POLICY BRIEF
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Municipal Broadband:
Demystifying Wireless and Fiber-Optic Options

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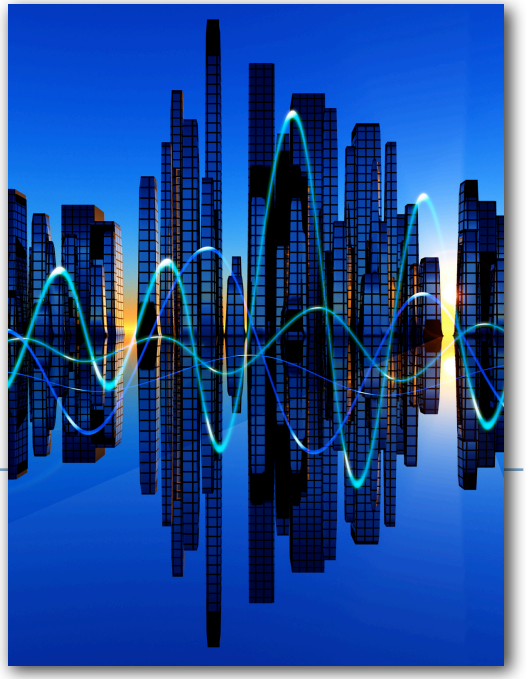

Executive Summary

The United States, creator of the Internet, increasingly lags in access to it. In the absence of a national broadband strategy, many communities have invested in broadband infrastructure, especially wireless broadband, to offer broadband choices to their residents.

Newspaper headlines trumpeting the death of municipal wireless networks ignore the increasing investments by cities in Wi-Fi systems. At the same time, the wireless focus by others diverts resources and action away from building the necessary long term foundation for high speed information: fiber optic networks.

DSL and cable networks cannot offer the speeds required by a city wishing to compete in the digital economy. Business, government, and citizens all need affordable and fast access to information networks. Today's decisions will lay the foundation of telecommunications infrastructure for decades.

Fortunately, we already know the solution: wireless solves the mobility problem; fiber solves the speed and capacity problems; and public ownership offers a network built to benefit the community.

Introduction

Minnesota's capital city, St. Paul, recently considered building a wireless network in order to quickly offer all 285,000 residents an affordable broadband connection. With the Republican National Convention date approaching in 2008, the City Council created a Broadband Advisory Committee and pressed it to move quickly.

The committee refused to act hastily and studied several broadband options for the city. Over the course of the next year, the committee decided a wireless network would not serve St. Paul's long-term interests and called for a fiber optic network, built in phases, that could have wireless as an add-on.

The same week the St. Paul City Council accepted the committee's recommendations and started studying fiber options, the front-page headline in USA Today declared, "Cities turning off plans for Wi-Fi."[1] Earthlink's apparent withdrawal from citywide wireless ventures has spawned a flurry of articles about the death of citywide wireless.

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One might see St. Paul's actions as confirming the death of wireless. We do not. Municipal wireless is not dead – many cities continue to investigate, build, and maintain wireless networks. MuniWireless' 2007 State of the Market Report showed that spending on municipal wireless networks in 2007 has increased and is projected to continue increasing in 2008.[2]

Earthlink's announcement[3] did not mark the demise of wireless; it signaled the end of a flawed business model. Cities can no longer find partners willing to shoulder the cost of the network solely for future subscriber revenue. With few exceptions, private providers (e.g. Metro Fi) will only build networks where the city will lock itself into anchor tenancy – where the city government will guarantee a revenue stream for the network owner by purchasing a set amount of services. Such networks depend on city funds to exist, while not offering any accountability to the city.

Many cities continue moving forward with publicly owned systems - where the public both pays for the system *and* has input on how it is managed and priced.

Cities look to wireless networks to allow police officers to submit reports from the squad car, enable fire fighters to quickly download building blueprints at the scene, and building inspectors to access plans and forms from the field. However, these mobility needs have not diminished the need for wired infrastructure, with its unmatched speeds and capacity.

Broadband networks are essential infrastructure and the U.S. is in the middle of an expensive transition away from copper-based networks to fiber-optic systems. The decisions made now will impact telecommunications infrastructure for decades.

As St. Paul found, fiber-optic wires form the communications foundation of the future. Fiber networks last for the long term while offering unmatched speeds and capacity. The question should not be whether to invest in fiber *or* wireless any more than one would ask whether shoes are "better" than hats. Ultimately, they solve different problems and neither offers a one size fits all solution.

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Wireless Networks

The key benefit of a wireless network is mobility. All laptop computers are now built with Wi-Fi cards in them, allowing them to access Wi-Fi networks. These computers can jump on the Internet anywhere that has a Wi-Fi network, whether the living room, coffee shop, or public square. Samsung, Nokia, and Apple all make phones that can use Wi-Fi networks as well. As these devices become more common, users will want to connect everywhere in order to check e-mail, sports scores, or the weather.

Wi-Fi

In 1997, a consortium of companies developed the Wi-Fi brand to popularize and sell interoperable devices to transmit and receive data wirelessly. Wi-Fi uses unlicensed radio frequencies, allowing anyone to easily set up a household network by buying a router. Nearly all laptops, and increasingly hand-held devices, can connect to Wi-Fi networks. Thus far, most city-wide wireless networks use Wi-Fi radios.

