

Boston Unplugged: Mapping a Wireless Future

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Museum of Science

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The Boston Foundation, Greater Boston's community foundation, is one of the oldest and largest community foundations in the nation, with an endowment of \$686 million. In 2005, the Foundation and its donors made a record-breaking \$63 million in grants to nonprofit organizations and received gifts of \$53 million. The Foundation is made up of some 850 separate charitable funds established by donors either for the general benefit of the community or for special purposes. The Boston Foundation also serves as a major civic leader, provider of information, convener, and sponsor of special initiatives designed to address the community's and region's most pressing challenges. For more information about the Boston Foundation, visit www.tbf.org or call 617-338-1700.

About the Museum of Science, Boston

One of the world's largest science centers, the Museum attracts approximately 1.5 million visitors a year with interactive, hands-on exhibits and lively staff demonstrations that present the excitement and relevance of science, engineering and technology in daily life. In 2004, the Museum launched the National Center for Technological Literacy (NCTL) to facilitate a nationwide expansion of technological literacy by creating K-12 engineering curricula and by collaborating with science centers across the country to produce exhibits and programs that engage visitors in technology and engineering and to encourage them to explore the interactions between technology and society.

John M. Tobin, Boston City Council

Boston City Councillor John M. Tobin, Jr. was elected as the District 6 representative to the Boston City Council in 2001. He was re-elected 2003 and in 2005. His district includes the neighborhoods of West Roxbury, Jamaica Plain and Roslindale. Councillor Tobin is a strong proponent of wireless expansion in Boston. In August 2004 he filed an order with the City Council that called for hearings to explore residents' access to wireless technology. Councillor Tobin and his office helped organize the city's first WiFi Summit and this report.

UNDERSTANDING BOSTON is a series of forums, educational events and research sponsored by the Boston Foundation to provide information and insight into issues affecting Boston, its neighborhoods and the region. By working in collaboration with a wide range of partners, the Boston Foundation provides opportunities for people to come together to explore challenges facing our constantly changing community and to develop an informed civic agenda.

Boston Unplugged: Mapping a Wireless Future

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Dear Friends:

Like Marconi's radio receiver and the creation of the first telephone network in the early 20th Century, wireless fidelity technology, better known as Wifi, is revolutionizing the way we communicate.

Cities across the nation and the world are embracing Wifi networks that give their citizens wireless broadband access anywhere, anytime. Wifi will change the way our children learn, the way we conduct business, and the way we deliver services.

Boston is known around the world for its innovation. Our technology, education, and healthcare institutions are recognized all over the globe. Our city attracts some of the brightest minds and talented professionals in a wide variety of fields. If Boston wants to maintain that edge it must keep pace with the changing world.

We believe its time for Boston to make universal Internet access a reality.

As technology becomes more pervasive, the digital divide debate too is evolving—from public access computers to in-home Internet access. And as this report will show you, Boston is making good progress. Internet access has become a core element of the economic infrastructure, compelling Boston to move aggressively to equip its residents, educational institutions and businesses with broadband access.

The growing availability and popularity of WiFi presents our city with a great opportunity and enormous possibilities. Wifi could help us to educate our children and strengthen local business districts. It could assist law enforcement and bolster tourism. And it could further bridge the "digital divide."

We urge our public, private, and corporate institutions to join in partnership to meet this critical challenge.

Sincerely,

John M. Tobin, Jr.
Boston City Council
District 6

Paul S. Grogan
CEO & President
The Boston Foundation

Ioannis Miaoulis
President and Director
Boston Museum of Science

“We have seen technology develop by leaps and bounds here in Boston – from leading the charge in providing internet access to schools to, most recently, developing free wireless internet access in our Main Streets districts. I look forward to working with our partners in further advancing this technology as a tool to encourage economic and educational opportunity and improve the quality of life for all Boston residents.”

Mayor Thomas M. Menino,
Keynote Address Boston WiFi Summit.
Museum of Science, May 19, 2005.

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Preface

Boston Unplugged: Mapping a Wireless Future has been created to give readers a detailed sense of the rapidly evolving spectrum and impact of sophisticated communications technologies. In a knowledge-based world, affordable access to reliable Internet connectivity is no longer a luxury, but a necessary part of 21st century life.

In this remarkable and innovative environment, educational excellence, corporate competitiveness and the very nature of how we live are being transformed on an almost daily basis.

This dynamic process has been clearly demonstrated by a wide variety of grassroots efforts in the Greater Boston area. The prospect of increased access to even more sophisticated communications tools has energized the local community and demonstrated its eagerness for expanded Internet connectivity.

In recent years, community leaders have been struggling to bridge the digital divide—providing increased computer and technology training to low income neighborhoods. While some goals have yet to be fully realized, recent developments in wireless fidelity communications have made the idea of universal Internet access a realistic possibility.

For Boston, the birthplace of critical technological innovations and a global economic player, a sophisticated yet affordable high speed broadband network is critical to maintaining the city's educational and economic standing in a rapidly evolving global socioeconomic environment.

This report is the result of a wide variety of community conversations about the vision and values of a wireless broadband strategy for Boston. Its purpose is to review a variety of different models that will allow Boston to become a single, citywide HotZone. While some cities have made the decision to deploy a single system that offers broad coverage, others are reviewing options that would foster the proliferation of community HotZones, systems that would work together collabo-

ratively, or collaterally with a larger citywide network. With the implementation of such a network, the city's residents, businesses, governmental services and nonprofit institutions will be empowered by the highest level of innovation of the Information Age.

Municipalities of all sizes, across the country, and around the world, are demonstrating the value of high speed, wireless connectivity. They are also providing models that point the way towards attaining this access in a rapid and affordable manner. Technology companies like Google, Earthlink and Hewlett-Packard are exhibiting a willingness to build coalitions that combine their technological power with the creativity and commitment of local communities.

Such partnerships are creating a highly competitive environment which is driving down the cost of Internet access and benefiting consumers all across the country.

Boston can meet this challenge by leveraging its historic technological, educational and financial assets to create such a local network and provide the city's businesses, residents and visitors with all the advantages such a system offers.

City leaders should embrace such a challenge because of the almost unimaginable wealth of opportunities it will provide. At the end of the day, such sophisticated communications technologies will produce imaginative concepts, generate valuable returns and demonstrate to the nation and to the world that Boston continues to be a critical center of creativity and innovation.

1.

Boston Unplugged: Mapping a Wireless Future



Introduction

An accelerating technological movement promises to transform the culture of San Francisco and Philadelphia, of Seattle and Cleveland, of Singapore and Sandoval County, New Mexico. Powered by high-tech giants like Google, Earthlink and Hewlett-Packard, this effort is generating seismic changes in computer networking and Internet communications. Some experts predict its social impact will be as important as the emergence of the telephone, the move from buggy whips to automobiles, and the once impossible notion of manned flight.

WiFi—the acronym for wireless fidelity—represents a technology that offers the possibility of no cost, or low cost, high speed wireless Internet access to cities around our country and across the globe.

In late September, Google radically reconfigured the Internet communications world when it submitted an RFP to city officials in San Francisco to build a free wireless network capable of providing service to all parts of the city's 49 square mile area. Originally, the system was estimated to cost over \$10 million of taxpayers' money to build, with perpetual costs for regular hardware updates and system maintenance that have to be calculated and included in the equation.

If its bid is accepted, Google will begin construction of the system within weeks of the approval.

The nationwide movement to build-out no-cost, or low-cost, municipal wireless networks is not an act of philanthropy by a handful of wealthy Internet communications companies. In San Francisco alone, 23 technology companies have submitted proposals to construct the Bay area wireless system. They have all run the numbers and come to the same conclusion—that future network advertising revenues will justify their initial costs of construction.

On the East Coast, Philadelphia recently awarded a contract to Earthlink to build out a system that will blanket that city's 135 square miles with 1M bps (bits per second) WiFi service by the end of next year. While other municipalities, from Miami Beach to Chaska, Minnesota, are moving rapidly to create their own wireless networks as well.

As these systems are created, it will become clear that every municipality will employ solutions designed to meet its specific needs. In some cases, the decision will be made to invest civic funds to assist in design, development and deployment, while other cities may choose to pursue other models that are reflective of the projects being developed in cities like San Francisco or Philadelphia.

As in many large municipal projects, cost and financing are central factors in the equation. Some potential wireless developers are offering to construct networks at their own expense in exchange for advertising revenue generated by the system. Other alternatives include tiered systems where basic services are provided for no cost or low cost, while more sophisticated capabilities would be made available on a scalable subscription basis.

These extraordinary national developments are not lost on Boston's political, community and corporate leaders. A powerful citywide wireless network brings with it the promise of increased governmental efficiencies, enhanced corporate productivity and educational excellence, while maintaining a competitive environment capable of providing affordable, high speed Internet access to all of Boston's residents and visitors.

Broadband (see inside back cover) is an essential component for personal and business productivity and success in the 21st century. Subscribers currently pay \$30 to \$50 a month for high-speed service supplied by traditional DSL and cable providers. In low income neighborhoods, these costs effectively restrict widespread Internet access, and the benefits it provides.

In turn, telecommunications companies are unwilling to make the large commitments of capital necessary to hard-wire these neighborhoods, because the anticipated scarcity of subscribers does not justify such expensive construction and maintenance.

One of the elements that make wireless networks so attractive is their ability to deliver reliable connectivity at a fraction of current costs. This capability makes Internet access possible for all people with the hardware to receive it. The diminishing costs of hardware, a diversity of devices, and open source software have all contributed to making universal access a more realistic possibility. And, as hardware becomes cheaper and computing becomes increasingly based on connectivity, a high-speed connection becomes increasingly important to bridge the digital divide.

An early example of this new generation of affordable hardware is an inexpensive laptop that has been developed at MIT's Media Lab (<http://laptop.media.mit.edu/faq.html>). When such innovative technologies are combined with an increasing willingness on the part of major technology companies to enter into public-private

partnerships, the solution to the puzzle of affordable citywide wireless networks suddenly begins to emerge.

The competitive response by Internet service providers (ISPs) and wireless corporations in San Francisco and Philadelphia also demonstrates to other cities that they only need to open their doors, welcome WiFi developers, and allow private businesses to build-out networks with no risk and little or no expense falling on local taxpayers.

The Hundred Dollar Laptop (<http://laptop.media.mit.edu/faq.html>):

To make a citywide wireless fidelity network truly successful it must be able to ensure "digital inclusion" for all the city's residents, regardless of income.

To make this possible it will not be enough for city leaders to be make a no-cost or low cost WiFi network available. Quality, affordable hardware must be obtainable as well. In an attempt to address this critical issue, Nicholas Negroponte, head of the MIT Media Labs, is working to develop a \$100 laptop computer.

The Linux-based machine is expected to have a 500MHz processor, with flash memory instead of a hard drive, which has more delicate moving parts. It will have four USB ports, and will be able to connect to the net through Wi-Fi—wireless net technology in addition to being cell phone-enabled—for sharing data easily.

It will also have a dual-mode display so that it can still be used in varying light conditions outside. It will use a color display, but users will be able to switch easily to monochrome mode so that it can be viewed in bright sunlight, at four times normal resolution.

Impressed with the implications such a machine could bring to Massachusetts public schools, Governor Mitt Romney has proposed legislation to spend \$54 million to buy one of Negroponte's laptops for every elementary school student. The first three grades would get computers during fiscal year 2007, while students in the other three grades would get them the following year.

Affordable Loan Program:

Another example of expanding access to hardware and technology is the work of Mayor Menino's Boston Digital Bridge Foundation which has established partnerships with Microsoft, Lexmark, HiQ Computers and Intel. Program participants in its signature Technology Goes Home@Community and Technology Goes Home@School programs can purchase a new computer and a printer for less than \$15 per month through a special Bank of America no-interest, no-down payment loan program. The TGH program provides parents and their children with 25 or more hours of basic technology training at no charge in addition to an introduction to financial literacy.

<http://www.cityofboston.gov/bra/digitalbridge/programs.html>

And as WiFi networks expand across the country, a level of competition will be introduced into the highly controlled broadband marketplace that will force service providers to either significantly reduce their prices—or fail.

Greg Richardson, founder of Civitium, an Atlanta-based organization that assists cities in their wireless efforts, sometimes uses the word inconceivable to describe this phenomenon.

"Last year we saw a lot of small communities testing and piloting," Richardson said. "This year there's been an increase in the number of larger cities, and the speed with which they go through this process. Cities are becoming smarter about this, becoming more efficient about the process."

The simple fact is that whether it is 6 months or 24, high speed broadband and wireless technologies will be a fact of life in most major cities—possibilities once thought to be rooted in the imaginative flights of science fiction are now emerging as real-world tools for life in the age of the Knowledge Economy.

A History of Innovation

Recent centuries have turned to the accompaniment of great bursts of inventiveness and innovation. The last decade of the 19th century, and the early years of the 20th century, brought to the world Marconi's radio receiver, Henry Ford's Model T, and the creation and installation of Alexander Graham Bell's telephone network.

Inventions of this power often deliver unexpected as well as expected outcomes. In the Model T's 19 years of production over 15 million units were sold, driving the invention of the assembly line and the necessity for the Federal Road Act of 1916, which led to the construction of the modern system of interstate highways and a transformation of American culture.

Likewise, after years of research and innovation, the integration of Marconi's radio receiver and Bell's system of telephonic communications provided the foundation for high-speed Internet access and now the design and deployment of wireless fidelity systems. While some have suggested that the city's ability to generate equally remarkable answers to 21st century problems has diminished, the opportunity now exists to prove these skeptics wrong.

