BROADBAND DEPLOYMENT AS TECHNOLOGICAL INNOVATION: ASSESSING THE NEEDS OF ANCHOR INSTITUTIONS

Charles C. Hinnant
Information Institute
Florida State University
Tallahassee, FL 32306-2100
1-850-645-8967

chinnant@fsu.edu

Charles R. McClure
Information Institute
Florida State University
Tallahassee, FL 32306-2100
1-850-644-8109

cmcclure@lis.fsu.edu

Lauren H. Mandel
Information Institute
Florida State University
Tallahassee, FL 32306-2100
1-850-645-2196

lmandel@fsu.edu

Nicole D. Alemanne
Information Institute
Florida State University
Tallahassee, FL 32306-2100
1-850-645-5683

nalemanne@fsu.edu

ABSTRACT

High-speed broadband facilitates a vast number of beneficial applications such as voice over internet protocol (VoIP), streaming media, gaming, online government and business services, and other interactive services that require high data transmission rates. While high speed broadband is purported to lead ultimately to social and economic development, a coherent proactive national policy regarding the development and use of broadband infrastructure in rural and underserved areas has been slow to appear in the U.S. The FCC's recent mandate to develop a National Broadband Plan and the $7.2 billion in funds specified in the American Recovery and Reinvestment Act of 2009 (ARRA) for broadband deployment and build-out indicates a significant shift in federal government policy to supporting broadband deployment. As the federal funding increases, local community anchor institutions such as public libraries, schools, and medical facilities will be looked to as drivers of successful deployment and adoption of broadband to local communities.

The purpose of this paper is to identify and discuss issues associated with large-scale technological innovations with emphasis on the widespread adoption of high-speed broadband by community anchor institutions. This will include the evaluation of and planning for broadband expansion and implementation. A case study of public libraries in Florida serves to highlight the means used to assess broadband adoption and implementation issues in community anchor institutions. By examining the factors that assist anchor institutions in deploying large-scale broadband projects, this paper also seeks to identify issues and opportunities for iSchools to play a role in assisting anchor institutions with successful deployment of broadband projects.

Categories and Subject Descriptors

C.2.5 [**Computer Systems Organization**]: Local and Wide-Area Networks – *High-speed (e.g., FDDI, fiber channel, ATM).*

General Terms

Measurement, Economics, Legal Aspects.

Keywords

Technological Innovation, Broadband Adoption, ARRA, Needs Assessments, Broadband Planning.

1. INTRODUCTION

In the global information society, the availability of high-speed broadband is an essential ingredient for the ability of individuals and communities to fully take advantage of new information and communication technology (ICT) applications that require high data transmission rates. Consequently, high-speed broadband is a necessary but not totally sufficient prerequisite for such ICT applications as voice over internet protocol (VoIP), streaming media, gaming, and other highly interactive applications. Coupled with more streamlined business and service delivery models, broadband-enabled applications and services are rapidly becoming ubiquitous in institutional service areas such education (distance education), medicine (telehealth and telemedicine), government (e-government, public health, and public safety), and business (e-commerce) [1].

While high-speed broadband supports a vast number of beneficial applications that facilitate social and economic development, a coherent national policy regarding the development and use of a broadband infrastructure has yet to emerge in the U.S. Moreover, there is little agreement regarding what characterizes "high speed

broadband" since its very meaning is tied to the data transmission requirements for more advanced applications at a given time and context. For example, the National Telecommunications and Information Administration (NTIA) defines broadband as an advertised speed of 768 kilobits per second (kbps) downstream and 200 kpbs upstream [2]. This definition is significantly lower than average transmission speeds advertised by many Internet Service Providers (ISPs). A study by the Organization for Economic Co-operation and Development [3] in 2008 cites the average download speed in the U.S. as 9.64 Mbps which drastically exceeds the requirements as outlined by the U.S. FCC [3]. That average ranked the U.S. 19th worldwide, with Japan leading the world with 92.85 Mbps average advertised download speed [3]. In the global Information Society, U.S. connectivity is much slower than other nations' and the FCC's definition of broadband seems inadequate. For this paper, high-speed broadband Internet refers to the average advertised download speed in the U.S. and not the FCC minimum definition that is insufficient for most highly interactive online services [2].