Wi-Fi networks do not require expensive radio spectrum licenses. However, costs have been much higher than anticipated for both public and private networks. Network designers first believed that 18-22 nodes (Wi-Fi radios mounted on utility poles) per square mile would provide sufficient coverage but are now suggesting 40-60 nodes/square mile for an effective network. Even then, areas with heavy foliage and houses with stucco walls may need to invest in an external antenna to connect.[4]

Aside from its inherent mobility advantage, some cities are attracted to Wi-Fi as a quick and less expensive way to offer broadband connections over a large geographic area. The price tag for a Wi-Fi network varies greatly depending on size, density, and geography, but the initial investment is generally an order of magnitude less than the initial investment for a fiber build. Ongoing costs include electricity to run the nodes, pole-attachment fees, maintenance, backhaul,[5] etc. The Wireless Minneapolis network, covering over 55 square miles, will cost $24 million and be built in under two years.

Depending on the above factors, the likely initial cost of a Wi-Fi network will be between $250,000 - $450,000 per square mile. Once the network is built, operations and maintenance requires an ongoing commitment. Radios will need upgrading and repairing. Due to the rapid pace of technological change, expect to start replacing radios after 2-3 years. These expenditures can run from 20-40% of the initial capital cost (or more in rare circumstances) each year. Over the course of five years, every wireless radio will likely be replaced.

Once the Wi-Fi network is operational, cities may be able to cut expenses on cellular cards for first responders and other workers requiring mobility in the field. Those who will not need connectivity outside network

boundaries should be able to rely on Wi-Fi rather than expensive subscription-based networks.

When calculating their return on investment for publicly owned wireless networks, cities should include revenue from subscribers as well as cost savings and productivity increases. Building inspectors will be able to access plans from the field, saving considerable time and resolving issues quickly. Police officers are increasingly free to complete paperwork in the field rather than behind a desk. Water, electric, and gas meters can use the network to report usage or problems, saving time and wasted resources from leaks undetected for too long. Many of these efficiencies are difficult to quantify but will benefit the community and reduce budgets.

Those who expect a future without wires are sadly mistaken. Existing wireless networks are perfectly adequate for voice, email, or Internet surfing, but their limitations preclude high-quality videophone applications and other bandwidth intensive applications.

Ubiquitous wireless networks are so new that no one can predict how they will be used in a few years as more network-aware devices become commonplace. Still, those who expect a future without wires are sadly mistaken. Existing Wi-Fi networks are perfectly adequate for voice, email, or Internet surfing, but their limitations preclude high quality videophone applications and other bandwidth intensive applications.

Current Wi-Fi networks offer theoretical speeds up to 54 Mbps but the real world of interference and physical barriers results in far slower speeds. Additionally, each node must share its bandwidth among multiple users; each user receives only a slice of the available connection. In practice, citywide wireless users are generally looking at no more than 1-2 Mbps, often less depending upon the signal strength at their location. These speeds are comparable to wired connections (as experienced by users) from phone and cable companies. Future Wi-Fi standards will bring faster connections but new applications constantly increase demand for faster speeds in a perpetual cycle.

For several years, a new technology called WiMAX (Worldwide Interoperability for Microwave Access) has been expected to offer faster, more reliable wireless connections. WiMAX networks should offer stronger signal strength, faster speeds, and better penetration, but require an FCC license to effectively deploy (specifically 2.5GHz in the U.S.). A licensed vendor may be able to offer a city faster wireless access that easily reaches inside buildings using fewer access points.

In order to offer this technology, a provider needs to secure a license in the geographic area in which it plans to operate. In the U.S., Sprint Nextel and Clearwire control the overwhelming majority of licenses, making WiMAX somewhat less attractive for municipal deployments. Just as some iPhone customers loathe being locked into long term AT&T contracts, communities should be wary of being locked to a single vendor.

Additionally, few laptops and devices currently support WiMAX networks (Wi-Fi cards cannot receive WiMAX signals). Until WiMAX networks are operational, no one knows how interoperable they will be - whether the Sprint WiMAX cards (marketed as Xohm) will work on other WiMAX networks. The WiMAX Forum and companies like Motorola and Intel have claimed that WiMAX products will be interoperable but major vendors (Sprint and Clearwire) have not finalized a deal at the time of this writing.

Cellular companies also offer a mobile, though slow, option for data transfer. First responders in many cities rely on cards from Sprint, Verizon, etc. that allow them to use the cell network to transmit data from their laptops. These connections tend to be considerably slower than the options discussed above.[6] When the I-35W bridge in Minneapolis collapsed, emergency personnel relied on the Wi-Fi network to use applications too bandwidth intense to operate over cellular networks.

Cable and DSL

Some cities have invested in Wi-Fi networks to offer their residents an additional broadband option. Many of these cities have been frustrated with their existing options. Neither cable nor DSL can offer the necessary bandwidth to be competitive in the digital economy. Understanding this important point requires some understanding of both the technology and oversubscription model.

Nearly all networks are oversubscribed - not all vehicles can drive on roads at the same time, everyone cannot draw water from the pipes at the same time, and the electrical grid will fail if everyone turns on every appliance and light at the same time.

Bits and Bytes

A bit is the smallest piece of information, the foundation of computing. Network speeds are measured in bits - kilobits per second (kbps), Megabits per second (Mbps), Gigabits per second (Gbps) for one thousand, one million, and one billion bits per second. To make things confusing, file sizes are measured in bytes (one byte = eight bits, 1 million bytes = 1 Megabyte or 1 MB).

Common Carriers and Regulation

Roads have been common carriers for centuries, allowing everyone to use them equally. When applied to telecommunications networks, a common carrier network allows different service providers to use the network. Roads, like telecommunications networks, are expensive to build, creating a natural monopoly for the first mover. New competitors face serious barriers to entry because an existing network can temporarily lower prices until the competitor files for bankruptcy. Without competitors, monopolists tend to stagnate because they have little incentive to innovate.

