Madison County Broadband Recommendations

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DESIGN NINE
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The telecommunications business is continually evolving. We have made our best effort to apply our experience and knowledge to the business and technical information contained herein. We believe the data we have presented at this point in time to be accurate and to be representative of the current state of the telecommunications industry. Market changes and new technology breakthroughs may affect our recommendations over time.

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Executive Summary

This Broadband Study for Madison County is intended to serve as a reference for decision-making. From it, patterns of support, activity, leadership, opportunity and next steps begin to emerge.

Over the next thirty years, the businesses, residents, and institutions of Madison will spend, very conservatively, more than $282 million on telecommunications services (voice, video, and data). This estimate (see the ***Costs*** section of this chapter) is based on current average expenditures, and does not consider what is expected to be rapid growth in new kinds of services (e.g., tele-medicine, tele-health, IP-based security applications, video on demand, online games, and many other emerging business applications and services). If these future services were included as part of the financial projection, the total spent on telecommunications in the Madison area would probably exceed $400 million (over 30 years).

The most evident recommendation that emerges from this study is that if the county is to meet its longer term economic and community development goals, wider (universal) access to broadband services with a wide choice of services at affordable price points must be available to institutions, businesses and homes.

While much information has been gathered and presented here, the local economy is complex, dynamic and changing. Therefore, this document should be regarded in part as a snapshot of broadband and telecom activities, and the information and recommendations provided should be reviewed, updated, and modified as local conditions, opportunities, and projects evolve.

As part of the work, two surveys, one of residents and another of businesses, was conducted. Findings from those surveys include:

- 52% of residents report that they are still on dial-up, which is much higher than the national average of 37% (from a 2009 study by Pew Research).
- 99% of residents that use the Internet in Madison county report that it is "Very Important" (73%) or "Somewhat Important" (26%).
- 73% are "Not at all satisfied" or "Somewhat satisfied" with their current Internet service.
- 76% report they are still on dial-up because they have no broadband options.
- 88% of residents indicated they want more choice in Internet service options.
- 29% of respondents report using VPNs (Virtual Private Networks) to access company work and data from home.
- 34% of residents report working from home part time (26%) or full time (8%). Another 34% report needing nights and weekends access to the workplace from home.

Some of the comments from residents include:

"...dial up is much too slow."

"We need broadband access--not available here without satellite..."

"BROADBAND BROADBAND BROADBAND!!!! Reliable broadband Internet connectivity would enable me to work more effectively at home - in particular video and other conferencing (netmeeting)....It is the single most significant improvement in infrastructure that can be made in the county today."

"I have (satellite) and every time the weather is bad it shuts me down. I run several businesses out of my home and I take online courses and this makes it very hard for me."

Business respondents to the survey provided additional information:

- 31% are "Not at all satisfied" with their current Internet service, and another 23% are only "Somewhat satisfied."
- 46% of businesses already use the Internet to receive orders and payments.
- 31% use video streaming, videoconferencing, and video on demand for business.
- 62% of business respondents report that the Internet is "very important" to the success of their business.

Comments from business respondents include:

"Really wish we could have fiber optic service. Our needs for data would be satisfied in every respect...."

"Main issues are bandwidth/speed....top speed is about 756K down and 1500K up..."

"...(need) speeds faster than 750K."

"ability to purchase broadband, phone, and TV packages bundled together."

"Just speed. And availability in remote, mountainous locations."

The fundamental challenge for the area is to ensure that businesses, government, and residents have a modern, twenty-first century digital ***transport system***. In the twentieth century, communities devoted much time and effort to the development of transportation systems needed to support growth in jobs and commerce. These transportation systems included railroads, highways, and airports. The Internet has rapidly changed the fundamental nature of many kinds of products and services--whole industry segments no longer need the same kind of transportation systems.

As an example, the Kindle, an ebook reader being sold by Amazon, is getting rave reviews, and Amazon has released a version for the iPhone. The surging popularity of this new device suggests that we may be seeing the beginning of the end of the era of the book as we know it--a paper-based item. As devices like the Kindle mature, books will become less expensive and more accessible--if book users have affordable access to a broadband network.

The Internet is a transport system that is making many other information transport systems obsolete. First it was music; vinyl records and CDs are not about the music itself, they are

simply a transport system to get the music to the buyer. Video stores are on the way out, as Netflix and Blockbuster, by using the Internet, are making the video cassette and DVD transport system obsolete. Newspapers are beginning to collapse, as the news-PAPER is just a transport system for reporting the news itself.

The news and journalism business, like the music and movie business, will survive and even prosper, but the underlying business models are collapsing because we don't need four different transport systems: one for music, one for movies, one for news, and one for books. The old-style analog telephone and TV "transport systems" are not needed either. So there is a total of six separate telecom transport systems we no longer need. A single, modern, shared broadband transportation systems handles all of those products and services efficiently and at very low cost.

And that's why every home and every business needs a high performance broadband connection; without it, residents and businesses of Madison might as well be living in 1400--before books, before newspapers, before any information distribution systems existed.

A shared countywide digital transportation system will not do away with private sector providers--these firms are vitally needed to continue providing the services they already offer--telephone, video, news, Internet access, business class services, and other residential and business services. The focus of this study has been to analyze the potential for the region to collaborate on the development and deployment of a modern, world class digital transport system that will meet the needs of the region's world class businesses for the next twenty to thirty years.

In the past several months, we have spoken to and received comments from a wide variety of area businesses, residents, educational institutions, local governments, and civic organizations.

Madison county has significant assets and advantages. These include:

- Excellent quality of life – Abundant possibilities for rural living and a historic Main Street in Madison (unlike many suburban communities) can be an economic development attractor, especially for self-employed businesspeople and entrepreneurs.
- Excellent recreational activities – The area has superb outdoor recreational activities, including extensive hunting opportunities, hiking, and other outdoor opportunities.
- Rich history – The region has a rich set of traditions and history dating back to the early 1700s that adds historical interest to the county and enhances the quality of life.

In our meetings with the Madison Broadband Management Team, we heard a real commitment to maintain the quality of life in the county and to improve and enhance the ability of businesses and residents to communicate effectively via affordable, high performance broadband services.

Given the rural nature of the county, commuting costs due to energy increases will encourage more work from home and business from home activities. Traffic and commuting patterns will change, and these shifts in commuting patterns may suggest different budgeting strategies for community infrastructure improvements and investments. As fuel prices continue to rise, a slow but steady increase in the number of home-based jobs and businesses is being driven by the corresponding increase in the cost of commuting. But home-based workers and businesses will require more than the current residential broadband services; business class broadband will become increasingly important as the area's small towns, neighborhoods, and rural roads transition to daytime business districts.

Residents and businesses are increasingly content creators, not just content consumers. This shift in locus of content development also means that both residential neighborhoods and existing commercial areas of the region require much higher performance networks with symmetric bandwidth to accommodate content creation.

World class broadband infrastructure will be necessary to maintain the county's attractiveness as a great place to live.

Next Steps

Next steps include:

- Read and review the three reports (Needs Assessment, Maps and Survey Results, and this report).
- Identify key ideas and concepts that may be important to future economic and community development initiatives.
- Meet with local leaders to discuss these key ideas and concepts in more detail.
- Consider requesting broadband stimulus funding, with a focus on funds that will be available from the Department of Commerce NTIA program. Final rules for submitting requests for the second round of funding should be issued by early to mid December, 2009.
- If leaders and stakeholders believe that telecom and broadband investments are needed to support the long term goals of the county, a project team should be assembled to move the effort forward.

Key recommendations include:

- ***Work with existing services providers*** – Given the rural nature of most of the county, wireless broadband will play an important role in expanding access over the next three to five years. The county should work with existing wireless providers and try to attract new providers to create more competition, which in turn will encourage innovation in services and a wider variety of pricing options.
- ***Make modest investments in basic telecom infrastructure*** – County investments should be in basic telecom infrastructure, including real estate for

additional tower sites, open access towers provisioned by the county and leased to private service providers; lease payments will provide a revenue stream to help pay for the maintenance and upkeep of the towers. When water, sewer, and road improvement projects are undertaken by the county, telecom duct and/or fiber cable should be included as part of the project. Special attention should be paid to getting fiber routes out to tower sites to lower costs to service providers and to improve wireless performance and bandwidth.

- ***Enhance public safety services by basic telecom infrastructure investments*** – First responders, public safety services, and fire and rescue squads will benefit from county investments in wireless towers, which can provide not only broadband access but improved voice communications throughout the county.

A Vision for the County

The text below is presented as a sample of the kind of vision statement that will be needed if a decision is made to move forward with additional planning and eventual implementation.

Madison county will continue to work to attract new residents and businesses to the area because of the combination of great quality of life and the availability of good broadband services everywhere in the county.

By 2010, the County staff and departments will be leveraging current and new investments in wireless towers and basic telecom infrastructure that will support innovative, effective and efficient delivery of government services to citizens and businesses, including public safety data and communications needs of police, fire, and rescue services.

By 2013, every residence in the region will have affordable access to a broadband infrastructure with as much bandwidth as they need to manage their personal affairs, obtain access to world class tele-health and tele-medicine services, keep their homes safe, and have the same level and quality of access to online goods and services as any other community anywhere in the world.

By 2012, the region will have a workforce that is able to work full time or part time from home, using broadband to be connected to their corporate business systems. Students and workers will be able to study and train from home using the advanced broadband infrastructure to attend classes, learn new skills, and reduce commuting time.

Why Invest?

The promised impacts of broadband on communities have yet to be fully realized; widespread access to affordable, high performance broadband services in communities has the potential to transform work life by providing more flexibility and control over when and where work is done. Fiber-delivered, business class broadband services can be a powerful

economic development strategy that can help retain existing Madison area businesses as well as attract new ones.

World class network infrastructure in Madison area will provide local businesses with unlimited bandwidth at affordable rates, enabling them to compete aggressively in the Global Knowledge Economy. The region would be able to offer:

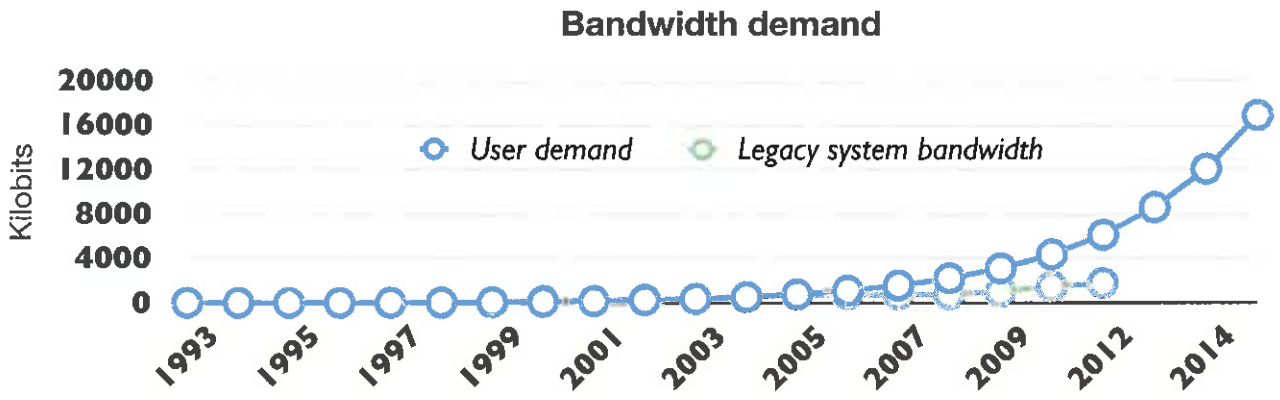
- A future-proof network infrastructure that offers abundant, affordable bandwidth
- Massive connections to the rest of the world
- Interoperability and support for a wide variety of information devices, including tablet and laptop computers, HD videoconferencing systems, converged home and business media systems, and support for wireless phones and next generation mobile devices.
- The potential to diversify the local economy by attracting more knowledge worker and knowledge economy businesses to complement the current strong manufacturing base in the region.

In addition to serving the employment base already in the area, the Madison communities will be attractive to an emerging new group of business-people that typically are well-educated, own their own businesses, and are making choices about where they live based on family needs and interests and the availability of affordable, high performance broadband. This new breed of entrepreneurs place a high value on the kinds of amenities that are already part of the region: mild climate, superb recreational activities, great small towns, good schools, and a sense of place.

Businesspeople and their families make decisions to stay in a community or to relocate based on quality of life and the availability of abundant and affordable broadband, because broadband is the enabler of these new Knowledge Economy businesses. Our discussions with local businesses and leaders suggests strong business support for a improved access to broadband and more affordable telecom services.

Area businesses and residents will face a substantial gap in network capacity and performance over the next five years. While other countries already are seeing congestion in 100 megabit fiber networks to the home and to businesses, the average bandwidth available to most businesses and homes in the U.S. is still hovering around 1 megabit.