Some Local Technological Innovations:

- 1876:** The Telephone
- 1903:** Marconi's First International Radio Transmission
- 1944:** Mark I – The First Automatic Digital Computer
- 1972:** E-Mail
- 1973:** Ethernet
- 1989:** World Wide Web
- 2005:** The \$100 Computer

WiFi networks are not replicable monoliths. They are, in the alternative, a variety of different communications systems and hardware being tried in imaginative configurations to produce optimum results. Earthlink is testing and deploying one type of system in Philadelphia, while a variety of other options are being proposed in San Francisco. At the same time, other cities and towns across the country are reviewing different alternatives to meet the particular needs of their areas.

The result is an environment of progressive innovation that invites the best and the brightest to step forward, anticipate future demands and provide visionary results.

It is an atmosphere perfectly suited for Boston's wealth of creative scientific and technological talent. It is an exciting and potentially rewarding test for a city with a demonstrated ability to successfully respond to such challenges.

A Global Resource with Community Implications

As the telephone and radio improved communications, and the automobile sped up commerce, new generations of Web services will be the dynamic engine that can power 21st century economic prosperity, educational advancement and the introduction of a wide variety of social services.

In fact it seems reasonable to say that it will be impossible for coming generations to prosper without the benefit of computer literacy. The story of this new century is that technology will fundamentally reshape economic and social systems not only in Boston, but in the United States and around the world as well.

Ioannis Miaoulis, director and president of the Boston Museum of Science, said recently that, "The United States—and our own region in particular—runs the risk of losing our reputation as a global center of technological development. Our economic productivity and educational competitiveness depend on our ability to promote an environment of independent innovation and scientific excellence."

Massive investments in global broadband connectivity, the reduction in the cost of computer hardware, and

Examples of Boston's Technology Infrastructure

Museum of Science Computer Clubhouses were established in 1993 by The Computer Museum in collaboration with the MIT Media Laboratory. The Computer Clubhouse program helps young people acquire the tools necessary for personal and professional success at six centers spread across Boston.

<http://mos.org/doc/1252?audience=educators>

Timothy Smith Centers are computer training centers established in 1996 by the city of Boston, through a bequest left to the city by longtime resident—Timothy Smith. The 39 centers located at various social service agencies and educational institutions in Greater Roxbury, provide more than one million hours of computer access to the community for a wide variety of programs including job training, educational enrichment and open access.

<http://www.timothysmithnetwork.org/default.aspx>

CTCNet and Faith Based Technology Centers include 45 community technology centers spread all across the neighborhoods of Boston. These tech centers are located at social service agencies, community centers, and faith based organizations. They are affiliated with TechMission, a national network formed in 2000 to support Christian community computer centers across the world to provide youth and adults with access, skills and relationships needed to succeed in the information age.

<http://www.techmission.org/membership/centers.php>

the emergence of powerful search engines like Google are making it easier for people to work and socialize with one another from almost anywhere in the world. Anyone with an affordable lap top, basic technological skills, and access to the Internet can now become a member of a rapidly expanding worldwide community. They can invent the next Firefox or Napster, refine their education for free with MIT's OpenCourseWare system, or provide information on affordable heating oil programs to local low income neighborhoods.

This means that high speed wireless networks are no

longer a luxury. They are a critical component to the infrastructure of any community seeking to share in the promise of 21st century socioeconomic prosperity. Boston and Dublin, Dorchester and Beijing have become next-door neighbors almost overnight. Walls that have separated cities and countries have been torn down and will never be rebuilt.

An electrifying future of unimaginable opportunities has arrived and Boston must now define its role in this accelerating world of technological innovations.

A World of Educational Excellence and Economic Prosperity

Economic prosperity and competitiveness in coming decades will be determined by cutting-edge educational programs capable of stimulating an environment of technological creativity. Critical training in the areas of science, technology and mathematics must be supplied to all segments of the population.

For some this process will be effortless because of their ability to afford an education focused on developing these new skills. But members of low income and disadvantaged communities in our city, this state and the nation will discover that gaining access to such a technologically advanced education will not be so easy.

Local public schools must be retooled to meet the increasingly sophisticated demands of a global economy. Hand-held calculators are being replaced with lap top computers, dictionaries replaced by search engines, and the entire school curriculum needs to evolve to embrace these inescapable changes. Such advancements will rekindle students' curiosity about science and technology and demonstrate the miracles that these disciplines can produce.

In the words of Bill Gates Jr., Chairman of Microsoft Corporation, "Training the workforce of tomorrow with the high schools of today is like trying to teach kids about today's computers on a 50-year-old mainframe. It's the wrong tool for the times."

Significant investments have already been made in Boston's technology infrastructure that position the city to reassert a vital local and national leadership role. Realizing full value from those investments is the next step in an important developmental process.

Success lies in the ability of business, political and community leaders to build a coalition capable of identifying the problems and crafting thoughtful long-term answers. Using current tools, they must develop powerful new ones, instruments with the ability to keep pace with an accelerating technological dynamic.

Examples of Educational Programs

TechBoston Academy, a Boston Public Schools pilot high school is designed to integrate technology throughout its curriculum. Students and teachers use a range of devices and software programs to enhance learning. From laptops, digital and video cameras and hand-held devices, to smart boards, software programs that are voice activated or self-paced, technology is used at its fullest to reinforce in-class learning with real-world learning.

On a recent trip to the Lowell Textile Mills at the Lowell National Park site, students used voice, video and text to capture information about what life was like for workers during the 1800s. Combining these resources with videos from American Memory shot by Thomas Edison at the turn of the Century about the emergence and impact of the textile industry in New England, students created a documentary on new technologies, immigration, and the role of women.
<http://www.techboston.org/tba/>

Machine Science Labs offer a state-of-the-art robotics program and hands on skills in engineering and programming devices for middle and high school students at 19 after-school locations.
http://www.machinescience.org/About/early_projects.html

South End Technology Center in partnership with MIT's Media Lab links MIT student mentors and high school youth of color for training and exposure in five areas: Robotics, Fuel Cell Technology to build model solar cars, Computers to design and build small machines at MIT's Fab Lab, Videography, and Web Design and Software Applications.
<http://fab.cba.mit.edu/labs/setc/photo.html>

While there is no question that such issues might present a complex cipher to city leaders, it is certainly no more difficult than many others they have solved in recent years. It can not be a one-size-fits-all solution. The diverse nature of the constituencies that must be served prohibits it. But it is a solution the city urgently needs strategically to position itself for success in the 21st century.

There is a critical relationship between educational excellence and economic productivity. This is not an issue of either/or—funding for education or the financing of initiatives to create better economic opportunities. The indisputable fact is that, today and in the foreseeable future, technologically enhanced educational systems and prosperous economic environments will be inextricably linked.

Respected global corporate leaders have been publicly advancing this argument in recent months. In February of 2005, Bill Gates told the National Education Summit on High Schools, a gathering of American governors, that, “If there is one single issue worthy of your focused attention, it is the state of America’s high schools.” The Bill & Melinda Gates Foundation, a major nonprofit source of funding for public education, is deeply concerned about the current state of the nation’s system of secondary schools. Gates told his audience at the Educational Summit that, “Our high schools were designed fifty years ago to meet the needs of another age. Until we design them to meet the needs of the 21st century, we will keep limiting—even ruining—the lives of millions of Americans every year.”

Emphasizing this point while observing the impact of investments being made by nations across the world, Marc Andreessen, a co-founder of Netscape has said that, “Today, the most profound thing to me is the fact that a 14-year-old in Romania or India or the Soviet Union or Vietnam has all the education, all the information, all the tools, all the software easily available to apply knowledge however they want. That is why I am sure the next Napster or Firefox is going to come out of left field.”

While there are some who would choose to view our current circumstance as a calamity, the words of the brilliant Stanford economist Paul Romer are relevant: “A crisis is a terrible thing to waste.”

A Wealth of Remarkable Local Opportunities

Blackberries, Palm Pilots, a universe of high speed laptop computers, cellular telephones that can access Apple’s iTunes music database, and built-in automobile and handheld Global Positioning Systems (GPS), all of which rely on wireless technologies, represent only a small fraction of the emerging digital revolution.

While many late ‘90s investors financed dozens of irrational dotcom start-up projects, some of today’s remarkable innovations were being developed by respected companies such as Cisco, Apple, Google and Intel.

Cities that are committing to building out infrastructures that employ these imaginative technologies, are cities that are serious about taking advantage of these new applications. The implementation of these developments holds the promise of entire municipal populations being able to wirelessly connect to the Internet at fast speeds and affordable costs.

Boston’s political and community leaders have been working hard in recent years to provide such a high speed wireless broadband network for all of its residents and visitors. Recognizing that such a system offers the prospect of increased competitiveness and productivity for area corporations, reduced cost of city services, improved quality of the neighborhood schools, while offering a broad range of services that will enhance the enjoyment of daily city life—Boston has been proactive in its efforts to encourage pilot projects aimed at informing the design, development and deployment of such a system.

A few examples of these programs include:

Main Streets WiFi: An initiative recently launched by Mayor Thomas M. Menino to bring wireless technology to Boston’s communities and neighborhood commercial districts. The program is designed to create a free entry point for residents to access the Internet, help attract and retain visitors to the city, and educate and inform local residents and businesses on the use and applications of wireless technology. The system is supported through a combination of donations and advertising revenue.
<http://www.mainstreetswifi.com>

Social Programs that can Benefit from WiFi:

Real Benefits Program is an on-line application for public benefits that provides eligibility screening and an efficient, simple and dignified process for applying for benefits such as food stamps, WIC, job training, health insurance, housing assistance and others. Developed by Healthcare for All and Community Catalyst
http://www.realbenefits.org/nonmembers/programs_initiative.htm#mass

CSP Tech Project provides technology support and assistance to improve the efficiency of 250 homelessness programs and shelters for coordination of services and data management. Developed and managed by the Center for Social Policy, UMass Boston. http://www.mccormack.umb.edu/csp/csp_tech.jsp

Matchbook.org links artists and performers to performance venues and to the **New England Cultural Database**, which enables arts organizations to contribute data to help wider audience access information and to understand the impact of the cultural sector. Developed by New England Foundation for the Arts
<http://www.newenglandarts.org/db/>

Speakeasy is a cellphone-based innovation that links volunteers with those needing real-time interpretation services for access to social service and economic resources. It was developed by Massachusetts Immigrant and Refugee Advocacy Coalition, Asian Community Development Corporation, and MIT.
<http://www.asiancdc.org/Speakeasy.html>

Tent City: A mixed income, 269-unit housing development in Boston's South End with a wireless network which was upgraded in March 2005 using RoofNet, an experimental 802.11b/g mesh network in development at MIT's Computer Science and Artificial Intelligence Laboratory (CSAIL) designed to provide affordable, low-cost broadband Internet access for public use.
<http://pdos.csail.mit.edu/roofnet/doku.php?id=tentcity>

Camfield Estates: A partnership in 2000 between the 100-unit housing development in Lower Roxbury, MIT and RCN equipped homes with high-speed cable internet access to study the impact of technology on community. In 2002, when the internet service commitment came to an end, many residents who had become accustomed to the high-speed connectivity found the market rate of \$39.99/month (at that time) prohibitive. In response a high-speed, fairly high-bandwidth wireless alternative was developed to support the multi-user wireless network. <http://www.camfieldestates.net>

The Boston Police Department: Used wireless broadband video surveillance to manage traffic and public safety concerns during the 2004 Democratic National Convention. Motorola's Canopy broadband radios monitored for incidents related to crowd management and officer deployment. Data transmitted at the rate of 256K also allowed traffic command to obtain a video

feed of the traffic situation in a convertible high occupancy vehicle lane along the Southeast Expressway. The technology is being reviewed for inclusion in the expansion of Boston's public safety network.

NewburyOpen.net: Provides a free Internet Cafe and wireless network for city residents, visitors and Newbury Street businesses. Its mission is to create new ways of accessing the Internet, promoting universal access to inspire wireless applications and software, publishing our ideas and specifications openly, and encouraging the creation of local wireless communities. www.NewburyOpen.net

The Charles River Wireless Collaborative: A non-profit organization whose mission is to assemble a sophisticated partnership of regional political, corporate and nonprofit leaders to develop and construct an innovative wireless communications infrastructure. This network will employ a forward looking vision, designed to advance educational excellence and economic competitiveness in the cities and towns of the Greater Boston area.

Projects such as these demonstrate Boston's wealth of technology talent and civic commitment to a future that incorporates wireless technologies into the city's daily life. They open the door for possible public-private partnerships such as those developing WiFi

networks in San Francisco and Philadelphia. Relationships capable of designing and constructing a no-cost or low-cost, wireless system that can provide high speed broadband Internet access to all of the city's residents and visitors.

The Mechanics of High Speed Internet Access

Wireless and high-speed broadband Internet technologies are evolving at extraordinary speed. New generations of hardware are being developed about every six months. It is a process that is generating fascinating concepts and concrete results.

Nationally, approximately seven out of every 10 households subscribe to cable. While many of these households do not use their cable connectivity for access to the Internet, many do. This allows cable companies to control a significant share of the broadband market. The issue of affordability continues to be a problem for these high-speed broadband providers.

It is this issue of cost that has been a major motivating force in the research into wireless development and deployment. To provide their communities with no-cost or low-cost wireless systems, hundreds of cities and towns across the country are accelerating their research and development of various WiFi tools.

While Boston has the more traditional broadband systems in place, it also has the more cutting edge systems as well. In addition the city is extremely fortunate to have a wealth of technological and scientific talent capable of designing new and even more innovative alternatives.

Currently the city's high speed Internet access infrastructure is built upon a foundation of the following systems:

DSL/Cable: These services are provided for a monthly fee. The internet signal comes into a house, apartment or business on a copper wire or cable and can be connected to an in-house router. This router then broadcasts the wireless signal—within a very short range—to computers equipped with wireless cards.

