

Pre-Publication
Subject to Further Technical and Editorial Correction

Fiber to the Library

**How Public Libraries Can Benefit From Using
Fiber Optics for their Broadband Internet Connections**

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June 2009



ALAAmericanLibraryAssociation

Office for Information Technology Policy

Fiber to the Library: How Public Libraries Can Benefit From Using Fiber Optics for their Broadband Internet Connections

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I. Introduction

Broadband access to the Internet is enormously important to fulfilling the mission and role of libraries in the 21st century to serve the American public. People of all ages and backgrounds increasingly depend upon the local library's public access computers and Internet access and support to search for jobs, take classes, complete homework assignments, obtain medical information, and receive government information and services. A local library's Internet capabilities can also play an essential role in disaster planning and the provision of emergency services, also essential for the public's well being.

Unfortunately, the ability of local libraries to meet these community needs is in jeopardy because of the lack of adequate broadband capability. Several recent news accounts report that library users are waiting in line to use public access computers,³ and research indicates that more libraries have insufficient broadband connections.⁴ Libraries depend on broadband not just to provide public access to the Internet but also to conduct their basic operations including circulation, cataloging, and interlibrary loan. Traditional telecommunications services are likely

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³ Richard Cowen, "Free Resources Draw Residents to Libraries," *The Record*, March 17, 2009. Accessed March 24, 2009, www.lexis.com; "Business Brisk at Area Libraries: In Bad Times, Free Resources are a Hot Commodity," February 2, 2009, available at <http://www.washingtonpost.com/wp-dyn/content/article/2009/02/01/AR2009020102331.html?hpid=topnews>. Accessed June 12, 2009; *Job-seeking in U.S. Public Libraries*. (2009). Public Library Funding & Technology Access Study, <http://www.ala.org/ala/aboutala/offices/ors/plftas/Issues%20brief-jobs.pdf>.

⁴ "Public Library Funding & Technology Access Study" findings available online at <http://www.ala.org/ala/aboutala/offices/ors/plftas/connectivity09.cfm#F4>.

to be delivered by the same pipe that brings Internet access into the library. These multiple uses of the same broadband connection are combining to create severe congestion difficulties.

The public need for Internet access will inevitably grow and raise more challenges for library connectivity in the next few years. The advent of streaming high-definition video over the Internet, the increasing prevalence of online job training and employment applications, consumers' increasing need for e-government services, and the growth in the number of computer terminals and wireless laptop computer users all point to the likelihood of a tremendous surge in use of libraries' Internet access. Rather than waiting for the need to materialize before beginning technology planning, libraries are better served by anticipating need and seeking forward-looking solutions today.

For all these reasons, libraries should strongly consider moving to a fiber-based broadband platform for the broadband service needed to serve the public. From a technical perspective, fiber optics are the most robust technology currently available. In contrast to other technologies such as DSL, cable modems, wireless, or satellites, fiber optic technology yields almost unlimited capacity. A fiber connection gives the library the flexibility to introduce new, innovative services and to adapt to the future information needs of its community. In some cases, the costs of a fiber connection may be in the same range as obtaining multiple T1 circuits, yet fiber can offer much more bandwidth, and it can be easier to add even more capacity simply by changing the electronics at either end of the fiber cable. For many libraries, fiber is the technology of choice for the 21st century.⁵

Some libraries have already been able to obtain a fiber optic circuit for their broadband connection. In Michigan, for instance, 14% of libraries have a fiber connection today, and Jackson County libraries in Michigan are putting fiber in place this year.⁶ Fiber has been built to serve the libraries in Beaver County outside of Pittsburgh, Pennsylvania. Fiber is also being used by libraries in a number of other states, which include Tennessee, Wisconsin, California, and Mississippi.

The process of obtaining a fiber connection may not be easy, however. For example, there is no standard process for ordering a fiber circuit or leasing fiber capacity. The ability of a library or consortium of libraries to obtain fiber connectivity will vary from location to location and will often require the library to explore several avenues. There must also be sufficient middle mile or backhaul capacity to the Internet to accommodate the Internet traffic.⁷

⁵ As explained in more detail below, the costs of obtaining a fiber connection can vary significantly from location to location and from provider to provider. Terrain or other issues can cause fiber optic solutions to be cost prohibitive in some remote locations. See Appendix B for a discussion of using a satellite as an alternative to fiber optics.