Broadband deployment and adoption is an important component of the Obama administration's policy of investing in core infrastructure areas. The FCC's mandate to develop a National Broadband Plan and the $7.2 billion in funds specified in the American Recovery and Reinvestment Act of 2009 (ARRA) to further this goal are both evidence of this intent. Furthermore, the $200 million set aside for Public Computer Centers (PCC) within NTIA's Broadband Technology Opportunities Program (BTOP) to assist in establishing and supporting local institutions to serve as community broadband anchors for broadband services shows a political intent to employ new broadband infrastructure and services in order to facilitate social and economic development, especially in rural and underserved areas.

The purpose of this paper is to identify and discuss issues associated with large-scale technological innovations with reference to the widespread adoption of high-speed broadband by community anchor institutions (e.g., schools, libraries, medical facilities). This will include the evaluation of, and planning for, broadband expansion and implementation. A case study of public libraries in Florida is used to highlight the means used to assess both broadband adoption and implementation issues. Ultimately, by examining the factors that assist anchor institutions in deploying large-scale broadband projects, this paper also seeks to identify issues and opportunities for iSchools to play a role in assisting anchor institutions in successfully deploying broadband projects.

2. SITUATIONAL CONTEXT OF ANCHOR INSTITUTIONS AND BROADBAND ADOPTION

2.1 Broadband Deployment as Technological Innovation

Since technological innovation is typically defined as "the situationally new development and introduction of knowledge-derived tools, artifacts, and devices by which people extend and interact with their environment," it seems that a better understanding of the innovation process would inform a more complete understanding of broadband deployment in community anchor institutions (anchors) [4].The innovation process for most complex organizations, such as anchors, is heavily influenced by the inter-relationship of social and technical factors within the organizations' internal and external environments, such as the technology itself, the availability of required resources, the fit with the organization's primary task, and an organization's structural arrangements [5]. Furthermore, examinations of advanced online technologies, such as personalization of services, also indicate that the adoption of new online services is often slowed by limitations of technical expertise and budgetary considerations [6].

A study by Tornatsky and Klein [7] indicates that three primary characteristics are repeatedly associated with the adoption of new technologies: relative advantage, ease-of-use, and compatibility. Similarly, the extent to which a particular technology alters existing organizational processes also plays a role in the innovation process. So-called radical innovations usually involve a significant alteration of an organization's processes or outputs, or significantly impact the organization's key stakeholders [8, 9]. Radical innovations that are clear departures from an organization's technological norms generally experience more risks for failure or setbacks than do technological innovations that involve only incremental changes in an organization's existing technological environment. This may be especially true for the adoption of broadband by anchor institutions in rural and otherwise underserved communities since the anchors and their core stakeholders may not possess or, initially have access to, sophisticated ICT infrastructures [5, 10].

The decision for anchor institutions to adopt a technological innovation, such as high-speed broadband, is predicated on the assumption that organizational decision-makers have sufficient awareness of new technologies to understand their potential benefits. The greater the information and knowledge assets that an anchor has at its disposal, the more likely it is to find new technologies to address operational problems, and the more likely it is to understand and implement the technology [11, 12]. Although all technologies require some learning on the part of the staff participating in the adoption, some technologies create a barrier to diffusion by placing more demands on adopters for new knowledge and skills [13]. In addition to the availability of resources, technologies that have greater levels of congruency with key organizational tasks, such as the relationship between high-speed broadband and the mission of many anchors to provide free public Internet and computing access to a wide audience, may be perceived as more useful and therefore, as a more successful adoption of technology [14, 15].

While technology characteristics, intraorganizational issues, and resource issues play important roles in technological innovation for anchor institutions, anchors also exist within a network of multiple government agencies, nonprofit organizations, and private sector organizations [5, 16]. This highlights that broadband innovation is not only a product of the potential demand from anchor institutions, or their immediate clients, but also a function of how the technology is supplied, or pushed, from other institutions that desire the innovation to take place [10, 17]. Therefore, any consideration of broadband adoption by anchors should also consider the extent to which institutions such as the national government subsidizes or regulates the deployment and adoption of high-speed broadband through its telecommunication policies [5, 18].