Numerous data-based analyses have shown a consistent doubling of bandwidth every two years, which means the average home and business in Madison will want a minimum of 50 megabit symmetric connections by 2013. In the next three to five years, wireless access in the more remote areas of the county will be critical to achieving 100% broadband coverage. Over the long term, only fiber to the home and to the business will be able to provide the bandwidth that will be demanded by residents and businesses. The legacy copper-based networks have reached their limits and are already saturated–calls for network neutrality and "Internet toll gates" reflect a growing inability of current providers to meet current demand.



	Next 2-4 years	Next decade	Twenty years
Small business needs (1-9 employees)	5-25 megabits of bandwidth	100 megabits of bandwidth	Gigabit+ bandwidth
Medium-sized business needs (10-100 employees)	50-100 megabits of bandwidth	Gigabit bandwidth	Multiple gigabit circuits and lightpaths
Large business needs (100-1000+ employees)	Gigabit+ bandwidth	Multiple gigabit connections	Multiple gigabit circuits and lightpaths
Residential needs	25-50 megabits to the household (not to the neighborhood)	100 megabits of bandwidth	Multiple gigabit circuits and lightpaths

Businesses and residents will use this bandwidth for a wide variety of services, and the business survey indicated that area businesses are already using their broadband connections for these services, which include:

- Full support for HDTV for business and residential use (10 to 15 megabits/channel)
- Streaming video for business and marketing purposes
- Voice telephone services (multiple lines) and other VoIP-enabled applications
- Desktop management of business computers over the network
- Backup over the network of business data
- Worldwide flat rate local and long distance calls
- Business security services
- Business video conferencing, including the capacity to support HD quality videoconference sessions
- Business Web servers and services
- Telemedicine and telehealth services
- Delivery of business information and services from local servers

Costs

Over the next thirty years, the businesses, residents, and institutions of Madison will spend, very conservatively, more than $282 million on telecommunications services (voice, video, and data). This estimate (see the table below) is based on current average expenditures, and does not consider what is expected to be rapid growth in new kinds of services (e.g., tele-medicine, tele-health, IP-based security applications, video on demand, online games, and many other emerging business applications and services). If these future services were included as part of the financial projection, the total spent on telecommunications in the Madison area would probably exceed $400 million (over 30 years).

The very conservative estimates of expenditures included in table below indicate that there are substantial funds available for investment in a world class, high performance broadband network (the expenditures are not adjusted for inflation or for typical price increases). It would take less than 6% of those expenditures to build the world's best network connecting every business in Madison, and much of that cost would be financed by revenue derived from the users of the network.

County of Madison 30 Year Telecom Expenditure Analysis			
	Low to Middle Income Households	Middle to Upper Income Households	Households with no Internet
Total households	5,453		
Total businesses	317		
Percentage of households	40%	40%	20%
Number of households	2,181	2,181	1,091
Average monthly telecom expenditures	Local phone: $25 Long distance: $25 Cable/satellite TV: $45 Dial up Internet: $20	Local phone: $25 Long distance: $25 Cable/satellite TV: $60 Broadband Internet: $40	Local phone: $25 Long distance: $25 Cable/satellite TV: $45
Annual telecom cost/household	$1,380	$1,800	$1,140
30 year telecom expenditure	$90,301,680	$117,784,800	$37,298,520
Total residential expenditures	$245,385,000		
Total telecom expenditures [1]	**$282,192,750**		

[1] Business, schools, institutions, and government costs estimated conservatively at 15% of residential expenditures

When considering the costs of developing a network for Madison, it is important to keep in the mind that it is not just the cost of the initial build out that should be included in making a decision about whether or not to move forward. In fact, a thorough financial analysis should include a careful evaluation of the these factors.

- **Community telecom expenditures** – As shown in the previous table, community telecom expenditures, extended over period of twenty or thirty years, is an important part of the decision-making process. These expenditures provide an indication of the economic impact (positive and negative) of the cost of telecom services on businesses, government, schools, institutions, and residents.
- **Cost of build out** – Capital expenditures, or Capex, tends to dominate discussions of community broadband projects. While accurately forecasting capex is necessary, it is not sufficient to make a decision about whether or not to move forward.
- **Cost of operation** – Some community projects have encountered financial difficulties because they failed to accurately forecast the cost of operating their network once it was built. Management, financial administration, equipment maintenance, and maintenance and repairs of outside plant (duct, fiber, wireless towers) all must be considered as part of an accurate financial analysis.
- **Revenue** – Revenue is collected from service providers that use the network to deliver services and additional fees may be collected from the homes and businesses connected to the network (e.g. tap fees, monthly connection fees, pass by fees).
- **Cost of capital** – Most communities will use some form of borrowing to finance the build out of their network, and interest paid on loans and revenue bonds can be a significant expense.
- **Income** – Income represents funds left after capex and opex costs have been paid and the interest has been paid on loans. If projected revenue exceeds expenses over an acceptable period of time (e.g. 7 to 10 years), then the network is affordable, regardless of the amount of the initial cost.

First Mile Connectivity Analysis

Telephone/DSL

DSL (Digital Subscriber Loop) technology utilizes existing copper twisted pair telephone lines to provide broadband services. There are many variants of DSL, and the differences among them are primarily bandwidth and distance. Most DSL systems are limited to a maximum of 18,000 cable feet from a telephone switch or remote access module (DSLAM). Faster variants of DSL are limited to as little as a few thousand feet, making the service areas inconsistent from a subscriber perspective. A neighbor a few houses away from a home with DSL service may be told that no DSL service is available (because of the cable limitations). Current low cost DSL residential service offerings are priced competitively compared to cable modem service, but also tend to be much slower.

Because of the requirement to deploy DSL equipment close to subscribers, rural areas are at a distinct disadvantage for DSL. It is not uncommon in rural areas to have cable runs of many miles (from a telephone switch), making DSL impractical without substantial equipment upgrades. Another problem in rural areas is the age of the telephone cable plant. Even if a home or business is located within the prescribed distance to DSL equipment, older copper twisted pair cable may not be capable of handling the DSL signal properly. In some cases, speed of the service is degraded, and in other cases, DSL may not work at all.

The primary problem with DSL is the lack of capacity over the long term. In an optimum DSL situation, with high quality cable plant and subscribers close to DSL switches, the fastest DSL is limited to 15 to 20 megabits under these optimum conditions. Most homes will never be able to receive DSL services at those speeds because of sub-optimal service conditions. DSL cannot provide the capacity needed by businesses and residents in the near future.

Cable Systems

Cable systems that provide broadband in most U.S. communities use what is called HFC systems, or Hybrid Fiber Coaxial systems. Typically, fiber delivers television and broadband signals to equipment located in or near a neighborhood, and copper coaxial cable is used to connect the subscriber's home or business with the equipment fed by fiber. Cable systems have never been widely deployed outside community boundaries (residential neighborhoods and business districts) because of the high cost of placing equipment near subscribers. In this regard, cable systems are limited in the same way that DSL systems are limited, and rural communities are at a distinct disadvantage because of the lower density of homes and businesses.

Cable systems also cannot provide the future capacity that will be required by homes and businesses in the near future. Some cable companies have begun to announce pilot projects offering Internet access at speeds "up to 50 megabits." While this is an improvement over current offerings advertised typically at bandwidth "up to 6 megabits," this bandwidth is

always shared among all users on a node. It is not unusual to have between 100 and 500 users (typically residential homes) on a single node. The advertised bandwidth (e.g. "up to 6 megabits") is shared among all users on a node, meaning that the usable per household bandwidth during peak use times like early evening is much lower.

Cable modem service also typically has asymmetric bandwidth, meaning that the advertised bandwidth ("up to 6 megabits," or "up to 50 megabits") is only available on the downstream side, coming into a home. The upstream bandwidth available to users to send data and content is often 1/10th of the downstream capacity. This makes most cable modem systems unsatisfactory for many kinds of work from home services and applications that require more balanced upstream and downstream bandwidth, like videoconferencing, which works best if the bandwidth is symmetric (the same capacity in both directions). This issue of symmetric bandwidth will become increasingly important as the cost of fuel changes commuting patterns and more people want to work from home part or full time.

Satellite

Satellite broadband is a wireless technology, and to avoid confusion, systems like WiFi are often referred to as terrestrial wireless. Satellite broadband uses geostationary satellites located 22,500 miles above the earth, and data traversing a satellite system has a 45,000 mile loop (up and down). As fast as radio signals are, this distance still introduces latency (time delays) that can cause problems with real time transmission of telephone (VoIP) and videoconferencing. Bandwidth is generally less than what is available from DSL or cable systems, with a typical residential service offering 700 kilobits/second downstream and 128 kilobits upstream for between $55 and $65 per month. Higher speeds (e.g. 1 megabit/second downstream and 200 kilobits upstream) are also available for $10 or $20 per month additional.

If a home or business already has satellite television service, a second small dish antenna is needed for broadband service. Some companies have tried combining both services on a single dish, but this has usually had poor results because of signal and satellite position issues. Inclement weather (e.g. heavy rain, snow) can degrade or temporarily cut off satellite signals.

There are two primary providers of satellite broadband in the United States: Hughes Network Services and Wild Blue. Wild Blue has partnered with many rural electric coops, with the coops acting as sales agents and installers. Hughes uses independent small businesses as installers and resellers. Despite some limitations, satellite is an excellent broadband service option in underserved areas; no major infrastructure investments are required to obtain service, and speeds are much better than dial up, and in some cases may be equal to or better than entry level DSL service packages. Satellite is not a business class service option for Madison, and satellite still remains relatively expensive compared to wired or terrestrial wireless service.

BPL

Broadband over Power Lines (BPL) has been available for several years and can be used in several different ways. Some BPL equipment is designed for in home use, where a broadband signal delivered by DSL or cable is delivered to different rooms in a home or business using the electric wiring. To provide service to a neighborhood, some electric companies use a system similar to cable systems, where fiber is used to get broadband near a cluster of homes, and then the signal is carried over electric lines for the last few hundred yards or last mile or two. In some other systems, the signal is carried via electric cables all the way from a broadband head end.

BPL has many of the same limitations as DSL and cable modem services. It is copper-based, and is limited in the amount of bandwidth that the technology can deliver. It requires technicians who have extensive training and experience working with high voltage systems, since special bridges are installed at every neighborhood transformer (which also makes it a relatively expensive service). Some electric coops are considering BPL as a way to quickly provide some form of broadband to their rural customers. BPL's main advantage is that no new cable must be laid to deliver the service to a home or business. However, like DSL and cable systems, BPL is not a long term solution.

In a recent conversation with a rural electric coop that has been "experimenting" with BPL for more than two years, the coop representative shared that they were only able to achieve about 250 kilobits of throughput over distances of twelve miles. While 250 kilobits is better than dial up, it will not meet the long term needs of rural residents and businesses.

Fiber

Fiber is a future proof investment. The upper limit of fiber capacity has not yet been found, and off the shelf hardware can handle thousands of times the needs of an average home or business well into the future. Fiber has a life expectancy of thirty to forty years, and may last much longer than that; every year, the number goes up as fiber systems installed in the 1970s continue to perform adequately. A single fiber can carry all the traffic and services needed by a home or business, including voice telephone service, television programming, live videoconferencing, and HD television.

Fiber's primary drawback is its apparent high cost compared to other systems. Fiber is often unfairly compared to wireless, with the misleading conclusion that wireless is much cheaper. Regrettably, most fiber versus wireless studies compare the start up costs for wireless to the thirty year life cycle costs of fiber infrastructure. During a thirty year period, fiber is installed just once, while wireless systems will have to be replaced entirely several times. Properly costed over a thirty year period, fiber is actually less expensive than wireless, with many times the capacity.

Metro Ethernet is a point-to-point service provided over two fiber optic strands (single fiber technology is available but the hardware is quite expensive and still relatively unused). Metro Ethernet networks can deliver service as far as 25 miles from network element loca-

tions in speeds up to 10 Gigabits per second (10GB Metro Ethernet circuits may be available from some providers).

SONET or Synchronous Optical Network is a point-to-point technology usually deployed in a bi-directional redundant ring. Most carrier and tier 1 service provider backbones are configured in a redundant ring. A SONET ring is self healing (provided that only one link is cut). SONET circuits are considered expensive and are usually a last resort if other fiber optic services are not available.

A Passive Optical Network, or PON, is a fiber optic network based upon a splitter technology. A single PON port can support up to 64 customers utilizing either daisy chained splitters or a central splitter location. For service providers PON is cost effective as it allows the service providers to create "fiber light" networks and fewer network elements. However, PON has many drawbacks including bandwidth limitations due to the shared nature of the feeder fibers as all customers fed from a splitter share bandwidth over a single fiber (or single pair in some networks). A major drawback of PON is the upgradeability of the network which usually requires additional feeder fiber to be deployed which is costly as it is considered a "forklift upgrade."

