Broadband Metrics Best Practices: Review and Assessment

Report prepared for
Massachusetts Technology Collaborative

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1. Executive Summary

This report provides an assessment of the current status and best practices experience of efforts to collect, share, and analyze data on broadband Internet access services for mass market consumers. It focuses on the efforts of states seeking to inventory the availability of broadband infrastructure and services, while also examining similar national and international efforts. Several core conclusions emerge from this analysis.

First, broadband markets are still in an early stage of their lifecycle. Broadband services are evolving rapidly and have only recently been recognized as essential infrastructure (since 2004).

Second, better metrics for broadband are necessary but pose a measurement challenge. This is due to the changing nature of broadband technology and markets. The appropriate standard for what constitutes broadband access and what needs to be measured will expand and evolve as the Internet continues to evolve. The following table provides an easy way to define the different categories of broadband service:

Defining Broadband

Level	Data rate[2]	Technology Platforms	Services enabled
0B	50Kbps	Dial-up modem – not considered to be broadband.	Pre-broadband Internet access
1B	500Kbps	1st gen DSL/Cable modem service, 3G wireless, satellite	Email, web browsing, VoIP
2B	5Mbps	2nd gen DSL/Cable modem, WiFi, WiMAX	Streaming video, rich interactive media
3B	50Mbps	xDSL, FiOS FTTH, Cable (DOCSIS 3.0)	Multichannel video, Triple play
4B	500Mbps	Next gen FTTH/"λ access"	Telepresence

Third, universal availability of broadband is still a goal to be achieved. While the majority of the population (living in metro areas) has had broadband available for several years, coverage gaps in rural and other areas persist. Even when universal availability is realized (elimination or near elimination of un-served areas), many areas will remain under-served due to a lack of competitive alternatives or due to a lack of advanced infrastructure capable of supporting higher quality broadband services.

Fourth, *digital divides* will continue because even when we have assured universal availability of an appropriate minimum standard of broadband, some citizens will have the option to purchase significantly faster, higher-quality service and some markets will offer more dynamic competitive choices than others. These will include Fiber-to-the-home (FTTH) offerings and wireless broadband services from multiple providers. It is unclear when, if ever,

[2] Data rates are approximate. See further discussion below.

such services will be geographically ubiquitous. This means that policymakers will have an on-going need to address broadband equity concerns.

Fifth, the challenge of collecting and analyzing meaningful broadband metrics will change over time, but will remain important. The focus will shift from addressing availability problems to focusing on the health of the market and its performance (quality, price, and selection of service offerings). Additionally, to assess economic impacts and evaluate trends, data will be needed for all communities, not just those that are perceived to be un- or under-served. Moreover, this data will need to be available on a comparable basis over time to allow before/after comparisons.

Sixth, the core data collection methodology will need to be GIS-based. This offers the best way to track data at a sufficiently geographically granular basis to appropriately address the local nature of broadband services. The tools and capabilities to address this challenge are evolving quickly, for reasons that go well beyond the need to have better data about broadband, our newest category of essential infrastructure.

To be most effective, it must be possible to share the GIS data with appropriate analysts (within government and potentially with independent third parties) to support flexible quantitative analysis. This means that the data needs to be presentable in a way that allows the data to be integrated with non-map-based data (e.g., Census demographic data or other data more easily presented in spreadsheet/tabular formats) and at various levels of aggregation, to address confidentiality and privacy concerns.

Service providers will likely be the principal source of data for the GIS system. Some of this may be compelled by regulation, under the auspices of the DTC, while other data may be contributed voluntarily following a model like that used in Kentucky and North Carolina. However, this data will need to be supplemented with survey data collected from end-users both as a cross-check on service provider data and to address questions of service quality, end-user habits and needs, and to monitor changing market conditions. Such end-user surveys may also aid in assessing adoption/usage rates, although here too, service provider data will be important.

A difficult challenge will be managing appropriate public access to detailed GIS data so as to respect valid confidentiality and privacy concerns. This problem is hardly unique to broadband service provider data, but is accentuated by the growth of broadband and advanced computing capabilities that make it possible to collect, process, and share ever-more-granular data about specific locations or individuals.

Most states have already or are in the processes of adopting broadband policies either as a consequence of executive (gubernatorial) or legislative action. The best initiatives being undertaken include the following features (where “BB” is short for “broadband”):

Activity	Description
Focused Statement of Goals	Governor's office has adopted a clear statement identifying BB as essential infrastructure and a policy goal to promote BB and achieve ubiquitous availability within several years.
Formation of leadership group	Establishment of a multi-stakeholder, public-private entity to pursue policy. This could be a Broadband Task Force (as in California), a new government authority/department (as in North Carolina), or a non-governmental public-private partnership (as in Kentucky and espoused by Connected Nation). Coordination requires engagement of service providers (to supply data on service availability), multiple government agencies (PUC, economic development authority, and GIS), and significant end-user interest groups (regional/minority interests, special industry users). Also requires grass-roots engagement to raise awareness and engage local communities in promoting broadband
Promote public facilities' access to broadband	Ensure all government facilities and public facilities (schools, libraries, community centers) have a broadband connection
Expand broadband use by government	Promote eGovernment, encourage policies to use broadband
Survey broadband demand	Survey broadband demand and uses on an ongoing basis. Specifically, survey consumers and key business segments on how they are currently using broadband and how they would like to use broadband.
GIS mapping	Create geographically granular, multi-layer maps of broadband service availability by technology and speed tiers at, ideally, the household address level. Be able to integrate with demographic data at the CBG or smaller.

In implementing the above, successful states have devoted significant resources. This has required \$1 to \$3 million per year for an operating budget to support development of the initial broadband data collection effort, formation of grass-roots and inter-agency policy coordination, and management of special broadband projects. A significant share of the initial year's costs is associated with the data collection effort.

In addition to doing the above, we recommend that Massachusetts adopt a nuanced and tiered set of goals and standards for measuring broadband in the state. This includes developing a series of measures and goals as follows:

Goal	Title	Description
		Achieving Ubiquitous Availability
L0	Town government is on-line	• *1B* broadband (say a T1 line) is available to at least one building (say Town Hall) in all 351 towns in MA.
L1	Public access BB is available	• *1B* broadband is available in every public library and public school, with no household more than 5 miles from a public-access terminal
L2	Ubiquitous BB available	• *1B* broadband available to (almost) every HH (95% availability in every town) from at least 1 provider
		Keeping BB on track
L3	BB adoption on track	• BB adoption rates are on par with national average. • $/Mbps/month for average, best, and entry service on par with national averages • Within state differences on par with peer states.
L4	BB is best in class	• BB availability and adoption rates for higher quality BB services (*2B, 3B, 4B*) are on par with national averages. • Within state differences on par with peer states

2. Introduction

As noted in the executive summary, this report provides an assessment of current practices and future needs for collecting data on broadband infrastructure and services, focusing on efforts that are and may be undertaken by state agencies. Its purpose is to provide guidance to policy-makers in Massachusetts and elsewhere who are examining the challenges of how to assess the status of broadband availability, infrastructure, and services within their state, with a focus on mass-market broadband services. The topic of this report is an issue attracting significant policy attention at all levels of government, in the United States and abroad, and as such, activity in this area is rapidly evolving. This report is based on research conducted during 2007.

The balance of the report is divided into five chapters:

- Chapter 3 focuses on explaining the poor current state of knowledge about broadband services, why improving this is important, but why it will be difficult.
- Chapter 4 looks at the challenge of measuring broadband more closely, in terms of the categories of data that may be collected and their roles.
- Chapter 5 focuses on the organizational and process challenges of collecting better broadband data.
- Chapter 6 summarizes best practices in a collection of states that provide representative role models for Massachusetts.
- Chapter 7 concludes with a series of recommendations about what needs to be done and appropriate goals for measuring broadband services into the future.

3. Why broadband metrics are important and challenging

This section explains why it is important to collect better information about the status of evolving broadband infrastructure and markets; the status of current data collection efforts; and why the collection, analysis, and interpretation of broadband data is difficult. This helps set the stage for evaluating current best-practice efforts to collect broadband data.

3.1. Broadband is essential infrastructure

Broadband access to the Internet has evolved rapidly to become essential infrastructure for our global information economy.[3] While large businesses have had high-speed access

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[3] President Bush in 2004 stated that: "This country needs a national goal for…the spread of broadband technology. We ought to have…universal, affordable access for broadband technology by the year 2007, and then we ought to make sure as soon as possible thereafter, consumers have got plenty of choices when it comes to [their] broadband carrier" (see http://www.whitehouse.gov/infocus/technology/economic_policy200404/chap4.html). Similar positions have been adopted in Europe, where the European Commission has concluded that "widespread and affordable broadband access is essential to realize the potential of the Information Society" (see http://ec.europa.eu/information_society/eeurope/2005/all_about/broadband/index_en.htm); in Australia, where a government report concludes that "ubiquitous, multi-megabit broadband will underpin Australia's future economic and social prosperity" (see http://www.dcita.gov.au/communications_for_consumers/internet/broadband_blueprint/broadband_blueprint_html_version/chapter_one_broadband_as_critical_infrastructure); in Japan, where the Japanese have

connections for data communication services for many years, mass market broadband only began to become widely available in the United States in the latter half of the 1990s.[4] Even as recently as mid-2000, there were only 4.1 million broadband lines in the United States and only 3.2 million of these were residential lines. By 2006, the number of broadband lines, excluding mobile wireless connections, had expanded to 53.5 million and 49 million of these were residential lines (see Table 1).

While the initial promise of the mass-market Internet was first demonstrated in the 1990s using dial-up access over traditional telephone lines, the low data rate of these services and the lack of "always on" connectivity severely hampered the end-user experience, limiting the full realization of the potential of global electronic communication networks. Such networks enable new models of communications (email, chat, peer-to-peer file sharing, blogging) and new markets (eCommerce, telemedicine, telecommuting, interactive media). The Internet facilitates new ways to share and access information (Web browsing, on-line education) and new ways to interact with each other and with our government (social networking, electronic government). Web-enabled businesses such as Google, Amazon, YouTube, Flickr, Facebook, MySpace, and a host of others that are changing the retail and mass media landscape depend critically for their growth on the fact that the majority of Internet users in the United States are now on broadband (although this only happened recently). These are just some of the most visible examples of how the Internet is changing our industrial and social landscape. The long-run implications of the Internet for our economy and society, for how we live and work, are likely to be as profound and transformative as the industrial revolution of an earlier century.

In short, broadband is now essential basic infrastructure for our economy and society. Similar to access to reliable electricity, clean water, and safe roads, broadband is becoming a necessity that all households and businesses need access to even if usage will differ.

3.2. Need for broadband metrics

Given the importance of the Internet for our society and economy, there is a pressing need to understand how the Internet is evolving and impacting us. Just as we need to know the state of other basic infrastructure such as our roads and transportation networks, power grids, and water supply, we need to know the state of our Internet infrastructure. Broadband access is an essential element of this. Such an understanding is needed to appropriately assess needs, monitor the performance of markets, and to target and evaluate public policies affecting broadband.[5]

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joined with regional partners to "enable all people in Asia to gain access to broadband platforms" by 2010 (see http://www.dosite.jp/asia-bb/en/pdf/abp005.pdf); and other countries.

[4] See Lehr, W. and S. Gillett (1999), "Availability of Broadband Internet Access: Empirical Evidence," paper presented to the Twenty-Seventh Annual Telecommunications Policy Research Conference, September 25-27, 1999, Alexandria, VA (available at: www.tprc.org).

[5] The need for publicly-accessible metrics is most obvious where infrastructure is being supported, in part, with public funds; however, even if the infrastructure is provided principally with private investment – as will most certainly be the case with broadband – good market data will be needed to support an efficient market and to address whatever gaps where public assistance is still required.

Although the need for good data to make good policy decisions is self-evident, it is worth noting that broadband and data collection efforts have attracted new attention in policy circles recently as demonstrated by such legislative initiatives as the *Broadband Data Improvement Act* (S.1492, introduced in the Senate, May 24, 2007)[6] that calls for federal action and support (including funding) to collect better and more detailed data on the status of broadband in the United States.[7] Similarly, presidential candidates on both sides of the aisle are highlighting the need to promote broadband and to collect better data.[8] And, finally, state and local policymakers are pursuing legislative agendas to enhance broadband infrastructure and data collection.[9]

3.3. Status of broadband in the United States

While the need for broadband metrics is obvious, it is perhaps surprising that we know (relatively) so little about the state of broadband markets in the United States.[10] Indeed, while many concur with the view that broadband is essential infrastructure,[11] we have only a very partial picture of the condition of such infrastructure, its use, and its impact on the economy and society. For example, the best publicly available national data on broadband deployment and

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[6] See "Inouye Introduces Broadband Data Improvement Act," press release, US Senate Committee on Commerce, Science and Transportation, May 24, 2007 (available at: http://commerce.senate.gov/public/index.cfm?FuseAction=PressReleases.Detail&PressRelease_id=248822&Month=5&Year=2007)

[7] Similar legislation has been moving through the House of Representatives. For example, Congressman Markey (D-MA) has been sponsoring the drafting of new telecommunications legislation that would drive improved data collection efforts for broadband. The *Broadband Census of America Act* (HR 3919) was introduced May 24, 2007 and draft legislation was reported out of the House Subcommittee on Telecommunications and the Internet on October 10, 2007. Among other things, the legislation directs the NTIA to prepare a searchable map (at the 9-digit zip code or census tract level) of broadband availability. The bill also creates a grant program with $50 million in 2008, $100 million in 2009, and $150 million in 2010 to support community-level efforts to assess broadband status and needs, and to promote broadband access (see http://www.benton.org/node/6019 for further details).

[8] For example, see http://www.wcai.com/taskforce/politics/index.php -- website of Wireless Communications International (WCA) – for summary of the broadband policy positions of presidential candidates, a number of which among both republicans and democrats support more action to promote broadband.

[9] For example, Governor Patrick's office filed legislation on October 18, 2007 to create a Massachusetts Broadband Incentive Fund, financed initially with a $25 million bond offering (see http://www.mtpc.org/broadband/index.html). Analogous legislative and governor-sponsored initiatives have been passed or are under review in a number of other states (e.g., see www.connnectkentucky.org for Kentucky, www.e-nc.org for North Carolina, or http://www.calink.ca.gov/pdf/CBTF_Prelim_Report.pdf for California).

[10] See Horrigan, John, Kenneth Flamm, William Lehr, and Amy Friedlander (2007), "Measuring Broadband: Improving Communication Policy-making through Better Data Collection," Pew Internet & American Life Project, November 11, 2007 (available at: http://www.pewinternet.org/PPF/r/227/report_display.asp). This report summarizes the results of an NSF-sponsored conference in June 2006 examining the broadband metrics.

[11] See note 3 *supra*.

penetration is provided by the Federal Communications Commission (FCC).[12] The FCC data reports the availability of broadband services by zip code, semiannually (as of June 30th and December 31st), starting in December 1999. Additionally, at the state-level, the FCC reports the number of broadband lines in service, from which it is possible to estimate the per capita penetration of broadband.

Unfortunately, the FCC data suffers from a number of limitations that make it less than ideal for assessing the current state of broadband infrastructure and services. For example, the FCC data is biased toward overstating broadband availability and the extent of competition for broadband services. The FCC defines broadband as follows:

> "A broadband connection is a line (or wireless channel) that terminates at an end-user location and enables the end user to receive information from and/or send information to the Internet at information transfer rates exceeding 200 kilobits per second (kbps) in at least one direction."[13]

Based on this definition, the FCC requires service providers to report the number of broadband lines they offer by technology on a statewide-basis, and then to list the zip codes in which they have at least one subscriber.[14] The FCC's reporting does not provide adequately granular data to assess the diversity of facilities-platforms available to consumers in a community (zip code) and thus tends to overstate the extent of consumer choice and competition.[15] For example, the FCC

[12] See http://www.fcc.gov/broadband/Welcome.html for link to FCC broadband initiatives and data collection efforts. The results of the FCC's data collection efforts are available at http://www.fcc.gov/wcb/iatd/comp.html in a series of biannual reports starting with December 1999.

[13] See http://www.fcc.gov/broadband/broadband_data_faq.html.

[14] The FCC requests line counts from facilities-based providers for the following technologies:

(1) ADSL
(2) SDSL
(3) Traditional Wireline (e.g., T1)
(4) Cable modem
(5) Fiber (only to the home, not to the curb)
(6) Satellite
(7) Fixed wireless (excluding WiFi used to share locally)
(8) Mobile wireless
(9) Power-line
(10) Other (provider must specify)

In addition, filers must report the percentage of lines in different speed tiers, share that are residential, and share that are provided over owned facilities (as opposed to leased from others). This represents the current status of the FCC's reporting requirements, which reflect a substantial expansion in the granularity and quantity of data collected from that in earlier years.

[15] For example, although cable modem and DSL services (the most common types of mass market broadband service available) are broadly comparable, they are not identical and the providers are subject to differential regulations that also impact their service offerings. More importantly, many of the providers are not facilities-based providers, but are selling retail services utilizing facilities provided by, in most cases, the incumbent telco.

reports the number of reporting service providers per zip code for every zip code with at least one service provider, but in order to preserve what is regarded as competitively sensitive data, the FCC reports the number of providers as an asterisk ("*") if the number is between 1 and 3. This substantially reduces the value of the provider count data because in the vast majority of locales there are at most two wireline facilities-based providers (the incumbent telco and the cable television provider). Thus, when there are more than three broadband providers reported, most of these are resellers (and in most cases, these are reselling DSL services, using copper loops leased from the incumbent telco). While the difference between knowing whether there are 9 or 10 broadband retailers matters little, it would be quite valuable to know whether consumers in a zip code faced a monopoly (1 provider) or duopoly (2 providers).

According to the most recently available data from the FCC on broadband availability,[16] broadband services were available in 99% of the zip codes in the United States. While this is impressive in light of how far we have come in a few short years, it greatly overstates the relative availability of broadband because evidence that there is a single customer with broadband in a zip code does *not* mean that every household in a zip code may obtain broadband services. For example, DSL services are not generally available at distances in excess of 18k-ft from the telco's central office, or if available, are available only with substantially lower data rates. Similarly, since the FCC has expanded its reporting requirements to include even providers with less than 250 lines in a state (the prior reporting cut-off up until 2004) and includes satellite providers, the extent of service availability is likely over-stated.

In addition to suggesting greater service availability coverage and competitive options for end-users, the FCC's definition of broadband appears anemic relative to what most end-users regard as an appropriate standard for broadband (see further discussion of this in the next section) and lacks pricing data to fully evaluate the price/quality options available to end-users. Moreover, since the FCC data only begins as of December 1999, it makes it difficult to track the impact of broadband over time, since by December 1999, almost 2/3rds of U.S. zip codes already had broadband according to the FCC data. This limits the usability of this data to learn about the economic impacts of broadband.

However, for all of its faults, the FCC data remains the best publicly available data on the geographic dispersion of broadband services across the United States, making it the preferred data set for assessing econometrically the determinants of broadband availability and its economic impacts. For example, see Gillett, Lehr, Osorio, and Sirbu, (2006)[17] and Crandall,

[16] See FCC, High-speed services for Internet Access: Status as of June 30, 2006, available at: http://fjallfoss.fcc.gov/edocs_public/attachmatch/DOC-270128A1.pdf.

[17] See Sharon Gillett, William Lehr, Carlos Osorio, and Marvin Sirbu (2006), Measuring Broadband's Economic Impact, Final Report National Technical Assistance, Training, Research, and Evaluation Project #99-07-13829, Economic Development Administration, U.S. Department of Commerce, February 28, 2006 (available at: http://www.eda.gov/ImageCache/EDAPublic/documents/pdfdocs2006/mitcmubbimpactreport_2epdf/v1/mitcmubbimpactreport.pdf).

Lehr, and Litan (2007)[18] for recent early studies of the economic impacts of broadband in the United States.

For international comparisons, the best data available is provided by the OECD,[19] which reports the per capita penetration of broadband for the 30 OECD member states. (Data for non-OECD countries is more sporadically available, with the best data offered by the ITU.[20])

One statistic that has attracted quite a bit of attention is the relative rankings of countries by broadband penetration. Based on the most recently available data from the OECD (as of December 2006), the United States ranks 15th out of 30 OECD countries in terms of broadband penetration per capita, which has lead some broadband advocates to worry that the United States is lagging peer nations in terms of the development of its broadband service markets (see Table 2). This concern is further heightened when one notes that the U.S. rank has fallen since 2000 (see Table 3) and when one notes that the quality (speed) of broadband is substantially higher and the price lower in a number of other OECD countries (e.g., Japan, Korea, Sweden, and France, see Table 4).

While better local data is available for some states and, within states, for some regions (as will be discussed further below), these more local data sets are not readily comparable and able to be integrated in a form that easily supports cross-state comparisons.

Regardless of what one believes about the relative health of broadband in the United States and what this means in terms of appropriate broadband policy,[21] it is clear that (1) broadband is evolving rapidly, and (2) we need better data to track what this means for the

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[18] See Crandall, Robert, William Lehr, and Robert Litan (2007), "The Effects of Broadband Deployment on Output and Employment: A Cross-sectional Analysis of U.S. Data," *Issues in Economic Policy*, The Brookings Institution, Number 6, July 2007 (available at: http://www.brookings.edu/views/papers/crandall/200706litan.htm).

[19] See http://www.oecd.org/sti/ict/broadband for a link to OECD data on broadband statistics and adoption.

[20] See International Telecommunications Union, *Yearbook of Statistics – Telecommunications Services (chronological time series 1996-2005)* and more generally, http://www.itu.int/ITU-D/ict/index.html for pointers to various data series published by the ITU. Among the core indicators (adopted by the ITU in 2005) are various metrics of ICT penetration, including broadband Internet subscribers per capita, computers per capita, share of households with home Internet access (see, *Core ICT Indicators*, United Nations, Partnership on Measuring ICT for Development, November 2005, available at: http://www.itu.int/ITU-D/ict/partnership/material/CoreICTIndicators.pdf).

[21] Cross-national comparisons of broadband performance are politically sensitive. Critics of the sorts of comparisons just noted claim that the per capita comparisons are misleading because household sizes are different in different countries, because of differences in the costs of deploying infrastructure (lower population density implies higher deployment costs generally), and because of differences in market environments (dial-up remains a more attractive option in the U.S. because of flat rate telephone service, whereas most other countries charge time-sensitive usage rates for telephone services). For further discussion of broadband statistics and how this relates to the broadband policy debate, see Atkinson, Robert (2007), "The case for a national broadband policy," white paper, Information Technology and Innovation Foundation, Washington DC, June 2007 (available at: http://www.itif.org/index.php?id=52).

economy at large and for our assessment of broadband services and infrastructure more narrowly.

3.4. Why is measuring broadband and its economic impact difficult

Obviously, to measure the economic impact of broadband, it is necessary to first have accurate measures of broadband inputs. However, even if such measures are available, it is complex and difficult to measure the economic impact of information and communications technology (ICT), or in particular, of broadband. The reasons for this are several (see Crandall, Lehr, Litan, 2007[22] for summary of ICT productivity literature and issues), including the following:

- Broadband is infrastructure
- Broadband changes the way businesses operate and people live and work
- Broadband is a moving target
- Broadband data is not readily available publicly
- Broadband causality is difficult to infer

Each of these factors is discussed further in the following sub-sections.

3.4.1. Broadband is infrastructure

Like other infrastructure, broadband is an input to the production of many other goods and services. The benefit or "output" from using broadband is not directly measurable, but must be measured indirectly, in the output of the goods and services produced using broadband. Because these goods and services are in turn used to produce even more goods and services downstream, the benefits of broadband are multiplied. These spillover benefits are hard to measure, which contributes to the difficulty of inferring the economic benefits attributable to broadband.

Furthermore, the impact of broadband is greatest in the service sectors (e.g., finance, healthcare, advertising), which are notoriously difficult to measure. Both the outputs and inputs used in the service sector of our economy are subject to substantial measurement error.

Finally, broadband is a network good. Its value increases with the total number of subscribers, giving rise to positive network externalities. This positive feedback effect contributes to the economic benefits realized by broadband.

3.4.2. Broadband changes the way businesses operate and people live and work

Broadband changes the way businesses produce goods and services and the way people live and work. For example, broadband facilitates such production changes as just-in-time production, customized product marketing, and outsourcing. It lowers the costs of geographically dispersing business operations and enables new ways of managing production and work. For example, broadband enables telecommuting which can expand the labor pool (e.g., enabling the elderly or infirm to work from home) and helps save on transportation costs (e.g., reduced

[22] See note 18 *supra*.

commuting travel time and energy costs). Broadband enables telemedicine, supporting at-home monitoring, care-at-a-distance, and faster response times to improve the quality of and lower the costs of healthcare. Broadband also enhances electronic commerce, enabling businesses to market their goods and services over wider geographic areas, expanding market reach and facilitating better supply-chain management. The impacts of on-line commerce and the broadband Internet also spill over to the bricks-and-mortar world. For example, even though most purchasers still buy their autos from dealers, they access the web for pre-purchase research and this has significantly altered traditional retail behavior. Similar impacts have changed the nature of retailing in industry sectors as diverse as financial services, healthcare, and entertainment media.