Wireless Mesh Network: A wireless network relies on a series of nodes in the network to propagate signals. Although the wireless signal starts out at some base

station (access point) attached to the wired network, a wireless mesh network extends the transmission distance by relaying the signal from one active device to another.

A typical wireless mesh system works with a series of transmission towers that broadcast a signal to remote radios or repeaters positioned on street and traffic lights and light poles throughout a city. These radios receive and transmit the signal creating a mesh of wireless transmitters throughout a particular service area.

Locally, NewburyOpen.net has created a partial mesh network broadcasting from two towers on Newbury Street to a series of repeater devices located in the immediate area. Some local technology experts refer to the NewburyOpen.net network as a "cloud" as it has a 1/2 mile limit.

WiMax: The WiMax protocol makes it possible to network computing devices together. It is still under development but is being designed to provide Internet access, in a similar way to WiFi. It is suggested that WiMax will be both faster and have a longer range than WiFi. WiMax does not necessarily conflict with WiFi, but is designed to coexist with it and may indeed complement it.

According to WiMax developers, a WiMax base station would beam high-speed Internet connections to homes and businesses in a radius of up to 50 km (31 miles); these base stations would theoretically have the power to cover an entire metropolitan area.

The claims of a 50 km (31 mile) range are, as yet, unproven. A continuing question remains as to whether these distances can be achieved without line-of-sight connectivity. Nonetheless, WiMax holds out the promise of a remarkable step forward in the development of wireless communications.

A Strategy for Boston's WiFi Future

The question is no longer whether Boston is going to build a citywide WiFi network but rather how and when. To do otherwise would be to remove the city from the mainstream of an exploding new world of high speed Internet communications, an option that is clearly not acceptable to Boston's political and community leaders.

In the Voices of Bostonians:

Their vision...

- Free, fast, universal access
- Being connected to the world at all times.
- Having information available on my fingertips
- Getting out of the classroom and making the entire city a classroom
- Using a portable laptop inside of my Police Cruiser to access on line information
- Technology and Information should be considered infrastructure in the 21st century

Its benefits...

- Health, income, employment, education
- Wireless will help build digital equity. I see particular benefits for children
- Leveraging my limited time for multiple tasks
- Convenience and availability
- Flexible work hours
- Timely communication, increased productivity
- Access all on-line services more easily
- To do my courses online, pay bills, communicate
- Save some money
- I imagine that people will use it in ways they don't even expect....

Their advice...

- Enough bandwidth to make it usable
- Access should be secure and quality of service high
- Affordable to all if not free
- Prioritize technology literacy, equipment and access for underserved/disadvantaged communities
- There should be a model for the entire city

Source: Boston WiFi On-line Survey, BTS Partners, April/May 2005.

At one point, a few months ago, it appeared as if the cost for the design, refinement and construction of a citywide wireless system was going to fall on the shoulders of the city's taxpayers. However, recent developments in San Francisco and Philadelphia have turned this accepted equation inside out. With a wide

variety of some of America's most innovative and respected technology corporations demonstrating their eagerness to reach out to develop public-private partnerships with interested cities like Boston, our direction seems clear.

Boston's civic leaders are uniquely positioned to organize and motivate their diverse constituencies to collaborate on, and develop a plan for, the deployment of a reliable citywide WiFi network. Acting as a powerful catalyst, they have the experience and the aptitude to identify and recruit respected representatives from the various technology, academic, governmental and neighborhood organizations to participate in a Boston Wireless Task Force, a group similar to San Francisco's TechConnect or Philadelphia's Wireless Philadelphia.

With a wide range of dynamic pilot projects in place, the city has created a rich developmental environment capable of testing a wide variety of system design solutions. The charge for this task force would be to review existing local projects, as well as to familiarize themselves with system solutions being designed and developed around the country.

Conclusion

Technological innovation and sophisticated Internet communications are transforming Boston, our country and the world. Traditional 20th century bricks and mortar solutions to complex socioeconomic challenges are rapidly being replaced by the wizardry of fiber optics and driven by the power of high speed wireless Internet connectivity.

This accelerating and inventive technological environment will enhance the productivity of local corporations allowing them to continue as vital members of the national and global economies.

In this new world parents can talk with teachers and schools from their kitchen tables. Students can exchange information with peers in Europe and Asia, access enormous libraries of information using Internet search engines, while developing the refined scientific, mathematical and engineering skills necessary to obtain quality 21st century jobs.

Key Recommendations

Based on well grounded information, a Request For Information (RFI) should be drafted, that calls for expressions of interest. It should include:

- An examination of the technical facilities necessary to implement an effective and affordable citywide, wireless broadband network;
- A consistently up-gradable system that will have the long-term capacity of providing high speed—in home—upload capabilities;
- An examination of the technical facilities necessary to implement an effective and affordable citywide high speed broadband and wireless network;
- The establishment of a realistic timeline for the network to be built out so as not to raise unrealistic expectations for local residents;
- A model for a public-private initiative capable of overseeing the overall project, as well as getting reliable commitments to invest in a long-term deployment and support effort;
- An examination of security and interference issues to ensure efficient and safe deployment of the

system and a strategy for education of citizenry around these issues;

- A way to maintain the ongoing political, and community commitment necessary to make such a system a demonstrable success;
- A method for deploying a network in a scalable manner that uses existing pilot projects as a possible starting point. These projects offer different objectives, architectures and deployment models, and represent ideal opportunities for Boston to not only realize full value from its current wireless investments, but also to test any future citywide wireless system designs.

Another critical factor should be an examination of existing and proposed state and federal regulations governing the creation and management of wireless fidelity networks.

Upon the timely conclusion of these responsibilities the task force should make recommendations to Mayor Menino as to the most efficient way to design, develop and deploy such a system for the city of Boston.

The impact on local government will be equally as profound. City inspectors, public safety and emergency services personnel will be able to communicate instantaneously with city offices, police stations, fire houses and hospitals. Parking meters will become automated—operated from a single central office.

Innovations which seemed almost impossible a few years ago will become realities in a few short months and years.

To succeed in this emerging digital environment, the cities and towns of this region must assemble a sophisticated partnership of local political, corporate and nonprofit leaders to formulate and construct a communications infrastructure capable of competing not only financially but educationally as well.

The foundation for this system will be a wireless fidelity network similar to ones currently under development and deployment in San Francisco and Philadelphia. While it will employ hardware and concepts being used in those cities, it will use an infrastructure unique to the needs of the residents visitors of the Greater Boston area.

Respected technology companies like Earthlink, Google and Hewlett-Packard are extremely interested in partnering with local government to come to Boston to build a low cost or no cost system capable of providing affordable and reliable service.

Unlike traditional “wired” networks such as DSL and cable, wireless fidelity systems can be designed, constructed and modernized at a fraction of the cost. Because the network is a system of small, relatively inexpensive radio repeaters broadcasting a wireless high speed signal throughout a service area, deployment is fast and upgrades are easy.

The system being constructed by Earthlink in Philadelphia is projected to cost users between \$9.95 and \$19.95 a month. While Google is suggesting to San Francisco officials that they will be able to construct a network that will be free to its users. These figures contrast impressively with the current costs of \$30-\$50 a month from traditional high speed broadband providers.

Of particular importance to the taxpayers of the Greater Boston area is that development and deployment costs for municipal WiFi can be realized at no cost to local residents or businesses. The technology

companies that are building out similar networks around the country have determined that generated revenues will pay for construction costs and long-term maintenance of the system.

The city of Boston finds itself at an important crossroads in its financial, educational and community future. Just as the New England economy was driven for decades by the factories and mills from Fall River to Pittsfield, it must now transition to a new global socioeconomic world driven by the power of fiber optics, high speed Internet communications and scientific creativity.

Our city is graced with a wealth of innovative and creative scientific, engineering talent fully capable of developing the sophisticated high speed telecommunications system required for success in future decades. And we know that cities, regions and nations that plan their futures by anticipating innovations instead of perpetuating antiquated modalities will realize the benefits of their vision.

The Greater Boston area can not afford to forfeit its respected position in technological innovation and development. To do so would be to diminish our capacity to compete and prosper in a dynamic 21st century world. By designing and constructing its own WiFi network city leaders can demonstrate that Boston is the educational and economic power that has regularly produced astonishing innovations for decades.

The design, development and deployment of a reliable and affordable high speed broadband and wireless network in the Greater Boston area will have a significant impact on the city, state and region. It will strengthen local schools, improve the city’s economy while providing important opportunities and services to all of the city’s residents. At the same time, it will furnish an important and replicable model for other Massachusetts municipalities and state government as well.

Boston should embrace such a challenge not because it is easy but because it is hard. At the end of the day such a network will produce imaginative concepts, generate valuable returns and exhibit to the nation and to the world that Boston is once again a dominant and world renowned center of technological innovation.

2. Where We Stand Today

Milestones to a Wireless Future

In early 2005, Boston City Councilor John Tobin asked the Boston Foundation to help investigate the answers to several important questions:

- What are the needs, benefits and concerns of the various constituents regarding Internet access?
- What are the main businesses models being used already in Boston and other cities to address this issue?
- How can new advancements in wireless (WiFi) technology be harnessed to allow inexpensive, ubiquitous access to the Internet for all Boston citizens?

In March 2005, The Boston Foundation provided a grant of \$25,000 to the Museum of Science, to help coordinate with Councilor Tobin's office a study to help guide the Boston wireless strategy. To advance this effort, an adhoc task force was organized by Councilor Tobin to construct a strategy for the design, development and deployment of a wireless fidelity network system for Boston. The monthly meetings which convened at City Hall, involved communications industry professionals, community leaders, advocates and experts, who provided input into the design of an online survey developed and conducted by BTS Partners, a technology strategy consulting company.

In April 2005, a limited online survey was launched at a community outreach forum organized by the Boston Wireless Action Group (Boston WAG) at the Boston Public Library to gather information from community-based organizations and residents. Respondents, covering practically all Boston neighborhoods and many suburban areas, indicated overwhelming support for free or affordable wireless Internet access in Boston. In addition, over 40 organizations provided input, offering a mix of enthusiasm and caution regarding critical issues of security and interference.



Over 200 individuals responded to the online individual survey. Those individuals represented all areas of Boston neighborhoods, from a variety of age groups (10 to 70 years old), mix of ethnicities, education and income levels. Nearly 20 percent of the respondents indicated they were students.

Key findings from the survey indicate that Boston is well primed to benefit from the information age:

- A total of 69 percent of participating individuals indicated they owned a computer and 80 percent indicated they had access to one at work, school, library, and/or through a friend or family member.

- Nearly 95 percent of respondents indicated they have Internet access with a variety of access types. The most common was cable, at 45 percent, followed by DSL at 33 percent, Wireless at 23 percent, and 16 percent used dial-up. Almost 90 percent of the respondents had cell phones.
- Survey participants used their computer for multiple activities. Primarily: Email (ranked first); Internet, second; work, third; and news, fourth.
- People accessed the Internet at locations and businesses that offered free WiFi. Over 70 percent of the respondents indicated that they own or have access to a wireless card or capability.
- Enhancements to personal and professional life created by access to universal WiFi include increased efficiency, mobility and flexibility; convenience and access to real-time information about services, traffic, weather; communication with friends and family; educational enhancement of children; improved quality of life brought on by convenience, telecommuting, bill paying, scheduling; and cost savings.
- There was overwhelming support for always-on, free wireless Internet access in Boston, particularly at work, in public and civic places, at educational and medical facilities, businesses and nonprofits.
- Respondents prioritized free WiFi for populations who don't have access; highlighted the importance of universal access for Boston's competitiveness, emphasized high quality of service and adequate bandwidth; and called out reliable Internet access as infrastructure for the 21st Century.

WiFi summit

On May 19, 2005, the Boston WiFi summit assembled a dynamic cross-section of participants from neighborhoods, government, business and academia at the Museum of Science. Participants ranged from a group of middle school students to university students, sophisticated technology experts, business professionals and public officials.

Discussions explored a wide variety of topics and created a vision for Boston as an innovative national and global leader, not only in the fields of advancing corporate competitiveness and educational excellence, but also in thoughtful and caring community services.

A central focus of the summit was to reinforce Boston's reputation as a leader in education, biotechnology and health care. It was pointed out that Boston's competitive fitness in regard to cultural, political and economic issues will in fact be determined by the quality of its communications infrastructure.

Jeff Kelly wrote in a SearchNetworking.com article that covered the Summit: "Among the benefits highlighted by the panelists, a citywide WiFi network could open previously untapped markets to many local companies and organizations, allowing them access to new customers and new streams of revenue. A wirelessly connected Boston would also attract many new businesses, as well as some of the world's brightest minds to live and work in the city."

Key recommendations that emerged from the summit included:

- Value and importance of digital inclusion
- A focus on innovation and leadership
- Importance of increasing competition to drive down price of access
- Appointment of a cross discipline Task Force to make recommendations for a citywide wireless strategy.

Digital Inclusion for a Changing Population

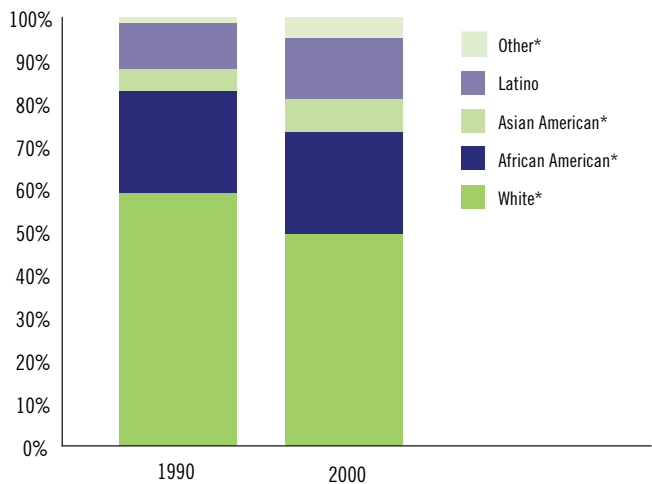
To date, affordable access to quality high speed Internet access in Boston seems directly related to income, level of education and ethnic background. Immigrant and minority populations are becoming an increasingly significant portion of the city and the region's future workforce. Research shows that these communities also largely represent populations that have limited access to technology.

