per capita income, in which case the perceived value of purchasing broadband at similar costs to urban areas does not make financial sense to rural consumers.

On the security side of home Internet access, 70 percent of respondents report using anti-virus software, almost 90 percent report utilizing updates regularly and less than half report using firewalls.

Mode of Home Internet Access

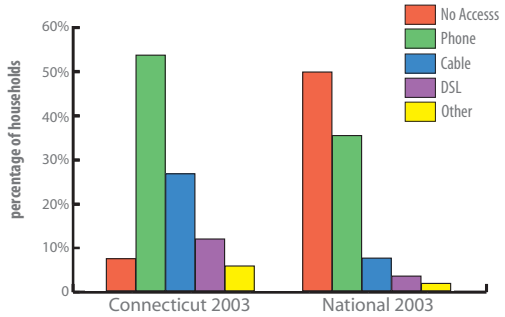

Figure 26

Why not use broadband?

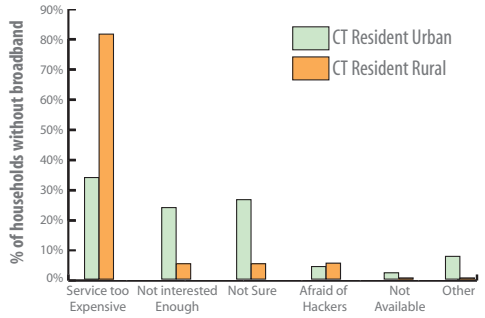

Figure 27

Connecticut – A Great State For Telecommuting

Due to Connecticut's proximity to major metropolitan regions and the high levels of broadband access, Connecticut is ideal for telecommuting. Twenty-seven percent of Connecticut respondents report having a telecommuter in the household. Over 10 percent of respondents reported full-time telecommuting.

27% of households have a resident who works out of a home office

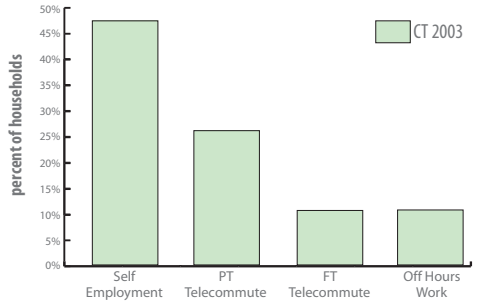

Figure 28

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Conclusions

Supply Side - Connecticut is well-positioned to compete in the 21st Century economy.

- Connecticut has significant amounts of network backbone compared to states with similar urban/suburban/rural populations.
- Connecticut has high levels of broadband access. All counties have some cable modem and DSL coverage. Most counties have significant cable modem and DSL coverage. Taking both DSL and cable modem access technologies together, Connecticut has exceptional broadband population coverage at 94.6 percent, the national average population coverage is about 80 percent.
- Throughout most of Connecticut, minimum performance standards (28.8Kbps data transfer) are met for dial-up speeds, but dial-up speeds vary significantly across counties. Dial-up will not support significant B2B, distance learning or bandwidth intense applications.

Demand Side - Connecticut's businesses and citizens adopt computer and Internet technologies at higher rates than national averages.

- The Connecticut business sample was much more involved in using the Internet than comparable states and national averages. Connecticut patterns reflect patterns typically seen in samples of larger, more sophisticated companies with higher proportion of revenue from Internet sales, higher rates of increases in Internet revenue, higher levels of sales increases and faster rates of productivity increase. Connecticut firms also exhibit higher rates of B2B participation.
- Connecticut residents report higher computer and Internet usage than comparable states and national averages. Connecticut residents are more intensive Internet users who are more engaged in e-commerce with daily connect times that are longer, lower levels of "no interest" responses with respect to Internet technologies and higher levels of broadband adoption. Survey results show that more than one out of four households in Connecticut has a resident who works out of a home office on the Internet.

Recommendations

Supply Side - Boost competition for broadband service offerings to Connecticut's most rural areas.

- Some rural/urban disparities exist with respect to Connecticut's overall information infrastructure. The private sector has made significant investments in the network throughout the state; the most remote rural areas sometimes require a public/private partnership to extend broadband to the businesses and citizens that could potentially benefi t from broadband the most.

Demand Side - Boost the usage of broadband services throughout Connecticut's households, businesses, schools and governments.

- Develop a public/private partnership to educate Connecticut's citizens, businesses, governments and educational institutions on the benefits of broadband adoption.
- Although Connecticut's citizens are well-positioned for the knowledge economy today, workforce training and computer/Internet access issues are critical to Connecticut's future success. Public entities need to emphasize the "critical" nature of computer skills for Connecticut's citizens, especially students and the workforce.
- Since applications can drive broadband use, encourage local governments to boost their web presence with robust citizen offerings online.
- Consider providing access in libraries and schools after hours with public training on Internet technologies and the benefits of broadband.
- Create a standard IT curriculum for K-12 and community colleges and distance learning applications to increase educational access in rural areas, which will provide portable skills for the future.
- Although Connecticut's large firms compare favorably to national averages with respect to adopting and integrating web-based technologies into their businesses processes, public entities need to develop methods to "sell" the usefulness of broadband for training, certification and relevant skills, particularly for small businesses. This can be accomplished through joint efforts with Chambers of Commerce through "Broadband Boot Camps" or e-Commerce training seminars.
- Provide public/private support for employee education and on-the-job training in web technologies and Internet skills.