Until 1968, the phone company was the sole provider of phones, renting them to generate revenue. In that year, the FCC required AT&T to allow others to attach non-damaging devices to the network (the Carterphone decision). Carterphone opened the phone network and led to decades of innovation, which resulted in fax machines, computer modems, answering machines, cordless phones, etc. Open networks create spaces for entrepreneurs and new technologies.

Unfortunately, modern trends are pushing networks back toward closed, monopolistic models. Broadband over DSL is no longer a common carrier service. Publicly owned networks can reverse this trend by opening the network to innovators and competition among service providers.

Network designers have to make assumptions when creating a network. The electrical grid is built to handle the likely load on the hottest day of the summer and then padded for security. Historically, the telephone network was built to survive Mother's Day, its busiest day of the year. Phone companies built their system assuming the average call would be three minutes long, based on years of similar patterns.

When households started using the Internet, they would use a computer modem to dial a local Internet Service Provider over their phone lines. In most areas, they could choose from multiple service providers, from a small business on Main Street, to America Online. As the Internet became more popular, phone companies began to fear for their networks because the connections lasted considerably longer than three minutes. They had to change their oversubscription assumptions and reengineer the network.

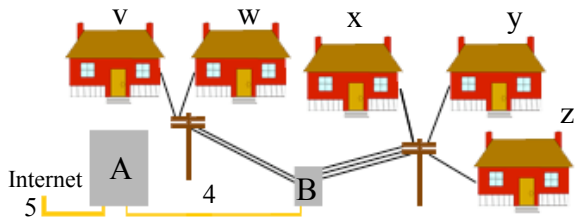
Over time, modem speeds increased slowly while expectations increased rapidly. Following the Telecommunications Act of 1996, phone companies rolled out DSL (short for digital subscriber line, but almost universally known by its acronym) over their wires. Because the telephone networks were then regulated as common carriers, phone companies had to compete with other Internet Service Providers for subscribers. Many people and businesses used a DSL connection from their incumbent phone company to connect to a different service provider for Internet access.

DSL connections use phone lines, but carry data at frequencies above human voices to avoid disrupting voice quality. Unfortunately, these frequencies cannot travel far, so subscribers must be physically close to the phone company's central office to subscribe. Even in large cities, many neighborhoods may be outside the reach of DSL.

Cable companies, upon realizing they could offer broadband access over their networks, began offering cable modem services. Though the networks were designed initially for a one-way transmission of information to subscribers, they have invested over $100 billion to date in order to upgrade their networks to offer broadband Internet access to subscribers.[7]

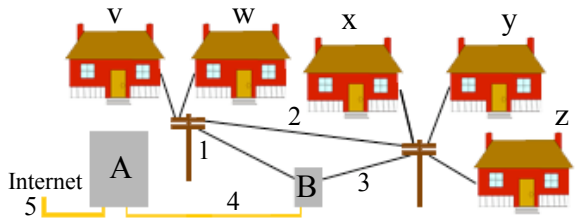
Ten years later, the vast majority of broadband users in the U.S. still connect using DSL or cable. Though they once offered speeds unimaginably fast, these technologies have not kept pace with increasing bandwidth

DSL Diagram



Each of the houses (v-z) have a dedicated connection to the central office (B). Oversubscribed fiber cables connect B to the regional switching center (A) which connects to the Internet. Their fastest speeds are limited by the distance from B to the home and any bottlenecks on 4 and 5.

Cable Diagram



This cable loop shares bandwidth among all the houses (v-z). The signal travels along the lines in an oversubscribed circular path: 1-2-3 (servicing 350-700 houses typically). The loop has 40 Mbps available, each subscriber has "up to" 6 or 8 Mbps. After returning to the node (B), it travels back along fiber to the routers at the centralized hub (A) which connects to the Internet.

needs. Neither cable nor DSL offer the fast speeds at prices needed to compete in the modern world.

DSL oversubscribes at the core of the network rather than the edge, as in cable. Speeds are limited both by bottlenecks and the subscriber's distance from the central office.

The cable network shares bandwidth among the hundreds of users in a neighborhood that share a loop. If a few subscribers are constantly using their connection to its full capacity, the connection becomes congested for everyone. Broadband cable advertisements therefore must use the "up to" language when describing network speeds. A user may experience "up to" 6 Mbps if very few of the neighbors are using it. However, when the neighbors come home from work and many users are on the Internet, they are lucky to see speeds of 1-2 Mbps. As more neighbors use the Internet more frequently, using increasingly bandwidth-intensive applications, everyone will suffer from slower speeds.

To manage its scarce bandwidth, Comcast enforces non-transparent transfer limits for Internet subscribers.[8] This means subscribers cannot use "too much" bandwidth. Comcast refuses to publish the limit, but it is thought to vary between 100 and 200 GB per month depending on the loop. As few users even approach this number currently, the practice is not well known among the general populace.

Every year, subscribers download more data. DSL and cable networks cannot handle the surge of traffic because they are built for a different era and do not have enough surplus capacity.

However, as subscribers begin downloading high definition movies (via XBox Live or Netflix in the future), they will easily approach the cap. A single HD movie may be 5-10 GB depending on compression and quality. Subscribers downloading two movies a week may start seeing letters from their cable company depending on how bandwidth intensive their everyday usage is.

Every year, subscribers download more data and the trend is likely to continue for the foreseeable future. DSL and cable networks cannot handle the surge of traffic because they are built for a different era and do not have enough surplus capacity.