Every business in Madison will eventually want fiber connections. Without ubiquitous fiber infrastructure, communities will not be economically competitive. Communities that already worry about losing too many young people to other areas have much more to worry about. In a recent college class, a professor asked 30 students how many would live in a community without broadband, and not a single student raised a hand. Fiber is the only transmission system that will be able to deliver all the services businesses and residents will expect and demand in just a few years. Communities that have not started fiber infrastructure investments by the end of 2009 will be at a severe disadvantage in the next decade when trying to attract and retain businesses and workers.

The Wireless Broadband Debate

We do not subscribe to the wireless vs. fiber debate. We believe both wireless and fiber systems are required in communities. Virtually everyone,within a few years, will have a very capable wireless device that supports phone service, email, Web browsing, gaming, TV, music and a host of other services. Residents and businesspeople will expect these devices to work everywhere; this means communities will need a well-designed wireless network of towers, antennas, and related systems, including fiber backhaul (fiber backhaul--some connection is needed to get the wireless signals onto the Internet from local wireless access points; fiber can be used to dramatically improve wireless performance by providing a very fast connection from the wireless radios to the rest of the network). Wireless systems work best when supported by a fiber backbone to carry traffic to and from its destinations. Fiber and wireless systems are complementary, not competitive.

Wireless is often touted as a broadband panacea. Across the country, many communities are rushing to offer some kind of wireless system. These municipal wireless systems often lack sustainable business plans, and many well publicized projects are beginning to have

problems. St. Cloud, Florida offers free wireless broadband throughout the County, but the quality of the service tends to be inconsistent, and many residents have refused to give up paid cable and DSL service. Philadelphia's well known project has found that more access points are needed than originally anticipated, raising costs and threatening sustainability of the project.

Current wireless systems lack the capacity to handle high bandwidth services like video when more than a few people are using the same access point. Systems like WiMax are very expensive, and while prices will decline, when costed over a reasonable life cycle, wireless systems are relatively expensive. Wireless systems are inherently less secure than cable based systems, and we never recommend that a business uses a wireless connection for its primary access unless no other alternative exists. The primary future use of wireless will be for mobile access to services, rather than fixed point access. In under-served areas, properly designed wireless systems are an excellent first step, but are not a complete solution over the long term. In Madison, wireless will be important over the next three to five years as a primary delivery system for broadband services in many parts of the county. Over time, wireless to the home will have to be replaced with fiber connections to meet demand, but wireless will remain important for mobile access to broadband (e.g. access to the Internet and email from mobile phones and laptops).

Wireless Technology Trends and Issues

Over the past several years, numerous communities large and small have attempted to build and operate municipal wireless Internet services. Large cities like San Francisco and Philadelphia have announced ambitious plans to build WiFi "blankets" to provide wireless Internet access to most homes and businesses. Smaller cities like St. Cloud, Florida and Sandoval County, New Mexico have also built municipal WiFi systems. There is now a wealth of lessons learned from these early efforts:

- WiFi is expensive if you truly want total coverage. Many WiFi projects have underestimated the number of access points that are needed--something that is causing problems with the much touted Philadelphia WiFi effort. Some contractors and vendors may be underestimating the number of access points to keep costs lower, so it is important to be realistic during planning stages about what a community can afford to do in terms of deployment of access points.
- WiFi is not a first choice for business class services. Few businesses of any size are willing to run their business on a WiFi connection unless the only other option is dial-up. It may be adequate for small one or two person businesses, but most businesses want a more secure and more reliable wired connection.
- Wireless vendors have to be selected carefully. Sandoval County, New Mexico experienced severe problems with two different wireless firms hired to build a wireless Internet system--both firms were unable to provide a working system and within budget.

- WiFi has reliability problems. Even if you are in range of an access point, foliage on trees, building walls, rain, snow, and other access points can degrade the signal. Because WiFi is an unlicensed service, anyone can run an access point. The popular and very common home wireless routers can cause interference and slow down other access points.
- WiFi, even the newer G and N services, can't handle video very well, and this limits the potential of such a service to be financially viable. A community broadband system has to have a solid business model that is financially sustainable, and that means being able to carry business and residential video services.
- WiMax is a newer set of frequencies and power standards that are widely advertised as a silver bullet for broadband, but there is nothing magic about WiMax. It uses many of the same frequencies that WiFi does, meaning that it still requires clear line of sight to get an adequate signal. WiMax radios can use both licensed and unlicensed frequencies, and the unlicensed frequencies will suffer from the very same interference problems from which WiFi suffers.
- Licensed WiMax frequencies will perform better because there will be less interference, but this presumes the licensed frequencies are available (some other private or public entity may have licensed the frequencies for a particular geographic area). The licenses, if available, may cost several thousand dollars to purchase and then there is an annual renewal fee.
- WiMax capacities and distances are widely exaggerated. It is very common to see promises of "up to 80-100 megabits" of capacity and distances of "10 to 20 miles." With respect to bandwidth, that 100 megabits of capacity will be shared among all connected users, so if 100 households are trying to access the network via a single WiMax access point, the usable bandwidth may be more like 2-4 megabits per household or per user. Distances are limited by line of sight. Both WiFi and WiMax signals will work over many miles, but only with narrow angle antennas and clear line of sight.

Wireless services will be important in Madison county. And wireless is not going away; it will remain as an important component of a well-designed community broadband system--as a mobility solution. As we travel around the community, we want to be able to access the Web, check email, make phone calls, and do other sorts of things. Wireless services enable that, and in rural areas, wireless services are an important step up from dial-up.

Communities need to regard telecom as essential public infrastructure, critical to community and economic development. And that well-designed community infrastructure includes both wireless access and eventually fiber to every home and business. With the right business and financial planning, such systems can pay for themselves and provide new revenue streams to local government, while lowering the cost of telecom services.

Fixed Point Access Wireless

Fixed point wireless Internet access should be considered as a useful first step for Madison. It can introduce additional competition for Internet access customers, which can lower prices and create incentives to offer better customer service from the providers. Over time, most fixed point Internet users (five to seven years out) will want to migrate to fiber connections which will have the capacity to provide a much wider range of services, including HD TV, telemedicine, and tele-health, among other applications.

Fixed point wireless infrastructure investments (e.g. locations for towers, towers, fiber and duct backhaul connections) can be re-used over time to support mobile wireless services and long term public safety voice and data services.

Mobile Access Wireless

Wireless access to the Internet and other mobile services like cellular telephone providers is a long term need that will not be replaced by fiber access. In fact, over the next five to seven years, the most common use for wireless Internet access will be for mobility--casual business, personal, and government access away from the home or office.

In Madison, mobile wireless access to the Internet will be a required component of any investment. Wireless investments should be made with care as there is some risk of spending too much too quickly; wireless systems, frequencies, and capacities change quickly, and there is always some danger of making a commitment to a protocol (e.g. WiFi, WiMax) that is superseded by another set of incompatible protocols and equipment. Madison can avoid risk by investing primarily in tower sites (real estate), towers, equipment shelters, and other passive network facilities that require little maintenance and that have long life spans. Space on towers can be leased to private sector service providers, which will provide a revenue stream to support ongoing maintenance costs.

Last Mile Strategies

Several different strategies are available for Madison to consider, and these strategies are not mutually exclusive. Some combinations, especially those including public safety uses, can be complementary. A Phase II study would provide more detailed financial analyses and more detailed cost estimates. The table below outlines what some of these options could be.

Strategy	Description	Discussion
Do nothing	Local government continues to leave all telecom investments to the private sector.	The advantage of this effort is that the county does not have to spend time or money on building and managing telecom infrastructure. The disadvantages include: • Lack of control over the county's economic future because infrastructure capacity is determined entirely by third parties not vested in the area's future. • Fewer work from home opportunities because of inconsistent home access to wired broadband services. • Higher costs for business broadband and inconsistent or no access to competitively-priced business broadband services.
Passive infrastructure	Madison County makes carefully targeted investments in passive infrastructure (duct, dark fiber, colocation facility, wireless sites and towers). These facilities are leased out on an open access basis to service providers (e.g. Virginia Broadband, other competitive providers) who pay based on a share of revenue from the use of the infrastructure.	In this approach, the County must invest some staff time and area resources to build and support the passive infrastructure. However, the infrastructure investments are not as expensive or as complex as current government-owned water and sewer systems. Some revenue would be received from leasing these facilities, and that revenue would be used to offset both the initial cost and the ongoing costs of maintenance and repairs. A passive-only investment strategy minimizes the technical complexity of construction and maintenance while ensuring that over a period of several years, most homes and businesses would have competitive access to broadband services.

Strategy	Description	Discussion
Full system	Madison County invests in a complete network, including both passive and active infrastructure (the electronics, software, and wireless/fiber equipment needed to operate the network).	This approach would maximize the potential financial benefit to the area over time, but there are two structural challenges that would be difficult to overcome. First, the largely rural, low density residential market means it would be more difficult to attract service providers needed to make the system financially successful. Second, it would require a substantial commitment from area leaders to create an appropriate organizational entity and to supervise the management and operation of the network. Even if many functions (like network operations) were outsourced, the effort would place a significant strain on local government and leadership resources.
Public Safety	The County limits investments to those required to support current and future public safety needs (fire, police, rescue, public works) for voice communications and data services.	This approach would ensure that County public safety agencies and first responders have the infrastructure support needed to deliver essential services to businesses and homes. However, this does not address economic development or workforce development needs for the community.

Broadband Education Strategies

The Advantages of Education

Madison County has excellent schools and a higher than average high school graduation rate than both the Commonwealth of Virginia and the nation. The county does lag behind slightly in workers with some college education, and has a deficit when comparing workers with a college degree. As factory jobs move off-shore, more jobs are being created--some estimates are three new jobs for every job lost. However, the lost jobs usually require only a high school degree at most, and the replacement jobs typically require one to two years of college education. Madison County faces some challenges to ensure that it has a workforce with the right skills, education, and training needed by employers in the next five to ten years.

Madison County investments in broadband and telecom may not have the expected economic development impact if the area does not have the right mix of skilled workers. It will be important for county leaders to ensure that high school graduation rates stay high and that a higher percentage of students acquire some college education.

According to a report from the Department of Commerce Census Bureau, education pays off. Workers who stay in school, complete high school, and get some college and/or attain a college degree will earn much more than those workers who do not attain basic levels of education. Over an adult's working life, high school graduates can expect, on average, to earn $1.2 million; those with a bachelor's degree, $2.1 million; and people with a master's degree, $2.5 million.

The estimates of work-life earnings are based on 1999 earnings projected over a typical work life, defined as the period from ages 25 through 64. In 2000, 84 percent of American adults age 25 and over had at least completed high school and 26 percent had a bachelor's degree or higher.

In the 1999 study, the differences in average annual earnings can be striking, depending upon how far a worker has advanced in terms of education. Wages ranged from $18,900 for high school dropouts to $25,900 for high school graduates, $45,400 for college graduates and $99,300 for the holders of professional degrees (medical doctors, dentists, veterinarians and lawyers).

Broadband will play an increasingly important role in workforce development and higher education as more workers find it necessary to re-train and/or acquire additional college credits for their current profession. Distance learning technology is increasingly incorporating more sophisticated multimedia materials like podcasts, streaming video, live video and audio chat, and eventually many classes will be available via full two way HD live video and audio. All these technological enhancements will require much higher bandwidth at the student's home--well beyond current wireless systems. In the residential survey, 41% of respondents indicated that someone in the home is already using their Internet

access for distance learning and school once a week or more (27% said "several times a week").

New Job Opportunities

New kinds of job and work from opportunities are developing, but virtually all work from home job opportunities require reliable and affordable broadband service. In particular, many work from home employers require both a land line telephone (i.e. cellphones are not permitted) and a landline broadband connection (i.e. WiFi wireless is discouraged or not permitted).

The "virtual call center" is rapidly becoming a popular alternative to bricks and mortar call centers. A variety of companies are now employing tens of thousands of workers; these employers work full or part time from their own homes, with wages typically starting at $9 to $10 per hour and can exceed $20 per hour for more specialized work. These jobs require basic literacy skills and basic computer/technology skills to qualify, and some specialized training is also usually required. Without affordable broadband available in homes in the region, even workers with the right skills and education will not be able to take advantage of these new opportunities.

While not everyone can or will want to work from home, the jobs can be an attractive alternative to working outside the area where long commutes and high fuel prices put stress on the workers themselves and their families. The residential survey indicated that over half of all residents are already doing some work from home, and 8% are already working full time at home.

Education Partners and Opportunities

Nearby community colleges offer residents of Madison the opportunity to attend technology classes and obtain college level educations as full time or part time students. This opportunity extends to Madison High School students who are able to participate in dual-enrollment classes.