⁶ Based on an interview with a leading broadband provider in Michigan.

⁷ In its Rural Broadband Report, the FCC described "middle mile" facilities as "the facilities that are commonly used to connect the "last mile" ISP with an Internet backbone service provider." (p. 48). See also, "[A]n ISP providing service to subscribers in a rural area must obtain connections to a node of an Internet backbone service provider.

Although challenges exist, libraries also have available a variety of options to satisfy the need for fiber connectivity to serve the public. In some places, libraries can obtain a fiber connection directly from their local telephone or cable company, a fiber builder, or an Internet Service Provider (ISP). Other libraries fare better by partnering with nearby anchor institutions in a municipal-wide network, or they can contract with their state research and education network for a fiber connection.⁸

ALA has prepared this document to assist libraries in understanding the benefits of fiber optic technology and to suggest strategies that they can use to explore obtaining fiber connectivity. This paper does not presume to be a comprehensive and detailed road map for obtaining fiber. The variety of circumstances in each location will vary significantly. Nevertheless, this paper attempts to address at a high level some of the basic issues involved in obtaining a fiber connection. ALA encourages every library to explore a fiber-based solution to its broadband needs. ALA hopes that this paper will provide basic information to make it easier for libraries to upgrade to fiber connectivity in the near future.⁹

II. The Basics of Fiber Optic Cable Transmission Technology

A fiber optic line is a thin strand of glass that is capable of carrying data in different wavelengths of light. Most non-fiber technologies can carry data at rates of 1 Megabit per second (Mbps) to perhaps 200 Mbps. In contrast, a single strand of fiber can carry at least 10 Gigabits (10,000 Megabits) per second. Furthermore, a single fiber optic cable may carry several fiber strands, so the true capacity of a fiber optic cable is virtually unlimited. The actual transmission speed depends upon the electronic equipment used at either end of the cable. To upgrade the speed, it is only necessary to change the electronics; no change is necessary to the transmission cable itself. For these reasons, fiber optics are often described as a “future-proof” technology.

Fiber optic cables are increasingly becoming the standard technology of choice. In the U.S., fiber optic cables long ago replaced microwave and satellites as the primary transmission infrastructure for long distance telephone and Internet traffic, and most large businesses and universities already have fiber connections. Many municipalities are deploying fiber to serve anchor institutions (schools, hospitals, city governments, and sometimes libraries), and many new housing developments install fiber in the ground to serve each household. Japan and Korea

The facilities making this connection are among those commonly referred to as “middle-mile” facilities.” FCC Rural Broadband Report, p. 67.

⁸ It is not recommended that libraries seek to take on the task of installing or owning their own fiber network, as the total costs of ownership and maintenance are likely to be beyond the libraries’ capabilities. This paper uses the term “obtain” a fiber connection to mean that the library receives a fiber-based circuit from a third party – either a commercial or government provider.

⁹ The Community TeleStructure Initiative (CTI) first identified “Fiber to the Library” as an important national goal in 2007. Under the leadership of Don Means, Founder and Principal of Digital Video Associates, CTI held a workshop in Sausalito, California to demonstrate the benefits of fiber to the library. See <http://www.telestructure.com/index.html>.

have implemented national programs to install fiber to the home, and several European (Sweden, the Netherlands, France) and Oceanic (Australia and New Zealand) countries are beginning to do so as well. Most experts now recognize that every home, business, and institution that serves the public will require a fiber optic connection to handle their technology needs in the foreseeable future.

III. The Benefits of Fiber to the Library

There are two ways to think about the benefits of fiber connections to libraries. First, fiber is exciting because it allows the library to introduce new services and applications that it may have previously been unable to provide because of limited bandwidth. Second, libraries may need to obtain fiber simply to provide adequate bandwidth for current services that are subject to increasing bandwidth requirements.