Cable companies have long promised faster cable speeds as they roll out a new standard (DOCSIS 3). They claim it will offer speeds over 160 Mbps as

Network Neutrality

Technically, a neutral network treats all packets equally. However, information networks are oversubscribed and treating all packets equally may not be the optimal solution. Some applications (e.g. video and voice) require packets to arrive in a specified order within a certain time limit. Other applications (e.g. email, file downloads) are less time critical. For optimal results, networks must be able to discriminate between the two needs.

Ideally, any prioritization would be based upon application need. However, some network owners want to prioritize their own traffic to disadvantage competitors. An incumbent offering broadband may degrade Vonage or Skype connections in order to sell its own voice services. This is the problem most network neutrality advocates are attempting to solve.

The problem is not theoretical. Late in 2007, Comcast was caught forging reset packets, effectively disrupting and slowing some file-sharing applications over its network.[1] In 2005, the FCC fined a North Carolina Telco for blocking VOIP on its network.[2]

Former AT&T CEO Edward Whitacre suggested they wanted to start charging companies for access to their users.[3] Under this scenario, Google, Yahoo, Vonage, etc. would have to pay twice - once to put their content online and again to let AT&T's users access it. It is hard to imagine a better way of slowing innovation or undermining the democratic nature of the net by advantaging those who can afford to pay for access to more users.

Though some in Congress are crafting legislations to mandate neutral networks, the technology is rapidly evolving and many fear any legislation will be over reaching or be difficult to enforce.

Under current regulations, it is not clear that a municipality could prevent a private network owner from blocking competing services. Network owners are afforded significant latitude in running and managing the network. This is one reason the Institute for Local Self-Reliance favors publicly owned networks, over which private service providers compete. UTOPIA, a fiber network in Utah, is a pioneer in this model whereas Burlington, Vermont, has developed a hybrid system where the city both offers a triple play and allows other service providers to compete on its non-discriminatory network.

[1] http://tinyurl.com/22l3na [Information Week]
[2] http://tinyurl.com/37g6x5 [CNET News]
[3] http://tinyurl.com/9svdw [Business Week]

Peer to Peer (P2P)

When the Internet started becoming popular among non-computer geeks, it was based on a server-client model. Most of the Internet traffic was people visiting websites. Distributing content, especially audio and video, was expensive. Though more people could produce and distribute content, the high prices prevented most from participating.

Peer to peer technology stepped into this void. Users connect directly to each other rather than routing traffic through a centralized server. File-trading programs like Napster and KaZaA first gained popularity by allowing users to share music, and later notoriety for easily allowing copyright infringement.

Though some have used these technologies for illegal purposes (copyright violations), they are also used commonly for legal activities. Skype uses peer to peer connections to make phone calls. Viacom is starting to use Joost, a peer to peer product, to distribute some of its content. Video game company Blizzard distributes patches with Bittorrent.

Bittorrent may be the most promising peer to peer technology. A user downloads multiple chunks of a file from many users simultaneously while also uploading previously received chunks to other users. This distributes the load, saving content producers significant costs. As HD cameras and studio recording equipment are available at affordable prices to everyone, bittorrent could remove the last barrier – distribution.

Unfortunately, peer to peer technologies were not included in oversubscription models. These technologies redistribute the load, but the last mile of DSL and cable is ill-equipped to deal with the increased demand. Without faster networks, distributing media cannot continue democratizing.

though it will compete with speeds offered over fiber connections. Unfortunately, this bandwidth will still be shared among neighborhoods, dramatically reducing the speed a typical user will experience. Though the current standards (both DOCSIS 1 and 2) offer 40 Mbps downstream, it only delivers "up to" 6-8 Mbps per subscriber (and most subscribers never see speeds that fast).

DOCSIS 3 cannot keep up with the rise of Internet traffic. The cable networks were built to solve a different problem (distributing video) and have limits. With massive investments to reduce the number of subscribers per loop, cable companies could increase bandwidth, but few appear likely to make that commitment. Incumbent cable providers should not be blamed for maximizing returns to their existing investments any more than communities should be blamed for seeking networks that meet their needs.

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Comcast plans to use DOCSIS 3 to offer faster speeds in some 20% of its footprint by the end of 2008.[9] They will undoubtedly deploy first to competitive markets, so investing in a publicly owned fiber system may put your community at the head of the list in your region. Ironically, fiber systems may help cable companies by reducing subscribers on the loop, thereby reducing competition for the shared bandwidth and improving the speeds of those still on the cable network.

Slow speeds are not the only fatal flaw in cable and DSL systems; they are usually configured to maximize the downstream connection while skimping on the upstream. These asymmetrical connections mean subscribers can receive information faster than they can send it. The entire model is premised on the outdated idea that users need to request and consume information rather than create and distribute it.

Asymmetrical connections pose a problem because the Internet has moved beyond text and images. If parents on a cable or DSL connection attempt to participate in a simple video chat with their daughter on a fast network at college, they may be able to see and hear her clearly while she receives garbled and choppy video. The parents' connection is fast enough to receive video but not fast enough to send it over the network.

Businesses are also disadvantaged by slow upload speeds. Whether employees need access to the Internet to answer questions or to share large files with clients, they depend upon fast, reliable, and affordable connections. When typical cable and DSL connection are insufficient, they have to turn to more expensive connections. Too many businesses have to make a difficult tradeoff between employee productivity and telecommunications expenditures. This is not a tradeoff shared by competitors in the more connected U.S. cities and many developed countries abroad.