Germana Community College

About thirty minutes away from Madison is the Germana Center for Advanced Technology, and about 45 minutes away from Madison is Germana's Locust Grove campus. The Germana Center for Advanced Technology is geared primarily toward workforce development and technology training. Germana also has an agreement with Old Dominion University (ODU) where students can complete classes online, and work towards Bachelors and Masters degrees.

Germana offers degrees in many fields of study including:

- Information System Technology - Information Management or Network Security
- Information System Technology - Networking
- General Studies - Radiologic Technology Specialization
- Engineering
- Business Administration

Some of the IT-related courses available include:

- Web Design
- Database Management Software
- Fundamentals of Networking
- Security Basics
- JAVA Programming
- E-Commerce Administration

Lord Fairfax Community College

About an hour away in Warrenton, is Lord Fairfax Community College. Full and Part time students at Lord Fairfax can obtain degrees in fields such as:

- Desktop Publishing
- Information Systems Technology - Network Engineering
- Information Systems Technology - Web Applications Development
- General Engineering Technology - Computer Aided Drafting (CAD)

Lord Fairfax also offers some general computing classes geared towards workforce development.

Madison County School System

Madison County Public Schools take an active role in helping the community get and stay involved with technology. MCPS offers dual-enrollment courses to its students which allows MCPS students to get credit for college level classes while finishing high school. This is often a good way for students to gain experience early, and to lighten the load in the first years away at college.

MCPS is a member of the Shenandoah Valley Technology Consortium, and participates in the Enhancing Education Through Technology grant. Madison is also involved with the Virginia Society for Technology in Education (VSTE) which is focused on integrating emerging technologies with education. It is one of the goals of MCPS's technology de-

partment to provide the instruction necessary for MCPS staff to master the Virginia Technology Standards for Instructional Personnel (TSIP), and to integrate technology into instruction for instructional personnel. Madison County Public Schools consistently perform well on the Virginia Standards of Learning test.

Piedmont Regional Adult Education Center

The Piedmont Regional Adult Education Center offers GED classes, tests, and course materials at Orange County High School which is about a thirty minute drive from Madison.

Career Readiness Certificate

Virginia's Career Readiness Certificate (CRC) is an assessment-based credential that gives employers and career seekers a uniform measure of key workplace skills. Businesses have trouble finding and hiring people who have basic employable skills and who are therefore trainable for specific jobs. The CRC gives workers a skills credential that assures employers that the job applicant actually has the basic skills they seek. The CRC helps close the gap that exists between the skills required in today's workplace and those exhibited by new and existing employees.

Madison's Network of the Future

A modern business-oriented open network in Madison would have the following characteristics.

Unlimited Bandwidth

Within the County

As a long term goal, businesses in Madison should eventually have as much bandwidth as they need to do whatever it is they need to compete globally. Fiber to every premise will eventually be needed to support the business class services that will be requested by commercial and retail businesses in Madison. Unlike roads, water, and sewer systems, fiber capacity can be increased incrementally as needed without incurring additional construction costs, making it a reliable and secure investment. Steady increases in work from home opportunities and home-based businesses require fiber in residential areas, not just commercial and retail areas of the County. Wireless access in Madison will be used in the short term to meet urgent needs for better broadband access, and in the long term, wireless will remain important for mobile access to the Internet and access to business information while away from the office.

Regional and national connections

Madison needs more and better fiber routes in and out of the County, especially to support the business activities of large enterprises. Many businesses in Madison are conducting business operations on a global scale, meaning they cannot afford to lose network connectivity for even a few moments. A Madison colocation facility where service providers can locate equipment and connect to local customers would be a significant economic development attractor. Redundant fiber cable paths are extremely valuable to Madison from an economic development perspective; many relocating businesses place a high value on prospective locations with cable path redundancy. Attracting more long haul fiber providers into Madison County is achievable by focusing on increasing demand locally. Some fiber providers already pass by Madison on Route 29 or have fiber facilities in nearby communities. As demand increases in Madison, some of these firms may see a market opportunity and build additional fiber into Madison.

Symmetric Bandwidth

Upstream and downstream data capacity of the broadband network should be equal. Most current broadband systems restrict upstream data capacity to a fraction of the downstream capacity--upstream capacity is often only 10% of downstream capacity. These limits restrict economic development, entrepreneurial activities, and work from home opportunities. Because Madison businesses and residents will rely on wireless access for several years, private sector providers should be encouraged to offer business class, symmetric wireless services.

Widespread Availability

With 52% of residents reporting that they are still on dial-up (i.e. no broadband service), widespread availability should be an important goal for the county. Over time, high performance network connections should be available at every business and resident in the County. Broadband is increasingly being used to make relocation decisions, not only for businesses, but for residences as well. Wide availability of broadband in the county will help preserve low density residential growth.

Affordability

It is more efficient from both network and financial perspectives to provide some basic infrastructure on a shared basis--leasing that infrastructure to private sector providers. County investments in basic infrastructure allow service providers to offer services at lower cost because their capital expenses have been reduced substantially while increasing their access to a much larger, aggregated market.

Support for a Wide Range of Services Beyond "Triple Play"

Telecommunications services have undergone a massive transformation in the past fifteen years, and that change will continue for at least an additional ten years as all services formerly delivered over narrow bandwidth analog networks (i.e. the traditional "triple play" of Internet, TV and telephone) are delivered over wide band digital networks. Many new services (e.g. YouTube, iTunes Music Store, VoIP phone services) were not anticipated or predicted by most industry pundits just ten years ago. Newly emerging high bandwidth services include a wide range of telemedicine and telehealth services, new kinds of online entertainment options, and many more kinds of business and ecommerce services. Any telecom infrastructure investments undertaken by Madison must be capable of supporting a wide range of future services that are going to emerge but cannot be predicted precisely.

Competitive Marketplace

A world class broadband infrastructure will lower costs for service providers offering services on the network and will increase competition among providers. This will increase the kind and type of service offerings while keeping prices lower than those in communities without a competitive marketplace for telecom and broadband services. This will make Madison more competitive from an economic development perspective and help to retain existing businesses and jobs and also help to attract new residents and businesses to the County.

Limited Government Involvement

The County government should limit its involvement to providing basic infrastructure; services provided to businesses and residents should be offered by private sector service

providers. Incumbent providers as well as other interested firms should all be invited to use this "open access" County infrastructure to sell current services and new, innovative services both to existing customers in Madison and new customers. This approach will keep County elected and appointed officials out of the business of providing telecom services directly to the public. Communities where the local government has chosen a "municipal retail" approach, where residents and businesses buy telecom services (e.g. telephone, Internet, TV) directly from the local government have often been sued by incumbent providers on the grounds that public funds should not be used to compete directly with the private sector.

While these communities have often won in court, such cases often take years to resolve at great legal expense. Financially, these network projects then face difficulties because the local government then must market the new network directly against the incumbent providers, who usually cut prices and engage in a price war with the local government. The open access approach avoids these difficulties by creating a market environment where service providers compete against each other instead of competing against the County.

Network Business Model Options

Private Sector Only

The "leave it to the private sector" model has obvious shortcomings, which is why so many communities are now beginning to consider telecom as essential public infrastructure. Private sector firms have a primary responsibility to preserve and enhance shareholder value. They do not make operational and service area deployment decisions based on community and economic development needs. For many communities, this has meant that broadband services have lagged well behind the rest of the world and places those communities at a competitive disadvantage when trying to attract or retain businesses.

The private sector model requires overbuilding, which means that each service provider must build its own network end to end to serve customers. This leads to completely duplicated networks, which increases costs and makes it more difficult for these firms to make a business case for enhanced services in many area. This business model is a fundamental weakness, because these private networks are not only expensive, but typically underutilized. Residential networks are only used heavily in late afternoon and evenings, and are virtually unused overnight and during the work day. Business networks that are only used heavily during work hours typically have very low utilization for the other two-thirds of the day. School and education networks are used only 8 to 12 hours per day, and are empty the rest of the time.

Community broadband projects overcome this fundamental weakness and substantially reduce the operating cost of networks by using a shared model, rather than a private model.

Municipal Retail

Also known as Muni (Municipal) Triple Play. Local government builds the network and sells services in direct competition with the private sector, offering only traditional "triple play" voice, video, and broadband. Muni triple play systems are usually closed systems that offer little choice to customers. Muni triple play systems compete directly with the private sector, and tend to have very low take rates. Opponents of community broadband often cite the low take rates of muni triple play projects to "prove" that community broadband is a poor investment. But the low take rates only show that muni triple play business models are not financially viable over the long term.

The two key issues with this model are:

- It requires local government officials and leaders to sign long term contracts (typically 5 to nine years) with the providers whose services will be resold over the network. This means that those local leaders must have a high degree of confidence that they can accurately predict, seven to nine years out, what level and quality of services the businesses and residents of the community will require. While contracts can be renegotiated as needs change, prices are likely to rise during that renegotiation.

- This model does place the local government in direct competition with incumbent providers. This not only tends to keep take rates low, which threatens financial viability, but adoption of this model also encourages lawsuits from the incumbents (Bristol, Virginia, Lafayette, Louisiana, Geneva, Illinois, and Monticello, Minnesota are examples of communities that were sued after selecting the muni retail model).

Wholesale

Local government builds the network and provides access to service providers, who must use Layer 2 Virtual Private Networks (VPNs). Services must be provisioned individually for each subscriber. Not a true open access model because of system complexity. Muni wholesale is also confusingly called "open access" by some parties. Muni wholesale systems may have some competition for some service categories, but the technical complexity of these systems limit the ability of smaller providers to take full advantage of the system. Technically, most "open access" systems are managed at what is called Layer 2; the limitations of Layer 2 open access tend to keep the cost of providing services high, compared to a true open services network that provides fully automated, end to end provisioning of services.

Problems with the wholesale approach include:

- Each service provider must have their own service provisioning system, which raises the cost of market entry and increases the cost of all services (because the service provisioning and support software must be duplicated by every provider). This can limit the number of providers to a few bigger ones that already have such systems or can afford to build or purchase them.
- The Layer 2 provisioning by each provider increases the technical complexity of debugging network issues and resolving customer service problems.

The Utopia network in Utah, the country's biggest community fiber effort, had difficulty with its initial Layer 2 (wholesale) network architecture and is converting to an open services model that will use a Layer 3 open services model. One key "lessons learned" from communities that have tried the wholesale model is that a sufficiently large base of connected businesses and residents is needed who have already indicated a willingness to buy services on the new network; Utopia connected premises without determining in advance if that connection would generate any income. A second lesson learned is that with both the wholesale and open services model, it is essential to ensure that sufficient service providers are prepared to sell services on the network. The high cost of becoming a service provider on the Utopia network discouraged smaller, innovative providers.

Open Access Infrastructure

In this model, local government limits investments primarily to passive infrastructure, which can include real estate, duct, dark fiber, handholes, splice cabinets, colocation facili-

ties, and wireless towers. Each service provider that wishes to use the common infrastructure must provision their own network electronics. Some of the issues that must be considered with this model:

- The requirement to provide electronics raises the cost of market entry for service providers. It can also limit competition, as the first service provider who spends the money to install electronics in a business area or residential area may "capture" a large portion of the available market, making it more difficult for the next service provider to justify the expense of trying to compete. However, the availability of the fiber can still give some customers options, especially business customers in retail areas and business parks, where there is more incentive for providers to compete aggressively.
- The fiber design for the network must be done carefully to avoid both running out of fiber and to ensure that there is enough fiber to support competition. Fiber capacity must be overbuilt in the last mile (first mile) portion of the network to ensure there is enough fiber cable to support multiple providers. Fiber cable cost has decreased substantially, so this is not as much of an issue as it once was.
- Splice cabinets and locations for equipment cabinets and colocation facilities must also be considered carefully with respect to both location and aesthetics--making it easier for providers to install equipment. If the authority provisions cabinets, it makes it much easier for service providers to compete, because finding locations for equipment cabinets is a major time and cost factor when entering a new market area.
- Costs can be quite modest if the focus is primarily on improving wireless access, as costs are limited to procuring sites for wireless towers, the towers, equipment shelters, provision of electric power, and a minimum of other equipment and facilities.
- For fiber, the initial investment is lower, but the cost of duct and fiber, as a rule of thumb, is likely to be 60% to 70% of the cost of a full open access network.

Open Access Network

Customer aggregation is a key advantage to a shared, community-owned telecommunications infrastructure. By building an integrated fiber and wireless system to every home and business, the community maximizes the market potential for private providers who want to sell services. The community investment allows these businesses to reach more customers than any single company could reach on its own. Some of the outcomes are:

- More customers -- When a community builds the transport layer of a digital road system (the roadway), each provider has a much lower cost of infrastructure needed to enter a market. In smaller towns and regions, this is a critical difference. Community investments allow more companies to profitably offer services in smaller markets than a firm could do on its own.