2.2 Social and Technical Issues of Broadband Adoption in Community Anchor Institutions

In regards to high speed broadband adoption, anchor institutions such as public libraries, schools, and medical facilities are impacted by rapid increases in the need for higher levels of bandwidth as well the availability, or supply, of such infrastructure services. As a growing number of ICT applications require higher amounts of bandwidth, anchors must consider the data transmission speed of their Internet connections since it directly impacts their ability to meet user and staff application needs [5, 19]. In addition, anchors do not usually serve a single user at one time. Rather, they often simultaneously serve many users on a single broadband connection thus further downgrading the data transmission capabilities and, therefore, the applications available to each user. Assuming that such anchors are aware of any potential deficiencies in their ability to adequately serve their clients, this can serve as clear marker of the need, or potential demand, for high speed broadband in community anchors.

Tied closely to both the awareness and motivation to innovate and the characteristics of a specific ICT is the anchor institution's available resources, such as financial resources, the number of available staff, or the knowledge assets that are required to adopt and implement a respective technology. For example, U.S. public libraries and K-12 schools may apply for E-rate discounts under the Universal Service Fund, Schools and Libraries Program, established by the Telecommunications Act of 1996 in order to maintain and expand public Internet access [20]. These discounts may be applied to selected telecommunications, Internet access, and internal connectivity [21]. This funding subsidy is critical for libraries and schools to sustain the provision of free public access Internet to U.S. communities.

In addition to E-Rate funds, the Federal government is currently making funds available to upgrade public computer center capacity through the ARRA, which includes funding for broadband build-out and public computer center upgrades through the BTOP administered by the NTIA and the Broadband Initiatives Program (BIP) administered by the Rural Utilities Service (RUS) [2]. The NTIA-administered BTOP program provides a targeted funding opportunity for anchors, through its emphasis on their importance in deploying and sustaining the adoption of broadband Internet. The BTOP includes set-aside funds for broadband build-out, public computer center capacity expansion, and sustainable broadband adoption education and training programs. The deployment and adoption of high speed broadband is clearly impacted by not only the need of anchor institutions to acquire higher capacity but also the ability of other institutions such as the federal government to push technological innovation through financial subsidies.

3. CASE STUDY OF BROADBAND NEEDS ASSESSMENT
3.1 Assessing the Need for Broadband

Almost all institutional innovation occurs in response to a perceived demand or need [10, 17]. Assessing the need for new technologies is a precursor to determining current, or future, demand on the part of anchor institutions and their broader communities. Therefore, this section provides an overview of a study (funded by a grant from the State Library & Archives of Florida) conducted to assess the need for high-speed broadband in Florida public libraries in order to carry out advanced E-government and emergency management services [22]. Although this project was limited to Florida public libraries, this section provides an overview for other community anchor institutions to conduct similar broadband needs assessments and services.

3.2 Methodological Approaches to the Needs Assessment Study

Research team members employed a multi-method data collection approach to conduct the needs assessment. Data-collection approaches used in this study include:

- Literature review: Review of the literature regarding public library technology and broadband use and deployment;
- Interviews: Interviews with selected public librarians, emergency management officials, and others knowledgeable about the topic to understand existing broadband connections and configurations in Florida public libraries and obtain feedback related to the usefulness of developed maps that indicate public library Internet connectivity;
- Public library case studies: Selected public libraries described and collected data on current broadband connections and infrastructure, workstation connectivity speeds, and network configurations;
- Public library site visits: Onsite review and tests of workstation connectivity speeds and network configurations at selected public libraries;
- Geographic Information System (GIS) analysis of public library telecommunications: Use of GIS software to manage, analyze and map Florida public library broadband data from the Bill & Melinda Gates Foundation Florida public library technology dataset [23] made available from the State Library; and
- Public library national survey data analysis: Analysis of the Public Library Funding and Technology Access Survey [24] related to technology and broadband use and deployment in Florida public libraries.

These methods were selected for their applicability to an exploratory, statewide public library technology needs assessment.

The study team employed a combination of purposeful and cluster sampling for the study's iterative multi-method data collection efforts. The study was exploratory and purposeful, thus limiting the generalizability of the data. The data collection approaches, however, provided detailed and overlapping findings regarding broadband capacity issues in public libraries. By using such an approach, the study team identified and triangulated perspectives on broadband needs for public libraries from both the public library and user populations, thus ensuring reliable and valid data.