Libraries that have a fiber Internet connection can think beyond basic services. With reliable, high-speed connections, libraries are incorporating interactive Web-based applications to engage their users. Libraries are adding podcasts of book talks, video-on-demand, geo-tagging of local landmarks, patron tagged catalogs, and tweets of the latest fiction. Young Adult librarians are asking teens to post book reviews on blogs and wikis; many hold live chat sessions or provide a platform on their websites for teens to have discussions on issues with which they are concerned. Innovative programming can include holding webinars, streaming video of community events, and providing real-time video conferencing for distance education courses. A fiber connection also permits equivalent upload and download speeds, which is distinct advantage compared to some other technologies such as DSL and cable modems that do not provide as robust uploading capability.

Upgrading to a fiber connection may soon be necessary simply to keep up with the changes in technology and the public's growth in data needs. To take one example, the nation recently converted from analog to high-definition video signals. The advantage of this is that the quality of a video will be much higher than it is now. The disadvantage is that real-time job-training videos or distance learning classes transmitted in high-definition format require much more bandwidth than today's video signals. For instance, a single real-time high-definition video stream over an Internet connection may require 2.5 Mbps of service, which is larger than the entire T1 connection many libraries have today.¹⁰ An increasing number of websites have video clips embedded into their home pages, which means that simply surfing the web requires significant bandwidth.

Furthermore, many libraries report that, when they add a second T1 line, the additional capacity becomes filled up immediately, an indication that there is pent-up demand for greater bandwidth. E-government services and employment, career and business information are driving much of

¹⁰ *Public Library Funding & Technology Access Study 2008-2009*, preliminary report available at <http://www.ala.org/ala/aboutala/offices/ors/plftas/connectivity09.cfm>.

this demand. In addition, to reduce their costs, many companies and government agencies are requiring that consumers apply for jobs or government benefits online rather than in person or over the telephone. While this may save them money, they are, in effect, shifting the burden onto libraries, often the only source of free Internet access in a community.

These trends indicate that libraries cannot just maintain the status quo. Simply relying upon existing broadband connections that provide less than high-speed capacity will inevitably mean that libraries fall behind.

Many libraries that encounter an increase in demand for Internet access often simply add a second T1 (1.5 Mbps) connection or upgrade to a DS3 (45 Mbps) connection. In many cases, this may not be the best choice. Adding a second T1 or upgrading to a DS3 line requires that the library upgrade its network hardware, such as purchasing a new router or an additional serial interface in an existing router, at a potential cost of \$5000. Rather than incurring these costs with technology that will likely be inadequate in just a few years, it may be wiser in the long run for the library to obtain a fiber connection that could last for decades.

IV. Fiber-Connected Libraries: Personal Testimonies

The following stories are drawn from librarians or network managers at libraries that recently converted to a fiber solution. These anecdotes emphasize the frustrations that libraries experience trying to keep pace with the increasingly bandwidth heavy applications and websites their users are accessing. More importantly, they illustrate the relief librarians feel when they have the bandwidth to accommodate their users' needs.¹¹

We had so many problems with up/down service with the old circuit that I was about to pull some wire and put some tin cans on it ... Fiber has definitely made a positive difference for our library. [W]e will have to explore a larger circuit due to the extreme overuse of the new circuit (already), but I am pleased as far as up/down time is concerned.

... a library with twenty PACs [public access computers] needs more than a T1. Before everything on the Internet was video [high-speed wasn't necessary], now everything is video and one PC on Disney.com can take up a T1... Libraries are getting busier with the economy's downturn, this shows in job searching.

Before we made the move, we had frequent daily periods when our ILS [Integrated Library System] was down for hours at varying branches because there was insufficient bandwidth... If your branch had not been able to connect to [the ILS] during the

¹¹ These anecdotes originate from personal phone conversations and e-mails between the authors and staff in libraries that recently implemented a fiber optic Internet connection. The quotes are from rural branch libraries, metropolitan branch libraries, and a network manager of a metropolitan system. The information was gathered in April and May 2009.