Adjusting to the business opportunities and changes associated with broadband requires firms and industry value chains to restructure. It enables entry by new firms (e.g., on-line firms such as Amazon, eBay, and Yahoo!) and requires new skill sets from employees (e.g., computer-literacy). The changes in complementary inputs (labor and capital) take time to occur and also complicate the challenge of measuring the impact of broadband on the economy and society.

Consequently, we should expect the impact of broadband to reveal itself over time. This is one of the most important reasons that we lack strong evidence of the impact of broadband. The emergence of a broadband mass market is a recent phenomenon and we are still in the early stages of realizing its impacts.

3.4.3. Broadband is a moving target

Broadband, like other ICT goods and services, is subject to rapid innovation, both in terms of how it is offered and used. This means that broadband is a moving target, increasing the challenge of tracking its progress over time. Innovations in such complementary elements as the computer literacy of the populace, the stock of personal computers, and the availability of broadband content and applications all contribute to changing the ways in which broadband is used. Likewise, falling prices for broadband and related ICT goods complicates the challenges of measuring broadband's economic impact.

In short, what passes for an acceptable level of broadband service will change over time. The growth in broadband data rates over time and the emergence of mobile broadband services provide obvious examples of this.

3.4.4. Broadband data is not readily available publicly

The emergence of broadband markets has coincided with the increased deregulation of telecommunication infrastructure markets. One unfortunate byproduct of this transition is that publicly available data related to the performance of broadband is more difficult to obtain and share publicly. Regulatory mandates to collect data are perceived as increasingly burdensome in light of the transition to market competition for all telecommunication services, including broadband. Contrast the current state of affairs with the days of public utility regulation of monopoly cable franchisees and incumbent telephone providers. Today, data on investment, the location of infrastructure, and especially data on adoption rates and market shares is regarded by suppliers as competitively sensitive. As already noted, such concerns severely hamper the usefulness of the FCC data for informing policy debates and assessing the status of broadband. As competition (hopefully) continues to grow, the resistance to sharing data will increase.

Furthermore, the challenge of collecting useful data will increase. For example, in the first phase of broadband growth, the most important concern was with respect to the availability of broadband. Although there are still important pockets of the country which still lack any broadband and many more that lack adequate choice among broadband providers, broadband is now available to the vast majority of households (likely in excess of 90 percent of households in the U.S.[23]). Increasingly, the interesting questions will not be about whether broadband is available, but rather about how it is being used, why some households may not adopt, and what choices (quality, price, and provider options) are available to end-users. In effect, the emphasis will shift from identifying which communities are *unserved* to identifying when communities are *under-served*, and the definition of what constitutes being "under-served" will change over time. Observing whether any broadband is available in a community is an easier challenge than observing the quality/technology of broadband available or its use.

Finally, broadband is a much more demanding service than the provision of dial-up Internet access. It requires more investment of capital and admits to a wider diversity of potential capabilities than does dial-up. For example, dial-up provided a peak data rate of around 50Kbps, whereas broadband services may range from a few hundred Kbps to hundreds of Mbps. Dial-up access was supported over relatively homogenous equipment and infrastructure (dial-up modems operating over copper loops), while broadband is available over multiple types of wired (metallic CATV cables, telco copper loops, and optical fiber) and wireless (satellite and terrestrial, fixed and mobile) technologies, provided by incumbent and next-generation carriers. The costs of deploying these different broadband options differ by geography (e.g., terrain characteristics and population density) and market conditions (e.g., condition of legacy plant). Furthermore, dial-up Internet emerged as an application that ran on top of existing and regulated telco facilities (e.g., flat-rate tariffed local telephone lines). In contrast, broadband requires new investment and is evolving in conjunction with on-going innovation in all complementary components (e.g., end-user equipment, applications, and multimedia content). Therefore, multiple generations of broadband technology and services will continue to co-exist in the marketplace (i.e., folks have dial-up, DSL/cable modem broadband, and even FTTH in different locations and even in the same geographic markets).

Consequently, broadband is "local" in a way that dial-up Internet access was not. This means that any analysis of broadband market performance must consider the greater heterogeneity of offerings and uses across and within specific geographic regions which complicates data collection and analysis – increasing the need for more geographically granular data. For example, knowing that dial-up access was available via a local phone call could reliably be interpreted as meaning dial-up access was available to every household in the local calling area since universal telephone access had been (essentially) achieved prior to emergence of the Internet. In contrast, knowing that fiber runs down a street does not mean that every building or home on the street can access that fiber. Significant new investment in outside plant

[23] Because of the limitations of the available data, already noted, this estimate is a bit of a guess, but it seems conservative.

and service design/marketing needs to occur with broadband, whereas analysts could reasonably assume such investments were already in-place when examining the availability of narrowband dial-up Internet access.

3.4.5. Broadband causality is difficult to infer

A final challenge worth noting in estimating the economic impacts from broadband relates to the problem of inferring causality. Put simply, the question is whether broadband contributes to the production of economic growth, or whether broadband is a consumption good and follows economic growth. This "chicken or egg" problem is a challenge that bedevils any econometric attempt to infer causality.

At one level, it may not matter. Regardless of whether broadband follows economic growth or helps promote it, the fact that folks want it demonstrates there is social value. Evidence of a positive correlation between the two demonstrates that the two go together. This is certainly more encouraging than observing a negative correlation, however, it is not very satisfying for policymakers seeking guidance regarding how to assess the need for broadband and the best ways to promote broadband.

To address this challenge, one seeks to identify econometric "instruments" that can be used to predict economic growth, but are not themselves related to observing the extent of broadband use. Such instruments are independent of broadband use and allow one to separate out the effects of broadband from other effects. For example, Gillett, Lehr et al. (2006)[24] used lagged estimates of job growth to predict future job growth as a way to tease out the impact on future job growth of broadband availability separately from past trends in job growth. There is no perfect way to address such issues, but more and better data (available for more observations and over a longer time frame) provide more options for the econometrician to address the challenge of inferring causality. As with other areas of active research, the accumulation of studies will help resolve the issue. All that can be said at this point is that the balance of preliminary evidence available to date supports the view that broadband availability and usage drives economic growth.

4. Understanding the broadband metrics challenge

This section considers the challenge of tracking broadband in the abstract, identifying the sorts of questions/issues that must be addressed either explicitly or implicitly by any metrics research effort.

4.1. Categories of Data

There are many types of data that may be collected, and different sources of data are more or less appropriate for addressing different types of concerns, but generally, multiple data sources are complementary. In short, more data is always better. In this sub-section, we describe the main sub-categories of data that may be collected. These include:

[24] See Note 17 *supra*.

- Supply v. Demand
- Business v. Consumer
- Investment trends and plans
- Infrastructure availability (where is basic infrastructure available?)
- Service availability and adoption (where are services available? What is penetration?)
- Pricing (best offered v. average adopted, affordability)
- Quality of Service (QoS) (for example, speed)
- Other

4.1.1. Supply-side v. demand-side

The focus of the data collection may be on the supply-side or the demand-side. Supply-side collection efforts target existing and potential network operators, whereas demand-side collection focuses on the customers who will purchase broadband services.

Supply-side data helps inform the current status of infrastructure and the needs for added facilities investment. It is the most relevant source of data for assessing the availability of broadband services. The best source of supply-side data is from the service providers themselves, and the large facilities-based providers (the incumbent telephone and cable system operators) have the most important data.

Demand-side data helps estimate the social value (revenue potential and surplus generated) of existing and potential services, which is important for needs and impact assessment. Better information about broadband demand (desire for service, adoption, usage) can help raise awareness, facilitate demand aggregation efforts, and generally be helpful in stimulating adoption, which in turn, benefits service providers. As discussed further below, efforts such as Connect Kentucky and Connected Nation have found the promise of demand-side data collection and stimulation efforts as attractive incentives to service providers to induce them to voluntarily share detailed supply-side data.

Furthermore, both supply and demand side data are important as cross-validation checks and in order to assess the overall health of broadband service markets.

As already noted, in most cases, it is reasonable to believe that the firms active in providing broadband services have the best available data about the state of their infrastructure, customers, and service offerings, and potentially, about the economics of the addressable market. Individual (especially smaller) providers may have only limited insight into the overall picture, depending on how large their share of the existing market is. However, service providers will be justifiably concerned about sharing information that might benefit competitors, may impose regulatory compliance costs (especially if such costs might entail pricing or service restrictions), may make their infrastructure more vulnerable to attack,[25] or may violate customer privacy (trust). While service providers would like to know more about what others in the market are

[25] For example, detailed map coordinates identifying precisely the location of essential facilities such as switches and routers might be used by terrorists seeking to disrupt provider networks.

doing, they are often predictably averse to sharing their own knowledge with competitors and potential customers. If service providers can be induced voluntarily to share information, they will likely require strong non-disclosure rules to limit access/use of the data for approved purposes. The more detailed the data, the more likely the restrictions will be strong or the data will not be made available.

Policy-makers may need to compel service provider reporting, but even so, the information obtained will be partial and will be subject to strong non-disclosure rules, limiting its availability to independent analysts and government policymakers in adjacent jurisdictions that might greatly benefit from access to the data.[26]

While there are numerous consultancies and market-research firms that collect market intelligence, their services are costly and often priced so as to be unavailable to most independent analysts and government policy-makers. And, in today's environment of proactive policy lobbying, it is often difficult to evaluate the independence and quality of such third-party data sources or analysis.

4.1.2. End-user market: Business v. Consumer

Demand-side markets may be further segmented into business, consumer, and government access; and because the business models for addressing these markets are different, this segmentation also has implications for supply-side market data collection (e.g., some service providers only target commercial customers).

Business surveys may also be stratified by the size of business (and number of business locations). Large enterprises will differ systematically from smaller enterprises both in terms of their needs and options for meeting those needs. For example, a large enterprise is likely to require higher capacity connections (which are subject to volume discounts) in more locations and for a wider array of electronic communication applications. Such enterprises are better available to support in-house IT departments that can design and negotiate custom service agreements with providers, or to undertake self-provisioning by installing their own infrastructure. When assessing the needs of large enterprises, including specialized IT-intensive sectors such as financial services, healthcare, or higher education, it is important to consider both access and backbone (e.g., long-haul fiber) infrastructure availability and the availability of critical inputs such as rights-of-way, conduit, or antenna sites for installing customer-owned or carrier facilities.

Assessing the quality of advanced telecommunication services, including broadband, for businesses in general, and for large enterprises in particular, is much more complicated and must consider a much wider class of services, technologies, and provisioning models. In this report, we focus on the needs of mass market consumers (and to a lesser extent, small businesses).

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[26] It is quite common for rules which establish procedures for collecting data for one purpose may preclude using the data for a related purpose. For example, the e911 database that the Massachusetts GIS department has access to cannot be used directly to infer the number of houses in particular segments of a community.

Smaller businesses are more like residential consumers who must look to the mass market for their broadband service options. Because the revenue potential of each individual customer is small, service providers address mass markets in aggregate, designing standardized services for market segments comprised of many small business and residential consumers. However, with continuing improvements in technology and falling costs, even mass-market customers may be able to realize a degree of customization in the broadband services available to them that previously was only available to larger enterprises.[27]

There are also obvious differences across industries. While virtually every business needs broadband, some businesses like financial services and real estate need broadband much more than others such as a barbershop.

4.1.3. Current v. Future Needs

Infrastructure assessment needs to consider both what the existing status of in-place facilities are, as well as future trajectories for planned and likely investment. Historical data on investment and capital expenditures may be useful in forecasting investment, and data on planned investment/deployment may be useful in benchmarking and monitoring service provider commitments to deploy services.

Additionally, demand-side analysis may consider both what current usage is and what users would like to do (needs assessment, willingness to pay).

Obviously, measuring legacy or current investment (supply-side) or usage (demand-side) is relatively easier than measuring planned or future investment or usage. First, the latter is likely to be more strategically sensitive for both suppliers and customers; and more susceptible to measurement error. For example, end-users may be poor predictors of their willingness to pay for services which they have little or no experience with. For example, studies have shown that broadband users value broadband more once they have gained experience with it.[28] Similarly, firm's investment plans are inherently uncertain and subject to change in response to endogenous and exogenous shocks. Firms may also have a strategic incentive to overstate the level of anticipated investment to deter entry by other firms or to lessen the likelihood of undesirable regulation.[29]

4.1.4. Infrastructure and service availability

To date, most of the focus on data collection has been on identifying what infrastructure/facilities are available, and what services are available over that infrastructure. If

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[27] Home-grade wireless routers, PBXs, storage solutions that mimic earlier such offerings to business customers expand the self-provisioning options of even mass market consumers.

[28] See, for example, Oh, Sangjo, Joongho Ahn, and Beomsoo Kim (2003), "Adoption of broadband Internet in Korea: the role of experience in building attitudes," *Journal of Information Technology* 18 (December 2003) 267-280.

[29] The opposite may also occur: firms may over-state costs (suggesting lower investment) in order to gain regulatory relief.

there is an active wholesale market, services may be available from a more diverse array of providers (resellers) than would be indicated solely by focusing on infrastructure availability. On the other hand, knowledge about what facilities are actually in place (location of switching centers, fiber runs, conduit, towers, etc.) is important for needs assessment, reliability planning (e.g., potential for diverse routing), and for understanding the costs and options for upgrading existing infrastructure. Broadband offered over different technologies (e.g., DSL v. cable) are imperfect substitutes.

In addition to knowing about what services and technology platforms are available, it is important to know about consumers' choices and for a more complete understanding of the status of competition, to know who owns what facilities. For example, knowing that one company has towers, another has conduit, and another has fiber does not mean that any service provider may be able to integrate those components into a coherent infrastructure platform. The ownership structure of facilities does matter.

4.1.5. Service adoption and usage

For certain questions, one may be interested in knowing whether service is available, but for other questions it may be more important to know about service adoption and use. Once broadband is available everywhere, the challenge of broadband policy and the drivers for market behavior will shift to influencing how broadband is used. Obtaining data on adoption and usage (traffic patterns) is more difficult and challenging than obtaining data on availability.

Service providers are generally more willing to share availability data, or it may be inferred more easily from afar (e.g., via construction permits or network sensing), obtaining usage/penetration data is more sensitive and more subject to measurement problems. First, service providers are more likely to regard such data as strategically sensitive and less likely to provide it unless compelled by regulators and guaranteed that the data provided will be protected from public disclosure, except in highly aggregated form.[30] This suggests that demand-side sampling and third party monitoring will become increasingly important in the future to acquire data on service adoption and usage patterns. The question of traffic metrics for the Internet is a very active research area.[31]

4.1.6. Pricing

Economic analysis of market performance and economic impact assessment requires data on service pricing. As long as competition is restricted to a small number of providers selling a limited number of services that are marketed nationally or at least regionally (which has approximately described the first generation broadband competition between cable modem and DSL service providers), it has been relatively easy to infer broadband pricing. However, with the

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[30] Collecting and sharing disaggregated, detailed traffic data is also problematic for end-user privacy reasons. Because of the large number of end-users, it is in principle easier to imagine anonymizing traffic data for a random sample of end-users than for service providers.

[31] See, for example, the website of the Cooperative Association for Internet Data Analysis (CAIDA) at http://www.caida.org/home/ and Horrigan, Flamm, Lehr, and Friedlander (2007), note 10 *supra*.

expansion in service options and the shift to new pricing models (see further discussion in next section), more attention to pricing data will be important.

In addition, while it may be possible to observe retail pricing offers, data on adoption rates and traffic may be required to estimate actual revenues and infer cross-elasticity effects and similar estimates of concern to policymakers and market analysts.

Moreover, the price of interest depends on the question. For example, to assess the availability to the most marginal subscribers (those least likely to be served), it may be most important to focus on the lowest-cost offer available. On the other hand, to assess market performance, it might be more relevant to look at the average price for the most typically adopted service.

Pricing data includes both recurring monthly charges which have typically been flat rate and non-recurring (e.g., installation) charges. The latter may be quite important since they tend to differ systematically by services. For example, installing a fixed wireless antenna may involve a charge of several hundred dollars, while installing a DSL or cable modem may be a few tens of dollars. There may also be rental charges for modems or other special services (e.g., extra on-line storage or email addresses), usage charges or limits (e.g., traffic volume charges), or termination charges (for premature contract termination). Finally, special promotions may substantially reduce the actual payments (e.g., installation charges are often waived or several months of free or discounted services are offered as inducements to new customers). Accounting for such details and adjusting for quality differences (e.g., services with different data rate or traffic limits) presents a difficult challenge for making apple-to-apple comparisons across service offerings. For example, in some cases, prices are reported as "$/Mbps/month" with average install costs spread over a standard period such as a year and the peak download data rate used to convert to a common broadband quality basis.

Finally, pricing data alone is insufficient to infer affordability, which is important in terms of targeting public subsidies. Actual adoption behavior needs to be interpreted in light of household budgets that may differ systematically across and within communities.

4.1.7. QoS

Closely related to the above, as broadband markets mature and subscription levels saturate, traffic will continue to grow. This raises the potential for localized congestion effects that may cause advertised service characteristics to differ substantially from actual experience. Data on actual traffic and performance will be needed to ensure appropriate "apple to apple" comparisons, to identify local "hot spots"/investment needs, and to monitor market performance. Unless one knows what quality of service is associated with the price for broadband service, it is not possible to appropriately interpret the price data.

4.2. Definitions of broadband

Before it is possible to start collecting data on broadband access, it is important to identify its key attributes so as to identify what constitutes broadband and to facilitate appropriate "apples-to-apples" comparisons.

The features that are usually considered in defining broadband access include the following:

- End-user market classification
- Data rate
- Technology
- Services
- Key characteristics such as "always on" connectivity, "openness," etc.

These features are discussed in the following sub-sections.

4.2.1. End-user market classification

While common infrastructure is used, the markets and service offerings available to commercial (large and medium size enterprises) and mass market (small business and residential households) are quite different. The needs and requirements, the economics of meeting those needs, and the market choices available differ substantially for commercial customers (large businesses) and mass-market end-users.

From the perspective of assessing the health of the economy, it is important to know about the needs and status of basic infrastructure for both commercial and mass market broadband. Whereas businesses, and especially larger businesses, have been using broadband data communication services for many years, predating the emergence of the Internet as the dominant data communication paradigm, the emergence of broadband Internet access as a mass-market data service is relatively new, and in turn, is changing commercial demand for data communication services as well.

As already noted, commercial data services are more diverse and the options for self-provisioning or purchasing from service providers typically greater than for mass market services, spanning a greater range of capacities and transmission services.[32]

This report will focus on the challenges of collecting and assessing data for mass-market broadband services targeted at residential households (and to lesser extent, small businesses).

The focus on residential availability will tend to present a more pessimistic view of true broadband availability since many users who do not have broadband at home (either by choice or because it is not available) may access the Internet over broadband either at work or via public access terminals in schools, libraries, and other government buildings where such access is provided.[33]

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[32] Business services range from standardized to custom services, with data rates ranging from fractional T1s (up to 1.5Mbps) to OC-192 (10Gbps) and beyond, and supporting a diverse array of transmission technologies such as ATM, frame-relay, and IP transport.

[33] For example, in a 2004 survey, researchers at Pew estimated that 34% of all adult Americans had access to broadband at home or at work, while 24% had access at home (see http://www.pewinternet.org/PPF/r/121/report_display.asp). The numbers would have been even higher if they had sought to estimate "how many adults lived within 5 miles of a public access terminal offering free broadband Internet access?" and, of course, are higher today in any case.

4.2.2. Data rate

The data rate is the single most commonly used feature to classify what constitutes broadband as distinct from other types of Internet access. There are several ways in which one might define the data rate, including:

- Peak rate: maximum rated transmission speed in megabits per second (Mbps). This is a technical characteristic of the service offering, although the actual peak rate achievable may depend on network conditions.
- Average rate: average realized over some period of time (megabytes transferred over time period, converted into Mbps). Usually this is characterized as some expected "actual" rate that an end-user my experience and so represents an averaging over multiple users and time periods. It may also be theoretical if the service is throttled (e.g., subject to volume limits over a time period).[34]
- Download/upload: most broadband services offer asymmetric peak/average rates downstream and upstream, with the downstream rates being substantially higher. This is because historically most of the traffic has flowed downstream toward the end-user (i.e., user sends a "click" upstream to select content, and a file is sent downstream to the end-user for viewing). Increasingly, new applications such as peer-to-peer (p2p) and video chat services put pressure on upstream data rates so there is pressure to make upstream and downstream rates either symmetric or at least less asymmetric than they have been.

In light of the complexity of assessing data rates, most data collection comparisons focus on the peak rated downstream capacity of a broadband service. However, knowing what the upstream rated capacity and whether there are any volume constraints is also important when evaluating the relative performance of different broadband services.

Whether a difference makes a difference depends on what one is doing. For example, cars differ widely in their performance in different driving situations (acceleration, turning, cruising speed). While it is possible to generally distinguish high-performance sports cars from economy cars, the boundaries between these categories are not sharp and the suitability of one or the other type of car will depend on the context. Similar (although less pronounced) considerations are relevant when comparing broadband. For example, the following provides one analyst's view of approximate data rates needed for different types of services:[35]

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[34] While it would not likely be helpful, one might also be interested in the Committed Information Rate (CIR), which is sometimes cited in commercial service level agreements for telecommunication services. This is the minimum average rate that the service guarantees. Service providers do not like to focus on this number since it is typically quite low (or appears that way to most consumers) and represents a worst-case commitment. For example, the CIR for most mass market broadband would be on the order of a few 10s of Kbps, reflecting peak-network-load provisioning decisions, were providers to focus on this.

[35] See "Mobile Satellite Industry: A new beginning," Canaccord Capital Corp Equity Research, July 25, 2005.

Application	Min. Bandwidth Requirements (Kbps)
Email (no attachments)	16
VPN/Intranet Access	512
Internet Browsing	256
File Transfer	512
Instant Messaging	16
Videocasting (1-way)	384
VoIP	16
Videoconferencing	384

With regard to average data rates, there are a number of important measurement issues that arise in the context of any data aggregation/summary exercise. Knowing the specific details (timing, number of users, what else was going on) of how average data is collected is important in its interpretation. For example, telecommunication service providers often keep track of the average of realized peak rates over some period rather than the raw average data.[36] Furthermore, in addition to knowing the average rate, it would be valuable to know other traffic statistical moments such as the variance and other parameters that characterize the distribution of the data.

Perhaps the best-known and most extensive data on actual data rates experienced by mass-market consumers is that collected by SpeedMatters.org (see www.speedmatters.org), a project supported by the Communication Workers of America. This provides a web-based on-line tool that measures the real-time upload/download speed of your Internet connection. Over time, they have collected data from thousands of users across the United States, allowing them to average the broadband data in order to derive an interesting perspective of broadband availability across the United States (see Appendix 1 for further write-up).[37]

While collecting more data (average as well as peak, upload as well as download) is more informative, there are obvious advantages to focusing on peak rated downstream data rates, including:

- Simplicity. If you know the generic technology, you can usually infer the rated speed, although service providers may even differentiate here (for example, DSL and cable modem services at various speed tiers).
- Independence from actual network conditions. Focusing on the rated capacity focuses on the quality of the infrastructure rather than the dynamics of traffic growth and congestion, which while also interesting, is harder to analyze.

[36] Thus, it may be more meaningful to report the average of 1,000 measurements of the actual traffic rate computed over five second increments over, say a week, then to report the total MB of traffic moved divided by the seconds in a week.

[37] There are other speed tests, and because the data is averaged over time, it is unclear how the picture is changing over time. Also, it does not provide information directly on the lack of broadband since gaps in the coverage are because no one has taken the test at a specific location. The reason for that may be because broadband is not available or because broadband users in that locale have not yet been interested in taking the test. Over time, however, as the test is publicized and more and more users take it, the resolution of where gaps exist will improve.

- Other measures are often reasonably well correlated with it. Thus, higher peak rates also usually translate into higher average rates (although this depends critically on how providers multiplex traffic in their backbone networks – upstream from the last-mile access connection and this varies across carriers, across a single carrier's network, and over time).

As an example of the general mapping of broadband data rates to technologies, consider the following table from a report by the California Emerging Technology Fund:[38]

Technology	Speed
Dial-up	56Kbps
DSL	384Kbps – 1.5Mbps
Cable Modem	1.5Mbps – 3Mbps
T-1	1.544Mbps
Satellite	Up: 50-128Kbps; Down: 400-500Kbps
WiFi	11-54Mbps, up to around 300 feet
WiMax	70Mbps, up to around 30 miles

While the data rates listed here are broadly consistent with rates cited in other sources, it is worth noting that even these are only approximate (and different rates are listed even in reports published by the California Broadband Task Force – see Appendix 2, where for example, they list DSL speeds as between 384Kbps to 6Mbps and Cable as between 768Kbps to 15Mbps).[39]

Given that most definitions of broadband focus on the peak download rate, it is worth commenting on current debates over what constitutes an appropriate cut-off rate. For example, the FCC has defined broadband as a service offering at least 200Kbps in one direction. The chief advantage of this threshold is that it is simple and excludes such non-broadband services as dial-up (around 50Kbps), ISDN (128Kbps), and first-generation satellite broadband services. However, in the early days of mass market broadband (pre-2000), many DSL broadband services did not offer peak rates of much higher than 200Kbps and setting a higher standard would have excluded such technologies.

With the growth of multimedia traffic and continued innovation and investment in networks, the 200Kbps threshold appears increasingly anemic. Even the ITU defines a higher threshold (256Kbps) when collecting data for international comparisons of broadband lines per capita. And, sponsors of new legislation (noted above) for collecting broadband metrics want to define broadband as a service capable of at least 2Mbps downstream and at least 1Mbps upstream.[40] More generally, better data should classify broadband into tiers so that the relative availability of different data rates is made explicit.