Glossary of Terms

Access: The technology choices available by which users can connect to the public data network at the level they demand or need (dialup, cable, DSL, ISDN, wireless, etc.)

B2B (Business-to-Business): The exchange of products, services, or information between two or more businesses using networked technologies.

B2C (Business-to-Consumer): The exchange of products, services, or information between businesses and consumers over the Internet.

Bandwidth: The amount of data that can be transmitted in a given amount of time over a particular connection.

Broadband: Data transfer over 200 Kbps. DSL and cable modem services are broadband services.

Cable modem: A device that enables a personal computer to be connected to a local cable TV line and receive and send data.

Dial- up access: Refers to connecting to the Internet via a modem and standard telephone line.

DSL (Digital Subscriber Line): A technology which enables the ordinary copper component of telephone lines to carry data at rates much higher than ISDN.

E-commerce (Electronic commerce): Commercial and non-commercial transactions facilitated through the use of networked technologies.

EDI (Electronic Data Interchange): The transfer of data between companies using computer networks, such as the Internet.

Gbps (Gigabits per second): A measurement of the rate of speed at which data is transferred (e.g., 1 Gbps equals 1 billion bits per second).

Infrastructure: The communication networks that connect users to the Internet.

IT (Information Technology): The broad subject concerned with all forms of technology used to manage and process information electronically.

ISDN (Integrated Services Digital Network): A service that allows for higher data transmission speeds and is capable of handling at least two services over one line simultaneously (i.e., voice and fax or voice and data).

ISP (Internet Service Provider): A company or organization that provides users with connectivity to the Internet.

Kbps (kilobits per second): The rate of speed at which data is transferred (e.g., 1 Kbps equals 1,000 bits per second).

Last mile: The connection from the ISP to the user's desk- top.

Mbps (Megabits per second): A measurement of the rate of speed at which data is transferred (e.g., 1 Mbps equals 1 million bits per second).

OC192 (Optical Carrier level-192): An optical fiber line that supports digital signal transmissions at 48 times the base rate of 51.54 Mbps or approximately 9.7 Gbps.

T1: Dedicated phone connection providing maximum speeds up to 1.544 Mbps.

Telecommunications: Refers to all types of data transmission, from voice to video.

Usage: The extent to which business, government and household users utilize the Internet access and infrastructure available to them.

Wireless access: A communications system in which radio- frequency or infrared waves carry a signal through the air, rather than along a wire.

World Wide Web (www): The system of Internet servers and users that support documents formatted in the HTML language.

REFERENCES

Baller, Jim, Casey Lide. 2006. The Case for Public-to-the-User Systems.
http://www.baller.com/pdfs/BHLG_White_Paper_Tenn_3-4-06.pdf

Chook, Vince. 2006. World Broadband Statistics: Q2 2006.
http://www.point-topic.com/cgi-bin/notlicensed.asp?product_id=13&comp_id=2283
(site requires free subscription)

Desmond, Michael. 2005. Broadband Bonanza.
http://www.pcworld.com/article/id,121394/article.html

Friedman, Thomas L. , 2005. *The World is Flat. New York: Farrar, Strauss and Giroux.*

Horrigan, John B. 2006. Home Broadband Adoption 2006.
http://www.pewtrusts.org/pdf/PIP_Broadband_0506.pdf

Kozischek, David R. 2006. Fiber, Coax or DSL? Meeting Customer Demand for Bandwidth.
http://www.broadbandproperties.com/2006issues/aug06issues/augtechnology.pdf

Lehr, William H., Carlos A. Osorio, Sharon E. Gillett, Marvin A. Sirbu. 2005. Measuring Broadband's Economic Impact. http://www.broadbandproperties.com/2005issues/dec05issues/Measuring%20Broadband%20Eco%20Impact,%20Lehr,%20Gilett,%20Sirbu.pdf

High Speed Services for Internet Access: Status as of December 31, 2005.
http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-266596A1.pdf

New Jersey Leads Nation in Broadband Penetration.
http://www.websiteoptimization.com/bw/0608

US Drops to 20th in Broadband Penetration.
http://websiteoptimization.com/bw/0607

What is Broadband?
http://www.fcc.gov/cgb/broadband.html

Executive Order S-23-06 by the Governor of the State of California, Twenty-First Century Government: Expanding Broadband Access and Usage in California, November 28, 2006.
http://gov.ca.gov/index.php?/executive-order/4585

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Connecticut Academy of Science and Engineering

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