Boston's racial/ethnic mix

Changes in racial patterns in Boston's population, over the decade of the 1990s, show that Boston finally reached the "minority as majority" status in the year 2000. Today, more than 25 percent of Boston's population is foreign-born. Over a 100 different ethnicities are represented in Boston's neighborhoods and 140 languages are spoken in its homes.

FIGURE 1

Population by Race/Ethnicity City of Boston, 1990 and 2000



Not Latino. Source: 1990 and 2000 U.S. Census

Minorities now comprise over 50 percent of the city's total residents. Share of populations by race indicate a population breakdown of White at 49 percent; African-American at 24 percent, Hispanic or Latino at 14 percent, Asian at 8 percent, and 4 percent who identify themselves as "other" or of two or more races. The fastest growing racial group in real numbers was Hispanic, which grew from 61,955 in 1990 to 85,089 in 2000—a 37 percent rate of growth. Asians, a smaller percentage of the total population also saw their numbers surge by a significant 49 percent. Boston's population, over the past decade grew primarily through immigration, increasing the diversity of the city and its work force.

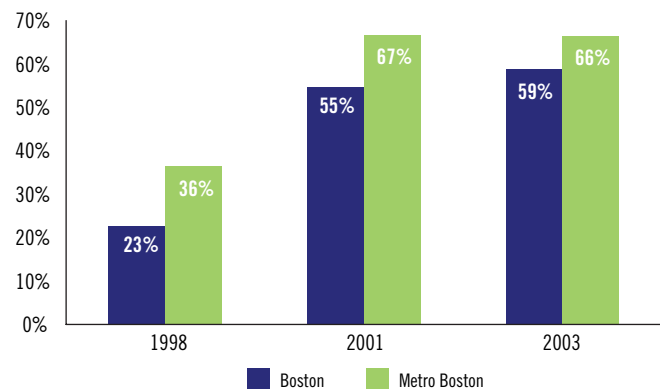
While strides have been made, in 2003, Internet access still varies by race, education and income level:

Computer and Internet Use Tabulations from the 2003 Current Population Survey conducted by the U.S. Census Bureau, indicate that only about two-thirds of Boston-area residents had a computer at home, and most of those two-thirds had some type of Internet connection.

Overall, there was little increase in the number of households with a computer or the number with an Internet connection between 2001 and 2003. Those with less education and income are still less likely to have a computer, but there is some evidence that the "digital divide" is narrowing, particularly with regard to race and ethnicity. Between 2001 and 2003, the share of black households in the Boston region that had a computer increased from 50 percent to 61 percent, and the share of Latino households with a computer at home increased from 36 percent to 47 percent. There was no change for white or Asian households.

FIGURE 2

Percent of Households with an Internet connection, Boston and Metro Boston: 1998-2003



Source: U.S. Census, Current Population Survey, Computer Use Supplement

Internet access by race, income, and educational attainment indicates digital inequity

Data for 2003 show that in the Boston PMSA, internet access varies widely by race, income and educational levels.

FIGURE 4

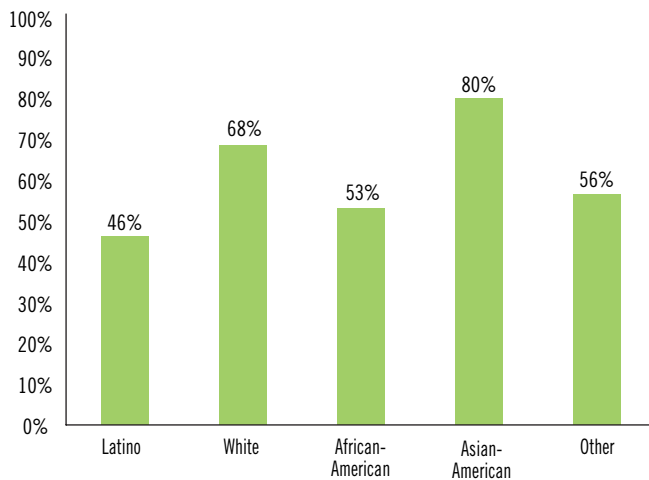
Percent of People Using the Internet by Household Income, Boston PMSA: 2003



Source: U.S. Census, Current Population Survey, Computer Use Supplement

FIGURE 3

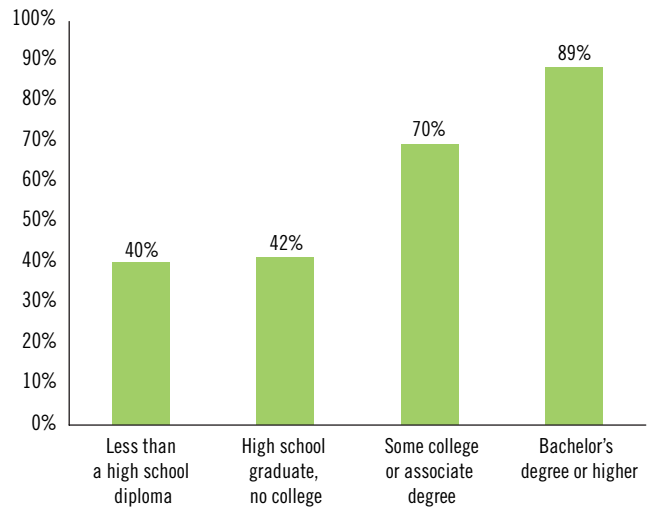
Percent of People Using the Internet by Race/Ethnicity, Boston PMSA: 2003



Source: U.S. Census, Current Population Survey, Computer Use Supplement

FIGURE 5

Percent of People Using the Internet by Educational Attainment, Boston PMSA: 2003



Source: U.S. Census, Current Population Survey, Computer Use Supplement

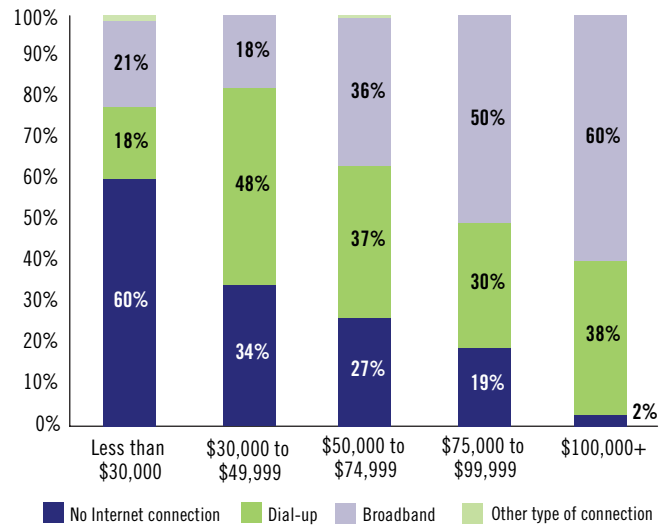
Households with higher incomes and education levels, and those that are white or Asian are more likely to have high speed broadband access:

Data indicates a sharper demographic gap when you consider broadband Internet access rather than any access. In 2003, among Latino households, almost 60 percent did not have an internet connection and almost 30 percent had only dial up access. Of African American households over 50 percent had no access, and over 35 percent had dial-up access. Only about 13 to 14 percent of African-American and Latino households had broadband compared to 37 to 38 percent of white or Asian-American households.

Concerns about digital inclusion persist for households based on their income and educational levels. About 60 percent of the highest income group had a broadband connection, compared to less than 20 percent of households with an annual income less than \$50,000, and about 20 percent of households with incomes below \$30,000. Similar patterns of inequities are evident in comparisons based on educational attainment.

FIGURE 7

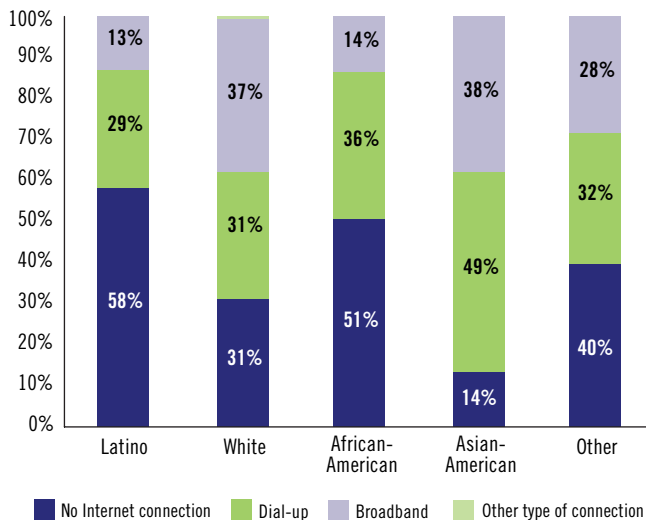
Internet Connection Type by Household Income Boston PMSA: 2003



Source: U.S. Census, Current Population Survey, Computer Use Supplement

FIGURE 6

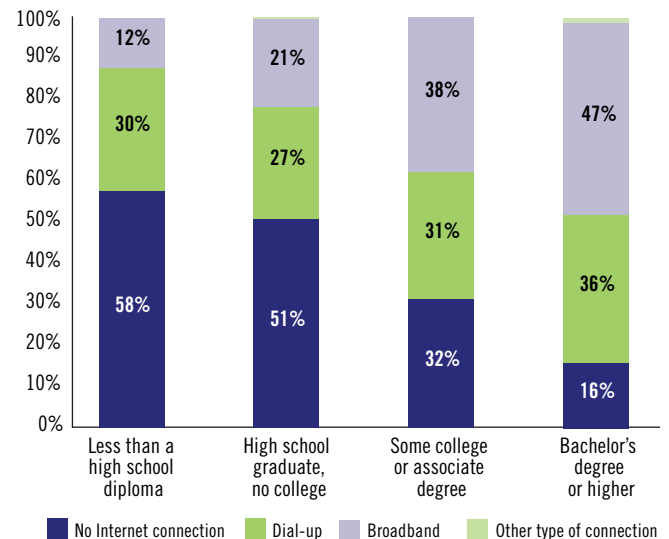
Internet Connection Type by Race/Ethnicity Boston PMSA: 2003



Source: U.S. Census, Current Population Survey, Computer Use Supplement

FIGURE 8

Internet Connection Type by Educational Attainment Boston PMSA: 2003



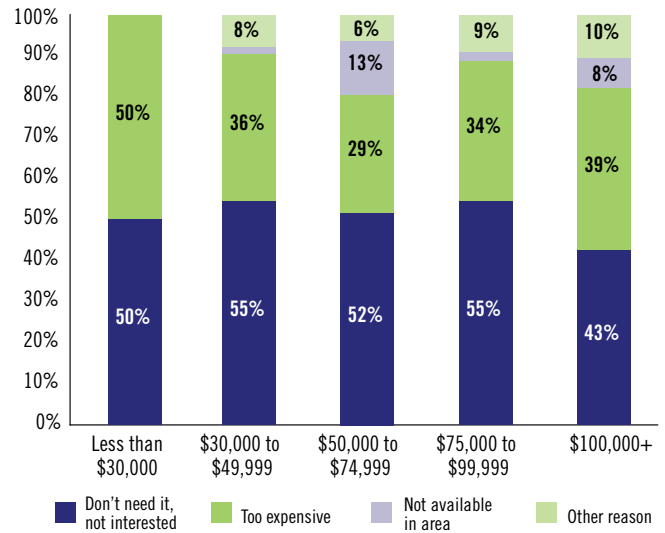
Source: U.S. Census, Current Population Survey, Computer Use Supplement

Concerns of cost and availability dominate reasons households lack broadband internet access:

Of particular concern is the fact that across the board—across racial, educational and income levels—over half the respondents who did not have internet access said they didn’t need it or were not interested. Other reasons respondents gave for not having high-speed (broadband) Internet access, include cost and availability. More than one-third said it was too expensive; 7 percent said it was not available in their area, and the remaining 6 percent had other reasons. As data show, the lowest income groups and those with the least education were most likely to say it was too expensive. Lack of availability was not a major reason, except among Asian Americans, although this result may be the artifact of a small sample size.