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extremely busy after school hours you were usually not going to be able to connect until after 5:30 each day when branches started closing for the day. Branches had to write down circulation information and enter it after peak network hours. Although we had this great automation system, at times, we were working as though we didn't have it, simply because we had insufficient bandwidth...

[S]ince all traffic was routed through Headquarters, the public computers users were affected as well. Pages were slower to load and to respond. Patrons needing assistance from the reference staff in locating information were not helped as efficiently... Users using our ILS catalog from home had slower response time. It affected all users- both staff and patrons. . . . Once we upgraded [to fiber] all of those problems were solved.

...we are able to have enough bandwidth to take care of the [ILS] needs, 13 patron PACs, and 3 OPACs [Online Public Access Catalogs] plus staff and any wireless patron-owned laptops (referring to a shared fiber system)

The larger pipes (6 Mbps) afford the regional library system faster speed, better connections, and more reliability. Interestingly, whenever we introduce bigger and faster connections, the bandwidth used in those connections is almost immediately “used up” by our Internet-loving patrons.

One non-profit fiber company described what one of their libraries is able to do now that they installed fiber: “the library is partnering with a state employment and training agency (name withheld) and setting up video conferencing for job interviews. So people come to the library to practice and do actual interviews.”

V. Fiber Deployment Options

There are a variety of models of fiber network deployment, and there is no “one-size-fits-all” solution even once a library has decided to obtain fiber. There are at least four scenarios:

A. Leasing a Fiber Connection from a Commercial Provider

One way for libraries to obtain a fiber connection is to contract with the local telephone or cable company or other commercial provider. The commercial provider may already have deployed a fiber network in the community, and it may be only a short distance to connect the library to that network. In most instances, however, the provider may prefer to provide a specific amount of bandwidth without specifying the technology. The providers often provide standard contract or tariff rates for different levels of bandwidth. It may require negotiation with the provider to find a mutually acceptable fiber solution.

Some telephone companies (e.g., AT&T and Qwest) are deploying fiber to the node, a network architecture that can be useful to a library. In this type of network, the telephone company deploys fiber from its central office to a cabinet (or a node) in the neighborhood, and copper is

used from the node to the library.¹² The library can most likely use existing routing and switching equipment, although some reconfiguration should be expected.

A fiber to the node network can deliver higher bandwidth than would be available on a pure copper circuit, and for that reason can provide a worthwhile first step for libraries. However, the remaining “last mile” copper segment between the library and the node restricts the capacity of the circuit. From the perspective of “future-proofing” the library’s network, bringing fiber all the way to the library’s door is a better long-term solution than a fiber to the node solution. A library should work with other anchor institutions in its vicinity to advocate as often and as loudly as possible to convince the service provider to deploy a fully fiber-based solution.

B. Using a Competitive Bid Process to Award a Contract to Serve Multiple Libraries

Another approach is for libraries to solicit competitive bids from among commercial providers for a fiber-based solution. Rather than build a single fiber optic cable to serve an individual library, a group of libraries may choose to develop a region-wide fiber network that will serve multiple libraries.

Building a regional library network can save costs and provide more efficiencies in at least two ways:

- a. A “bulk” order is likely to yield a less expensive price per library.
- b. Multiple libraries can aggregate their traffic to a central hub. The costs of the hub can be shared and the direct link to the ISP can also be shared, thereby reducing the transmission costs.

For instance, one main library with four branches in Tennessee used a competitive bidding process among several local telecommunications providers. This library system switched to fiber in 2007 securing a 100 Mbps connection at the main library and 10 Mbps at each of the branches. In this example, the provider that won the contract is a certified E-rate provider and the library system is able to pay for the fiber connection with its E-rate discount.

Beaver County in Pennsylvania provides another useful example of a library system that opted to deploy fiber to all 11 libraries in its region. Prior to installing fiber, each library had a cable modem and 3 to 4 computers sharing the broadband connection. The fiber provider, not a telephone company, connected each of the 11 libraries with a fiber connection back to the main library located at the community college. The provider aggregated the traffic from all 11 libraries onto a single high-capacity connection to a “carrier hotel” in Pittsburgh, where it connected to the Internet backbone provided by Internet2.