3.3 Findings from a Needs Assessment of Florida Public Libraries

The findings present a preliminary picture of Florida public library broadband connectivity and the extent to which Florida public libraries have adequate broadband Internet access to provide public access Internet and computing and a range of other electronic and networked services. Library outlets across the state report insufficient data transmission speeds and the majority of Florida public libraries report that the number of public access workstations is insufficient to meet patron needs some or all of the time. This situation is more pronounced in rural and suburban public libraries.

Connection speeds impact the level of services libraries can offer the public (see Table 1), and in fact, over 75 percent of Florida public libraries report existing connection speeds are insufficient to meet patron and staff demand. Also, most of the librarians who participated in case studies were unaware of the loss of data transmission speeds between their institutional connection and individual workstations at the individual branches. Only Sarasota County public libraries average connectivity speeds over 50 Mbps (75.94 Mbps), the highest for the state (Figure 1). The next highest average speeds are public libraries in Indian River (50 Mbps), Charlotte (45 Mbps), and Leon (33 Mbps) Counties. Without these speeds, public libraries may be able to provide only minimal E-government and emergency management services such as filling out online forms. Furthermore, they will not be able to support advanced applications such as large volume file transfer, digital video streaming, downloading, and sharing, remote education, and building control and maintenance [25].

Situational factors play a critical role in affecting each library's technology access and services. These factors cannot be ignored when considering how best to assist libraries improve network efficiencies and computer equipment. The current cost and speed of broadband for Florida's public library outlets disable many librarians and libraries from adequately serving their communities. These communities turn to their public library outlets for free and publicly available broadband Internet access to participate in today's Information Society. However, slow Internet connectivity speeds, high broadband costs, and situational factors greatly impact libraries' ability to adequately support public access Internet and computing. The needs assessment study discussed here highlights how the skills associated with the iSchools (especially the study of the intersection of people, information, and technology) can play an important role in assisting public anchor institutions by assessing the overall need to innovate by upgrading their broadband capacity and, ultimately, expanding broadband access in the U.S.

Table 1. Comparison of Internet services possible at different speeds [25]

Speed range	Possible services that can be supported
500 kbps – 1 Mbps	Voice over Internet protocol (VoIP), short message service (SMS), basic email, web browsing simple sites, streaming music using caching, low quality and highly compressed video
1 Mbps – 5 Mbps	Web browsing complex sites, email with larger file attachments, remote surveillance, Internet protocol TV-standard definition (IPTV-SD), small and medium size file sharing, ordinary telecommuting, one channel of digital broadcast video, and streaming music
5 Mbps – 10 Mbps	Advanced telecommuting, large size file sharing, multiple channels of IPTV-SD, switched digital video, video on demand SD, broadcast SD video, two to three channels of video streaming, high definition (HD) video downloading, low definition telepresence, gaming, basic medical file sharing and remote diagnosis, remote education, and building control and management
10 Mbps – 100 Mbps	Telemedicine, educational services, broadcast video SD and some HD, IPTV-HD, complex gaming, telecommuting with high quality video, high quality telepresence, HD surveillance, smart building control
100 Mbps – 1 Gbps	HD telemedicine, multiple educational services, full HD broadcast video, full IPTV channels, video on demand HD, immersion gaming, and telecommuting with remote server services
1 Gbps – 10 Gbps	Research applications, uncompressed HD video streaming telepresence, live event digital cinema streaming, telemedicine with remote control of medical instruments, interactive remote visualization and virtual reality, sharing terabyte size datasets, and remote supercomputing

3.4 Considerations for Community Anchor Institutions

While most results from this needs assessment are not generalizable beyond Florida, the needs assessment methodology is transferable to other institutional contexts. The findings, however, are suggestive of issues and topics that are likely to be significant in other states as well. This study shows the value of a broadband needs assessment for evaluating the current situation and for recommending actions to facilitate successful innovation. Anchors across the U.S. can employ some or all of the methods described to evaluate their own network efficiencies and broadband levels. This is crucial for individual anchors to understand more fully the situational context in which they provide Internet access and services, including any successes, deficiencies, and inefficiencies. Such knowledge not only impacts their ability to more effectively adopt and management broadband technology but also impacts their ability to obtain addition funding resources through BTOP, E-Rate, and other government subsidy programs.