- Lower costs -- When a firm can reach more customers via a community broadband system, lower costs of service usually results. Typical reductions in cost in open access systems are usually on the order of 15%, and are frequently much more than that. It is not unusual to see the cost of telephone service decline by 40% or more.

Services aggregation occurs when communities build open networks, meaning that any qualified service provider can offer services using the community digital roadway. In this business model, there are usually several service providers competing for customers in each category of services (e.g. voice telephone service, TV, Internet access).

- More choice-- A natural outcome of more services is more choice for purchasers of services. Instead of a single monopoly provider of telephone or television, customers can pick and choose among a variety of service plans at various price points.
- More competition -- When more services are available, there is more competition for customers, which requires that service providers sell services for the lowest possible price, and also creates incentives to provide excellent service to customers. Compare this to a monopoly environment where there is no competition and hence little pressure for a company to provide good service--customers have no other service options.
- More services -- When there is a wider choice of services on the community system, there is more opportunity to use more services. This is, in part, what makes open service provider networks financially sound investments for communities: Open systems create a bigger market for telecom services, and thereby creates more revenue flowing through a community revenue sharing plan.

Summary of Differences

Features	Private Sector Only	Municipal Retail	Muni Wholesale	Open Architecture
Basic Concept	Three separate services (voice, video, data) with little or no sharing of network.	Only three services (voice, video, data) with little or no sharing of network.	Network services limited by requiring VPNs (Virtual Private Networks) for each service provider.	Very high efficiency achieved by end to end automated service provisioning. All providers share network capacity.
Government Involvement	No government involvement. Private sector decides where and when to offer services. Some areas get little or no service.	Government competes directory with the private sector. Government decides what services are offered.	Government provides relatively low performance digital road system with high cost of operation. Buyers have limited choice of services.	Government does not compete with private sector. Government provides high performance digital road system that benefits all public and private users. Buyers have rich set of choices.
Governance	Owned by a private company. Community must accept whatever services are offered.	Owned and operated by local government. Limited triple play services sold directly by local government.	Owned and operated by local government. Limited selection of services offered by the private sector.	May be owned by local government or by a community enterprise like a broadband authority or coop. Wide variety of services sold by private sector companies.
Competition	Little or none in most areas. Cartel-like pricing keeps prices high.	Government bureaucrats pick providers of each service. No incentive to lower prices.	Limited. High cost of administering services using VPNs limits market competition.	Level playing field creates robust competition. Service providers drive down costs and provide great service to get customers.
Service Options	Limited. Providers can offer triple play at most.	Limited. Government resells triple play services.	Limited. High cost of providing services and support effectively limits service options	Unlimited. Low cost of market entry and high level of service automation attracts service providers and encourages innovation.
Revenue	Limited by low returns on the individual services.	Limited by low returns on the triple play services.	Limited by low returns on the triple play services.	Unlimited. Revenue directly linked to demand. Revenue increases with demand.
Service Area Expansion	Limited to high density population areas. Rural areas at a structural disadvantage.	Limited by triple play approach, which keeps funds for expansion low.	Limited by small number of service providers.	Unlimited. Expansion completely supported by revenue sharing. Open services network can provide become financially sustainable relatively quickly.
Risks	Some areas do not get adequate service or affordable pricing.	Government officials must predict business technology needs years in advance.	High cost of provisioning services keeps smaller, innovative ISPs out of the market--limits competition.	More complex network management required, but reduces costs sharply for service providers, which encourages competition.

Case Studies

Other communities across the United States are already actively pursuing new and innovative public/private partnerships to improve the access and affordability of telecom services delivered via broadband. In September (2008) he Fiber To The Home Council provided some statistics on the growth of residential fiber in the United States. Over 1.6 million homes were connected with fiber in the past twelve months, but only about 10% of American homes have fiber connections at this time. The deployment of fiber is highly dependent upon location, so some densely populated urban areas, primarily on the East Coast, are getting fiber much more rapidly than other areas of the country.

Communities that have affordable broadband are enjoying a faster rate of economic growth than communities that lack broadband, based on a CMU/MIT study (Measuring the Economic Impact of Broadband Deployment, Sirbu and Gillett, 2006). Crandall, Lehr, and Litan, in a similar study in 2007, found a significant and measurable impact on employment by the availability of broadband services.

A new digital divide is emerging, with fiber as a differentiator. Communities with affordable broadband infrastructure and the ability (i.e. fiber) to expand capacity as demand grows over the next seven to ten years should enjoy a measurable economic development advantage over communities that lack such infrastructure.

Danville, Virginia

The City of Danville, Virginia is operating an open access, open services network (www.ndanville.net) focused on creating the right kind of economic development incentives and accompanying infrastructure that will help retain existing businesses and help attract new ones. Danville has a County-owned electric utility, and the growing fiber network is being managed as part of the electric utility operations. Using a multi-phase approach, the County first hooked up government offices and local schools in 2004, and in 2006 began planning for extending the high performance all fiber network to local businesses and residents throughout the electric service area, which includes a large part of very rural Pittsylvania county. The first businesses began to get hooked up in late 2007, and Danville expects to have fiber to every parcel in its business parks before the end of 2008. The County-county business incubator was one of the first locations to receive the fiber services. The County has begun doing advanced planning for taking fiber to some of its residential neighborhoods. The County is not selling any services to businesses or residents; all services are offered by private sector service providers that use the network and pay the County for the use of the network via a revenue sharing agreement.

Accomack/Northampton Broadband

Accomack and Northampton counties, on the Eastern Shore of Virginia, have formed a broadband authority and are about to begin construction of a 60 mile high performance fiber backbone that will reach from the northern border of Maryland and will extend across

the 17 mile Chesapeake Bay-Bridge Tunnel to meet other regional fiber networks in the Norfolk area.

The authority was formed in the spring of 2008, and construction on the fiber backbone will begin later in early fall, 2008. The region made the commitment to form the authority to provide fiber services to private sector firms that were demanding better connectivity to both the NASA Spaceport and Navy facilities in Chincoteague, Virginia and to provide higher performance and less expensive fiber routes off the the Shore. The Authority is currently developing plans for the deployment of wireless and fiber services throughout the region.

Farmers Telecom Coop

Farmers Telecom Coop serves 20,000 subscribers in rural Georgia (www.farmerstel.com), and the customer-owned enterprise has begun executing on its plan to take fiber to every premise. The telephone company chose an active Ethernet network design because an active network can scale up more easily to meet future demand than an equivalent PON system, and because network troubleshooting and diagnostics was deemed easier to perform. Customers will receive a 100 megabit fiber connection capable of delivering a wide variety of services, including the traditional triple play of voice, video, and Internet, but also video and movies on demand, HD business videoconferencing, telemedicine and telehealth services, and a wide variety of other business and residential services and applications.

The Wired Road

The Wired Road is an open access, open service network jointly owned and managed by Carroll and Grayson counties and the County of Galax (Virginia). The three localities formed a regional broadband authority and began construction in September of 2007. The first institutional customers were added to the network (Carroll County Public Schools, Carroll County, Crossroads Institute) in March of 2008. Residential and business customers will be offered services in summer, 2008. The Wired Road is not selling any services to businesses or residents; all services are offered by private sector service providers that use the network and pay the Authority for the use of the network via a revenue sharing agreement. The three governments see the network investments as a way of differentiating the region and providing a valuable economic development marketing tool. The Wired Road is being designed as an integrated fiber and wireless network, with fiber in the three major towns and all business parks, and wireless services as the initial offering in under-served rural areas where many residents are still on dial up. The long term vision is to provide fiber to every home and business that requests it.

West Point, Virginia

The Town of West Point has begun investing in fiber infrastructure by installing fiber alongside a water main extension; construction began in the spring of 2008. The fiber line will provide fiber access in the new business park in the community, and the fiber design

includes taking fiber to a new eighty home residential development planned for the community. The Town is engaged in advanced planning to extend the fiber to the Main Street area as well as surrounding residential areas of the community.

Vint Hill Economic Development Authority

Vint Hill is a 695 acre mixed use office park in Fauquier County that has begun deploying fiber and telecom duct for tenant use. The EDA's first fiber investments were made in the spring of 2008 to help a tenant win a major contract with the Federal government that required fiber connectivity across the park and to the tenant building. At the same time, fiber was installed to help a local wireless service provider purchase lower cost Internet service to improve availability of wireless Internet access both in the park and in the surrounding area. The EDA has made improvements and upgrades to a tower located in the business park and made the tower available to private sector wireless providers.

Ripton Broadband Coop

Coops are a great ownership and governance model because they firmly vest the enterprise in the community–every subscriber is also a shareholder in the enterprise, and shareholder/members are able to vote and select board members. The Ripton Broadband Coop serves customers in rural Vermont via wireless, using an open access, open service model. Two service providers are selling services on the network. Coops have some unique advantages because membership fees can be used to help fund the initial development of the network. The Ripton Coop assesses a $200 membership fee and collects an additional $150 for customer premise equipment. For more information, visit www.ripton-coop.net.

Oklahoma County Government Network

The government of Oklahoma County, Oklahoma has installed a WiFi wireless network for public safety use. The wide area network covers 555 square miles and was funded from a public safety sales tax and County capital improvement funds. The County installed 1,200 wireless access points on utility poles, street lights, and other structures around the County. The network gives first responders, police, fire, and rescue personnel wide area access to County databases and the Internet. Local police have found the access extremely useful, as they can get access from patrol cars almost anywhere in the County. Public safety uses include getting detailed maps for use in search and rescue operations, photographs of suspects or victims, and information on hazardous materials to assist during a haz-mat clean up operation. On a per access point basis, the system cost about $5,000 per node.

Powell, Wyoming

Powell, Wyoming is building a 100% fiber network throughout this city of 2,650 households and 5,500 people. Citizens supported the City-led effort because of poor service from the incumbent providers. The City government expects a financial return of more

than $22 million over thirty years on the $4.9 million initial investment required to build the network. Powell is an electric city, which makes it easier to get started because the electric utility poles, equipment, and crews can be used to help install and maintain the system.

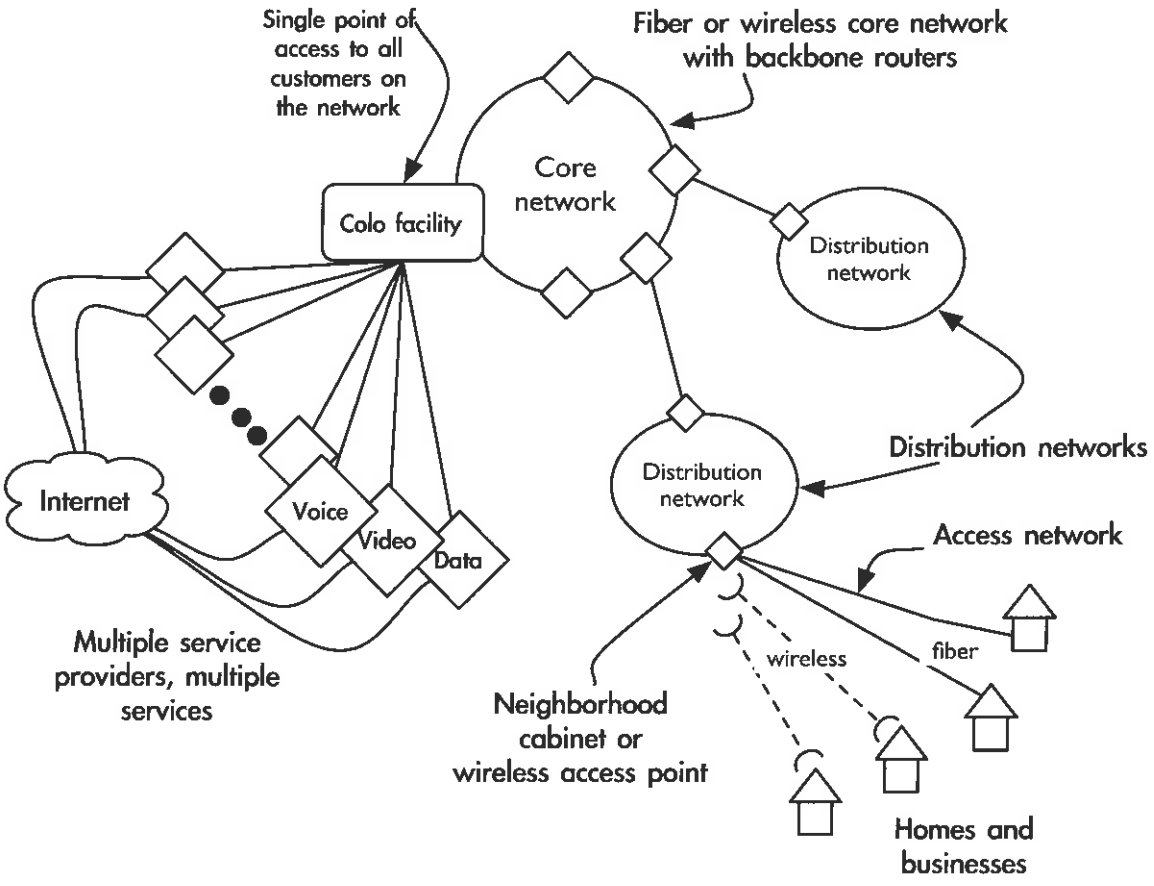
The Utopia Project

Planning for the Utopia project was begun in 2004, and the effort includes fourteen cities and towns in Utah and a total population of 300,000 people. Although the project had some early funding problems, the towns involved were so pleased with early results of the all fiber service that they voted overwhelming in 2008 to provide additional bond funds to complete the build out of the network. Utopia has reported a lower than expected cost of maintenance on the system, which is attributed to high reliability of fiber.