¹² The fiber to the node option is most often possible in suburban locations where new construction includes fiber or where providers are switching copper systems to fiber.

C. Participating in a Municipal Fiber Network

The library may also be included in an overall municipal fiber project designed to serve other anchor institutions in the community. This scenario may be even less expensive than seeking bids from commercial providers simply because the number of additional entities using the fiber network is even larger. The city may also have easier or less expensive access to the rights-of-way than commercial providers. However, this municipal fiber network scenario depends upon convincing other institutions – namely the local government – to undertake such a fiber project.

Some municipalities have begun deploying municipal fiber networks to serve their communities, often including libraries. For example, the city of Rose Hill, Virginia deployed a fiber optic network in 2007 that provides high-speed Internet connectivity to 150 homes, the Rose Hill Elementary School, the Rose Hill Public Library, and several small businesses. Funding for this fiber network came from a variety of federal and state sources and was spearheaded by U.S. Congressman Rick Boucher.¹³

This solution depends upon community partnerships. Today, businesses, schools, social service organizations, healthcare facilities, governments, and of course, libraries, all require a robust and sustainable Internet connection to provide their services. All of these entities benefit from a fiber connection. The library can take the lead in establishing a community network. To be successful, it may be necessary for the library to look beyond its usual partners. Reaching out to the business community and small telecommunications providers can yield additional and unexpected allies. However, librarians should be aware that municipal networks that seek to provide services to the general public may find their attempts opposed by the incumbent telecommunications carrier or restrained in some manner by state utility commission regulations or state statutes.

D. Working with a State Research and Education Network

Over 30 states have non-profit research and education networks whose specialty is providing high-bandwidth networking capability to state government offices and other anchor institutions across the state.¹⁴ In Michigan, for instance, the Merit Network is a non-profit network owned by the public universities in Michigan. Merit provides a 1 Gigabit per second (Gbps) fiber connection to the Ann Arbor main library and also serves the other four libraries in the city.

In another case, a direct fiber connection was provided by a non-profit state research and education network owned and operated by the universities in the state. In this particular case, the upfront cost of providing the fiber to the library was only \$16,000 because a fiber cable had already been laid in the neighborhood, which meant that the length of the new fiber connection for the library was relatively short. The network provider investing in research and engineering

¹³ See http://www.boucher.house.gov/index.php?option=com_content&task=view&id=1119&Itemid=.

¹⁴ See <http://www.thequilt.net/>.

recovered the cost of building the connection by assessing a monthly charge to the library over three years.

VI. Financing the Library's Fiber Connection

Perhaps the biggest question concerning fiber to the library is the cost of obtaining and using it. It is extremely difficult in this high-level document to give even a range of costs for obtaining and paying for a fiber connection. The costs vary substantially from location to location and from provider to provider. An analysis of costs also must take into account both the up-front costs of deploying the fiber and the ongoing maintenance and/or leasing costs. Each library must make its own investigation of the prices of fiber-based service and additional associated costs that would be incurred.

In its research, ALA has uncovered anecdotal evidence that indicates that the costs and prices of obtaining a fiber connection can sometimes be more reasonable than previously thought. For instance, in our interviews of fiber deployment companies, we were told that the upfront costs to the fiber provider will often fall in the range of \$20,000 to \$40,000 in urban or suburban areas. The cost estimates varied significantly, however.¹⁵ Some libraries received price estimates of less than \$20,000, while others have received estimates well over \$100,000.¹⁶

For instance, if there is a fiber network already deployed nearby, the costs of extending that fiber to the library will be less. The costs will also vary from provider to provider. A company that specializes in deploying fiber (a “fiber builder”) may have lower costs than an incumbent provider.