FIGURE 10

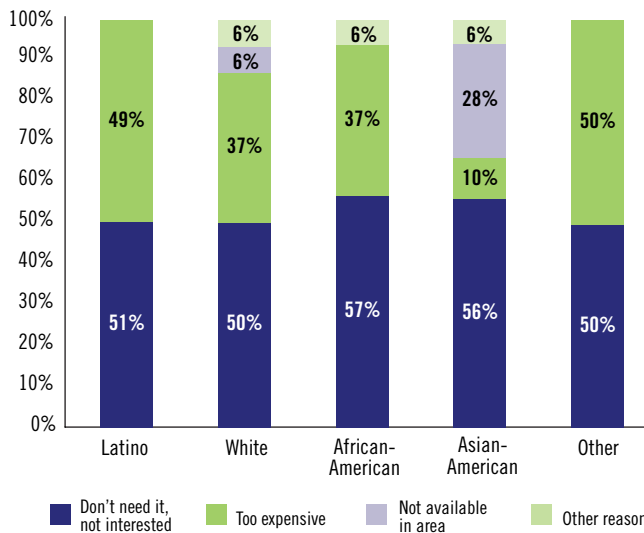
Reason Household Lacks Broadband Internet Connection by Household Income, Boston PMSA: 2003



Source: U.S. Census, Current Population Survey, Computer Use Supplement

FIGURE 9

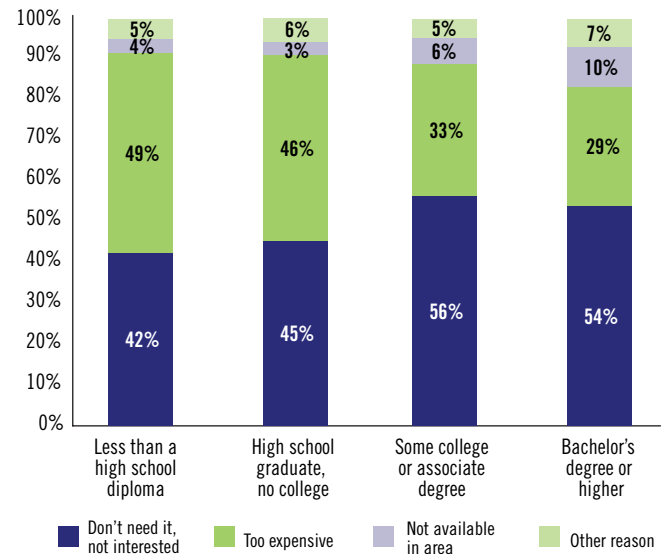
Reason Household Lacks Broadband Internet Connection by Race/Ethnicity, Boston PMSA: 2003



Source: U.S. Census, Current Population Survey, Computer Use Supplement

FIGURE 11

Reason Household Lacks Broadband Internet Connection by Educational Attainment, Boston PMSA: 2003



Source: U.S. Census, Current Population Survey, Computer Use Supplement

Users of the Internet indicate a preference for in-home access. Usage covers a wide range of activities.

Overall, two-thirds of Boston area respondents indicate that they used the Internet someplace.

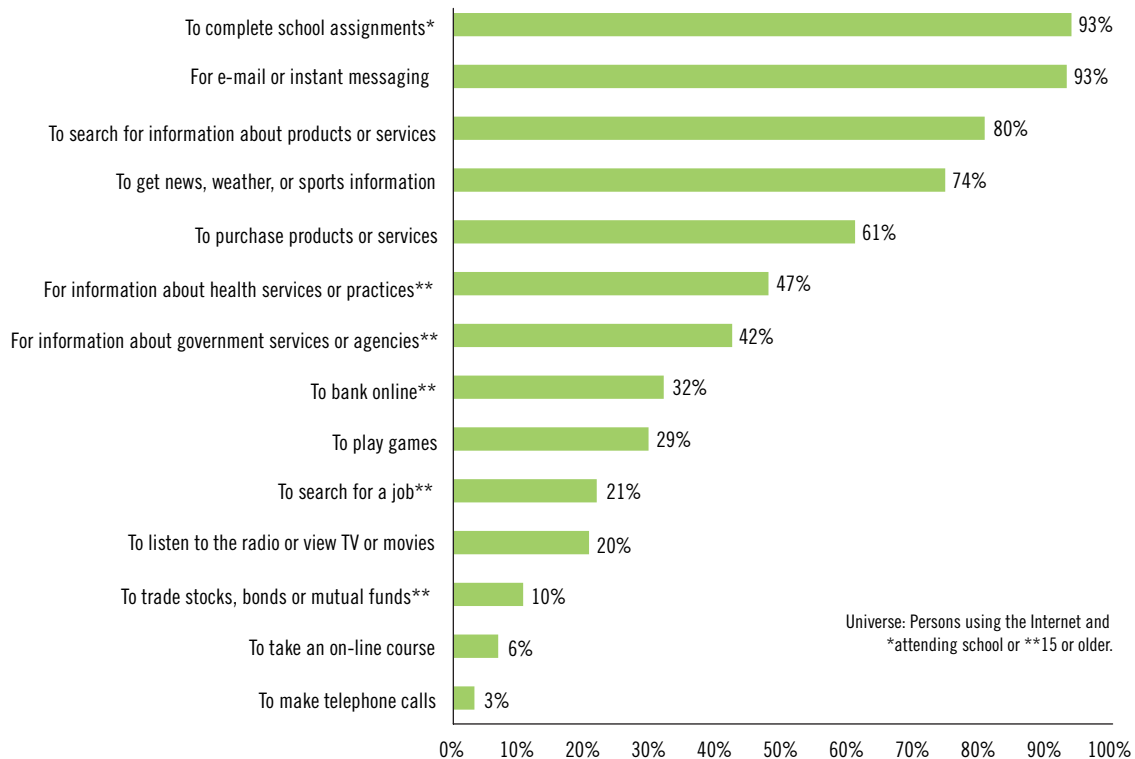
Use in public places is relatively low. Only 8 percent reported using the Internet in public libraries, 6 percent at an airport or hotel, and 2 percent at a café or coffee shop. Airport and hotel use is much more common among higher income and better-educated people. Public library use followed a similar pattern for the most part. African-Americans and Asian-Americans had higher rates of public library Internet use than whites or Latinos. Largely internet usage occurs in settings such as school, work or at home.

The most common use of the Internet is for e-mail or instant messaging, with 93 percent of Internet users using this application. The next most common usages are, searching for information about products or services, getting news sports, or weather, and purchasing products or services.

Use of the Internet for specific purposes indicates that a high percentage of those attending school use it “to complete school assignments.” It is important to note that this data only captures a universe restricted to those 15 or older, and does not account for the city’s almost 66,000 school age children (5-14 year olds) who use it for home work, entertainment and academic enhancement purposes.

FIGURE 12

Percent of Internet Users Using the Internet for Specific Purposes, Boston PMSA: 2003



Source: U.S. Census Bureau, Current Population Survey Computer Use Supplement.

Educational Tools in Transition

Boston has been an influential force in the American educational system since the early 17th century. The city's colleges and universities have regularly produced some of the most brilliant and innovative minds not only for this country, but for the global community as well.

This important leadership role has allowed our region and this country to maintain a competitive economic and educational position for over three centuries.

In recent years, however, we have begun to lose our advantage.

Developing nations like China, India and Ireland are providing well educated, highly skilled work forces all of whom are willing to work for wages that are insignificant in relation to their American counterparts.

The reality of the 21st century is that the strength of our economy, our national security—our very quality of life—will depend upon our ability to compete in a global economy driven by technological skill.

The United States is falling behind in our ability to produce a workforce trained in science, mathematics and engineering. In Germany, 36 percent of undergraduate students receive degrees in the sciences and engineering, in China it is 59 percent, in Japan, 66 percent and in this country it is only 32 percent.

Remote Chinese cities are able to provide reliable wireless communications networks, while India offers seven Institutes of Technology, and a variety of private sector equivalents. Also available to the country's over one billion people are six Indian Institutes of Management and an economic culture that encourages its best and brightest to do their most innovative work. The result is an enormously creative, gifted and prolific work force capable of exporting imaginative work to its global customers, a work product which is regularly accelerating the speed of business.

In the 1970s and 1980s young Americans wanted to be lawyers and swamped those interested in a career in the sciences or engineering. In the midst of the 1990s dot-com boom, pursuit of MBAs again overwhelmed the number of young people seeking degrees in the sciences. As a result, this country began to lose its ability to remain technologically competitive.

Intel chairman Craig Barrett has said, "The sort of inspired leadership critical for quality education in science and engineering in the United States is totally missing."

So what steps are going to be necessary for America to prosper in this new world?

The National Academy of Sciences, the National Academy of Engineering and the Institute of Medicine formed a bipartisan study to answer that question.

In early October they released their findings in a report called, "Rising Above the Gathering Storm." The report concludes that American workers are ill equipped to compete with workers in other countries who are well trained in technology and the sciences. If this trend continues the report concludes this country may lose its edge in the sciences and technology and never get it back.

The report says that among America's top priorities should be:

- 1 Annually recruiting 10,000 science and math teachers by awarding four-year merit-based scholarships, to be paid back through five years of K-12 public school teaching. (We have too many unqualified science and math teachers.)
- 2 Strengthening the math and science skills of 250,000 other teachers through extracurricular programs.
- 3 Creating opportunities and incentives for many more middle school and high school students to take advanced math and science courses, by offering, among other things, \$100 mini-scholarships for success in exams, and creating more specialty math-and-science schools.
- 4 Increasing federal investment in long-term basic research by 10 percent a year over the next seven years.
- 5 Annually providing research grants of \$500,000 each, payable over five years, to 200 of America's most outstanding young researchers.

- ⑥ Creating a new Advanced Research Projects Agency in the Energy Department to support “creative out-of-the-box transformational energy research that industry by itself cannot or will not support and in which risk may be high, but success would provide dramatic benefits for the nation.”
- ⑦ Granting automatic one-year visa extensions to foreign students in the U.S. who receive doctorates in science, engineering or math so they can seek employment here, and creating 5,000 National Science Foundation-administered graduate fellowships to increase the number of U.S. citizens earning doctoral degrees in fields of “national need.”

Boston is well positioned to play an important leadership role in this critical reorientation of the American educational system. To do so we must demonstrate to

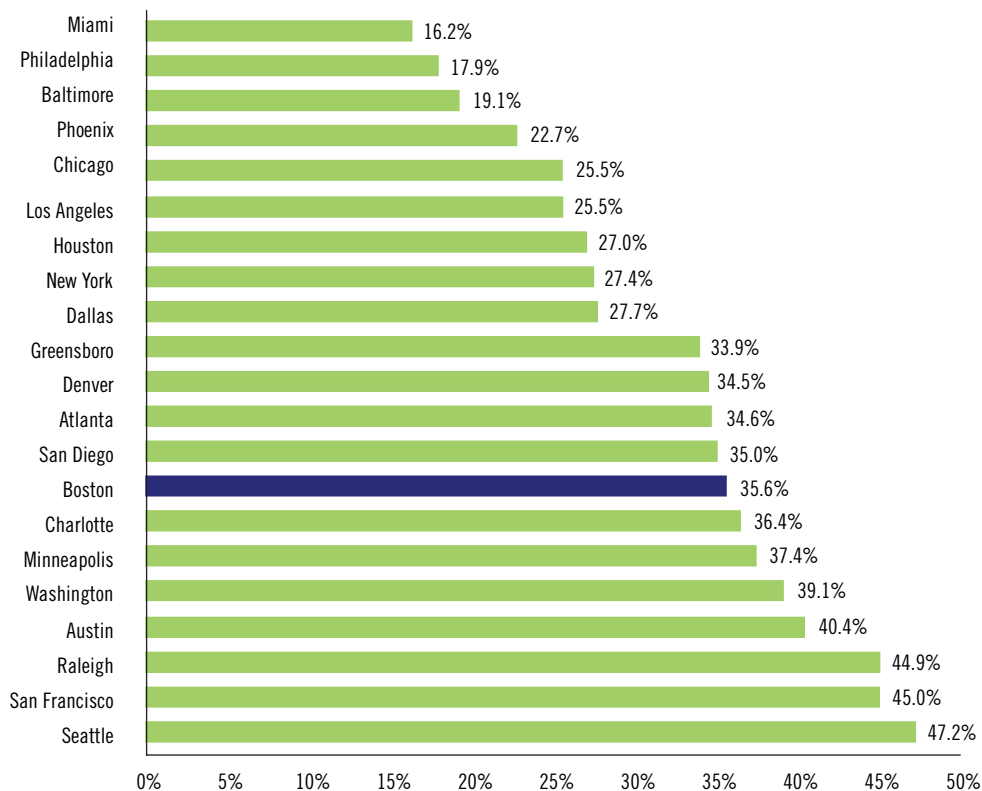
the city, our region, the country and the world that the United States is shaping its economic and educational agendas not based on past successes, but rather on the demands of future decades. That we understand that passivity in a global economy means failure and that is not an outcome we are willing to accept.

To assume this position, city leaders must take an aggressive posture in reigniting the imaginations of the students in grades K -12 as to the magic of the technological revolution.

A critical long-term component in this reawakening process will be to provide these students not only with the tools to educate themselves, but to also observe and talk to a world that is wired with millions of miles of fiber optic cable, and communicates using high speed broadband and wireless networks.

FIGURE 13

Percent of Residents with B.A. or Higher Educational Attainment Boston and Selected Cities, 2000



Source: 2000 U.S. Census

This is a remarkable opportunity for Boston to provide an innovative and forward looking vision capable of generating new discoveries, more unimaginable technologies and the economic vitality necessary to safeguard not only our quality of life but also that of our children and grandchildren.

It is an opportunity our city and this country can not afford to waste.

Boston's higher education infrastructure

The Boston area's 75 colleges, with a combined enrollment of some 265,000 students (one-third of all college students in New England) in Metro Boston's universities, create fertile ground to spawn new ideas and drive innovation.

Many of these students, who come from all over the world, often return home or seek more rewarding options elsewhere. The population of the greater Boston region ranks third among metropolitan areas with most highly educated workforces in the nation. In 2000, 39 percent of the residents of the Boston metropolitan area had a Bachelors degree or higher—behind only the San Francisco metropolitan area (44 percent) and the Washington, D.C. metropolitan area (42 percent). The City of Boston also ranks fairly high in this measure. In 2000, 36 percent of the population of the City of Boston had at least a Bachelor's degree. However, comparable U.S. cities are fast pacing ahead. According the 2000 U.S. Census, cities with a higher percentage of college graduates include Seattle (47 percent), San Francisco (45 percent), Raleigh (45 percent), Austin (40 percent), Washington (39 percent), and Minneapolis (37 percent). (See figure 13 on page 25.)