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[38] See, page 3 in "Strategic Action Plan," California Emerging Technology Fund, June 2007.

[39] Also, these are rated rates, not rates that may actually be realized in practice. Thus, WiMAX is unlikely to deliver anything close to 70Mbps at 30 miles if more than a few customers are being serviced; and many (most?) WiFi connections are substantially less than even 11Mbps except under near ideal conditions.

[40] See, for example, http://www.speedmatters.org/plan/new-definitions.html or legislation cited earlier.

Several analysts have noted that broadband could be classified on the basis of tiers that separate the different generations of broadband in terms of what they can support. For example, in comments to the FCC, the VoIP service provider, Vonage, argues that in order to properly support advanced services broadband should be at least 768Kbps downstream and 384Kbps upstream.[41] The Internet Innovation Alliance provides a classification of broadband speeds based on what can be done with services at different speeds as follows:[42]

Broadband Applications and Download Speeds

DOWNLOAD SPEED	APPLICATION	TECHNOLOGY
56 kbps	Low Quality, Streamlining Audio	Dial Up
200 kbps	FCC Definition of High Speed	DSL Lite: (256 kbps)
1 mbps	Streaming Video	Satellite DSL Cable
4 mbps	Standard TV	DSL
6 mbps	Videoconferencing	
20 mbps	High Definition TV ADSL	

Source: S. Derek Turner, Broadband Reality Check, Free Press, August 2005.

Alternatively, the FCC's current broadband collection efforts focus on classifying services into the following data rate tiers:[43]

- More than 200kbps but less than 2.5Mbps
- More than 2.5Mbps but less than 10Mbps
- More than 10Mbps but less than 25Mbps
- More than 25Mbps but less than 100Mbps

Any definition of broadband into speed tiers will need to change and evolve over time as technology and markets continue to evolve. One approach is to tier broadband services into

[41] See page 4 of *Comments of Vonage Holdings Corp.*, In the matter of Development of Nationwide Broadband Data to Evaluate Reasonable and Timely Deployment of Advanced Services to All Americans, Improvement of Wireless Broadband Subscribership Data, and Development of Data on Interconnected Voice over Internet Protocol (VoIP) Subscribership. Federal Communications Commission, WC Docket No. 07-38, June 15, 2007.

[42] See, Internet Innovation Alliance, The Broadband Factbook, available at: http://www.internetinnovation.org/DesktopModules/iBN%20News%20Articles/Download.aspx?AttachmentID=4. Note these rates are approximate. See Appendix 2 which provides a different set of estimates from the California Broadband Task Force.

[43] See: http://www.fcc.gov/Forms/Form477/477instr.pdf.

different generations analogous to the way in which mobile services are tiered into first generation (1G), second generation (2G), and third generation (3G) services.[44] Analogously, one might classify broadband into generations representing an order of magnitude (10x) increase in data rates as follows:[45]

- 0B (50kbps): this is dial-up Internet access. (Here and subsequently, the "B" replaces the "G" to distinguish between the generations of Broadband service as distinct from the "G" which is used commonly to refer to the generation of mobile services.)
- 1B (500kbps): this corresponds to the lowest tier of broadband services available in some under-served rural areas, over some wireless-broadband services, or to wired broadband customers that are far from the cable or DSL serving office.
- 2B (5Mbps): this corresponds to the current generation of DSL/cable modem services which is what most mass market broadband customers have today.
- 3B (50Mbps): this is the next generation of broadband services that is being deployed by Verizon (FiOS fiber optic services) in a growing number of markets, and will be deployed by cable operators via the DOCSIS 3.0 standardized technologies to be released in the near future.
- 4B (500Mbps): this is the placeholder for whatever comes next and is associated with such technologies as wave-division multiplexed fiber-to-the-home (FTTH).

Households differ on how much bandwidth is needed. If all one wants to do is handle voice calls or relatively low-data rate web traffic, email, and first-generation Internet applications, then 1B/2B services are sufficient. If one wants to do active streaming of video media and support a full platform of voice, video, and data services, then 3B services are needed. And, still higher data rates may be needed depending on how many independent video streams one wants to support per household and the architecture for supporting those. For example, a study intended to estimate residential household needs for broadband in the United Kingdom estimated that 18Mbps/3Mbps (downstream/upstream) would be needed by 2008, rising to 23Mbps/18Mbps by 2012.[46] While any such estimates are speculative and depend critically on assumptions about what users will be doing and how the bandwidth will be provided, it seems likely that data rate requirements will increase substantially beyond today's levels and that keeping track of such progress and the diversity of access available will be important to policymakers, end-users, and industry participants.

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[44] With mobile, 1G refers to analog mobile telephone services such as AMPS; 2G to digital mobile telephone services such as GSM or CDMA; and 3G to digital broadband mobile telephone/data services such as cdma2000 or w-cdma.

[45] This recommendation follows from the work of SQW Consultants in assessing the state of broadband for Scotland (see SQW Consultants (2006), "Next Generation Broadband in Scotland," report prepared for Scottish Executive Social Research, Edinburgh, Scotland, 2006 (available at: http://www.scotland.gov.uk/Publications/2007/01/09153006/0)).

[46] See Broadband Stakeholder Group, "Predicting UK Future Residential Bandwidth Requirements," May 2006 (available at: http://www.broadbanduk.org/component/option,com_docman/task,doc_download/Itemid,9/gid,45/)

It is also worth noting that this will complicate efforts to define what constitutes being under-served and public policy notions of equity. For example, it is substantially less expensive to commit to a social welfare promise of ensuring that every household, regardless of location, should have access to basic telephony services than to commit to providing broadband access at fiber-optic enabled speeds.

4.2.3. Technology

As already noted, the focus on peak data rates (downstream) is related to the choice of technology, or conversely, knowing what the technical platform is that is used to offer broadband (something customers surveyed may be expected to know better than what the peak data rate is) may provide an easier way to characterize the broadband service. Knowing what the technology is for providing broadband provides an indirect way to infer a good amount of useful information because:

- Technologies and service providers are closely identified. For example, knowing that the provider is a cable or telco provider allows you to infer that the technology is cable modem or DSL most likely (and visa versa).
- Knowledge of the technology provides insight into the nature of service economics (operating and capital costs, performance capabilities, and market dynamics).
- Knowledge of the service and technology allow one to infer the specific service offering from retail marketing and advertising literature.
- Knowledge of the technology is important for analysis of reliability, interoperability, and future infrastructure planning.

There are a number of broad classifications of broadband access technologies, which include the following:

- Wired or wireless: traditionally, the first broadband services were offered over wired facilities (copper telephone loops and metallic coaxial television cables). Wireless may be point-to-point (e.g., microwave) or point-to-multipoint (e.g., WiMAX or mobile cellular), but differs from wired in that it requires RF spectrum and uses towers instead of actual wires to transmit signals.
- Mobile or fixed wireless: Fixed wireless services are generally higher capacity than are mobile wireless systems because of the added technical challenges of supporting mobility, especially at vehicular speeds. Mobile wireless includes the 3G offerings of mobile telephone providers (e.g., Verizon, Sprint, and AT&T), while fixed wireless broadband includes offerings from new types of carriers (e.g., municipal WISPs) using technologies such as WiMAX (IEEE 802.16), WiFi (IEEE 802.11), and other proprietary technologies (e.g., Motorola's Canopy system).
- Legacy telecom or new broadband: there are a number of legacy telecommunication service offerings that have been purchased by commercial customers that may be used to support broadband. These include leased line services like T1s (1.5Mbps) or higher data rate services like DS-3 (44Mbps), OC3 (155Mbps), and so on. These come in a variety of technologies ranging from ATM, frame-relay, and simple point-to-point leased lines. Service offerings like DSL or cable modem broadband may offer comparable performance to lower-end versions of the legacy services at lower prices and with substantially different (less strict) quality of service guarantees.

- Satellite or terrestrial wireless: Satellite has added challenges of higher latency, but the advantage of wide coverage area. Typically, satellite services lag terrestrial systems in terms of capacity and bandwidth rates supported, and are more expensive for comparable quality services. Terrestrial wireless services include both fixed and mobile services. The major mobile providers in the U.S. – Verizon Wireless, AT&T Wireless, and Sprint PCS – are all well advanced in their roll-out of national mobile broadband services that compete quite favorably with low-end DSL services but which suffer from incomplete coverage (still mostly available in major metro markets) and high prices. Other fixed wireless alternatives are more diverse and less generally available.
- Fiber optic (or metallic): next generation wired infrastructure uses fiber optic cables. Such systems offer a number of important advantages such as lower maintenance costs (not susceptible to rust), much higher bandwidth capacity, and better security (harder to tap). Fiber optic cables are the preferred future-proof technology for new infrastructure. It seldom makes sense to deploy new copper wired loops, and when outside plant is replaced, fiber is often the medium of choice. However, even among fiber systems there is a diverse array of capabilities and service options enabled by the different fiber types (older multimode v. newer single mode) and architectures (passive v. active fiber systems).
- Other: there are a number of other technologies that may be used to provide last-mile data access, including:
    - Broadband over power line
    - Mesh/ad hoc networking, for example, using WiFi.
    - Free space optics: sending signals using optical wavelength frequencies over the open air. Basically, fiber optics without the cable.
    - Ultrawideband and other more esoteric wireless technologies that are technically viable for providing high-speed access, but not currently used for this.

The menu of technologies and service providers will continue to change over time and differs locale by locale. For example, a survey of residential consumers does not need to ask about legacy services such as private lines since such services are almost always purchased by commercial customers; while in contrast, a survey of commercial customers needs to ask about such services since they remain the most common mode of business data access in use today.

The FCC's current reporting requirements require suppliers to list (for each state) the number of lines by type of technology, as follows: [47]

1	ADSL
2	SDSL
3	Traditional wireline (e.g., T1)
4	Cable modem
5	Fiber (only to the home, not to the curb)
6	Satellite
7	Fixed wireless (exclude WiFi used to share locally)
8	Mobile wireless
9	Power-line
10	Other[48]

While this represents substantially more granularity than simply asking for the number of lines with a data rate in excess of 200Kbps, even this level of granularity obscures a lot of important variation in the types of services/technologies offered (e.g., there are many types of fixed wireless or traditional wireline, as noted earlier).

Finally, it should be noted that with the large-scale deployment in recent years of mobile 3G services and the growing deployment of 3B/4B services such as Verizon's FiOS service, a more (technically) granular interpretation of what constitutes broadband will be important in the future.

4.2.4. Services offered

Another way to categorize broadband services is based on the range of services that are supported. In contrast to traditional legacy voice-only telephony or television-only cable networks, broadband networks can support multimedia voice, video, and data services. The transition to broadband heralds a transition to platform competition, where it is expected that broadband service providers will support a "triple play" of telephony, television, and broadband data services, including:

- Voice (telephony)
- Video (TV)
- Data
    - Web
    - eMail
    - eCommerce
    - Gaming
    - Chat/Blog
    - Streaming video

[47] Not voice grade equivalent lines. Technology associated with what is used in last link to customer location, so excludes back-haul facilities. Since "other" included in last option, this is comprehensive list of mutually exclusive categories.

[48] Filer must indicate technology used for each "other" in comments section of form.

- P2P sharing

With 1B/2B services, it is possible to support low speed versions of most of the data services above, and telephony via VoIP technology, but not up to the standards assumed for first-line telephone service. Delivery of high-quality television services over the broadband connection requires upgrading the broadband to 3B speeds. As the broadband market matures, new applications will be developed and these are likely to increase the needs for symmetric bandwidth and fuel exponential growth in network traffic, which will drive additional investment in backbone networks (second-mile and backbone infrastructure investment) and will motivate new architectures (e.g., increased caching in edge networks, for example, making use of end-user maintained DVRs or network-side cache servers).

As competition in the market shifts toward bundled "triple play" offerings – or perhaps even "quadruple play" where mobility is added -- it will be important to track the purchase of both bundled and "a la carte" options. This means that data collection efforts focusing on residential broadband service competition will also need to consider and be consistent with data tracking of residential television and telephony access since these services will be important.

4.2.5. Key characteristics such as "always on" connectivity, "openness," etc.

In addition to the above, there are certain other features that are usually regarded as important and associated with broadband Internet access. Since most 1G and 2G services shared these characteristics, there was no need to collect differential data on these but if this changes, it will expand the range of features/characteristics that need to be monitored. Some of the important characteristics include:

- Always on connectivity: In contrast to dial-up Internet access, broadband connections are always on, allowing someone to (nearly) instantaneously browse the Web with the click of a mouse or take advantage of automated software upgrades, real-time email notifications, and the like. This is recognized as offering a substantial improvement over dial-up access (where one had to first initiate a connection before being able to access the Internet) that dramatically increases the Internet's usability. However, it also raises some problems such as increasing user exposure to security threats. In the early days of broadband, not all services were always on and intermittent services might be priced on a per-time basis. Were future Internet services to differ with respect to their "always on" capability, this would need to be tracked.
- Openness to run and use third party applications: To date, most broadband services have been quite open to allowing users to run third party applications such as Voice-over-IP or p2p programs. The expectation of whether this should continue in the future underlies current debates over network neutrality. In the future, it is reasonable to expect that service providers will offer a wider array of capabilities and services (e.g., security and specialized-caching services) that may impact the openness of future broadband services.[49] Again, any changes in the classification of broadband services which alters this aspect would need to be tracked since it would represent a material change in the quality of broadband services.

[49] See http://ijoc.org/ojs/index.php/ijoc for a collection of recent articles on the Network Neutrality debates and what this may mean for broadband.

- Flat rate to metered usage: To date, most broadband services (and a growing array of all telecom services) are capacity-priced at a flat rate per month. A number of analysts have suggested that broadband services will need to move toward usage-based pricing that reflects the divergence in traffic loads imposed by differing classes of users and applications. Such usage-based charging may come in the form of service tiering (for example, bronze, gold, and platinum offerings supporting different monthly MB limits, peak, and average data rates, etc.), explicit traffic limits, or differentiated quality-of-service offerings. Comparing services with very different metering and pricing models is inherently complex and will need to be addressed by future data collection efforts.
- Coverage (is it universal? what is the quality of service?): prior to the advent of 3G and WiFi broadband services, most broadband access was limited to a fixed location. The emergence of 3G services and next-generation satellite services (offering broadband speeds in excess of 200Kbps) raises the potential for services that support ubiquitous, roaming access. For many users and applications, the benefits of roaming may be more important than any loss of data rate and may change the assessment of what constitutes viable broadband services. Additionally, with the emergence of very high-speed services such as FTTH, it will become important to rethink our commitments to universal service. For example, it may not be desirable or economically feasible to seek universal access to FTTH, while still seeking universal access to higher data rate services than are currently available from 0B/1B/2B services.

5. What data is collected and how

The prior section identified the types of data collected (commercial v. residential, availability v. usage, etc.) and more specifically the broadband access characteristics (peak data rate, technology, pricing, etc.). In this section, we consider some of the other practical and organizational issues that characterize the data collection effort, including:

- Goal of data collection
- Timing
- Methodology and details of collection efforts
- Presentation of results

5.1. Goal of data collection

The goals of the data collection effort may be narrow or broad. For example, a narrow goal may be to ensure that there is universal availability of broadband services. A broad goal might be to support economic development efforts.

The goal of the data collection effort will inform the scale of effort that is appropriate and will influence incentives for service providers and end-users to cooperate with the effort.

For the contexts of this report, we have assumed that the goal of the data collection effort is relatively broad: to develop a sustainable and robust methodology to track and monitor the performance of advanced communications infrastructure, including broadband in the state. This means that the effort needs to consider:

- Supply-side and demand-side data collection: both are needed to assess the performance of broadband markets.

- Address usage, as well as availability:
  - While initially, focus may be on achieving universal availability of threshold broadband access (e.g., every town has at least one broadband connection, or every household has availability of 2B services from one or more providers), data collection should also consider the health of next-generation broadband services (e.g., availability of mobile wireless broadband? FTTH?). Moreover, to measure economic effects, it is as important to track the progress of broadband in communities that are served as it is to track communities that are unserved or under-served.
  - The usage data is needed to assess the health of competition and to estimate economic impacts and evaluate broadband policy effectiveness.
- Support multiple representations of the data and linkage with other data sets
  - Data should be presentable both in terms of geographic maps (GIS) and tabular data (spreadsheet/table). The former is needed to allow sufficiently granular analysis of broadband (consideration of local effects) as well as to facilitate interpretation (maps are easy to understand). The later presentation is important for linking with non-GIS-based data (e.g., demographic or economic performance data not available as point-GIS estimates) and for further quantitative analysis of effects. This presents thorny and complex issues for database design and integration.
  - Enable incorporation of proprietary (protected) and public data. Some of the data collected may be available only if its privacy is protected (e.g., data provided under regulatory mandate) and it will likely be necessary to restrict access to the data to different classes of users (the general public v. data collection agency).
  - Enable benchmarking and integration with data collection efforts in other states, federal, and international data.
- Repeatable over time and robust to changing needs of markets
  - An important goal is to enable a sustainable and repeatable data collection methodology that will generate a time-series of observations so that performance may be tracked over time.
  - Designing for the future, while inherently uncertain, is important to ensure that past data incorporates what is needed to support future analysis and data collection needs, to the extent such needs may be reasonably anticipated.
- Scope: for fairness reasons and certain types of policy questions, in some cases policymakers will want a census of broadband, while in other cases, a survey (partial sample) may suffice. Conducting a census is more expensive and time consuming (and because measurement errors are unavoidable, is always more of an ideal than a reality). Often more limited census data is supplemented with additional data obtained via partial sampling.
- Cost effective: funding for data collection is usually quite scarce and so any effort will need to pay strict attention to minimizing the costs of the project. This also means minimizing the costs on service providers and end-users to make it more likely that they will cooperate with the project. The need to minimize costs typically pushes one toward collecting less data (categorical instead of levels, fewer survey questions) and to using more off-the-shelf or automated technologies. For example, sampling is less expensive than a census, and voluntary surveys (on-line tool) are less expensive than telephone surveys.

5.2. Timing of survey

As noted above, the data collection effort may focus on a one-time measurement or a repeatable study. While the focus here is on repeatable methods, many of the state efforts reported to date (see further discussion below) reflect one-time studies. Even with repeatable studies, there are likely to be significant one-time costs (e.g., setting up the basic GIS framework and encoding perpetual geographic features).

In addition, the timing of the study also affects the time frame over which data is collected. The more burdensome and ambitious the data collection effort (more detail and data collected), the longer the lag time before the data may be presented because of the increased complexity of validating and interpreting the data (including determining whether anomalies reflect measurement errors or unforeseen effects). Depending on the goals of the effort and the pace of market changes, this may impact data collection design. For example, assessments of economic impact/project evaluation may need to wait for a project to be completed or for the availability of data metrics (e.g., 2010 Census data for assessment of demographic impacts of policies put in place in 2000 or earlier). Alternatively, too complex an approach that introduces significant lags may miss the window of opportunity (e.g., universal access of 2B broadband may be achieved by end of 2007 and so not relevant concern for design of data collection methodology for future).

5.3. Methodology and details of collection efforts

In addition to addressing the concerns discussed above, the data collection methodologies being undertaken by the various states differ substantially with respect to their scope and organization. In this section, we discuss in general terms some of the key dimensions along which these efforts differ, including:

- Organization (who conducts effort? Statutory or other?)
- Cross-validation
- Data ownership
- Funding

5.3.1. Organization (who conducts effort? Statutory or other? Scope of effort?)

The data collection efforts differ substantially in terms of who conducts the effort (is it a government agency or NGO?) and the framework under which the data is collected (statutory or otherwise). Most states have adopted some sort of broadband initiative, but these differ widely in how far they have proceeded in implementing such initiatives (see further discussion below). In some cases, the initiatives have been put in place by legislative mandates; elsewhere by initiatives from the governor's office (or regional or local authorities); and in still others, by quasi-independent government bodies like the Massachusetts Technology Collaborative (MTC).

The range of organizational entities engaged in data collection efforts include:

- State Public Utility Commission (PUC): the PUC is responsible for regulating telecommunication and cable television service providers in the state, and as such, in many states, has assumed a leading role in assessing and reporting on the state of broadband within the state. The PUC is the most common entity to play a role in collecting data under mandatory reporting requirements, when such requirements exist.

- Broadband Task Force: a number of states formed task forces of stakeholders to assess the status and priorities for broadband policy within the state. The stakeholders are drawn from multiple government agencies (e.g., housing and economic development authorities, PUC, GIS), public interest groups (e.g., universities, minority interests, user groups), and industry providers.
- Broadband Authority: a number of states have formed new state government departments or authorities to promote broadband within the state (e.g., North Carolina) or have formed public-private partnerships (e.g., Kentucky) to direct broadband efforts within the state.
- State GIS: most states have in-house Geographic Information Services (GIS) that produce and maintain detailed maps of infrastructure in the state for use in planning, administration (tax assessment and property deeds), and construction.
- Regional and local authorities: there are diverse array of regional and local authorities that are organized to promote broadband in states.

In all cases, evaluating the progress of state-based initiatives is challenged by the newness of such efforts. As with all things broadband, it is only recently that states have determined that there is a need for a government policy focus on broadband. For example, North Carolina was one of the earliest states to launch a formal initiative in 2000, with even leading states like Kentucky only launching their initiatives in 2004, and most states waiting until 2006 or 2007 to announce formal broadband initiatives.

In addition to these larger initiatives, there are a number of one-time studies of the state of broadband available for individual states. In many cases, these have been prepared by the state public utility commissions. While state public utility regulators continue to play an important role in tracking the progress of telecommunications and cable television infrastructure in their states, and in most cases, are the agency with a regulatory mandate to compel data reporting and licensing authority, much of the new activity in promoting broadband has a broader charter. Instead of leading the effort, in many states, the public utility regulator is cooperating with and complementing broadband initiatives that have a broader scope.

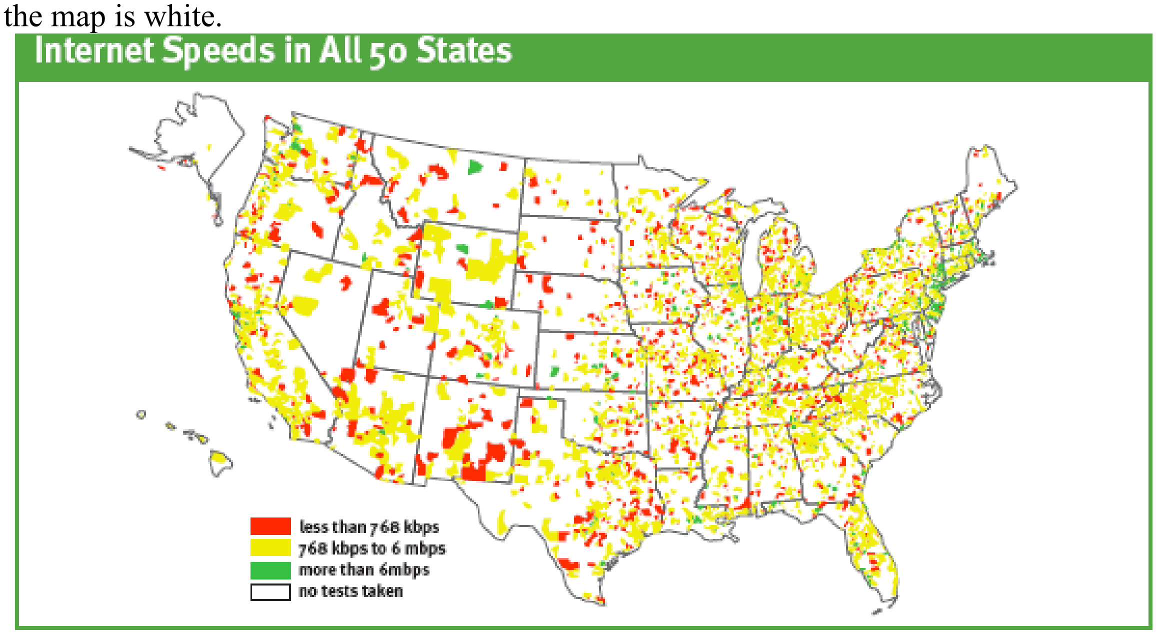
This shift in leadership with respect to broadband reflects the fact that broadband is increasingly being viewed as a tool for economic development and its status as a form of infrastructure is ambiguous (e.g., is it a telecommunication service? Cable television service? Or, something else?).

5.3.2. Cross-validation

As noted above, because the initiatives are quite early, there is no generally available basis for cross-validating studies or verifying the quality of data reported in the various studies. Older state-based efforts to track service availability have tended to focus on table-based data formats, rather than GIS-mapping formats, which makes it more difficult to integrate data from multiple sources which do not make use of some common geographic area locator (zip codes, census block groups, counties, community). For these reasons, most analysts who have been interested in making cross-state comparisons have focused either on FCC data or have built their own datasets through arduous data manipulation.