In addition to the up-front deployment costs, there are several types of maintenance expenses. For instance, if the fiber is installed over telephone or electric poles (aerial fiber), there may be a small per-pole charge or some maintenance costs associated with storm damage. Also, most libraries choose to purchase a monthly maintenance contract as insurance in case the fiber is broken (for instance, by construction) or if the fiber needs to be moved (for instance, to accommodate a new highway or building). Libraries are not required to purchase such a contract and can choose to self-insure; however if the fiber is broken or needs to be moved, the costs can be significant – as much as the initial investment or more.

Another difficulty in estimating fiber costs to the library is that the cost to the service provider may be quite different from the price paid by the library. Many of the initial deployment costs are rolled together with the maintenance costs and both are recovered by the service provider in a monthly charge from the library. One provider charged the library a higher monthly charge for 3

¹⁵ See Appendix A for a description of some of the factors that affect the costs of deploying a fiber facility.

¹⁶ In general, the more remote the location of the library, the more likely it is for the costs to be much higher. Because the cost for fiber optic solutions varies depending on numerous local conditions, some libraries may need to seek alternative solutions. See Appendix B for a discussion of using satellite technology as an alternative to fiber optics.

years until it had recovered the up-front construction costs; at the end of the third year the monthly charge dropped substantially. Libraries will need to obtain specific price information from the provider of service before it can decide how best to pursue the fiber option.

There are several options for financing a fiber connection. In all cases, however, it is important to understand the total cost of receiving the service including: maintenance, fiber electronics upgrades, network monitoring, technical staff requirements, etc.

A. Amortizing the Cost in the Library's Monthly Payment

As discussed above, many fiber providers will recoup the costs of deploying the fiber connection by amortizing monthly payments. Some non-profit providers will only seek to recover their costs, and will reduce the monthly charges after receiving compensation for their construction costs over three or five years. Commercial providers, however, often seek to assess a monthly charge for use of the fiber without any end date.

B. Obtaining E-rate assistance

A library may be able to obtain E-rate discounts if it obtains commercially available capacities (services) from an Eligible Telecommunications Provider. The E-rate program, however, has many particular requirements. For instance, dark fiber is not currently E-rate eligible.¹⁷ It is also important to emphasize that the lease of fiber from a municipality is not eligible for receiving E-rate discounts.

C. Obtaining a Grant or Loan from the Federal Government Broadband Programs

The federal economic stimulus legislation (American Recover and Reinvestment Act – ARRA) provides a total of \$7.2 billion in funding for broadband connectivity. That Act divided the money between two programs – the National Telecommunications and Information Administration (NTIA) within the Department of Commerce is responsible for \$4.7 billion, while the Rural Utilities Service (RUS) within the Department of Agriculture is responsible for \$2.5 billion. NTIA's broadband program specifically mentions "libraries" in two places as eligible entities for this funding. As of this writing, the rules for both the NTIA program and the RUS broadband program are expected to be issued in late June or early July. The library community should follow these programs closely to determine their eligibility for obtaining a grant or loan.¹⁸

In addition to applying themselves for a grant or loan under one of these two ARRA programs, libraries should contact their local telephone company, cable company, or other service provider to determine whether or not their library can be included in any plans that the commercial

¹⁷ Dark fiber refers to laid fiber that has no electronics attached at the ends of the cable that would allow information packets, or traffic to be sent across it.

¹⁸ Detailed information about federal broadband stimulus developments may be found at <http://www.ala.org/knowyourstimulus>, a Web resource of ALA's Washington Office.

providers have to apply for a grant or loan. The ARRA programs have generated a lot of interest within the telecommunications industry, and many providers are considering applications for grants and loans. The ARRA specifically indicates that providing service to community institutions such as libraries is one of the key goals of the legislation. It is likely that including libraries in the application will increase the chances of receiving funding, so commercial providers have a strong incentive to work with libraries in their application process.

D. State Broadband Programs

Even before the passage of the ARRA by the federal government, several states have embarked on their own broadband funding programs. For instance, California, Idaho, Illinois, Virginia, and several other states provide funding to enhance broadband capabilities. Libraries should explore the opportunities for obtaining funding for a fiber connection through their states in addition to the federal programs. In anticipation of the ARRA funding program, many states are accelerating their state-wide broadband strategies. It is important that libraries participate in the development of such plans and are identified by states as a key priority by the state.