Utopia is operated as an open services network, meaning that private sector service providers offer telephone, TV, Internet, and other services. Utopia has a very low churn rate of less than 1%, meaning very few customers leave once they have been hooked up. As of early 2009, eight different companies offer services on the network, and Utopia is delivering 100 megabit connections to homes and businesses in the 14 Utopia communities. In rural areas, Utopia is achieving a customer take rate of more than 50%, and since switching to a service-oriented architecture, the number of service providers on the network has increased from three to eight. Bonds have been used to provide most of the financing for construction, and the project says it can break even with a 30% take rate.

Network Architecture

Community Broadband Network Components



Core Network

The core network is often referred to as the "backbone" network. It is a high capacity route or set of routes throughout a community or region that provides transport between towns, neighborhoods, business districts, and other major facilities.

Ideally, the core network is designed as a redundant fiber ring, which provides both capacity and gives the network the ability to continue operating even if the fiber is cut or damaged in one location. A fully redundant ring can be expensive to construct, and so the "ring" feature may be a long term design goal. The initial core network can also be designed using high capacity wireless links if funding is constrained. Later, as fiber links are added to the core network, the wireless connections can stay in place to provide redundant routing.

Distribution Network

Distribution networks are connected to the core network, and provide primary network paths through a town, neighborhood or business district. The distribution network connects the core network (the network backbone) with the individual connections within a neighborhood or business district that connect to home and businesses. This portion of the network can be fiber-based or wireless, but fiber will be required over the long term to support video services and other kinds of high bandwidth applications like telemedicine.

Access Network

The access network is what is commonly called "the last mile," although "the first mile" might be more appropriate, since customers should be a primary consideration when designing a network. The access network is a direct fiber link between a fiber switch located within a neighborhood or business district, or it may also be a direct point to point wireless link from a wireless access point on a tower or building and the home or business. Network subscribers have to have Customer Premise Equipment (CPE) to get a network connection, and this is simply a small box that looks like a hub or switch. In a fiber network, the fiber cable is connected to one port, and one or more copper Ethernet RJ45 ports allow users to connect computers, phones, and TV set top boxes to it. In a wireless portion of the network, a small box with a radio and possibly an external antenna is mounted on a side of the home or business with clear line of sight to a nearby tower or building where the access radio is mounted.

Colocation Facilities

A colocation facility is a controlled environment (i.e. heated and air-conditioned) room with Internet access via wired and/or wireless systems. The colocation facility will be a place where fiber, wireless, and copper-based network facilities meet. It will be equipped to house high-end network equipment, servers, and other electronic gear. A variety of middle layer network components and services can be located within the colo including, for example, directory services, replicated content servers, routing services, and other elements needed to deliver new multimedia services to the home and small office from multiple, competing providers. Characteristics of a colocation facility include:

- A reliable source of AC electric power is required, with backup UPS (Uninterruptible Power Supply) service available by an onsite generator.
- Controlled access to the facility (e.g. by electronic keycard) 24 hours/day, seven days a week.
- Racks for locating network equipment and servers, and optionally locked cages for equipment racks.

Functions of colocation facilities include:

- Hub for new broadband infrastructure development at the community and corporate campus level.

- Location for a regional and community network exchange point for local service providers. Also called a peering point or inter-exchange point, this kind of facility can reduce costs and increase performance in a win-win-win scenario (because it helps keep local traffic local and reduces service provider costs, thereby reducing the price of services).
- Insertion point for multimedia services from multiple competing providers to reach subscribers over single broadband medium (fiber, wireless, other).
- Community, campus, or building point of presence for new middle layer components required to implement next generation Internet (directory services, caching, routing).
- Focal point for technical resources and management of community infrastructure.
- Aggregation point for low cost access to gigabit scale network services.

Backhaul

Every community network requires one or more paths (routes) out of the community to carry voice, video, and data traffic (in both directions). Backhaul network connections can be purchased from a local incumbent telephone company. In some communities, there may be other backhaul providers available. Backhaul connections are usually terminated at the community-owned colocation facility.

The long term goal for a Madison Broadband network is to provide businesses and residences with a choice of broadband services across the county. Investments should be focused on wireless infrastructure in the more remote areas of the county that still have no broadband access, and some limited fiber investments may be desirable in the town of Madison.

Fiber in Madison

Fiber in business and commercial areas is becoming increasingly important as a part of the business relocation decision-making process, and other other localities and economic development agencies in the U.S. are beginning to invest in telecom duct and fiber as basic business infrastructure, much as water and sewer facilities were a major area of investment in the last century. Services in these areas, if the infrastructure was built out, could be provided by local private sector service providers. There would be no reason for local government to offer telecom services.

Downtown

Downtown Madison has a thriving Main Streets with many fine old buildings some of which have undergone extensive renovation. Fiber in the core downtown area would increase the value of these properties and would make them more desirable for professional businesses (e.g. lawyers, accountants, consultants) as well as entrepreneurial start up businesses. Fiber-delivered services, quality office space, and nearby coffee shops and restaurants would make this area very competitive for business relocation. There are already service providers in downtown Anderson that could immediately begin using the fiber infrastructure to deliver services.

Both towns have downtown retail areas, and most businesses would benefit from improved access and affordability in telecom services. Even retail stores typically process credit card transactions over the Internet today (rather than using a dedicated phone line), and many retail stores now also have a Web site where much of their merchandise is for sale. It is not uncommon for a small retail shop to have a higher percentage of sales online than in the bricks and mortar store.

Business and Industrial Areas

Across the country, more and more business and industrial parks are installing telecom duct and fiber to every building in the park. Businesses in every category--manufacturing, distribution, services, finance, and more--require full time, continuous, and affordable telecom services, including Internet access, telephone service, and specialized needs like VPNs (Virtual Private Networks). Parks that invest in basic fiber infrastructure can facilitate tenant access to a wider variety of competitive telecom services at lower cost and with higher performance.

Information-intensive businesses require 24/7/365 uninterruptible telecommunications services. This is accomplished by providing redundant fiber and wireless data communications routes, both to individual businesses and to the park itself. Damage to a single fiber cable or wireless tower should not disable essential business telecom services. Business parks need a strategy to provide fiber cable redundancy both within the park itself and to the park.

These same businesses also need reliable electric service to power the network and computer systems that run the business. Many relocating technology-driven businesses are now actively seeking business parks with redundant electric service from two different substations.

Business parks that install telecom duct and fiber should contract with a telecom service provider to offer Internet access and VoIP (Voice over IP) telephone service in the park as a fee-based amenity. No business would be required to use this service, but it is a valuable amenity to offer, as it should reduce the overall telecom costs for businesses that use it because of the aggregated demand and efficiency savings of using park-owned fiber to deliver the services. The park can also derive a modest income from the services by charging a small revenue share fee to provider of the services.

As the long term cost of travel continues to trend upward, business quality videoconferencing will continue to grow in importance as a complement to conventional business travel. In particular, larger firms have been investing heavily in HD (High Definition) videoconferencing systems that offer a much higher quality meeting experience (telepresence) than previous generations of business videoconferencing systems. Business parks should provision one or more common space meeting rooms with fully equipped "telepresence" videoconferencing equipment. This shared amenity is particularly valuable to smaller firms that may not be able to justify the cost of such systems for the occasional need for a telepresence meeting.

Schools

Madison County Schools already have fiber connections via Federal E-Rate and through the local incumbent telecom provider. Fiber to the schools should be considered as more services become available on the network which can supplement and/or enhance the current communications that the schools enjoy.

Wireless in Madison

Madison is a challenging locality for wireless broadband due to the region's topography, but with targeted investment based upon studies of availability and population density, broadband can be delivered via existing and new wireless facilities (towers). Wireless broadband, while far superior to dial-up Internet and satellite Internet, is not a substitute for fiber for businesses and can provide only limited support for the high bandwidth services like video-on-demand or video conferencing.

Depending on conditions at the broadcast site and at the customer location wireless broadband can be propagated several miles. Considerations need to be made for the height of the broadcast location, customer location and tree cover as current technologies used for wireless broadband are limited to "line-of-sight" and will not penetrate hills, buildings, or a heavy tree canopy. Technologies which will become available for wireless broadband in the future will have superior coverage, but will still require towers for broadcast. Due to this, any current investment in building towers or arranging a long term lease with tower owners will not be limited to today's technology.

Pilot Project Design

Overview

A potential pilot project is illustrated and described in the next several pages. As noted in the Gap Analysis section of this report, the long term bandwidth and service needs will be only be met by fiber to the premise (FTTP). A full build out of fiber to all homes and businesses that request it would take two to four years depending upon how funding is developed. Fiber service to the industrial and business areas and fiber in the downtown area (both business and residential) would the highest priority. This can be built in an incremental fashion as customers are identified by the network operator or by service providers.

Fiber

Fiber service in the downtown Madison core retail and residential areas would substantially increase the value of property there and would enhance the desirability of locating medical and professional businesses downtown. Residential areas adjacent to the Main Street commercial area would very attractive to professionals and business people who want a walk to work option, which is already gaining more importance as gas prices continue to rise.

When deploying fiber, Madison should consistently look for opportunities to expand the network capacity. Utilizing "open ditch" policies to put conduit or fiber along water lines, under road or sidewalk improvements or other opportunities. When performing a fiber build for a customer or provider, Madison should market to potential customers along the route and put in additional fiber for the future.

By aggregating the demand, Madison will make it more attractive for service providers to provide fiber services in the areas accessible to long haul fiber.

Wireless

Use of the county assets (water towers and existing communications towers) would be used to provide wireless point to multi-point access to residences and businesses with line of sight access to the towers. Wireless service would provide improved access to broadband to some residents and businesses that do not receive fiber immediately or currently have access to DSL or High Speed Cable service. As the fiber system is extended, the wireless

network would remain in place to provide network redundancy and to provide mobile access to services for residents, visitors, and public safety officers and first responders.

Wireless networks require a backhaul, not only out of the region, but back to the core sites or nodes which have access to the long haul fiber. By building additional towers or even making existing towers available for colocation by service providers, Madison can accelerate wireless services in the county.