While Greater Boston has some of the finest private institutions of higher education in the world, a majority of its students come from other states and nations and plan to return home or explore other cities—only 50 percent of local college graduates typically choose to remain in the region.

Massachusetts' public higher education system is critically important for workforce training and retention; however, funding for Massachusetts public higher education system is among the lowest in the nation. According to Grapevine data compiled by the Center for the Study of Education Policy at Illinois State University, Massachusetts ranks 49th among states

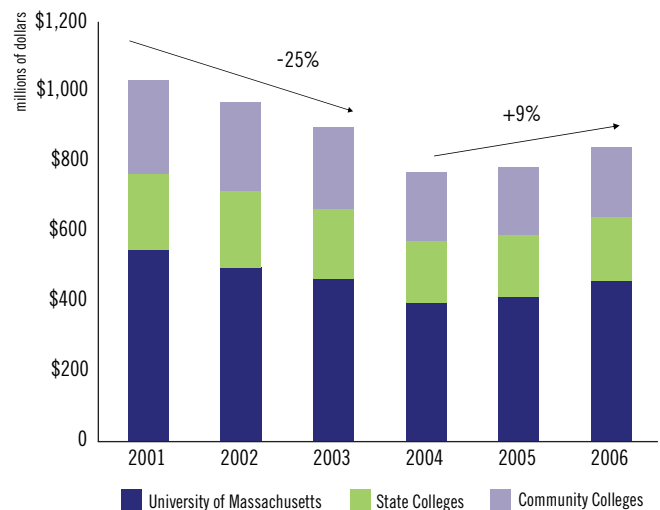
on FY05 tax appropriations for higher education per \$1000 of personal income, as cited in the 2004 Boston Indicators report.

The Boston area has several well established efforts for science and technology higher education at area universities. USCollegeSearch.org lists 43 engineering colleges in Massachusetts that provide a degree in engineering. In addition, community colleges provide technical skills training and award two-year associate degrees. Massachusetts ranks number five (with 12.65 per 1000 residents) in the nation in conferring Science and Engineering degrees to 18-24 year olds.

Universities and colleges are actively installing wireless Local Area Networks (WLANs). Factors driving their efforts include the demand and expectations of ubiquitous Internet access from their constituency—today's technologically savvy young people; Research agendas and innovative curricula and new ways of teaching and learning via the internet; as well as the historic nature of colleges and university buildings which are difficult and expensive to wire. Among local universities using wireless networks are: Harvard, MIT, the University of Massachusetts, Boston University, Boston College, Suffolk, Northeastern, Tufts.

FIGURE 14

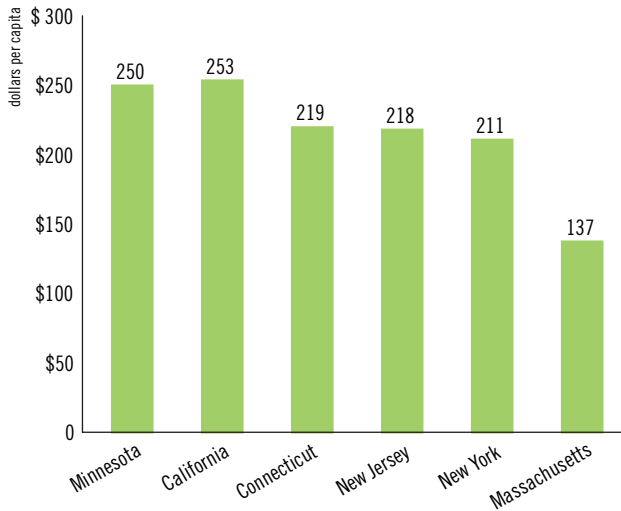
Massachusetts State Expenditures on Public Higher Education, Fiscal 2001-2006



Note: Adjusted to 2004 dollars using CPI-U.
Source: Massachusetts Taxpayers Foundation

FIGURE 15

State Tax Appropriations for Operating Expenses of Public Higher Education, Fiscal 2005



Source: Grapevine, Center for the Study of Education Policy, Illinois State University

Public education continuum for IT

The Boston Area Advanced Technological Education Connections (BATEC) established in 2002, is a partnership of: University of Massachusetts Boston; Bunker Hill, Middlesex, and Roxbury Community Colleges; K-12 Districts of Boston, Cambridge, Chelsea, Everett, Medford, Newton, Northeast Metropolitan, Revere, Somerville, Watertown, and Winthrop; business and industry leaders; government and community.

Funded by the National Science Foundation, BATEC is engaging the region’s secondary school, community college and four-year faculty in professional development for new and emerging information technologies and curriculum designed to deliver a new IT education and workforce continuum. It also supports student success in IT fields in partnership with industry.

Technology infrastructure in Boston public schools

In 2001, Boston became the first city in the United States to wire all of its schools to the Internet and achieved a remarkable ratio of one computer to every four students. Rapid changes in technology have already rendered a lot of that equipment obsolete. In 2004, the ratio of Boston students’ access is at eight students to one “modern” computer. On a statewide level, there are 4.2 students to one machine.

TechBoston Academy, a pilot school in Boston is the only school that approaches a 1:1 ratio of students to up to date, high-speed computers according to the Massachusetts Department of Education (<http://profiles.doe.mass.edu/>). On issues of Internet connectivity, about 98.5 percent of Boston schools have classrooms connected to the Internet and two Boston public schools, the TechBoston pilot school and the John D. O’Byrant School of Mathematics & Science are wireless. The Media And Technology Charter School also has a wireless network.

TechBoston, a program of the Boston Public Schools, gives students training in network design and management, webmaster, MOUS, MCSE, and Robotics. It serves an impressive 2500 students each year.

Boston has also invested in training its teachers. In 2004, 95 percent of all Boston Public Schools teachers had received 50 hours of technology training. However, use of technology for teaching and learning is still very limited and has a long way to go.

Concurrent with in-school efforts, the City has also focused its energies on promoting greater in-home access and technology skills training for students and their families through the Technology Goes Home @school program offered in 21 public schools across Boston. TGH@School is focused on elementary schools and requires a parent and a student to participate in technology training at the end of which they get a computer, a printer and 1 year of paid internet access. About 600 students have benefited from this effort. Participants are families that do not have a computer at home.

Technology Infrastructure in Boston's Neighborhoods

Boston has an extensive infrastructure of technology centers and nonprofit and private technology training programs that encourage in-school, out-of-school, college-prep and skills development. These include:

Technology Centers:

Timothy Smith Centers are computer training centers established in 1996 by the City of Boston, through a bequest left to the city by Timothy Smith, a longtime resident of Roxbury, who died in 1918.

The 39 centers located at various social service agencies and educational institutions in Greater Roxbury, provide in total more than 1 million hours of computer access to the community for a wide variety of programs including job training, educational enrichment and open access. Funding for these activities is being provided by foundation, corporate, and governmental agencies and through user fees. The Timothy Smith Fund, an endowment fund, has pledged to provide the ongoing support necessary to maintain these Centers' state-of-the-art status until the year 2019.

Museum of Science Computer Clubhouses were established in 1993 by The Computer Museum (now part of the Museum of Science, Boston) in collaboration with the MIT Media Laboratory. In 1999 Intel Corporation announced its support for establishing 100 clubhouses worldwide. The goal of the Intel Computer Clubhouse Network, is to proliferate the highly successful Clubhouse learning approach and establish it as a replicable model for technology learning.

Six of the 100 worldwide locations are in the Boston area, with a flagship Clubhouse located at the Museum of Science. Other Clubhouses are located at the Charlestown Boys & Girls Club, Jordan Boys & Girls Club in Chelsea, Blue Hill Avenue Boys & Girls Club in Dorchester, Roxbury Boys & Girls Club and the South Boston Boys & Girls Club.

CTCNet and Faith Based Technology Centers include 45 community technology centers spread all across the neighborhoods of Boston. They are located at social

service agencies, community centers, and faith based organizations affiliated with TechMission, a national network of 500 tech centers. TechMission was formed in 2000 to support Christian community computer centers across the world in their effort to provide access, skills and relationships needed to succeed in the information age. These centers affiliated with CTC Net and TechMission offer open access to technology, run after school and remedial education programs using technology, and offer technology training programs for adults.

In addition, all Housing and Urban Development (HUD) funded housing development and Boston Housing Authority sites have technology centers.

Technology training and support programs:

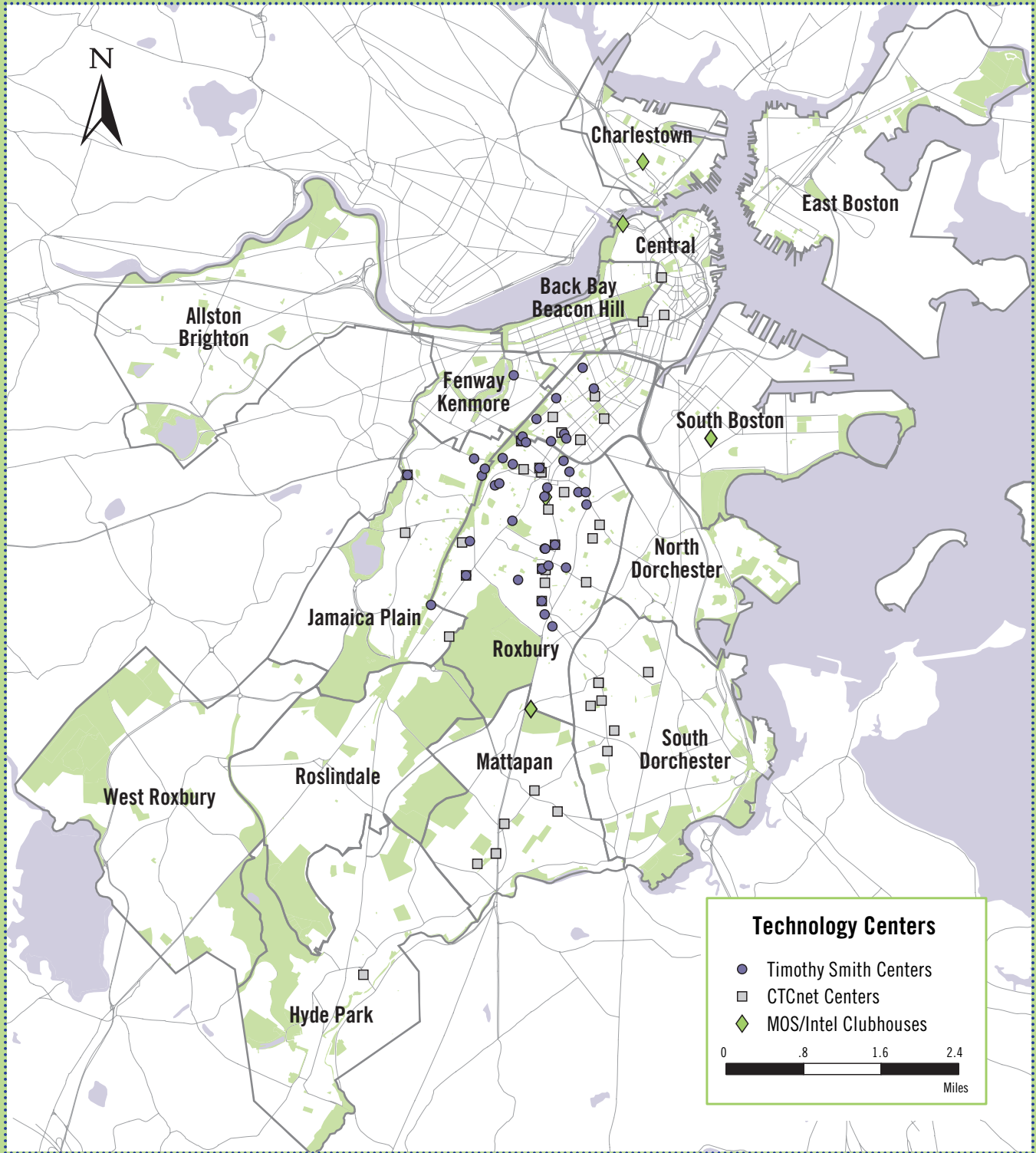
Boston has a host of technology training and support programs focused on building skills and capacities for the New Economy. Some notable examples that are at scale include the following.

Technology Goes Home (TGH), an initiative of the Boston Digital Bridge Foundation, is an innovative program designed to bridge the digital divide by bringing technology into low-income families' homes.

The program's community component Technology Goes Home @Community prepares adults for employment opportunities and helps children improve academic performance. Neighborhood programs operate in six communities through coalitions of community-based organizations. Coalitions select participating families, and provide training, practice lab space and ongoing support. Participating neighborhoods include Allston-Brighton, Codman Square, Grove Hall, Lower Roxbury, Mission Hill and Uphams Corner. To date over 1200 computers have been disbursed through the Technology Goes Home program.

The Massachusetts Association for Community Action (MASSCAP) is a statewide association of 25 Community Action Agencies (CAA) working with Massachusetts Department of Housing and Community Development to promote self-sufficiency for low-income residents. Launched in 1999, its Information Technology Project, has developed IT programs tailored to the needs of the people they serve, at 11 CAAs.

Technology Centers in Boston



Bringing IT Home is an effort of community development and housing nonprofits, advocacy groups and intermediaries to provide technology access to residents in low-income housing developments. A task force of led by CHAPA, a housing advocacy organization and supported by One Economy, a national organization, is crafting public policy with state housing agencies. The policy to include wiring of homes in new and substantially rehabilitated housing developments and cover the cost of internet connectivity for residents is modeled on practices established and adopted by 13 other states across the country.