In the future, we anticipate that the transition to GIS mapping formats will make it easier, in principle, to integrate data across states and to link such data with other third-party data sources and layers such as demographic data (e.g., per capita income, educational attainment, population density) to facilitate analysis. The greater challenge will not be technical (can the data be integrated?) but rather political/legal (can the data be shared? Is it legal to integrate the data? Who has access to the data?). The transition to GIS will make this feasible because the tools to provide such interoperability are in development and because states recognize the importance of having robust GIS capabilities for many government agencies and functions (basic infrastructure management such as roads, water, electricity, telecom and now broadband; tracking property boundaries for zoning and tax revenue; and to facilitate flexible data/policy analysis). The drive toward enabling such capabilities is abetted by the growth of eGovernment which is, itself, promoted by and enabled by the growth of broadband.

In addition to allowing cross-state and cross-data set comparisons, it will be desirable to integrate both supply and demand-side data sets. Surveys and independent analysis can supplement and provide crosschecks to data collected in other forms (e.g., supplier-provided data). We anticipate that in the future that end-consumer initiated or participatory data collection will play an important role in verifying and cross-validating data collected under regulatory mandate from providers. The reports published by SpeedMatters.Org on broadband speeds, and implicitly, on availability provide perhaps the best-known example of such data.[50] For example, the following national map shows graphically the patterns of broadband availability by speed across the U.S. Since this is not a census, but a voluntary survey, we can infer that broadband is available wherever we see a color, but can only guess that broadband may not be available where the map is white.



Speed Test results for September 2006 through May 2007

[50] See www.speedmatters.org and http://www.speedmatters.org/document-library/sourcematerials/sm_report.pdf for state-by-state maps of broadband speed tests (conducted between September 2006 through May 2007). For many states, they have thousands of individual site test results. As this database expands and evolves, it will provide a map not only of what speeds are available but also, by the gaps that appear, a map of where no service is available.

The quality and opportunities for cross-validation will be enhanced by making more and better data publicly available, or at least available (potentially under non-disclosure agreements) to independent analysts to support verification of existing data. The more data, the more important broadband is (and hence, the more folks that are interested in it), the better will be data-informed policy analysis.

5.3.3. Data ownership, presentation, and access

The best data is proprietary (owned by the service providers or consultancies and market research firms) or under non-disclosure constraints imposed as a condition for the data collection, whether collected by a regulatory authority such as the FCC under regulatory fiat or contributed voluntarily as in the case of Connect Kentucky. Such constraints are understandable.

First, creating detailed data sets is expensive. Those who collect the data, including for-profit entities, can be expected to restrict access to enable recovery of data collection costs (and earn a profit).

Second, highly granular data raises privacy and competitive issues. Data on service availability by service providers may be competitively sensitive. More interesting data on adoption rates and usage is even more sensitive, and moreover, is likely to be regarded as private information that end-users may resent being shared. The better the data, the more likely it will threaten privacy or competitive interests, and hence the greater the likelihood its sharing will be limited.

Third, public dissemination of detailed GIS information on the location of essential infrastructure may be regarded as posing a security risk, enabling terrorists or others to better target attacks. As higher-and-higher resolution locational information becomes available (e.g., Google maps), this is posing both an opportunity (better emergency services) and challenge (easier targeting by terrorists) to security agencies and policy-makers more generally.

While access and sharing restrictions on detailed data impose complications and increases the costs of data analysis, such constraints are unavoidable. The appropriate balance between public access and private/limited access will need to be worked out and will require a complex balancing of conflicting objectives (market efficiency vs. privacy, security v. transparency, etc.).

In addition to limiting who has access to the data (e.g., to those who are willing to pay or to employees of specific government agencies), data access is also limited by the forms in which data is presented. This is a common strategy employed by statistical agencies that report various summary tabulations but not the results on individual survey points. For example, the Census Bureau presents numerous tabulations and complex ways to roll-up the data included in such surveys as the Decennial Census or Annual Consumer Expenditure Surveys, but they do not provide the individual survey results because to do so would violate privacy constraints. For much analysis, the summary data is all that is needed.

In the context of broadband data, many of the GIS efforts only make available the map, and potentially, only at a lower resolution than is feasible. This limits the use of the map for other analysis or integration with other data sources that would be enabled if users could have access to the raw data or even summary data in tabular format. In principle, one could re-code a hard-copy map to generate a lower-resolution copy of the data (just as one might tape record a CD to generate a lower quality copy) but this is time-consuming, error-prone, and expensive. In the context of broadband analysis, availability of only the maps in hard-copy (even electronic "pdf" format) severely limits the usability of such data for detailed assessments of the progress of broadband, although such maps do provide compelling visual summary evidence of broadband disparities, as the chart above demonstrates.

5.3.4. Funding

As already noted, much of the best data is collected by for-profit entities such as consultancies and market research firms who sell access to the data to industry professionals. As long as the market works efficiently and there are a complex array of competing stakeholders with access to the data, the market process benefits.

However, policymakers often lack sufficient budget to purchase such for-profit datasets and must rely on what is available publicly through other sources, what they may be able to compel via regulatory fiat (which for service provider data is usually under the management of the state public utility commission or FCC), or may collect from its own efforts (which includes hiring contractors to collect the data).

There are a number of models for funding such data collection efforts. First, the data collection may be delegated to one or more state government agencies, and paid for via their general budget, funded through the normal process for funding state government. This is the way public utility commissions are funded and the approach followed in a number of states like California.

Second, the broadband data collection costs may be funded from a special fund associated with a legislative broadband initiative directed at promoting broadband and economic development within the state. This is the approach that was followed in Kentucky and North Carolina, which appropriated special funds for their broadband initiatives. Such funding may be raised via a dedicated bond offering or by earmarking general funds.

Third, the broadband data collection effort may be partially funded by voluntary contributions from interested stakeholders, which includes contributions of data. This is the model that a number of public-private initiatives have turned to support their data collection efforts, including Connect Kentucky. Analogously, the Communication Workers of America (CWA) publish summaries of their data as part of their lobbying efforts to drive additional investment in telecommunication facilities (which benefits their membership) and induces individuals to voluntarily contribute their data (which lowers data collection costs relative to a direct survey) by offering an attractive on-line test tool that is both fun and interesting for end-users to use. The CWA encourages other websites that are seeking to sell broadband services or otherwise highlight the state of broadband to link to their tool, which expands its reach.

Fourth, the broadband data collection effort may be partially funded by charging fees for differential access. For example, while access may be free to government agencies or other non-profits, for-profit entities may be required to pay for access. Connect Kentucky relies on the carrot of better access for those who contribute their data (an implicit fee) as well as annual fees from "steering committee" members who pay $20k a year to influence the organizations direction and to benefit from shared publicity. In the future, it is reasonable to expect that quasi-public/private data centers might sell customized consulting services to recover part of their operating and data collection costs.

Fifth, it is conceivable – although we are unaware of any examples of this currently – to fund data collection efforts through general taxes levied on service providers or end-users. The logic for such a funding approach is to tie the costs of administering the market to those who participate in the market. Better public information about how the market operates might be viewed as a public good that benefits all market participants and hence a legitimate cost of market participation.

The various approaches for funding data collection efforts are generally a collection of all of the above and other novel funding mechanisms are likely to be discovered in the future. Better data on funding approaches is difficult to collect because, first, because the details of funding are often viewed as either not interesting (except to the management and those directly concerned with budgets) or sensitive; and second, because data collection is seldom undertaken as an independent task. Rather, data collection and management is part of the larger agenda of a broadband initiative or an agency mandate and its cost is embedded in the funding for the large program.

5.4. Summary of State Broadband Legislative Initiatives

As already noted, most states have passed some sort of broadband legislation in recent years. Michelle Larson-Krieg of the National Conference of State Legislatures has been maintaining a list of some of these legislative initiatives.[51] These initiatives may be organized into a number of categories (see the Table below which reports the status as of November 2007):[52]

[51] See State Legislation on Broadband, compiled by Michelle Larson-Krieg, National Conference of State Legislatures, November 2007, and available on-line at: http://www.ncsl.org/programs/lis/legislation/broadbandstatutes.htm.

[52] The following table classifies the legislation according to a smaller range of groups than is reported in the list of categories identified by Michelle Larson-Krieg. Her categories are: Assessment, BPL, Coordination and Leadership, Definition, Financing, Government Ownership & Operation, Passenger Rail Access, Regulation, Rights-of-Way, Rural Access, Tax Incentives, and Universal Service.

Category of Legislation	Examples of Legislation
Coordination, leadership, assessment	• Create task force/office/authority/public-private partnership to assess and promote BB in state (like Connect Kentucky) (CO, GA, HI, KY, MA, MD, ME, MI, NC, NE, NH, OR, SC, TN, VT)
Financing and tax incentives	• Establish high cost or other fund to subsidize BB projects in rural and other areas (AR, IN, KY, LA, MD, MI, NC, NE, NH, VA) • Tax holiday/exemption or investment credit for BB-related services/investments (CT, FL, GA, HI, ID, MI, MO, OR, VA) • Include BB projects as eligible for economic development funding in the state (IN, SC) • Other programs such as jobs funding (OH) or allowing local governments to assess taxes (NH, WA)
Government ownership and regulation	• Allow municipalities to offer or finance BB (AL, NC, NH, VA) • Restrict or limit municipalities from offering BB (CO, FL, LA, MI, WI) • Restrict PUC regulation of BB (AL, FL, GA, IN) • Limit VoIP regulation (FL) • Provide rights-of-way access for BB (MD, VT) • Modified regulations for rural or small telecoms (PA, TX) • Re-examine universal service to include BB (CA)
Definition	• Specifies minimum symmetric data rate (following FCC): At least 200Kbps up/down (AL, GA, MS, NC, TN) • Specifies minimum rate, but maybe not symmetric and maybe lower or higher than FCC: At least 150Kbps up/down (OK), At least 256Kbps up/down (UT), At least 384Kbps up/down (AR), At least 1.5Mbps down/384Kbps up (IN), At least 190Kbps (SC), At least 200Kbps data rate (MI), At least 1.5Mbps data rate (KS); At least 3Mbps transmission path and at least 1.5Mbps to unserved areas (VT). • Describes technology or services that can be offered: Transmission facilities handling frequencies higher than what required for voice (4KHz) (MT); At least 200Kbps data rate and enabling users to send/receive high quality video, voice, and data (NE); Enables users to send/receive high quality voice, video, data (OR); Network extending the range of fully switched, addressable, robust transport services over the fiber network and increasing in multiples of OC-1 (51.84 Mbps), including OC-3 (155.52 Mbps) and OC-12 (622.08 Mbps) (OK)
Other	• Broadband-over-Power Line (BPL) enabling legislation (AR, NE, TX) • Broadband on Public Rail (IL)

The above demonstrate the wide range of similar activities underway across the states and are characterized by several commonalities:

- Special effort to promote broadband: formation of task force or special agency to promote broadband. This usually includes requirement to prepare initial assessment and report back to state legislature and government on status of broadband and with recommendations on policies to enhance broadband within the state.
- Funding: allocate dedicated funds or allow economic development funds to be used to support broadband promotion efforts. Most funding directs that public funds should be leveraged with federal funds and private matching funds. In many cases, the funds are targeted at under-served rural or poorer urban areas.
- Definition of broadband: the most common approach to defining broadband is to focus on peak data rates, referencing the FCC's prior focus on a 200Kbps rate. Another common approach is to identify broadband as a service capable of supporting high-quality voice, data,

and video services. The diversity in definitions highlights the challenge of defining a moving target.

6. Current best practices status

In this section, we summarize what we have learned about data collection efforts in the United States, focusing on the states that are leading and provide guidance as to what possible best practices are. As noted already, most states are still in the early stages of framing/implementing their broadband initiatives, including their data collection efforts. This is true in Massachusetts as well as most of the peer states, which include:

Peer States

(1) California (CA)
(2) Connecticut (CT)
(3) Illinois (IL)
(4) Massachusetts (MA)
(5) Minnesota (MN)
(6) New Jersey (NJ)
(7) New York (NY)
(8) North Carolina (NC)
(9) Pennsylvania (PA)
(10) Virginia (VA)

Additional information is available via the Web at the links identified in Tables 5, 6, and 7 which provide an overview of the data collection efforts underway across the states.

In the following sub-sections, we provide summaries of states that demonstrate best-practice approaches to broadband data collection, including California, Kentucky, and North Carolina.

6.1. California

California is a leading broadband state, due largely to the presence of a strong high-tech sector that offers a strong commercial and residential market for broadband services. California's approach to promoting broadband is typical of a large number of other states, in that it relies on a governor-sponsored initiative, principally motivated by the desire to promote economic development in the state. More uniquely and noteworthy, the California Public Utility Commission (CPUC) was instrumental in creating a $100 million fund, the California Emerging Technology Fund (CETF) in 2005 to provide financing for broadband initiatives within the state targeted at serving underserved areas. California is also noteworthy because it has the foundation-funded Public Policy Institute of California which is an independent research center that has conducted a number of important detailed analyses of broadband and its impact within the state.[53]

[53] The Public Policy Institute of California (PPIC) is a San Francisco-based, private non-profit which was founded in 1994 with an endowment from William R. Hewlett (of Hewlett-Packard fame) (see http://www.ppic.org/). Specifically, Jed Kolko has authored a series of reports on broadband and telecommunications infrastructure within the state, including "Broadband for all? Gaps in California's

6.1.1. California Broadband Task Force (CBTF)

In 2006, Californian Governor Schwarzenegger assigned principal authority for his government's statewide broadband initiative to the Business, Transportation, and Housing Authority (BTH) and established a public/private stakeholder task force, the California Broadband Task Force (CBTF), to report on the state of broadband in California and make recommendations for state agencies and other initiatives to promote broadband in the state. This task force issued a preliminary report in June 2007.[54] The California broadband initiative does not appear to have a special designation of funding, but is being implemented as part of the action agendas across the various government agencies and departments, with the BTH providing lead coordination. The current initiatives appear to be largely about mobilizing state resources to work together to enhance and expand broadband services in the state, including such things as mandating that the California university system work with BTH on spending rural funds to support telemedicine and instructing the California Department of Housing and Community Development to enable broadband access in multifamily affordable housing units. The plan calls for coordination to ensure access to broadband for K-12 schools, efforts to encourage telecommuting and broadband adoption, and a mandate for state GIS authorities to coordinate conduit mapping to assist facilities providers seeking to promote broadband. The report issued this summer provides a high-level snapshot, but there is little evidence of how future data collection and broadband promotion efforts will proceed.

The June 2007 report sets forth a number of high-level objectives and recommendations, but did not include much useful data assessing the current state of broadband in the state. The best example of such an assessment available at that time was a report prepared by the California Public Utility Commission (CPUC) in September 2006.[55] That report relied heavily on the FCC data as its principal source for assessing the location of broadband service availability. It is noteworthy in that the CPUC notes that "as of this report, Kentucky, Vermont, North Carolina, and Wyoming have produced the best publicly available maps of broadband access and adoption."

In January 2008, the California Broadband Task Force issued its final report, which offers a substantially more detailed picture of broadband within the state.[56] The analysis of broadband included GIS mapping data provided voluntarily by suppliers working with the CETF and detailed broadband speed test data compiled by Speedtest.net (see Appendix 1) for end-users who took the test in California. The data included in these detailed maps was current as of October 2007 and included most (and all of the largest) providers in California. The CBTF reports that the analysis considered in excess of 22 million address locations across the state. The

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Broadband Adoption and Availability," California Economic Policy Vol. 3 No 2, Public Policy Institute of California, 2007 (available at: http://www.ppic.org/main/publication.asp?i=758).

[54] See "The State of Connectivity: Final Report of the California Broadband Task Force," January 2008 (available at: http://www.calink.ca.gov/pdf/CBTF_Prelim_Report.pdf.)

[55] See "Connecting California: California Public Utility Commission Telecommunications Division, Broadband Report Update," September 20, 2006 (available at: ftp://ftp.cpuc.ca.gov/PUC/Telco/Reports/california+broadband+report+for+sept+2006+cetf+meeting.pdf)

[56] See http://www.calink.ca.gov/pdf/CBTF_FINAL_Report.pdf.

speed test data was based on over 1.2 million tests conducted for 350,000 users across the state. The maps provide a detailed view of broadband availability by speed tier across the state.

The California GIS effort provides useful insight into what is involved in such an undertaking. First, while the CBTF was a state-government organized entity (and so implicitly, the threat of regulatory compulsion was present), the data used to create the initial map was contributed voluntarily by the service providers. Getting the service providers to support this effort and contribute the detailed data on a consistent basis proved a major challenge that was significantly aided by the star-studded, high-level composition of the CBTF, which included a number of members with strong contacts with service providers. Numerous telephone calls and discussions by these folks and others were instrumental in getting the providers to agree. This re-enforces the conclusion that the quality of leadership and high-level support within the state are important in implementing effective broadband policy.

Second, developing detailed GIS maps is difficult and expensive. There are many nitty-gritty technical issues that need to be resolved in discussions engaging folks with significant GIS experience to address the problem appropriately. In California, the CETF provided the funding support to hire the Pennsylvania-based GIS consultancy, Michael Baker Corporation,[57] in the amount of $400k. The total resource commitment at the state-level was likely several times this number since a number of state government employees were engaged full-time for the six months it took to complete the initial mapping effort.[58] The effort was launched in March of 2007 and data began to come in from service providers in August and the maps were ready by October 2007.

Third, while costly, the effort expended appears to have already delivered some important benefits. For example, California was successful in its bid for funding from the FCC for a telemedicine project in the amount of $22 million – one of the highest grants made by the FCC. Apparently, California's effort to promote broadband played a part in building the state's profile and in helping them win these funds.[59] The expected benefits for economic development in the state associated with the growth of telemedicine services and capabilities within the state are likely to be significantly larger.

Fourth, while the GIS effort appears to have been a success. It is not yet clear how the effort will be sustained into the future and how the maps will be updated. The original charter for the CBTF was to complete a one-time assessment and the participation of the service providers was not solicited with the goal of keeping the maps current. As noted earlier, if one takes seriously the perspective that broadband is basic infrastructure, then it seems obvious that there will be an on-going need to track the status of infrastructure.

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[57] See http://www.mbakercorp.com/gis/services/consulting.html.

[58] The cost of the mapping effort in California was amplified by the need to create a parcel map. It is our understanding that Massachusetts' GIS agency already has a current parcel map for the state. Additionally, an advantage of following the lead of other states is that some of the service providers have already been through the process once and a baseline exists for developing consistent maps.

[59] See "California receives $22 million FCC grant to expand telemedicine," Government Technology, November 21, 2007 (available at: http://www.govtech.com/gt/articles/208101).

Providing support for an on-going effort will be a challenge that the state must consider. It remains unclear whether lead responsibility for this effort will reside with the CETF, the CPUC, or some other entity within the state (e.g., state GIS department?). Additionally, there are concerns about how to continue to obtain service provider data and address confidentiality concerns. For example, while the maps are based on quite detailed data, the published maps report only the maximum broadband speed available in an area and do not identify the provider or number of providers offering service in specific locations. To accurately assess consumer choice and the health of the market, such information may be necessary.

6.1.2. California Emerging Technology Fund (CETF)

As already mentioned, the CETF established in 2005 is noteworthy in that it is intended to be a $100 million fund to support broadband initiatives within the state directed at underserved communities. The core funding for the CETF was committed to by SBC (now, AT&T) and Verizon in the amounts of $45 million and $15 million, respectively, as conditions for the CPUC's approval of the SBC-AT&T and VZ-MCI mergers.[60] The balance of the funding is expected to come from other non-profit sources. The CETF is to be established as a 501(c)(3) non-profit grant-making authority. The board was fully established in 2006, and during 2007, the CETF engaged in an assessment of stakeholder interests and needs for funding, with a goal toward identifying target development projects as part of a final plan that will be implemented starting in 2008. This is described in the CETF's Strategic Action Plan.[61] They anticipate collecting proposals for projects grouped into three categories targeting (a) rural areas; (b) disadvantaged urban areas; and (c) persons with disabilities. The CETF also has designated at least $5 million to be used for telemedicine.

The CETF relied on analysis by Jed Kolko of PPIC[62] assessing broadband trends across the state in adoption based on private survey data from Forester Research[63] which looks at trends in broadband adoption and usage across demographics such as race, education, and per capita income. Dr. Kolko combined the Forester data with FCC data to infer enhanced availability estimates that show that the FCC data overstates availability.[64]

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[60] See http://dev.cetfund.org/Investments/Overview.aspx. AT&T and Verizon are contributing $9 million and $3 million per year to the fund from 2005 through 2010 as part of their commitment. The CPUC and the companies each appoint four members to the CETF governing board, and then together appoint an additional four appointees to manage the CETF. The remaining appointees should be reflective of the diversity of California and may have special expertise relevant to promoting broadband.

[61] See http://dev.cetfund.org/docs/verify.aspx?file=CETF%20Strategic%20Action%20Plan.pdf

[62] See Kolko, Jed (2007), "Why should governments support broadband adoption?," Public Policy Institute of California , Working Paper No. 2007.01, January 2007.

[63] Annual survey of between 60-100k households in the continental United States.

[64] Dr. Kolko uses data on known adoption rates and the number of service providers by zip code to infer the availability of service in zip codes with fewer numbers of providers using a novel and interesting econometric approach.

The CETF has not explicitly targeted funds or efforts to assess the status of broadband in the state, although its strategic plan calls for it to work with the BTH and CPUC to track broadband within the state at the Census Block Group (CBG) level.

6.2. Kentucky

Kentucky is viewed by many as a leader in its approach to promoting broadband within the state. The Connect Kentucky project was launched by the governor in 2004 with the creation of a 501c3 non-profit with the charter to help support technology-based economic development in Kentucky. Connect Kentucky built upon an earlier effort dating from 2002 sponsored by the preceding governor to use economic and rural development funds to promote broadband in the state.

Connect Kentucky was envisioned as a grass-roots organization to coordinate public-private initiatives to promote a number of technology-based initiatives across the state, including the promotion of broadband connectivity. In 2007, Connect Kentucky described its "Prescription for Innovation" as follows:

> "The *Prescription for Innovation* is Kentucky's comprehensive plan to accelerate technology growth, particularly in the areas of broadband service and technology use. The initiative has four key goals for expanding technology in the Commonwealth:
> -- Full broadband coverage by the end of 2007;
> -- Dramatically improved use of computers and the Internet by all Kentuckians;
> -- A meaningful online presence for all Kentucky communities; and
> -- eCommunity Leadership Teams in every county that bring local leaders together to plan technology growth strategies for every sector of the community."[65]

Core activities include benchmarking broadband access by creating a detailed, multi-layer GIS map for each county in the state. These maps, constructed with the cooperation of and with data provided by service providers, show the locations of DSLAMs and the surrounding 2.5 mile coverage area,[66] the location of cable modem service availability on a household-by-household basis, and wireless service coverage areas for WISPs. Connect Kentucky seeks the voluntary cooperation of all service providers in the state and integrates the data into a detailed overlay map that shows where each type of broadband service is available and the location of major features such as towns, roads, water towers, and other potential antenna sites. The color-coded maps show where broadband service is unavailable (unserved), available from wireless providers, or available from one or more wired providers. The resolution of the map is quite high (1-inch=few hundred feet). The statewide map is about 1-inch/10-miles, and then you can successively drill down to finer and finer resolution using the interactive map,[67] and you can select the features you wish to display. At the finer resolutions you can see individual street names and tower and cable-run locations. The data that is provided via these maps is a coarser

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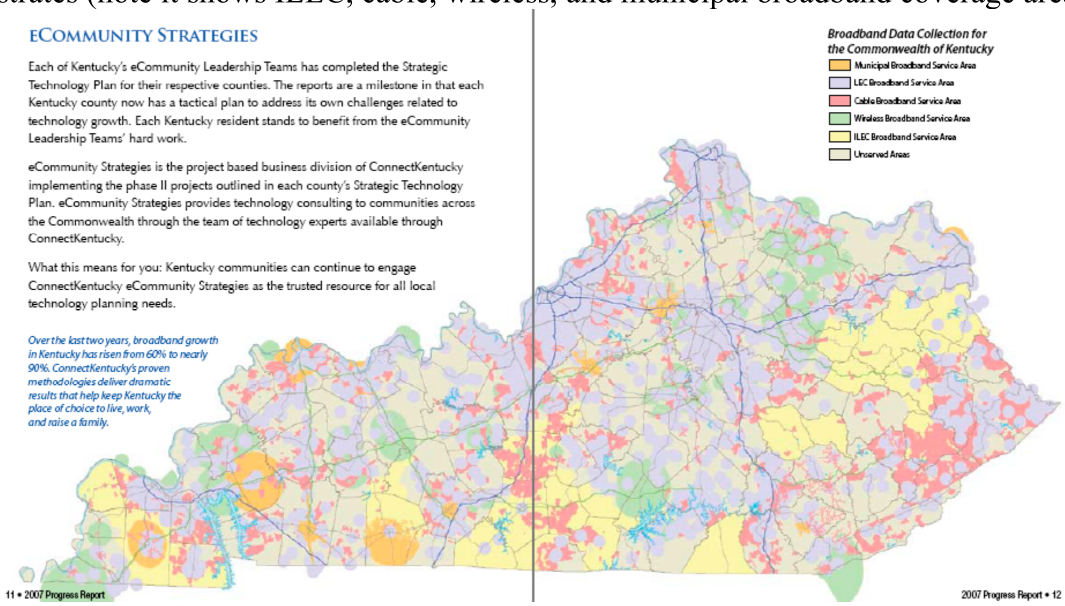
[65] See Connect Kentucky 2007 Progress Report (available at: http://www.Connect Kentucky.org/_documents/Connect Kentucky_2007_report.pdf)

[66] This represents an approximation of the maximum distance from the DSLAM for providing DSL services.