T.1 lines are a common commercial connection, offering 1.5 Mbps. Though the cost of T.1 lines is decreasing, businesses must bundle more of them together to satisfy increasing bandwidth needs. The rise of tele-

Business Connectivity Options

	Mbps	Cost/Month*
Cable/DSL	6/.9**	$100
T.1	1.5	$350-$1200
T.3	45	$3K - $12K
OC3	155	$15K-$100K

* Costs are approximate and vary based on local markets.
** "Up to" 6Mbps downstream, 896kbps upstream.

commuting means speeds to the home also need to be fast and symmetrical in order to fully support modern business needs. As network access becomes more important, companies increasingly prioritize locations with fast, affordable connectivity everywhere.

Municipal governments also require fast connections to govern effectively. Many cities currently lease connections to meet their bandwidth needs. Each community is different, due to federal programs like E-Rate to subsidize school and library connectivity. Some cities have negotiated discounted network connectivity as part of their cable franchise agreements. These Institutional Networks (or I-Nets) tend to start out impressive and solve municipal needs. However, the franchisee rarely has incentive to maintain and upgrade the network as frequently as the municipality would prefer.

I-Nets have been a nice perk of franchise agreements but are increasingly a relic of the past as states adopt new state-wide cable franchising laws. These laws allow video providers to deal with the state as a whole rather than community by community when offering video services. Such deals rarely include any I-Net provisions.

However, the I-Net legacy lives on. Many communities remain dependent on their I-Net even when it contains little excess capacity, leaving them unable to take advantage of high-bandwidth applications (e.g. remote trainings or video conferencing).

E-Rate

In 1997, the FCC established the E-Rate program by setting aside a maximum of $2.25 billion each year from the Universal Service Fund to subsidize school and library Internet connections. Discounts range from 20-90%. Over the past ten years it has distributed $19 billion to service providers.

Though E-Rate has clearly succeeded in increasing school and library connectivity, it has not solved the problem of connecting the schools. If the program ended tomorrow, thousands of schools and libraries would be unable to afford their connectivity. E-Rate should be structured to incentivize self-sufficiency so communities could invest in a long-term solution to connectivity rather than relying upon a federal fund year after year.

UTOPIA

Fourteen cities in Utah have formed the Utah Telecommunications Open Infrastructure Agency to build an open access fiber optic network. Open access means they run the network like a road. Publicly owned, any service provider can use it under equal terms. The network is not yet fully built but features several service providers. Subscribers have access to speeds far in excess of incumbent offerings at comparable prices.

For more information, http://www.utopianet.org/

Fiber Optic Networks

Some cities have built their own citywide fiber networks to ensure their residents and businesses would not be stuck on slow, asymmetrical networks. In Utah, a publicly owned fiber network built by UTOPIA has introduced competition to several cities, including the city of Murray and its 45,000 residents. In September 2007, Kyle Waters testified before the Utah Government Competition and Privatization Subcommittee on behalf of his company, Venture Data, which subscribes to the UTOPIA network in Murray. He noted that both people and businesses are moving into UTOPIA's footprint for its faster speeds at lower prices.

Venture Data uses two service providers – one for a 30 Mbps Internet connection at $109/month and another for its voice services. Without UTOPIA, they would be paying considerably more for a slower connection. The price advantages are so great that Venture Data, when considering a new location, realized it could not leave the UTOPIA boundaries.[10] Elsewhere in UTOPIA, an accounting firm switched from leasing a T.1 line at 1.5 Mbps for $650/month to using a 30 Mbps connection from a UTOPIA service provider for $150/month.[11]

Businesses across the country are paying attention to these fiber networks. When Nucomm International

Comparative Speed Table

	Speed	$ / month	$ / Mbps
T.1 in Utah	1.5 Mbps	$650	$433
DSL*	5/.8 Mbps	$100	$20
UTOPIA	30 Mbps	$150	$5
Japan Average**	61 Mbps		$0.27

* Cost reflects business service
** http://tinyurl.com/yptog4 [NY Times]

needed to locate a new call center – one that would add 1,000 jobs with benefits to the local economy – it chose Lafayette, Louisiana, because the city is building a massive fiber network to connect everyone.

Fiber networks should not be considered an alternative to wireless networks. As noted previously, each solves different problems. Fiber networks can actually lower the cost of building a wireless network. Once the fiber network is completed, wireless nodes can be easily connected, offering considerably faster speeds than those without ubiquitous wired backhaul.

Fiber optic cables are called the gold standard – the best long-term investment for wired networks. The immense capacity of fiber (which is limited only by the budget for electronics), coupled with a modern network designed for future needs, make these networks far superior to DSL and cable.

As with any wired network, the installation costs are high. Fiber cabling is frequently installed underground in public rights-of-way, but some cities have hung the cables from existing utility poles. Either way, the installation takes significant time, labor, and capital. However, once the fiber is there, it lasts many decades.

Much of the cost of installing fiber comes from having to bury it. Forward-looking communities have been installing ductwork and conduit (tubing through which fiber will eventually pass) wherever they are working underground. When streets or sidewalks are torn up, the costs of installing conduit are minimal. Fiber can later be pulled or blown through the conduit when it is needed. Similarly, many developers install conduit and fiber into new housing developments because it can be done at practically no cost when roads and sidewalks are not yet even built.

The costs of a fiber network vary greatly from community to community, depending on the size of the community, population density, the fiber-optic technology employed,[12] whether the lines are installed aerially on poles or buried, etc. Generally, however, there are three major costs associated with building such a network.