Anchor institutions should consider whether an upgrade in broadband capacity actually translates into meaningful broadband data transmission speeds at the level of individual workstations. A key evaluation metric of success will be the number of extant workstations with connection speeds of less than 768 kbps down and 200 kbps up versus the number of workstations that meet or exceed these speeds after adoption of new higher speed broadband connections. Without careful planning and implementation, it is possible that an upgrade in broadband connection still may not meet the FCC requirements for broadband connectivity at the level of the individual workstation. Poorly designed and deployed networks serving too many workstations, wireless routers, and bandwidth-intensive applications can result in the anchor institution still possessing data transmission rates too low to meet the FCC standards for broadband connection speed at the

workstation. This is especially true in anchor institutions such as public libraries and public schools where countless users access the network at one time, many of whom rely on the institution to access bandwidth-intensive applications such as file-sharing, Web 2.0 tools, and E-government forms and services. In such instances, additional onsite assessment may be necessary to re-configure the technology or improve the overall telecommunications infrastructure and capacity for data transmission.

Anchor institutions in other states may have access to GIS, statewide school, library, hospital, and other Internet connection data files and can produce maps depicting the Internet connection speeds and costs for in their state. This process may be facilitated by the nationwide broadband data-mapping project currently being implemented by NTIA. In addition to mapping
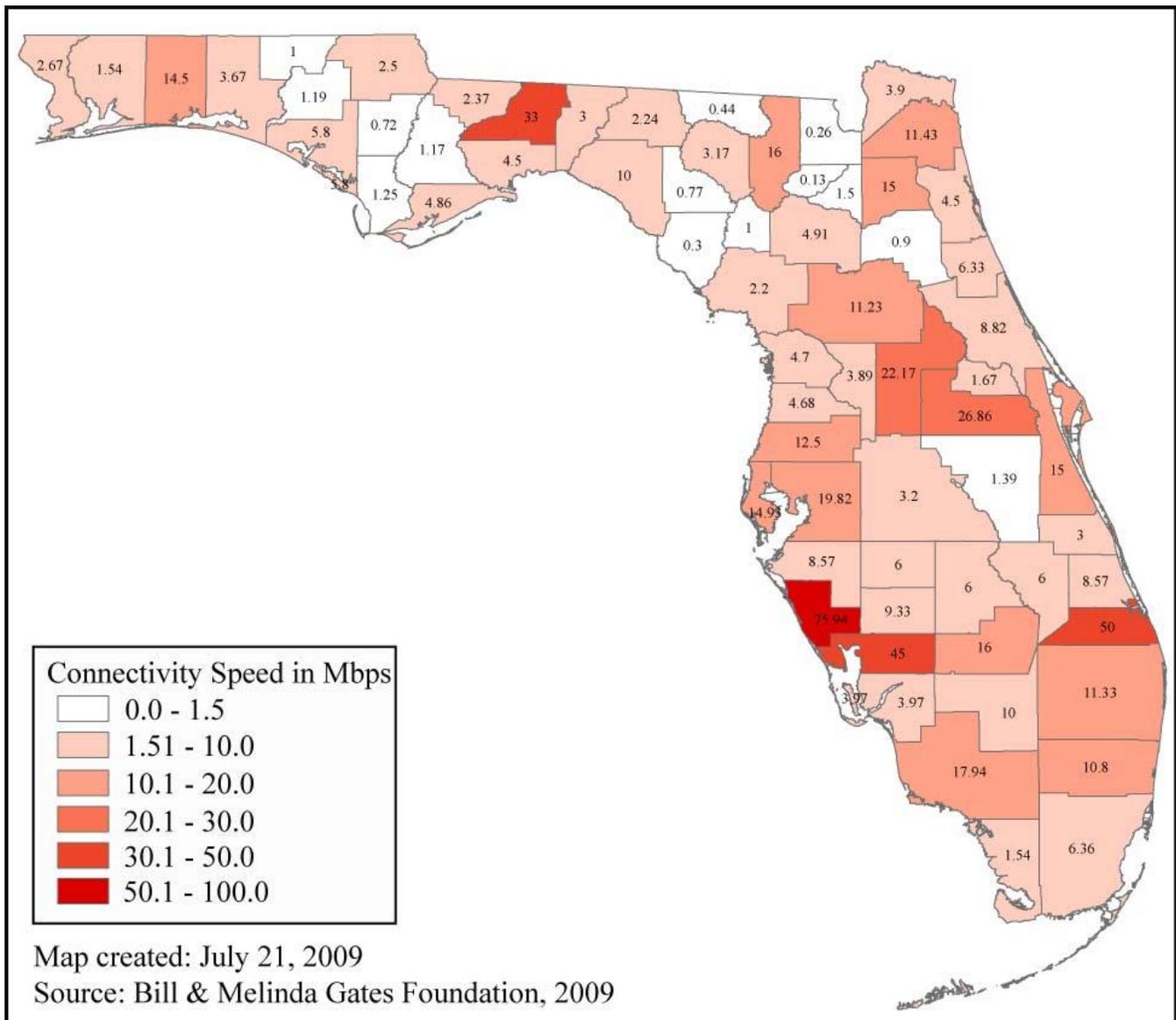