[67] See http://12.180.242.34/kybroadband/default.aspx for the Connect Kentucky interactive map.

version of that which is made available to the service providers, and it is not readily available in a format for flexible cross-linking to other third party sources.

The Connect Kentucky model relies on voluntary participation by service providers across the state for the data used to populate its maps. Connect Kentucky does not provide a definition of broadband,[68] but leaves it to service providers to tell them what services they offer where. It solicits such participation by promising to limit access to the detailed data and by seeking to offer an acceptable alternative to regulatory mandated data collection. The service providers contribute to Connect Kentucky's funding and participate in its steering committee, which gives them a degree of control over how the data is presented. Such control raises questions of independence and the limited access provided to such data may prove inadequate for doing more than tracking availability rather coarsely. It does not readily provide a capability to measure competitive dynamics in the markets (changes in the availability of service offerings by providers over time or the quality of those offerings). Nevertheless, the Connect Kentucky maps ability to display multiple layers of coverage by service providers does offer an visually impressive way to quickly see an inventory of the state's broadband availability, as the following demonstrates (note it shows ILEC, cable, wireless, and municipal broadband coverage areas):[69]



Connect Kentucky supplements its mapping effort with focused end-user surveys. For example, in 2005, Connect Kentucky conducted a 10k household survey to track broadband

[68] According to an interview with Joe Mefford, the statewide broadband director of Connect Kentucky in December 2006 at the Wireless Internet Institute (W2i) Digital Cities Convention in Philadelphia, he said that Connect Kentucky used the FCC's definition of what constituted broadband "which is 256Kbps." (see http://www.connectkentucky.org/_documents/Artilce_KYNonprofitMapsTacklesRuralDigitalDivide_022007.pdf). This is apparently an error because the FCC did not have a definition of 256Kbps as the relevant rate. In any case, Connect Kentucky collects data from service providers by platform so it can infer what the relevant service rate is (or is likely to be).

[69] See http://www.Connect Kentucky.org/_documents/Connect Kentucky_2007_report.pdf. The interactive capabilities allow users to zoom in to see the detail on this map at much higher resolution.

usage and attitudes toward broadband across the state. This includes collecting data on what users were doing on line (time, activities, spending).

The Connect Kentucky program was funded by a mix of state public and federal funds (approximately 80%) and funds from participating service providers (about 20%). Total funding for the project in its first three years (2004-2007) was approximately $7million and Connect Kentucky's operating budget is around $2.5 million per year, with a staff of about 30.[70]

As was also the case in Wyoming, it appears that Connect Kentucky relied heavily on outside consultants to prepare its broadband maps.

The success of the Connect Kentucky model in eliciting service provider support and their early lead in establishing useful tools such as the interactive maps motivated a number of other states to seek to copy their model, including for example, Tennessee. The Connect Kentucky model has been used as the basis of the Connected Nation initiative, which seeks to establish this as a national platform for tracking broadband data. Connected Nation summarizes itself as follows:

> "Connected Nation is non-profit organization known for its ability to bridge the digital divide. With results-oriented public private partnerships Connected Nation improves access to and use of broadband Internet and the related services that are enabled when communities and families have the opportunity and desire to connect. For America, this means better education, more jobs, improved healthcare, more efficient government, and a better quality of life."[71]

In addition to its data collection and mapping services, Connected Nation seeks to provide a nexus for an array of programs designed to promote broadband growth and grass-roots initiatives across the country. These programs include coordinating eCommunity planning and other local promotion efforts; strategic planning and reporting; advocacy at the state, local and national level; "No child left offline" computers for kids program; and mapping market intelligence and survey research.

The eCommunity effort to organize grass roots, public/private stakeholder task forces across the state is typical of the best broadband initiatives. These groups provide a nexus for collecting information on current conditions and can help mobilize resources to raise consciousness and implement initiatives, and a source of suggestions and feedback from the field. The activities of these efforts can be coordinated centrally by Connect Kentucky, which provides support to help these entities organize and communicate. This includes helping to organize meetings, provide supporting materials on the website, and sundry other back-office support to coordinate the grassroots activities.

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[70] Connect Kentucky does not publish annual financial statements. This estimate is based on telephone interviews and trade press estimates.

[71] See http://www.connectednation.com/index.php.

The desire to expand Connect Kentucky's efforts nationwide reflects a desire to leverage its expertise and realize scale and scope economies nationwide. Many of the most important service providers offer services across multiple states if not nationwide. A significant share of the costs of establishing a GIS infrastructure mapping capability, of developing expertise regarding the details of broadband data sets, and establishing relationships with service providers is fixed and can be readily leveraged to support similar efforts in adjacent states. This enables opportunities to share the costs of data collection and maintenance. For the service providers, who seem to favor this approach, it potentially offers a credible industry-sponsored alternative to federally or state-mandated data collection and reporting efforts. This provides service providers with some hope that they can avoid costly or potentially embarrassing public disclosure of data.

The Connected Nation enterprise has much to offer but also raises concerns about the data that will be made available and control over that data. Most states will need to maintain in-house GIS capabilities in any case, but they may find it less expensive to outsource the tracking of broadband infrastructure to a national effort such as Connected Nation. At this point, too little is known about the details of the Connected Nation proposal to determine whether this offers a good approach for the nation or an individual state. In any case, it would be unwise to rely solely on this or any single approach to track the progress of broadband data. However, the Connected Nation approach appears to be worth serious consideration as a potential candidate for undertaking the more extensive mapping of broadband enabling infrastructure in Massachusetts.

In light of the success of the Connect Kentucky effort, and the national umbrella organization is helped spawn, Connected Nation, a number of vocal critics have emerged who argue that the Connected Nation approach is flawed because it is too dependent on voluntary cooperation by the service providers. For example, Art Brodsky, of the consumer advocacy group Public Knowledge, has argued that Connected Nation is too close to telecom provider interests to be trusted.[72] Mr. Brodsky notes that the former president of Connect Kentucky and current CEO of Connected Nation, Brian Mefford, is the son of a long-time BellSouth senior manager who was instrumental in helping to launch the Connect Kentucky effort. Certainly, BellSouth's early support and willingness to cooperate with Connect Kentucky was crucial to its success in acquiring the detailed availability maps and in gaining the support of other providers across the state. However, as Mr. Mefford has pointed out, Connect Kentucky obtained data from 81 providers who compete with each other.[73] Moreover, corporate funding comes not just from large service providers in the state (like BellSouth) but also from large corporate customers such as financial and healthcare institutions.

Large incumbent telecommunication companies such as AT&T (which includes BellSouth) and Verizon have endorsed the Connected Nation approach based on voluntary data. In discussions with senior management from Connected Nation, they have identified a number of important benefits of their public-private partnership approach that relies on voluntary data sharing by the service providers:

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[72] See "Connect Kentucky provides uncertain model for Federal legislation," Art Brodsky, Public Knowledge, January 9, 2008 (http://www.publicknowledge.org/node/1334).

[73] See Brian Mefford's comments on January 11, 2008 in response to Art Brodsky at http://blog.apt.org/my_weblog/2008/01/getting-the-rec.html#comments.

- The best data on service availability is in the collective hands of the service providers. Each of them knows where their facilities are located and which consumers they can currently address or are planning to address in the near future. A survey of service providers can assemble a comprehensive picture of service availability by technical platform and by service provider at the needed household level of granularity.
- This data is sensitive for a variety of reasons, as already noted, and the service providers will not willingly share this data except in situations where they believe it will be properly protected and used.
- A purpose-driven public-private partnership that relies on voluntary participation and is willing to sign strong non-disclosure agreements is better able to gain support and happy compliance from the service providers than would a government-mandated data collection effort. The purpose of Connect Kentucky is to promote broadband in the state, which aligns with the interests of the service providers. In contrast, data provided to a PUC might be used to justify or enforce regulation that the provider might sooner avoid. The purpose of making the data available on-line (via interactive maps) is two-fold: (a) to allow service providers to identify areas that are under-served and adjacent resources like roads, towers, and the like; and (b) to allow individual home-owners to identify what services may be available at their address. It is not intended to be used to regulate broadband or to target public investment in broadband (since the expectation is that broadband investment should be undertaken principally by the private sector).
- The public-private partnership offers service providers the carrot of being able to access better market intelligence as to which areas may be under-served and where demand may be. The demand-side surveys and grass-roots organization efforts that are undertaken as the other two prongs of the Connected Nation program help raise broadband awareness, may facilitate local demand aggregation efforts, and help stimulate broadband adoption. Increasing broadband penetration aligns well with service provider interests.
- The process of maintaining broadband service maps is on-going and the service providers will need to continue to be involved to update their data.
- The nation will benefit if broadband mapping is done on a consistent basis across states. The largest service providers whose data will provide the core of the mapping effort operate in multiple states. A homogeneous model should reduce overall data collection costs and should facilitate cross-state benchmarking, and Federal policy-making.
- A non-profit, public-private partnership can include sufficient participation from diverse stakeholders (including end-customers) and can operate under sufficiently transparent and open rules to maintain trust (thereby avoiding claims of being too closely associated with provider interests). Additionally, this organizational approach likely provides greater flexibility and diminished bureaucracy than would be encountered by a pure government-driven effort. Finally, a public-private partnership is uniquely well-positioned to opportunistically make use of diverse data from both government and private sources under strong non-disclosure operating rules.

Connected Nation's business model is evolving. They are willing to provide a scalable array of services, ranging from undertaking the full infrastructure assessment role to a more narrow and focused activity. Under its current model, Connected Nation serves as the umbrella organization that helps set up affiliated non-profits in states that elect to adopt their model. Currently, Connected Nation has or is in the process of producing broadband GIS maps for

Kentucky, South Carolina, West Virginia, Tennessee, and Ohio; and they are in discussions with policymakers in a much larger number of states. For large state (like Ohio) with many counties and diverse terrain, the cost of operating a "Connect X" is on the order of $2.5 to $3 million per year. As already noted, they recommend the three-tiered approach of GIS mapping (with service provider data), demand-side surveys, and grass-roots organization to stimulate broadband. This provides the benefit of helping to induce service providers to cooperate with the data collection effort and provides cross-validation data of the GIS mapping results.

When invited into a state, Connected Nation will assess the availability of local resources to accelerate their work. They estimate that they can produce a first round map with five to six months of starting work, and they will work with whoever in the state is able and willing to work with them. For example, in West Virginia, they used data included in the e911 data files maintained by the State's GIS authority to facilitate their service availability mapping efforts.

While the Connected Nation has much to recommend it, the concerns raised by Art Brodsky and others have some merit. In other proceedings, the incumbent providers are arguing vociferously in favor of further regulatory relief, justified in part by their assertions that competition for broadband access and other last-mile telecommunication services is robust. This raises a justifiable concern that the providers might seek to bias the data collection or reporting processes so as to further support their arguments. Perhaps even more important, there are concerns about who and how the data collected by Connected Nation might be accessed.

While the need for detailed broadband data is obviously essential to identify gaps in availability and to accurately target programs to promote broadband, this is not the only use for which policy-makers may need such data. First, state regulators would need such data to properly regulate broadband services. While a number of states have adopted legislation to limit their Public Utility Commissions (PUCs)[74] from regulating broadband (see Section 5.4), this approach is not universal and the prospect for some kind of broadband regulation remains an open issue. Second, other agencies or programs within the state might need the data to administer broadband-related programs (e.g., to qualify addresses for participation in broadband subsidy programs or for public safety programming). Before investing on order of $1 million or more to map broadband availability in a state, it is important to consider how access to that data will be controlled and whether policymakers across the state with a valid need to access the data will be able to do so. Third, as broadband becomes basic infrastructure and a more complex and embedded component of our regional economy, state government expertise (in-house) to understand broadband infrastructure will remain important.

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[74] There is a Public Utility Commission, or Public Service Commission (PSC) in every state. In Massachusetts, the Department of Telecommunications and Cable (DTC, see http://www.mass.gov/?pageID=ocaagencylanding&L=4&L0=Home&L1=Government&L2=Our+Agencies+and+Divisions&L3=Department+of+Telecommunications+and+Cable&sid=Eoca). For a listing of the PUCs, see the National Association of Regulatory Utility Commissioners (NARUC, see http://www.naruc.org/commissions.cfm.)

6.3. North Carolina

In contrast to Kentucky, North Carolina opted for creating a new state authority (rather than a public-private non-profit) by means of legislation to promote technology-based economic development, including broadband, in the state.

North Carolina's broadband initiative dates to 2000, when its legislature mandated a focus on extending broadband to rural areas. In 2003, the legislature created the e-NC Authority (www.e-nc.org) with the mission to be a "grassroots initiative to encourage all North Carolina citizens to use technology, especially the Internet, to improve the quality of life and their economic prospects."

As is common with other broadband initiatives, North Carolina adopted aggressive targets to extend universal access to broadband (using the FCC's characterization as the definition). In the case of North Carolina, they set a target of 2006 by which to achieve such access. In the early years, the e-NC allocated $13.5 million in connectivity grants and had an operating budget of $2.5 million for the 18 months ending June 2007.[75] In addition, they received $30 million in funding support from the MCNC, the Microelectronics Center of North Carolina and operator of the state's research education network. The e-NC uses these funds to support broadband initiatives and to leverage additional funds (matching or otherwise) from other sources of federal, state, and private sources. Access to such funds provides e-NC with additional leverage to implement its programs.

This is in contrast to Connect Kentucky which does not appear to have access to significant funds directly with which to fund broadband initiatives. Rather, in Connect Kentucky, the eCommunity teams work with community planners and help them identify sources of funding (e.g., from state or federal development funds). Legislation that provides targeted funding offers the potential for significantly more leverage in pursuing its broadband initiatives. In Michigan, as noted earlier, this appears to have resulted in early acclaim being followed by subsequent disgrace because of apparent malfeasance in how the funds were managed. In North Carolina, the spending was apparently significant in accelerating the pace of North Carolina's catch-up.

In addition to engaging in many of the same activities as Connect Kentucky, the e-NC also manages and runs a series of telecenters around the state which are intended to provide focal points for economic development and to provide broadband access capabilities to smaller businesses in less-developed areas.

Similar to Kentucky, North Carolina has deployed a multi-layer GIS mapping capability, as well as an on-line interactive version. The e-NC maps offer even more data layers than the Connect Kentucky maps.[76] The e-NC map also supports a number of interesting database queries

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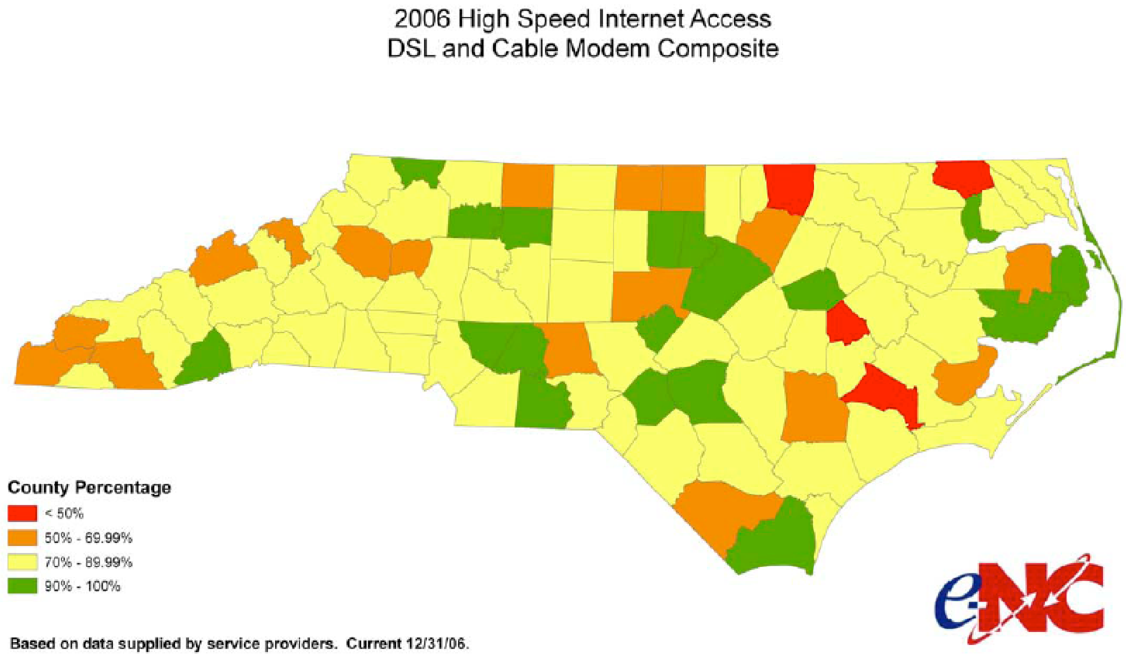
[75] See "The e-NC Authority Biennial Report," January 2006-June 2007 (available at: http://www.e-nc.org/pdf/e-NC_Biennial_Report_06-07.pdf).

[76] See http://204.211.239.208/enc-telco-maps/eNC_LaunchMap.htm. The data layers a user may select to make visible include: Wireless Towers; CLLI Central Offices; Distressed Schools; Public Internet Access Sites; TV Stations; Water Towers; TowerMap Towers; Health Care Facilities; Public Airports; Unincorporated Communities; Railroads; BlueRidge Parkway; Interstates; Primary Highways; Secondary

that allow you to select data using standard database queries (e.g., select all wire centers that offer ISDN Basic Rate service which would highlight all of the wire centers in the state which offer such service – which turns out to be almost all of them). The e-NC maps allow you to look at such things as the percentage of local loops that are DSL enabled by wire center serving area (based on estimates provided by the carriers, and in five color-coded ranges from 0-29% at the low end to 90-100% at the high end).

The e-NC map provides a lot of detail as to the data structure, describing precisely what is included in each layer. For example, the DSL availability data is listed as being from 2003. This highlights an important challenge to any such mapping effort, namely, keeping the data current. Because of system upgrades, new capacity investment, and mergers/acquisitions, the maps change over time. The e-NC mapping effort has an on-line tool -- the Service Provider Update (SPU) application – that allows service providers to update their data directly.

Since 2001, North Carolina has been producing annual reports that track the availability (by share of households served) of broadband in the state by county. To get an idea of how the FCC data is likely to over-state broadband availability ("in excess of 99% of zip codes"), consider the following chart from the e-NC annual report:[77]

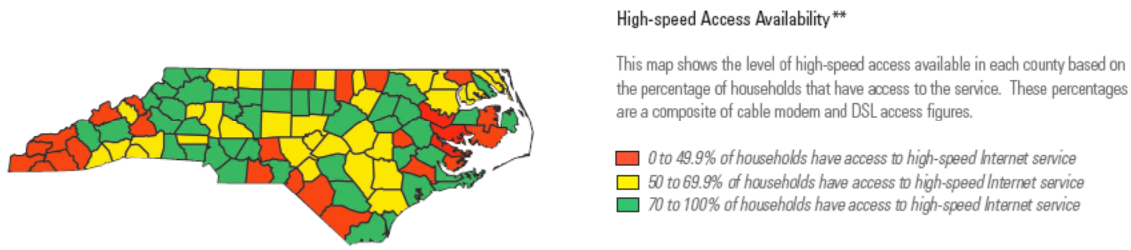


From this it is clear that e-NC has a way to go before meeting its 2006 goal of universal availability, but that the problem areas are relatively isolated and significant progress has been

Highways; Local Streets; Major Rivers; Wireless Tower Service Areas; Cable Modem Service Areas; Activated Cable Franchise Areas; % DSL Capable Lines; Wire Center Boundaries; Area Codes; LATA Regions; Incorporated Cities; Major Water Bodies; County Boundaries; US House Districts (2001); NC Senate Districts (2003); NC House Districts (2003); Zip codes; Economic Development Regions; COG Regions; Non-Distressed Urbanized Areas; Census Blocks 2000 Household Density

[77] See http://www.e-nc.org/pdf/e-NC_Biennial_Report_06-07.pdf.

made. To see this more clearly, compare the above map to the following one from their 2002 annual report (note the larger coverage of red, and the fact that green corresponds to 70%-100% -- demonstrating the need to redefine progress as progress is realized):[78]



While it is reasonable to believe that the e-NC data may be better than the FCC data, it should be possible to develop a comparable FCC statistic by rolling up the population of zip codes with broadband access into counties and comparing that to the North Carolina reported data.

Unlike Connect Kentucky, e-NC publishes annual financial statements so it is clear what its budget is. The e-NC's income statements from 2006/2007 (fiscal year ends June 30) show the following sources of funding and expenditures:[79]

Annual report for 2007/2006 reports following Income Statement…

Year ended Jun2006 ($000s)	Jun-06	Jun-07	Jun-06	Jun-07
Grants & gifts	($000s)	($000s)	Share	Share
Federal government	$38	$-	2%	0%
State of North Carolina	$700	$580	31%	32%
Other	$80	$104	3%	6%
Contract revenue	$1,339	$959	58%	52%
Interest income	$131	$104	6%	6%
Other income	$5	$90	0%	5%
Total Revenue	$2,292	$1,837	100%	100%
Technology-based programs	$1,284	$937	40%	37%
Other grant programs	$898	$536	28%	21%
Management & general	$991	$1,032	31%	41%
Total Expenses	$3,173	$2,504	100%	100%
Change net assets	$(880)	$(667)	138%	136%

This shows that the bulk of e-NC's funding comes from state revenues and contract revenue. The latter are fees charged to other government agencies, non-profits and others (e.g., large end-

[78] See http://www.e-nc.org/pdfs/2002%20Annual%20Report.pdf.

[79] See e-NC 2006/2007 Annual Report (available at: http://www.e-nc.org/pdf/e-NC_Biennial_Report_06-07.pdf).

user customers) who benefit from the programs undertaken by e-NC, including surveying broadband demand or mapping efforts. In many cases, these represent funds for project-specific grants.

6.4. Examples of Status of Broadband Initiatives in Other States

In this section, we provide brief summaries of data collection efforts underway in other states.

6.4.1. Illinois

In 2005, the Governor created the Illinois Broadband Deployment Council. The Department of Commerce and Economic Opportunity commissioned a report of broadband availability and pricing at the zip code level from the Illinois State University Institute for Regulatory Policy Studies[80]. In addition, Southern Illinois University is hosting a project, ConnectSI[81], to establish an inventory of infrastructure and GIS map of availability, which appears to be in the early stages. Part of this includes a service-provider survey that mimics the FCC data reporting approach.

6.4.2. Michigan

Michigan was an early leader in launching a legislative broadband initiative in 2002 with the formation of the Michigan Broadband Development Authority (www.broadbandauthority.org). The MBDA was established with a line of credit of $50 million, and in its early years reviewed projects worth $100 million and funded $30 million worth of broadband projects. Then, in 2006 an audit review uncovered accounting improprieties, resulting in the closure of the agency. Its website is no longer live.

Interestingly, and as a demonstration of how much things have changed in a few short years, it is worth noting that Technet.org, a high-tech industry lobbying organization focused on promoting progress toward high-speed access for all (see www.technet.org) ranked Michigan the #1 state for broadband policy in 2004, and ranked Kentucky, North Carolina, and California much lower, and Massachusetts did not even rate in the top 25 (see Table 8).[82]

6.4.3. Pennsylvania

In 2004, the Pennsylvania legislature passed Act 183, its e-Fund School Grant Program that provides funds and outreach for promoting broadband adoption and deployment. In 2006, the Governor estimated that this would provide funding in the amount of $2.3 million to support "Broadband Outreach and Aggregation Fund (BOAF)" program.[83] The governor's office has also

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[80] See http://illinoisbroadbanddeployment.pbwiki.com/f/IRPS+Broadband+Report+080907.pdf.

[81] See http://gis-connectsi.geography.siu.edu/Connect-SI/front_page.htm.

[82] See, "The State Broadband Index: An Assessment of State Policies Impacting Broadband Deployment and Demand," a report prepared for Technet.org by Analysys, 2004 (available at: http://www.technet.org/resources/State_Broadband_Index.pdf).

[83] See http://www.newpa.com/newsDetail.aspx?id=534/

launched a provider survey to collect data on broadband coverage, and they offer a tool at the site that provides DSL and wireless coverage maps by county (presumably they are still completing their inventory of cable coverage since that is not reflected on the map).[84]

6.4.4. Ohio

Ohio launched its Ohio Broadband Council in November 2004 as the coordinating body for its state efforts to create a backbone next generation network for the state, combining OSCnet and NextGen Network with state funds for investment. This new network is to replace the state's older copper-based Ohio Academic Resource Network (OARnet).[85]

Over the years, Ohio has completed a number of studies in an effort to assess the status of infrastructure for advanced telecommunication services, including broadband. For example, in 2000, they completed the ECom-Ohio study, and in 2006 followed this up with their report, "Availability and Cost of Broadband Internet Service Options in Ohio," a study conducted by the Ohio Supercomputer Center for the Ohio Department of Development.[86] It is worth noting the role played by the state's academic research community through the supercomputer center in contributing to the formulation of broadband policy. State research universities are big customers for and typically operate in their own right, or in conjunction with state government, advanced telecommunication networks across the state.