1. Electronics – municipal fiber networks are often built with a centralized hub to house sophisticated electronics. Larger networks will also require aggregation points in the field with expensive electronics.
2. Fiber pass throughout the neighborhoods – the fiber cables must run from the central office to every neighborhood and business district. This frequently runs between $500-$1500 per passed premises.
3. Last-mile connection and electronics – each house or building must be connected to the fiber pass. This cost covers both the electronics and the actual fiber drop from the premises to the network. Costs here can range from $500 to $1000. These costs are incurred when customers are connected.

Reedsburg, a community of 9,000 residents near Madison, Wisconsin, built a network for $13.5 million. The central office cost $2.5 million. Monticello, Minnesota, will soon start building a network for its 10,000 residents at an expected cost of between $20 and $25 million. Lafayette, Louisiana, has already broken ground on its $110 million network for its 110,000 people.

Though fiber networks are considerably less expensive to maintain than cable networks, the network owner must budget for some operations and maintenance cost. These costs vary based on the network, but each year will likely hover around 3-5% of the initial capital cost.

Municipal deployments frequently use 20 year financing to pay off the network. Fiber is commonly expected to last at least 20-30 years but may last considerably longer. If new fiber is needed, pulling it through existing conduit is easy and well below the cost of the original install. Network electronics should be budgeted for replacement every 3-7 years depending on the device. The electronics can last longer but changes in technology and increased efficiencies generally encourage replacement in that time frame. The cost of electronics (and amount of electricity required) is constantly dropping due to technological innovations.

Burlington Telecom

Burlington, the largest city in Vermont at 39,000 people, built a citywide fiber network to serve its 16,000 households and more than 2,000 businesses. The network was built incrementally and financed using a tax-exempt municipal capital lease. This arrangement allowed Burlington to build the network without aid from the electric utility or tax dollars.

After 4 years and $33 million dollars, the network is nearly completed. They are approaching a positive cash flow, meaning that it will soon generate more revenue than it expends to run the network. They are on schedule to have a positive free cash flow by late 2009, when the network will generate enough income to make debt payments in addition to running the network.

As Burlington Telecom is a city department, excess income will stay in the community, going into the City's General Fund. Once they have serviced the debt, some 20% of the General Fund could come from network revenues.

For a full case study on Burlington Telecom, see *http://www.newrules.org/info/bt.html*

Broadband Considerations

Though Burlington and others have had financial success with carefully planned broadband investments, cities should not rush into this arena with a get rich quick mentality. Broadband systems are large investments with finicky technologies that require specialized expertise to run efficiently. Once the system is correctly configured, it requires an advertising/promotional strategy and technical support, requirements that may be outside the city's existing expertise. Cities frequently deal with this by recruiting experienced people, contracting pieces out, or turning to consultants.

Many cities with municipal utilities have enjoyed success when expanding into telecom because they already have billing and customer support experience. Perhaps more importantly, the utility already has the trust and confidence of the community.

Though existing broadband providers have few competitors, they fight for each subscriber. Incumbent providers have launched many lawsuits against publicly owned projects while winning few judgments. Incumbents know lawsuits are a can't-lose prospect because the litigation costs, combined with months of lost revenue while the project must await a decision, greatly disrupt municipal business plans.

Additionally, new providers planning to offer video services are rarely prepared for the difficulties of negotiating contracts with the channels. ESPN's owners demand any system carrying ESPN must carry ESPN2 and a number of other channels. The owners of another popular must-carry channel may specify that two of their channels must be within 2 clicks of ESPN. Inevitably, putting a channel lineup together takes longer and costs more than expected. Open access systems can relieve the network owner of some of these hassles because the providers must work out the arrangements.

Communities considering a broadband network can be overwhelmed by the technical details. As muni fiber networks are young, but rapidly expanding, new firms and consultants are entering the arena, eager to "help." Before trusting an engineering firm, vendor, or consultant, be sure to talk to those who have built municipal networks before. A publicly owned, municipal fiber network is not just like any other network. Network architecture is important and quite expensive to change after constructed -- especially if a poor design results in revenues below forecasts. As each community is unique, beware the cookie-cutter solutions; consider a network architect to maximize network value.

Make no mistake; building a municipal broadband system is a difficult task, but cities wishing to remain competitive regionally, and certainly globally, have few alternatives.

Ownership

Public ownership can take many forms, from a utility model, to a city department, to a coop, etc. Each is linked by the common theme of local determination. Too many cities are currently reliant on private providers for essential infrastructure – a point brought home to Michigan when Comcast chose to stop supplying some police and fire stations with free broadband and television services.

Comcast has also been in the news for disrupting network traffic for certain applications, though other cable companies (e.g. Cox Cable) also engage in the practice.[13] While Comcast has refused to admit exactly what it is doing, investigators have determined that it actively disrupts some file-sharing applications, regardless of what content is being shared. The business application Lotus Notes was caught in the crossfire, leaving telecommuters unable to work effectively. In early 2008, the F.C.C. announced it would investigate the situation.

Cable providers, operating their shared-bandwidth network, are fearful that some users will use too much bandwidth and cripple access for other subscribers. This is a clear admission that existing cable networks are barely sufficient for today's needs, to say

Community Benefits

Publicly owned networks offer more to a community than just affordable triple-play offerings. Though new statewide cable franchising laws have preempted local authority and lessened funding for public, government, and educational television, municipal fiber networks now offer new opportunities. Rather than forcing community television into a few channels, these networks can create as many channels as needed.