VII. Questions to Ask When Considering How to Acquire a Fiber Connection

ALA encourages libraries to explore which of these options provides the best strategy to upgrade their broadband capability. There may be some remote locations (for instance, in extremely rural areas) where libraries may need to seek alternatives to fiber (e.g., via cable, wireless, or satellite¹⁹). In many communities, however, some fiber deployment is likely to be both necessary and realistic. One of the scenarios above is likely to offer a solution.

Here are some of the questions that a library should ask as it explores a fiber strategy:

1. Is there a contract held by another entity (state government, higher education institution, county government) from whom the library can purchase service?
2. At the libraries you wish to connect, are there existing commercial providers who offer fiber-based services that you could purchase?
3. If there is more than one provider locally, do you have the resources and expertise to create a request for proposal (RFP)?
4. Is there an existing fiber network owned by a local or nearby municipality, utility or electric cooperative from whom you can purchase fiber capacity?
5. Is there sufficient middle mile capacity from the ISP to the backbone network to support investment in the last mile connection?

¹⁹ See Appendix B for more detail about satellite-delivered broadband.

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6. Do you have or can you hire the expertise to hire a fiber design engineer to design a network? If not, here are some additional questions to ask:
 - a. Is there a fiber node or a fiber network already in the community?
 - b. How far is the library from that fiber?
 - c. Who are the area's Internet service providers?
 - d. What kind of local and state telecommunications ordinances are in place?
 - e. What is the geographical make-up of the area?
 - f. Is the library in a rural, suburban, or metropolitan area?
 - g. Is the library part of a library consortium (i.e., county, regional, or state)?
 - h. Is the library part of a branch system?
 - i. What is the current technological infrastructure of the library?

In addition to questions about obtaining fiber to the library, the library should carefully assess its current capacity needs and understand the network as it is currently configured. Such a site inventory helps the library understand its bandwidth use today and anticipate its future needs. The answers to these questions will vary depending on the individual library's circumstances and will influence the costs of obtaining a fiber connection.

In order to take advantage of the ARRA broadband funding, which requires all the funding be expended within two years of receipt, libraries need to be able to estimate the time line necessary to complete a fiber upgrade project. A time estimate should be negotiated with the fiber company as part of the contract.

VIII. Conclusion

Fiber optic technology provides some unique capabilities that are unmatched by other transmission media. The capacity of a fiber cable is almost unlimited – a fiber connection is often capable of carrying several hundred Gbps, and may be easily upgraded by changing the electronic equipment used to transmit the data. As discussed above, the costs and processes of laying or stringing fiber are so closely linked to local circumstances libraries will need to understand what influencing factors are at play in their own communities. Strong leadership and a willingness to partner with people and organizations that can champion the library will help libraries of all sizes make the case for supporting a fiber to the library initiative.

Libraries need to be proactive and take advantage of existing resources that will inform them of the details necessary for establishing a fiber connection. Using publicly available information it

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is possible, in some communities, to determine where there are multiple carriers who could supply a fiber optic line and also where fiber is already laid. Libraries can use this information to estimate the costs of obtaining a fiber connection. In many cases, a library may find that it is worthwhile to pay a little more for a fiber connection because of the greater bandwidth that it provides, or because it will be easier to upgrade the bandwidth later on to accommodate future growth and service needs.

No matter whether a library negotiates with an ISP or fiber provider to obtain a fiber connection, decides to obtain a fiber optics network by partnering with other community anchor institutions, or whether it opts to connect to a local node, the library will need to have a clear site inventory prepared prior to starting the project. The inventory should include a plan to be able to meet future broadband needs as well as a plan to sustain the network. When negotiating terms of service with whoever provides the service, the library should address network maintenance, recurring costs, and accountability for end-to-end service. Fiber optics may be the surest path to adequate long term bandwidth capacity, but the library needs an equally sure plan for sustaining the connection.