The earlier ECOM-Ohio study (2000) looked at current use and demand for broadband services my mass-market consumers across Ohio as part of an eReadiness assessment for the state. Its focus was on the quality of telephone lines used for dial-up Internet access and emerging evidence of DSL and cable broadband service availability across the state, as well as surveying demand perceptions to assess likely business and residential adoption rates for broadband services. The more recent 2006 Broadband report focused on the cost and availability of broadband to government, health, and businesses in 88 counties of Ohio. The data was collected from service providers via a standardized survey of 94 providers across the state. In their report, they define two levels of broadband: *lower capacity* broadband as offering Internet connections at data rates between 200Kbps and less than 10Mbps; and *higher-capacity* broadband as offering data rates in excess of 10Mbps. These higher speed links were the focus of the 2006 survey.

The reports conclude, as is typical of the findings across much of the United States, that metro areas are well provisioned with multiple broadband service providers offering a range of advanced telecommunication services and with prices that are lower than in less well-served rural (low-density) counties of the state. They conclude there are ample opportunities for public-private partnerships to leverage existing infrastructure to reduce the observed disparities.

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[84] See http://www.newpa.com/default.aspx?id=199

[85] See http://www.ohiobroadbandcouncil.org/index.shtml.

[86] See http://www.osc.edu/networking/broadband/index.shtml.

The report includes a number of useful maps to allow one to visualize the state of infrastructure availability on a state-wide, county by county basis.[87]

Figure 2:
Counties Classified by
Census Density Categories

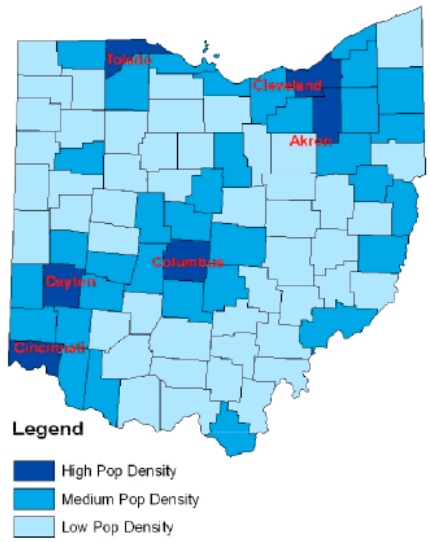
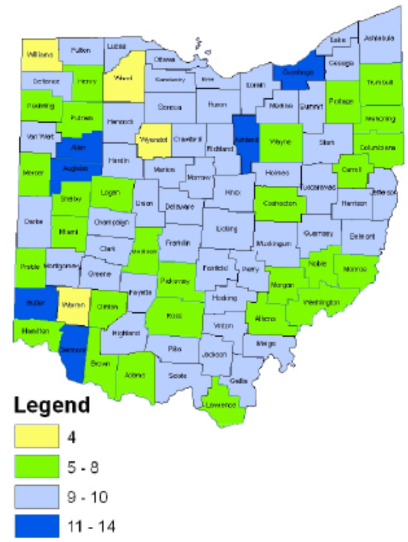


Figure 3:
Number of DS3
Service Providers



[87] See "Availability and Cost of Broadband Internet Service Options in Ohio," a study conducted by the Ohio Supercomputer Center for the Ohio Department of Development, 2006, available at: http://www.osc.edu/networking/broadband/index.shtml.

Figure 4: Number of Sample Locations with DS3 Service

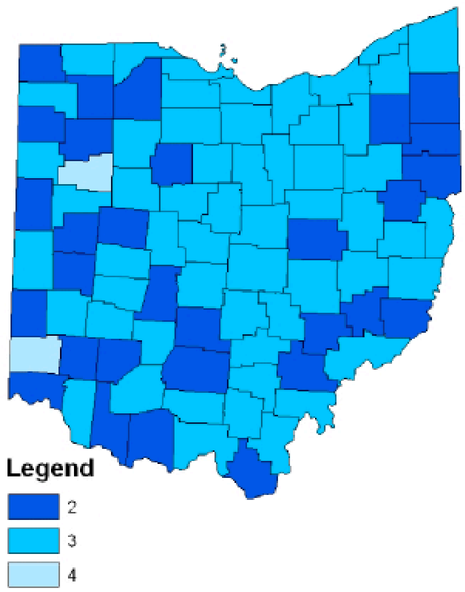
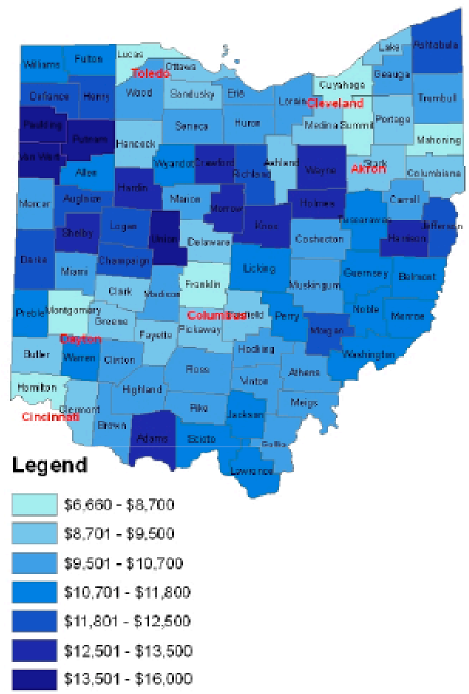


Figure 5: Average Monthly Costs for DS3 Services



These and other charts and tables included in the report show useful data on the dispersion and pricing of different types of advanced telecommunication services (higher-capacity than what is required by mass-market consumers) across the state at the county-level. However, they do not have an updated and equivalent survey of mass-market services which is unfortunate since we know that much has changed since 2000. The picture of service availability in rural areas across most of the United States was substantially worse then than it is today. Moreover, as we noted earlier, analysis at the county level is far to aggregated to provide an accurate picture of the level of service coverage in the state.

In July 2007, the Governor announced his “Turnaround Ohio” program to make Ohio a leader in broadband.[88] This sets forth the goals of Ohio Broadband Council along lines analogous to those established in California.

6.4.5. Tennessee

Tennessee adopted the Connected Nation approach, forming Connect Tennessee as a non-profits public-private partnership (see http://www.connectedtennessee.org/). The enterprise was announced in May 2007 and they already have an interactive mapping application up and running to allow home-owners to identify what services are available in their area (see (http://www.connectedtennessee.org/mapping_&_research/Interactive_Mapping.php).

[88] See http://www.ohiobroadbandcouncil.org/vision/ExecutiveOrder2007.pdf.

The speed with which the on-line mapping capability was implemented suggests the scale/scope economies inherent in the Connected Nation approach. Additionally, many of the same incumbent service providers who operate in Kentucky and participated in the Connect Kentucky effort also operate in Tennessee.

The Tennessee map includes color-coded maps of broadband adoption (5 colors with lowest being <27% and highest being >55%, where state average adoption is 43%). It is also possible to draw maps of broadband availability (yes/no) and to identify the number of unserved households within map grids of 0.25 square miles (coded into 5 ranges).

Finally, the Tennessee mapping website has three large buttons users can click on:

- "I want to test my connection speed": it takes you to http://speedtest.connectedtn.org/ and asks for your location (business or home), your zip code, and your county. The test is apparently implemented using the Speedtest.net (see Appendix 1) tool.
- "Broadband is not available to me yet": this takes you to a form that allows you to enter your name, address, home phone, and county (mandatory), as well as additional data and comments.
- "How broadband has changed your life?": it generates an email for the user to put in a broadband testimonial or other comments.

These "buttons" provide a useful way to supplement Tennessee's on-going data collection efforts and provide additional cross-validation checks for the service-provider data on service availability.

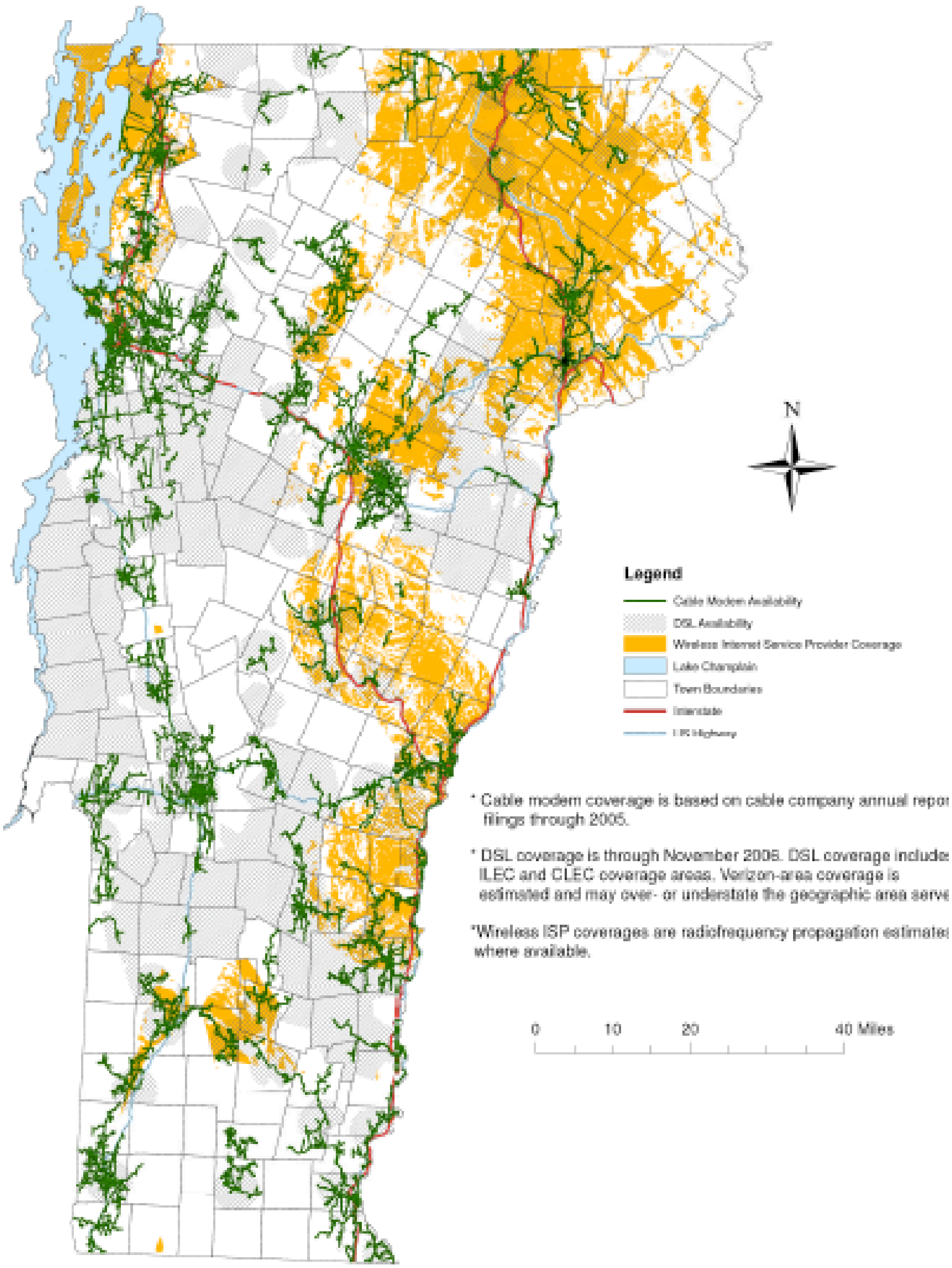
6.4.6. Vermont

As already noted in the discussion of what California is doing, Vermont has been a leader in collecting and presenting granular, GIS-based data on the availability of broadband across the state. Vermont, as a primarily rural state, was dismayed when it looked at the FCC data on broadband availability, finding that that data over-stated the extent to which broadband services were generally available to households in Vermont.

The Vermont Department of Public Service (VtPSC) took the lead in assessing broadband conditions in the state, and infrastructure maps were prepared by the state's in-house GIS department, the Vermont Center for Geographic Information (VCGI, www.vcgi.org). A representative map is reproduced below:[89]

[89] See "Approximate Broadband Availability in Vermont – 2006" (see http://publicservice.vermont.gov/cable/broadband_availability_map.html.pdf).

Approximate Broadband Availability in Vermont - 2006



This map was created for the VT Deptartment of Public Service in 2007 by the Vermont Center for Geographic Information (VCGI) with data distributed by VCGI - www.vcgi.org

In a series of two reports, "Access for all: meeting Vermont's Broadband and Wireless Goals" and "Understanding Broadband Deployment in Vermont" (both released in February 2007),[90] the VtPSC sets forth its assessment of the state of broadband infrastructure in the state. It concludes that "85 to 90 percent of Vermonters have access to at least one mass-market broadband service." At county-level, availability varies widely. However, there are counties where less than half of the population has available broadband service.

The map (reproduced above) was prepared with data collected from service providers for multiple types of broadband (cable, DSL, and wireless), and then summarized in the "Understanding Broadband Deployment" reports availability on a per county basis. The different technologies are reported separately, obviating the need to have a "speed-based" definition of what constitutes broadband. The report incorporates analysis from other third-party studies of broadband availability elsewhere and discusses the relative differences in alternative broadband infrastructure. The report "Access for all" assesses the impact of state broadband policies and makes further recommendations.

The VtPSC website[91] provides a link to the Vermont Rural Broadband Community Internet Project (http://vtruralbroadband.com/) that provides further links to broadband development projects around the state, as well as a registry for users to note locations which lack available service. This allows users to indicate their interest in broadband service (name, address, telephone, email) for home, business, or both; or to indicate that they already have broadband service from a provider (write-in) and to indicate their level of happiness with the service.

The Vermont effort is noteworthy in that the state PUC has played a strong leading role in driving the project, in conjunction with state GIS resources. It is also noteworthy that the principal recommendation of their assessment is the need to create a Vermont Telecommunications Authority (VTA) which is explicitly charged with the "mission to achieve universal access to broadband and cellular access in Vermont."[92] The VTA would serve as a coordinator for management of private-public investments to promote broadband, and it is recommended that it be funded with a $40 million state-issued bond and should be empowered to work with other state and federal sources of rural and economic development funding. The creation of this separate entity recognizes the importance of broadband and the need to leverage public development funds to address challenges in un- and under-served communities. It also implicitly recognizes the inability of the VtPSC to undertake this role because of its on-going responsibilities as a regulatory authority, one that might conflict with its ability to manage public-private partnerships.

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[90] "Understanding Broadband Deployment" (http://publicservice.vermont.gov/Broadband/Broadband%20Deployment%20in%20Vermont%20Final.pdf); and "Access for all:: Meeting Vermont's Broadband and Wireless Goals" (http://publicservice.vermont.gov/Broadband/Act172FinalReport.pdf).

[91] See http://publicservice.vermont.gov/cable/broadband-availability-map.html.

[92] See "Access for all:: Meeting Vermont's Broadband and Wireless Goals" (http://publicservice.vermont.gov/Broadband/Act172FinalReport.pdf).

6.4.7. Virginia

Virginia has announced a number of programs that are related to promoting broadband and technology-driven economic development in the state, but there is no centralized focal broadband initiative akin to what Kentucky, North Carolina, or even California has done. For example, the Governor in 2006 created a new government office "Office of Telework Promotion and Broadband Assistance" via executive order, but it is unclear precisely what they are doing and there is little content at their website (http://www.otpba.vi.virginia.gov/).

6.4.8. Wyoming

In 2005, the Wyoming Telecommunications Council started a project, with a consulting firm, CostQuest, to identify Broadband Gap Areas in the state and estimate the cost of providing service to those areas.[93]

CostQuest used Census data and road maps to estimate locations for all housing units in the state. They analyzed all populated census blocks, ignoring the vast areas of the state that are completely uninhabited. They then collected cable, telephone and wireless provider deployment maps in a variety of formats, and digitized them for use in a GIS system. Initially GIS-compatible electronic data was requested, but only one of the providers was able to supply such data. Coverage areas had to be estimated or projected in some cases because complete data was not provided – for example, a cable provider may indicate that an entire town is serviced, even though there are areas ("urban holes") where service is not actually available. In some cases, they assumed that all locations within a certain radius of a fiber node were serviced. They estimated that 79% of housing units in the state had access to terrestrial broadband service (satellite broadband was available to almost the entire state). Broadband was defined as a service providing a minimum of 1 Mbps downstream and 256 Kbps upstream.

CostQuest also developed a proprietary cost model to estimate the costs of providing service to the remaining households. This model is based on models they had already developed for Universal Service and other studies, approved by several state PUCs and used by telecom carriers operating in over 30 states. It uses an optimization algorithm to determine the least expensive network paths for DSL and cable build outs, given a road network. Cable service area is very limited in Wyoming, so significant new build is required, whereas DSL involves mostly augmentation of the existing fiber/copper DSLAM network. For fixed wireless, the Motorola Canopy™ architecture was chosen, and the algorithm allocated customers to existing towers, with state-owned towers prioritized over privately-owned towers and assuming that no new towers would be built. Terrain data was used to predict line-of-sight areas for towers. Proprietary data about various cost and engineering design parameters was requested from providers and blended into a non-specific model.

It was found that fixed wireless could cover over 90% of unserved households. For cable and DSL, there would be significant variation in costs across households. Maps were produced

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[93] See http://cio.state.wy.us/telecom/broadband/CostsAndBenefitsofUniversalBroadbandAccessInWyoming.pdf and other materials listed in http://cio.state.wy.us/telecom/Broadband/TopicIndex.pdf.

to show the cost of providing broadband to all unserved areas, and the project identified particular areas where fixed wireless coverage could be extended relatively inexpensively ("low-hanging fruit"). It appears that CostQuest will continue to update the data and models and potentially publish detailed results on a website.

6.5. Overview of State Data Collection Efforts

In our review of data collection efforts, we discovered a wide array of approaches to how states were managing their data collection efforts. Most states are still in the early stages, but things are changing rapidly. Many do little more than rely on FCC or other public data sources, or what their state public utility commission has to assess the condition of broadband services in the state. Most states seem to have some sort of broadband initiative today, which is not surprising given the growing evidence of the importance of broadband as essential infrastructure. Core components of such initiatives include:

(1) Statement of goals to promote broadband and ensure universal availability within at most a few years.
(2) Formation of a public/private multi-stakeholder task force or entity (e.g., Connect Kentucky) to produce a report assessing current demand and availability of broadband, cataloging local and state initiatives related to broadband promotion, and making recommendations on how to better promote broadband. This includes representatives from research universities and those who run the state's backbone research networks (a critical element in providing broadband access); representatives from the public utility commissions, economic development agencies and other government departments engaged in telecommunications related infrastructure management and regulation; representatives from local community groups, consumer watchdog agencies, and significant commercial end-user communities (e.g., healthcare, financial services); as well as telecommunications industry participants, including service providers.
(3) Plans to expand broadband access for K-12 schools and universities (which are often engaged as partners in promoting broadband in the State) and other public buildings such as libraries.
(4) Plans to expand broadband use by government and eGovernment services.
(5) Survey of broadband use/demand (supplier and end-user surveys) that may be executed via a mix of regulatory mandated data collection (via the state public utility commission) and voluntary data collection.
(6) GIS-based mapping of basic infrastructure that may be overseen by the State's in-house GIS entity or may be undertaken by a separate entity. The first generation of these maps show where broadband is available. Increasingly, these maps provide indication of the speed of broadband service available and current adoption rates.

As noted above, it seems likely that the future of broadband data collection efforts will entail a significant GIS component. This is needed to adequately reflect the local character of broadband and will be feasible and desirable because GIS-enabled data capabilities for use by federal, state, and local policy-makers will become generally more available. The trend toward GIS is a byproduct of the general trend toward more enhanced ICT capabilities, including a greater array of location-aware and granular data collection and analysis techniques. Capabilities such as Google maps, image processing software (e.g., including OCR software as well as variety of other automated image analysis software), and enhanced computer capabilities (faster processors, more storage/memory, better display monitors, and broadband) are all contributing to the growth and drive to easier access to visual, location-contextualized, map-based data access. Efforts to track broadband services will benefit from this.

While we believe most states already have some GIS capabilities, and will eventually (if they do not already) integrate data on communications facilities infrastructure and other data elements related to tracking the progress of broadband, Kentucky and North Carolina offer the most advanced versions of such systems that we have identified. Nonetheless, the on-line versions of these systems, while impressive, are still rather cumbersome to use and do not provide ready access to third party analysts seeking to analyze the data in formats other than as hard-copy maps.

With respect to the use of broadband surveys, many states have engaged in some level of active data collection. In many cases, this was done in the context of preparing the task force report. These surveys have included telephone and mail-based surveys, as well as on-line surveys. Of course the latter approach is severely hampered for communities without Internet access.[94] The states with legislative mandates to promote broadband access seem the more likely to repeat surveys on a regular basis to provide the basis for time-series analysis of broadband trends and impacts (before/after analyses). However, this is somewhat speculative since many states that have completed surveys have only one or two thus far. State-level trend data is typically not readily available at a high level of aggregation, and thus is not much better than what is available from the FCC (e.g., share of households with broadband available in the state or total number of lines in the state or by county).

7. Future recommendations/issues

Our review of current data collection practices in the United States and abroad, and the current status of state-based broadband initiatives, suggest a number of features that characterize the best programs. These include:

- Mission is well defined: broadband is recognized as basic infrastructure and state assumes responsibility for leadership in ensuring health of broadband in the state for all citizens. Clear goals articulate what it means to achieve universal services. A focused message from the top (e.g., from the governors' office) committing to making ubiquitous broadband available across the state helps align government agencies.
- Definition of broadband is nuanced to the goal and is capable of evolving as the quality of broadband services improves over time. Definition will need to address both the minimum threshold standard for acceptable service, as well as quality/technology tiering to allow tracking of service evolution over time. The diversity of definitions of broadband (see Section 4.2 and 5.4) suggests the complexity of the challenge.
- Core data collection framework is GIS-based to ensure adequate granularity of data (geographic resolution is fine-grained, capable of point and area representations).

[94] Most citizens have dial-up Internet access or may be able to access broadband at a public library or school, however, this imposes a significant cost on the respondent that would likely diminish the number of responses.

- Data collection includes grass-roots organization. This is helpful both to facilitate demand-side data collection and to raise awareness of broadband services and to stimulate adoption.

7.1. Have a clear mission

It is important for state leadership in the governor's office to recognize the importance of broadband as basic infrastructure. This signals to other state agencies that broadband is important and will continue to be so in the future.

Part of defining a clear mission is to have an appropriate definition of what constitutes broadband. This should be nuanced. From the perspective of data collection, a relatively low data rate threshold for reporting is desirable to capture as many services as possible, but data collection efforts should focus on the technology and range of data rates available in different geographic segments of the market.

For the purposes of framing policy, the data rates should be used as rough guidelines for the range of services that they characterize. We recommend adopting a tiered definition of broadband that reflects the evolving nature of broadband and supports recognition of disparities in the quality of service available (see chart below). The simplest tiering approach would be based on peak data rates. For example, first-generation broadband (1B) could be defined as offering at least an peak data rate of 500Kbps. This is an approximate data rate. Qualifying 1B services should support a peak data rate of at least 200Kbps in both the downstream and upstream directions, but may include services with asymmetric bandwidth offering rates of up to 3Mbps in at least one direction. This means to be comparable to today's most commonly available generation of DSL or cable modem services. The average peak up/down data rate ought to be at least 400Kbps.

Higher levels of broadband would represent order of magnitude increases (e.g., 2B is greater than 5Mbps, and 3B is greater than 50Mbps). Again, the categorization with respect to data rates is to allow sorting service offerings into a limited set of categories. A 2B service ought to offer at least 1Mbps upstream (and downstream) and at least 5-20Mbps downstream, with an average peak up/down rate of 5Mbps. Similarly, a 3B service ought to support at least 2-3Mbps upstream and 30-100Mbps downstream, with an average peak up/down rate of about 50Mbps.

These categories might be modified to reflect actual market distinctions but are reflective of the level of precision needed to classify services. In addition to the focus on peak data rates, policymakers should be aware of other key features such as "always on" or other attributes that may impact the openness of platform (MB limits or other usage restrictions or usage fees that may reflect a change in the quality of broadband service).

Defining Broadband[95]

Level	Data rate	Technology Platforms	Services enabled
0B	50Kbps	Dial-up modem. Not BB.	Pre-broadband Internet access
1B	500Kbps	1st gen DSL/Cable modem service, 3G wireless, satellite	Email, web browsing, VoIP
2B	5Mbps	2nd gen DSL/Cable modem, WiFi, WiMAX	Streaming video, rich interactive media
3B	50Mbps	xDSL, FiOS FTTH, Cable (DOCSIS 3.0)	Multichannel video, Triple play
4B	500Mbps	Next gen FTTH/"λ access"[96]	Telepresence

7.2. Establish reasonable goals for broadband progress

Appropriate broadband policy has multiple goals. To address equity concerns, policymakers need to insure that services are available fairly, which means that all consumers across the state have access to at least a minimum standard of broadband services (in terms of price, choice, and quality). To address efficiency concerns, policymakers need to insure that there is a robust market for broadband services and that more advanced services are available to those that need them (e.g., hospitals and IT-intensive businesses) and where it makes economic sense to provide such services (e.g., FTTH). Because the appropriate minimum standard for equitable ubiquitous availability will change over time (in terms of the data rate offered, the number of providers a consumer can choose among, and the price), it is necessary to have goals that can evolve over time and are appropriate to address different levels of service.