All government meetings can be recorded and archived for video on demand over the Internet or on the television. High school sports, plays, and concerts are no different. Local businesses may want to wrap advertisements around local content to cover the cost of capturing the video, though many parents would undoubtedly volunteer the needed time.

As applications and technology change, the community can decide when they need upgrades for faster speeds, rather than hoping their needs coincide with incumbent provider shareholder interests.

The technology has moved so quickly that few are prepared for a world of nearly unlimited bandwidth. The future is just beginning.

nothing of tomorrow's. In response to these fears, they may change the way the network operates without notifying anyone. Those who were dependent on Lotus Notes for their business received no explanation for the disruptions to their application.

Joseph Franell, Director of Information Technology for Ashland, Oregon, explains why the cable companies do not respond to bottleneck fears with network upgrades:

> "Where there is a high rate of return on investment with old technology without any threat of competition, monopolistic incumbents have little reason to improve their networks and/or product offerings."[14]

Private network owners simply have different motivations from public network owners. Private companies are legally required to maximize profit for their shareholders. Public entities have a different mission; they are focused on maximizing social and economic benefit to the community. This distinction seems to have been lost in much of the discussion around municipal broadband systems. Companies like Comcast and AT&T must look out for their bottom line, not the communities in which they operate. Communities should not shun such companies, but neither should communities rely upon them for critical infrastructure.

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Groups like the Heartland Institute and Pacific Research Institute frequently attack publicly owned systems as a waste of taxpayer money. "Wi-Fi Waste: The Disaster of Municipal Communications Networks," a report from the Pacific Research Institute, uses figures out of context to suggest all the publicly owned systems surveyed were failures. When one actually examines the context, labeling these systems as failures is absurd.

Before actually examining numbers and context, remember that large networks require massive upfront capital investments. In the early years, all network owners lose money until they have enough subscribers to pay for operations and debt servicing – this usually takes several years. Therefore, any examination of municipal networks in the early years will show losses on the accounting sheet.

Some systems reach a positive cash flow faster than others. Both Burlington and Reedsburg required four years to achieve a positive cash flow. Cedar Falls, Iowa, built a municipal broadband cable system in 1997 and had a positive cash flow three years later. It has been building a cash reserve to pay off its debt ahead of schedule and finance its conversion to a fiber network.

Other systems have gone longer without being able to fund all operations and debt payments with subscriber revenue. Though groups ideologically opposed to public ownership are quick to pronounce them failures, the truth is that any business model expecting to break even from these investments in the first few years is bound to fail. It takes years to build the system and sign on customers. In many communities, the network adds subscribers as fast as possible with their take rate limited only by how fast they can physically connect eager subscribers.

In other cases, some networks have had lower take rates than forecast because incumbents lowered prices and locked in customers with long term contracts. Though these systems may take longer to pay off their debt, all subscribers in the community benefit by paying significantly less for services. This money stays in the community and inevitably outweighs the costs from extending debt payments or tapping tax dollars.

Broadband networks encourage economic development, both bringing in new jobs and retaining existing jobs. Communities benefit when local companies with growing telecom needs can get the speeds they need without moving. In the UTOPIA footprint, businesses saving hundreds, or even thou-

Ashland Fiber Network, Oregon

Ashland built a publicly owned hybrid fiber and cable system after the incumbent provider refused to meet the broadband needs of the community. However, the network cost twice as much to build as forecast. Further, Charter purchased the incumbent provider and aggressively dropped prices and improved services to maintain their subscribers. After AFN faced operating losses for several years, the city leased the cable system to a private provider, getting the city out of the video business and turned an operating profit.

Though the initial business plan did not call for tax dollar support, the city has had to pay down some of the debt. On the whole, the community has benefited greatly from faster broadband and lower cable and phone bills. Home businesses can get a 100 Mbps connection from the network. Perhaps the best indicator of its success is the drop-off in angry phone calls to the mayor. Prior to posting AFN operating budget surpluses, he received 5-12 calls a day from those opposing the network. Now, he goes months between calls.

sands, of dollars a month are unlikely to be concerned that the network is taking longer to pay off the debt than originally forecast.

Whether it is the funding they receive from incumbent providers, a rigidly libertarian philosophy, or simply an intoxication with the private sector, groups like the Pacific Research Institute are quick to forget the many ways private businesses benefit from government's role in providing essential infrastructure. UPS, FedEx, and DHL can all compete with equal access to government-run roads. General Motors cannot buy the roads and prevent Nissan or Ford vehicles from using them.

The municipal decision may be between private and public ownership, but it actually pits incumbent providers against the thousands of businesses, residents, and public entities that all depend on competitive, affordable connections.

The municipal decision may be between private and public ownership, but it actually pits incumbent providers against the thousands of businesses, residents, and public entities that all depend on competitive, affordable connections. This decision should be made based on what is best for the community.

Cities can start by building a publicly owned network to meet their own needs. Connecting government buildings with a city owned network will immediately cut telecom expenditures by allowing the city to aggregate its needs into one contract for the network. When Burlington consolidated just their voice services (1000 phone lines), they realized a savings above 35%.[15] Phased business plans offer flexibility and offer a reasonable learning curve for the network owner.

When planning a publicly owned system, cities must be aware of a practice called "conditioning." Historically, fiber provided by cable companies for an I-Net came with certain provisos. The city could use it for official functions but was not allowed to share it with commercial traffic. Similarly, conduit is sometimes offered to public entities on the condition that the fiber running through it is only used for official city needs. Though this seems a grand deal, if the city later decides to build a citywide network to share fast, affordable connections with citizens and businesses, it must find new fiber and/or conduit because it cannot use those conditioned assets. Plan ahead and negotiate for unconditioned infrastructure wherever possible.