Appendix A: Laying the fiber

In order to understand how a fiber company arrives at the fee structure it is helpful to consider the process of establishing a fiber line to the library. The company would begin the fiber to the library build-out with a preliminary site review. For a buried fiber to the library project this includes determining:

- how far the library is from any existing fiber
- if there are existing conduits in the library to reach to the existing fiber
- if the physical entry point at the library is adequate to pull fiber through existing conduits
- if the equipment room is equipped with appropriate power, space, and HVAC systems
- what kind housing for the fiber splicing is available
- if the library plans to network different libraries together

After a site review, the company engineers a plan for the library. Part of the design plan will address the time frame of the project as well as cost estimates. At this point, the company assesses the geography of the area to help establish the time and cost of laying the fiber; the more rock in the way, the higher the cost and the more time intensive the process, for example.

The company will need to acquire any necessary construction permits, determine public right-of-ways, negotiate any private easements, verify if there are construction moratoriums in place, and obtain any necessary waivers. For example, one community prohibits opening manhole covers every three years; prior to starting a fiber project, the company may have to obtain a waiver. Finally, the company will procure any equipment necessary to service the project.

Some fiber companies prefer to string fiber on telephone poles rather than invest in burying fiber cables. Though in some areas stringing fiber along already existing telephone poles may be the most cost effective and practical technique, it is still necessary for the provider to determine who owns the poles, whether there is enough room for an additional line, be granted permission to attach a fiber line, and at what cost. Wire clearances are determined by local, state, and federal regulations. Poles are not necessarily owned by the same entity nor are prices standardized. All of these intervening factors contribute to the time and cost of the fiber to the library project. These issues can be significant and the fiber company needs to be adept at working through them.

These are the costs incurred by the fiber company that affect the provider's total cost for the library. In addition, if there are any preliminary site renovations that need to occur within the library, those costs would most likely be the responsibility of the library but can be addressed in the initial contract negotiations.

Appendix B: Satellite options for broadband

A fiber optic Internet connection is not necessarily the right broadband solution for all libraries. In some regions of the country libraries may find that their best broadband alternative is via satellite.

From the perspective of a rural library, a satellite connection operates similarly to a hybrid copper/fiber connection with an Ethernet hand-off. The satellite provides access to the Internet up to the library's 'door' and a satellite modem 'translates' the signal to an internal Ethernet network. In this case, the satellite company routes incoming information (packets) via microwave signals sent from its own satellite dish to a satellite orbiting the earth and back down to the library's dish. From the library's satellite dish the signal goes through a satellite modem that connects the computers to the satellite network. The process is reversed for outgoing information. Upload and download speeds vary depending on the satellite provider and the packages it offers. Download speeds are often faster than upload speeds with one company offering 1.5 Mbps down and 256 Kbps up and another company offering 5 Mbps down and 300 Kbps up (\$95.90 per month and \$349.99 per month plus installation respectively). In addition to the monthly service fees, there are several initial one-time fees: an installation charge, a "start up" fee for activating the service (for example, \$99.95 for lease start up costs); and an equipment cost for the satellite dish, modem, cable lines, and internal routers.

Satellite service is available virtually throughout the United States and is not dependent on an existing fiber or cable line being in the area. It does, however require a clear view of the southern sky to be able to send and receive signals from the orbiting satellite.²⁰ While satellite is a solution for communities for which fiber is cost-prohibitive, it is not future-proof. Because of the transmission technology, there is often at least a half-second delay (latency) between the time one end user sends a piece of information out and it is received at the other end. The delay is unavoidable because satellites are located 22,000 miles above the earth's surface. In practice this can interfere with the streaming of a video or disrupt interactive games. Users will notice a decrease in performance with these bandwidth-intensive applications. In addition to latency issues, weather can also affect quality of service and speed with satellite.²¹

²⁰ For more information and comparisons of Broadband options see: High Speed Internet at <http://www.high-speed-internet-access-guide.com/>.

²¹ See http://www.wildblue.com/aboutWildblue/qaa.jsp#5_6 for an example of one satellite provider.

Anticipated Additions for the Final Publication

- Acknowledgments (there have been many contributors)
- Summary letter
- Photos / illustrations / figures / charts