[95] As discussed in the text, the data rates are approximate. One suggestion for making this classification more formal might be as follows (rates in Kbps):

Level	Min up	Min down	Avg Up/down at least
1B	200	200	400
2B	1,000	5,000	8,000
3B	1,000	30,000	50,000

[96] Technologies capable of delivering the capacity of an individual optical wavelength (λ) to each household.

An reasonable set of goals are summarized in the following table:

Goal	Title	Description
		Achieving Ubiquitous Availability
L0	Town government is on-line	• *1B* broadband (say a T1 line) is available to at least one building (say, the town hall) in all 351 towns in MA.
L1	Public access BB is available	• *1B* broadband is available in every public library and public school, with no household more than 5 miles from a public-access terminal
L2	Ubiquitous BB available	• *1B* broadband available to (almost) every HH (95% availability in every town) from at least 1 provider
		Keeping BB on track
L3	BB adoption on track	• BB adoption rates are on par with national average. • $/Mbps/month for average, best, and entry service on par with national averages • Within state differences on par with peer states.
L4	BB is best in class	• BB availability and adoption rates for higher quality BB services (*2B, 3B, 4B*) are on par with national averages. • Within state differences on par with peer states

A threshold goal (call it "L0") might be to ensure that there are no un-served towns in Massachusetts. There ought to be at least T1 (1.5Mbps) access to a public building somewhere in all 351 towns in Massachusetts (e.g., the town hall). This goal might be expanded to include the goal that there be a broadband public access terminal (offering at least 1B service) no more than five miles from every home in Massachusetts. Achievement of such an L0 goal would address the lowest standard for ubiquitous accessibility to broadband services.

The next level of goal would be L1 to ensure broadband access for every public library, public school (K-12), and most government offices/buildings (including every town center) across the state. This is necessary to support eGovernment and for ensuring universal access because not all homes will have computers even when broadband is available. As a byproduct, it will also ensure the feasibility of implementing cost-effective on-line data collection to assess the progress of broadband markets. From the collection of broadband-enabled public buildings, the goal should be to provide sufficient public access points (open terminals) to meet goal L0 above. This goal may be met with ensuring all public libraries and most public schools have public access broadband terminals.

Next, an L2 goal would be to ensure that at least 1B access is ubiquitously available to all households in Massachusetts from at least one provider. Over time, it may be appropriate to redefine what the minimally acceptable level of service is (in terms of data rate and capabilities).[97]

Going forward, it will be necessary to continue to track broadband progress in the state. Two additional goals will help frame that: L3 focuses on equity (digital divide) issues, and L4 focuses on efficiency and the health of the Massachusetts broadband-based economy. These goals are perforce more nebulous because they need to evolve over time.

The L3 goal will be to promote broadband competition and quality of service. The average level of broadband available should improve over time, in line with peer states. In most markets (wherever it is economically feasible), nearly all homeowners should have access to two or more facilities-based providers of 1B service. Policymakers will need to track the average level of ubiquitously available broadband in terms of quality of service, pricing, and adoption (actual usage). This will ensure on-going progress toward improving availability in under-served areas. Data on adoption rates are needed to cross-validate availability data and to diagnose other resource constraints.[98] Large disparities in the general availability of the lowest tier of broadband (which should itself improve over time) should be the cause for policy interventions. Relevant statistics to track might include measures such as the average adoption rate (which ought to be on par with peer states and at or above the national average[99]), the average price per Mbps per month ($/Mbps/month) paid by the average consumer with broadband service, and the range for the highest and lowest quality/price service offerings available.

The L4 goal should be to keep Massachusetts a national and global broadband leader. This means ensuring that Massachusetts meets the needs of businesses and homeowners for advanced telecommunications infrastructure and services, including broadband. Benchmarking against peer states, on-going market analysis, and active feedback solicitation from stakeholders should ensure that Massachusetts remains in the forefront of delivering state-of-the-art broadband services and infrastructure in Massachusetts. This includes seeing timely expansion of 2B/3B service availability and adoption, where timely must be defined with reference to peer states (and markets). It is not reasonable to expect that all communities, regardless of location, will have access to the same quality of broadband (e.g., FTTH), but we should expect that the minimum bar of service available to subscribers in metro areas will increase over time. Evidence that the availability of broadband in Massachusetts (in terms of price, quality, and competitive options available) lags progress in other states should induce proactive policy interventions to correct this deficiency. Relevant statistics here might include such things as the share of the

[97] Of course, from a data measurement perspective, it is important to keep track of the generations of technology and how they change over time. This will facilitate assessment of economic impacts.

[98] The availability of broadband services is only part of what is necessary to ensure that under-served communities may make effective use of broadband. For example, broadband services need to be affordable (and what is affordable varies by household) and homeowners need to have a home computer and the requisite skills to use broadband. Evidence of low adoption rates in communities where service is available may suggest the need for broadband education or other types of promotion programs.

[99] Expecting Massachusetts to be above the national average is reasonable in light of its higher level of education and general economic well-being compared with the nation as a whole. Evidence has shown that use of advanced technology increases with prosperity and education.

population that have available and that have adopted 3G wireless services or FTTH services. Traffic metrics such as the average MB/month/user may be useful for tracking the intensity of broadband use, or the investment in broadband-related infrastructure per capita. It may also be appropriate to consider specialized L4 metrics that address the needs of specific IT-intensive industry sectors such as healthcare or financial services.

Taken together L3 and L4 represent on-going commitments to address problems of under-served areas (L3, either in terms of quality/price or level of consumer choice) and to ensure that the broadband options available to Massachusetts residents and businesses match or exceed those of leading peer states.[100] While disparity in broadband access will continue to exist in the future, Massachusetts should be able to commit to ensuring improvements for all classes of broadband customers, wherever they live and whatever their needs for advanced communication services.

7.3. Establish GIS-enabled Broadband Tracking Capability

As already noted, the future platform for tracking broadband data should be established on a GIS database framework. This will need to track infrastructure availability and service offerings from all broadband service providers in the state and at the level of the individual household address.

This GIS capability ought to be able to integrate multiple layers, including all essential infrastructure in the state, including roads, public buildings, electric power grids, water supply, as well as telecommunications infrastructure. With respect to the latter, it will be necessary to track the coverage areas of broadband service for service providers (which presents a slightly more difficult challenge for wireless providers, for which it may be more difficult to estimate true coverage).

The GIS capability ought to be able to be integrated with additional third-party data (e.g., Census demographic data) and should be exportable in tabular (spreadsheet) form to support further analysis.

The underlying database should maintain a temporal dimension to allow before/after and trend analysis. For most features, annual updates may be sufficient.

This database will be important for inventorying infrastructure across the state, which is necessary input to assess availability gaps and to target future investment (to eliminate bottlenecks or to address un-/under-served areas).

The best source for this data will be the service providers. If their cooperation cannot be obtained voluntarily than it may need to be compelled. The PUC ought to be involved in any discussion as to what data service providers may provide.

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[100] One may think of this as paying attention to both ends of what will continue to be a distribution: at the low-end, we want to ensure that everyone's options and performance meets some minimum acceptable standard; while at the high-end, we want to make sure that we are continuing to remain competitive with the "best in breed" competition.

7.4. Maintain on-going demand-side surveys and tracking capability to supplement

On-going capability to collect demand-side data will also be important. This may be maintained both through service provider reporting (potentially, both voluntary and under regulatory mandate via the DTC) and end-user sampling/surveys. End-user surveys should be conducted on a biannual or more frequent basis. These should include collecting data on availability of service offerings, actual usage, and desired usage (adoption and traffic/time on-line/applications).

This data is necessary to track the availability of options in the market (prices, service tiers and descriptions of offered QoS) and may be culled from retail advertisements, as well as tariff filings by service providers. Knowing what is available is important for tracking the progress of competition and for knowing what the envelope of lowest and highest tier services are.

In addition, actual usage (adoption and traffic) metrics are needed to accurately measure the health of broadband services in the state. It is not enough to know that services are available; it is also necessary to have insight into how they are being used. Some of this data (subscriber counts) may be obtained from service providers (again, via regulatory fiat or voluntarily) and it may not be necessary to obtain this data on as granular a basis. Certainly, to address competition and privacy concerns, any data that is reported publicly should be aggregated (possibly by technology or speed tier if reported on a geographically granular basis such as by town; possibly by service provider if reported on the basis of a large geographic aggregation such as a state).

This data will include both Census data (total lines, by technology, by CBG for all service providers) and sampling data (partial surveys). The partial surveys could be mounted as on-line or targeted telephone surveys. The latter provide more robust data for analysis but are more expensive. The advantage of on-line surveys is that they provide an inexpensive and quick way to gain insights to understand changing conditions and as a crosscheck on data collected in other ways.

7.5. On-line tools will be an important component

Broadband facilitates use of on-line tools more generally, and efforts to promote and track the progress of broadband should expect to make use of such tools. At the simplest level, a website provides a way to share information about best practices and a low-cost platform for making data accessible to citizens and analysts within and outside government.

It is also relatively easy to launch on-line surveys and collect data in a timely fashion. On-line tools to allow service providers and others to submit data electronically further facilitate this.

On-line collaboration tools (wikis, chats, email) are also useful for organizing grass-roots communities and sharing and coordinating information.

7.6. Appropriate Organizational Structure for Managing Broadband Policy

Ultimately, the success of state-level broadband policy will depend critically on the quality of the organization put in place to pursue the policy. High-level state government support (from the governor's office and with legislative support) and appropriate commitment of resources will help make whatever policy is adopted more successful.

The focus of this report is on the narrow question of data collection metrics for assessing broadband infrastructure – this is a part of the broader, and ultimately more interesting question of how best to promote economic development in the state and what policies and funds should be allocated to promoting broadband. It is also part of the larger question of how to track the progress of information and communications technology (ICT) and the full spectrum of communications services, of which broadband is only one component. Independent of considering this larger context, which may differ substantially state-by-state, it would be inappropriate to recommend a specific organizational approach for institutionalizing the collection of broadband metrics into the future. However, it is worthwhile discussing some key questions that will be relevant for addressing this challenge.

7.6.1. Is there a need for a new broadband authority or is a task force sufficient?

In the long run, it seems unlikely that we will need a specialized authority or agency focused on broadband policy. This will be something that will be part of the responsibilities of the State's general GIS authority, PUC responsibilities, economic development authority, and a number of other government departments.

This might suggest that a task force approach with a limited charter may provide the best way to address this issue in the near-term. While this might work, it should be clear that the task is something that will take a few years and will require real resource commitments. The advantage of creating a special agency (like e-NC) or public-private entity (like Connected X) is that such an entity provides a focused framework for building institutional capabilities. While the specific policy challenges currently motivating broadband policy awareness may change, the need to continue to collect relevant market data will endure. It would be nice to ensure that whatever resources are used to establish an initial assessment will also contribute to building a sustainable capability.

7.6.2. How to address the growing challenge of data confidentiality?

As noted already, good GIS maps will likely require the compliance of service providers. Service providers have an understandable reluctance to share their detailed data without some assurances as to how the data will be shared and used. The problem is worse today, in part, because of broadband and the Internet, which makes the sharing of all kinds of data easier than ever before.

Privacy, security and trust issues are not limited to service providers – or indeed, any type of business – but arise with all individuals and will become more important as our cyber-environment continues to evolve. The challenge of how to collect and protect the confidentiality and integrity of detailed data while respecting privacy and security concerns of those whose data is collected are difficult challenges that we are far from having adequate solutions to address. Privacy advocates have justifiable concerns about what kinds of information government (or businesses) collect and share about individuals.[101] On the other hand, detailed information about individuals facilitates the ability to deliver customized services, including such things as e911 emergency responsiveness.

This is an interesting policy dilemma that is hardly unique to the problem of collecting better broadband metric data; however, broadband/Internet metrics may be one of the places where we confront these issues first. All else being equal, this might provide a further rationale for establishing a specialized entity to manage broadband data since this might provide a more flexible and focused way to learn about how to address the difficult issue of how to collect and maintain public-private data and what is the best institutional form. The lessons from this experiment would help resolve similar issues that are sure to arise in the future in other contexts.

7.6.3. Which state agency should assume principal responsibility for the metrics activity?

It is not clear what government agency might be most appropriate for assuming responsibility for the broadband metrics activity. There are a number of obvious candidates, each with advantages and disadvantages. For example, the state GIS authority might be the natural candidate to assume responsibility for mapping basic infrastructure, which is technically/analytically-sophisticated task in its own right. However, telecommunications infrastructure changes rapidly and identifying what data is relevant may require more industry/technology-specific expertise than is commonly associated with GIS mapping experts.

The PUC (or DTC in Massachusetts) is another logical candidate. They are more likely to have the requisite telecommunications industry and technical expertise and on-going relationships with service providers. However, because of their regulatory role, there is an inherent adversarial aspect to their relationship with the industry that may make it difficult to acquire the relevant data. While it is conceivable that regulatory rules might be passed requiring service providers to supply data, the outcome of such a process is uncertain. If appropriate data (which includes being verifiable) could be acquired voluntarily, that would likely offer a lower cost approach for all parties concerned.

Furthermore, assuming that the state commits significant resources (e.g., a broadband development fund) to promote technology-based economic development in the state, then the PUC would not be the logical entity to manage such a fund. Regardless which agency assumes management responsibility for such a fund, there would be a need for good metrics to ensure the fund was used appropriately. This might suggest that principal responsibility for broadband metrics might go with the economic development authority responsible for overseeing the fund. Once again, such an approach might lack the technology/industry-specific expertise that is relevant to broadband policy at this stage in broadband's industry/technology lifecycle.

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[101] Interestingly, in Europe there appears to be greater privacy concerns about what information businesses collect than about government; while in the United States, the opposite concern appears more common.

While each of the above agencies/government departments have relevant interests with respect to broadband metrics and ought to be involved, it is not clear which if any of them should have principal responsibility. In summary, therefore, the special challenges of collecting detailed broadband infrastructure at this stage in the technologies growth, the transition toward greater deregulation of communication markets, and the growing issue of trust/privacy in cyberspace might be best served if the metrics function were established as part of a new entity/program. If principal responsibility is established with an existing agency, then there ought to be a special task force which will help coordinate this specialized activity across the multiple agencies and private stakeholders who will need to be involved (e.g., as was done in California).

7.6.4. Should the activity be outsourced?

Certainly, elements of designing the initial metrics approach, its implementation, and subsequent on-going operation are amendable to out-sourcing to outside (of state government) consultants and non-profit organizations. This may offer benefits in tapping into expertise with scale/scope economies not currently available within state government. It may also provide a framework more conducive to eliciting the voluntary participation of service providers. As already discussed, this is one of the benefits that sponsors of the Connected Nation approach have highlighted.

There are two potential drawbacks to significant outsourcing. First, as already noted, there will be an enduring need for an institutional capability within state government to understand broadband infrastructure. Acquiring this capability via an outsourcing relationship or in-house may be no more than a matter of financing and such decisions are commonplace in the provisioning of government services of all kinds. While the decision of whether to outsource is somewhat different with respect to a start-up activity (e.g., resources required to produce a first map are likely to be greater and more specialized than what is required for on-going maintenance), it is important to recognize that an on-going capability will be needed and this will require an on-going commitment of resources.

Second, the success of certain out-sourcing approaches such as that advocated by Connected Nation has benefited from the fact that the purpose for which the service-provider data was collected was clearly articulated and limited. This allows Connected Nation to enter into restrictive confidentiality agreements that might not be suitable if one considers the wider-context of public needs for current and future access to the data. Obtaining appropriate public access is not necessarily inconsistent with the voluntary approach adopted by Connected Nation or similar models, but it does suggest an area of concern that ought to be carefully considered.

Finally, deciding whether outsourcing makes sense in any particular situation depends on the details of the negotiated agreement, including its price. Based on the data available from other states, it seems reasonable to expect that a contract to create a baseline GIS map for Massachusetts would be in the range of $300 to $700k. Because of the advantages of marrying such an effort with grassroots organization/broadband promotion and with demand-side surveying, this would be part of a larger budget that would likely be on-order of $1 to $3 million per year for Massachusetts for at least the next few years.

8. Tables and Appendices

Table Number	Table Description
1	FCC Broadband Data, June 2006
2	OECD Broadband Lines by Technology and Per Capita (December 2006)
3	OECD Broadband Per Capita, 2001-2005
4	ITIF Broadband Penetration, Speed, Pricing Comparisons by Country (June 2007)
5	Summary of Data Collection Efforts by the States
6	Quick answers for State Collection efforts
7	URL links to State and other data sources
8	Rankings of States by Broadband Policy from TechNet (2004)

Table 1: FCC Data on Broadband Availability[102]

Table 1
High-Speed Lines [1]
(Over 200 kbps in at least one direction)

Technology [2]	2000	2001	2002	2003	2004		2005		2006
	Jun	Jun	Jun	Jun	Jun	Dec	Jun	Dec	Jun
ADSL	951,583	2,693,834	5,101,493	7,675,114	11,398,199	13,817,280	16,316,309	19,515,619	22,575,010
SDSL and Traditional Wireline	758,594	1,088,066	1,186,680	1,215,713	1,407,121	1,468,566	898,468	904,539	948,160
SDSL	-	-	-	-	-	-	411,731	394,348	337,438
Traditional Wireline	-	-	-	-	-	-	486,737	510,191	610,722
Cable Modem	2,284,491	5,184,141	9,172,895	13,684,225	18,592,636	21,357,400	23,936,536	26,469,242	28,513,500
Fiber [3]	46,635	81,248	105,991	111,386	130,928	159,653	315,651	448,257	700,083
Satellite and Wireless	65,615	194,707	220,588	309,006	421,690	549,621	965,068	3,814,122	11,872,309
Satellite	-	-	-	-	-	-	376,837	426,928	495,365
Fixed Wireless	-	-	-	-	-	-	208,695	257,431	360,976
Mobile Wireless	-	-	-	-	-	-	379,536	3,129,763	11,015,968
Power Line and Other	-	-	-	-	-	-	4,872	4,571	5,208
Total Lines	4,106,918	9,241,996	15,787,647	22,995,444	31,950,574	37,352,520	42,436,904	51,156,350	64,614,270

For data through December 2004, only those providers with at least 250 lines per state were required to file.
Some data have been revised. See additional notes following Chart 10.

Table 3
Residential High-Speed Lines [1]
(Over 200 kbps in at least one direction)

Technology [2]	2000	2001	2002	2003	2004		2005		2006
	Jun	Jun	Jun	Jun	Jun	Dec	Jun	Dec	Jun
ADSL	772,272	2,490,740	4,395,033	6,429,938	10,759,495	13,119,326	14,442,823	17,370,536	20,143,255
SDSL and Traditional Wireline	111,490	138,307	223,599	250,372	393,049	419,215	159,489	129,439	112,043
SDSL	-	-	-	-	-	-	153,978	122,215	102,631
Traditional Wireline	-	-	-	-	-	-	5,511	7,224	9,412
Cable Modem	2,215,259	4,998,540	9,157,285	13,660,541	18,525,265	21,270,158	23,497,069	25,625,191	27,720,407
Fiber [3]	325	2,623	6,120	16,132	22,719	34,959	83,293	213,484	442,027
Satellite and Wireless	64,320	182,165	202,251	288,786	387,563	422,623	428,367	533,480	1,839,368
Satellite	-	-	-	-	-	-	265,017	320,149	382,047
Fixed Wireless	-	-	-	-	-	-	160,775	203,188	301,153
Mobile Wireless	-	-	-	-	-	-	2,574	10,143	1,156,168
Power Line and Other	-	-	-	-	-	-	4,447	4,550	5,093
Total Lines	3,163,666	7,812,375	13,984,287	20,645,769	30,088,091	35,266,281	38,615,489	43,876,680	50,262,193

[102] Source: FCC, High-speed services for Internet Access: Status as of June 30, 2006, available at: http://fjallfoss.fcc.gov/edocs_public/attachmatch/DOC-270128A1.pdf.

Table 9
High-Speed Lines by Technology as of June 30, 2006
(Over 200 kbps in at least one direction)

State	ADSL	SDSL	Traditional Wireline	Cable Modem	Fiber	Satellite	Fixed Wireless	Mobile Wireless	Power Line and Other	Total
Alabama	268,970	9,409	5,691	310,548	995	*	704	*	*	615,510
Alaska	53,687	8,108	358	*	*	*	4,292	*	0	125,005
American Samoa	*	*	0	0	0	*	*	0	0	*
Arizona	276,261	1,741	8,114	761,419	2,272	*	16,964	*	0	1,392,711
Arkansas	180,883	920	2,974	148,940	2,148	*	581	*	0	363,933
California	4,001,529	38,728	161,115	2,956,932	132,473	*	39,329	*	0	9,395,285
Colorado	404,989	2,538	12,928	476,463	1,073	*	11,067	*	0	1,165,853
Connecticut	*	4,118	6,588	441,092	2,776	*	0	*	0	1,024,053
Delaware	*	307	1,528	*	*	*	0	*	0	157,648
District of Columbia	*	2,898	2,185	*	423	*	*	*	0	200,221
Florida	1,722,888	8,784	33,858	1,939,409	48,814	*	23,422	*	0	4,408,427
Georgia	1,008,705	8,230	22,043	649,583	1,900	*	503	*	0	2,054,077
Guam	*	0	*	0	0	*	0	0	0	*
Hawaii	*	*	2,224	*	*	*	*	*	0	294,612
Idaho	97,662	480	1,514	75,185	1,078	*	21,915	*	0	202,521
Illinois	1,094,088	14,523	40,916	987,640	*	*	19,750	*	*	2,611,672
Indiana	443,473	4,649	11,935	490,020	22,187	*	6,296	*	*	1,191,752
Iowa	189,267	4,114	2,250	225,545	2,133	*	11,651	*	0	446,657
Kansas	179,430	3,976	4,282	316,866	2,652	*	11,232	*	0	595,979
Kentucky	250,715	4,592	4,014	306,487	1,683	*	1,715	*	0	629,538
Louisiana	235,750	4,762	3,551	378,613	9,843	*	1,143	*	0	730,203
Maine	89,964	3,198	3,484	145,831	*	*	*	*	0	248,440
Maryland	450,019	7,202	11,003	637,405	*	*	*	*	0	1,492,484
Massachusetts	*	7,896	11,551	954,812	*	*	*	*	0	1,811,845
Michigan	533,835	4,059	23,377	888,018	12,378	*	2,755	*	*	1,786,572
Minnesota	330,736	20,216	4,954	518,063	4,897	*	20,203	*	0	1,057,576
Mississippi	128,585	*	1,824	114,140	448	*	*	*	0	262,671
Missouri	468,334	4,754	9,871	400,808	4,219	*	5,084	*	*	1,016,732
Montana	70,471	2,411	880	54,056	202	*	6,460	*	0	139,946
Nebraska	95,404	2,640	688	218,335	350	*	6,804	*	0	355,013
Nevada	168,086	1,144	7,683	*	1,407	*	3,430	*	0	614,151
New Hampshire	85,247	2,477	2,892	201,873	*	*	*	*	0	302,957
New Jersey	638,293	7,636	17,419	1,312,433	20,032	*	*	*	0	2,654,674
New Mexico	129,076	544	1,428	100,157	*	*	2,160	*	0	250,439
New York	1,001,018	26,755	21,789	2,765,476	54,134	*	464	*	0	4,852,849
North Carolina	561,102	24,545	14,569	650,767	6,670	*	12,917	*	0	1,601,938
North Dakota	38,729	4,282	287	19,861	2,592	*	2,859	*	0	70,615
Northern Mariana Island	*	0	*	0	*	*	*	0	0	*
Ohio	752,633	5,392	18,693	1,115,618	19,046	*	11,669	*	*	2,392,030
Oklahoma	246,899	1,937	4,545	284,184	3,816	*	1,947	*	0	569,398
Oregon	280,286	6,686	5,964	407,195	9,444	*	10,129	*	0	860,385
Pennsylvania	871,164	22,253	15,726	1,164,080	42,214	*	1,413	*	0	2,646,898
Puerto Rico	*	0	3,406	*	*	*	*	*	0	169,917
Rhode Island	*	1,318	1,649	*	1,488	*	0	*	0	276,141
South Carolina	242,548	225	7,402	368,338	3,792	*	*	*	0	645,886
South Dakota	32,763	3,999	215	37,514	840	*	4,375	*	0	83,275
Tennessee	348,344	2,475	9,293	506,143	5,707	*	150	*	0	1,153,432
Texas	1,733,423	15,471	32,321	1,692,433	104,719	*	51,814	*	0	4,371,655
Utah	189,240	4,378	2,974	*	766	*	8,642	*	0	471,137
Vermont	51,382	1,129	1,864	*	*	*	409	*	0	108,622
Virgin Islands	*	*	*	0	0	*	*	*	0	7,226
Virginia	440,990	6,752	17,121	892,955	43,338	*	6,219	*	*	1,787,359
Washington	491,409	6,919	10,448	725,832	14,206	*	12,721	*	*	1,575,375
West Virginia	86,507	2,832	1,833	145,450	*	*	*	*	0	245,597
Wisconsin	359,530	7,725	15,252	542,881	*	*	4,078	*	0	1,034,646
Wyoming	38,541	1,247	164	*	56	*	2,126	*	0	83,086
Nationwide	22,575,010	337,438	610,722	28,513,500	700,083	495,365	360,976	11,015,968	5,208	64,614,270

Table 2: OECD Broadband Statistics (December 2006)[103]