Communities have a variety of options for funding broadband networks. Some cities have turned to existing municipal utilities to expand operations or offer loans. Other cities have used their bonding authority – both general obligation and revenue bonds have been used to secure funding.

Burlington financed its network using a tax-exempt municipal capital lease from private investors. Though cities frequent use this mechanism to finance a variety of purchases from computers to fire engines, few have considered it for a citywide network. Yet, many investors prefer this method because it requires a solid business plan, something every community should develop regardless of the source of funds.

Conclusion

Cities across the United States are wrestling with the problems of increasingly important telecommunications. Everything has become more dependent on connectivity – from entertainment to education to commerce to governance. Recognizing the importance of this infrastructure, communities across the United States are taking control of their future.

Though some have invested in wireless because it is more affordable in the short term, communities should think carefully about their long term needs and what serves them best. Fiber is the future. The question is not whether businesses and homes will eventually be connected; the question is who will own the connection. The network owner decides whose needs to meet: the community or shareholders.

Communities have a historic opportunity to guarantee their relevance in an increasingly digital future. Some see publicly owned networks as an economic development strategy whereas others focus on attracting a creative class of citizens. Some are fearful of a pandemic and are ensuring the economy can function with remote workers. Ultimately, these communities have recognized their connectivity is too important to leave to massive phone and cable companies who are legally bound to respond to shareholders first and foremost.

St. Paul chose to forgo the short-term gains of wireless to pursue a long-term strategy. Though it will not roll out a network this year, St. Paul's fiber system could easily accommodate wireless nodes if the community deems it necessary. Regardless, St. Paul will no longer be dependent on an incumbent provider for inadequate speeds at inflated prices.

Cities have a golden opportunity to invest in superior networks and open them to competition. Once private network owners are wired for fiber, they will be in a far stronger position to maintain their monopoly status. We are fortunate neither General Motors nor UPS owns the roads. With wise investments now, we can extend that lesson to the digital avenues of commerce and entertainment.

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Other publications from the New Rules Project of the Institute for Local Self-Reliance

Minnesota Feed-In Tariff Could Lower Cost, Boost Renewables and Expand Local Ownership, by John Farrell, January 2008

The Policy Gap: Minnesota Energy Policy vs. Minnesota Climate Policy, by John Farrell, John Bailey and David Morris, November 2007

Burlington Telecom Case Study, by Christopher Mitchell, August 2007

Wind and Ethanol: Economies and Diseconomies of Scale, by John Farrell, July 2007

Energizing Rural America: Local Ownership of Renewable Energy Production is Key, by David Morris, April 2007

Localizing the Internet: Five Ways Public Ownership Solves the U.S. Broadband Problem, by Becca Vargo Daggett, January 2007

Big-Box Swindle: The True Cost of Mega-Retailers and the Fight for America's Independent Businesses, by Stacy Mitchell, November 2006, Beacon Press

Broadband networks will play as crucial a role in the future as canals, roads and the electrical grid have in our past. The Telecommunications as Commons Initiative investigates the benefits of public ownership as a means to guarantee universal access, network neutrality and community control when it comes to access to information.

Endnotes

[1] http://tinyurl.com/3camfx [USA Today]

[2] http://tinyurl.com/yupgvs [MuniWireless]

[3] http://tinyurl.com/3dhkrl [Computerworld]

[4] There are actually two types of antennas. The more common antenna is used inside the house and connects to a computer or hub via a simple ethernet cord. Occasionally, an external antenna is necessary and will be mounted on the exterior of the house.

[5] Backhaul is the connection from the nodes to the servers and routers at the central office (managed by the network owner). Many wireless networks ultimately rely on fiber for the backhaul due to its reliability and speed. However, connecting all nodes to fiber is expensive. Thus, nodes without a wired connection send their data from node to node (each node is called a "hop") until it hits a wired connection. Due to the overhead, each hop halves the usable bandwidth. Thus, network designers attempt to keep all nodes within three hops of a backhaul node.

[6] The speed of the network depends on its generation (e.g. 2G, 3G). 2G runs at 9.6Kbps, 2.5G (aka EDGE) runs at 110 kbps, and 3G (such as EVDO) runs up to 3 Mbps.

[7] http://tinyurl.com/2cqu9k [NCTA]

[8] For instance, see http://tinyurl.com/25lr57 [DSL Reports].

[9] http://tinyurl.com/2bnnjn [DSL Reports]

[10] http://tinyurl.com/28t6x4 - Utah Government Competition and Privatization Subcommittee, Sept. 26. Venture Data testifies toward the end of the broadband section.

[11] http://tinyurl.com/ok9sl [IEEE Spectrum]

[12] The two main options are between passive and active. Though some of this decision appears to be one of religion, population density should play a large role in deciding which technology to go with.

[13] http://tinyurl.com/2m6vss [DSL Reports]

[14] "Open Access Saves a Municipal Broadband System." August 2007 in Broadband Properties Magazine.

[15] Burlington Telecom Case Study - available at http://www.newrules.org/info/bt.html

The Institute for Local Self-Reliance is a nonprofit research and educational organization that provides technical assistance and information to city and state governments, citizen organizations and industry.

Since 1974, ILSR has researched the technical feasibility and commercial viability of environmentally sound state-of-the-art technologies with a view to strengthening local economies. The Institute works to involve citizens, governments and private enterprise in the development of a comprehensive materials policy oriented toward efficiency, recycling and maximum utilization of renewable energy sources.