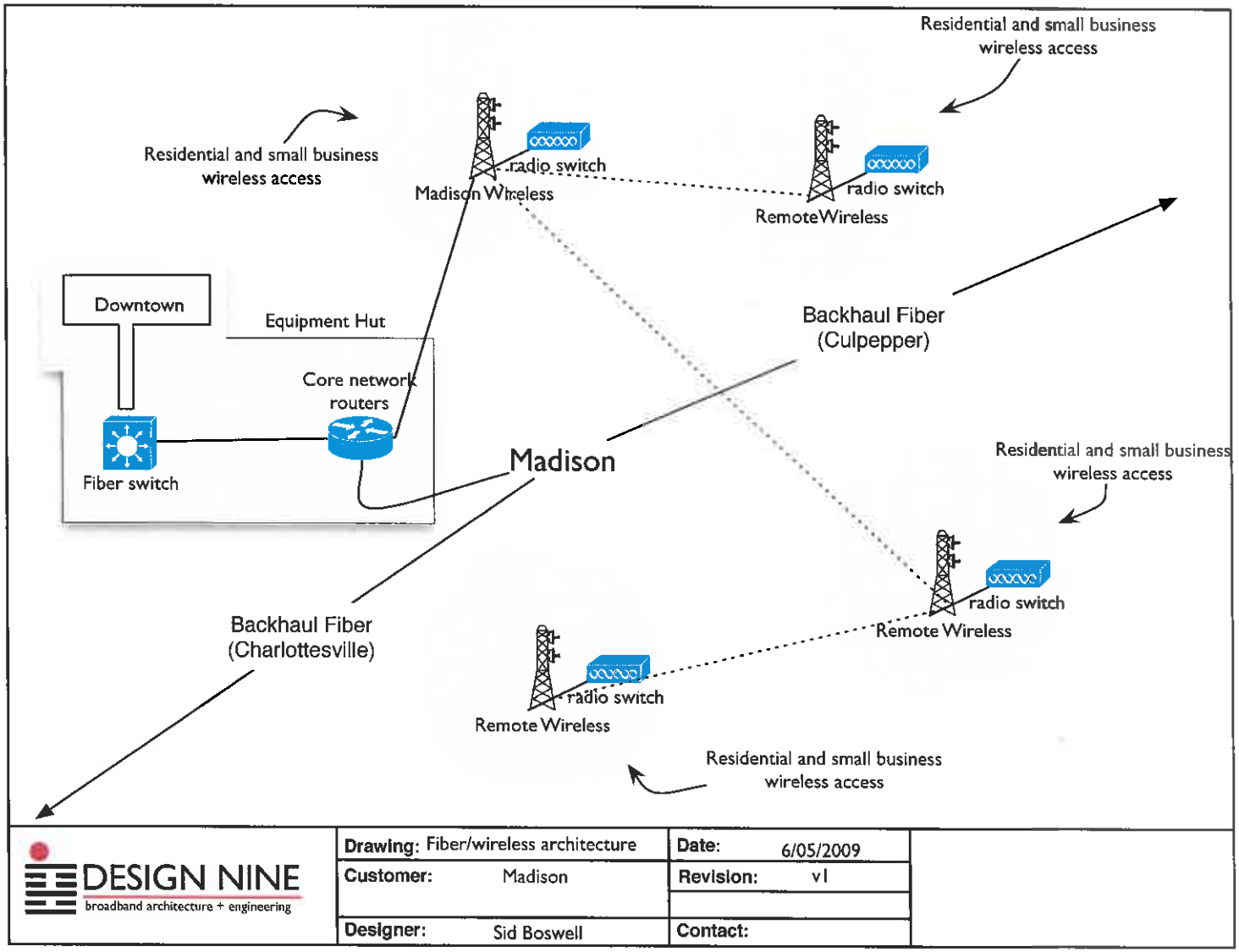
Equipment

By building equipment "huts" and colocation facilities, Madison will lower the cost of entry for service providers interested in providing services in Madison County. Not only do these equipment locations save the cost of construction for service providers, but it will allow the service providers to provide services over the existing long-haul fiber at a more attractive price by aggregating the services at the point of entry into the Madison network.

A phased approach

Madison needs to take advantage of funding opportunities though both the American Recovery and Reinvestment Act (also known as the Broadband Technology Opportunities Program and commonly referred to as the Broadband Stimulus) to built an initial wireless and fiber network. This can include fiber in the downtown areas and point-to-point and multipoint wireless in more remote areas.

The diagram below is an illustrative example of a network for the Madison region.


Residential and small business wireless access
Residential and small business wireless access
radio switch
Madison Wireless
radio switch
RemoteWireless
Downtown
Equipment Hut
Core network routers
Fiber switch
Backhaul Fiber (Culpepper)
Madison
Residential and small business wireless access
radio switch
Remote Wireless
Backhaul Fiber (Charlottesville)
radio switch
Remote Wireless
Residential and small business wireless access
DESIGN NINE
broadband architecture + engineering
Drawing: Fiber/wireless architecture
Date: 6/05/2009
Customer: Madison
Revision: v1
Designer: Sid Boswell
Contact:

Open Infrastructure vs. Open Network Considerations

In the ***open infrastructure*** model, the community invests primarily in passive telecom and broadband infrastructure: dark fiber (no electronics), duct, colocation facilities, cabinets, and wireless towers. Private sector service providers lease access to the assets (dark fiber, wireless towers) and sell services directly to their own customers. Each service provider has to provide their own electronics.

In the ***open network*** model, the community builds a fully operational broadband network capable of handling any anticipated service, including video, voice telephone services, Internet access, video on demand, telemedicine, telehealth, and other advanced residential and businesses services. Incumbent and new service providers lease capacity on the network (bandwidth) and have to provide only a very small amount of equipment.

Features	Open Infrastructure	Open Network
Basic Concept	Only provide passive infrastructure to the premise (e.g. dark fiber), wireless towers, colocation facility. Private sector service providers each have to add their own electronics to service customers,	Active network includes dark fiber and all network electronics end to end. Service providers do not have to add electronics to serve customers.
Service Provisioning	Each service provider has to buy or build their own software to provision services like voice, video, and Internet access. This raises the cost of service and makes it more difficult for smaller providers to compete.	The network includes a single provisioning system used by all service providers. This keeps costs low for service providers and makes it much easier for smaller service providers to compete effectively.
Fiber Management	Network design must be done very carefully to ensure that enough fiber is available end to end to meet demand. The need to overbuild increases construction costs. More splice cabinets and equipment cabinets are needed to accommodate equipment overbuilding by providers. Fiber cable management has to be done carefully.	No overbuilding of fiber is required because all providers use the same end to end system and share bandwidth on the community fiber, rather than each firm having dedicated fiber to customers. Fewer cabinets and splice points needed because all providers share the same fiber infrastructure. Fiber management is much simpler.
Competition	Higher cost of providing services effectively limits the number of service providers. In residential areas, the first provider to make an equipment investment can effectively "capture" that area because it becomes too risky for a second provider to try to compete. Small businesses may also have a smaller range of of service options.	The low cost of market entry and high level of service automation attracts service providers and encourages innovation. Both business and residential areas will have a wider range of competitive service options, which drives down prices.
Revenue	Revenue is lower because only fiber is being leased, not network capacity (i.e. bandwidth).	Revenue is much higher because the value of a full network (end to end electronics and automated service provisioning) sharply reduces capital costs for service providers.
Risks	Lower initial and long term financial exposure because most investments (e.g. fiber, wireless towers) can be amortized over twenty to thirty years. Community and economic impact may be lower because of limited competition and higher prices for services.	Higher initial costs and higher recurring costs because the network electronics have to be replaced on a recurring cycle, as well as replacement due to weather and physical damage. Community and economic impact can be substantial because of increased competition, a wider range of services, and lower costs for services.

Risk Factors

Market Size

Market size is a key consideration for evaluating risk. Market size (called "addressable market," or the number of potential customers) determines the level of interest of service providers, who are the primary customers of an open network. Certain kinds of services are essential to the financial viability of a community network, especially TV and telephone services. While telephone services can be offered affordably in even very small markets, the overhead costs of establishing a local or remote TV head end (equipment that manages and distributes the channels available from a provider) is still relatively expensive compared to providing other services like Internet access. A rule of thumb for evaluating market size is that a minimum of four to five thousand potential residential customers (households) are needed to attract an IP TV provider. Note that fiber is required for adequate TV package offerings.

Madison has a residential market of 5,453 households (2008 estimate) and a business market size of approximately 317 establishments. With many households and home-based businesses still using dial-up, Madison represents a business opportunity for service providers who can make a business case for providing services like Internet access and VoIP telephone service. Alternatives to existing cable and satellite TV offerings will not become available until fiber connections are more widely available.

Take Rate

Take rate refers to the number of customers that actually subscribe to one or more services. Take rate targets are established in a detailed financial projection, and are adjusted over time as actual take rate data becomes available once the network is in operation. If the take rate is too low, revenues will not meet goals, and lowered revenues may affect the project's ability to pay its bills and maintain and operate the network.

Take rate projections are a significant risk factor in any project of any size, and must be considered carefully. Take rate risk can be managed by only building in areas where businesses have made a threshold commitment to buy a minimum dollar value of services (e.g. 40% of businesses in a defined area must commit in advance before build out would commence).

Funding

Excellent leadership and hard-nosed business management of the enterprise are essential to the project's ability to obtain necessary funding. Although the network will be operated as a local government effort, it must be managed with the same attention to costs, revenue, and financial administration as any private sector business. The project must be able to develop and maintain "investment quality" financial reports and business models to attract

private sector sources of funding like revenue bonds, municipal leases, commercial loans, and business contributions.

If Madison County restricts investments to basic infrastructure like tower sites, towers, and equipment shelters, maintenance costs will be relatively low and it should be possible to structure attractive tower space lease rates to cover routine maintenance, minimizing financial risk and requiring limited funding. A modest ARRA stimulus grant request could provide the funds for the initial investment without requiring the County to take on any debt.

Service Providers

While in many respects a community broadband network shares many similarities with other public utilities (e.g. roads, water, sewer) there is one fundamental difference. Other public utilities like water and sewer have a captive audience and the utility is able to operate as a monopoly–meaning the customer base can be taken for granted. Early discussions with service providers have been positive, with at least two providers making requests for additional information about the effort.

A community broadband network is a public/private enterprise, and service providers are the primary customers of the network. Service providers cannot be taken for granted. Instead, a fair fee structure, a high quality network, excellent maintenance and operations processes, and organizational flexibility will be required to recruit and retain service providers.

Projects that are not successful in attracting service providers will fail. Affordable lease rates for tower space and/or fiber connections will attract service providers. Other open access projects in Virginia (Danville, The Wired Road) have not had any difficulty getting service providers to use the infrastructure.

Technology

A question that often dominates early discussions of community broadband projects is, "Are we picking the right technology and systems?" Everyone has experienced the rapid obsolescence of computers, cellphones, printers and other IT equipment.

There is always some risk associated with making a substantial investment in a network. However the risk can be managed. In a predominantly fiber network, a large portion of the investment will be dedicated to getting fiber in the ground or on poles throughout the community. Properly installed fiber has a minimum 25 to 30 year useful life, and fiber installed by the telephone companies in the seventies is still in use today. Fiber also has a useful property not shared with other public systems like water, roads, and sewers. The capacity of fiber can be increased without replacing the fiber or adding additional fiber. Instead, fiber capacity can be increased indefinitely by replacing the electronics at each end of the fiber. This means that a community investment in fiber creates a stable, long term asset for the community with long lasting value.

The equipment used to light the fiber has a shorter useful life, and is usually depreciated over a period of 7 to 9 years. Some equipment may remain useful longer than that. Wireless equipment must be replaced much more often (typically 2 to 4 years of useful life) because it is typically exposed to much harsher conditions (extreme heat and cold, lightning strikes, ice, snow, rain, wind).

The primary technology risk is selecting a vendor who provides equipment that does not perform as advertised. This risk can be managed by a careful procurement process which would include a careful analysis of network capacity and features, detailed RFPs that specify equipment features and functions explicitly, and a thorough RFP evaluation process.

Madison's risk is this area will be relatively low if investments are confined to passive infrastructure.

Marketing

As noted above in the discussion of service providers, a community broadband effort is inherently a public/private enterprise with some distinct differences that set it apart from other public monopoly services like water and sewer. Even if the network successfully attracts a good mix of service providers, a successful project must have a well-designed, long term strategy for marketing and public awareness. Even if incumbent providers are offering services on the new network, many businesses may be slow to change from their current telephone, TV, or Internet provider for a variety of good and bad reasons (e.g. apathy, perceived difficulty of switching, lack of understanding of benefits, poor marketing by service providers). While service providers will each have their own marketing efforts, the network itself, especially in the first two to three years, must make a concerted effort to help the businesses understand the benefits of buying services on the new system (e.g. lower costs, new services, faster Internet access, etc.).

Applying for Stimulus Funds

Final rules for the second round of ARRA broadband stimulus funding will be released in November or early December, 2009; but applications for this second round of funding will likely be accepted until mid-January, 2010. Awards will not be made until May, 2010. This gives communities more time to put together good solid proposals.

If Madison County decides to submit a proposal, this study will provide valuable documentation that the region has already completed substantial planning and is "shovel ready."

Pre-work

- Discuss proposal with local leaders, and stakeholders
- Identify the grant writing team (no more than 3-5 people with previous grant writing experience and the time and influence to get all needed information, support, and commitment letters.
- Identify 20% match sources. If cash match from local sources, get firm letters of commitment. If in-kind match, provide very specific information about the kind and type of match and how the cash equivalent value was determined.
- Get a DUNS number (Dun and Bradstreet). A DUNS number is free and can be obtained from the D&B Web site.
- Meet with local elected officials to discuss proposal. Prepare draft resolutions of support. If there is only 30 days to submit an application, there may not be time to get an elected body (town council, board of supervisors) to advertise and vote on the resolution, so start immediately on this work.
- Identify the proposed project management team and collect both half page and one page resumes from each management team member (note that the project management team may NOT be the same as the proposal grant writing team). Keep in mind that the management team must have business, financial, and telecom experience in broadband and business management. Management teams that consist only of public employees and community nonprofit leaders may not be competitive.
- Gather local data that will be needed to show need:
    - Unserved and under-served areas.
    - Literacy rates
    - Free lunch percentages
    - Unemployment figures
- Meet with economic development officials and get both letters of support but assistance tying the proposal to broader economic development goals.

Proposal Preparation

The second round application is likely to be similar to the first round application. If each of these areas are addressed in draft form (typically 1-2 pages each), it will be relatively quick and easy to adapt the draft materials to meet the exact proposal format.