Figure 1. Average connectivity speed for all public library outlets by county: Florida 2009.

Internet connectivity, other anchor institutions may employ the methodology discussed here to better understand the situational factors impacting Internet access and broadband-enabled service provision. Ultimately, this study demonstrates situational factors can be identified, assessed, and planned for prior to the adoption, or upgrade, of high speed broadband. Furthermore, this study shows the necessity of a thorough institutionally-specific assessment of situational factors prior to the adoption of high speed broadband.

4. DIRECTIONS FOR FUTURE RESEARCH

Considering the social and technical factors that influence the technological innovation process, there are several research agendas through which iSchools can assist anchor institutions in successfully adopting and implementing new forms of ICT such as high speed broadband. These can be approached through the following research questions:

- What kinds of planning and evaluation activities should be included in anchors' assessments of needs and planning, as well as the development of funding sources and acquisition strategies?

- How much and what kind(s) of information are necessary for anchors to plan for broadband deployment and adoption?

- By which metrics can anchors assess the level of fit between broadband and the institutional goals it is attempting to address through high speed broadband adoption, and which of these metrics are most appropriate?

- Which resources (e.g., funding, staffing, and government support) do anchors need in order to sustain higher levels of broadband service, and how much of these resources are necessary to sustain different levels of broadband service?

- How do federal, state, and local information policies and regulations affect the success with which anchors can access and deploy broadband?

- At what point is the return on investment of in-house knowledge for broadband deployment low enough to make external expertise the more efficient investment of anchors' resources?

The preceding list offers questions intended to begin the discussion of such agendas. An understanding of the issues associated with technology innovation serves as a necessary foundation from which iSchools can investigate these questions.

5. CONCLUSION

The deployment of high-speed broadband to underserved and rural communities is a crucial technological innovation if such communities are to achieve the economic and social benefits of the so-called Information Society. Without the successful adoption and implementation of high speed broadband, many communities will be unable to make use of services such as VoIP, streaming media, and interactive applications that are almost ubiquitous in many locations across the globe. As the federal government looks to community anchor institutions such as public libraries, schools, and medical facilities to serve as local foundations for high speed broadband deployment, it is imperative to understand better the social and technical factors that will impact the successful adoption of such technologies.

This paper provides a review of selected literature in technological innovation as a means of highlighting how technology characteristics, intra-organizational issues, and the broader innovation environment impact the ability of anchor institutions to successfully adopt and implement high-speed broadband. Furthermore, it has described a case study of public libraries in Florida that illustrates how to assess the social and technological need for high-speed broadband at the level of anchor institutions. While the findings of this case study are not generalizable to other states they are suggestive of issues likely to be in place in other states. The methodology it employs can be a useful guide for anchor institutions in other locations. Such studies are especially crucial as anchors seek to assess and understand the situational contexts in which they provide Internet access and services prior to seeking funding through BTOP, E-Rate, and other government programs. Finally, the discussion presented in this paper highlights the fact that the interests, skills, and expertise possessed by iSchools make them well positioned to play a role in assisting anchor institutions such as public libraries, schools, and medical facilities increase their ability to successfully adopt new broadband technologies as well as the applications and practices they enable.

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