In addition, the Community Development Corporations (CDCs) Technology Initiative, a collaboration of Boston-area CDCs, Boston LISC and the Massachusetts Association of CDCs is working toward the use information and communication technology to advance their mission of rebuilding communities, and provide low and moderate income residents with access to technology.

Year Up is a one-year, intensive training program that provides urban young adults 18-24, with a unique combination of hands-on technical and professional skills, college credits, and a paid corporate apprenticeship.

Participants focus on skills in one of two areas: Desktop Support/IT Help Desk; and Web Production. Equal emphasis is placed on professional skills required in today's workplace such as effective communication, leadership, and teamwork. After training students are placed in paid apprenticeships with local partner companies. A stipend is paid to all participants throughout the one-year. In addition, Year Up's 150 students are dually enrolled in Year Up and Cambridge College, and can earn up to 18 college credits.

Boston's broadband & wireless infrastructure

While Boston has the more traditional broadband systems in place, it has the more cutting edge systems as well. In addition the city is extremely fortunate to have a wealth of technological and scientific talent capable of designing new and even more innovative alternatives.

Currently the city's high speed Internet access infrastructure is built upon a foundation of DSL/Cable, WiFi Mesh Networks, and WiMax systems:

DSL/Cable

These services are provided for a monthly fee. The internet signal comes into a house, apartment or business on a copper wire or cable and can be connected to an in-house router. This router then broadcasts the wireless signal—within a very short range—to computers equipped with wireless cards.

Direct Subscriber line (DSL): Verizon is the primary traditional telecommunications provider in New England, offering Internet Access packages and price points to both business and residential users. Residential DSL packages start at \$29.95 per month and small business packages start at \$39.95 per month. It is common for Verizon customers to use WiFi to network their homes for wireless access to Verizon's DSL connection. This results in many cases, to the same wireless signal either interfering with that of the neighbors or the signal being available to the neighbors for access to the Internet.

Earthlink provides home DSL at the monthly rate of \$39.95 per month and for 1.5Mbps for downloading and 128Kbps for uploads.

Cable Companies: The main cable providers in the Boston area are Comcast and RCN. The Boston region is one of the few areas of the country where some areas have the choice of different cable providers.

Comcast offers 3-6Mbps cable modem access to the Internet with a variety of packages and price plans for both residential and business customers. Price plans start at \$39.99 per month. In addition, Comcast has teamed up with T-Mobile to offer their subscribers

access to T-Mobile's entire network of hotspots throughout the country at places like Starbucks, Borders Books, Kinkos, & various airports. However, this access is not free of charge.

RCN offers high-speed cable modem access to the Internet with a variety of packages and price plans for both residential and business customers. Like Comcast, many of RCN's modems have built in wireless routers for WiFi access. However, RCN requires no term contracts of their customers but instead charges a slightly higher monthly subscription rate—starting at nearly \$60 per month for residential clients. Additionally RCN has run cabling in housing developments throughout the city. It would be valuable to explore ways that the housing development, community agencies, and/or city can use or benefit from this capacity beyond the regular service offerings of RCN.

Wireless mesh network

A wireless network relies on a series of nodes in the network to propagate signals. Although the wireless signal starts out at some base station (access point) attached to the wired network, a wireless mesh network extends the transmission distance by relaying the signal from one active device to another.

A typical wireless mesh system works with a series of transmission towers that broadcast a signal to remote radios or repeaters positioned on street and traffic lights and light poles throughout a city. These radios receive and transmit the signal creating a mesh of wireless transmitters throughout a particular service area.

Locally, NewburyOpen.net has created a partial mesh network broadcasting from two towers on Newbury Street to a series of repeater devices located in the immediate area. Some local technology experts refer to the NewburyOpen.net network as a "cloud" as it has a 1/2 mile limit.

Wireless providers: Boingo, Cingular, T-Mobile, AT&T, Wayport are among some 140 wireless service providers in the Boston area who provide service for a fee.

In addition, Boston has an increasingly growing number of municipal, community and institutional wireless networks.

WiMax

The WiMax protocol is a concept intended to be able to network computing devices together. It is still under development but is being designed to provide Internet access, in a similar way to WiFi. It is suggested that WiMax will be both faster and have a longer range than WiFi. WiMax does not necessarily conflict with WiFi, but is designed to coexist with it and may indeed complement it.

According to WiMax developers, a WiMax base station would beam high-speed Internet connections to homes and businesses in a radius of up to 50 km (31 miles); these base stations would theoretically have the power to cover an entire metropolitan area.

The claims of a 50 km (31 mile) range are, as yet, unproven. A continuing question remains as to whether these distances can be achieved without line of sight connectivity. Nonetheless, WiMax holds out the promise of a remarkable step forward in the development of wireless communications.

TowerStream, a fixed-wireless broadband provider offers dense Internet and VoIP Phone Service coverage in the Greater Boston area. Using fixed-wireless technology that is the basis of WiMAX, TowerStream provides service at speeds that are T1 Equivalent, 100 Mbps and up to one Gigabit-per-second. They serve large businesses, institutions and enterprises. Their prices for: T1 Internet with four unlimited phone lines are \$525/month; T1 Internet backup for \$175/month, and 100 Mbps (66 T1s) for \$5000/month.

Municipal and Community Wireless Efforts

According to CNETnews.com, in Massachusetts, the communities of Nantucket, Malden, Boston, Brookline, Newton, Wellesley, North Andover, Worcester, Concord, and Taunton have either functioning fiber-to-the-premise (FTTP) or large wireless networks deployed or in process of being deployed. Projects range in purpose from economic impetus of serving Nantucket's tourist community to Malden's efforts around municipal service to a broader approach of the Brookline Municipal Broadband Initiative aimed at providing free Internet access for its public buildings, parks and main commercial areas. Currently courting likely vendors, who might be interested in supplying the network, maintenance and hardware the Brookline project is still in its developmental stages. Other communities in Massachusetts that are exploring WiFi solutions include Waltham, Cambridge and Somerville.

These efforts across the state do not include municipally owned Hybrid Fiber Coaxial (HFC) cable networks or the small wireless hot spots installed in public places, such as cafes or airports or the private and grassroots efforts to deploy technology.

Municipal wireless projects in Boston:

Boston Public Library (BPL) and its 26 neighborhood branches began to offer free WiFi access in 2003. The BPL system has a total of 553 public access computers. Direct plug-in ports are also available in Bates Hall in the Central Library. In addition, nine sites in Roxbury that are part of the Timothy Smith Network are designated virtual public library sites.

Main Streets WiFi is an initiative recently launched by Mayor Thomas M. Menino is bringing wireless technology to Boston's communities and neighborhood commercial districts. This program is designed to create a free entry point for residents to access the Internet, help attract and retain visitors to the city, educate and inform local residents and businesses on the use and applications of wireless technology. A collaboration between Boston Main Streets program and four private businesses (ASCIO Wireless, Colubris

Networks, Community Wisp and Single Digits), the system is supported through a combination of donations and advertising revenue

Piloted and recently launched in Roslindale and West Roxbury, WiFi projects are also planned for East Boston, Jamaica Plain Center/South, Washington Gateway, and Chinatown.

The Boston Police Department used wireless broadband video surveillance to manage, traffic and public safety concerns during the 2004 Democratic National Convention. Motorola's Canopy broadband radios monitored for incidents related to crowd management and officer deployment. Data transmitted at the rate of 256K also allowed traffic command to obtain a video feed of the traffic situation in a convertible high occupancy vehicle lane along the Southeast Expressway. The technology is being reviewed for inclusion in the expansion of Boston's public safety network.

This wireless broadband system has been used to support security in Boston during Super Bowl festivities in February after this year's New England Patriots victory and to support Internet connectivity at the 40th Head of the Charles Regatta in October, supporting applications such as allowing vendors at the celebration to run credit card transactions in real-time. The technology is now being considered for expansion for an expanded public safety network.

Community wireless projects:

Tent City is a mixed income housing development in Boston's South End. It consists of 269 residential units in 12 four story buildings. 25 percent of the units are set aside for low income families, with many being single parent households.

Tent City has a community technology center in the basement of a gateway building which has a cable connection of 3 megs download and 512K upload. The first phase of the project installed Cisco access points on the roofs of several buildings. Those access points are all connected by Ethernet and bridged to the gateway building. The wireless network in place, however did not provide good coverage to apartments, unless they are within the signal range of the roof-mounted access points or bridges located inside the buildings.

In March 2005, RoofNet an experimental 802.11b/g mesh network in development at MIT's Computer Science and Artificial Intelligence Laboratory (CSAIL) was installed at Tent City. Its purpose was to improve coverage to those units experiencing significant signal degradation.

RoofNet was developed to provide affordable, low-cost broadband Internet access for public use. It has been made available to community groups in Cambridge, at the Tent City, and the Castle Square Housing Development in Boston's South End.

Castle Square Tenants Development is a 500-unit low and moderate income housing development in Boston's South End. With over 500 youth in this development, they have worked with HUD, CTC Net and Mass. Housing to provide a wide range of technology programs to the community's younger residents. These programs are run out of a technology center funded by HUD. With funding from The Boston Foundation, a research team from CSAIL is working to install a RoofNet system as well.

Also in place is a technology, health and multimedia program funded by the Stride Rite Foundation. Its primary purpose is to improve access to such assets for Castle Square's younger women.

Currently, 60 percent of the residents have access to computers and dial-up or high speed access, but the cost of high speed access is prohibitive for most families. J. Ryan Solutions and The Benjamin Franklin Institute of Technology are providing ongoing tech support and training to residents.

Villa Victoria is a 435 unit housing development in Boston's South End which is primarily low income, with 77 percent female headed households and a population that is mostly Latino (77 percent), Asian, and African American. In 2000, Villa Victoria, a development, which grew out of the protest against the building of I-95 through the neighborhoods of Boston, made history once again by becoming the first digital community in the city. Inquilinos Boricuas en Acción, the development's management agency, working in partnership with Cisco Systems, HP, and the Boston Foundation, wired homes for the Internet and provided residents with computers. Villa Tech. Inc. a community-based nonprofit organization was established by IBA to provide low-income families with the

tools (affordable high-speed internet, computers and in the home) and the support (community support-desk, trainings, classes) needed to thrive in the digital economy. "El Batey" Technology Center was set up with support from the City's Timothy Smith Fund to offer free public access, job training and classes for over 50 hours every week. Sections of the development not feasible for wiring were provided with wireless access.

Madison Park Village is a low income housing development serving 546 families in Boston's Lower Roxbury neighborhood. This is a smaller experimental project involving 20 families who are graduates of the Mayor's Technology Goes Home program. The purpose of this effort is to empower community residents and enable them to use their political and economic power to create positive change.

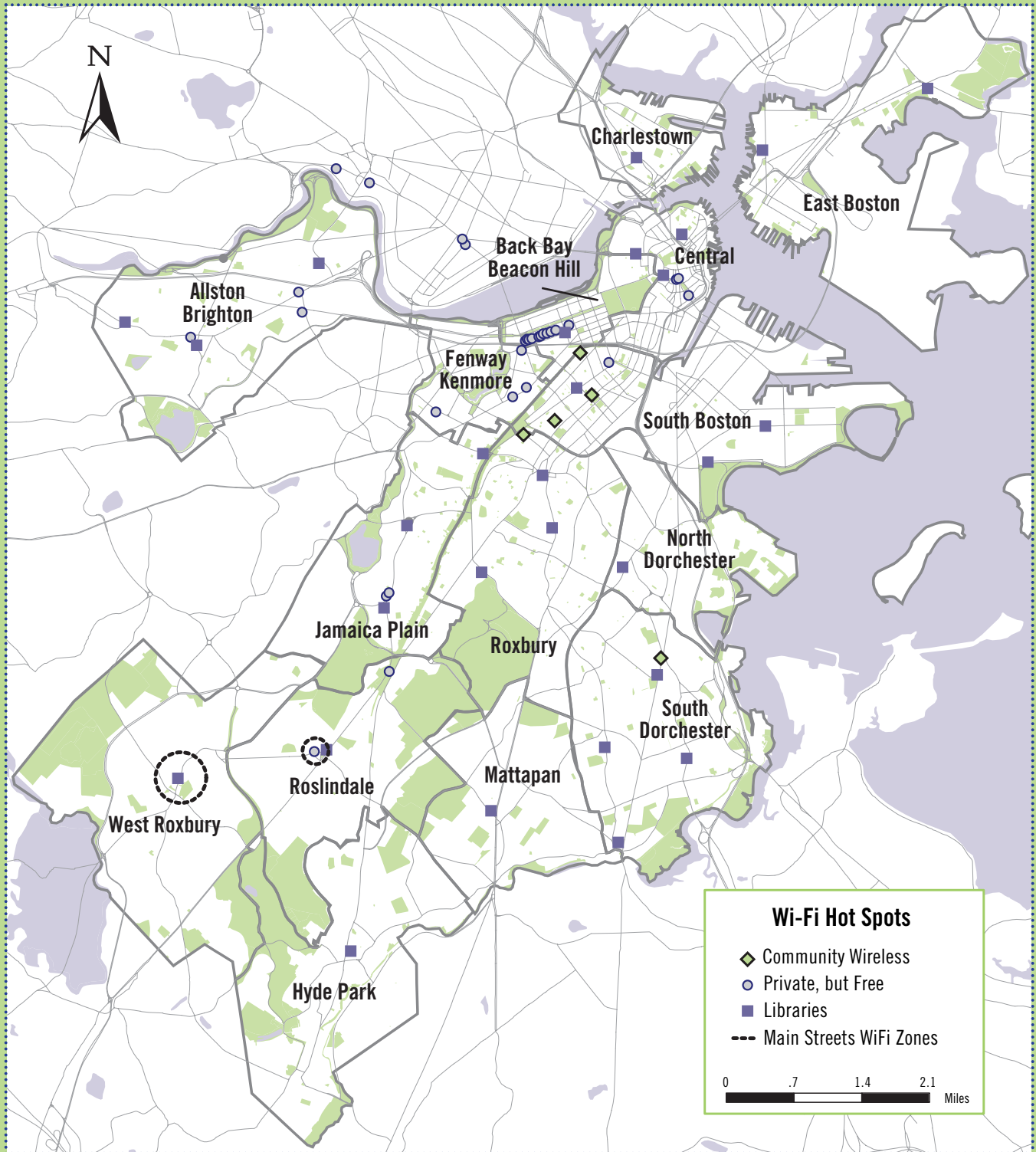
Launched in 2002, Madison Park Village uses standard 802.11b WiFi with Cisco 350 series access points and bridges. With a single T-1 connection into the development's Technology Center bandwidth to homes varies depending on the quality of the connection and speed of the wired connection.