Broadband subscribers per 100 inhabitants, by technology, Dec. 2006

	DSL	Cable	Fiber/ LAN	Other	Total	Rank	Total Subscribers
Denmark	19.6	9.4	2.6	0.4	31.9	1	1 728 359
Netherlands	19.5	12.0	0.4	0.0	31.8	2	5 192 200
Iceland	28.8	0.0	0.2	0.6	29.7	3	87 738
Korea	11.4	10.7	7.0	0.0	29.1	4	14 042 728
Switzerland*	18.8	8.8	0.0	0.9	28.5	5	2 140 309
Norway	21.7	3.8	1.5	0.6	27.7	6	1 278 346
Finland	23.5	3.5	0.0	0.3	27.2	7	1 428 000
Sweden*	16.0	5.2	0.0	4.8	26.0	8	2 346 300
Canada	11.4	12.3	0.0	0.1	23.8	9	7 675 533
Belgium	14.0	8.4	0.0	0.1	22.5	10	2 353 956
United Kingdom	16.5	5.1	0.0	0.0	21.6	11	12 993 354
Luxembourg	18.2	2.2	0.0	0.0	20.4	12	93 214
France	19.1	1.1	0.0	0.0	20.3	13	12 699 000
Japan	11.1	2.8	6.2	0.0	20.2	14	25 755 080
United States	8.5	10.3	0.3	0.6	19.6	15	58 136 577
Australia*	15.0	3.3	0.0	1.0	19.2	16	3 939 288
Austria	10.6	6.4	0.0	0.3	17.3	17	1 427 986
Germany*	16.4	0.5	0.0	0.1	17.1	18	14 085 232
Spain	12.1	3.1	0.0	0.1	15.3	19	6 654 881
Italy*	13.8	0.0	0.4	0.6	14.8	20	8 638 873
New Zealand	12.7	0.6	0.0	0.7	14.0	21	576 067
Portugal	8.7	5.1	0.0	0.0	13.8	22	1 460 341
Ireland	9.1	1.3	0.0	2.0	12.5	23	517 300
Hungary	6.1	3.8	0.0	2.0	11.9	24	1 198 709
Czech Republic**	4.8	2.1	0.0	3.7	10.6	25	1 086 620
Poland	5.2	1.6	0.0	0.1	6.9	26	2 640 000
Slovak Republic	3.4	0.7	0.9	0.2	5.1	27	274 108
Greece	4.4	0.0	0.0	0.2	4.6	28	512 000
Turkey	3.8	0.0	0.0	0.0	3.8	29	2 773 685
Mexico*	2.7	0.8	0.0	0.0	3.5	30	3 728 150
OECD	10.5	4.9	1.1	0.3	16.9		197 463 934

[103] Source: OECD Broadband data, See http://www.oecd.org/document/7/0,3343,en_2649_34223_38446855_1_1_1_1,00.html

Table 3: OECD Broadband Statistics (time series)[104]

Broadband subscribers per 100 inhabitants, 2001-2006

	2001	2002	2003	2004	2005	2006
Australia	0.9	1.8	3.5	7.7	13.8	19.2
Austria	3.6	5.6	7.6	10.1	14.3	17.3
Belgium	4.4	8.7	11.7	15.5	18.2	22.5
Canada	8.9	12.1	15.1	17.6	21.0	23.8
Czech Republic	0.1	0.2	0.5	2.5	6.4	10.6
Denmark	4.4	8.2	13.0	19.0	24.9	31.9
Finland	1.3	5.5	9.5	14.9	22.4	27.2
France	1.0	2.8	5.9	10.5	15.1	20.3
Germany	2.3	4.1	5.6	8.4	13.0	17.1
Greece	0	0	0.1	0.4	1.4	4.6
Hungary	0.3	0.6	2.0	3.6	6.3	11.9
Iceland	3.7	8.4	14.3	18.2	26.4	29.7
Ireland	0	0.3	0.8	3.3	6.7	12.5
Italy	0.7	1.7	4.1	8.1	11.8	14.8
Japan	2.2	6.1	10.7	15.0	17.6	20.2
Korea	17.2	21.8	24.2	24.8	25.2	29.1
Luxembourg	0.3	1.5	3.5	9.8	14.9	20.4
Mexico	0.1	0.3	0.4	0.9	2.2	3.5
Netherlands	3.8	7.0	11.8	19.0	25.2	31.8
New Zealand	0.7	1.6	2.6	4.7	8.1	14.0
Norway	1.9	4.2	8.0	14.8	21.8	27.5
Poland	0.1	0.3	0.8	2.1	2.4	6.9
Portugal	1.0	2.5	4.8	8.2	11.5	13.8
Slovak Republic	0	0	0.3	1.0	2.5	5.7
Spain	1.2	3.0	5.4	8.1	11.5	15.3

[104] OECD broadband data, see http://www.oecd.org/document/7/0,3343,en_2649_34223_38446855_1_1_1_1,00.html.

Sweden	5.4	8.1	10.7	14.5	20.2	26.0
Switzerland	2.0	5.6	10.1	17.5	24.1	28.5
Turkey	0	0	0.3	0.7	2.1	3.8
United Kingdom	0.6	2.3	5.4	10.5	16.4	21.6
United States	4.5	6.9	9.7	12.9	16.3	19.6
OECD	2.9	4.9	7.3	10.2	13.5	16.9
EU15	1.6	3.4	5.9	9.7	14.2	18.6

Table 4: ITIF Broadband Rankings[105]

Rank	Nation	Penetration	Speed	Price	Overall Score
		Subscribers per Household	Average Speed (mbps)	Price per Month for 1 mbps of Fastest Technology (USD PPP)	
1	Korea	0.90	45.6	0.45	15.73
2	Japan	0.52	61.0	0.27	14.99
3	Iceland	0.83	6.0	4.99	12.14
4	Finland	0.57	21.7	2.77	12.11
5	Netherlands	0.73	8.8	4.31	11.87
6	Sweden	0.49	18.2	0.63	11.54
7	France	0.49	17.6	1.64	11.41
8	Denmark	0.70	4.6	4.92	11.37
9	Norway	0.64	7.4	4.04	11.29
10	Canada	0.62	7.6	6.50	11.11
11	Belgium	0.54	6.2	6.69	10.60
12	United States	0.51	4.8	3.33	10.47
13	Switzerland	0.68	2.3	21.71	10.40
14	Australia	0.50	1.7	2.39	10.23
15	Austria	0.42	7.3	5.99	10.08
16	Portugal	0.42	8.1	10.99	9.92
17	United Kingdom	0.50	2.6	11.02	9.92
18	Germany	0.38	6.0	5.20	9.81
19	Italy	0.38	4.2	3.36	9.78
20	Luxembourg	0.51	3.1	18.48	9.71
21	Spain	0.44	1.2	12.46	9.48
22	New Zealand	0.36	2.3	9.20	9.26
23	Ireland	0.37	2.2	13.82	9.14
24	Poland	0.20	7.5	13.00	8.69
25	Czech Republic	0.27	1.6	24.10	8.11
26	Hungary	0.30	3.0	44.24	7.53
27	Greece	0.12	1.0	33.19	6.93
28	Slovak Republic	0.16	2.8	50.15	6.58
29	Mexico	0.16	1.1	60.01	6.00
30	Turkey	0.17	2.0	115.76	3.81
Average		**0.46**	**9.0**	**16.52**	**10.00**

[105] Source: see Table 1, Atkinson, Robert (2007), "The case for a national broadband policy," white paper, Information Technology and Innovation Foundation, Washington DC, June 2007 (available at: http://www.itif.org/index.php?id=52).

Table 5: State Broadband Survey Efforts Summarized

State	Organization	Description
AZ	Government Information Technology Agency (GITA)	Several products: Regional maps of major long-distance infrastructure Community telecom assessments Online database of telecom providers
CA	Broadband Task Force	Very thorough GIS mapping project, using provider data at the household level. Also used speed measurements collected by speedtest.net.
CA	Public Policy Institute of California	Attempted to predict broadband availability based on Forrester Research survey of broadband adoption. Predicts demand for broadband from income and other demographic data; assumes that if adoption does not correlate with the predicted demand, availability must be limited.
CA	Public Utility Commission	Analyzed FCC data.
IL	Illinois St. Univ. Institute for Regulatory Policy Studies	First, attempted to identify all of the broadband providers in the state, using several channels. Then surveyed these providers to determine availability and pricing at the zip code level. 31% of the providers responded. Some data could not be made public. Used a modified version of a survey instrument created by the Iowa Utilities Board.
IL	ConnectSI (Southern Illinois)	Still in progress. Online GIS map of availability in southern Illinois.
KY	Connect Kentucky	Mapping based on provider data, and phone surveys of consumers.
ME	ConnectME	Online GIS map of availability at township level.
MN	Center for Rural Policy and Development	Annual surveys mostly focused just on how many people are using the Internet, not on mapping.
MO	Missouri Public Service Commission	Study of availability using provider data, analyzed at the local exchange level. DSL data is more detailed than cable.
NC	E-NC Authority	Many studies. Online GIS mapping system.
NC	Western Carolina University Institute for the Economy and the Future	Phone survey of households getting their power from the university's grid. They were interested in the feasibility of BPL.
PA	Center for Rural Pennsylvania	Provider surveys. Cable franchise and estimated DSL service areas, overlaid with census block groups via GIS.
TN	ConnectedTennessee	Mapping of provider data, and phone surveys of customers interactive online GIS-based map of availability -- primarily based on provider data, which is not public
VT	Department of Public Service	Map of broadband service areas, based on provider data.
WY	Telecommunications Council	Consultant loaded provider data into a GIS system, and attempted to estimate coverage gaps at a household level. Also estimated cost of providing broadband to unserved households.
National	Speedmatters.org	People voluntarily come to their site to do a speed test; no demographic information or provider information collected.
National	Pew Internet and American Life Project	December 2005 and February-April 2006; entire US. Phone survey; called a random sample of phone numbers (listed and unlisted). 3011 total adults; 1931 Internet users
National	US Government Accountability Office (GAO)	Case studies of 8 states (AK, CA, KY, MA, ND, OH, TX, VA), interviewing people from many organizations. Also used phone consumer survey data (1500 households nationwide) and FCC data. Developed econometric models of deployment and adoption.

Table 6: Quick Summary of Data Collection Efforts

State	Organization	Report date	Survey date	Provider or consumer data	Geographical level of detail	Mapping	Data ownership
AZ	GITA			Provider		yes	
CA	Broadband Task Force	Jan 2008		Provider and some consumer data	household	yes	Third-party
CA	PUC	Sep 2006	Dec 2005	Provider (FCC data)	zip codes	yes	Public
CA	Public Policy Inst.	Jul 2007	Multiple years	Consumer (extrapolated)	zip code	no	Proprietary (Forrester)
IL	IL St. Univ.	Aug 2007 (preliminary)	2006	Provider	zip code	yes	Detailed data is confidential
IL	ConnectSI	ongoing				yes	
KY	ConnectKY	ongoing		Provider	DSLAMs, households (for cable)	yes	Proprietary
ME	ConnectME	ongoing		Provider???	Townships	yes	Public
MN	Ctr for Rural Policy	annual		Provider and consumer		minimal	Provider data is proprietary
MO	PSC	Sep 2007	???	Provider	Exchange areas, cable franchises	yes	Proprietary
NC	e-NC	May 2005	1999 to 2004	Consumers		yes	Public
PA	Ctr for Rural PA	Sep 2003	Oct-Dec 2002	Providers	DSLAMs, cable franchises	yes	Proprietary
TN	ConnectedTennessee	ongoing		Provider	Census block	yes	Proprietary
VT	Dept of Public Service	Feb 2007		Provider	DSL, cable, wireless coverage areas	yes	Proprietary
WY	Telecom Council	Oct 2006		Provider	household	yes	Proprietary
Nat'l	Speedmatters.org	ongoing		Consumer	zip code	no	
Nat'l	Pew	Jun 2007, annually	Feb-Mar 2007	Consumer	N/A	no	Public
Nat'l	US GAO	May 2006	2005-06	Consumer and provider	N/A	No	Public (FCC), proprietary (phone survey)

Table 7: Quick Links

State	Organization	Link
AZ	GITA, ATIC	Regional maps: http://www.azgita.gov/telecom/ciac/supplementary/maps.htm Community assessments: http://www.azgita.gov/telecom/ciac/supplementary/assessments.htm Provider database: http://www.arizonatele.com/ GITA CIAC Year in Review (2006): http://www.arizonatele.com/atic/docs/AZ_GCIT_CIAC_Year_in_Review_2006.doc AZ Broadband Initiative Framework report (review of other states' broadband policies): http://www.azcommerce.com/doclib/prop/originals/arizona%20broadband%20initiative%20framework.pdf ATIC: http://www.arizonatele.com/atic/
CA	Broadband Task Force	http://www.calink.ca.gov/pdf/CBTF_FINAL_Report.pdf
CA	Public Policy Institute of California	http://www.ppic.org/main/publication.asp?i=758 and see also a working paper by the same author: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=985713
CA	Public Utility Commission	http://www.cpuc.ca.gov/PUC/Telco/Reports/Broadband+Reports/06broadbandreport.htm (2006 report) and http://www.cpuc.ca.gov/PUC/Telco/Reports/Broadband+Reports/0505_broadbandreport.htm (2005 report)
IL	IL St. Univ.	http://illinoisbroadbanddeployment.pbwiki.com/f/IRPS+Broadband+Report+080907.pdf
IL	ConnectSI	http://gis-connectsi.geography.siu.edu/Connect-SI/Launch_map.htm http://gis-connectsi.geography.siu.edu/Connect-SI/front_page.htm (under construction)
KY	Connect Kentucky	http://Connect Kentucky.org/researchpol/ http://Connect Kentucky.org/Mapping/ http://Connect Kentucky.org/researchpol/SRS.htm http://Connect Kentucky.org/NR/rdonlyres/2F6BAAC1-A6D0-4DD7-BEDF-385030488D6C/0/CKdocSRSBroadbandAdoptionBenchmarks.pdf "Broadband Adoption and Barriers to Use" report: 11,000 households, Oct-Dec 2005
ME	ConnectME	http://megisims.state.me.us/website/BroadBand2/viewer.htm reached from http://www.maine.gov/connectme/
MN	Center for Rural Policy and Development	http://www.mnsu.edu/ruralmn/research.php http://www.mnsu.edu/ruralmn/pages/Publications/reports/Providers%202003.pdf
MO	Missouri Public Service Commission	http://psc.mo.gov/the-commissioners/robert-m-clayton-iii-documents/FINAL%20Broadband%20Report%20Sept%2018%20350pm.pdf reached from http://psc.mo.gov/the-commissioners/robert-m-clayton-iii (bottom of page)
NC	E-NC Authority	http://www.e-nc.org/pdf/distressed_urban.pdf "High-Speed Internet Connectivity in North Carolina's Distressed Urban Areas" report from UNC Center for Urban & Regional Studies, did focus groups in several distressed urban areas http://www.e-nc.org/citizen_survey.asp http://www.e-nc.org/eImprovement/tool/eAgriculture.asp http://www.e-nc.org/pdf/statewidesurveyfinal.pdf
NC	Western Carolina University	http://ief.wcu.edu/index.php?option=com_content&task=blogsection&id=5&Itemid=168

PA	Center for Rural Pennsylvania	http://www.ruralpa.org/reports.html http://www.ruralpa.org/broadband_report.pdf
PA	Dept. of Community and Economic Development	http://www.broadbandinpa.com
TN	ConnectedTennessee	http://www.connectedtennessee.com/mapping_&_research/availability_maps/ http://www.connectedtennessee.com/mapping_&_research/research.php
VA	Chris Thompson, DHCD	http://www.dhcd.virginia.gov/AboutDHCD/ContactDHCD.htm
VT	Dept. of Public Service	http://publicservice.vermont.gov/Broadband/Broadband%20Deployment%20in%20Vermont%20Final.pdf
WY	Telecom Council	http://cio.state.wy.us/telecom/broadband/CostsAndBenefitsofUniversalBroadbandAccessInWyoming.pdf see also http://cio.state.wy.us/telecom/Broadband/TopicIndex.pdf
National	NTCA	http://www.ntca.org/ka/ka-3.cfm?content_item_id=4500&folder_id=588 reached from http://www.ntca.org/ka/ka-2.cfm?Folder_ID=588
National	Pew Internet and American Life Project	http://www.pewinternet.org/PPF/r/184/report_display.asp questionnaire: http://www.pewinternet.org/pdfs/PIP_Broadband_questionnaire.pdf
National	Speedmatters.org	http://www.speedmatters.org/
National	US GAO	http://www.gao.gov/docdblite/summary.php?rptno=GAO-06-426&accno=A53380

Useful general links:

National

SpeedMatters.org Document Library, http://www.speedmatters.org/document-library

Internet Innovation Alliance report: Broadband Fact Book, http://internetinnovation.org/Editor/News/tabid/56/articleType/ArticleView/articleId/52/Broadband-Fact-Library.aspx

Illinois Broadband Deployment wiki, http://illinoisbroadbanddeployment.pbwiki.com/

International

World Bank report on ICTs (2006), http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTINFORMATIONANDCOMMUNICATIONANDTECHNOLOGIES/0,,contentMDK:20831214~pagePK:210058~piPK:210062~theSitePK:282823,00.html

OECD Broadband Portal, http://www.oecd.org/sti/ict/broadband

Table 8: Rankings of States by Broadband Policy from TechNet (2004)[106]

Ranking	*State*	*Score*
1	Michigan	144.4
2	Florida	80.6
3	Missouri	75.7
4	Texas	73.0
5	Ohio	71.1
6	Washington	70.0
7	Kansas	67.3
8	Virginia	65.6
9	Colorado	58.5
10	Iowa	55.9
11	Oregon	52.1
12	Arizona	51.2
13	Indiana	47.5
14	California	46.6
15	Illinois	45.3
16	Minnesota	45.0
17	Nebraska	42.7
18	North Dakota	37.7
19	North Carolina	35.8
20	South Carolina	34.3
21	Maine	26.0
22	Pennsylvania	25.5
23	Alaska	25.2
24	Kentucky	24.3
25	Wisconsin	23.0

[106] Source: "The State Broadband Index: An Assessment of State Policies Impacting Broadband Deployment and Demand," a report prepared for Technet.org by Analysys, 2004 (available at: http://www.technet.org/resources/State_Broadband_Index.pdf).

Appendix 1: Note on Speedmatters.org (and Speedtest.net)

Most of the reports discussed above focus on the theoretical maximum speed of a user's connection, which is generally the speed advertised to consumers. However, the actual speed experienced by a user may be much smaller, because of a variety of factors. One website which measures a consumer's actual connection speed is speedtest.net, which launched in July 2006. They have collected measurements from almost 129,000 distinct IP addresses for the state of Massachusetts. It is hard to know how many people this corresponds to, because providers do not necessarily assign an IP address to one and only one individual customer. It is possible that the same user could use different IP addresses at different times, and conversely, the same IP address could be used by different people at different times. Furthermore, as data is collected entirely voluntarily, it is hard to know how representative it is of Internet connectivity in general in a particular area. In addition, these tests only measure the user's speed at one particular moment in time. Nonetheless, the California Broadband Task Force did use data from speedtest.net to get some information about users' broadband experiences in California.

Speedmatters.org uses the same software as speedtest.net, but their database of measurements is separate. Thus they have data for a different set of consumers than speedtest.net (although the two sets may overlap). Speedmatters.org is hosted by the Communications Workers of America (CWA), a telecommunications industry trade union. Not surprisingly, the CWA are supporters of increased investment in national broadband.

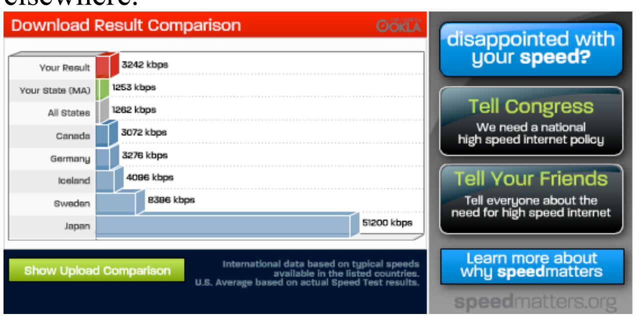
One issue with these kinds of testing services is determining the user's location. There is no simple, reliable way to do this, short of asking the user to enter his or her address or zip code. There are companies selling proprietary databases which map IP addresses to a town/city name and an Internet service provider. Speedtest.net uses the GeoIP database from the company MaxMind (based in Boston). Databases such as this are not 100% accurate, but they are accurate enough to be used by advertisers to target ads to potential customers based on location. They generally can not identify a user's location within a city or town, limiting the usefulness of this data for detailed geographic mapping.

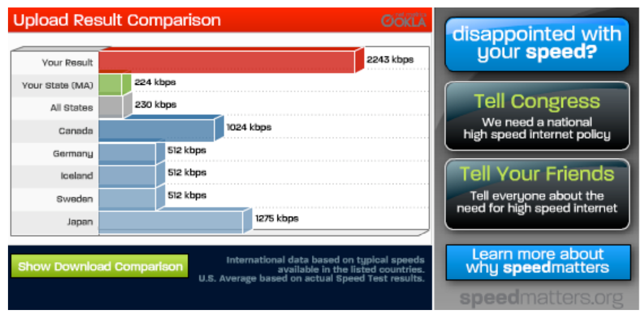
An example of the results of such a test (from www.speedmatters.org for a Comcast cable modem service in Concord, MA) are reproduced below:

(1) Start the test (see right-hand side)

(2) Here are results of test, generated by running a test download and upload file to determine that my connection is 3.2Mbps/2.2Mbps (down/up). Incidentally, my service provider is Comcast in Concord, MA.

(3) Here are charts they produce showing how my service compares with rest of state and elsewhere.





Note that the performance experienced by this connection is higher than average in the state, and substantially lower than in a number of other countries. As is typical, the download speed is faster than the upload speed; although my connection has atypically high-speed upload. The performance experienced will vary depending on when you conduct the test.

Note also the “Tell Congress” button. This used to generate a signature to a petition to advocate for federal policies to encourage faster speed broadband, an policy issue that the Communications Workers of America (CWA), who host the site, supports.

Appendix 2: "What is Broadband"

The following provides one view of how to define broadband from the California Broadband Task Force.[107] They adopted as a working definition a data rate of at least 512Kbps but are also careful to note that this is likely to need to increase over time and they list the speed tiers associated with supporting different types of broadband applications as well as the rates of speeds associated with different broadband technology platforms.

What is Broadband?

To evaluate the status of and set metrics for broadband deployment in California, the CBTF developed a working definition of broadband.

- Broadband is defined by the ability to perform online applications at a reasonable performance level for the end user.
- Broadband is a range of speeds and will evolve over time as applications and needs change. It is a summation of the downstream data rate (transmission to the user) and upstream data rate (transmission from the user).
- The ratio of the downstream and upstream must be a minimum of 10:1 (the ratio of the downstream and upstream data rates can increase from 10:1 to a fully symmetrical 1:1).
- Broadband must have the capability to be always on, and have a sustainable steady state data rate.
- Burst-able speeds provide benefit to users, but should not be considered in the same manner as steady data rates.
- The minimum speed required to use the most basic of broadband-enabled applications is 512 kbps, and this minimum data rate is expected to increase over time.
- An increasing scale that continues to differentiate within speed tiers allows stakeholders to measure specific broadband availability over time.

Upstream and Downstream Speed Range	Applications
500 kbps - 1 Mbps	Voice over IP SMS Basic Email Web Browsing (simple sites) Streaming Music (caching) Low Quality Video (highly compressed)
1 Mbps - 5 Mbps	Web Browsing (complex sites) Email (larger size attachments) Remote Surveillance IPTV-SD (1-3 channels) File Sharing (small/medium) Telecommuting (ordinary) Digital broadcast video (1 channel) Streaming Music
5 Mbps - 10 Mbps	Telecommuting (converged services) File Sharing (large) IPTV-SD (multiple channels) Switched Digital Video Video on Demand SD Broadcast SD Video Video Streaming (2-3 channels) HD Video Downloading Low Definition Telepresence Gaming Medical File Sharing (basic) Remote Diagnosis (basic) Remote Education Building Control & Management

[107] See "The State of Connectivity: Final Report of the California Broadband Task Force," January 2008 (available at: http://www.calink.ca.gov/taskforcereport/).

10 Mbps - 100 Mbps	Telemedicine Educational Services Broadcast Video SD and some HD IPTV-HD Gaming (complex) Telecommuting (high quality video) High Quality Telepresence HD Surveillance Smart/Intelligent Building Control
100 Mbps - 1 Gbps	HD Telemedicine Multiple Educational Services Broadcast Video full HD Full IPTV Channel Support Video on Demand HD Gaming (immersion) Remote Server Services for Telecommuting
1 Gbps - 10 Gbps	Research Applications Telepresence using uncompressed high definition video streams Live event digital cinema streaming Telemedicine remote control of scientific/medical instruments Interactive remote visualization and virtual reality Movement of terabyte datasets Remote supercomputing

Technology	Advertised Broadband Product Speed Ranges in California *(Downstream rate)*
Cable	768 kbps - 15 Mbps
DSL	384 kbps - 6 Mbps
Fixed Wireless	768 kbps - 3 Mbps
FTTH	1 Mbps - 50 Mbps
Mobile Wireless	200 kbps - 1.4 Mbps
Satellite	512 kbps - 2 Mbps