	Topic Area	Description	Length
❑	**Executive Summary**	Overview of the project, description of proposed service areas, households and businesses passed, community anchor institutions served by the funding, qualifications of the applicant (Madison county), estimated costs, and estimated jobs created.	3 pages
❑	**Benefits Narrative**	Discuss economic development strategies for the community/region, complementary community development efforts (e.g. Main Street revitalization), and outcomes (new jobs, new business attraction, improved focus on cluster business development, work from home opportunities.	2-3 pages
❑	**Project Purpose**	Purpose of the project and how it supports the objectives of the BTOP program.	2 pages.
❑	**Match Narrative**	Describe all sources of match funds. For non-cash and in-kind match, provide detail on how cash equivalent match was calculated. Cash match is preferred and will help improve the strength of the application.	1 pages
❑	**Budget Summary**	Spreadsheet that shows major budget categories.	1 page spreadsheet
❑	**Budget Narrative**	1-2 paragraph descriptions of major expenditures in each budget category.	2-4 pages as needed
❑	**System Design**	Detailed maps of service areas, description of network, network design diagrams, and cost estimates.	Depends on size of project.
❑	**Maps**	Well-illustrated, appropriate maps of service areas and community/region. Note that the proposal will need both detailed network route maps and will also have to use the online mapping tool that is part of the online application process.	As needed.

Topic Area	Description	Length
❑ **Management Team**	Management Team bios of the team/board of directors that will be responsible for managing grant funds, purchasing, hiring consultants and contractors, and filing grant reports.	1 page bio per team member.
❑ **Organizational Readiness**	Key factors to show how the community/organization is prepared to implement, manage, and operate the requested infrastructure investments. Describe the organizational, governance, and management approaches. Address how you will handle sales, billing, operations, and maintenance.	About 1 page (4000 character limit)
❑ **Key Partnerships**	Identify key partnerships and stakeholders, including public sector, private sector, and nonprofits, especially anchor institutional users and public safety users. Provide supplementary documentation for each partner (letters of support).	1/2 page description, no limit on support letters.
❑ **Organizational Chart**	An organization chart that details the structure of your organization, including partnerships, governance boards, affiliates, and community organization relationships.	1 page.
❑ **Demonstration of Financial Need**	Explain why the project would not be implemented without Federal support. Provide specific data to help make the case that assistance is needed (e.g. community economic and jobs data).	About 1 page (4000 character limit)

Stimulus Grant Proposal Writing and Development Team

No more than 3-5 members to keep decision-making efficient. Grant writing team should have:

- Prior experiencing writing grants
- Substantial influence in the community to make calls and request support.
- Time in May, June, and July to plan the project, contact all needed participants and stakeholders, collect commitment letters, meet with key appointed and elected officials, develop a project budget, and take responsibility for writing and submitting the grant.

Name	Affiliation	Phone Number	Email

Recommended Areas of Attention

Madison's most urgent need to make some broadband service (e.g. wireless) available throughout the county. The County's goals for low growth/low density residential land use will be distorted as potential home and property buyers avoid those areas of the county without broadband. In our conversations with real estate agents in other communities, we hear regularly that professionals and younger families routinely include the availability of broadband (or the lack of it) in home-buying decisions.

A public/private partnership approach that makes key broadband infrastructure like wireless towers available to private sector service providers limits the expense and effort required by the county to improve broadband access and affordability while quickly getting better service available throughout the county.

Ownership and Management

Madison County should consider direct county ownership of any infrastructure investments. This is the simplest approach if the county opts for limited investments in passive infrastructure.

The strategic objectives for a broadband infrastructure initiative should include:

- Ensure that affordable broadband services are widely available to government, business and residential end users within the county.
- Leverage the telecom and broadband infrastructure investments to support broader county economic and community development goals.
- Avoid public sector competition with private sector service providers that want to sell services in the region.
- Establish an ownership and management structure that is efficient and that does not unduly tax the capacity of the local government staff to manage and maintain the infrastructure. Note that specialized operations and maintenance can be outsourced to qualified private sector firms, so staffing requirements should be manageable.
- Ensure that there is adequate revenue derived from the leasing of the network to support maintenance, repairs, upgrades, and some expansion.

Action Step: The Management Team should make a recommendation to the Board of Supervisors to adopt a policy of making limited and manageable investments in open access broadband infrastructure.

Infrastructure

Madison County should consider a short term strategy (next 12 months) to make wireless broadband services available everywhere in the county by investing in additional tower sites and towers, and making tower space available on an open access basis to private sector service providers.

Action Step: Fund Line of Sight (LOS) studies to identify candidate locations for additional towers.

Action Step: Meet with existing providers like Virginia Broadband and others to determine where those firms would like to be able to offer expanded service offerings.

Action Step: Coordinate tower location sites with existing county property to minimize the cost of site leases (e.g. K12 schools, water/sewer pump stations, etc.).

Action Step: Get assistance from a qualified broadband planning firm to develop an implementation plan that includes detailed cost estimates for sites, towers, equipment shelters, and related costs.

Madison County should consider a long term (next 2-3 years) to create a fiber backbone that will connect county facilities, county schools, towns, and wireless towers. Over time, this fiber backbone can become the basis for a public/private countywide fiber to the premise project.

Action Step: Fund a modest implementation planning effort to obtain detailed pre-engineering cost estimates for a countywide fiber backbone.

Action Step: Consider including a middle mile fiber backbone project in an ARRA broadband stimulus funding request.

Public/Private Partnerships

Madison County not compete directly with the private sector by becoming a service provider. Instead, the county should focus on making investments that support an open access business model that lowers the cost of basic broadband infrastructure for private sector service providers.

Action Step: Provide summary recommendations of this report to area service providers and solicit their participation in the effort, including support for an ARRA broadband stimulus funding proposal.

Financing

Madison County should consider submitting a modest ARRA broadband stimulus funding request in round two or three of the broadband stimulus funding.

Action Step: Convene a meeting to determine if there is sufficient interest to submit an application.

Action Step: If the County decides to submit an ARRA stimulus funding request, a small (3-5 people) grant writing team should be assembled to prepare the local material needed for an application.

Action Step: Identify a qualified broadband planning firm to provide the technical and financial information needed for a competitive application.

Provide adequate staff time and personnel to support the development of an ARRA stimulus proposal.

Action Step: Meet with county government department heads and leaders who will need to provide information, cost estimates, and other materials needed for the stimulus application.

Action Step: Develop a timeline and milestones to ensure that all stimulus application materials are gathered and coordinated without undue stress and strain (i.e. try to avoid a last minute, late night work effort).

County Initiatives

There are numerous opportunities for Madison County to make prudent investments in telecom infrastructure without spending large amounts of money, or in some cases, without spending any money at all directly. County policy changes can have a substantial impact on the installed telecom infrastructure in the community over time, if those policy changes are embraced and pursued diligently.

Develop a fiber overlay (middle mile) plan for the County that will take fiber to all critical County facilities, including public safety and first responder locations, water and sewer pump facilities, schools, high water and water monitoring locations, parks and recreation facilities, and all key traffic management equipment.

Action Step: Develop a fiber overlay plan that identifies all major routes for fiber and all needed wireless tower and/or antenna locations.

Action Step: Perform wireless Line of Site (LOS) studies to identify the best locations for additional wireless towers (if needed) and for utilization of existing water and communications towers.

Madison County should have an "open ditch" policy that considers installing fiber alongside water and sewer extensions and improvements.

Action Step: Meet with County department heads and planners to review the fiber overlay plans.

Action Step: Develop a policy of including telecom duct in any open ditches (for water and sewer improvements), and other public works projects when the work matches routes in the fiber overlay plan.

Action Step: Consider training county public works staff to install fiber cable. This has been done successfully in Galax, Virginia, where the City public works department has connected more than 60 buildings with fiber in the downtown area.

The County should have a pandemic emergency plan in place that would allow County employees to work from home in the case of an epidemic that requires long term quarantines (e.g. 40 days or more).

Action Step: Audit County employees to determine who has broadband access from home and who does not. Determine if critical staff are still on dial-up service at home, and evaluate the impact on County operations if those staff were not able to work from home during a pandemic emergency of days or weeks.

Action Step: The IT department should review the capacity of the County IT infrastructure to have most or all County employees accessing County servers and information from home. Dependencies on data, security issues, and backup strategies should be evaluated for robustness.

Madison County should evaluate utilization of a next generation network to support shared public safety and government communications goals.

Action Step: County planning and IT staff should meet to discuss how a next generation network could improve response and management of public safety emergencies (e.g. pandemics, weather catastrophes, etc.).

Action Step: The County should consider taking fiber to all County and County radio towers to provide better support for wireless communications and to provide better support for Emergency Communications.

Action Step: The County should explore FEMA and Homeland Security funding options for using fiber for redundant emergency communications routes and for improved wireless communications.

Action Step: The County should explore eliminating all or most POTS (Plain Old Telephone Service) voice lines and replace them with VoIP (Voice over IP) telephone systems (savings could range from 25% to 60% of current voice costs).

Ensure that businesses and citizens in Madison County have adequate information about the value of the community investments in telecom infrastructure.

Action Step: Use public meetings, newspaper and radio, civic group meetings, and other community events to acquaint citizens and businesses with the project and why it is being considered.

If there is agreement to move forward, the effort should include at least one or two well-publicized public meetings to give citizens and business people an opportunity to learn more about the study effort and to ask questions.

Action Step: Hold a public meeting in the fall of 2009. Evening meetings work best, and should include a brief presentation about the opportunities, including business attraction and work from home opportunities.

Provide information to local community groups on the broadband study.

Action Step: Members of the Management Team should attend community group meetings (e.g. Rotary, Chamber of Commerce, Lions, etc.) to give brief presentations and to explain why the broadband investments are important to the county.

Community

Numerous opportunities exist to improve the living and work spaces in Madison, especially when new construction is underway. Remarkably, many builders and architects still fail to include adequate network cabling in their residential and commercial building designs. The County can play a leadership role by encouraging stepped up private sector investment in telecom infrastructure.

All new commercial and retail buildings constructed in Madison should have appropriate "Internet ready" structured cabling from a Building Distribution Frame (BDF) to all office and workspaces.

Action Step: County planners should begin meeting with developers, builders, and architects to encourage adding appropriate telecom facilities in all new buildings.

Discussion

All new commercial buildings in the County should include appropriately designed telecom facilities (e.g. telecom closet(s), cable trays in the ceilings, 4" risers between floors, etc.). The building spaces become more valuable, and when the appropriate infrastructure is designed in, the cost to the tenants is lower.

All new commercial and retail buildings constructed in Madison should have a minimum of two 4" ducts from a pedestal or hand hole in the public right of way to the telecom closet or BDF (Building Distribution Frame) area.

Action Step: All new commercial buildings in the County should have telecom duct installed from the structure to a County-designated demarc point in the right of way. Property owners would be responsible for the duct to the County demarc point. The County would own the conduit in the right way (pedestal to pedestal duct).

All new residential developments in Madison should have duct from each home to a pedestal or hand hole, and duct from each pedestal or hand hole back to a neighborhood demarcation point for network electronics and/or optical splitters.

Action Step: All new homes in the County should have telecom duct installed from the home to a County-designated demarc point in the right of way. Homeowners would be responsible for the duct to the County demarc point. The County would own the conduit in the right way (pedestal to pedestal duct).

Action Step: County staff and planners should begin meeting with local builders and developers to encourage the inclusion of structured cabling (Ethernet cables) in all new residential single family homes, rental units, and condominiums.

Action Step: A short handout should be prepared that describes the adequate level of structured cabling needed in new homes. This should be circulated to County and county planners, local builders, developers, and real estate agents.

Action Step: County planners should begin meeting with developers to discuss this initiative and to help educate developers and builders on the enhanced value that accrues from this investment.

Discussion

The cost of adding structured cabling to a new home is a tiny fraction of the cost of construction (typically less than $500). At least three Cat 5e/6 cables should be pulled to every living space in the home (with the exception of bathrooms) to provide for complete voice, video, and Internet access in every room. All cables should be run back to a structured cabling panel on an outside wall, near the building entrance for utilities. A recent study showed that homes with fiber to the premise sell for $5,000 to $7,000 more than homes without fiber.

All new residential developments in the County should have telecom duct installed by the builder. Duct would be routed from the side of the home where other utilities enter the home to a nearby pedestal or handhole. Eventually, duct from the handhole would run back to a neighborhood cabinet or optical splitter location for network aggregation. The cost of this work (duct from the home to the curb or rural road right of way) is typically only $200-300 per home.

Ensure that local businesses understand the importance of a Disaster Preparedness Plan for their businesses, especially those that rely on telecommunications and technology for some or all of their business operations.

Action Step: Approach a local education partner (e.g. public schools, community college) about developing a short course or courses on disaster preparedness that covers topics like maintaining business operations during a pandemic emergency, power generators for businesses, backup and recovery services, off-site backups, and reconstituting a business after a flood or natural disaster.