While access is available to all residents, Madison Park has worked especially closely with the 20 families on tracking and usage which varies from household to household. Residents that have developed and refined their technology skills are involved in community outreach, improved access to community schools, researching employment opportunities and online communications. An example of civic activities they are engaged in can be viewed at roxvote.org—a website promoting voting in Roxbury.

DotWell is an alliance of two health centers in Dorchester. With funding from the Boston Foundation, Dotwell is working with Tropos Networks and the Boston Police Department to provide wireless access to residents in a 1-mile radius. The project is seeking to provide reliable Internet access throughout the community with an eye towards improving local health care, educational opportunities and the development of essential technology skills.

As part of their service, DotWell will provide e-mail accounts to its subscribers, mailing lists, information portals and personal web sites that will permit subscribers to develop and expand shared community resources.

Community Wireless projects and WiFi hotspots



The mission of DotWell is to improve communications and services between the participating health centers and the local community by providing access to their high speed network. It is also interested in pursuing possible public-private partnerships to improve the system's technological infrastructure and communications outreach.

Camfield Estates is a partnership between the 100-unit housing development in Lower Roxbury and MIT. Launched 5 years ago, it is focused on studying the impact of technology on the local community.

High-speed Internet connectivity was initially offered jointly by RCN a local cable and Internet service provider and MIT. Each project participant was provided with a cable modem for Internet access. In November of 2002 the joint agreement expired.

Recognizing the importance of Internet connectivity, but unable to afford the \$39.95 monthly fee, residents began to explore viable alternatives. A multi-user wireless mesh network became an attractive alternative. The Camfield Neighborhood Technology Center already had a fractional T1 connection capacity capable of supporting the 100 unit mesh network.

Security became a central issue to guarantee user buy-in. The implementation of a proprietary Media Access Control (MAC) solved the problem and provided the necessary security for the system.

NewburyOpen.net is a pioneering WiFi project which provides a free Internet Cafe and wireless network for city residents, visitors and Newbury Street businesses. Its mission is to create new ways of accessing the Internet, promoting universal access to inspire wireless applications and software, publishing our ideas and specifications openly, and encouraging the creation of local wireless communities.

Projects such as these and several institutional efforts at universities and hospitals demonstrate Boston's wealth of technology talent and civic commitment to a future that incorporates wireless technologies into the city's daily life. They open the door for possible public-private partnerships such as those developing WiFi networks in San Francisco and Philadelphia. Relationships capable of designing and constructing a no cost, or low cost, wireless system that can provide high speed broadband Internet access to all of the city's residents and visitors.

The people infrastructure:

Boston's wealth of committed residents bring their expertise, knowledge and passion to promote ubiquitous broadband access in the city and to the quest for innovation. In addition to several professional organizations and institutions tow notable examples include:

Boston Wireless Action Group (BostonWAG) is a growing citizen group focused on education, advocacy and action around open wireless networks to benefit individuals and communities. BostonWAG (www.bostonwag.org) focuses on areas: *Spectrum Policy* - federal, municipal, and corporate. *Organizational Models* of successful networks and communities; and *Technical tools* for providing access.

Active in educating the Boston community about wireless, Boston WAG worked closely with City Councilor John Tobin's office on conducting a citizen and organizational survey of attitudes, aspirations and concerns about a Wireless Boston, as well as in organizing the first ever WiFi Boston summit in May 2005 at the Boston Museum of Science.

The Charles River Wireless Collaborative is a non-profit organization whose mission is to assemble a sophisticated partnership of regional political, corporate and nonprofit leaders to develop and construct an innovative wireless communications infrastructure. This network is working to employ a forward looking vision, designed to advance educational excellence and economic competitiveness in the cities and towns of the Greater Boston area.

National and international wireless networks

Competitiveness, cost-saving and quality of life capacities appear to be the driving forces and often the starting point of municipal efforts for building out their broadband infrastructures. Whether it is the delivery of city services, enhancing security, promoting business growth or bridging the digital divide, communities across the world are rapidly creating and extending their broadband networks.

According to CNETnews.com, a publisher of computer and technology news and information, that tracks municipal broadband efforts nationwide, Massachusetts is among one of 32 states across the nation that have functioning municipal wireless projects. They join a number of other international communities who are either developing, or who have already built-out their own wireless infrastructures.

These cities include:

San Francisco: Based on its preexisting SFLan project, San Francisco Mayor Gavin Newsom created the TechConnect task force to determine the feasibility of creating a free citywide wireless network. In August, the city issued an RFP to design, develop and deploy such a system. On October 15th, 2005 TechConnect released 17 proposals from industry leaders such as: Google, Earthlink and MetroFi to build-out a system to service the 49 square miles of the San Francisco Bay area. The network is expected to be active within this year.

Philadelphia: In April 2005, Mayor John F. Street announced the formation of "Wireless Philadelphia" a non-profit corporation whose mission is to develop a public-private partnership to provide affordable wireless Internet access throughout the city. At the same time, the mayor released the corporation's RFP. Philadelphia received proposals from Earthlink, Hewlett-Packard and a number of other large Internet technology companies. On October 4th, Philadelphia awarded the contract to Earthlink. It will begin with a 15 square mile pilot project to test the system's infrastructure. Upon successful completion of the pilot project Earthlink will build-out a network that will service all 135 square miles of the city. That system is expected to be fully operational by the end of 2006.

Cleveland: Working with a consortium of business, academic and community leaders, the city is working to develop a municipal strategy designed to implement an innovative, community-oriented technology platform to encourage educational excellence, corporate productivity and governmental efficiency. Called OneCleveland, it shares the objectives of other national and municipal leaders to make high speed broadband and wireless fidelity technologies an affordable daily reality in the lives of all the city's residents and visitors.

Singapore: The city-state that ranks number one on the Global Information Technology Index, is preparing to launch its Wireless Community project at Nanyang Polytechnic (NYP). This initiative is a collaborative of world class players such as Agilent Technologies, Anritsu, CET Technologies, Cisco Systems, Fluke Networks, Infineon Technologies, Intel, Oki Techno Centre, Rohde & Schwarz. NYP will provide companies in the Singapore Wireless Community access to its expertise in areas such as technical consultancy, design services, test solutions and professional training.

Dublin: Irish Broadband, a subsidiary of NTR plc, the country's leading private sector developer and operator of public infrastructure, has wireless sites around Dublin. They also have 3.5 GHz licenses to provide wireless fidelity access in Cork, Limerick, Galway, Waterford, Drogheda and Dundalk.

Taipei City: The city's "M-City" (Mobile City) project evaluated numerous bidders and chose a collaborative proposal submitted by Nortel and Qware to build-out a high-speed wireless local area network (LAN) broadband access and wireless fidelity network. The system will initially provide services in the city's rapid transit stations, selected commercial buildings and other key locations around the city. The Nortel/Qware project expects to have 10,000 wireless access point in service by year-end 2005 to provide coverage for Taipei City, an area of 105 square miles where 90 percent of Taipei's 2.65 million people live.

Business Models and Their Implication

Model Name	Funding Source	Owner	Examples	Applicable Areas
Free WiFi	Corporate	Government/ business partnership	San Francisco proposal by Google	City Wide and High Density Area
Traditional WiFi	Customer Subscriptions	Corporate entity	T-Mobile/ WayPort	Airports/ Hotels/ Business Areas
Cooperative Wholesale	Participating ISPs, Anchor Customers	Non-Profit entity	Philadelphia	City Wide and High Density Area
Business/ Advertiser Supported	Sponsor “donations”	Consortium or business	NewburyOpen.net, Main Streets	High traffic Business Areas
User Owned Networks	User funding	User themselves	Universities and Healthcare institutions	Academic. Institutional and Business campuses and Adjacent Areas
Local Re-Sale	Neighbors	Local Resident	SpeakEasy	Residential Areas
Community Based Initiatives	Grass Roots, Grants	Sponsoring Organization, Community Group	Tent City Roof Net, DotWell Wireless Initiative, Dudley Square project	Wherever the community decides. Wide applicability.

(Source: BTS Partners—preliminary study)

Sources for Ongoing Wireless News

The following links provide valuable access to existing sources of research and news about wireless broadband efforts. In a technological environment that is experiencing so many accelerated and innovative refinements these websites can provide useful and timely information.

www.muniwireless.com/reports/index.html

www.wi-fiplanet.com/news

www.fcc.gov/wbatf

www.cnet.com/news

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What is Broadband?

Broadband—a term used for different types of high-speed, high-bandwidth connections to the Internet, including Cable, DSL, and Wireless. The larger the bandwidth of a carrier, the greater the amount of information it can carry.

Broadband Internet service has several major advantages over traditional dial-up access. For one, broadband is always on—in other words, it doesn't tie up the phone line—and it's 10 to 20 times faster than dial-up. More specifically, a broadband connection transmits information at between 256 kilobits per second (kbps) and 10 megabits per second (Mbps) depending on the type of service. In contrast, a typical dial-up modem maxes out at speeds of 56 kbps.

The difference in speed is staggering. For instance, it takes about 21 seconds to download a 150 kilobyte Microsoft Word document using a 56 kbps dial-up modem, but less than one second on a 1.5 Mbps broadband connection. With a broadband connection, a user can download an 8 Megabyte PowerPoint presentation in 43 seconds; over dial-up, the same file would take about 19 minutes to download.

Broadband is available through a variety of technologies, including a digital subscriber line (DSL), cable, satellite and wireless. In most cities, DSL and cable are the most common.

A big advantage of **DSL** is that it operates using twisted pairs of copper telephone lines, which most businesses already have. A digital technology that is offered by telephone companies, DSL transmits voice and data on two different frequencies, allowing users to talk on the phone and use the Internet at the same time.

DSL is generally the most affordable type of broadband service, and it comes in a variety of speeds, allowing users to select the type of service that suits them best. One drawback to DSL is that the speed of the service is dependent on the distance, measured by the length of cable used, between the user and the telephone company's central office. In addition, the reliability of this service often suffers if the copper wires are in bad shape.

As with DSL, **cable broadband** uses existing infrastructure. Cable companies offer high-speed Internet service by using a hybrid fiber coax, a technology that combines fiber optics and coaxial cable. Fiber serves as the backbone of the cable broadband network, with strands running out from the companies' main fiber optic lines and terminating in nodes located in neighborhoods throughout the city—usually in a manhole, a sidewalk vault or on a telephone pole. Each node converts optical signals

carrying data, video and other information into electrical signals and redistributes them to homes and businesses on coaxial cable, the same technology that delivers cable television service.

Once inside the home or business, the coaxial cable can be split, with one line connected to the cable TV box and the other hooking up to a modem for high-speed Internet access.

Cable modem service often provides more reliability and higher speeds than DSL, but it is often slightly more expensive. And while DSL is generally available to any business or residence in the city that has a telephone, cable modem service still isn't available in a handful of areas because the fiber backbone hasn't yet been extended there.

T-1 lines are dedicated phone connections supporting data rates of 1.544Mbps per second. T1 lines and T3 lines often are faster and more reliable than a DSL or cable modem connection, and are the broadband mode of choice for most large firms in the city. Unlike DSL or cable modem users, who share a connection with other users in the area and experience slower transmission speeds during times when many people are online, T1 and T3 users enjoy fast service at all times over specially dedicated lines. T lines transmit data and voice service over either copper phone wires or fiber optic cables. A T1 line offers speeds up to 1.5 Mbps with high reliability and generally provides quality service over longer distances than DSL while a T3 is equivalent to about 28 T1 lines.

A T1 connection is ideal for companies that employ 20 or more workers who need to be online at once, and for firms that want to put employees from multiple offices on the same network for both voice and data. But the high cost of T1 service means that it is not an option for many small businesses. One option some businesses that share quarters pursue is to split up the bandwidth from a T1, and its cost, amongst the members of the group.

WiFi or Wireless Fidelity is a way of transmitting information in wave form using radio frequency typically of the 802.11 family of standards. It uses low power microwave radios to link one or more groups of users together within an area called a hotspot. Hotspots can be linked to expand the network exponentially.

(Adapted for Boston) Source: Center for an Urban Future, New York, NY, December 2004.

Type	Speed	Method	Typical Price per Month	Problems
Dial-up	Up to 56 kbps	Telephone line	\$20 and below	Slow, unreliable
DSL	128 kbps-1.5 Mbps	Paired copper lines	\$30-\$200	Speed is dependent upon distance from central telephone company office
Cable	384 kbps- 3 Mbps	Fiber coaxial	\$50-\$350	Cost of access, deployment and upgrading
T-1	Up to 1.5 Mbps	Dedicated copper or fiber lines	\$350-\$1200	Cost of access, deployment and upgrading
Wireless	Depends on particular network	Antenna/ radio transmission	\$0-19.95	Limited range, but can be extended exponentially by mesh networking.

